Managing Mississippi Ponds and Small Lakes

A LANDOWNER'S GUIDE

MISSISSIPPI STATE UNIVERSITY™
EXTENSION

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A LANDOWNER'S GUIDE

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Ponds and small lakes are abundant in Mississippi and are favorite fishing places for Mississippi anglers.

A pond that consistently produces good catches of fish is a result of proper planning, construction, and management. Poor planning, improper construction, or lack of proper management results in lakes and ponds that are relatively unproductive or problematic.

It is critical that as a landowner you clearly define your objectives in the beginning, before the first soil is moved.

Do you want to catch good numbers and sizes of bass and bream? Or do you want trophy bass? Maybe you prefer to catch big bream? Or just channel catfish? How much will the pond be fished? Will the pond be used for purposes other than fishing?

You must decide before construction begins how the pond will be used so you can create a proper management plan for the pond. Keep in mind that all objectives cannot be met in a single pond, and compromises may be necessary. Landowners with multiple ponds may consider applying different management plans on different ponds.

After the pond is completed, success or failure depends on using practices to establish and maintain good fish populations. Proper stocking with the correct species and numbers of fish, stocking at the proper time of year, a balanced harvest, water quality management, and aquatic weed control are basics you should understand. Many unmanaged ponds could produce many more pounds of fish than they now produce if good management practices were followed.

Mississippi has more than 160,000 water bodies up to 100 acres, totaling more than 190,000 acres.

SOURCES OF ASSISTANCE

If you need assistance in planning a new pond or managing an old one, contact one of the following agencies or one of their field offices located throughout the state:

Planning

NATURAL RESOURCES CONSERVATION SERVICE

100 West Capitol Street
Suite 1321, Federal Building
Jackson, MS 39269
(601) 965-5205
(Local service center in each county)
www.nrcs.usda.gov

When contacting your local NRCS office, be clear that you are seeking Conservation Technical Assistance (CTA).

DEPARTMENT OF WILDLIFE, FISHERIES, AND AQUACULTURE

Mississippi State University
Extension Service
Box 9690
Mississippi State, MS 39762
(662) 325-3174
(Extension office in each county)
extension.msstate.edu

Management

MISSISSIPPI DEPARTMENT OF WILDLIFE, FISHERIES, AND PARKS

1505 Eastover Dr.
Jackson, MS 39211-6374
(601) 432-2400
www.mdwfp.com/fishing-boating/pond-assistance-office-locations

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All of the information contained in this guide and much more is at your fingertips at **extension.msstate.edu**.

PLANNING

Setting Objectives

Perhaps the most important decision you make as a pond owner is deciding what purposes the pond will serve. If the pond is to be used for something other than fishing—like irrigation, fire protection, swimming, wildlife habitat, livestock water supply, or home cooling—these uses may require different design considerations from those for fishing alone. Design of fishing ponds is described below.

During the planning stages of the pond, determine the species and sizes of fish you would like to catch. This is called the "management objective." Stocking and management differ based on this objective. Some pond owners prefer bream fishing and manage the pond to produce a good crop of large bream. Some prefer a good all-around fishery for bass and bream. Many want only a chance at catching trophy bass, while others are happy with quality catfish. **Usually, a pond can be managed successfully for only one management objective at a time.**

Site

Site selection is extremely important. Natural Resources Conservation Service (NRCS) personnel can assist in site selection, soil suitability, engineering survey, and design. They can estimate the cost of the earthwork, make quality control checks during construction, and provide information on other aspects of planning, design, and construction. This service is free and may save you money in future reconstruction costs needed to fix a poorly designed or sited pond. When contacting your local

The first step in a successful pond construction project should be to contact the Natural Resources Conservation Service (NRCS). The NRCS office nearest you can help with site selection, soil testing, pond sizing, and other construction considerations.

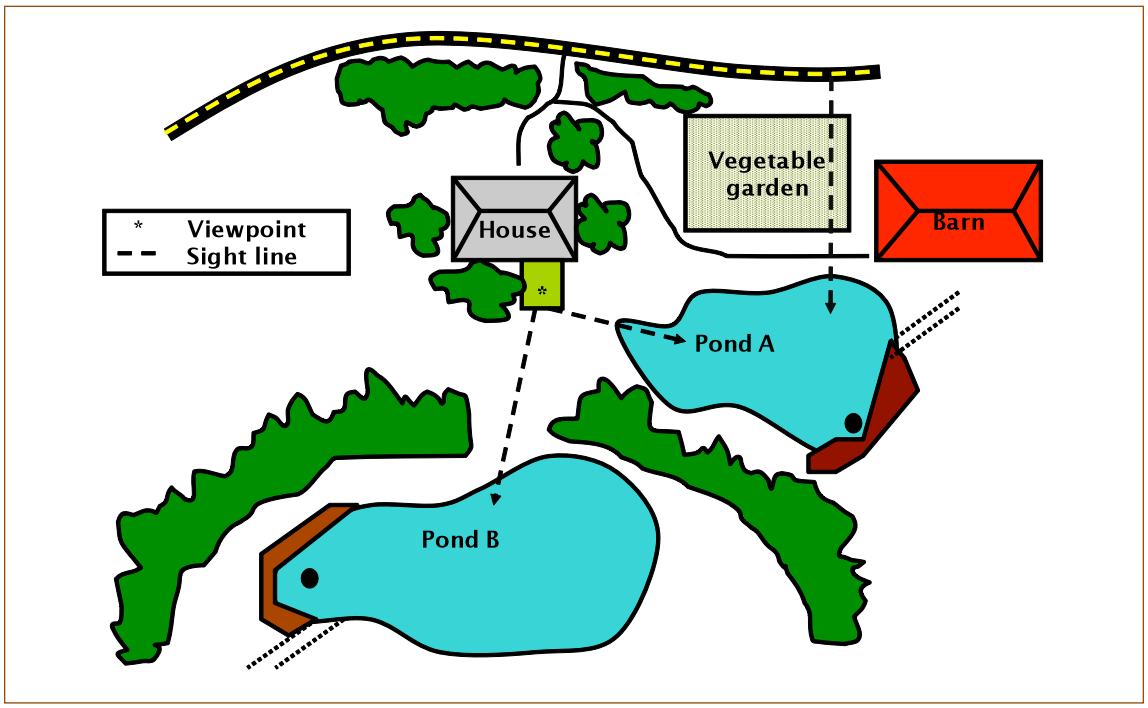


Figure 1. Considerations for pond site selection. Pond A is in full view of a highway that invites trespassers; runoff from the vegetable garden may enter the pond; and the emergency spillway flows toward the barn. Pond B is in a better location, since it is not visible from the road, nor are there issues with runoff or water release.

NRCS office, be clear that you are seeking Conservation Technical Assistance (CTA). Also, be sure to download Agriculture Handbook Number 590 *Ponds – Planning, Design, and Construction* from the NRCS. Search the complete title to find an available source.

Before you select your pond site, consider the shape of the land (topography), water supply, and soil type. If possible, consider more than one location, and study each one to select the most practical, attractive, and economical site. Consider potential problems, such as runoff from agriculture, past land uses, or potential to attract trespassers (Figure 1).

Topography

Consider topography first, because it directly affects building costs and management. Place the pond where enough water can be held with the least amount of earth moved. A good site is usually one where you can build a dam across a narrow section of a valley and where the slope of the valley floor lets you flood a large area. Such sites are ideal and minimize areas of shallow water (water less than 2 feet deep). Avoid large areas of shallow water because they become too shallow to use in late summer and fall dry periods, and they encourage the growth of undesirable aquatic plants. Likewise, steep sloping valleys may make the pond too deep, which may lead to poor fish production and possible fish kills. Also avoid locations with constantly flowing creeks or streams, as these flush the pond and make it difficult to manage pond water chemistry.

Water Supply

Water availability should be adequate, but not excessive, and may be provided by springs, wells, or surface runoff. Check well water for potentially high levels of dissolved substances, such as iron, which may cause problems in the pond. Also, well and spring water may be low in oxygen when it is pumped or flows out of the ground. Do not use standing surface water (such as pumping from creeks and sloughs) to fill ponds if you can avoid it, because it is a source of unwanted fish, parasites, and fish diseases.

For ponds where surface runoff is the main source of water, the contributing drainage area should be large enough to maintain a suitable water level during dry periods. The drainage area should not be so large, though, that expensive overflow structures are needed and water exchange occurs too frequently. **As a rule, a pond should have 10 to 15 acres of drainage area for each acre of impounded water in Mississippi.** The amount of runoff from a watershed depends on local climate, topography, soil type, and plant cover.

Soil

Suitable soil is one of the main factors in selecting a pond site. The soil should contain a layer of clay or silty clay

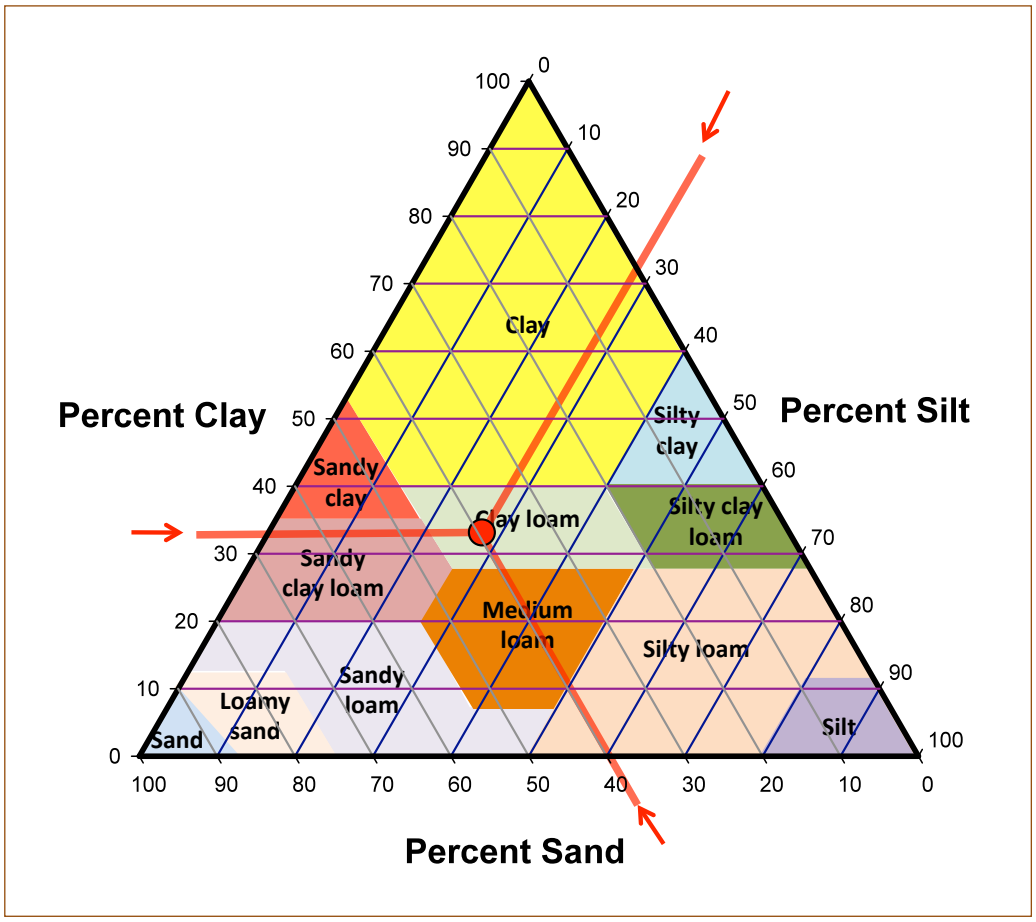


Figure 2. A soil triangle can be used to determine the type of soil present in potential pond sites. To use the triangle, the percent of each component (clay, sand, silt) must be determined from a sample. The soil type is where the lines for percent clay, sand, and silt meet.

material that water will not seep through. Sandy clays are also usually satisfactory. The more clay in the soil, the better it will hold water. **At least 20 percent clay is necessary to hold water** (Figure 2)**.** To determine soil suitability, take soil borings at frequent intervals and have them analyzed. The NRCS office can assist with this evaluation. Not evaluating the soil properly could result in a pond that will not hold water.

It is much easier to check the soil for lime requirements and to lime the pond bottom just after construction before the pond begins to fill with water (see Liming Ponds on page 26). Your county Extension agent can advise you how to collect soil samples for analysis to determine the lime requirements (of the pond bottom) for the site you have selected. The MSU Extension Soil Testing Lab charges a small fee for this analysis.

Permits

Mississippi law requires that anyone proposing to build, modify, or repair a dam must get written authorization from the Mississippi Department of Environmental Quality (MDEQ) before beginning construction. Written authorization is not required if the dam is less than 8 feet high, impounds less than 25 acre-feet of water at the top of the dam, or does not impound a watercourse with a continuous flow of water (as long as failure of the dam would not threaten public safety downstream). A surface water impoundment permit may be required, even if written authorization to build the dam is not required. The impoundment permit has a fee of $10 and is good for 10 years. Penalties may be imposed for failure to file. To apply for an MDEQ dam construction permit, use the form at https://www.mdeq.ms.gov/wp-content/uploads/2017/06/Dam-and-Impound-APPLICATION.pdf.

If the construction is expected to disturb between 1 and 5 acres (construction of the dam and area excavated for dirt used in the dam), then small construction permit conditions will apply. If the construction is expected to disturb more than 5 acres, then a large construction permit will be required. To apply for an MDEQ Large Stormwater Construction Permit, use the form at https://www.mdeq.ms.gov/wp-content/uploads/2022/03/LCNOI-2022.pdf.

Landowners are also urged to check with the U.S. Army Corps of Engineers to see if a 404 permit will be required. Visit this site to determine if you need a 404 permit: https://rrs.usace.army.mil/rrs/home/permit-process-guide

CONSTRUCTING

Selecting a Contractor

Your local NRCS office can usually provide a list of contractors capable of constructing ponds and small lakes. You should shop around, and check with their previous clients to ensure that their product is acceptable. Select a firm that is licensed, insured, and bonded and that will fix any leaks within an agreed-upon period following construction.

When to Build

You can build a pond any time of the year, but summer is usually the best because weather and soil conditions allow use of heavy equipment. Fall and winter rainfall fills the new pond and lets you stock fish at the right times.

Size

Determine pond size by your needs and desires. Bigger is not always better. Small ponds (1 to 3 acres) provide enjoyable fishing if you follow good planning and proper management guidelines. Larger ponds and lakes provide many other uses, such as water supply, limited irrigation, swimming, boating, and hunting, and they are less susceptible to water level changes. For surface runoff ponds, use the area of land that flows into the pond to determine the pond's size (see Water Supply on page 7). In general, 10 to 15 acres of drainage area are required for each surface acre of pond water.

Depth

Ponds in Mississippi should have an average depth of about 5 to 6 feet and be no more than 10 to 12 feet deep

in the deepest areas. About half of the pond should be in water that is 4 to 5 feet deep. This lets fish forage on the bottom, even in summer when low oxygen concentrations are common in deeper water, while maintaining enough depth to sustain the fish during drought. But about 20 percent of the pond bottom should be at least 6 feet deep to provide winter refuge and summer refuge in extremely dry years. During summer, evaporation can reduce water levels at a rate of up to a half-inch per day, and ponds may lose 2 feet or more in water depth. The pond banks should slope quickly to at least 3 feet deep to minimize risk of aquatic plants becoming established. Deep ponds are not necessary for productive fisheries and may lead to water quality problems, such as low dissolved oxygen, which can kill fish. Most Mississippi ponds have low oxygen levels at depths greater than 4 feet in summer.

Dams

Dams should be at least 8 to 12 feet wide at the top, depending on the height of the dam. Dams less than 12 feet high require an 8-foot top width. Dams between 12 and 15 feet high require a 10-foot top width, and those higher than 15 feet require a 12-foot top width. Dams with tops wider than the required minimum are much easier to maintain. If you plan to use the dam as a road, it should be at least 16 feet wide across the top.

In many areas of Mississippi, soil types are such that dams must be cored with clay to prevent seepage. The slope of the dam should be no steeper than 3:1 on the waterside. On the backside, a 4:1 to 5:1 slope lets you safely maintain the vegetation on the dam. For example, a dam with a 3:1 slope will have a 1-foot rise for every 3 feet of horizontal measurement.

Establish suitable perennial vegetation on the dam as soon as possible to prevent erosion, muddy water, and maintenance problems. Nonnative grasses such as Bermuda and Bahia are commonly planted because they establish a sod quickly and tolerate frequent mowing to just a few inches in height. A good, deep-rooted native grass (such as switchgrass or big bluestem) is an alternative perennial cover that provides better wildlife habitat, requires less mowing, and tolerates drought better than nonnative grasses. If native grasses are established as cover on the dam, do not mow them shorter than 6 inches in height.

If dam construction is completed before or after the recommended planting dates, plant a temporary cover to limit soil erosion until the permanent cover establishes. **Sowing a temporary cover of browntop millet (25 pounds per acre broadcast from May to July) or winter wheat (90 pounds per acre broadcast from August to November) protects exposed surfaces and provides wildlife food and cover.**

Lime, fertilize, and seed the dam with an appropriate grass as soon as construction is complete. We recommend mulching the dam and other sloping areas. It is very important to prevent erosion of the dam.

Complete the pond in summer before stocking fish in the fall. If practical, do not let the pond fill with water until just before stocking. This prevents the pond from becoming contaminated with unwanted fish species, lets grass cover the pond bottom, and helps prevent muddy water.

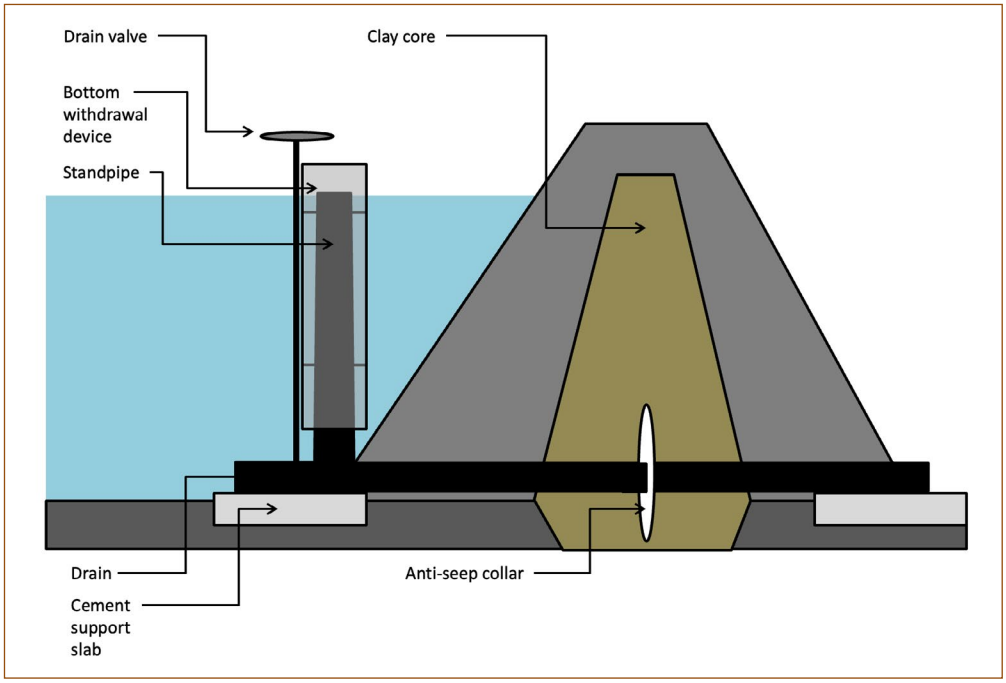


Figure 3. Diagram of recommended pond levee and water control structures (slopes not to scale).

Do not let trees or shrubs grow on the dam, since they weaken the dam and increase the likelihood of leaking or failure. But if large trees are growing on an older pond dam, don't remove them, because their decaying root systems may weaken the dam.

A properly maintained dam can be mowed, front and back. **Never** let trees become established on new dams.

Water Control Structures

A combination drain and overflow pipe (Figure 3), as well as an emergency spillway, are necessary for good management. **It is very important that you place the drainpipe on the pond bottom so you can completely drain the pond.** Controlling the water level is important for weed control and fisheries management. **A drain is necessary to manage the pond efficiently.** The overflow pipe is the outlet for normal water flow through the pond. **The emergency spillway is an area lower than the top of the dam on one side of the dam to safely release excessive runoff from heavy rainfall.**

Overflow and drainpipes may be corrugated metal, aluminum, steel, or polyvinyl chloride (PVC). Some materials are more durable than others and may be preferred. For example, PVC pipe, although inexpensive, is prone to breakage and vandalism. Be sure the pipe meets the standards for use in a pond dam. You can add drains to existing ponds, but you will need professional assistance.

It is also a good idea to fit a larger pipe over the standpipe, starting 18 inches off the bottom and extending 12 inches above the surface (Figure 4). This pipe will draw water from the deeper areas of the pond, where there is no oxygen. During periods of water flow through the pond, this improves the water quality in the pond, increases usable habitat, and reduces the risk of a fish kill. The outside pipe must be at least one and a half times the interior width of the standpipe to allow for maximum flow.

Banks

Banks should be moderately sloped until reaching a water depth of 3 feet near the shoreline to eliminate shallow water areas around the pond edge where aquatic plants often start. **Use a 3:1 slope where possible (the depth increases 1 foot for every 3 feet away from shore) until reaching the minimum depth.** Cattle may cause bank erosion and muddy water. Fence the pond to limit or prevent damage by livestock.

Seepage

Seepage in new ponds sometimes develops. Often you can correct seepage by draining the pond and compacting the bottom. If the bottom soils have marginal water-holding capacity, a blanket of clay or other soil sealant packed with a sheepsfoot roller may reduce the seepage. If the seepage problem persists, contact any NRCS office or Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) district office.

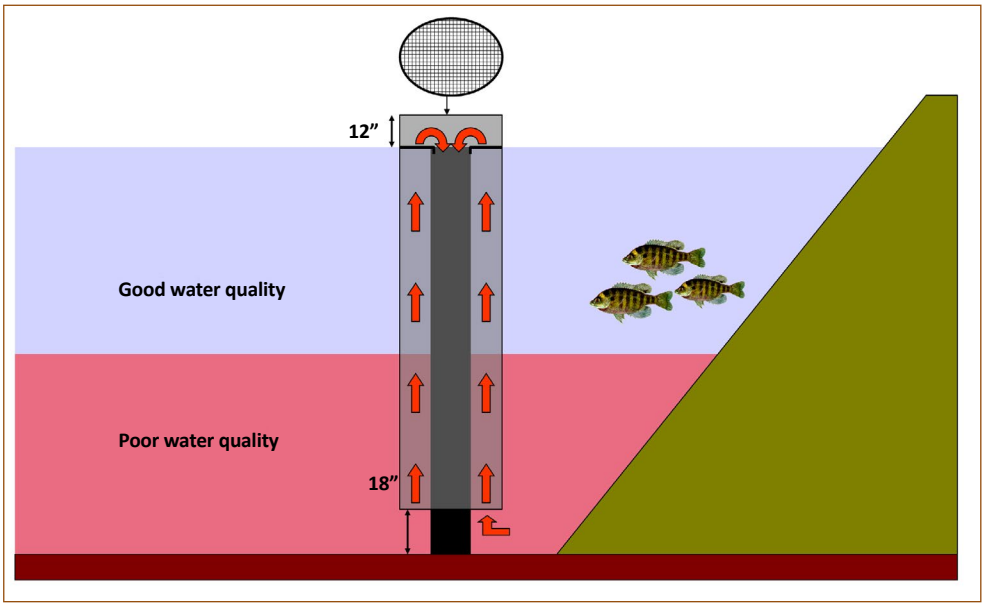


Figure 4. Schematic of a bottom draw-off device used to remove deep, low-oxygen water, which increases water quality and available habitat.

Pond Bottom

Many pond sites have trees in the basin, most of which should be cut and salvaged or piled and burned. It is acceptable to leave some trees, bushes, and brush piles. During construction, decide which trees to leave and clear unwanted trees,


Stocking fingerling fish.

which you can use for fish attractors. Such underwater cover provides habitat for certain aquatic organisms fish eat, as well as cover for game fish. Be sure you can find these areas after they are flooded.

Usually 10 to 25 percent of the pond bottom should have some tree cover (fish attractors) where possible. **It is important to leave tree cover in the right areas**. Leave bushes and trees in deeper water areas, along creek runs, and in the middle of the pond or lake. Leave trees in small clumps. Cut standing trees about 2 feet above the normal water level, and anchor brushy tops to the base of the tall stumps. These stumps will serve as permanent markers to brush top locations and avoid the dangers of falling limbs in later years. Do not leave trees or bushes in shallow areas, narrow coves, or along the bank, because these areas will become difficult to fish and may develop aquatic vegetation problems. Too much cover in shallow water makes it hard for bass to feed on the bream. You should be able to navigate the entire shoreline by boat.

If there are no trees or brush to leave for cover, you can establish fish attractors during pond construction. See Attracting Fish on page 36 for more detailed information. Prepare the pond bottom during construction because equipment and labor are available then. Use excess earth from construction to make underwater contours, piers, and islands. Most landowners are unwilling to drain the pond later for necessary bottom improvements, so it is important to complete all work during construction.

Lime the pond bottom after all other digging and dirt work are complete. Liming is extremely important and is discussed in greater detail later. **Before flooding, prepare gravel fish spawning beds, and build wooden and/or earthen piers. Plant wheat, rye, millet, or other suitable grasses in the pond bottom to produce lots of aquatic life when the pond is filled and to reduce erosion and siltation.**

STOCKING

Stock ponds with fish only from reliable fish hatcheries to prevent bringing in undesirable fish species, parasites, or diseases. Consult the district offices of the MDWFP, your NRCS office, or your county Extension office for a list of licensed game fish hatcheries in Mississippi. Ask for Publication 2525 *Sport Fish Suppliers and Stocking Guidelines for Stocking Mississippi Ponds*.

Selecting a Supplier

As a pond owner, you face decisions in selecting a fish supplier. Here are some questions to ask before making an informed decision:

- **Is there a warranty on the fish?** Keep in mind that fish may be delivered alive but may die several days later because of hauling stress, insufficient tempering to the pond water, or disease. Get it in writing!
- **Does the supplier produce the fish or buy them from a third party?** Vendors who produce their own fish are more likely to know the health history of the fish.
- **What species and sizes of fish do they supply?** Not all suppliers sell all species of fish, and the sizes, strains, or reproductive capacity might not be right for your pond.
- **Check references! Ask to contact some of their satisfied customers.** Check out the company with the Better Business Bureau in its state. **Remember, commercial fish producers are in the business of selling fish. It is not in your best interest to get your stocking recommendations from them.** Your county Extension agent, local MDWFP biologist, specialist from the Wildlife, Fisheries, and Aquaculture Department at Mississippi State University, or NRCS biologist can assist you with stocking plans free of charge.

Stocking Options

Bass and Bream Combinations

A healthy pond has a balance between predator and prey populations. In ponds of at least 1 acre, largemouth bass and bluegill provide this balance better than any other species. You can add a few other species, specifically redear sunfish (shellcracker or chinquapin), channel catfish, triploid grass carp, and fathead minnows, to provide

Table 1. Recommended stocking rates (number of fish fingerlings per acre) and species combinations for farm ponds larger than 1 acre. Stock all species except bass in the fall when the pond is at least half full and filling, and then stock bass during the following spring. Use the regular (Reg) stocking rates unless you intend to immediately initiate and maintain a fertilization program. If you will fertilize, use the fertilized (Fert) stocking rates. Most ponds are stocked at a predator to prey ratio of 1:10, but if your objective is trophy bass, you can increase this ratio to 1:20[a] to promote abundant prey by either increasing prey or reducing bass.

Stocking combination	Largemouth bass[a,b]		Bluegill		Redear sunfish		Channel catfish[c]		Fathead minnows[d]		Grass carp[e,f]	
	Reg	Fert	Reg	Fert	Reg	Fert	Reg	Fert	Reg	Fert	Reg	Fert
Bass-bluegill	**50**	100	**500**	1,000	n/a	n/a	n/a	n/a	**10 lb**	10 lb	**5**	5
Bass-bluegill-catfish	**50**	100	**500**	1,000	n/a	n/a	**50**	100	**10 lb**	10 lb	**5**	5
Bass-bluegill-redear	**50**	100	**350**	700	**150**	300	n/a	n/a	**10 lb**	10 lb	**5**	5
Bass-bluegill-redear-channel catfish	**50**	100	**350**	700	**150**	300	**50**	100	**10 lb**	10 lb	**5**	5
Channel catfish only	**15**	n/a	n/a	n/a	n/a	n/a	**100-150**	n/a	n/a	n/a	**5**	5

[a] To promote faster bass growth and maximum size, you can stock 25 bass and 500 bluegill or 50 bass and 1,000 bluegill, but understand that this will result in slower growth of bluegill.

[b] No additional stocking is necessary after the initial stocking of largemouth bass, bluegill, or redear.

[c] Channel catfish will not reproduce well in ponds with bass and must be replaced when they have been removed. Stock 8- to 10-inch catfish when bass are present. Bass are required to prevent catfish overpopulation.

[d] Fathead minnows are optional for bass ponds and will provide extra food and faster growth. However, they are quickly eliminated and must be restocked on a regular basis as desired.

[e] Grass carp are recommended to prevent aquatic weed growth. Large grass carp (20 pounds) are not as effective at controlling weeds, so restock two to three grass carp per acre every 5–7 years to maintain control.

[f] Larger lakes (>10 acres) that have significant open water should only stock three grass carp per acre.

a variety of fishing opportunities. These species, when stocked at recommended rates and managed properly, can provide years of good fishing (Table 1).

You can stock channel catfish with bass and bream or alone, but do not stock other species of catfish in ponds. Crappie are never recommended for small lakes and ponds less than 50 acres because they tend to overpopulate, resulting in a pond full of small, skinny crappie, bream, and bass. Crappie compete with bass for food, and should not be stocked into lakes less than 500 acres if trophy bass fishing is the desired objective. If you wish to stock crappie in lakes larger than 50 acres, consult a fisheries biologist for recommendations. If you have a pond with crappie already established, the two options are to renovate the pond and start over (see Pond Renovation on page 37) or to manage the pond for crappie. For more information on managing for crappie, see Crappie Management on page 20.

Largemouth bass are predatory and eat a variety of foods. Their diet includes small fish, frogs, crawfish, and insects. Largemouth bass are well adapted to ponds and reproduce successfully, usually spawning only once a year. They grow rapidly in ponds where food is plentiful, generally reaching sexual maturity and spawning at 1 year of age. In the spring, when water temperatures reach 60°F, mature males fan out depressions or "nests" on the pond bottom. Females lay their eggs in the nest. The male fertilizes the eggs, and they usually hatch within 4 days.

The two types of largemouth bass commonly stocked in ponds and lakes are the largemouth bass (native to all parts of Mississippi) and the Florida bass (not native). Crosses between these two, called hybrids, are also available. Although some research has been conducted to determine which, if any, of these bass species or hybrids are best for stocking farm ponds and small lakes, no conclusive answer has been found. A few observations, based partly on science and partly on field experience, are described below to help you decide which bass species to stock. Your ultimate success in **managing your bass depends more on the quality of your management program (including bass harvest strategy) than on species selection.**

- Largemouth, Florida, and hybrid bass have all been used with success in Mississippi. Florida and hybrid bass have greater genetic potential to attain trophy size. However, Florida bass may be harder to catch.
- Many hatcheries no longer maintain pure Florida bass, but rather slightly hybridized fish with varying percentages of largemouth bass and Florida bass genes.
- It is not known at this time whether all hybrids are equivalent in growth and catchability. For example, a hybrid that is 50 percent Florida and 50 percent northern **may** perform differently from a hybrid that is 25:75.
- F1 hybrid bass are first generation hybrids (50:50) and may experience enhanced growth. The offspring, though, are likely to experience reduced growth as compared to their parents and possibly lower than either species.

Bluegill (commonly called bream) and **redear sunfish** (shellcracker, chinquapin) are also well adapted to ponds and eat a variety of foods. When small, they eat microscopic plants and animals. As they grow, their diet changes to include insects, snails, crawfish, and small fish. If enough food is available, these fish grow rapidly, reaching sexual maturity at 1 year. When water temperatures reach 70 to 75°F in the spring, redear sunfish begin spawning, followed by bluegill, when temperatures reach 80°F. Bluegill may spawn several times in one season, while redear sunfish normally spawn only once or twice. Bream spawn in groups, and their collections of nests are called spawning "beds."

The two strains of bluegill commonly stocked in Mississippi are native bluegill and a Florida strain called coppernose bluegill. Biologically, the two are very similar, as are general growth rates and other characteristics. Opinions vary regarding the pros and cons of stocking coppernose instead of native bluegill, and many questions have yet to be answered. Both are readily available from hatcheries in Mississippi. Ultimate performance of the bluegill, regardless of strain, depends more on the quality of your management program than on strain stocked. **Do not stock hybrid sunfish with any other sunfish or if bass is a target species.**

Pulling a seine to catch juvenile fish.

Size of the pond has a direct influence on future fishing potential, but limitations are very few if you have reasonable expectations. **A farm pond stocked with bream and bass should be at least 1 acre in size, preferably larger.** Although small ponds can normally provide unlimited bream fishing, there is a potential for overharvesting the bass in ponds smaller than 1 acre. See the section on Stocking Options for Ponds Smaller than 1 Acre (page 14).

Stocking Recommendations for Ponds 1 Acre or Larger

It is important to stock a pond in the proper order and with the recommended numbers to achieve a balanced fish population. To begin, choose the desired stocking combination from Table 1, and stock those species as follows:

- **Stock fingerling (2 to 3 inches) bream (bluegill and redear sunfish), catfish, triploid grass carp, and fathead minnows in the fall or winter.** The pond should be at least half full and filling.
  - » Stock 500 bream per acre. This can be all bluegill or, if desired, 350 bluegill and 150 redear sunfish.
  - » If you want channel catfish in your pond, stock at 50 catfish per acre.
  - » Stock five triploid grass carp per acre to avoid weed problems. For lakes larger than 10 acres that have much open water, stock three grass carp per acre.
  - » Fathead minnows can be stocked at 3 pounds per acre with bluegill in the fall or winter to provide additional prey (optional).
- **Stock 50 fingerling (2 to 3 inches) largemouth bass per acre the following spring when the bream and fathead minnows are ready to spawn.** This ensures that small bream and minnows are available for the small bass.
  - » The stocking ratio of bream to bass should be 10:1.

Bluegill and redear sunfish fingerlings stocked in the fall and winter will spawn the next spring. Stock largemouth

bass fingerlings in the spring to coincide with the first bream spawn. They feed on the small bream, preventing an overpopulation of bream. Fathead minnows provide supplemental winter forage for largemouth bass and bream. **If timing is such that you cannot stock the pond in this order, consult a fisheries biologist to discuss an alternative stocking strategy that might work.** Since all situations are different, no single recommendation easily applies to all cases.

If you plan to immediately implement and continuously maintain a fertilization program, follow the fertilized stocking rates in Table 1 for quicker results and to avoid bream crowding.

You can stock a properly fertilized pond with 1,000 bream per acre in the fall, either all bluegill or 700 bluegill and 300 redear sunfish, followed by 100 largemouth bass per acre the following spring. You can stock up to 100 catfish per acre in fertilized ponds. Keep triploid grass carp stocking rates at five per acre for weed prevention.

After you complete the initial stocking of fingerling fish, do not add any fish to the pond except on the recommendation of a fisheries biologist.

Adding fish to the pond year after year can lead to overcrowding and stunted fish. This has ruined the fishing in many ponds in Mississippi. With proper management, a correctly stocked pond generally results in a balanced fish population, ensuring good fishing for years to come. **You can restock catfish after you remove more than half of the fish from the original stocking. Remember to stock larger (8- to 10-inch) catfish to avoid feeding catfish to your bass in established ponds.**

Stocking Options for Ponds Smaller than 1 Acre

The bass-bream stocking combination tends to be less successful in ponds smaller than 1 acre in size because bass are easy to overharvest and the bream become too abundant to grow to a harvestable size. But other options are available. These are catfish-only and hybrid-bream combinations.

Catfish Ponds

Channel catfish grow well, with few disease problems, stocked at 100 to 150 per acre. Fish grow faster with supplemental feeding. Natural foods include decaying organic matter, plant material, crawfish, small fish, and insects. The relatively low stocking rate (100 to 150 per acre) ensures good growth to a harvestable size in a reasonably short time. You do not want to encourage catfish spawning because of potential crowding and disease problems. **To control the possibility of unwanted spawning, stock 25 largemouth bass per acre to eliminate any catfish fingerlings smaller than 6 inches.** Bass are stocked primarily as a management tool to eat the catfish offspring. **Return all bass back to the pond to maintain high predator numbers.** You can restock catfish after you remove more than half of the fish from the original stocking. **Remember to stock larger (8- to 10-inch) catfish to avoid feeding catfish to your bass in established ponds.**

One of the most common mistakes pond owners make is stocking too many catfish. Recreational catfish ponds are intended to be much less intensively managed than their commercial counterparts. **In general, most farm ponds can support no more than 500 pounds of fish per acre without supplemental aeration.** When you stock and grow catfish to catchable sizes (1 to 3 pounds), you exceed the limit when more than about 150 catfish are present. Attempts to exceed this natural limit in farm ponds without supplemental aeration and feeding usually cause stress and disease in the catfish, and oxygen can be depleted to low levels where total fish kills may occur.

Hybrid Sunfish Ponds

Hybrid sunfish are a good option for small ponds because they grow quickly, especially when fed, and they are easy to catch. The most commonly used hybrid sunfish results from crossing male bluegill with female green sunfish. These hybrids are 85 to 95 percent males, readily accept artificial feed, and grow faster than bluegill or redear sunfish under similar conditions.

Successful hybrid sunfish ponds require that you carefully follow the stocking rates and harvest recommendations. You can get best growth by stocking 750 hybrids and 50 bass per acre and then feeding a commercially prepared feed of at least 28 percent protein. Commercial

catfish pellets are the most economical feed. **Never give the fish more food than they will eat in 5 to 10 minutes, and adjust the amount as fish grow.** If fish do not eat all the feed offered in that time, you probably are overfeeding and wasting feed and money.

A demand-type or automatic fish feeder is a good investment. One problem with hand-feeding is that someone has to be there to do it! Most people tire of the novelty of feeding fish within the first season, and then the fish may become neglected. Installing a feeder ensures that the fish receive feed on a regular basis, regardless of your schedule and availability.

Never stock hybrid sunfish into ponds managed for other objectives, and never stock them in combination with other bream species.

Hybrid bream will not produce enough offspring to yield good bass growth rates, and they will cross-breed with other sunfish species and create undesirable offspring. Hybrid sunfish should only be stocked in small ponds following the exact recommendations found in this section.

Always stock hybrids in combination with a predator fish because, contrary to popular belief, they are not sterile. Most hybrid populations are 85 to 95 percent males and thus have lower reproductive potential. They do reproduce, and they will overpopulate unless largemouth bass have been stocked with them. Hybrid sunfish offspring do not share the same qualities as their parents and are not desirable.

When stocked with bass, most hybrid offspring do not survive because the bass quickly eat them. This prevents overpopulation and provides conditions for best growth of the originally stocked hybrids. Hybrid sunfish are best suited to ponds less than 3 acres.

It is important to remember that hybrid sunfish management is for production of big bream, and bass growth will be less than desirable. Bass are stocked primarily as a management tool to eat the hybrid offspring. **Return all bass that are caught to the pond to maintain high predator numbers.** Also, this is a "put and take" fishery, meaning that hybrids are grown, caught, and replaced by other hybrids stocked in future years. In this sense, hybrid ponds are more like cattle feed-lot operations than some other, more traditional pond management options.

Periodic restocking is necessary to sustain a fishery for more than a few years. Record the number of hybrids removed and plan to restock when 50 to 70 percent of the originally stocked fish have been caught and removed. **At restocking time, stock larger hybrid sunfish fingerlings (3 to 4 inches), since they are less likely to be eaten by the bass than smaller fish.** Restock at the same rates as the initial stocking. You may want to check with local suppliers before starting a hybrid bream pond to make sure larger fingerlings are available. If they are not, you will need to drain or kill all of the fish in the pond and start over when fishing quality declines.

MANAGING

You can enjoy good fishing for years if you follow a sound pond management program. Building the pond properly, stocking the correct species at recommended rates, and controlling weeds are necessary first steps for proper pond management. **Continued good fishing depends on harvesting the correct number, sizes, and species of fish each year.** See the Farm Pond Management Calendar on page 41 for more information on timing of management activities.

Fishing

Fishing and harvest are critical to good pond management. **To ensure a balanced fish population, release all of the bass that are caught the first and second years of fishing.** In most cases, after the first year of fishing, you can remove as many bream as you desire without harming the population.

By the third year, harvest 15 pounds of bass per acre per year from ponds that are not fertilized. In fertilized ponds, this number will need to be doubled. Harvest primarily small bass less than 13 inches, and release intermediate-sized bass (14 to 18 inches). This will ensure rapid growth of bass, an adequate number of bass for reproduction, as well as control of the bream. Underharvest of bass leads to bass stockpiling and slow growth of bass, which is a common problem in Mississippi ponds.

The biggest mistake most pond owners make in managing their ponds is they do not harvest enough bass and bream from the pond. This leads to crowding and slow growth of their bass.

If you want quality bream fishing, remove 45 pounds of bream per acre per year.

Although less common than bass underharvest, removing too many bass can lead to bream crowding. When bass are overharvested, the remaining bass can no longer eat enough bream, and the bream become overcrowded and grow very slowly. Once bream become overcrowded, bass reproduction is reduced or stopped completely.

Keep a record of fish harvested, and ask others who fish the pond to tell you the number and size (at least length) of bass and bream they remove from the pond. See page 41 for a Farm Pond Harvest Record Sheet.

If the pond is also stocked with channel catfish, spread the catfish harvest over 3 to 4 years. Channel catfish may reproduce, but offspring usually do not survive because of bass predation. Restock with channel catfish when 60 percent of the originally stocked catfish have been removed. **In a bass and bream pond, it is necessary to restock with 8- to 10-inch channel catfish to ensure the bass do not quickly consume the catfish.** Do not overstock catfish, since overstocking leads to poor growth and possible disease problems as well as excessive competition with bream for food.

Management Options

By the second year, you need to decide your fishing objective for the ponds. The balance between predators and prey determines the fish community. You will manage for your pond objective by manipulating this relationship.

Option 1 – Big bream, bass crowded: A bass-crowded condition commonly occurs in Mississippi ponds where bass fishing is primarily catch and release. Bass will become abundant in these ponds, so food becomes limited, and most bass are 13 inches and smaller with thin bodies. Because predation is high, few bream live to become adults, but those that do are healthy and can reach sizes of 1 pound or more (Figures 5 and 6). If you want trophy bream, encouraging a bass-crowded pond is the starting point.

Option 2 – Balanced fishery: When bass and bream are both harvested adequately, predators and prey can maintain a relative balance. Both predators and prey grow well and are healthy, providing good fishing for both species. To keep this situation, continue consistent harvest, especially of smaller bass.

Figure 5. Managing a pond to be bass-crowded can produce trophy bream (see Figure 6).

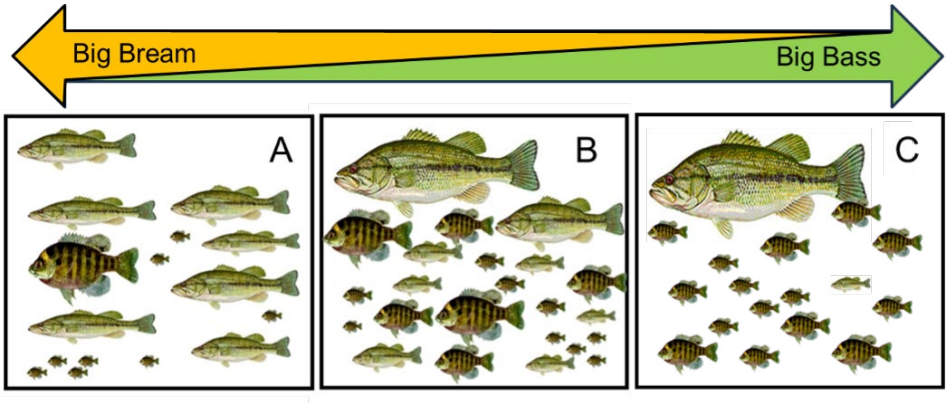


Figure 6. Bass and bluegill ponds represent a predator-prey balance spectrum. Depending on predator population size, the pond fishery can produce A) a bass-crowded pond with larger bream, B) a balanced fishery with good sizes of both species, or C) a bream-crowded pond with few but larger bass. The management objective for the pond can be achieved by modifying bass harvest to shift the spectrum left or right.

Table 2. Assessment of pond balance in a bass-bream pond using a seine. Does not apply to ponds managed for trophy bass.

Largemouth bass	Bluegill/redear sunfish	Other species	Population condition
No young bass present	Many recently hatched sunfish, no more than one or two midsize sunfish	No other species	**Bass crowded**
No young bass present	No recently hatched sunfish, many midsize sunfish	No other species	**Bream crowded**
Young bass are present	Many recently hatched sunfish, a few midsize sunfish	No other species	**Balanced population**
Young bass are present	No recently hatched sunfish, no midsize sunfish	No other species	**Bass crowded; bream may be absent**
Few or no young bass	Few or no bluegill	Carp, shiners, suckers, bullheads, shad, other sunfish species, or other undesirable species	**Undesirable fish population**

Option 3 – Big bass, bream crowded: When there are few predators, bream can become abundant, thin, and slow-growing. The few bass that survive have the potential to get exceptionally large because prey is abundant. To achieve this scenario, selectively harvest small and intermediate-size bass to encourage larger bass.

Determining Fish Balance

Seining—the use of a net to capture fish—is a quick and easy way to determine the condition of your pond, and an investment in a good seine is highly recommended for all pond owners. A 30-foot seine that is 6 feet deep and made of quarter-inch mesh works well. You can purchase it from any net maker. Attach the seine ends to wooden or metal poles to make handling the seine much easier.

Check balance using a seine every year in late-May to July. During this period, both bass and bream have reproduced, and the young are still small enough to be caught effectively using the seine.

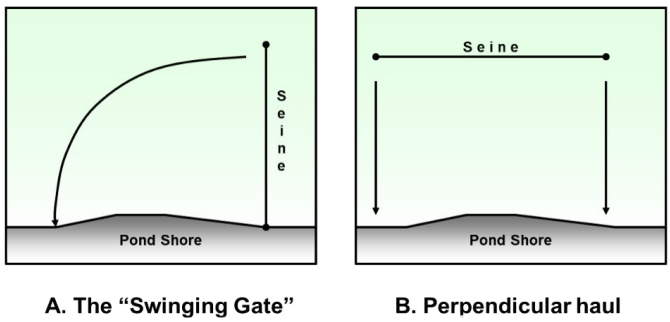


Figure 7. Two easy seining techniques for determining bass and bream reproduction in ponds. Ponds should be assessed using a seine from late-May to July.

Fishing the seine is easy. You can use a "swinging gate" or perpendicular haul (Figure 7) in several areas of the pond to capture young fish. Just make sure you keep the weighted line of the seine on the bottom at all times, or the fish will escape under the net. **Make about five hauls around the pond, and then compare your catch to Table 2 to determine the condition of your pond.**

You can also determine balance of bass and bream by close examination of your catch through fishing. This is much easier if you keep good catch and harvest records throughout the year (see page 41 for a Farm Pond Harvest Record Sheet). Make sure to use a variety of types and sizes of lures or baits. Good catch rates of both bass and bream of all sizes indicate the pond is in balance (Table 3; Figure 8).

Corrective Management Measures

Corrective actions for pond balance problems vary, depending on the cause of the problem. Recommendations for common balance problems are listed below. While these recommendations can lead to improvements in fish size, they may need to be modified as conditions change within the pond. In some cases, ponds may be so far out of balance that the only solution is to renovate the pond and restock. See Renovating Ponds on page 37.

Bass-Crowded Ponds

When fishing produces large numbers of small bass and large bream, you probably have an overpopulation of

Table 3. Assessment of pond balance using record of fishing catch. Does not apply to ponds managed for trophy bass.

Largemouth bass	Bluegill/redear sunfish	Other species	Population condition
Bass usually less than 12 inches and thin, a rare trophy bass possible	Sunfish mostly large, may average 8 inches or more	No other species	**Bass crowded**
Very few bass caught, and those caught are large	Mostly small sunfish, typically 3–5 inches	No other species	**Bluegill crowded**
Bass average 12–16 inches, but smaller and larger sizes also caught	Sunfish typically 6 inches or larger, but all sizes caught	No other species	**Balanced population**
Bass usually less than 12 inches and thin	No sunfish caught	No other species	**Bass crowded; sunfish may be absent**
Few bass caught	Few sunfish caught	Carp, shiners, suckers, bullheads, shad, other sunfish species, or other undesirable species	**Undesirable fish population**

bass. If catching large bluegill is your objective, a bass-crowded pond is the desirable situation. But if you want large bass, the following recommendations may help you improve bass growth and size. In 1 year, remove 35 pounds of bass per acre that are less than 13 inches long. In a fertilized pond, remove 50 pounds of bass less than 13 inches. Return all larger bass to the pond. Reassess the pond the following year, and repeat intensive bass harvest as necessary. When annual balance checks indicate the pond is once again in balance, revert to harvesting bass and bream at the normal recommended rates described previously.

In rare cases, bream can be eliminated from bass-crowded ponds through heavy predation. **If seine sampling or angling reveals no bream present, remove bass as described above and then stock 250 advanced fingerling (3- to 5-inch) bluegill per acre.**

Bream-Crowded Ponds

When only a few large bass and many small bream are caught, the pond is probably overpopulated with bream. If aquatic weeds are a problem, eliminate the weeds following recommendations in this publication (see Controlling Aquatic Vegetation on page 20). Remove many intermediate bluegill using rotenone along shorelines in the early fall. After bream removal, stock 35 adult (10- to 12-inch) largemouth bass per acre to eat small bream, and use a winter drawdown to help the bass more effectively feed on the small bluegill (see Drawdowns on page 32).

Undesirable Fish Population

If the pond contains significant populations of gar, bullhead catfish, green sunfish, crappie, or other species not recommended, renovate the pond and restock with recommended species and stocking rates. For information, see Renovating Ponds on page 37 or consult your county Extension agent.

Balanced Population

Maintain recommended harvest rates (at least 15 pounds of bass per acre annually), keep accurate catch and harvest records, and reassess the pond the following year.

Managing for Trophy Bass

Largemouth bass are one of the most popular sport fish in Mississippi, and a favorite management option for ponds is trophy largemouth bass. Growing big bass consistently requires careful management. It is critical to follow water quality, aquatic weed control, and fish management programs as defined in this publication or as prescribed by a fisheries professional.

The way to achieve big bass is through their stomachs! A basic bass and bream combination can produce big bass, but you can increase your success by increasing food available to each bass. You can do this in three steps:

- Increase prey production by managing water chemistry and fertility.
- Add new prey species or supplement prey.
- Manage bass size structure and abundance by removing small bass.

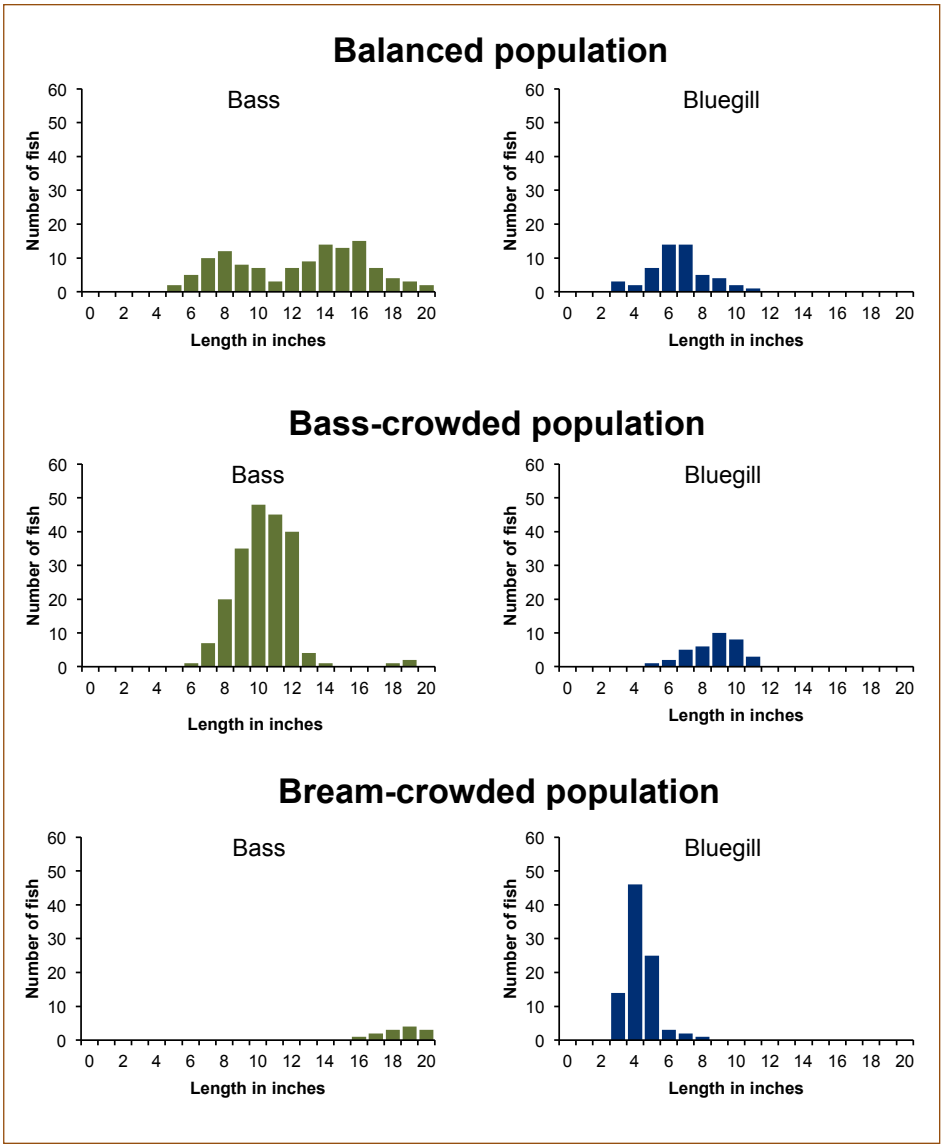


Figure 8. You can construct simple bar graphs such as these from fishing catch data if you keep good records. These bar graphs are important management tools you can use to diagnose population balance problems.

You can increase prey production through proper water chemistry and pond fertilization. Check to see if the lake needs agricultural limestone (see Liming Ponds on page 26 for details), and consider implementing a fertilization program. **Trophy bass ponds can benefit from a properly conducted and maintained fertilization program, since fertilizing can double or triple the pounds of fish per acre, which can be manipulated to produce bigger bass.** (See To Fertilize or Not to Fertilize? on page 28 for more details.)

Two additional prey species are commonly recommended for supplemental prey in Mississippi ponds:

Fathead Minnows — good prey for bass with no negative impacts on the fish community. But bass feeding quickly eliminates these fish from Mississippi ponds. **Fathead minnows are best suited for new ponds to accelerate initial bass growth, but once bass are established, additional stockings of fathead minnows can be ineffective.** It is best to stock this species fall to spring, when water temperatures are cooler.

Threadfin Shad — excellent forage fish for largemouth bass and provide abundant prey year after year. **Threadfin shad are cold sensitive and die when water temperatures fall below 36°F.** This may occasionally result in threadfin shad die-offs in northern Mississippi during the coldest winters. Threadfin shad will need to be restocked the following spring. Threadfin shad may compete some with bream, so stock them only in ponds where you want trophy bass.

Buy threadfin only from licensed distributors to ensure proper species identification. **Never collect shad from the wild, because it is very difficult to distinguish threadfin shad from gizzard shad!** Gizzard shad should only be stocked in specific situations based on the advice of a fisheries biologist.

Producing big bass requires a commitment to proper harvest of bass. Do not harvest bass the first 2 years after stocking. **Beginning in year 3, harvest 15 (30 for fertilized ponds) pounds of bass (less than 12 inches) per acre per year.** Removing these small bass reduces competition with remaining bass, providing more food for those that remain. **Also, remove 5 pounds (10 for fertilized ponds) of 12- to 15-inch bass per acre each year.** Release all bass over 15 inches unless you harvested them as trophies. Harvest bream as desired. **Important: Supplying additional food alone will not produce trophy bass. Bass harvest must occur consistently!**

The biggest mistake in bass management is catch and release of all bass. Small bass need to be harvested to allow more food for fast growth of intermediate-sized bass.

Crappie Management

We do not advocate stocking crappie in ponds smaller than 50 acres. But many ponds have crappie already, and many people do not wish to renovate the pond and stock the recommended species. Although bass and bream ponds may produce good fishing with crappie for several years after stocking, the eventual result is a pond with small, skinny bass, small, skinny crappie, and small, skinny bream.

If you have a pond with crappie, you can manage it to produce decent crappie fishing. The secret is to maintain a population of many small bass, which eat most of the crappie reproduction. Thus, the few crappie that survive can grow to larger sizes. But you will not grow many large bass using this approach. **Catch and remove all largemouth bass that are longer than 15 inches, and return all smaller bass to the pond.** Fish for crappie often, and never throw a crappie back in the pond. If bass catch rates decline or crappie appear skinny and slow growing, stock 35 to 50 bass (10 to 12 inches long) per acre to eat more crappie. If possible, use a drawdown every winter to concentrate the fish and make it easier for bass to catch and eat crappie (see Drawdowns on page 32).

CONTROLLING AQUATIC VEGETATION

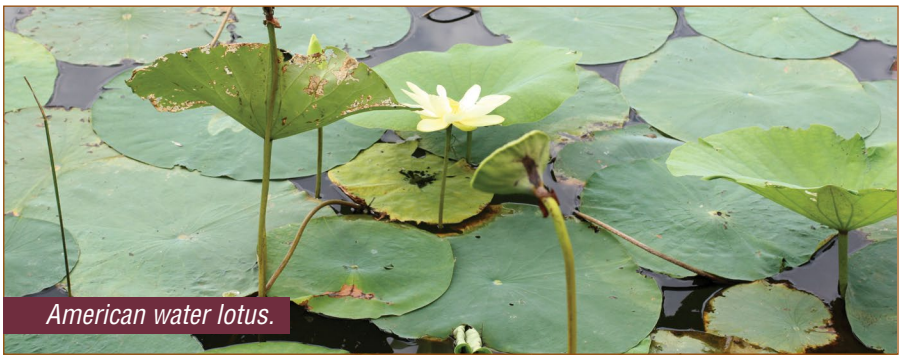
Aquatic plants fulfill many natural functions and are vital in aquatic and wetland environments. Some aquatic plants are desirable and serve as food sources for waterfowl and other wildlife, habitat for fish, and a substrate and food source for invertebrates (such as insects and snails). Some plants may become too plentiful and interfere with fishing, swimming, and boating in private ponds and lakes. Many plant species should be controlled only when they become pests by interfering with the preferred use of a particular pond or lake. Others, particularly nonnative species, must be dealt with when they first appear.

Prevention should always be your first action, if practical, since it is usually easier and cheaper to prevent an aquatic weed problem than it is to cure one. Preventive methods include proper pond location, design, construction, and drawdown. Refer to the sections on Site Selection (page 6), Pond Construction (page 8), and Drawdowns (page 32) for specific details on these aquatic weed prevention measures. **Also, stocking five triploid grass carp per surface acre into ponds that do not have weed problems helps prevent weeds from becoming established.** If you use proper preventive methods like using 3:1 slopes, aquatic weeds are seldom a problem.

If aquatic weeds become a problem, you can control them through physical, mechanical, biological, and/or chemical methods. Each method has advantages and disadvantages, and combining methods into an integrated weed control plan is usually most effective.

If you have a weed problem in your pond, follow these steps in aquatic weed control:

- **Identify the problem weed.**
- **Choose the most economical and efficient control method or combination of methods.** A combination of techniques usually provides the best long-term control.
- **If you select a chemical method of control, be sure it is economical, safe, effective, and legal.** Calculate pond area or volume to be treated, and follow aquatic herbicide label instructions.
- **Pay close attention to use restrictions following herbicide treatment.**



American water lotus.

Physical Control

Physical control is the alteration of the environment surrounding plants in such a way that they can no longer survive in that area. Rooted plants cannot grow where sunlight does not reach the bottom, so deepening shallow pond edges so they drop quickly to 3 feet deep is an effective means of reducing weed coverage. Use a 3:1 (1 foot increase in depth for each 3 feet from shore) slope so the bank remains stable and does not collapse.

Another physical technique, called a drawdown (a reduction in water level), can be effective and economical in controlling many kinds of aquatic weeds. However, some species can spread when using drawdowns, so consult MSU Extension when using this technique. For detailed information on winter drawdowns, see Drawdowns on page 32 or request Extension Publication 3873 *Winter Drawdown: A Useful Management Tool for Mississippi Farm Ponds* from your county Extension agent.

You can use pond dyes to control submersed aquatic weeds by shading the plants so they do not get enough sunlight. Use dyes only in ponds that have little outflow, since flowing water washes the dye out of the pond. Pond dyes work best on plants growing in deeper water (more than 2 feet) and lose efficacy in shallow waters as they can't block enough sunlight to inhibit plant growth. Pond dyes also need to be applied early in the year and reapplied periodically to maintain effectiveness. Dyes shouldn't be used if plants are within 2 feet of the water surface. Also, dye reduces pond productivity and should not be used in ponds that are fertilized.

Although pond liners are a form of physical control sometimes used for aquaculture and municipal ponds, they are generally too expensive and impractical for private ponds.

Mechanical Control

Mechanical control involves damaging plants or removing them from a water body to control them. This may be as simple as cutting a willow tree or removing a few unwanted plants (such as cattails) that have just gotten started along the water margin, or it may involve raking or seining algae on the bottom or free-floating at the surface. While cutting and removing a few plants by hand can be effective in small and limited areas, mechanical aquatic weed control on a large scale is generally difficult, impractical, and expensive. Mechanical plant removal is usually not a permanent solution, as plants may grow quickly and recolonize, but it can be used to clear the majority of plants to improve effectiveness of other techniques such as biological or chemical control.

Seining filamentous algae.

Biological Control

Biological control uses an animal or other living organism to control the weeds. **Biological control has many advantages over other weed control means. It takes much less human effort than most mechanical control means and does not require expensive and sometimes hazardous aquatic herbicides.** And using animals provides longer-term control than other means, since the animals usually live several years. **Triploid grass carp (white amur) from China are commonly used for aquatic weed control.**

How much vegetation grass carp will consume depends on several environmental conditions, such as water temperature, water chemistry, and the kinds of plants available. Consumption rates also vary with fish size. For example, until they reach weights of about 6 pounds, grass carp may eat 100 percent of their body weight in vegetation per day. As they grow larger, consumption decreases; up to about 13 pounds, they will eat 75 percent of their body weight per day, and above 13 pounds, they slow down to about 25 percent of body weight per day.

Grass carp prefer soft, low-fiber aquatic weeds such as duckweed and various underwater plants. But grass carp cannot necessarily control some of the plant species they "prefer" to eat. These plants grow very quickly, and grass carp may not be able to eat them quickly enough. Duckweed is a good example of a plant that grass carp love but usually cannot control. One solution is to increase the density of grass carp, but this carries its own risks. **In cases where 15 or more grass carp per acre are stocked, it is a good idea to remove many of these fish once weeds are controlled.** You can catch grass carp using heavy tackle and grapes for bait.

Table 4 lists plants that grass carp typically control. If the species of plants they want are not available, carp feed on

Table 4. Control of some common aquatic weeds and algae with herbicides and grass carp. Note: Approved aquatic herbicides change regularly, so please check the most recent edition of Extension Publication 1532 *Weed Control Guidelines for Mississippi* for up-to-date use restrictions, and always follow label recommendations. See the appendix (page 43) for specific recommendations on application.

Aquatic plant	2,4-D	Chelated copper[a] Copper sulfate[a]	Diquat	Endothall[b]	Florpyrauxifen-benzyl	Flumioxazin	Fluridone	Glyphosate	Imazamox	Imazapyr	Penoxsulam	Peroxidases[c]	Topramezone	Triclopyr	Triploid grass carp
Algae															
Chara and *Nitella*		■													■
Filamentous		■	■									■			
Planktonic		■													
Floating weeds (not attached to bottom)															
Duckweed			■			■	■								
Mosquitofern			■			■									
Salvinia						■		■							
Water hyacinth	■							■	■					■	
Water lettuce			■			■									
Watermeal			■			■									
Emersed weeds (attached to bottom)															
American lotus	■		■		■									■	
Spatterdock	■				■	■									
Water lily	■			■	■										
Water shield	■				■	■									
Water pennywort	■							■							
Submersed weeds															
Bladderwort			■				■								■
Naiads (*Najas*)		■	■								■				■
Coontail				■		■									■
Egeria		■	■	■			■								■
Elodea			■	■		■									■
Fanwort				■		■								■	■
Hydrilla		■	■	■	■	■	■						■		■
Parrotfeather	■		■							■				■	■
Pondweeds (*Potamogeton*)				■			■				■				■
Slender spikerush			■												■
Watermilfoil	■		■	■	■										■
Marginal weeds															
Alligator weed								■	■	■				■	
Cattail								■	■	■					
Hydrolea								■							
Juncus	■														
Parrot's-feather	■		■						■					■	
Phragmites								■	■	■					
Rushes (bullrush)								■							
Smartweed	■							■	■	■					
Torpedograss						■		■		■					
Water pennywort	■							■							
Water primrose	■					■		■						■	
Water willow	■														

[a] Check pond water alkalinity before using products containing copper because of risks with copper toxicity. Use only when alkalinity is 50 mg/L or higher.
[b] Be very careful when using endothall as it can be toxic to fish when misapplied.
[c] Primarily for cyanobacteria, such as *Lyngbya*.

new growth of less-desirable plants and on plants above the water surface. It is this strong appetite for plants that makes grass carp useful in preventing aquatic weed establishment.

The number of grass carp required to control weed problems varies, depending on the degree of weed infestation, kind of weed, size of pond or lake, and size of fish stocked. The general rule in farm ponds is to stock enough grass carp to control the weeds in one to two seasons but not so many that they quickly eat all vegetation. The best approach is to consider the grass carp as a weed maintenance tool rather than a total elimination tool.

For most farm pond situations where weeds have already become a problem, 5 to 10 grass carp per water surface acre usually achieve desired weed control. In ponds with severe weed problems, higher rates of 15 to 20 grass carp per acre may be necessary for plant control. In such cases, it is sometimes more effective to treat the pond chemically with an herbicide first, and then stock moderate numbers of grass carp to prevent weed regrowth. You can get assistance in diagnosing the situation by contacting your county Extension agent or a fisheries biologist from other state or federal agencies.

In new ponds where you stock triploid grass carp for weed prevention, five fish per acre usually is sufficient. Grass carp are very good at preventing weed establishment, and even eat nonpreferred plant species when they first begin to grow and are still soft and tender.

Although regular "diploid" grass carp will not reproduce in ponds, they may reproduce if they are washed downstream into rivers. They can have environmental impacts on native plants and animals, so many states have restricted or prohibited the use of grass carp. They are not recommended for control of plants in farm ponds in Mississippi. Triploid grass carp are sterile, so they cannot reproduce if they escape into the wild. **Only triploid grass carp should be stocked in Mississippi ponds.**

Chemical Control

Chemical control uses chemicals (i.e., herbicides) to control plants. **Identifying a problem weed is the first step to controlling it.** Some herbicides are selective to certain vegetation taxonomic groups, meaning they are effective only on certain plants. Herbicides are expensive, so it would not be wise to randomly select an aquatic-approved herbicide, since it may not be effective.

Chemical control requires using aquatic herbicides (and surfactants) that have met strict Environmental Protection Agency (EPA) standards **for use in an aquatic environment**. The herbicides are of low toxicity to fish and wildlife (and humans) when used according to guidelines, rates, and restrictions specified on the label for each herbicide. Some herbicides have water use restrictions for a period of time following herbicide application that may prohibit drinking (human and livestock), swimming, and irrigation.

Chemical control has its limitations. Applying herbicides may require specialized equipment and expertise. Some herbicides can be very expensive, and some may not provide prolonged weed control. Rooted aquatic plants usually develop in water that is too shallow or too clear. Even after treatment of vegetation, the conditions may still be present for aquatic weed recolonization. Return of the same or another weed problem is often likely, requiring more applications of herbicides. **It is important to eliminate the conditions that encourage the growth and spread of aquatic plants.**

Before using any chemical control, correctly identify the aquatic weed to be treated so you can select the most effective and economical herbicide. For assistance with aquatic weed identification, contact your county Extension agent, the NRCS, or the MDWFP. In most cases, you can ship or mail a sample of your weed in a zip-top bag wrapped in a damp (but not wet!) paper towel to any one of these offices, and a biologist can make an accurate identification. You can also email close-up, clear, detailed digital photos to these agencies for proper plant identification and recommendations. For accurate identification, send three photos that include 1) a close-up of the stem and leaf structure, 2) a photo of the flower if present, and 3) a broad habitat shot showing the extent of the plant coverage.

Table 4 lists many of the common aquatic weeds that occur in Mississippi and the herbicides that have activity on them. Table 5 lists the water use restrictions for the herbicides listed in Table 4. **You must know the surface area and/or volume of water in the pond, since the amount of herbicide to use is determined by either the surface area or water volume to be treated. Pond volume is determined by multiplying the surface acre age by the average depth of the pond, and is measured in acre-feet.** Several important calculations are provided in Box 1 (page 25).

Table 5. Herbicide trade names and treated water use restrictions. Always follow label instructions and recommendations. Note: Approved aquatic herbicides change regularly, so please check the most recent edition of Extension Publication 1532 *Weed Control Guidelines for Mississippi* for up-to-date use restrictions, and always follow label recommendations. Application details are provided in the appendix (page 43).

Common name	Example trade name	Use restrictions (days)						
		Human			Animal	Irrigation		
		Drinking	Swimming	Fish consumption	Drinking	Turf	Forage	Food crops
2,4-D	DMA 4 IVM, Navigate, AquaKleen, Aquacide, Weedar 64	[a,b]	0	0	0	21[b,c]	21[b,c]	21[b,c]
Chelated copper, copper sulfate	Algimycin PWF, Captain, Clearigate, Current, Cutrine-Plus, Cutrine-Ultra, Harpoon, Komeen, K-Tea, Nautique, Symmetry	0[d]	0	0	0	0	0	0
Diquat	Harvester, Redwing, Reward, Weedtrine-D, Tsunami DQ	1–3	0	0	1	1–3	5	5
Endothall	Aquathol K, Aquathol Super K, Hydrothol 191, Hydrothol Granular	7–25[e]	0	0	0	0	0	0
Florpyrauxifen-benzyl	ProcellaCOR SC	0	0	[f]	0	0	[f]	[f]
Flumioxazin	Clipper, Clipper SC, Propeller, Schooner	0	0	0[d]	0	0.5–5[g]	0.5–5[g]	5
Fluridone	Avast, Sonar A.S., Sonar One, Sonar PR, Sonar Q, Sonar SRP, Whitecap, Alligare	0	0	0	0	30	30	30
Glyphosate	Avocet, Aquapro, Rodeo, Shore-Klear, Shore-Klear Plus, Round-Up Custom	0	0	0	0	0	0	0
Imaxamox	Clearcast, Top Deck, Imox	[h]	0	0	0	[h]	[h]	[h]
Imazapyr	Aquapier, Gullwing, Habitat, Ecomazapyr	2	0	0	0	120[i]	120[i]	120[i]
Penoxsalum	Galleon SC	0	0	0	0	[j]	[k]	[l]
Sodium carbonate peroxyhydrate	Pak 27, Phycomycin SCP	0	0	0	0	0	0	0
Topramezone	Oasis	[p]	0	0	0	[o]	[o]	[o]
Triclopyr	Navitrol, Navitrol DPF, Renovate 3, Renovate OTF	[m]	0	0	0	[n]	120	120

[a] See the label for distance allowed from potable water intake.
[b] A shorter interval may be used if an approved assay indicates less than 0.1 ppm 2,4-D.
[c] Do not use in ditches where water will be used to irrigate highly susceptible crops, such as cotton, grapes, and tomatoes, unless an approved assay indicates that 2,4-D concentrations are less than 100 ppb.
[d] Do not apply to waters used for crayfish farming.
[e] Do not use for livestock watering of irrigation until residues reach 1 ppb or less.
[f] Treated water may not be used as source for livestock until an approved assay indicates carfentrazone-ethyl and degradate is below 0.2 ppm.
[g] This is the interval for applications made to more than 20% of water surface. Consult label for reduced restriction criteria.
[h] Drinking water restrictions are product-specific; read the label carefully.
[i] The manufacturer suggests a 600-foot potable water application setback.
[j] See the table on the label.
[k] Water can be used when an approved assay indicates imazamox concentrations are less than 50 ppb.
[l] Use restrictions can be reduced if an approved assay indicates imazapyr concentrations are less than 50 ppb.
[m] Water treated wtih penoxsulam can be used for turf irrigation if concentrations are less than 30 ppb.
[n] For other nonfood crop irrigation or for other irrigation uses, contact SePRO Corporation before irrigation if concentrations exceed 1 ppb.
[o] Do not irrigate established food crops, other than rice, until penoxsulam concentrations are no more than 1 ppb in the irrigation water source. Do not irrigate established rice if concentrations in the treated water exceed 30 ppb.
[p] Drinking water can be used only when triclopyr concentrations are less than 0.4 ppm by an approved assay.
[q] If triclopyr residues are determined to be nondetectable by an approved assay, there is no restriction for use of irrigation water on established grasses.

Box 1. Calculations for amount of herbicide needed on basis of parts per million by weight (ppmw)

Volume of pond: V (acre-feet) = A × D Ditch or canal: W = A × L × C × 0.0000625 Lake or pond: W = A × D × C × 2.71

Symbols

A = Pond surface area (acres) D = Average pond depth (feet) W = Pounds of active ingredient needed
L = Length of channel (feet) C = Desired concentration of herbicide in parts per million by weight (ppmw)

Useful conversion factors

1 acre = 43,560 feet^2
1 acre-foot = 43,560 feet^3
1 foot^3 = 7.48 gallons
1 gallon = 4 quarts
1 quart = 2 pints
1 pint = 2 cups
1 cup = 8 fluid ounces
1 pound = 16 ounces

Conversion for various volumes to attain one part per million (ppm)

Amount active ingredient	Per unit of volume
2.71 pounds	acre-foot
0.000998 ounces	cubic foot
8.34 pounds	million gallons

Consult your county Extension agent, NRCS representative, or regional MDWFP office for assistance with determining herbicide dosages and pond volumes.

For effective aquatic weed control, you must select the appropriate herbicide and apply it properly. Some herbicides may be used directly from the container; others must be mixed with water or with water plus a surfactant before being used. Always follow label instructions and precautions when applying herbicides and surfactants. Some may be applied by hand (low volume, spot spray), while others require the use of power sprayers (high volume, tank mix) or drip lines.

Time of Application

The time to apply herbicides is very important. **Usually, treatments applied in the spring or early summer when the weeds are actively growing deliver the best results.** Herbicide applications in the late summer and fall are generally less effective for many species. Failure to control some problem aquatic plants can result in an increase in the affected area requiring treatment. Many of these plants make mature seeds by midsummer that sprout the following year.

In hot weather, be careful not to deplete oxygen by killing too many weeds at one time. Low dissolved oxygen levels can result from the natural decay of treated (killed) aquatic plants. Fish kills may result if the dissolved oxygen level becomes too low in your pond. **It is seldom safe to treat more than a third of the pond at one time in the summer unless you are treating marginal aquatic weeds.**

A good rule to prevent oxygen depletion is to treat one-third of the weeds at a time, waiting 2 weeks between treatments.

For many types of marginal (shoreline) vegetation problems, you may simply spot treat as needed to maintain good control. On older ponds and lakes where aquatic vegetation is well established, seek professional help to gain the control you need.

It is against federal law to use any chemical other than aquatic herbicides approved and registered by the EPA. Improper use of chemicals may result in serious environmental damage, fish kills, contaminated water supplies, and danger to human health.

Diuron (Karmex) is not approved for general aquatic use. Never apply it to recreational fishing ponds.

The legal aquatic herbicides listed in Table 5 are for educational purposes only and generally represent various products on the market at the time of publication. Reference to commercial products or trade names is not an endorsement and is made with the understanding that no discrimination is intended against other labeled products that may also be suitable or become available in the future. **Read and**

observe label precautions before using any chemical in an aquatic environment.

Common Problem Plants

Plant Growth Forms

Aquatic plants can be generally classified into two groups. The algae are primitive plants that have no true roots, stems, or leaves, and do not produce flowers or seeds. The higher, more advanced group is the vascular plants, which usually have roots, stems, and leaves and produce flowers and seeds.

Algae come in many forms but can be generally classified as *planktonic*, *filamentous*, and *macroalgae*. *Planktonic* algae are microscopic simple plants (not all are true plants) suspended in the water or floating on the surface as "scums." *Filamentous and colonial* algae are long strands, mats, clumps, or webs of algae that may start growing from the pond bottom and then rise to the surface to form mats. *Macroalgae* are a more advanced group that resembles vascular plants in growth habits.

Vascular plants typically exhibit one or more of three potential growth forms—*submersed, emergent,* or *floating*—and are often categorized using these criteria.

Submersed plants spend their entire life cycles at or below the surface of the water, although the flower parts of the plants may extend above the surface of the water. Usually the plants are rooted in the soil, but masses of plants may tear loose and float free in the water. Some submersed plants may appear to be emergent or floating plants, particularly when support structures for flowers are present. Some of the most invasive aquatic plant species are submersed.

Emergent plants are rooted in the bottom soil, and their leaves, stems, and flowers extend above the surface of the water. Many can grow in both aquatic and terrestrial environments. These plants are rigid and do not require the water for support. Many emergent plants may appear as submersed plants during the early growing season before they "top out," and a few species may remain submersed indefinitely. In addition, a few may form extensive floating mats and, therefore, appear to be floating plants. Emergent plants are typically marginal except in water bodies that have extensive shallow water, or where they form mats that extend out to deeper water.

Floating plants include both free-floating plants not rooted or attached to the bottom soil and the floating-leaf plants with roots that attach to the bottom, stems that extend toward the surface, and leaves that float on the surface. A few species may mature to have leaves that extend well above the surface, making them appear more like emergent plants. Likewise, some species of floating plants may appear to be submersed plants during certain seasons, growth stages, or environmental conditions. Management may differ depending on whether the species is rooted or free-floating.

There are many species and subspecies, and accurate identification is critical for selecting a control method. **The appendix (page 43) has photos of some common plant species in Mississippi ponds and their recommended controls.**

LIMING PONDS

Just like many gardens in Mississippi, some ponds can benefit from the occasional addition of agricultural limestone. This is true for ponds that have an alkalinity less than 20 ppm. Ponds with low alkalinity are unproductive, even when sufficient nutrients are in the water either naturally or because the pond is fertilized. **Fertilizing a pond with alkalinity less than 20 ppm is a waste of time and money.**

What Is Alkalinity?

Alkalinity is the measure of the buffering capacity of the water. In waters with low alkalinity, pH might fluctuate from 6 or lower to as high as 10 or above every day, which can make fish sick or grow slowly. Alkalinity is related to hardness, so soft water (low hardness) usually has low alkalinity.

What Is the Recommended Alkalinity?

For fish production and health, **alkalinity of at least 20 ppm is recommended.** Greater production in bass-bluegill ponds is attained in waters with adequate alkalinity because this buffering capacity makes phosphorus and other essential nutrients more available to the plankton. Also, fish are stressed by extremes in pH and by rapid changes in pH and tend to grow more slowly and be more susceptible to illness when alkalinity is low. After oxygen, poor water chemistry is the next-most common cause of fish kills in ponds. When alkalinity is very low, stressed fish may die during weather changes and rain events,

with a few fish of all species dying each day. **A pH value between 6.5 and 9.0 is optimum for fish ponds.**

Alkalinity testing kits are widely available at many pool and spa stores and at county agricultural co-ops. These test kits are easy to use. Also, most county Extension offices or NRCS service centers can test water alkalinity.

Note: When treating algae using a copper-containing compound, a minimum alkalinity of 50 ppm is required to prevent copper toxicity that may kill fish.

What If Alkalinity Is Less than 20 ppm?

For ponds with alkalinity less than 20 ppm, pond health can be substantially improved by increasing alkalinity. **The most common method of increasing alkalinity in waters is by adding agricultural limestone (calcium carbonate).** Adding lime to these ponds elevates alkalinity and stabilizes pH in the water. Neutralization of bottom soil with lime prevents phosphate from adhering to it, thereby increasing phosphorus concentrations in the water (the primary nutrient in ponds). As a result of these changes in water quality, phytoplankton blooms develop, and pH fluctuates less.

If a pond has a high rate of water flow in and out, liming may not be a solution. Such a pond has a low water retention time, and the lime washes out quickly.

Soil Testing

If you are building a new pond, have the MSU Extension Soil Testing Laboratory test the soil to determine how much lime is needed before filling the pond. Soil sample boxes, instructions, and information sheets are available at your county Extension office.

Here is how to sample pond soils:

- If the pond is larger than 3 acres, partition it into 3-acre blocks, and sample each block separately. (If the pond is less than 3 acres, it is one block.)
- Collect about a pint of soil from each of 10 locations per block.
- Thoroughly mix the 10 samples together in a bucket.
- Take one sample from the mixture and air-dry. Place this sample in a soil sample box and submit to the Soil Testing Lab at Mississippi State University. Be sure to indicate in the "crop grown?" window on the submission form that this sample is for a farm pond (Code 50).
- Repeat this procedure for each 3-acre block in the pond. The sample will be analyzed, and you will receive a report indicating if your pond needs lime and how much to apply. **Important note: This liming recommendation will need to be adjusted based on the agricultural limestone available in your area. See Box 2 for information on conversion.**

To collect a soil sample from a pond containing water, use a tin can nailed perpendicular on a long stick or a long PVC pipe (depending on pond depth) to collect bottom mud. Use an S-shaped pattern to collect samples as described above.

Box 2. Conversion of soil testing laboratory lime recommendations to specific liming materials

The soil analysis report from the State Soil Testing Laboratory will provide a liming recommendation in tons per acre. However, this recommendation is for pure calcium carbonate, which is 100% active. Commercial liming materials vary in their ability to neutralize soil due to chemistry and particle size.

The neutralizing value (NV) depends on the chemical itself. Pure calcium carbonate has an NV of 100%. Agricultural limestone may have NV values between 85 and 109 depending on its specific chemical composition.

The neutralizing efficiency (NE) of agricultural limestone depends on the fineness of the mixture. Finely crushed agricultural limestone contains different sizes of particles. Small particles dissolve more quickly and completely and are more reactive than larger particles.

The liming requirement (from the soil test), NV, and NE (ask your limestone distributor for NV and NE) can be used to calculate the precise amount of lime needed as shown below. If either of these values is not available, use NV = 0.85 and NE = 0.75 as a conservative estimate.

Tons needed = Liming Requirement / (NV × NE)

Example:
$CaCO_3$ recommendation: 3 tons/ac
Crushed lime NV: 0.85
Crushed lime NE: 0.75

Tons needed = 3 tons/acre / (0.85 × 0.75) = 4.7 tons/acre

Multiply 4.7 by the surface acreage of water to get total lime requirement.

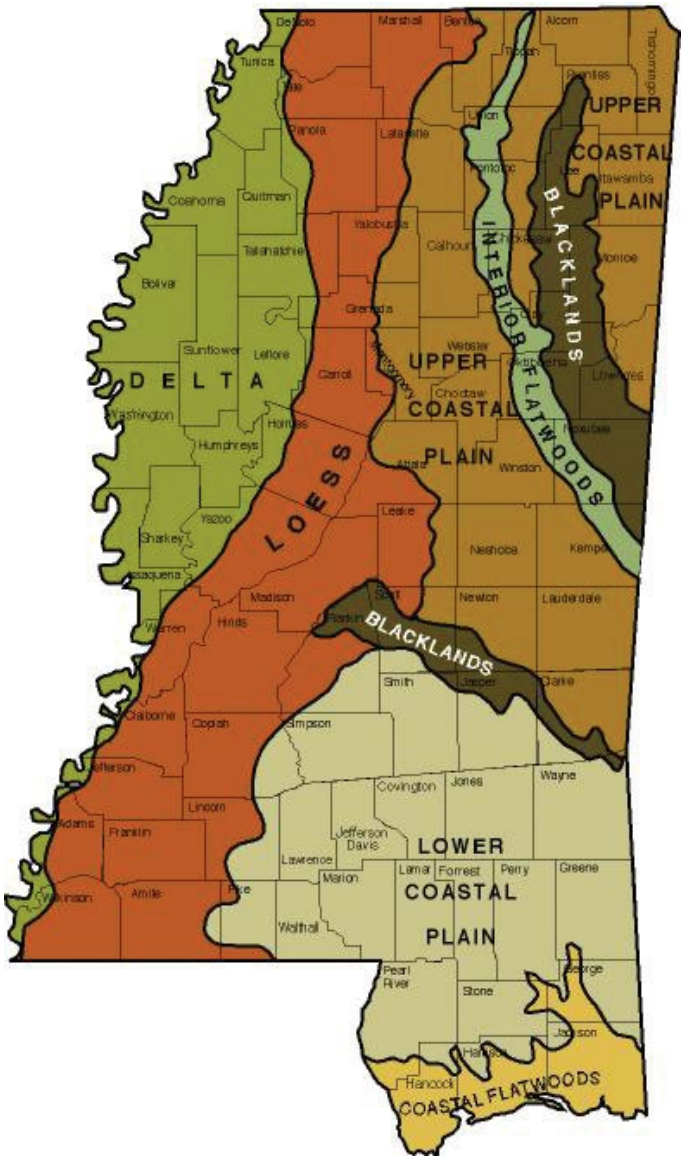


Figure 9. Location of major soil types in Mississippi.

Ponds in the Delta generally do not need additional lime, and ponds in the Black Belt and thick and thin loess soils need only small amounts. Ponds in the red clay hills of north and central Mississippi usually need 2 tons of lime per acre, and the sandy soils of south Mississippi usually need from 2 to 3 tons of lime per acre (see Figure 9).

Liming Agents

Only agricultural limestone should be used for existing ponds with fish populations. This is the same form of lime farmers use on their crop and pasture land. You can buy it in bulk or bag form. **Never use quicklime, hydrated lime, slaked lime, builder's lime, or other more potent liming agents! These other forms are different chemical compounds that are very caustic and may kill fish.**

When to Apply

It is best to lime the pond in fall or winter at least 2 months before the growing season. Liming a pond in the spring removes soluble phosphorus and reduces free carbon dioxide. This affects the productivity of the pond. By liming the pond in the fall or winter, it has time to equilibrate before the growing season.

Lime Application

It is easiest to apply lime when the pond is dry. For the lime to be effective, spread it evenly over the entire pond bottom. To accomplish this, a spreader truck or tractor spreader can be driven along the pond bottom, or the lime can be spread by hand. It is not necessary to disc the lime into the soil, but this accelerates its neutralizing activity.

It is more difficult to apply lime in ponds that are full of water, but this is more often when ponds are limed. **The lime needs to be spread across the entire pond surface as evenly as possible. Remember, you are liming the soil, not the water!** For small ponds (smaller than 1 acre), it may be possible to back the spreader truck up to the pond in several locations and broadcast the lime. For larger ponds, it will be necessary to load the lime onto a boat or barge and then shovel or wash the lime uniformly into the pond.

If you have one or two johnboats, you can make a simple liming barge. One boat works well but cannot handle very much lime at a time. Two boats tied together are better, because these boats can handle more lime per trip. Attach a large sheet of heavy plywood (half-inch or larger) across the bow of the boat(s), and load a safe amount of lime. You can shovel the lime across the pond or use a spray washer. Using a standard water or trash pump, pull water from the pond and spray across the lime pile, washing it into the pond.

A lime treatment usually lasts from 2 to 5 years, depending on how much water flows through the pond and how acidic the bottom soils are. A method that usually works well is to apply the lime the soil testing report calls for, then apply a fourth that amount each year to be sure the lime requirement continues to be satisfied.

TO FERTILIZE OR NOT TO FERTILIZE?

The decision of whether to fertilize a fishing pond should be considered very carefully. Proper fertilization

significantly increases the total weight of fish produced in a pond, often by as much as two to three times. But there are many reasons not to fertilize, including potential water quality issues, high expense, and the fact that it is a long-term commitment. Consider the following when making your decisions.

Fertilizer stimulates growth of microscopic plants, called phytoplankton. Phytoplankton forms the base of the food chain, and small animals eat these small plants and serve as food for bream, which in turn are eaten by bass. Phytoplankton makes the water turn green, or "bloom," which also shades the bottom and discourages growth of troublesome aquatic weeds.

Most ponds should not be fertilized. If only a few people fish a larger pond, it does not necessarily need fertilization to have good fishing. **But in a heavily fished pond, proper fertilization produces the best fishing.** Fertilization significantly increases the total weight of fish produced in a pond, increasing the number of fish that need to be harvested. **In fertilized ponds, increase harvest to 30 pounds of small bass (< 13 inches) per acre each year, and remove 90 to 120 pounds of bream per acre each year in fertilized ponds.** Bream harvest can begin in year 2, and bass harvest should begin in year 3. In ponds that are not fertilized, only half as much harvest is required.

When Not to Fertilize

Many Mississippi ponds should not be fertilized. Here are some cases where this is true:

- **Ponds not fished heavily.** Fertilizing a large pond is a waste of time and money if you fish it only occasionally. You just produce more fish that aren't caught, increasing the possibility of crowding and slow growth.
- **Muddy ponds.** Mud keeps sunlight from passing through the water and binds up phosphorus from fertilizer. This prevents good plankton growth. If a pond stays muddy most of the time, do not fertilize the pond until the mud problem is corrected.
- **Ponds infested with undesirable fish.** If undesirable fish dominate the pond, renovate the pond, restock, and then begin fertilizing. See Renovating Ponds on page 37 for more information.
- **Ponds infested with weeds.** During warm months, pond weeds use up the fertilizer the microscopic plants should get. The pond stays clear even after repeated fertilizer applications, and you gain more weeds.
- **Fish populations out of balance.** If the bass population is overcrowded, it means there is not enough harvest of bass. Fertilization would require more bass harvest.
- **Ponds that are fed commercial feed.** It is not a good idea to fertilize ponds if you follow a feeding program. Commercial feed adds nutrients to the water, and adding fertilizer can degrade water quality.
- **Too much water flow.** In some spring-fed ponds, too much water flows through the pond to maintain plankton blooms. In this case, fertilizer that is constantly being diluted has little positive effect.

When to Fertilize

Some Mississippi ponds benefit from fertilizer. Here are some cases where this is true:

- **Ponds that are heavily fished.** Ponds that receive heavy fishing pressure may be at risk of overharvest or poor fishing. Fertilization can increase the abundance of fish to compensate for heavy fishing.
- **Ponds managed for trophy fish.** Producing big bass relies on overabundant prey and low bass density. A fertilization program and removal of small bass can achieve good results.

Type and Rate of Fertilizer

Fertilizer is always marked with three numbers separated by dashes. These numbers indicate the percentage of the fertilizer product that is made of nitrogen (N), phosphorus (P), and potassium (K), respectively. A fertilizer with an N-P-K of 13-37-0 is 13 percent nitrogen, 37 percent phosphorus, and 0 percent potassium. The key ingredient for ponds is phosphorus (middle number), so select a fertilizer with high phosphorus content.

Several types of fertilizer can be used, and all can be effective if the pond soil pH and water chemistry are in the correct ranges. Pond fertilizers are available in liquid, granular, or powdered forms. Liquid fertilizers dissolve most readily, followed by powders, and then granular types.

Typical formulations for liquid fertilizers include 10-34-0 and 13-37-0. Apply these fertilizers at the rate of 0.5 to 1 gallon per surface acre, depending on pond location and soil fertility (Table 6). Powdered, highly water-soluble fertilizers, such as 12-49-6 or 10-52-0, are available and have proven to be effective and convenient. These formulations are typically applied at the rate of 2 to

Table 6. General fertilizer recommendations for the various soil regions in Mississippi (see Figure 9). Make sure your pond needs a fertilization program before you begin.

Region	Lime	Liquid	Granular (0-46-0)	Water soluble powder
Delta	not needed	usually not needed	usually not needed	usually not needed
Thick and Thin Loess Bluff	usually not needed	½ gal/acre each application	4 lb 0-46-0/acre each application	2–4 lb/acre each application
Blacklands	usually not needed	½ gal/acre each application	4 lb 0-46-0/acre each application	2–4 lb/acre each application
Upper Coastal Plain and Interior Flatwoods	2 tons/acre	¾–1 gal/acre each application	8 lb 0-46-0/acre each application	4–6 lb/acre each application
Lower Coastal Plain	2–3 tons/acre	1 gal/acre each application	12 lb 0-46-0/acre each application	6–8 lb/acre each application

8 pounds per surface acre, again depending on pond location and soil fertility (Table 6).

Granular fertilizers are less expensive and are available in many formulations. Most older ponds respond well to a phosphorous-only fertilizer such as triple superphosphate (0-46-0), which is the most economical formulation. Rates range from 4 to 12 pounds per acre per application. In some areas, it may be difficult to buy 0-46-0, but 0-20-0 is usually available. If it is, use twice the amount recommended for 0-46-0.

When to Apply Fertilizer

Begin fertilization when water temperatures have stabilized at 60°F or higher. Usually this temperature occurs around March 15 in south Mississippi and April 1 in central and north Mississippi. Early fertilization shades the pond bottom and helps control filamentous algae, a common problem in Mississippi ponds in spring.

Make the first three applications of fertilizer 2 weeks apart. This should establish a good bloom. The ideal bloom makes the water green and results in a visibility of about 18 inches. Use a yardstick with a white tin can lid on the end to measure the bloom, or make or buy a Secchi disk (Figure 10). When you can see the lid in 24 inches of water, it is time to fertilize again. This is usually about every 2 to 4 weeks. When water temperature drops below 60°F in the fall, stop fertilizing for the year. In general, about 10 to 15 applications of fertilizer are required each year.

How to Apply Fertilizer

Never broadcast granular fertilizer, and never apply undiluted liquid fertilizer. The fertilizer will rapidly sink to the bottom and be tied up in soils instead of becoming available in the water. You will not achieve a bloom and are wasting your money.

You can broadcast finely powdered water-soluble fertilizers into areas at least 2 feet deep where it will dissolve before reaching the bottom.

If you use granular forms, apply them in a way that minimizes fertilizer-soil contact. You can do this by making fertilizer platforms—one for each 5 to 6 acres of water. Build the platforms so you can raise or lower them. Pour the right amount of fertilizer on the platforms so 4 inches of water covers them. Waves will distribute the fertilizer throughout the pond.

Building a permanent platform can be difficult in ponds with water. **An alternative would be to use heavy plastic laundry baskets.** These can be attached to floats and anchored so that they float at the surface and allow fertilizer to dissolve in the top 18 inches of water, or they

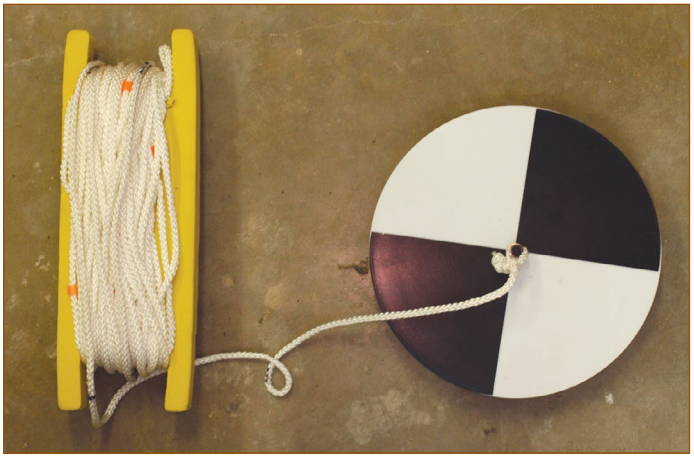


Figure 10. A Secchi disk is useful for measuring water clarity to determine if you need more fertilizer.

can be weighed down with rocks or bricks in shallow areas of the pond.

Dilute liquid fertilizer with at least two parts water to one part fertilizer before application. In small ponds, you can spray liquids effectively from the bank with hand-held sprayers. Boats make application easy in larger ponds. You can spray the diluted fertilizer over the water surface or let it flow into the prop-wash of an outboard motor. You can pour or broadcast powdered formulations directly on the water surface.

New ponds, or those that have never been fertilized, sometimes fail to respond to fertilizer, and it can be difficult to start up a plankton bloom. **If your first efforts to produce a bloom with 0-46-0 or other low-nitrogen fertilizer don't work, even after liming the winter before, use a more complete (high-nitrogen) fertilizer, such as 20-20-5, at a rate of 40 pounds per acre on the specified schedule until the pond gets a green bloom.** Continue with a normal application rate of high-phosphorus pond fertilizers after that.

Important Points on Fertilization

- **Once you start fertilizing, you must continue fertilization from year to year!** Stopping fertilization leaves the pond with too many fish for the food produced, and fish starve and crowd quickly, resulting in poor condition and growth.
- **Improper fertilization is worse than no fertilization.** Follow the fertilization recommendations in this manual and maintain the recommended bloom density for the entire growing season.
- **Do not try to kill aquatic plants by applying fertilizer.** Although fertilization can shade the bottom and prevent weed growth, fertilization after weeds are established usually just makes more weeds.
- **A phytoplankton bloom should develop after two to three applications.** Many Mississippi fish ponds do not develop a satisfactory phytoplankton "bloom" when fertilized at recommended rates because of low soil pH and water alkalinity. Lime can increase fish production in ponds with acid bottom mud and soft water by altering the soil pH and alkalinity of the water. If a bloom does not develop after four applications of fertilizer, check for lime requirements, too much water outflow, too many weeds, or muddy water.

MUDDY WATER

Muddy water limits fish production in ponds because the phytoplankton (single-cell plants) at the base of the food chain must have sunlight to grow. Silt and mud deposits also cover fish eggs and fill the pond, and most pond fish feed using their sight.

Controlling the erosion in a pond's watershed is essential for permanent control of most muddy water problems. Consult your local NRCS office for erosion control techniques and suggestions. If livestock are muddying your pond, fence off the pond and install drinking troughs below the pond. Some fish species, such as bullheads and common carp, can keep a pond muddy. In this case, renovate the pond and start over.

After you have identified and corrected the source of muddy water, have your county Extension office test your pond water for alkalinity. Ponds with low alkalinity also tend to have low hardness and variable pH, which can cause clay particles to remain in suspension for long periods of time. **If alkalinity is less than 50 ppm, adding agricultural limestone may help clear the pond.** Spread at least 2 tons of crushed agricultural limestone per surface acre following the recommendations presented in Liming Ponds on page 26. The limestone dissolves and releases calcium and magnesium ions that settle the clay over several weeks. Once the pond is cleared, the small algae begin to grow, and muddy water conditions are unlikely to redevelop.

If alkalinity is above 50 ppm or if adding agricultural limestone does not clear the pond, one of the following methods may help remove the clay from the water:

- 500 pounds of organic material per surface acre such as old hay (approximately 10 square bales per acre broken up and broadcast evenly over the pond surface), cotton seed husks, compost, or other similar organic material. **Be careful using organic material in the summer, since decomposition may deplete oxygen and cause fish to die.**
- Apply 40 to 90 pounds of alum (aluminum sulfate) per acre-foot of water. The dosage depends on the severity of the muddy water. Treat moderately turbid water (can see about 12 inches in the water) at 40 pounds per acre-foot, but severely turbid water (can see less than 6 inches into the water) may require up to 90 pounds per acre-foot. This translates to about 200 to 450 pounds of

alum per surface acre of water for a pond with 5-foot average depth. **Alum removes alkalinity from ponds, lowers pH, and can lead to fish kills in ponds with low alkalinity. To counteract this, apply hydrated lime at the same time as alum at half of the alum rate. Hydrated lime by itself can cause fish kills, so be careful when using this method to clear ponds.**

- Use gypsum (calcium sulfate dihydroxide) at the rate of 260 to 600 pounds per acre-foot of water, depending on the severity of the turbidity. This translates to about 1,300 to 3,000 pounds of gypsum per surface acre of water for a pond with 5-foot average depth. Spread the gypsum from a boat over the pond surface, and stir with an outboard motor. The gypsum keeps the water clear as long as it is not washed from the pond. When used according to recommendations, it does not kill fish, change the pH of the water, or harm livestock. When water clears, you can return to your regular fertilization program.

FEEDING

You do not normally have to feed fish in a healthy bream and bass pond to produce good crops of fish. Natural food organisms are typically abundant enough to feed fish. But you can increase growth of bluegill with a supplemental feeding program. Bluegill readily accept feed and can be attracted quickly to feeding areas.

Always feed small ponds stocked at high density with channel catfish or hybrid sunfish to maximize fish growth. Not feeding gives poor results. Here are some points to consider about feeding:

- Feed at the same time and place each day.
- Use floating feed, with a pellet size small enough to be easily eaten.
- Never feed more than the fish will eat in 5 to 10 minutes. Keep in mind that uneaten feed may pollute the water.
- If fish quit eating, stop feeding for a few days. Watch for signs of disease.
- Do not feed in very cold or very hot water.
- Reduce the feeding rate as winter approaches to about one-fourth of the feed rate of the previous summer.
- Automatic feeders give good growth results where small ponds are unattended for long periods.

Catfish consuming floating feed.

- Do not try to feed fish up to large sizes without some harvest to reduce the number of fish. Otherwise, crowded large fish may become diseased and die.

Following these simple rules will provide good growth rates while minimizing the risks of deteriorating water quality.

DRAWDOWNS

One of the most useful and inexpensive pond management practices is called a "winter drawdown." **Water levels are reduced in a pond to some predetermined level, generally exposing 35 to 50 percent of the pond-bottom area. In most farm ponds, lowering the water level 2 to 4 feet usually exposes the proper percentage of the pond bottom.** Winter drawdowns can be useful in controlling some species of aquatic weeds and can help manipulate fish populations. They are also useful when repairing, redesigning, and liming ponds. To perform a winter drawdown, make sure the pond has a drain pipe that lets the water levels be lowered and kept down throughout the winter. Ponds without a drain pipe can be retrofitted; detailed information on how to do this is available through your county NRCS office. However, some species of plants can spread to other areas during drawdown, so check with your county Extension office before using drawdown for aquatic plant control.

Drawdown for Aquatic Weed Control

Aquatic weed problems are common in farm ponds and usually are challenging to manage. Of the four basic weed control methods (physical, mechanical, biological, and chemical), physical control can be the least expensive and most convenient if it consists of a winter drawdown. Winter

drawdown exposes weeds to air-drying and freezing temperatures. This can be an effective weed control technique for most plant species, especially if done in successive years.

For effective weed control, drop the water level of the pond to expose aquatic weeds in the more shallow portions of the pond. Usually, water levels are reduced enough to expose 35 to 50 percent of the pond bottom, but this percentage may vary greatly, depending on topography and design of the pond. **Maximum drawdown should be accomplished by mid- to late November, and the water level should remain low through February.** Spring rains will fill the pond.

If necessary, deepen the shoreline to 3 feet deep while water levels are reduced. This reduces the likelihood of weeds returning. After reflooding, if weeds persist and begin to sprout, apply an appropriate herbicide. The combination of a winter drawdown, shoreline deepening, and effective early spring herbicide application usually eliminates or greatly reduces aquatic weed infestations.

Drawdown for Fish Management

Winter drawdown is also a good fish population management technique in largemouth bass/bluegill ponds. **By reducing the water level and pond area, you drive forage fish, such as bluegill, out of shallow water refuges and concentrate them in open water, making them more available for bass to eat.** This is a good technique to use in ponds having "crowded bluegill" but still containing viable bass populations.

The increased feeding by largemouth bass on bluegill reduces bluegill numbers and provides more food for the bass. Routine annual drawdowns can help maintain a balanced bass/bluegill fishery.

Drawdowns can make bass-crowded situations worse. If you have a bass-crowded pond, follow the recommendations in Managing on page 15, and do not use winter drawdowns until pond balance is restored.

Winter drawdown also provides a good opportunity to do repairs on piers, docks, and boat ramps, as well as minor dam repairs and shoreline renovation. Fish attractors, such as brush tops and gravel beds, can be more easily put in place while the water is down, and this is a good time to deepen edges to the recommended minimum depth of 3 feet. You can use dirt from the shoreline-deepening operation to build earthen piers at various locations around the pond. These piers increase the shoreline area of the pond and provide increased access for fishing.

You must consider the topography of the pond, amount of shallow water, and pond shape and design. Reach the maximum depth of drawdown by late November, and let the water remain down through February. **In south Mississippi, the stand pipe can be raised a little earlier, perhaps mid-February, to let the pond refill and not hamper bass spawning activities that begin earlier in that part of the state.**

Winter drawdown can be a useful tool if you do it properly. It poses no threat to the fish population and costs nothing if the pond is equipped with a water control structure. Drawdowns for this purpose should be done only in the winter—never in summer! The extreme temperatures in Mississippi summers, coupled with the increased activity level of fish and reduced oxygen levels in warm water, will likely result in fish kills in a summer drawdown.

UNEXPECTED FISH KILLS

Occasionally, a fish kill occurs in farm ponds because of water quality problems, infectious disease, swarming fire ants (in the spring), or misused agricultural chemicals (pesticides). In some cases, the losses may be enough to affect the balance of the fish population. **Get professional help to evaluate the fish population balance after a fish kill. In many cases, a phone call will provide enough information.**

Oxygen Depletions and Pond Turnovers

By far the most frequent cause of fish kills in farm ponds is low oxygen. Low oxygen can be the result of two separate phenomena in ponds. The first is simple oxygen depletion, which usually occurs July through September when water temperatures are at their highest. Dieoffs caused by low dissolved oxygen levels result from natural biological processes, and preventive measures are rarely efficient (other than running an expensive aerator every night).

Following are factors that can contribute to low oxygen levels:

- Dense phytoplankton blooms or dense stands of pond weeds.
- Several days of cloudy weather that reduce phytoplankton oxygen production.

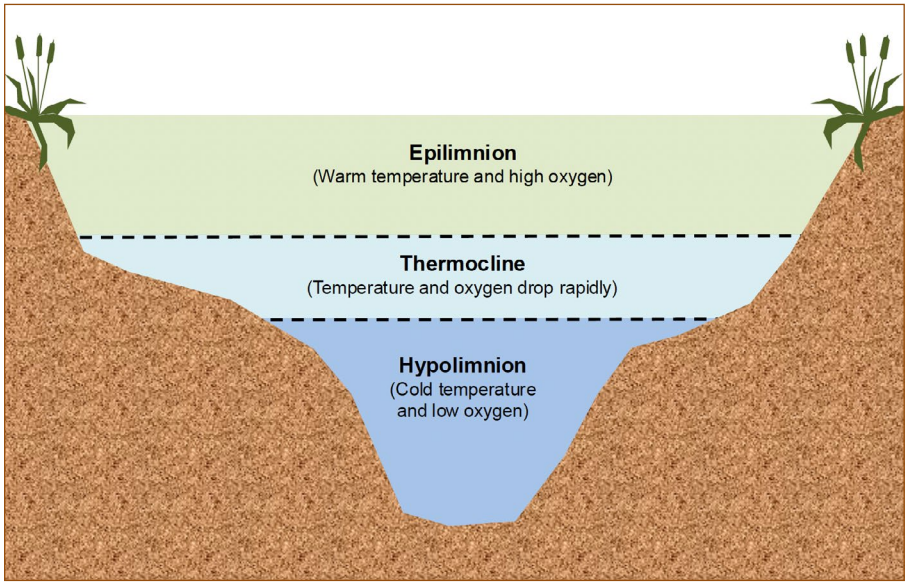


Figure 11. Stratification of water layers in a pond during summer.

- High temperatures, which decrease the solubility of oxygen in water and increase oxygen consumption by plants and animals.
- Sudden die-off of plants or algae, especially associated with herbicide use.
- Unusual weather patterns, such as storm fronts and heavy, cold rain.
- Overstocking fish, excessive fertilization, or high feeding rates.
- Input of organic matter, such as hay, straw, or cottonseed meal for turbidity or algae control, and materials such as animal manure or sewage.

Another condition, often called "pond turnover," can occur after heavy cold rains in late spring to early fall when temperatures drop suddenly. During calm, hot days, the pond develops temperature layers called "stratification." The layer of water at the surface is exposed to the sun and warms quickly. This warm layer weighs less than the cool water below, so these layers do not mix (Figure 11).

Surface layers contain high levels of oxygen produced by the phytoplankton. The cooler bottom layers are cut off from the surface layers and their sources of oxygen, so oxygen levels drop over time because of normal biological processes. In fact, these deep waters can actually develop an "oxygen demand," which is like having negative oxygen levels. When a heavy, cold rain enters the pond, or when there are sustained high winds, it mixes the two layers of water. When this occurs, oxygen levels throughout the pond may drop too low for fish to survive.

A severe mixing event can kill nearly every fish larger than an inch or two in one night. It is not uncommon to find large dead fish on dry land in the watershed above the pond following a turnover. These fish swam up the incoming rain waters seeking oxygen. **Adult fish die first, and intermediate-sized fish follow if the oxygen levels are too low or if low oxygen conditions continue for many days.**

Usually, by the time you recognize there is an oxygen problem, it is too late to save your fish. But an early symptom of a low-dissolved oxygen level is fish at the surface of the pond at sunrise. Fish appear to be "gasping for air." If you discover the low oxygen event early enough, you may be able to save some fish by using emergency aeration. A powerhouse-type aerator works great, but most people don't have access to aquaculture equipment. You can back a boat with an outboard motor halfway into the pond and tilt the motor at a 45-degree angle to the water surface. Run the motor at high speed to move a "rooster tail" of water into the air and across the pond. Any technique that mixes water and air can help provide an oxygen refuge for fish.

Following a severe fish kill, some fingerling fish usually survive, but overcrowding bream tends to follow. **After a severe fish kill, contact a fisheries biologist to assess the status of your fish population.**

pH and Mineral Problems

Poor water chemistry is the second leading cause of fish death in Mississippi ponds. **Fish in acidic water with low alkalinity and hardness are more likely to get sick,** especially during times of stress, such as spawning season or periods of rapid temperature change. A few fish, usually of different species (although catfish are especially sensitive), die every day, and many may have sores or lesions. If this is the case, have your pond water alkalinity measured to determine if agricultural limestone is needed. Liming increases the dissolved minerals in the water, which reduces stress on the fish. See Liming Ponds on page 26 for more information.

Dead fish after an oxygen depletion.

Infectious Diseases and Parasites

Bream and bass generally do not have significant problems with infectious diseases in well-balanced ponds, although you may see an occasional sore on individual fish during spawning season or after an injury. This is normal, and these external sores do not pose any health hazard to humans.

The one known exception is largemouth bass virus (LMBV), which is not common in Mississippi ponds. This virus becomes evident during the hot summer, when largemouth bass are seen sick or dead on the surface and around the pond. A few bass die every day during warm weather, and larger fish seem to be more affected. When water temperatures cool in September/October, no more fish die from the virus, but the virus persists in the pond. The best way to avoid LMBV and other health problems is to follow stocking and harvesting recommendations and to avoid stocking fish from other natural systems.

Occasionally, bass and bream have small white or yellowish grubs embedded in the flesh. These grubs, although not pleasant to look at, pose no threat to humans. You can trim away the affected area, and the rest of the fish is safe to eat if properly cooked.

Infectious diseases and parasites of channel catfish are common problems in catfish ponds. Overstocking, inconsistent feeding, and poor water quality contribute to this in recreational ponds. **Disease and parasite problems of catfish rarely occur when you use low stocking densities (50 to 100 per acre).** Stress from handling may cause die-offs of fish within 2 weeks of stocking new or established ponds.

If you choose to stock catfish at rates higher than recommended (100 to 150 per acre), plan to cope with problems that may occur. If you suspect a parasite or disease, see the section on Transporting and Shipping Samples below. You can also consult your county Extension agent. They can help you submit a sample to the Mississippi State University College of Veterinary Medicine for diagnosis. You must arrange for someone to receive your catfish before you ship them. Do not send fish samples to the MDWFP or to any agency other than the Mississippi State University College of Veterinary Medicine.

Fire Ants

Fire ants often wash into ponds or fly in during breeding swarms, and small and intermediate-sized bream may die from eating these insects. Bass are rarely affected. This generally does not hurt the population balance.

Determining Factors in Fish Kills

If possible, send this information and the fish sample to the disease specialist:

- What species and sizes died?
- Number of fish lost since the die-off started.
- Approximate number of fish lost each day.
- Date and time of day the losses started.
- Were fish seen "gasping" at the surface of the water?
- Size of pond (surface acres).
- Average pond depth.
- Number of fish stocked in the pond.
- Condition and color of the bloom before and after fish kill:
  Light – You can see at least 18 inches deep, and the pond has no accumulation of algae in the corners or on the downwind side.

  Moderate – You can see 12 to 15 inches deep, and the pond may have some algae in the corners or on the downwind side.

  Heavy – You can see no more than 12 inches deep.

Transporting and Shipping Samples

Arrange for shipping and delivery. Samples should arrive at the lab within 12 to 18 hours. **Call the lab and provide details on your case and the anticipated arrival time.** Mississippi State University operates two labs, the

CVM Diagnostic and Aquatic Research Laboratory on campus (662-325-1104) and the Aquatic Research and Diagnostic Laboratory in Stoneville (662-686-3302).

Place live fish in a plastic bag with no water, and seal it. If you are sending catfish, clip the spines to prevent them from puncturing the bag in transit. Then place the bag in an ice chest containing crushed ice.

If the fish are to be hauled for a short distance, you may place them in a container or ice chest containing well-oxygenated water. Add a few chunks of ice to keep the water cool.

You can freeze fish for transport to the lab when there is no other way to keep them from spoiling. Frozen samples are hard to work with. Avoid them whenever possible. Frozen samples are acceptable if they are for pesticide analysis.

Immediately ice down all dead fish that are still acceptable for examination (freshly dead with gills still red) to slow further tissue breakdown.

ATTRACTING FISH

The primary purpose for many farm ponds in Mississippi is recreational fishing. With proper management, even small ponds can provide excellent fishing. **One of the best ways to enhance the fishing experience is to create fish attractors at strategic locations in a pond or lake with a well-managed fish population.**

Game fish such as bass and bream are attracted to cover or shelter of all types. Shelters provide areas where prey fish can hide from predators and where predators can find prey species. They also provide spawning areas and harbor large numbers of invertebrates and insects that small fish feed on. Natural cover that provides shelter for fish includes ditches, creeks, trees (standing or tree tops), stumps, vegetation, and other irregular features of the bottom. In ponds where natural shelter for fish is missing or is inadequate, you can establish artificial structures to act as fish shelters that will attract and hold fish.

Trees as Fish Attractors

You can develop fish shelters that will increase fish harvest and angling success in existing ponds with small trees such as blackjack oak, post oak, or cedar. Discarded Christmas trees make good temporary shelters, but they decompose quickly and must be replaced often. For small ponds, bushy-crowned trees 10 to 15 feet tall are sufficient. You can use larger trees in larger lakes. In ponds smaller than 1 acre, one brush shelter is enough. Larger ponds need one or two shelters per acre.

Select attractor sites anglers can get to. **Good locations are in water 4 to 8 feet deep near creek channels, near points, or at dropoffs. Drive a stake or use a floating buoy to mark the shelter site permanently.** Place three to five trees at each location. Green trees will usually sink without weights. Some trees, such as cedar, will float. Add weights to these varieties to keep the shelters in place.

Many new pond sites have trees in the basin. Cut and salvage most of these, then cut and pile or burn them. You can keep some trees, bushes, and brush piles to use in establishing fish shelters. From 10 percent to no more than 25 percent of the pond area can have some tree shelter.

Placing Christmas trees as habitat.

Figure 12. A pea gravel spawning bed has been installed in front of this fishing pier during water level drawdown. This gravel bed will attract bream during the spawning season, making them easy to catch.

Leave bushes and trees in deeper water areas, along creek runs, and in the middle of ponds and lakes. Leave the trees in small clumps, then cut the standing trees about 2 feet above the normal water level, and anchor the brushy tops to the bases of the stumps. The tall stumps serve as permanent markers for the shelter locations. Do not leave trees or bushes in shallow areas, in narrow coves, or along pond banks, because these areas will become difficult to fish and may develop weed problems. Also, too much cover in shallow water makes it hard for bass to effectively feed on bream and prevents navigation of the entire shoreline by boat. Fish will immediately inhabit brush-top shelters.

Gravel Beds as Fish Attractors

Gravel beds are extremely attractive to bream for spawning, and bream will use these gravel beds frequently throughout the spring and summer (Figure 12). **Select an area in water 3 to 4 feet deep that is convenient for fishing. Drive a stake to mark the spot, and place washed gravel (half-inch diameter) around the stake, creating a bed of gravel 4 to 6 inches deep.** A 3- to 5-cubic-yard load makes a gravel bed 12 to 15 feet wide. For best results, you can provide a frame to hold the gravel in place. If the frame is made of treated lumber or other material that can float, make sure the frame is securely anchored to the bottom. You can add gravel beds to flooded sites or strategically place them during drawdowns. Avoid sites that have a high silt erosion problem.

Other Fish Attractors

If trees or brush piles are not available, you can place other types of structures in the pond to attract fish. Many artificial fish habitats are available for purchase that can last indefinitely. Developing irregular bottom features during construction, such as ditches and underwater dirt mounds, also provides fish-attracting cover and creates excellent places to fish. **Humps that rise to 3 to 4 feet of depth and are surrounded by deeper water are fantastic fish attractors, especially in combination with brush piles or gravel beds.**

RENOVATING PONDS

The ultimate fate of many farm ponds in Mississippi is an unbalanced fish population that is undesirable to anglers and has little recreational fishing value. **Once a fish population reaches such a condition, the best solution is usually to eliminate the resident fish and restock with a desirable combination of fish at recommended rates.** Consult a fisheries biologist by calling any MDWFP district office to determine the condition of your pond and the possible need for a complete fish population renovation.

The easiest way to renovate a pond is to drain and completely dry the pond. This also lets you modify the pond or add habitat. If any pools of water remain in the basin, drain or treat with a fish toxicant, because small fish can survive in these pools for a very long time and ruin your renovation attempts. Also, many ponds were not constructed with a drain, and all of the water cannot be removed. These ponds will need to be chemically renovated.

Rotenone is a fish toxicant registered by the EPA for removing unwanted fish. Currently, rotenone is the only fish toxicant labeled to remove scaled fishes.

What Is Rotenone?

Rotenone is available at most farm and chemical supply stores. **It is classified as a "restricted-use pesticide," and you cannot buy it without a private pesticide applicator's certificate. You can get this certificate through your county Extension agent.**

Rotenone comes from the roots and stems of several tropical plants. Rotenone has many common and brand names, including Prenfish, CFT Legumine, and Zoecon. Note that brand availability and names change frequently.

Rotenone keeps fish from using oxygen, but it does not remove oxygen from the water. Fish in ponds treated with rotenone move to the shallow water or to the surface of deeper water soon after exposure to the chemical. Fish species respond differently to rotenone, so it is a good idea to know what species you have before you treat the pond.

Rotenone breaks down when exposed to the environment. The breakdown is rapid and is affected by temperature, light, oxygen, and alkalinity. Most waters are safe for restocking within 5 to 6 weeks. In general, the cooler the water, the longer rotenone lasts.

Table 7. Rotenone concentrations (using 5% active liquid rotenone) required for selected applications.

Purpose	Acre-feet treated per gallon	Active rotenone concentration (ppm)	5% formulation concentration (ppm)
Selective shad kill	30	0.005	0.1
Complete renovation; no carp, bullheads, bowfin, or gar	3.0	0.05	1
Complete renovation; ponds with carp and/or bullheads	1.5	0.1	2
Complete renovation; ponds with bowfin and/or gar	1.0	0.15	3

Preparing the Pond

You can treat ponds of any size with rotenone, but it can be difficult to spread rotenone for an effective fish kill in larger ponds or lakes. It is also expensive to treat large volumes of water. For these two reasons, you will need to reduce the water area and volume as much as possible before treating. You can do this by draining the pond as low as possible with a built-in standpipe, pump, or siphon device. The less water you have to treat, the more cost-effective the treatment. Also, lowering the water level pulls fish out of their shallow water cover that can be difficult to treat.

How to Apply Rotenone

Rotenone is available in a wettable powder or a liquid formulation. Liquids are easier to get into solution and are more reliable for total fish kills. The liquid formulations typically contain 5 percent rotenone, although some contain 2.5 or 7 percent.

Treatment rates for a complete kill vary between 0.1 and 3 parts per million rotenone, depending on the objective of the pond renovation and the species present (Table 7). All formulations must be diluted with water and evenly distributed throughout the water column. The key is to have an even distribution; otherwise, fish may find "safe" areas and not be killed. Application in a random "S" pattern throughout the pond maximizes coverage.

The best time to eradicate fish from a pond for restocking is late summer or early fall. Water temperatures are at their highest at this time, and the weather is usually dry, allowing easy draining. Killing the fish at this time reduces the time between the kill and the restocking, which minimizes the chance the pond will be contaminated by unwanted fish before restocking. This is an important consideration, since letting in unwanted species can defeat the purpose of the renovation.

If you drain the pond, it is critical to treat all remaining puddles to kill any fish there. Many small fish can survive in these pools, puddles, or stump holes for a long time. You must kill all fish to have a successful renovation. Otherwise, these surviving fish can contaminate the new fish population, and the renovation will have been for nothing.

When to Restock

It is important to wait until the rotenone dissipates before restocking. If you poison in early fall, the rotenone should be detoxified by the time early winter rains come to refill the pond. **A good general rule is to wait 1 month.** A simple test can help determine when it is safe to restock. Place a few bream (bluegill or redear) in a small cage in the pond or in an aerated container with water from the pond. If the fish survive 24 to 36 hours, it is safe to restock the pond. **Do not release these fish into the pond unless they are part of your restocking plan!**

NUISANCE SPECIES

Turtles

Turtles usually aren't a biological problem in farm ponds, but they might sometimes compete with fish for food items such as crawfish, insects, or other small food items. They can, however, be a nuisance to anglers when they are caught on hooks and must be removed, when they take baits intended for fish on trot lines, or when they eat fish on stringers left in the water. Turtles also become a problem in ponds where fish are being fed, because turtles quickly learn that fish food tastes good and represents an easy, free meal.

But turtles can be beneficial. Their greatest service is as scavengers to eat dead fish and other animals or to eliminate diseased or weakened fish. Except for snapping

varieties, turtles do not capture many live fish and should not be considered a problem.

Before pursuing any type of control method, consider whether or not turtles are a genuine problem in your pond. Unless numbers are high and the interference with other pond uses is severe, it is probably best to leave the turtles alone. But if you have significant problems, you may need to consider removing some turtles.

Shooting turtles as they bask in the sun or as they swim in the water is an old practice you should never use. **Shooting into or across water is dangerous!** Shooting also creates the possibility of killing a protected species, since identification from a distance is impossible. You can't use repellents or toxicants, so trapping is the only choice.

Trapping can effectively reduce local populations. The best seasons for trapping are spring, summer, and early fall. Most turtles are inactive through the winter and feed very little, which makes baited traps ineffective during that time.

Although you can trap snappers and soft-shelled turtles using underwater baited traps, you usually don't have to remove these species from a farm pond. The more aggravating species are the "baskers," which often crowd together in large numbers on stumps, logs, or other structures above the water surface. By taking advantage of this, you can trap these species with a trap-box in the area turtles normally use. This trap has boards leading up from the water, with pivoting "balance boards." When the turtles crawl onto these platforms, they weigh down the boards, dropping the turtles into the collection box (Figure 13).

Check traps daily and remove all turtles, then take the turtles to another location at least several miles away and release them into their natural habitat. Be careful not to violate state laws when transporting turtles, and do not carry them across state lines, since other states have different laws. Notify your local conservation officer before transporting turtles off of your property. If you do not plan to visit the trap for a long while, flip it over on its side so turtles are not captured and left in the trap.

Refer to Figure 13, and modify it using your own ideas and available materials. Your county Extension agent or NRCS office can provide you with other design illustrations.

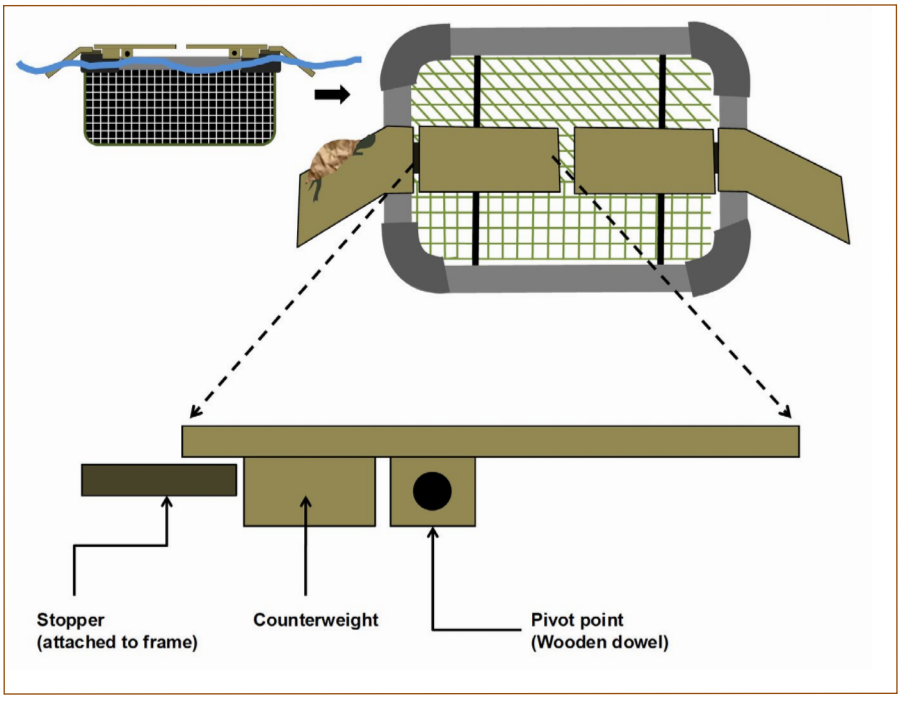


Figure 13. Simple turtle trap design. Floating PVC frame with a capture net below. Resting boards pivot under the turtle's weight, dropping it into the collection area. Pivoting boards return to resting position using counterweight once the turtle is collected.

Other Problem Animals

Many animal species can take up residence on small lakes and ponds. Beavers, muskrats, nutria, alligators, and geese can be a nuisance or even cause damage. Burrowing and damming activities can cause dam failure or flood adjacent landowners. Tree cutting and flooding can cause loss of valuable timber. Beaver dens or huts may be great places to fish, but it is at the landowner's expense. Fish attractors can provide the same benefit.

Otters can quietly steal your fish at night. A family of otters, although cute, can virtually eliminate catchable-size fish in a small pond.

The best control is immediate action at the first sign of these animals living in your lake. For species such as nutria, beavers, and muskrats, trapping is the most effective control. **For detailed assistance, contact USDA Wildlife Services (662-325-3014) or your county Extension agent. If an alligator is residing in your lake, contact your nearest MDWFP office to have the animal removed.** Do not make repairs to animal damage until you have controlled the problem animals.

OTHER CONSIDERATIONS

Private Pond Consultants

Personnel from the MSU Extension Service, NRCS, and MDWFP are available to provide advice free of charge. However, at times you may want to hire a private consultant to handle specific management tasks. Several reputable companies are licensed to work in Mississippi. **The guidelines on the next page were developed by the Southern Division of the American Fisheries Society to help you make an informed selection if you decide to hire a private consultant.**

Consumer questions for pond management consultants:

- **How many years of experience do you have in this business?** An established business may have more experience with unusual problems or needs.
- **Do you have a staff member with a fisheries management degree?** A manager with a fisheries degree would be better trained in scientific pond management.
- **Do you carry liability insurance or bonding for your services?** Insurance may protect the consumer if a problem arises as a result of damage or mismanagement.
- **How will you survey my pond, and will I receive a written report?** At a minimum, a qualified pond manager should check a pond firsthand and provide a written report on findings and recommendations to the pond owner.
- **Will you perform the needed management?** A good manager should be able to implement the recommendations, not simply stock fish as a cure-all for your problems.
- **Can you provide me with a list of references?** An established, reputable manager should have plenty of satisfied customers.
- **How are your fees based?** Managers may charge by the job or by the hour. Get an estimate in writing, up front.

Making Money from Your Pond

Fishing is a top recreational pastime in Mississippi, and many ponds and small lakes are visited every year in this pursuit. The increasing demand for quality fishing has led to congestion and overexploitation of some of our public waters. Fee fishing in private ponds can help alleviate the supply shortfall for quality fishing opportunities, while providing the pond owner with a new source of income. Other revenue-generating opportunities from ponds may exist, as well, including waterfowl hunting and bird watching. For more information on these and other natural resource enterprise opportunities, visit **naturalresources.msstate.edu**.

FOR MORE INFORMATION

This publication should be helpful as you develop, improve, or maintain your small lake or pond in Mississippi. Trained professionals—Extension agents, district conservationists, and MDWFP fisheries biologists—are available to answer more specific questions to achieve your goals and objectives. And this service is free!

Many other sources of information are also available, such as publications, local workshops, and seminars. Contact any of the three agencies that have provided this publication for details. MSU Extension and NRCS maintain offices in every county of the state. Also, you can contact MDWFP district offices at (601) 432-2200.

If you have questions about information in this publication, or if you have situations or problems not covered here, we encourage you to seek professional help. Proceeding with management techniques when you are uncertain about the correct thing to do can be frustrating and sometimes expensive! It can also delay the progress and development of your pond. It is wise to remember and heed the old adage, "A wise person asks many questions"!

FARM POND HARVEST RECORD

Instructions: Accurate and complete data are important to fisheries management. All anglers should complete a record after each trip. **Under each column, in each size group, enter the number of fish harvested (H) and released back into the lake (R).**

Date	Angler	Bass						Bluegill				Catfish		Other	
		<12 inches		12–15 inches		>15 inches		3–6 inches		>6 inches					
		H	R	H	R	H	R	H	R	H	R	H	R	H	R

FARM POND MANAGEMENT CALENDAR

Use this calendar to help plan pond management activites throughout the year.

Management Action	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stock bluegill/redear (1-3 in.)	■									■	■	■
Stock bass fingerlings (1-3 in.)					■	■	■	then ←				
Lime if needed	■									■	■	■
Fertilize if desired*				■	■	■	■	■	■			
Check density of bloom				■	■	■	■	■	■			
Drawdown pond for winter	■	■	then ↓								■	■
Refill pond		■	■									
Chemical weed control			■	■	■	■	■					
Biological weed control	■	■	■	■	■	■	■	■	■	■	■	■
Stock catfish when needed	■	■	■							■	■	■
Check pond balance					■	■	■					
Feed fish if desired			■	■	■	■	■	■	■	■	■	
Fish and harvest pond	■	■	■	■	■	■	■	■	■	■	■	■
Trim grass/brush on levee					■	■	■	■	■			

*Be sure your pond needs to be fertilized before beginning a fertilization program. Once you begin fertilizing, it must be continued consistently and indefinitely. Begin fertilizing in mid-March in northern parts of the state, early March in central, and mid-February in southern.

APPENDIX: COMMON PLANTS AND THEIR CONTROL

Your local county Extension office can provide plant control assistance. Follow the herbicide label; it is the law.

Notes:

- Where we recommend diluting with 9 parts water, this means, for example, for each gallon of herbicide required, dilute it with at least 9 gallons of water.
- Non-ionic surfactants are sold by various trade names, including Activator 90, AirCover, Alligare 90, Brewer 90-10, Cide-Kick, Cide-Kick II, Crystal Blue Plex Mate, Dyne-Amic, Induce, MSO Aquatic Surfactant, Non-Ionic Surfactant, and Sunenergy. Follow label instructions.
- Buffering agents are sold by various trade names, including AquabupH, Aqua-King Plus, Buffer P.S., BS-500, Combine, LI-700, Penetrator Plus, Spray-Aide, and Yardage. Follow label instructions.

Algae

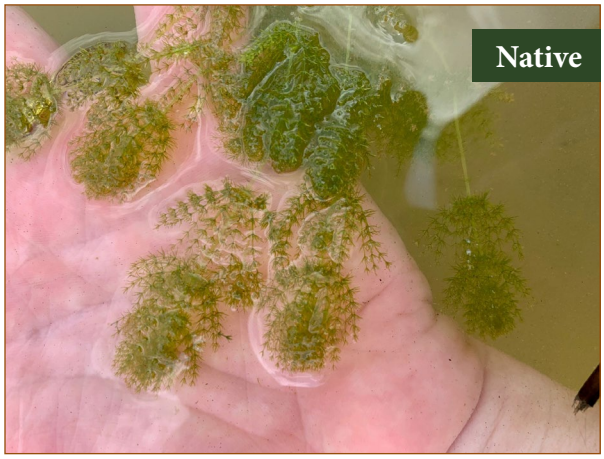
Chara: *Chara* has a rough texture and strong musty or garlic-like odor. Whorls of six to eight branchlets do not have further branching. Prefers hard water.

Option 1: Triploid grass carp are the best, long-term solution. Use 5 to 25 fish per acre depending on severity. Stock 8- to 10-inch triploid grass carp in ponds that have established largemouth bass.

Option 2: If water alkalinity is at least 50 ppm, copper sulfate (pentahydrate) is the most economical solution. Five pounds per acre-foot controls most infestations; this is about 30 pounds per surface acre for the average Mississippi pond. Dissolve at a rate of 1 pound per 5 gallons of water, and spray uniformly over the pond surface.

Option 3: Chelated copper. Apply a liquid chelated copper (0.9-pound formulation) at a rate of 1.5 to 3.0 gallons per acre-foot, depending on depth, plant height, and plant density. Dilute with 9 parts water and spray uniformly over the pond surface or use bottom injection (subsurface application using a wand or hose).

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Apply on sunny days when water temperature is above 60°F. Use of copper when alkalinity is less than 50 ppm may kill fish. For heavy blooms, treat only one-third of the pond at a time during the early morning hours. Wait 2 to 3 days between treatments of plankton.



Nitella: Closely related to *Chara* but is smooth to the touch and does not emit a musty or garlic odor. It has six to eight branchlets along the internodes, but these branchlets have additional lateral and terminal branches that give the alga a bushy appearance.

Option 1: Triploid grass carp are the best, long-term solution. Use 5 to 25 fish per acre depending on severity. Stock 8- to 10-inch triploid grass carp in ponds that have established largemouth bass.

Option 2: If water alkalinity is at least 50 ppm, copper sulfate (pentahydrate) is the most economical solution. Five pounds per acre-foot controls most infestations; this is about 30 pounds per surface acre for the average Mississippi pond. Dissolve at a rate of 1 pound per 5 gallons of water, and spray uniformly over the pond surface.

Option 3: Chelated copper. Apply a liquid chelated copper (0.9-pound formulation) at a rate of 1.5 to 3.0 gallons per acre-foot, depending on depth, plant height, and plant density. Dilute with 9 parts water and spray uniformly over the pond surface or use bottom injection (subsurface application using a wand or hose).

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Apply on sunny days when water temperature is above 60°F. Use of copper when alkalinity is less than 50 ppm may kill fish. For heavy blooms, treat only one-third of the pond at a time during the early morning hours. Wait 2 to 3 days between treatments of plankton.

Filamentous algae: Filamentous algae blooms are most common in spring and summer and are a nuisance that can lead to water quality problems. The "slimy" forms are easier to treat than the more "cottony" forms.

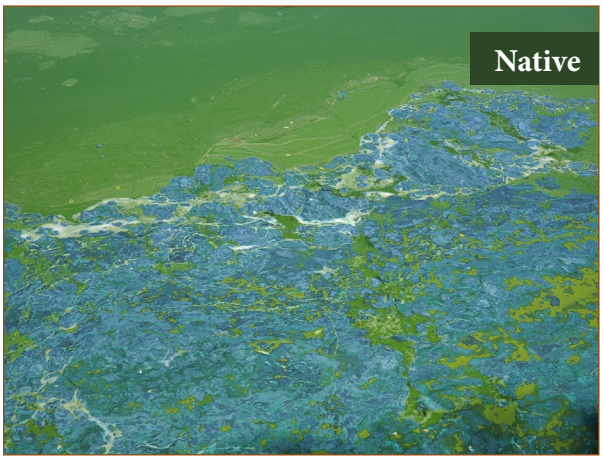
Treatment is based on acre-feet or surface area. For surface area, use the area of the whole pond.

Species other than Pithophora or Lyngbya: Use 1.5 gallons of chelated copper (0.9-pound formulation) per acre-foot. Dilute each part of chelated copper with 9 parts water and spray to wet all surface mats. Injecting (subsurface application using a wand or hose) diluted liquid chelated copper or broadcasting granulated chelated copper can be used to kill algae growing on the pond bottom. Granular rate is 1 pound per 720 square feet (60 pounds per acre).

For Pithophora: Mix 1 gallon of chelated copper liquid (0.9-pound formulation), 1 gallon of diquat (3.73-pound formulation), and 9 gallons of water for each acre-foot to be treated and spray to wet all surface mats. Determine pond volume before applying algaecide. Injecting (subsurface application using a wand or hose) the mix above or broadcasting granulated chelated copper can be used to kill algae growing on the pond bottom.

For Lyngbya: Apply peroxide (e.g., Phycomycin) at a rate of 75 pounds per surface acre. Wait 48 to 72 hours for the Lyngbya mat to detach from the lakebed and float to the surface. Once the mat detaches, apply a chelated copper compound containing D-limonene (e.g., Cutrine-Ultra) to the surface of the water body at 2 gallons per surface acre. Dilute in 9 parts water and spray to wet all floating algae.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Copper can be toxic to fish when water alkalinity is low. Do not use copper in catfish or koi ponds with alkalinity less than 50 ppm. Apply on sunny days when water temperature is above 60°F. Use of copper when alkalinity is less than 50 ppm may kill fish. For heavy blooms, treat only one-third of the pond at a time during the early morning hours. Wait 1 week between treatments.



Planktonic algae: Green water is the sign of productivity, but if the water is too green (visibility less than 12 inches) or there are severe surface scums, this may indicate potential oxygen problems for the pond.

Planktonic blooms will usually go away on their own, and treatment can cause other issues, including fish kills. Treat only if necessary.

Option 1: Copper sulfate (pentahydrate) is the most economical solution. Five pounds per acre-foot controls most planktonic species. Determine pond volume before applying algaecide. Dissolve at a rate of 1 pound per 5 gallons of water and spray uniformly over the pond surface. Not recommended for cyanobacteria. Do not use copper sulfate in ponds when alkalinity is less than 50 ppm.

Option 2: Chelated copper. Apply a liquid chelated copper (0.9-pound formulation) at a rate of 1.5 gallons per acre-foot. Determine pond volume before applying algaecide. Dilute 1 part chelated copper with 9 parts water and spray uniformly over the pond surface. Do not use copper in catfish or koi ponds when alkalinity is less than 50 ppm. For cyanobacteria, chelated copper is most effective when used with a non-ionic surfactant.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Apply on sunny days when water temperature is above 60°F. Use of copper when alkalinity is less than 50 ppm may kill fish. For heavy blooms, treat only one-third of the pond at a time during the early morning hours. Wait 2 to 3 days between treatments of plankton.

Coontail: Dark green, relatively stiff, and whorled leaves with many forks and small teeth. Branch tips crowded, resembling the tail of a raccoon. The plant is very rough to the touch.

Option 1: Endothall (4.23-pound formulation). Dilute 0.75 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (subsurface application using a wand or hose).

Option 2: Flumioxazin (4.0-pound formulation). Dilute 2.1 pints per acre-foot of water in 9 parts water and apply as a submersed injection. Mix with a buffering agent when water pH is greater than 7.0.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Option 3: Stocking 10 to 15 triploid grass carp per acre may provide control when herbicides are not an option. Stock 8- to 10-inch fish in ponds that have largemouth bass. Too many grass carp can impact other fish, and they can live up to 20 years. If herbicides are used, stock three to five triploid grass carp per acre to prevent reinfestation.

Naiads: The stems and leaves of naiads are slender, with short leaves, usually one-fourth to three-fourths inch in length. Leaves are opposite one another, and this characteristic can be used to separate naiads from all similar species.

Option 1: Stock 5 to 15 grass carp per acre depending on severity. Stock 8- to 10-inch fish in ponds that have largemouth bass. Too many grass carp can impact other fish, and they can live up to 20 years. If herbicides are used, stock three to five triploid grass carp per acre after treatment to prevent reinfestation.

Option 2: Diquat (3.73-pound formulation). Dilute 0.25 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 3: Chelated copper (0.8-pound formulation). Apply at a rate of 1.5 gallons per acre-foot. Dilute 3.3 gallons per acre-foot of water in 9 parts water and apply as a submersed injection. Do not use copper in catfish or koi ponds when alkalinity is less than 50 ppm.

Option 4: Penoxsulam (2.0-pound formulation). Dilute 1.75 ounces per acre-foot of water in 9 parts water and apply as a submersed injection.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Watermilfoil: Watermilfoils have characteristic feather-like leaves under the water. The non-native Eurasian watermilfoil is the most likely problem species; it usually has 12 or more pairs of leaflets on each leaf.

Option 1: Florpyrauxifen-benzyl (0.0052-pound formulation). Dilute 9.6 ounces per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 2: Endothall (4.23-pound formulation). Dilute 1.92 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 3: 2,4-D (3.8-pound formulation). Dilute 0.75 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 4: Diquat (3.73-pound formulation). Dilute 0.25 gallons per acre-foot of water in 9 parts water and apply as a submersed injection. Determine pond volume before applying.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

***Hydrilla*:** This non-native plant's leaves are small with obviously serrated margins, often with one or more small, tooth-like structures on the underside midrib, giving the plant a rough feel. The leaves grow in whorls of three to eight.

Option 1: Stock 5 to 15 grass carp per acre depending on severity. Stock 8- to 10-inch fish in ponds that have largemouth bass. Too many grass carp can impact other fish, and they can live up to 20 years. If herbicides are used, stock three to five triploid grass carp per acre after treatment to prevent reinfestation.

Option 2: Flumioxazin (4.0-pound formulation). Dilute 2.1 pints per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose). Use a buffering agent when mixing with water exceeding a pH of 7.0.

Option 3: Endothall (4.23-pound formulation). Dilute 1.92 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 4: Florpyrauxifen-benzyl (2.5-pound formulation). Apply 5.4 ounces per acre-foot of water. Dilute in at least 9 parts water and apply as a submersed injection.

Option 5: Chelated copper (0.8-pound formulation). Dilute 3.3 gallons per acre-foot of water in 9 parts water and apply as a submersed injection. Do not use copper in catfish or koi ponds when alkalinity is less than 50 ppm.

Option 6: Diquat (3.73-pound formulation). Dilute 0.5 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

***Egeria*:** *Egeria* is a non-native plant that has leaves in whorls of four to six that become denser toward the ends (near the surface). *Egeria* does not have midrib teeth and feels smooth.

Option 1: Stock 5 to 15 grass carp per acre depending on severity. Stock 8- to 10-inch fish in ponds that have largemouth bass. Too many grass carp can impact other fish, and they can live up to 20 years. If herbicides are used, stock three to five triploid grass carp per acre after treatment to prevent reinfestation.

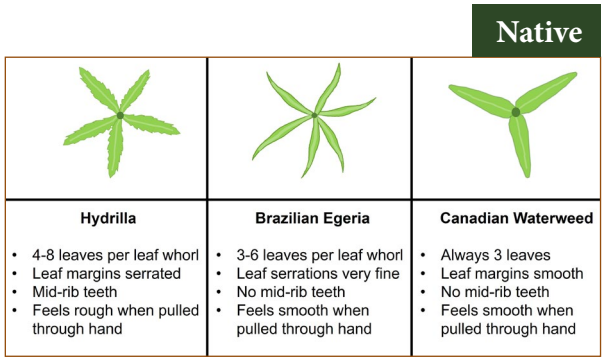
Option 2: Chelated copper (0.8-pound formulation). Apply at a rate of 1.5 gallons per acre-foot. Dilute in 9 parts water and apply as a submersed injection. Do not use copper in catfish or koi ponds when alkalinity is less than 50 ppm.

Option 3: Diquat (3.73-pound formulation). Dilute 0.5 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 4: Endothall (4.23-pound formulation). Dilute 3.2 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 5: Fluridone (4.0-pound formulation). Dilute 5.1 ounces per acre-foot of water in at least 9 parts water and apply as a submersed injection; reapply at the same rate 30 days after initial treatment. Do not use fluridone in ponds with high flow rates.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.



***Elodea*:** Also known as Canadian waterweed, *Elodea* is a native species that looks very similar to invasive *Egeria* and *Hydrilla*. It can be differentiated by its leaves, which are in whorls of three and soft and smooth to the touch.

Option 1: Stock 5 to 15 grass carp per acre depending on severity. Stock 8- to 10-inch fish in ponds that have largemouth bass. Too many grass carp can impact other fish, and they can live up to 20 years. If herbicides are used, stock three to five triploid grass carp per acre after treatment to prevent reinfestation.

Option 2: Diquat (3.73-pound formulation). Dilute 0.5 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 3: Endothall (4.23-pound formulation). Dilute 1.9 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 4: Flumioxazin (4.0-pound formulation). Dilute 1.5 pints per acre-foot of water in 9 parts water and apply as a submersed injection. Use a buffering agent when mixing with water exceeding a pH of 7.0.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Pondweeds: A varied group of rooted plants with leaves that are either totally submerged or float on the water surface. Pondweeds always have alternate leaves. Flowers and fruits are usually green to brown, small, and close together in oblong or ball-like spikes.

Option 1: Triploid grass carp. Stock 5 to 10 grass carp per acre to reduce moderate pondweed infestations; stock 15 or more per acre for severe infestations. Note that abundant grass carp can impact other fish, and they can survive 20 years. Stock 8- to 10-inch triploid grass carp in ponds that have established largemouth bass populations.

Option 2: Endothall (4.23-pound formulation). Dilute 1.92 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 3: Fluridone (4.0-pound formulation). Dilute 0.85 ounces per acre-foot of water in at least 9 parts water and apply as a submersed injection; reapply at the same rate 30 days after initial treatment. Do not use fluridone in ponds with high flow rates.

Option 4: Penoxsulam (2.0-pound formulation). Dilute 3.5 ounces per acre-foot of water in 9 parts water and apply as a submersed injection.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Fanwort: Leaves usually opposite although occasionally whorled, creating a finely dissected fan shape. May have floating leaves.

Option 1: Endothall (4.23-pound formulation). Dilute 3.2 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 2: Flumioxazin (4.0-pound formulation). Dilute 2.1 pints per acre-foot of water in 9 parts water and apply as a submersed injection. Use a buffering agent when mixing with water exceeding a pH of 7.0.

Option 3: Triclopyr (3.0-pound formulation). Dilute 2.3 gallons per acre-foot in 9 parts water and apply as a submersed injection.

Option 4: Stock 5 to 15 grass carp per acre depending on severity. Stock 8- to 10-inch fish in ponds that have largemouth bass. Too many grass carp can impact other fish, and they can live up to 20 years. If herbicides are used, stock three to five triploid grass carp per acre after treatment to prevent reinfestation.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Bladderwort: Characterized by many small carnivorous bladders. Has no roots, but anchors to the bottom. Has alternate, finely dissected leaves. Flowers extend above the water surface on tall stalks and are usually purple or yellow but can be white or blue.

Option 1: Diquat (3.73-pound formulation). Dilute 0.5 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

Option 2: Fluridone (4.0-pound formulation). Dilute 3.8 ounces per acre-foot of water in at least 9 parts water and apply as a submersed injection; reapply at the same rate 30 days after initial treatment. Do not use fluridone in ponds with high flow rates.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. For diquat, treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Slender spikerush: Can grow as a rigid shoreline emergent or as a submersed plant. Slender spikerush has very fine, long, bright green filaments that occasionally branch. This species looks like green hair and is sometimes referred to as hair grass.

Option 1: Diquat (3.73-pound formulation). Apply 0.5 gallons per acre-foot of water as a submersed injection (application using a wand or hose). Dilute with 9 parts water.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Option 2: Triploid grass carp. Stock 5 to 10 grass carp per acre to reduce moderate pondweed infestations; stock 15 or more per acre for severe infestations. Note that abundant grass carp can impact other fish, and they can survive 20 years. Stock 8- to 10-inch triploid grass carp in ponds that have established largemouth bass populations.

Floating Plants

Duckweed: Duckweeds are free-floating green plants that form blankets on the surface of sheltered water. Duckweeds are light green with roots hanging below fronds. Duckweeds can be a serious pest in Mississippi.

Option 1: Diquat (3.73-pound formulation). For each gallon of water, mix 1.28 ounces diquat and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Flumioxazin (4-pound formulation). For each gallon of water, mix 0.1 ounce flumioxazin and 1.3 ounces non-ionic surfactant. Use a buffering agent when mixing with water with pH greater than 7.0. Spray to wet all plants.

Option 3: Fluridone (4.0-pound formulation). Dilute 2.5 ounces per acre-foot of water in at least 9 parts water and apply as a submersed injection; reapply at the same rate 30 days after initial treatment. Do not use fluridone in ponds with high flow rates.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. For foliar treatments, treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Watermeal: Tiny, rootless plant that gets its name from the fact that it looks and feels like green corn meal. Watermeal is a free-floating plant that can form blankets on the surface of sheltered water, is difficult to control, and is a serious pest where it occurs.

Option 1: Flumioxazin (4.0-pound formulation). For each gallon of water, mix 0.2 ounces flumioxazin and 1.3 ounces non-ionic surfactant. Use a buffering agent when mixing with water with pH greater than 7.0. Spray to wet all plants.

Option 2: Diquat (3.73-pound formulation). For each gallon of water, mix 1.28 ounces diquat and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Multiple herbicide applications may be necessary to eradicate all plants. Treat when water temperature is at least 60°F and plants are actively growing.

Water hyacinth: Non-native species that usually floats freely in large masses but may be rooted in the soil in shallow water or wet areas. The leaves are leathery and deep green, with inflated and spongy stems for floatation. The flowers are a showy spike of up to 20 light purple, blue, and yellow flowers.

Option 1: 2,4-D (3.8-pound formulation). For each gallon of water, mix 0.75 ounces 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Triclopyr (3.0-pound formulation). For each gallon of water, mix 0.5 ounces triclopyr and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 3: Imazamox (1.0-pound formulation). For each gallon of water, mix 0.5 ounces imazamox and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 4: Glyphosate (5.4-pound formulation). For each gallon of water, mix 1.0 ounce glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. For severe infestations, treat one-third of the pond at a time, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Salvinia: Aquatic fern that floats on the surface of the water. Leaves are in whorls of three, with two opposite leaves with distinct midribs, and a third submersed leaf that resembles roots. This particularly nasty plant can form mats several feet thick.

Option 1: Flumioxazin (4.0-pound formulation). For each gallon of water, mix 0.05 ounces flumioxazin and 1.3 ounces non-ionic surfactant. Use a buffering agent when mixing with water with pH greater than 7.0. Spray to wet all plants.

Option 2: Glyphosate (5.4-pound formulation). For each gallon of water, mix 1.0 ounce glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all exposed plants. Do not exceed annual herbicide rate limits as stated on the product label.

NOTE: Multiple herbicide applications may be necessary to eradicate all plants. In cold temperatures (less than 50°F), apply flumioxazin. In warm temperatures, use glyphosate or a glyphosate-plus-flumioxazin tank mix.

Water lettuce: Non-native plant that forms large, floating colonies and can cover a small water body in a very short time. The leaves are arranged in rosettes and are pale green to medium green or grayish with deep grooves radiating outward. Leaves up to 6 inches.

Option 1: Flumioxazin (4-pound formulation). For each gallon of water, mix 0.1 ounce flumioxazin and 1.3 ounces non-ionic surfactant. Use a buffering agent when mixing with water with pH greater than 7.0. Spray to wet all plants.

Option 2: Diquat (3.73-pound formulation). For each gallon of water, mix 1.28 ounces diquat and 1.3 ounces non-ionic surfactant water. Spray to wet all plants.

NOTE: For severe infestations, treat one-third of the pond at a time, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Mosquito fern: Small, floating plants with clusters of tiny, fern-like leaves; leaves usually one-half to 1 inch across; gray to green when young and rusty red when older. Roots dangle beneath each leaf. Often found with duckweed.

Option 1: Flumioxazin (4.0-pound formulation). For each gallon of water, mix 0.1 ounce flumioxazin and 1.3 ounces non-ionic surfactant. Use a buffering agent when mixing with water with pH greater than 7.0. Spray to wet all plants.

Option 2: Diquat (3.73-pound formulation). For each gallon of water, mix 1.28 ounces diquat and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Multiple herbicide applications may be necessary to eradicate all plants.

Emergent Plants

American lotus: American lotus is a native plant that has characteristic large, round leaves that may be floating or emergent. Large, showy flowers are yellow, and unique seed pods are characteristic of this plant.

Option 1: 2,4-D (3.8-pound formulation). For each gallon of water, mix 5.1 ounces of 2,4-D and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 2: Diquat (3.73-pound formulation). Dilute 0.25 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 3: Triclopyr (3.0-pound formulation). For each gallon of water, mix 5.1 ounces of triclopyr and 1.3 ounces of surfactant. Spray to wet all exposed plants. Do not exceed annual herbicide rate limits as stated on the product label.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Water lily: The water lilies have round, generally floating leaves with a deep notch. Flowers usually float on the water surface and are white or yellow.

Option 1: 2,4-D (3.8-pound formulation). Apply 1.75 gallons per acre-foot of water as a submersed injection. Dilute with 9 parts water.

Option 2: Endothall (4.23-pound formulation). Apply 1.3 gallons per acre-foot of water as a submersed injection. Dilute with 9 parts water.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Water shield: This small, floating-leaf plant has dark green kidney bean-shaped leaves that are red on the underside. The stems and leaf undersides are usually coated in a thick, protective slime.

Option 1: Flumioxazin (4.0-pound formulation). Dilute 1.1 pints per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose). Use a buffering agent when mixing with water with pH greater than 7.0.

Option 2: 2,4-D (3.8-pound formulation). For each gallon of water, mix 1.28 ounces 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Water primrose: Primrose has several growth forms, including a vegetative "creeping" form and a more erect flowering form. Leaves are alternating, often on reddish stems, and the flowers are yellow.

Option 1: Glyphosate (5.4-pound formulation). To each gallon of water, add 0.75 ounces glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Flumioxazin (4.0-pound formulation). To each gallon of water, add 0.05 ounces flumioxazin and 1.3 ounces non-ionic surfactant. Spray to wet all plants. Use a buffering agent when mixing with water with a pH greater than 7.0.

Option 3: 2,4-D (3.8-pound formulation). To each gallon of water, add 1.0 ounce 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 4: Triclopyr (3.0-pound formulation). To each gallon of water, add 1.25 ounces triclopyr and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants. Following treatment, stock three to five triploid grass carp per acre to prevent reinfestation.

Alligator weed: Non-native plant found free-floating, loosely attached, or rooted; can even grow on dry land. The leaves are opposite and lance-shaped and have a distinct midrib. Flowers are white and round and resemble clover blooms. Stems are usually hollow.

Option 1: Glyphosate (5.4-pound formulation). For each gallon of water, mix 3.8 ounces of glyphosate and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 2: Imazamox (1.0-pound formulation). For each gallon of water, mix 1.2 ounces of imazamox and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 3: Imazapyr (2.0-pound formulation). For each gallon of water, mix 0.6 ounces of imazapyr and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 4: Triclopyr (3.0-pound formulation). For each gallon of water, mix 5.1 ounces of triclopyr and 1.3 ounces of surfactant. Spray to wet all exposed plants. Do not exceed annual herbicide rate limits as stated on the product label.

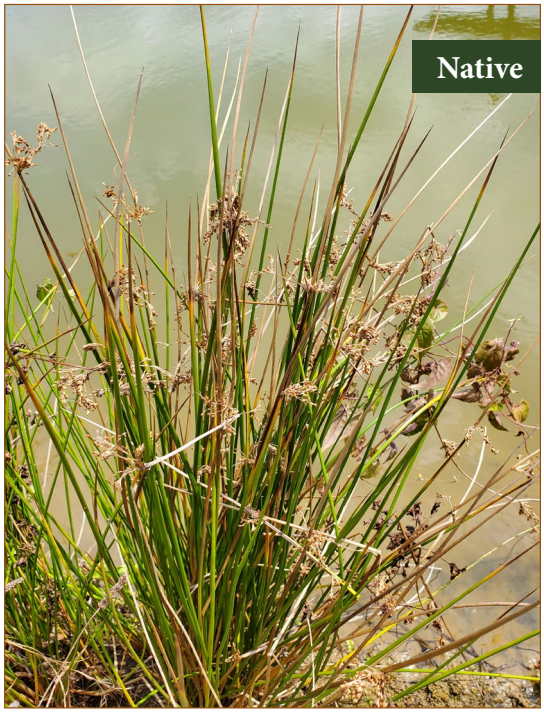
NOTE: Mixing imazapyr or imazamox with either triclopyr or glyphosate may provide better control. Use the full recommended rate of each herbicide. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. One or more repeat whole-pond applications may be necessary to eliminate remaining plants. Following treatment, stock three to five triploid grass carp per acre to prevent infestation by other species. Stock 8- to 10-inch triploid grass carp in ponds that have established largemouth bass populations to avoid predation by bass.

Spatterdock: This rooted plant has spade-shaped leaves with a deep notch at the base, and small, round, yellow flowers. The leaves float on the water's surface but are frequently emergent.

Option 1: Flumioxazin (4.0-pound formulation). Dilute 1.1 pints per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose). Use a buffering agent when mixing with water with pH greater than 7.0.

Option 2: 2,4-D (3.8-pound formulation). Dilute 1.4 gallons per acre-foot of water in 9 parts water and apply as a submersed injection.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.



Juncus: Flowering plants that grow along pond margins characterized by round, hollow, and pointed stems growing in dense clumps. The flower appears to be on the side of the stem.

Option 1: 2,4-D (3.8-pound formulation). To each gallon of water, add 0.6 ounces 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. Multiple applications may be necessary.

Phragmites: This large reed has both native and invasive species. Can reach heights of 15 feet in extremely dense stands. Leaves are sharp and pose a late-summer fire risk.

Option 1: Imazapyr (2.0-pound formulation). For each gallon of water, mix 0.9 ounces of imazapyr and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 2: Imazamox (1.0-pound formulation). For each gallon of water, mix 2.5 ounces of imazamox and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 3: Glyphosate (5.4-pound formulation). To each gallon of water, add 6.0 ounces glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. Multiple applications will be necessary.

Torpedograss: Torpedograss is a growing problem in Mississippi. This non-native plant has alternate leaf blades that are flat to folded and stiff; leaves grow at a 45-degree angle from the stem. May grow in water or on dry land, with tremendous root systems that are difficult to kill.

Option 1: Glyphosate (5.4-pound formulation). To each gallon of water, add 1.0 ounce glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Imazapyr (2.0-pound formulation). For each gallon of water, mix 2.0 ounces of imazapyr and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 3: Flumioxazin (4.0-pound formulation). Flumioxazin (2.2 pints per acre-foot of water) should be applied as a submersed injection (injection using wand or hose). Use a buffering agent when mixing with water with pH greater than 7.0. Dilute with 9 parts water.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Repeat applications will be necessary. Glyphosate and imazapyr can be tank mixed. Alternating between foliar (glyphosate and/or imazapyr) and submersed (flumioxazin) herbicide treatments may enhance torpedograss control. Wait at least 8 weeks between each treatment.

Water-willow: Willows are small shrubs or trees with simple, alternate leaves. The flowers appear in the early spring before leaf-out. Dense growth around pond edges or on pond levees can be a serious problem.

Option 1: 2,4-D (3.8-pound formulation). To each gallon of water, add 1.0 ounce 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. One or more repeat whole-pond applications may be necessary to eliminate remaining plants.

Smartweed: Smartweed has a distinctly jointed stem, with enlarged joints. Leaves are alternate and lance shaped. Flowers are typically white, pink, or pale green. Common in any damp or wet area.

Option 1: Glyphosate (5.4-pound formulation). To each gallon of water, add 0.5 ounces glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Imazamox (1.0-pound formulation). For each gallon of water, mix 1.0 ounce of imazamox and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 3: Imazapyr (2.0-pound formulation). For each gallon of water, mix 0.25 ounces of imazapyr and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 4: 2,4-D (3.8-pound formulation). To each gallon of water, add 1.0 ounce 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

Cattail: This common plant has flat leaves that may be 4 feet or more long, and its characteristic long, brown flower spike resembles a cigar.

Option 1: Glyphosate (5.4-pound formulation). To each gallon of water, add 5.0 ounces glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Imazamox (1.0-pound formulation). For each gallon of water, mix 1.5 ounces of imazamox and 1.3 ounces of surfactant. Spray to wet all exposed plants.

Option 3: Imazapyr (2.0-pound formulation). For each gallon of water, mix 2.6 ounces of imazapyr and 1.3 ounces of surfactant. Spray to wet all exposed plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies with significant coverage of plants, with 2 weeks between applications. Multiple applications will likely be necessary to achieve full control.

Rushes: A common pond edge plant, rushes are extremely variable in appearance but generally have round stems and leaves. The leaves are not obvious, often forming a sheath around the stem.

Option 1: Glyphosate (5.4-pound formulation). To each gallon of water, add 5.1 ounces glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies with significant coverage of plants, with 2 weeks between applications. Multiple applications will likely be necessary to achieve full control.

***Hydrolea*:** Also known as waterpod or waterleaf, hydrolea has characteristic long thorns above the leaf base and a small blue flower. This plant can prevent bank access in shallow areas.

Option 1: Glyphosate (5.4-pound formulation). To each gallon of water, add 1.0 ounce glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. One or more repeat whole-pond applications may be necessary to eliminate remaining plants.

Water pennywort: Pennywort may have a few floating leaves or may form large mats that stand a foot or more off the water's surface. Leaves are dark green and rounded with indentations, and veins radiate from the center.

Option 1: 2,4-D (3.8-pound formulation). To each gallon of water, add 1.25 ounces 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 2: Glyphosate (5.4-pound formulation). To each gallon of water, add 0.5 ounces glyphosate and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

NOTE: Treat when water temperature is at least 60°F and plants are actively growing. One or more repeat whole-pond applications may be necessary to eliminate remaining plants.

Parrot's-feather: Parrot's-feather is a non-native plant that has whorled, pale-green leaves finely divided into many threadlike leaflets. The stem is stout and sparingly branched. Although most of the plant is underwater, branch tips usually extend a few inches above the water.

Option 1: Diquat (3.73-pound formulation). Dilute 0.25 gallons per acre-foot of water in 9 parts water and apply as a submersed injection (application using a wand or hose).

Option 2: 2,4-D (3.8-pound formulation). To each gallon of water, add 0.6 ounces 2,4-D and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 3: Triclopyr (3.0-pound formulation). To each gallon of water, add 2.5 ounces triclopyr and 1.3 ounces non-ionic surfactant. Spray to wet all plants.

Option 4: Imazapyr (2.0-pound formulation). For each gallon of water, mix 0.25 ounces of imazapyr and 1.3 ounces of surfactant. Spray to wet all exposed plants.

NOTE: Acre-foot = average depth of pond multiplied by pond acreage. Treat when water temperature is at least 60°F and plants are actively growing. Treat one-third of the pond at a time for larger water bodies, with 2 weeks between applications. A repeat whole-pond application may be necessary to eliminate remaining plants.

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