MP360

Farm Pond Management for Recreational Fishing

Cooperative Extension Program, University of Arkansas at Pine Bluff, U.S. Department of Agriculture, and County Governments in cooperation with the Arkansas Game and Fish Commission

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Introduction

Recreational fishing in Arkansas is a favorite pastime for both residents and visitors. Arkansas has more than 600,000 acres of lakes and 9,700 miles of rivers and streams that are the pride of Arkansas' excellent angling reputation. Additionally, there are about 128,000 small water bodies in the state of Arkansas that comprise slightly more than 156,000 acres. These farm ponds are often stocked for a specific type of fishery, with largemouth bass, bluegill and catfish being the most commonly-stocked species. With proper management, farm ponds can provide excellent fishing and trophy-size fish.

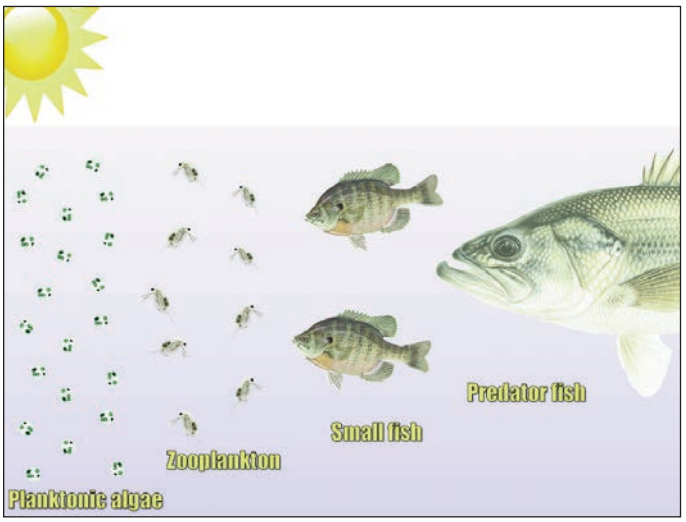
The purpose of this publication is to provide farm pond owners with information on stocking and maintaining ponds used primarily for fishing. Farm ponds are complex ecosystems, and the information provided here is only a guide. Also, this information is specific to Arkansas ponds. These recommendations may not be suitable for ponds in other parts of the country due to differences in soil composition, seasonal temperatures and other environmental factors. University of Arkansas Cooperative Extension Service county agents can provide localized guidance and recommendations (Appendix B-3).

The Pond Ecosystem

Farm ponds are complex and dynamic systems. However, these systems are not that different from traditional animal agriculture. Sunlight shines on a pasture, grass grows and produces oxygen, and cattle eat the grass. In ponds, microscopic plants called planktonic algae grow and produce oxygen. Planktonic algae are then eaten by microscopic animals called zooplankton. Zooplankton are then eaten by small insects and fish. Those small insects and fish are then eaten by larger fish.

The farmer manages soil chemistry and fertilizes to increase the growth of pasture grasses so more cattle can be grown. In ponds, managing water chemistry and fertilization can boost planktonic algae growth, and ultimately fish growth. Farmers can grow cattle faster by providing commercial cattle feed. Fish production can be enhanced by providing fish feed. The main differences between raising cattle and raising fish are water and that pond owners are usually trying to grow predators. Growing a predator, such as the largemouth bass, adds one more link to the food chain. This additional link increases the complexity of management, but the whole food chain is still based on sunlight and nutrient availability.

It is also important to ensure that the sunlight and nutrients are not being wasted on nuisance aquatic plants. A pasture overrun with weeds is no good for cattle, no matter how much sunlight or nutrients are available. A pond overrun with aquatic plants usually does not grow fish well and can be costly to fix. Ponds that have excellent fishing are those that are well managed.



Pond Design and Construction

Ponds are built for a variety of reasons, including watering livestock, fishing, recreation, irrigation, wildlife or to enhance the beauty of a homestead. Before building a pond, it is important to decide which uses are most important. The design can then be tailored towards the primary use of the pond. Some alternatives are mutually exclusive. For example, commercial fish farming requires ponds with regular shapes and smooth bottoms to facilitate harvest. In contrast, ponds built for wildlife often have standing timber, islands and shallow areas to promote the growth of aquatic plants.

Expert advice on pond site selection, design and construction is essential. Well-built ponds provide many benefits to landowners, while poorly built ponds provide chronic problems. Fixing problem ponds is often expensive, and it may even be cheaper to build a new pond than to repair a poorly built one. The pond must be located on suitable soil and properly constructed to hold water. There must also be enough runoff to fill the pond without overflowing it. Once a pond is built, proper maintenance extends its useful life and beauty. In addition, most farm ponds are filled by runoff from land uphill from the pond, called a watershed. Protecting the watershed from erosion and sources of pollution ensures a quality supply of water to the pond.

Decide on the purpose of the pond before building it.

Planning

It is important to take the time to properly plan. The first step is to make sure that the land has a suitable pond site. The lay of the land and soil texture will often limit potential pond locations. Creating the largest pond possible with the least amount of dirt work requires expert assistance. The United States Department of Agriculture, Natural Resources Conservation Service, or NRCS, provides assistance with pond site selection and design under its Small Watershed program. Priorities for the NRCS are ponds for livestock watering systems and ponds which have a dual purpose of grade stabilization and erosion control. To locate the nearest office, contact the state NRCS office in Little Rock at (501) 301-3100. A list of USDA Service Centers in Arkansas can also be found online (Appendix B-4).

Dams 25 feet tall, or taller, and dams impounding more than 50 acre-feet of water require construction and operation permits from the Arkansas Natural Resources Commission.

The NRCS Agriculture Handbook 590, *Ponds – Planning, Design, Construction,* provides a detailed guide to building ponds (Appendix B-4). The USDA Consolidated Farm Service may provide partial funding for pond construction that meets local priority conservation criteria.

Ponds should be built with a drain and overflow pipe.

The Arkansas Natural Resources Commission (ANRC) regulates dams in Arkansas. The regulations state that all private dams with a height of 25 feet or more and dams containing 50 acre-feet or more of storage at normal pool must have a valid construction and operation permit from the ANRC. If smaller dams pose a threat to life or property, they may also be regulated by the state based on petition by downstream landowners and results of public hearings. Ponds should be located so dam failure would not cause destructive flooding. It is also essential to make sure that the proposed pond will not inundate public land, such as highway right-of-ways, utility lines or the property of adjacent landowners. Farmers and landowners participating in USDA programs should contact the NRCS before building a pond to make sure that the land that will be converted into a pond is not considered a wetland or to arrange for mitigation (Appendix B-4).

Site Selection and Pond Design

There are three basic types of ponds – watershed, levee and dug-out. Ponds with one to three dams in gently-sloping locations filled by rainwater runoff are watershed ponds. Levee ponds are constructed on flat sites by cutting earth from the pond basin and using the soil to build up four surrounding levees. Levee ponds require groundwater supplied by a well, or pumped-in surface water. Well water is recommended because surface water is a source of unwanted fish species and associated parasites. If surface water must be used, expect to have unwanted fish show up in the pond eventually. Filtering the water through a fine mesh screen could help alleviate the problem, but it is difficult to keep such screens clean and intact. Dug-out ponds are basically holes in the ground, such as borrow pits where dirt has been removed for road construction. Dug-out ponds typically fill from groundwater and cannot be drained.

Locations on steep slopes, over 5 percent grade, are generally undesirable; such sites require a tall dam for a small pond. Gently rolling land creates favorable sites for watershed ponds. For ponds to hold water, sites should have soil containing at least 20 percent clay. The best soils have a good mix of coarse and fine particles including clay, silt, sand and gravel. In areas where the ground is underlain by limestone, such as in parts of northwest Arkansas, bedrock fractures and even sinkholes can result in pond failure.

Matching the anticipated pond volume to the area and characteristics of the watershed is critical. Watersheds that are too large result in excessive water flow through the pond; fish can be flushed downstream along with fertile water and the dam can be damaged by high water. Watersheds that are too small cannot

keep the pond full. Depending on the watershed vegetation and soils, somewhere between 5 to 30 acres of watershed are required for each acre of pond area. For example, more water runs off pastureland than wooded land. Therefore, fewer acres are needed to keep a pond full if it is surrounded by pastureland. Avoid sites where the runoff water is muddy or contaminated. If the watershed is too big for the proposed pond, a diversion ditch can be installed to channel a portion of the runoff around the pond.

Two important design features of a dam are the width of the top and the slope of the sides. If the dam will be used as a road, the top should be at least 16 feet wide. The side slopes of the dam will depend upon soil type. In general, the pond-side slope should be 3:1, or 3 feet horizontal to each 1 foot vertical. The outside slope should be a minimum of 2:1. And, for silty clay and clayey silt soils, a 3:1 slope is recommended. In general, build the widest dam with the gentlest slopes that the budget will allow, as this will prolong the life of the dam.

There is no advantage to water deeper than 12 to 14 feet in Arkansas fishing ponds.

Ponds should be built with a drain and an overflow pipe. Many older ponds were constructed without drains, making it difficult for pond owners to make repairs or to renovate fish populations. A drainpipe also allows ponds to be easily drawn down in late summer or early fall to help manage fish populations. Ponds should have an overflow pipe to discharge excess water from normal rainfall events. The pipe may be part of the drain structure, such as a trickle tube, or separate. The NRCS provides assistance in selecting appropriate pipe diameters for ponds and advice on methods to properly install the pipes (Appendix B-4).

An auxiliary, or emergency, spillway is a critical component of a well-designed watershed pond. These spillways are designed to divert water around the main dam, over grass-covered soil, to prevent dam failure during heavy rains. The wide, flat auxiliary spillway crests below the main dam and allows flood water to exit the pond in a broad shallow sheet. An overflow pipe must be sized correctly to keep the auxiliary spillway dry most of the time. If the spillway stays wet, grass usually dies off, leading to unstable soil and increased erosion. The NRCS can provide recommendations for appropriate spillway dimensions based on the pond and watershed characteristics (Appendix B-4).

There is no advantage to water deeper than 12 to 14 feet in ponds meant for recreational fishing in Arkansas. Deeper ponds are not more productive and tend to have more oxygen problems that can lead to fish kills. Excessive shallow areas, less than 3 feet deep, should also be avoided unless aquatic vegetation is desired. Constructing pond banks that quickly drop to at least 3 feet deep will help prevent nuisance aquatic plant growth. A 3:1 slope, 1 foot deep for every 3 feet away from shore, is a good angle for both aquatic plant prevention and shoreline stability.

Construction

Proper pond construction is essential to prevent leaks and to extend the pond's lifespan. Several key elements help the pond hold water. The core trench within the dam should extend down into clayey soil. This prevents water from seeping under the dam. During dam construction, each 6- to 8-inch layer of dirt, or lift, must be thoroughly compacted with appropriate equipment. Bulldozers, for example, are not the best for compaction because they are designed to spread their weight over large, wide tracks. A sheepsfoot roller is a better choice because it is designed to apply its weight over a much smaller area, increasing compaction. Soil moisture is an important factor in compaction. Properly moistened soil can be compressed into a firm ball that holds together by hand.

Ponds for Watering Livestock

If a pond is to be used for watering livestock, refer to University of Arkansas Cooperative Extension Service publications FSA3021, *Water for Beef Cattle*, and FSA3128, *Watering Systems for Cattle Ponds,* for more information (Appendix B-9). It is best to prevent livestock from entering the water, especially in small ponds, if fishing is important to the owner. Livestock can damage the shoreline, create muddy water and greatly reduce water quality for both the fish and the livestock.

Dam Maintenance

Healthy grass cover on earthen pond dams and auxiliary spillways is critical for soil stability. However, do not let trees grow on pond dams or levees. The large roots can open channels for water to flow through the dam, especially if the tree dies or gets blown over during a storm. If the dam already has trees greater than six inches in diameter growing on it, it is probably best to leave them alone.

Spillway Barriers

Fish can escape ponds during floods by passing over the auxiliary spillway; grass carp are notorious for this. Fencing the spillway is not recommended because the wire mesh easily clogs with leaves and

debris. Badly clogged spillways can cause the pond water level to rise and overflow the main dam, which can cause dam failure. Parallel-bar spillway barriers are less prone to clogging. However, even these spillway barriers need regular inspection and cleaning to prevent major clogging.

Rehabilitating Old Ponds

Over time, pond shorelines erode and pond bottoms fill with silt. Shallow water and excessive nutrients often lead to dense-rooted aquatic vegetation. For some of these old worn-out ponds, the best solution is to rework them to restore proper shoreline slope and pond depth. Avoid the temptation to deepen the pond beyond its original depth unless the pond was originally too shallow. Water deeper than 12 to 14 feet is not advantageous for fish production, and deepening the pond beyond its original depth could compromise the layer of soil that was sealing the pond bottom from leaks. If this happens, it could take quite some time for the pond to reseal, or it may continue leaking indefinitely.

Do not allow more than 25 percent of the pond to contain standing timber and never allow live trees on or near the dam.

Fish Attractors

A fish attractor is anything in or near the water that provides valuable fish habitat. Examples include brush piles, stumps, logs, stake beds, gravel beds, rocks and vegetation. Adding fish attractors to ponds that lack any of these features can usually improve fish production and fishing quality.

Brush Shelters and Trees

Brush shelters are an easy and inexpensive way to enhance fish habitat. Almost any type of wood can be used. The best brush shelters feature combinations of large limbs with large gaps between branches and smaller limbs with small gaps between branches. The larger, open limbs provide space for large fish to hold while the smaller, dense limbs provide shelter for small and recently hatched fish.

The best time to build brush shelters is during pond construction. Arrange brush shelters in T, X or C configurations to help concentrate fish. The top of the X and T, and the left side of the C, should be parallel to the shore. The opposite end of the piles should extend into deeper water. These structures can be anchored in place by pushing dirt over the bases or by fastening cinder blocks or concrete to the limbs with cables. Three to five trees or large limbs at each site is usually enough. However, in ponds over an acre, larger brush shelters, 10 feet by 15 feet or more, can produce better results. A good rule of thumb is to only place one brush shelter in ponds less than 1 acre. In larger ponds, up to two brush shelters per acre is acceptable.

Standing trees can also be left in the pond bottom following construction to provide habitat. However, do not allow more than 25 percent of the pond to contain standing timber, and never allow live trees on or near the dam. Another method in which trees can be used as fish attractors is hinge-cutting. This involves cutting trees along the shorelines so that they fall into the water but do not completely detach from their base. This keeps the trunk in place and provides good shoreline habitat. Although adding cover can be beneficial, adding too much cover can be detrimental. Woody cover breaks down over time. This process consumes oxygen. A pond overloaded with decomposing woody cover could potentially have fish kills because of oxygen depletion. Additionally, it is more difficult to locate fish if there is an overabundance of cover relative to the number of fish in the pond. The fewer pieces of cover available, the more likely each piece of cover will attract fish to it, which can lead to more efficient fishing.

Gravel Spawning Beds

Many pond fish species, such as largemouth bass and bluegill, require firm pond bottom substrates, such as sand and gravel, to build their nests on and spawn. Without adequate spawning habitat, reproduction in ponds can be limited or fail completely. These spawning areas also act as fish attractors and can be highly effective places to fish during the spring. Ponds lacking quality spawning areas can benefit from the installation of gravel spawning beds. To construct a gravel spawning bed, first select an area of the pond that will end up being two to five feet deep when the pond is full, preferably in an area that is convenient for fishing. Avoid sites that have high silt erosion. Once the site is chosen, construct a frame using 2 × 6-inch boards anchored to the pond bottom.

Finished size of the frame simply depends on how much money one wishes to spend. Once the frame is complete, cover the pond bottom within the frame with material, such as Visqueen®, that will prevent vegetation growth. Once the vegetation barrier is in place, fill the frame with ½-inch diameter washed pea gravel, until the gravel bed is 4 to 6 inches deep. Installation is far easier when the pond is empty or drained. However, it is possible to construct gravel beds in a full pond by spraying or dumping the washed pea gravel into a selected location.

Catfish Attractors

Catfish prefer to spawn within holes and cavities. This kind of habitat is usually absent from most farm ponds, making it difficult for catfish to reproduce enough to maintain their populations. Structures made of old tires, plastic drums and large PVC pipe placed along the edges of the pond can provide acceptable

catfish spawning habitat. Larger structures can be built using two 50-gallon plastic drums, sign posts, wooden pallets and cinder blocks. First, cut the plastic drums in half from top to bottom. Next, place the barrels together in an area that will become 2 to 5 feet deep when the pond fills. Anchor the barrels by driving galvanized sign posts into the pond bottom and attach them to the barrels using lag bolts. Next, drive a longer sign post into the middle of the cluster of barrels and thread wooden pallets onto the sign post so that they lie on top of the barrels. Next, place cinder blocks on top of the pallets to keep them from floating. The resulting structure will provide quality catfish spawning habitat while also attracting other fish species.

Other Fish Attractors

Simple and effective fish attractors can be made using switch cane and concrete. Line the inside of a 5-gallon bucket with a 30-gallon trash bag. Then, fill the bucket with concrete and quickly place eight to 15 pieces of switch cane into the concrete. Cut the cane to lengths that will prevent them from breaking the water surface where they will be placed. Allow the concrete to harden overnight before removing the bucket and trash bag. Finally, sink the structure near a creek channel edge, point, or along other depth changes within the pond for maximum effectiveness.

Almost any item or structure can act as a fish attractor and there are many more options than what is described here. Avoid adding items that could pollute the pond, such as old appliances and equipment, limit the input of organic material, and do not place fish attractors where they might be hazardous to swimmers or boaters.

Pond Environment Management

This section covers strategies to enhance fish production and survival by manipulating the pond environment. Most ponds in Arkansas can naturally provide enjoyable fishing through appropriate stocking and management. However, many pond fisheries could benefit from liming, fertilizing, feeding, aerating and managing nutrient input. Owners must decide if the additional fish production is worth the added risk and costs of enhancement programs.

Liming

Liming is recommended if the total alkalinity of pond water is below 20 mg/L, and if the pond owner considers fish production important. If fish production is not important, liming is usually an unnecessary expense. Total alkalinity is the concentration of acid-neutralizing bases, primarily carbonates and bicarbonates, in water. In ponds with low alkalinity, daily fluctuation in pH can be extreme and stressful to fish. Fish in these low alkalinity ponds usually do not grow well and are prone to health issues. Some parts of northern Arkansas contain ponds with high alkalinity due to limestone-based soils. Many ponds in southern Arkansas have low alkalinity. As a rule of thumb, if pastures or fields near the pond require regular liming to be productive, the pond would probably benefit from lime as well. Alkalinity is easily measured

Applying agricultural limestone to ponds with alkalinity below 20 mg/L can boost pond productivity.

with inexpensive test kits or water samples can be sent to University of Arkansas Cooperative Extension Service county offices for analysis (Appendix B-3).

Testing water can only indicate if a pond could benefit from liming. Soil tests are required to determine exactly how much lime is needed. It is much easier to sample soil and apply lime before the pond fills with water. Collect about 10 soil samples per acre in an "S" pattern across the pond basin and combine them. The mud then needs to be dried, crushed, poured into a soil sample box and delivered to the local University of Arkansas Cooperative Extension Service county office for evaluation (Appendix B-3). If the pond is already filled with water, a tin can strapped to a pole can be used to collect the mud samples.

Ponds that need lime usually need at least 2,000 pounds per acre. These ponds need to be re-limed about every 4 years, or more often if high volumes of water regularly flow through the pond. Only agricultural lime should be used in ponds already containing fish. Finely ground agricultural limestone is best, as it reacts quickly. Pelletized lime is easier to apply, but reports indicate that the binder used in making the pellets can turn pond water brown. Hydrated lime should not be used in ponds that contain fish. It changes water pH too quickly and can kill fish. However, hydrated lime can be used when a pond is being built or renovated, well before fish are stocked.

Liming is most effective when the lime is spread evenly across the entire pond. Boats can be used to distribute lime across water-filled ponds either by spreading bagged lime from a jon boat motoring around the pond or by spraying lime from a flat platform atop a pontoon boat with a high-pressure hose. If boats are not an option, a spreader truck can be backed up to the pond edge in several locations to cover as much of the pond as possible.

The best time to lime is in the late fall or winter. This gives time for the lime to react with the bottom mud to counteract soil acidity before the next growing season. Do not apply lime and fertilizer at the same time. Calcium in the lime binds to phosphorus, usually the most important nutrient for aquatic plant growth, in the fertilizer and renders it unavailable. Basically, if applied together, the lime inactivates the most important nutrient in the fertilizer, which defeats the whole purpose of fertilizing.

If the pond has low alkalinity and liming is not an option, raising catfish or hybrid bluegill with fish feed is a good strategy to increase fish production. Fish feed replaces the tiny natural foods that low-productivity ponds lack. However, the fish health risks associated with low alkalinity water will still remain.

Fertilizing a pond infested with aquatic plants is like throwing gasoline on a fire. Don't do it!

Fertilization

Microscopic plants, also known as phytoplankton or planktonic algae, are the base of most pond food chains. These plants give the water a green or brownish green color and are often referred to as blooms. Fertilization stimulates increased growth of planktonic algae and, eventually, increased growth and numbers of fish because more food is available. Fertilized ponds tend to turn a more intense green from higher densities of planktonic algae. Fish feed indirectly enhances planktonic algae growth through fish wastes and uneaten feed. If the bloom is too light, sunlight can reach the pond bottom and rooted aquatic plants can take over. If the bloom is too dense, problems with low dissolved oxygen can develop, especially overnight following cloudy days.

Low fertility ponds typically support around 50 to 150 pounds per acre of fish. Fertilization can increase fish production in these ponds by three to four times, resulting in more and larger fish if properly managed. However, there is little reason to fertilize if the owner is not interested in improving fish production. Additionally, owners must consider if changing the pond appearance to a more intense green color and the added risk of dissolved oxygen problems are worth the additional fish production. Most ponds in Arkansas are fertile enough to support an enjoyable fishery without any fertilization.

Follow recommended fertilization guidelines. Overfertilization can lead to dense planktonic algae blooms, oxygen depletion, fish kills and thick algal scums that make the water unsuitable for livestock. Discharge from these overfertilized ponds can also pollute natural waters downstream, especially in ecologically sensitive watersheds.

Ponds located on fertile watersheds, such as those receiving runoff from nearby livestock or poultry operations, usually do not need additional fertilization. For example, broiler litter contains an average of 69 pounds of phosphorus (P_2O_5) per ton. Ponds require only 3 to 4 pounds per acre of phosphorus to develop a planktonic algae bloom. Runoff from this fertilized land will usually carry enough phosphorus with it to sufficiently fertilize a pond.

If the fish in a pond are to be fed, there is usually no need to fertilize because uneaten feed and fish wastes will serve as fertilizer. Do not fertilize ponds that contain higher aquatic plants, muddy water, or

those that already have dense planktonic algae blooms or out of balance fish populations until the problems are corrected. Also, do not fertilize ponds with water flow rates so high that the entire pond volume is flushed in less than 2 to 3 weeks.

Test the alkalinity of the pond before fertilizing. Ponds with alkalinity below 20 mg/L may not respond to fertilizer. An application of lime in the fall may be needed before the fertilizer can provide any benefit.

Applying Fertilizer

Fertilization programs should begin in the spring when the water warms above 65ºF, usually in March. Once a fertilization program is started, it should be maintained throughout the growing season until water drops below 60ºF in the fall. Do not abruptly stop fertilization programs. Fish will become accustomed to the additional food resulting from fertilization and could starve if the fertilization stops. The number of applications needed varies from one to five or more, depending on the response of the pond to fertilization. Older ponds typically contain higher levels of nutrients and do not need as much fertilizer, if any.

It is best to use fertilizers high in phosphorus because it is the most important nutrient in ponds. Nitrogen is beneficial, especially in newer ponds, but potassium is rarely needed. The formulation, or grade, of a fertilizer is indicated by three numbers. For example, 12-52-4 represents the percentage by weight of nitrogen (12), phosphorus (52) and potassium (4). By convention, phosphorus is expressed as P_2O_5, and the amount of elemental phosphorus is only 44 percent of what is listed on a bag of fertilizer. Fertilization recommendations for ponds have taken this into consideration so that no additional calculations are needed.

Fertilizer comes in liquid, powdered and granular forms. Powdered fertilizers are more expensive, but they are also the easiest to apply because they dissolve quickly and can be broadcast over the pond surface. Liquid fertilizer is heavier than water and must be diluted with water at ten parts water to one part fertilizer before being splashed or sprayed over the pond surface. Granular fertilizer is in the form of small pellets and is typically the easiest type to find in stores. However, granular fertilizer should not be spread out into the pond. Granular fertilizer dissolves slowly in water and most of it sinks to the bottom where the phosphorus becomes chemically bound with the mud and lost. If granular fertilizer is used, it must be kept off of the mud until the pellets dissolve. Granules can be placed on a wooden platform set 4 to 12 inches below the water surface, or the fertilizer bag can simply be split open on top in an "X" and carefully sunk in shallow water.

Granular fertilizer should not be spread out into the pond.

Table 1 provides suggested fertilizer rates for ponds. There is not one set fertilizer rate that works in all ponds because each pond is unique. Ponds located on infertile watersheds will need more fertilizer than ponds located on fertile ones, for example.

Table 1. Suggested fertilizer rates per application for farm ponds. These are only starting points; modify application rates based on pond conditions and responses. After the initial application, apply one-half the recommended rate on following applications.

Fertilizer Type	Grade	Water (Calcium) Hardness	
		Low (<50 mg/L)	Moderate (>50 mg/L)
Liquid	11-37-0 13-37-0 10-34-0	0.5 to 1 gal/acre	1 to 2 gal/acre
Powder	12-52-4 12-49-6 10-52-0	4 to 8 lbs/acre	8 to 16 lb/acre
Granular	18-46-0 00-46-0	4 to 8 lbs/acre	8 to 16 lb/acre

Monitoring the Bloom

Monitor changes in water color following fertilizer application; the water should turn a green or green-brown color within a week. Planktonic algae blooms develop faster in warmer water. A week or two after fertilizer application, measure the bloom density with a known arm length or with a Secchi disk. A Secchi disk is nothing more than a pie tin, round, flat plastic or wood plate, painted with alternating black and white, nailed to the bottom of a yardstick. Secchi disks are meant to be lowered into the water to the point that they disappear from view; record that depth. The disk is then raised up until it can be seen again; that depth is also recorded. The average of those two measurements is the Secchi disk depth. Ideal water clarity in ponds is between 18 and 24 inches. If the Secchi disk depth is less than 18 inches, do not fertilize. If it is deeper than 24 inches, the pond can be fertilized again. Wait at

least one, preferably two, weeks between fertilizer applications so the bloom can be measured.

Feeding

Fish do not need to be fed in ponds, but it is a way to increase the average size and total weight of fish in the pond. Plus, it is fun to watch the fish eat. Uneaten feed essentially becomes fertilizer for the pond, so additional fertilization is rarely necessary. Feeding over 30 pounds per acre per day greatly increases the chances of dissolved oxygen problems and possibly fish kills. If this much feed is going to be provided, installing a pond aerator should be strongly considered.

If a feeding program is started, do not end it until the waters cool in the fall and the fish stop responding to feeding. Fish that are regularly fed can become dependent on that food source, especially if

there are a high number of fish in a pond. There may not be enough natural food in the pond to support the added fish weight if the feeding program stops. The fish will get skinny and may become sick. Fish do not feed much in winter because their metabolism is highly dependent on water temperature. They may eat during warm spells in winter, but feeding should be kept at a minimum.

Only some fish species will eat fish feed, including channel catfish, bluegill, hybrid sunfish, hybrid striped bass, minnows and grass carp. Largemouth bass and crappie usually do not eat feed. However, they benefit indirectly from the increased production of their forage species. Therefore, a feeding program can increase the production of several species and allow for higher stocking densities and faster growth. Feeding is particularly beneficial in ponds lacking natural foods because of low nutrients, muddy water or other water quality problems.

Floating catfish feed is available in many farm supply stores and is formulated specifically for fish. Floating feed is best because it is easy to observe how much the fish are eating and whether too much feed has been provided. Fish can also eat dog food. However, even cheap dog food is often more expensive per pound than floating catfish feed. Catfish benefit more from diets with 28 to 32 percent protein; dog food is usually around 18 percent protein. Dog food also contains about twice the fat that catfish need. No harm will come to fish that eat dog food; it is just not the best option.

Do not feed fish more than what they will eat in 5 to 10 minutes. Throw feed into the pond and watch the fish eat. When the fish slow down and stop eating, stop feeding. Try to feed in the same place at the same time of day so fish become trained. It is best to feed in the morning during summer and in the late afternoon during the spring and fall.

Wind can push floating feed against the shoreline before fish have a chance to eat it. If this is a problem, feed from the upwind side of the pond so that it takes longer for the feed to reach the shoreline. Another solution is to install a floating feeding ring. These are often 3- to 4-foot square or circular rings of PVC pipe secured somewhere in the pond; fishing piers and boat docks are popular locations. Choose a feeding location over water that is several feet deep and free of vegetation.

Aeration

Dissolved oxygen problems are common and the most frequent cause of fish kills in ponds. Most oxygen problems can be solved by installing a pond aerator and running it every night during the summer. Commercial surface aerators are the best options for aerating ponds. These aerators provide good oxygen transfer and are relatively energy efficient, well designed and long lasting. Research has shown that paddlewheel aerators are the most efficient at transferring oxygen but also one of the more expensive options.

Aerators can be purchased through aquaculture supply houses or directly from the manufacturer in

some cases. The typical aerator has ½ to 2 horsepower (HP), retails for $900 to $1,500, and should provide 5 to 7 years of service. Air blowers or compressors can also be used to inject oxygen into the water through air lines and diffusers. These systems are best for deep ponds or for a series of small ponds because they are relatively inefficient in shallow water. Aeration at a rate of ½ to 1 HP per acre should be sufficient in ordinary fishing ponds in most cases. Commercial catfish ponds require a minimum of 2 to 4 HP per acre. Although they are not required in order to have a successful fishing pond, aerators provide insurance against oxygen problems that can ruin many years and many dollars worth of fish stockings and management efforts. Contact University of Arkansas Cooperative Extension Service county agents for assistance in locating aerator manufacturers (Appendix B-3).

Destratification

Stratification is common in ponds during the summer. Ponds deeper than 12 to 14 feet are more prone to severe turnovers and fish kills because of stratification. Warm oxygenated water floats on top of the cooler, oxygen-poor water. If this stratification is broken by a strong storm or cooler weather, oxygen in the pond can be diluted to lethal levels, resulting in a fish kill. A way to reduce stratification in ponds is to install an aerator or circulator that will help mix the water. Start mixing in the spring and continue through the summer to prevent, or at least reduce, stratification. Do not try to mix a deep pond that is already stratified, as it could cause a fish kill.

Nutrient Reduction

Pond owners who experience undesirably dense planktonic algae blooms or who want clear water will need to avoid adding nutrients to their ponds. Thick vegetative buffer strips around the pond can help. Circulating pond water during the summer can also help. Unfortunately, ponds that already have dense planktonic algae blooms may take several years to clear because nutrients are recycled.

Livestock Ponds

Ponds intended for livestock watering should not be fertilized and the fish within them should not be fed. These added nutrients are not needed and usually result in dense planktonic algae blooms. It is best to keep livestock from entering the pond. Gravity-fed watering troughs below the pond are a great option. If that is not feasible, another option is to fence off all but a small section of the pond, then reinforce the pond bottom in that section with gravel and rocks. This will allow the livestock access to water while reducing damage to the shoreline and the pond environment. For more detailed information on livestock watering ponds, refer to University of Arkansas Cooperative Extension Service publications FSA3021, *Water for Beef Cattle*, and FSA3128, *Watering Systems for Cattle Ponds* (Appendix B-9).

Fish Species Recommendations

Recommended Fish Species

Not all fish species work well in ponds. What to stock depends on the characteristics of the pond and what the owner wants to catch from the pond. Once a primary sportfish is selected, other fish species are selected to either feed or control the population of that sportfish. Selecting fish species that are compatible with each other and the pond environment is critical to the pond's success. This section will first discuss species that are highly recommended for ponds in Arkansas. Next, alternative fish species, with less certain probabilities of success, are described. Finally, fish species that should be excluded from the pond will be identified.

Largemouth Bass

The largemouth bass is a popular farm pond species. It is easily identified by its large mouth and dark blotches down the length of its long body. Young largemouth bass feed on microscopic animals (zooplankton) and insects. The diet shifts to fish, crayfish, frogs and larger insects as the largemouth bass matures. Although growth rates vary from pond to pond, largemouth bass can usually reach 12 inches or more in two years when food is abundant. Bluegill are the primary food source for largemouth bass in ponds. Largemouth bass will not eat floating fish feed. Largemouth bass typically spawn once between April and June when water temperatures reach about 65°F.

There are two strains of largemouth bass available commercially, the northern and Florida strains. The northern largemouth bass is native to

Arkansas and is found in most waters of the state. The Florida largemouth bass is nonnative, but it has been introduced to some locations in Arkansas. Florida largemouth bass can get larger than northern largemouth bass. However, they tend to be more difficult to catch and they are often outcompeted for food by the more aggressive northern largemouth bass in ponds. Hybrid crosses between the northern and Florida strains are also commercially available. These hybrid largemouth bass may experience enhanced growth and aggressive behavior, but their offspring will not retain these traits.

Bluegill

Bluegill, also called bream, are compressed, deep-bodied sunfish with small mouths. Bluegill have a dark spot at the base of the soft dorsal fin with dark vertical bands along their sides. Their underside is yellow to reddish orange and their chin is often blue. Young bluegill feed on zooplankton. Adults feed primarily on insects, and they do very well on floating fish feed. Bluegill will spawn multiple times throughout the spring and summer. This frequent reproduction is perfect for providing largemouth bass with abundant food. Bluegill are also great food for humans. If bluegill are stocked in a pond, largemouth bass should also be stocked to control the bluegill population. Otherwise, the pond will become overrun with small bluegill.

The two strains of bluegill available commercially are the native bluegill and the nonnative coppernose bluegill. Contrary to popular belief, coppernose bluegill are not hybrids. They are actually a strain of bluegill from Florida and southeast Georgia. Native bluegill and coppernose bluegill share very similar biology, but there are some differences. Research has shown that coppernose bluegill can grow faster and larger than bluegill from other parts of the country. However, proper pond management tends to have a greater impact on fish growth than the strain of fish stocked.

Redear Sunfish

Redear sunfish, also known as shell cracker, are close relatives to the bluegill and can provide additional largemouth bass forage and fishing. This species can be identified apart from bluegill by red-orange markings on the outside edge of its ear flap with no vertical bars along its sides and no dark spot on its soft dorsal fin. Redear sunfish typically get larger than bluegill, but they do not reproduce as frequently. Redear sunfish alone cannot support a largemouth bass population for long in ponds. Redear sunfish spawn from about April through August in Arkansas. They feed primarily on zooplankton, bottom-dwelling insects and snails. Like bluegill, redear sunfish are fun to catch and enjoyable to eat. Redear sunfish also help prevent parasitic grubs in sportfish filets by eating snails. Without snails, these grubs cannot complete their lifecycle and therefore cannot persist. Ponds stocked with redear sunfish rarely have issues with parasitic grubs.

Channel Catfish

The channel catfish has a dark back fading to light grey or silver sides with several black spots down the length of the body. Channel catfish can reach 1 to 2 pounds within 2 years and may reach more than 10 pounds in 5 to 10 years if food is abundant. Adult channel catfish eat a variety of natural foods, including insects, snails, crayfish, plant material and small fish. They will also grow very well eating floating fish feed.

Channel catfish usually do not reproduce well enough in farm ponds to maintain their populations.

They require spawning cavities, and their offspring are quickly eaten by other fish. As a result, farm ponds require periodic restocking of channel catfish to replace losses from natural mortality and fishing harvest. When restocking a pond that has largemouth bass in it, only stock channel catfish larger than 8 inches in length. If smaller fingerlings are stocked, many of them could be eaten by the largemouth bass.

Grass Carp

Grass carp, also known as white amur, are silvery-gray in color with long slender bodies. They are regarded as an economical long-term aquatic plant control option. The grass carp is good at controlling many soft, submersed aquatic plants. However, they will have little to no effect on the firmer, emergent aquatic plants. Stock newly-built or renovated ponds with three to five grass carp per acre. Ponds with moderate to heavy aquatic plant problems will require ten or more grass carp per acre to have an effect, and it can take a couple of years before their impact is noticeable. New ponds can be stocked with 2- to 6-inch grass carp. However, only 8- to 12-inch grass carp should be stocked into ponds that have adult largemouth bass. Grass carp eat vegetation almost exclusively, but they will eat some fish feed if it is available. As grass carp get larger, they become less efficient at controlling aquatic plants. For this reason, they should be replaced with new grass carp every 5 to 7 years. Grass carp can be harvested by snagging, bow fishing, spearing or angling. Although somewhat bony, the grass carp is considered an excellent fish to eat.

Supplemental Forage Species

Fathead Minnow

The fathead minnow, also known as toughie or flathead minnow, is a small, cylindrical, pug-headed fish, typically less than 3 inches in length. Normally-colored fish have dark olive backs fading to silver sides. A popular color variant of fathead minnow, called the rosy-red (pictured), is orange. These short-lived fish reproduce repeatedly in the spring by nesting on the undersides of firm surfaces, such as sticks, stones or lily pads. Pallets, boards or tiles are often added to ponds to increase nest site availability. Fathead minnows are a common bait and forage fish species. They are often stocked at the same time as fingerling largemouth bass to give the largemouth bass something to eat before the bluegill begin to reproduce. In ponds that already contain fish, fathead minnows are consumed rapidly and usually disappear altogether.

Golden Shiner

Golden shiners are widely sold as baitfish, but they are also used as forage fish. They have shiny silver sides with dark olive backs. Breeding fish may develop gold-colored fins and young fish may have a dark lateral stripe. Their heads are triangular with an upturned mouth, and their tail is deeply forked. Golden shiners usually remain less than 6 inches long and reproduce multiple times throughout the spring. Their adhesive eggs are scattered onto vegetation, with no parental care. In general, golden shiners are an excellent forage fish. However, they will eat fish eggs and compete for the same foods that young largemouth bass and bluegill eat, primarily zooplankton. Golden shiners usually do not last long in ponds that already contain largemouth bass.

Threadfin Shad

Threadfin shad are small, shiny and herringlike, with a sharp edge to their bellies and a threadlike

filament at the end of their dorsal fin. Threadfin remain less than 7 inches long as adults. The highly similar-looking gizzard shad will grow much larger, too large to serve as a forage fish. These large gizzard shad can stockpile in ponds, consuming a great amount of resources. For this reason, it is critical to correctly identify the species and avoid stocking gizzard shad. Unfortunately, these species are often found schooling together in lakes and rivers. Threadfin grow quickly and become abundant in ponds because they are filter feeders, eating mostly zooplankton and large planktonic algae and because they reproduce in great numbers. However, threadfin are delicate, difficult to handle and temperature sensitive. Water temperatures below 45ºF will cause mortalities, and 40ºF water will kill most threadfin. Many ponds, especially in northern Arkansas, get below this lethal temperature each winter.

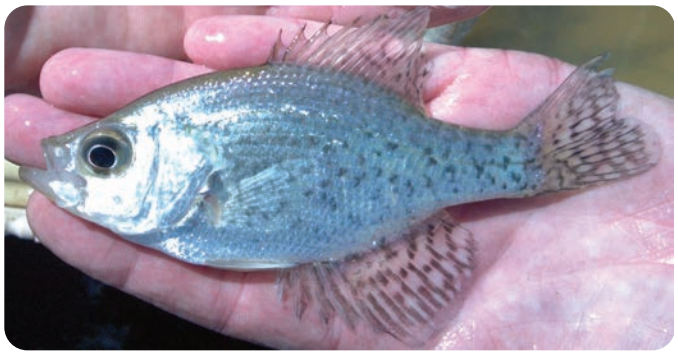
Tilapia

The most commonly available species of tilapia are the Blue, Nile and Mozambique. Tilapia look similar to bluegill but have an interrupted lateral line. Tilapia are suggested as a seasonal forage fish in some states because they reproduce in great numbers throughout the summer and because they die in water below about 50ºF. Almost all ponds in Arkansas get below this temperature in the winter each year, unless a spring or warm water effluent outlet discharges into the pond. Some states completely prohibit the introduction of tilapia because they are nonnative and often considered an aquatic nuisance species. Tilapia are aggressive and compete with native species for nesting sites. In Arkansas, tilapia is an approved aquaculture species but it cannot be released into the wild. Stocking tilapia into ponds that could flood or discharge directly into public waters is discouraged.

Alternative Fish Species

The stocking and management of farm ponds in the southeastern United States has traditionally focused on largemouth bass and bluegill. This species combination is well understood and often successful. However, there are alternative strategies that may be attractive to pond owners who are more adventurous, who are interested in other game fish species or who have the financial means to adopt a more aggressive management plan. The risk is that some of these species are untested or they are only successful in certain situations. This section will focus on describing some of these alternative species.

Black Crappie



The black crappie is a compressed, deep-bodied fish with a small head and relatively large mouth. Its sides are silver with black speckles and blotches. The black crappie can be distinguished from the white crappie by the number of dorsal spines: black crappie have seven to eight, while the white crappie have five to six. Black crappie spawn when water temperatures are 64º to 68ºF. Young black crappie feed on planktonic algae, zooplankton and small insects. Adults feed primarily on fish and aquatic insects. Black crappie will not eat floating fish feed. Black crappie and largemouth bass diets are very similar, leading to competition for limited food resources. Additionally, both white and black crappie are prone to inconsistent, but sometimes extremely large, numbers of young. This makes it very difficult to keep crappie populations balanced with other species. Black crappie tend to be somewhat less prolific and unpredictable than white crappie. This makes the black crappie a better option for pond stocking. Strategies for successful black crappie ponds are discussed in the section Fish Stocking Strategies: Black Crappie Option.

Hybrid Sunfish

Hybrids are a cross between two different species and typically have physical characteristics of both

parents. The most common hybrid sunfish in the southeast comes from crossing bluegill or redear sunfish with green sunfish. These fish do not reproduce much because 85 to 95 percent of them are male. However, largemouth bass are needed to keep the limited and inferior hybrid sunfish offspring from becoming too numerous. The hybrid sunfish offspring will compete with the adult hybrid sunfish for food and will not grow as large as their parents.

Hybrid Striped Bass

The hybrid striped bass is a cross between striped bass and white bass. Their backs are olive-green to blue-gray fading to silvery or brassy sides and a white belly. They are easily recognized by the seven to eight prominent, but randomly broken, black stripes running down the length of the body. Hybrid striped bass grow very well eating floating fish feed. They can reach 3 to 7 pounds within three years and provide excellent fishing and table-fare. Studies show that the success of hybrid striped bass in Arkansas is highly dependent on the alkalinity and hardness of the pond water – the higher the better.

Unwanted Fish Species in Farm Ponds

Species to avoid in farm ponds include white crappie, gizzard shad, green sunfish, common carp and bullhead. Some of these species interfere with predator/prey relationships; others are detrimental to water quality. Fishing potential is lost and management is more difficult when these species are abundant in ponds.

White Crappie

White crappie typically have olive-green backs fading to silvery sides with several dark vertical bars down the body. They are a relatively thin, but deep bodied sunfish with five or six dorsal spines. The white crappie is not recommended in ponds because it is more likely to overpopulate than black crappie.

Green Sunfish

Green sunfish are similar in shape and appearance to bluegill. However, their mouths are much larger and their fins have white or orange margins. Green sunfish are not recommended for ponds because they tend to overpopulate and compete with largemouth bass and bluegill for food.

Gizzard Shad

Gizzard shad are silvery with a single dark spot behind their gill plates. They have a long, whiplike final dorsal ray and their mouths are below their blunt snouts. Threadfin shad look nearly identical to gizzard shad. However, threadfin shad mouths are right at the edge of their more pointed snouts, and their maximum size is much smaller. Gizzard shad are not recommended in ponds because they can quickly get too large for largemouth bass to eat. Once that happens, large numbers of these herbivorous fish uncontrollably graze on planktonic algae and can negatively influence the overall productivity of the pond. They are not usually caught by hook and line and are not considered a good food item for humans.

Bullhead

Bullhead species can easily be differentiated from channel catfish by the absence of a deeply-forked tail. Bullhead bodies are squat and their tail is round or square. The chin barbels are pigmented on brown bullhead and white on yellow bullhead. Brown bullhead

sides have brownish mottling over a light background. Yellow bullhead have yellow-olive to black backs fading to yellow or yellow-olive sides with little to no mottling. Bullhead are not recommended in ponds because their bottom feeding behavior causes muddy water. Muddy water is less productive and many fish species do not grow as well in it.

Common Carp

Common carp are heavy bodied, laterally compressed minnows with long dorsal fins, arched backs and large scales. The first rays of the dorsal and anal fins are stout, serrated spines. Their small triangular head is scaleless and tapers to a blunt snout. The small protrusible mouth contains no teeth and is located below the snout. There are two pair of barbels on the upper jaw. Their backs are brassy green fading to bronze or golden sides. The belly is yellowish white. Fins are typically yellow, orange, golden or light olive in color. Common carp, like bullhead, are not recommended in ponds because their bottom-feeding behavior causes muddy water.

Aquatic Nuisance Species

Humans have introduced and moved around many plant and animal species, sometimes intentionally, sometimes accidentally. Many introductions cause no harm, but some species are invasive and cause ecological damage and/or economic losses. For example, the invasive aquatic plant hydrilla has become established in Lake Ouachita. If not for the control program implemented by the U.S. Army Corps of Engineers and the Arkansas Game and Fish Commission, hydrilla would likely choke out recreational waters, interfering with boat traffic, fishing and swimming. Similarly, giant salvinia, a highly invasive water fern that rapidly covers ponds, is found in Louisiana and Texas and could spread into southern Arkansas.

Report new or unusual aquatic plants and animals to the Arkansas Game and Fish Commission.

Pond owners can help prevent the spread of aquatic nuisance species by not introducing nonnative aquatic plants or animals and reporting new or unusual aquatic plants and animals found around their ponds to the Arkansas Game and Fish Commission (Appendix B-5). University of Arkansas Cooperative Extension Service county agents can help identify suspicious plants or animals (Appendix B-3). Early detection and control can help eliminate invading species before they spread further, reducing costs and harm.

Fish Stocking Strategies

Obtaining Fish for Pond Stocking

Fish fingerlings used to stock ponds can be purchased from commercial fish farms. Large orders can be delivered by truck straight to the pond. Smaller orders can be obtained by visiting the fish farm or by meeting a fish truck that makes routine stops locally. Most fish farms pack small orders of fish in oxygenated plastic bags that can maintain fish for several hours. However, larger fish, especially large catfish, are difficult to transport in plastic bags. Water-filled barrels, tanks or other rigid containers are better options for transporting larger fish. Keep in mind that oxygen will eventually run out in these containers without aeration and fish could die before reaching the pond. The number of fish that can be transported in this manner depends on temperature, water volume, the surface area of the container and the size of the fish. It is wise to discuss fish-transportation options with the fish farmer.

Be sure to slowly acclimate new fish to the pond before releasing them. Rapid temperature changes can kill fish quickly or cause sub-lethal stress that can lead to death up to a week later. Allow unopened fish bags to float in the pond for about 30 minutes. If transporting fish in larger containers, use a bucket to add pond water to the container. This will slowly change the temperature inside the bags and other containers to match the pond water temperature. After 30 minutes has passed, release the fish from their containers into the pond. It is best to transport and stock fish in the spring and fall when water temperatures are cooler. If fish must be moved during the summer, stock early in the morning while the surface water is a little cooler. To find suitable fish farms, ask for a copy of the Sportfish

Table 2. Species selection and stocking rates (fingerlings per acre) for new or renovated largemouth bass and bluegill ponds.

Species Combination	Largemouth Bass (LMB)	Bluegill (BG)	Redear Sunfish (RS)	Channel Catfish (CC)	Grass Carp	Fathead Minnow
LMB-BG	50	500	-	-	5	3 to 10 lb
LMB-BG-CC	50	500	-	100	5	3 to 10 lb
LMB-BG-RS	50	400	100	-	5	3 to 10 lb
LM-BG-RS-CC	50	400	100	100	5	3 to 10 lb

*Largemouth bass, bluegill, redear sunfish and catfish stocking rates can be doubled if the pond is fertilized or if feed is provided regularly.

Supplier List updated regularly by the University of Arkansas at Pine Bluff Aquaculture/Fisheries Center and distributed through University of Arkansas Cooperative Extension Service county offices and the Arkansas Game and Fish Commission (Appendix B-1, B-3, B-5). Contact information, business hours, species for sale and shipping information is provided. Be sure to check on prices and availability before visiting the farm.

Ponds smaller than one acre do better with single species fisheries.

Largemouth Bass and Bluegill

In ponds larger than about one acre, the most common stocking recommendations focus on largemouth bass and bluegill. Bluegill reproduce multiple times a year and in great numbers. This provides plenty of food for the largemouth bass that control bluegill and nuisance species populations. As long as the populations of bluegill and largemouth bass are balanced by stable reproduction and appropriate fishing harvest, ponds can provide enjoyable fishing for years without needing to be restocked. Redear sunfish, channel catfish, grass carp and fathead minnows are species that can be added to the basic largemouth bass/bluegill pond if desired.

It is best to consult with professionals before attempting to stock fish into a pond already containing fish.

The timing of fish stocking is important for the initial success of the pond. The trick is to give the bluegill and forage fish time to spawn at least once and become established in the pond before predators are added. This will ensure that the largemouth bass have all sizes of food available for healthy growth. Stock bluegill, redear sunfish and fathead minnows in the fall after the pond is at least half full. Stock largemouth bass the following spring. Channel catfish and grass carp can be stocked in the spring or fall, but it is best to stock them before the largemouth bass get very large.

Stocking rates are designed to establish appropriate population ratios from the beginning (Table 2). There must be enough individuals to account for natural losses but not so many that they overwhelm the limited resources within the pond. The typical fishing pond contains a community of prey and predatory species; it takes many prey fish to grow a single predator fish. A stocking ratio of at least 10 bluegill/redear sunfish to one largemouth bass is recommended. Fertilization and regular feeding can substantially increase the number and size of fish in a pond. However, with more nutrient input and higher numbers of fish, water quality issues become more likely. Ponds involved in these expensive enhancement programs with valuable populations of fish should also be fitted with supplemental aeration equipment for emergencies.

Stocking adult fish is an option for reducing the amount of time before harvesting can occur. Success with this strategy is less certain because it has not been researched as much as conventional fingerling stocking strategies. Far fewer individuals are needed in this option because adults are more likely to survive and each one requires more resources than a fingerling would (Table 3). Bluegill/redear sunfish and largemouth bass can be stocked together in the spring with this stocking strategy. Stocking 3 to 10 pounds of fathead minnows per acre can give the largemouth bass a smaller food option than the bluegill immediately after stocking. Channel catfish can also be stocked in the spring as long as they are at least 6 to 8 inches long to prevent predation losses.

Table 3. Adult stocking recommendations (adults per acre) for new or renovated largemouth bass and bluegill ponds.

Species	Number Per Acre	Size (Inches)
Largemouth Bass	20	8 to 14
Bluegill	70	3 to 5
Redear Sunfish	30	3 to 5
Channel Catfish	100	6 to 8

*Double recommended stocking rates if the pond is fertilized or if feed is provided regularly.

Please note that all stocking recommendations provided here are meant for newly built or renovated ponds with no pre-existing fish populations. Stocking rates for ponds with existing populations of fish will need to be discussed with professionals on a case-by-case basis (Appendix B-1, B-3, B-5).

Without appropriate fish harvest, ponds almost inevitably become over-populated with one or more species. Appropriate harvest rates will help maintain population balances and average size of each fish. Harvest should begin two or three years after fish are stocked, although fishing without harvest can begin sooner (Table 4).

Without appropriate fish harvest, ponds almost inevitably become over-populated with one or more species.

Table 4. Harvest rates for largemouth bass and bluegill ponds.

Species	Size (Inches)	Pounds Per Acre Per Year
Largemouth Bass	< 13	10 to 15
	13 to 15	0
	> 15	As desired
Bluegill and Redear Sunfish	> 5	40 to 50
Channel Catfish	Any	As desired

*Double recommended harvest rates if the pond is fertilized or if feed is provided regularly.

Black Crappie Option

Crappie are a highly popular sportfish. However, they are very difficult to successfully manage in ponds smaller than about 25 acres. Their reproduction is inconsistent and sometimes very large. This leads to crappie that are either rare or overpopulated to the point of starvation. Overcrowding the pond with largemouth bass can be a way to control crappie reproduction. Starting with a pond stocked to the standard largemouth bass and bluegill pond recommendations (Table 2), implement a 15-inch minimum length limit on largemouth bass and harvest no more than 10 pounds of largemouth bass per acre per year. This will help increase the number of small largemouth bass who will feed heavily on small crappie. Allow two largemouth bass spawning seasons to occur before stocking 100 adult (6 to 8 inches or larger) black crappie per acre.

Crappie are very difficult to manage in small ponds.

If stocking crappie into an older pond with long-established largemouth bass and bluegill populations is desired, implement the same 15-inch minimum length limit on largemouth bass with no more than 10 pounds of largemouth bass harvest per acre per year. Then, stock 15 adult (6 to 8 inches or larger) black crappie per acre. The number of largemouth bass in older ponds is far less certain than in newly-built and stocked ponds. Therefore, this more conservative stocking approach is recommended for older ponds.

Poaching of largemouth bass in a crappie pond can be disastrous. A single poacher could remove enough largemouth bass in a single afternoon to upset this management scheme because the hungry largemouth bass will be easy to catch. Also, keep in mind that the overall size of largemouth bass must be sacrificed to properly manage a crappie pond. If big largemouth bass are desired, do not stock crappie.

Even properly managed crappie ponds can get out of balance over time. This is indicated by an entire population of crappie that are too small to catch. If this occurs, stock 30 to 50 adult (8 to 14 inches long) largemouth bass per acre. If this does not seem to help, reduce the water level in the pond by half in early fall. This will help the largemouth bass get to the small crappie and eat them. Allow the pond to refill over winter and early spring; repeat the process the following fall if needed.

Hybrid striped bass are another option for controlling crappie populations. Hybrid striped bass are fast-swimming, open-water predators that grow quickly, will eat fish feed and are very fun to catch. Because of their highly active metabolism, hybrid striped bass will consume large amounts of crappie offspring. Stock up to 25 adult (6 to 8 inch) hybrid striped bass per acre into ponds overcrowded with crappie. Hybrid striped bass will not reproduce in ponds. Therefore, they must be restocked periodically to maintain their presence in the pond.

Channel Catfish Option

Channel catfish are an excellent option for small or constantly muddy ponds. Largemouth bass and bluegill are primarily sight feeders and do not grow as well in very muddy ponds. Additionally, population balances are very difficult to maintain in small ponds. For these reasons, single species fisheries are often recommended for ponds smaller than one acre. Stock 100 channel catfish fingerlings per acre. If fish feed will be provided, 200 channel catfish fingerlings per acre is acceptable. The more fish are stocked, the more they must be fed, and the more water quality issues become possible. Consider the added costs and risks of high stocking rates before stocking a pond. Channel catfish that are regularly fed should reach harvest size, about three-quarters of a pound, in about a year. Channel catfish will need to be

restocked periodically because they do not reproduce well in ponds. The frequency and number of fingerlings that need to be restocked will depend on how many fish have been harvested.

Hybrid Sunfish Option

Hybrid sunfish are another great option for small ponds. The most common hybrid sunfish in the southeast is a cross between bluegill or redear sunfish and a green sunfish. These fish grow quickly and are very fun to catch. Typical ponds can support stocking rates of 450 hybrid sunfish fingerlings per acre. Around 25 largemouth bass fingerlings per acre should also be stocked to control unwanted fish species and the limited offspring that hybrid sunfish may produce. Do not harvest largemouth bass from hybrid sunfish ponds. Stocking rates can be doubled if fish feed is provided regularly. Hybrid sunfish readily accept fish feed and can grow very quickly with regular feeding; they are capable of reaching 2 pounds in about six years but most will average around ½ to ¾ pound. Hybrid sunfish must be restocked to replace natural and fishing-related losses. The frequency and number to restock depends on how many have been removed.

Hybrid sunfish should only be stocked into newly built or renovated ponds without existing fish populations. The enhanced growth potential of hybrid sunfish is wasted if they have to compete with bluegill and other sunfish for food. Do not stock hybrid sunfish as a replacement for bluegill and redear sunfish in a largemouth bass and bluegill pond. The hybrid sunfish do not reproduce enough to support a largemouth bass population.

Fish Management Strategies

Evaluating Fish Populations

Stocking a new pond is easy. Trying to figure out what is going on in an older pond with an established fish population is much more difficult. Angler catch logs and seining can provide clues.

Keeping a detailed angler catch log is a great way to keep track of the size and, to some extent, the relative number of largemouth bass and bluegill in a pond. Each time someone fishes the pond, they should record the time spent, what was caught, what sizes were caught, and whether those fish were harvested or released back into the pond. An example of a simple catch log is provided in Appendix D.

Seining is used to evaluate the reproduction of largemouth bass and bluegill by sampling shoreline spawning areas in the late spring. The best time to sample in Arkansas is usually mid-May to late-June

after largemouth bass and bluegill have spawned. A 20 foot long, 4 to 5 feet deep, ⅜-inch mesh seine is acceptable and can usually be purchased at sporting goods stores fairly cheap. Make three to five semicircular passes in shallow areas of the pond. Be sure to allow an arch in the seine while dragging it through the water so fish cannot easily swim around it. At the end of each haul, drag the seine onto shore, then record the number and sizes of each species caught.

Managing Fish Populations

Once the angler catch log has been filled in and seining results have been collected, refer to Table 5 to see if the pond is in balance. Balance is a commonly used term to describe the equilibrium between largemouth bass and bluegill populations in a pond. A balanced pond is one where both largemouth bass and bluegill populations have stable reproduction each year and there is a range of sizes from small to large in both species. Essentially, bluegill are providing enough food for the largemouth bass, and the largemouth bass are keeping the bluegill population under control. Balanced ponds typically provide enjoyable fishing and can be maintained with standard harvest rates for several years (Table 4).

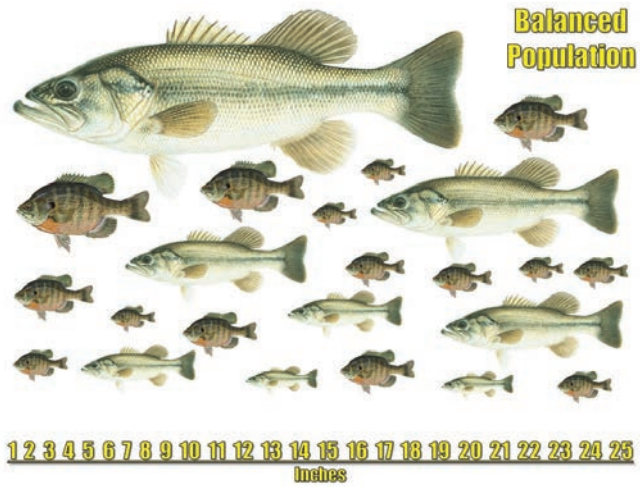
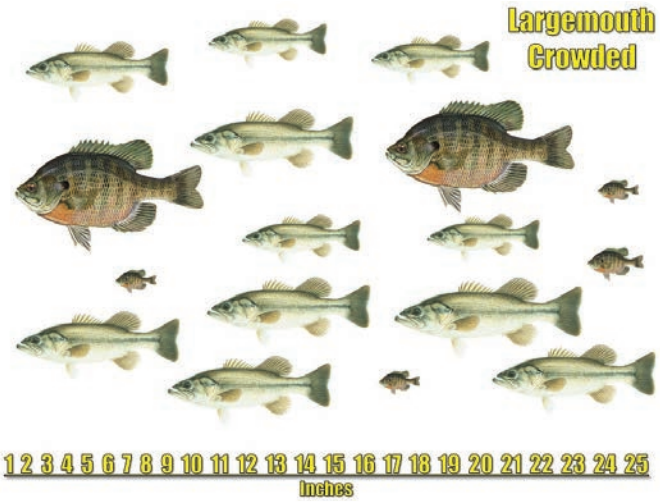


Table 5. Fish population status based on seine and angler catch of largemouth bass and bluegill.

Population Status	Seine Data	Angler Catch Data
Balanced population	Many recently hatched bluegill (< 2 inches) Some intermediate sized bluegill (2 to 4 inches) Some recently hatched largemouth (1 to 4 inches)	Largemouth and bluegill of various sizes
Bluegill crowded	No or very few recently hatched bluegill Many intermediate sized bluegill No recently hatched largemouth	Largemouth average size is large (> 15 inches) but catch rates are low; few large bluegill (> 6 inches)
Largemouth crowded	Many recently hatched bluegill No or very few intermediate sized bluegill No or very few recently hatched largemouth	Largemouth average size is small and thin (< 12 inches) but catch rates are high; bluegill few but large (> 8 inches)

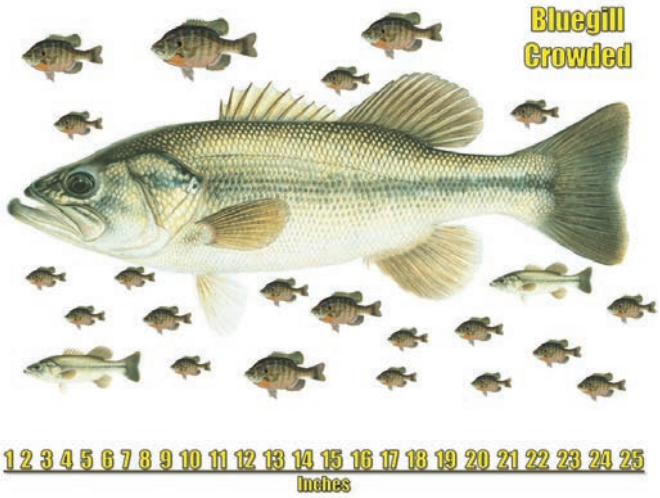
Largemouth Bass Crowded

Ponds lacking appropriate harvest of largemouth bass often end up overcrowded by largemouth bass. These ponds are full of small hungry largemouth bass and few, but often very large, bluegill. When largemouth bass overpopulate, bluegill are eaten before they can grow more than 2 to 4 inches long. The lucky few bluegill that somehow evade largemouth bass long enough to outgrow their mouths can grow to very large sizes. These ponds are usually very entertaining to fish because the hungry largemouth bass are easy to catch, and the few bluegill that are available are very large. However, if bigger largemouth bass are desired, simply harvest about 35 pounds of largemouth bass less than 12 inches long per acre per year until average size improves. Once a desirable size has been achieved, return to the standard harvest rates for a largemouth bass and bluegill pond (Table 4).



Bluegill Crowded

Ponds lacking enough predators can become overcrowded with bluegill. These ponds are full of 2- to 4-inch bluegill and very few, but often very large, largemouth bass. When bluegill overpopulate, they devour



anything they can eat, including recently hatched largemouth bass. The few largemouth bass that do survive grow very slowly because the bluegill are consuming the same food items that small largemouth bass need. The even fewer largemouth bass that somehow get large enough to start eating the stunted bluegill can then grow very quickly because they have an abundant food supply and little competition. These ponds can be enjoyable for largemouth bass enthusiasts who are more interested in the size of fish caught than the number of fish caught. However, beginners and casual anglers may find these ponds frustrating because there are fewer fish to catch and the bigger largemouth bass tend to be more difficult to catch. Returning bluegill crowded ponds to a balance can be challenging, but there are options. A combination of removing every bluegill caught while fishing and one or more of the following methods can help correct bluegill crowding:

1. Reduce the pond volume by half in the late summer to early fall. Allow the pond to refill over winter. This approach concentrates the bluegill so the largemouth bass can eat them easier. If a built-in pond drain is not available, an example of a homemade pond siphon is provided in Appendix C.

2. Stock 20 to 30 adult (8 to 14 inches long) largemouth bass per acre. The additional largemouth bass will help reduce the bluegill population.
3. If all else fails, completely drain the pond and kill all of the fish. Restock the pond after it refills at least half way with the appropriate ratios of fish (Table 2) and harvest fish as recommended (Table 4). This is also the best option when the pond is overrun with undesirable species, such as bullhead catfish and green sunfish.

Channel Catfish

If channel catfish are desired and are not being caught, simply stock more channel catfish. Even if catfish remain in the pond, they may have become wise to angling attempts, especially if strict catch and release has been enforced. In ponds containing largemouth bass, only stock catfish at least 6 to 8 inches long to prevent predation losses. Keeping records of the number of catfish stocked and harvested can help determine if and when additional stocking is needed (Appendix D). Most Arkansas ponds can support about 100 channel catfish per acre without feeding or fertilizing.

Complete pond renovation may be the only effective option in severe cases of fish population imbalance or undesirable species infestations.

Drawdowns

Reducing the water level in a pond, also known as a drawdown, can provide benefits beyond fish population management. Winter drawdowns allow shoreline vegetation to grow on the exposed soil. When the pond refills during spring, that vegetation provides cover for newly hatched fish. Winter drawdowns are also useful in controlling some, but not all, forms of nuisance aquatic vegetation. The key is dry soil and hard freezing temperatures. Some aquatic plants can become worse following a drawdown; this makes correct identification of the aquatic plant species critical. Drawdowns are also convenient times to make repairs to fishing piers, dams and water control structures, or to install fish attracters and apply agricultural lime, if needed.

Starting Over

If it is determined that a complete pond restart is needed, there are a couple of methods available. One method is to simply drain the pond completely and allow it to completely dry before refilling. If draining is not possible, another option is a chemical called rotenone. Rotenone is a natural chemical derived from the roots of tropical derris plants. Rotenone is approved for the removal of unwanted fish populations from lakes and ponds. Rotenone works by disrupting cellular processes that produce energy, causing exposed fish to slip into unconsciousness and die. Rotenone is a restricted use chemical, and a special license is required to purchase and apply it. Contact the local University of Arkansas Cooperative Extension Service county office for instructions on acquiring this license (Appendix B-3).

Common aquatic plants in Arkansas can be found in Appendix A.

Read the rotenone label for application instructions and use restrictions. Be sure that treated water cannot escape the pond during the treatment period; fish and wildlife downstream could be unintentionally harmed. After about three weeks has passed since the rotenone treatment, a simple test can be done to determine if the water is safe for restocking. Fill a bucket or ice chest with pond water and add several minnows to the container. If the minnows survive overnight, the pond is ready for restocking. Do not release the minnows into the pond unless that species is part of the new stocking strategy.

A rotenone treatment is futile if undesirable species can easily reinfest the pond after the treatment (refer to Fish Species Recommendations: Unwanted Fish Species in Farm Ponds). Rotenone treatments are not recommended for ponds that are connected to flowing streams or for ponds that occasionally connect with other infested water bodies during heavy rains. In these ponds, it is best to maintain a large population of largemouth bass to control undesirable species.

Aquatic Plant Management

Aquatic plants provide many benefits to the pond ecosystem. They are a primary source of oxygen, food and habitat for many organisms. Some aquatic plants can help strengthen pond shorelines, filter runoff and reduce erosion. Microscopic aquatic plants called planktonic algae establish the base of most pond food chains. The planktonic algae is eaten by microscopic animals called zooplankton, which are eaten by small fish, which are eaten by bigger fish, and so forth. Despite the potential benefits, uncontrolled aquatic plant growth can sometimes hinder fish growth, fishing and other pond uses.

Aquatic plant problems are more common in shallow, nutrient-rich ponds that are more than 5 years old. Both native and nonnative plants can become problematic if not monitored and controlled

appropriately. Prevention, in the form of proper pond construction, can make aquatic plant management far simpler.

Aquatic Plant Identification

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

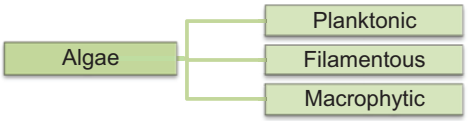
Algae

Algae generally have simple structures. However, macrophytic algae species such as chara and nitella can resemble higher plants. Algae can be divided into three categories: planktonic, filamentous and macrophytic. Planktonic algae are usually single-celled plants that, at high densities, can make water appear green. Planktonic algae blooms can also leave an oily or scummy appearance on the water surface. Oxygen problems and fish kills are possible following dense bloom die-offs. Limiting excessive nutrient input, especially nitrogen and phosphorus, can reduce the risk of dense planktonic algae blooms and associated problems (Appendix A-1).

Correctly identifying the nuisance plant in a pond is the first step to controlling it.

Filamentous algae, often referred to as "moss," initially grows on the pond bottom and on top of other submersed plants. When filamentous algae colonies become dense, they can sometimes float to the water's surface creating thick mats that make fishing, swimming and boating difficult. There are several different types of filamentous algae, including spirogyra, lyngbya, cladophora and pithophora. Pithophora, sometimes referred to as cotton ball algae, is course to the touch and difficult to tear apart. Pithophora is common in Arkansas and is one of the more difficult forms of algae to control (Appendix A-2).

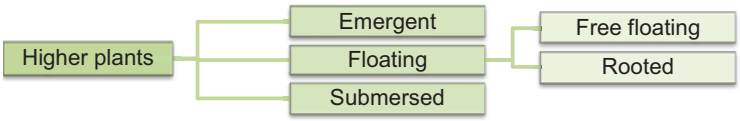
Online Aquatic Plant Identification Resources can be found in Appendix B-11-12.



Macrophytic algae, such as chara and nitella, resemble higher vascularized plants, but they are actually independent algae cells joined together to form complex structures. These colonies usually form low-standing beds attached to the pond bottom. Chara is more common in hard water, is rough to the touch and has a distinctive garlic-like musty odor (Appendix A-3). Nitella is more common in soft water, is smooth to the touch and lacks a strong odor (Appendix A-4).

Higher Plants

Higher plants can be divided into three categories: emergent, floating and submersed. Floating plants can be further divided into free floating and rooted.



Emergent plants typically grow near the shoreline with most of their green vegetation above the water surface. This group includes both grasslike and broadleaf plants. Common Arkansas grasslike plants include cattails, bulrushes, sedges and common reed. Common broadleaf plants include alligator weed, water primrose, parrot feather, water pennywort, smartweed, water willow and lizard's tail (Appendix A-5-17).

Floating plants, as their name suggests, float on the surface of the water. Floating plants can either be free floating or rooted to the pond bottom. Free-floating species include watermeal, duckweeds, water hyacinth, azolla and giant salvinia. Some free-floating plants have short roots that hang below the plant into the water. Free-floating plants commonly form dense blankets that cover the surface of calm, stagnant water. Rooted plants are anchored to the pond bottom and their stems are attached to floating leaves and flowers. These plants typically grow best in water less than 4 to 5 feet deep. Rooted floating species include frog's bit, American lotus, fragrant water lily, watershield and spatterdock (Appendix A-18-27).

Submersed plants are rooted to the pond bottom with most of their green vegetation below the water surface. Species in this category include hydrilla, elodea, egeria, coontail, southern naiad, slender naiad, Eurasian milfoil, eelgrass, fanwort, sago pondweed and Illinois pondweed (Appendix A-28-39).

Aquatic Plant Control Methods

The numerous potential aquatic plant control methods are broken into four categories: physical, mechanical, biological and chemical. The best results usually require a combination of more than one method.

Physical

Physical control methods are strategies that attempt to limit or prevent aquatic plant growth. Limiting light penetration is one physical control

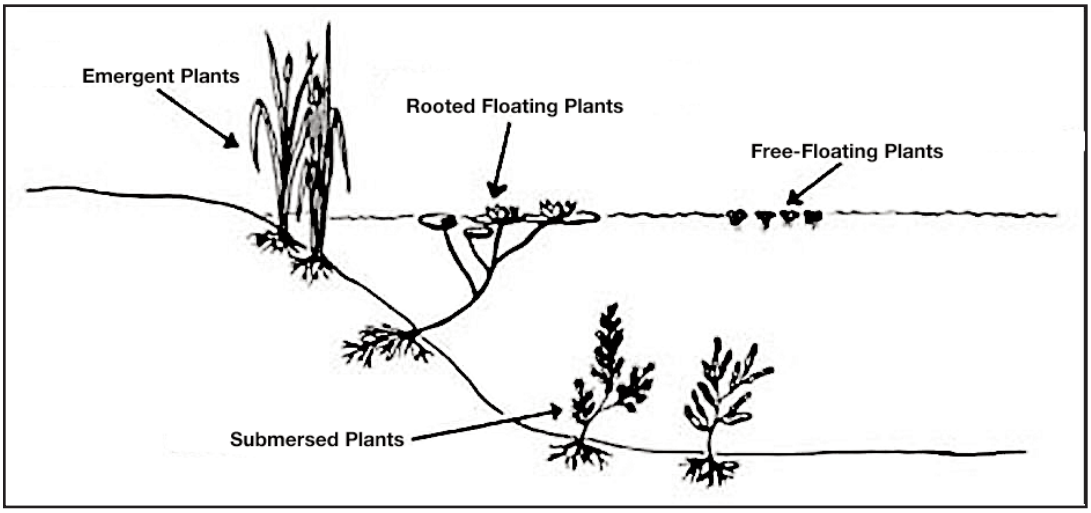


Illustration courtesy of Purdue University Extension

method. Before aquatic plants become established, fertilizing the water can stimulate a planktonic algae bloom which can reduce light penetration. However, do not apply fertilizer to a pond that already has higher aquatic plants or filamentous algae in it! All that will do is make the established aquatic plants worse. Aquatic dyes are another option to reduce light penetration. The best time to start a dye treatment is in the winter, before the aquatic plants begin to grow. The dye will not kill or prevent plant growth, but it can limit light penetration which can reduce the growth of many aquatic plants. Dyes and planktonic algae blooms are only effective in ponds more than about 3 feet deep. Sunlight can penetrate even treated water less than 3 feet deep, allowing for aquatic plant growth.

Steps for controlling aquatic plants:

1. Identify the nuisance plant
2. Choose an appropriate control method or combination of methods
3. Follow guidelines of the appropriate control method or methods

Burlap, nylon or PVC fabric anchored to the pond bottom can serve as physical barriers and provide localized control around a boat dock, fishing pier or swimming area. These barriers can be expensive and difficult to install. But, they can be effective for small areas.

Drawdowns for aquatic plant control are more effective during colder temperatures.

Reducing the water level to expose shallow areas, also known as a drawdown, can be used to control certain submersed aquatic plants. This technique works best during hard winters by exposing bottom sediments to freezing temperatures that kill plant roots and dormant reproductive structures. Drawdowns in northern Arkansas tend to be more effective. However, certain aquatic plant species become worse following drawdowns. Discuss the situation with a University of Arkansas Cooperative Extension Service county agent before proceeding (Appendix B-3).

Aquatic plants can only grow if nutrients are available. Therefore, the final physical control method is inactivating and/or preventing nutrients from entering the pond. Although rooted plants can obtain nutrients from the soil, certain chemicals, such as alum, can remove important nutrients from the water. Alum binds phosphorus and is also used to help clear muddy water. These chemicals can be expensive, and improper use can lead to fish kills. For more information, refer to Southern Regional Aquaculture Center publication 460, *Controlling Clay Turbidity in Ponds* (Appendix B-10).

Preventing nutrients from entering the pond in the first place is another approach to reduce aquatic plant growth. Planting buffer strips around ponds has proven effective at catching nutrients before they enter the water. Buffer strips also help stabilize shorelines, which reduces erosion and extends the pond's lifespan. It is important to keep livestock from entering the pond. Manure from livestock acts as fertilizer and can lead to dense aquatic plant growth.

Mechanical

Mechanical control involves methods that remove aquatic plants by hand or with machines. This includes pulling plants by hand, dragging a seine or heavy object through the pond or using a mechanical harvester. While hand removal is "free," renting a mechanical harvester can be quite costly. There are

some situations where removing aquatic plants by hand is the only option due to local regulations and other restrictions. Although aquatic plant removal by hand is effective for small areas, the effort required to clear larger ponds by hand is usually beyond what most owners are willing to invest. Additionally, many aquatic plants can re-grow from fragments left after breaking up the original plant.

Biological

The introduction of animals or organisms that eat or kill aquatic plants is considered biological control. Generally, biological control agents require one to two years to effectively control aquatic plants and may never control certain plant species. The most common biological control agent in Arkansas ponds is the grass carp. They are available in various sizes. Smaller fish are less expensive but highly vulnerable to largemouth bass predation. If largemouth bass are present in the pond, stock larger grass carp at least 8 to 12 inches in length to avoid predation losses. Typical stocking rates are 5 to 10 per acre. However, higher stocking rates can sometimes control aquatic plants faster. Grass carp prefer submersed plants that are soft, succulent and not fibrous. Grass carp should be restocked every five to seven years because as they get larger they get less efficient at eating vegetation. Grass carp are also known for flowing with water currents. Parallel-bar spillway barriers are needed to help prevent their escape during rainy parts of the year. For more information, refer to Southern Regional Aquaculture Center publication 3600, *Using Grass Carp in Aquaculture and Private Impoundments* (Appendix B-10).

The label is the law! Using herbicides in a way not described on their label is illegal.

Duckweed and watermeal are free-floating aquatic plants commonly found together in nutrient rich, stagnant waters. Goldfish stocked at a rate of 35 to 65 pounds per acre can sometimes effectively control these plants. However, all but the largest goldfish are very vulnerable to largemouth bass predation. If there are largemouth bass in the pond, the goldfish will be eaten.

Stocking tilapia at 200 to 400 fish per acre has been shown to effectively control filamentous algae within several months. They can also provide excellent largemouth bass forage. In ponds with bass, tilapia populations may be reduced to the point where they do not control the filamentous algae. In addition, tilapia are nonnative and should not be allowed to escape into public waters. Tilapia are also cold intolerant and will start to die when water temperatures drop below about 50ºF. The larger tilapia can be netted out of the pond as they start to die and prepared for the dinner table. Tilapia will need to be restocked each spring if they are desired.

Tilapia are nonnative and should not be allowed to escape into public waters.

Chemical

Chemical control is the use of herbicides. Herbicides are widely used for both public and private waters and can quickly control many aquatic plants. Unfortunately, herbicides tend to be very expensive and some only control aquatic plants for short periods of time. Treatments can target a single plant species or several species all at once.

The University of Arkansas Cooperative Extension Service publication MP44, *Recommended Chemicals for Weed and Brush Control,* contains a section on aquatic herbicides (Appendix B-9). Refer to this publication for further details. All herbicides listed have undergone EPA review and are legal for aquatic use in Arkansas as long as they are used in accordance with the instructions on the label. While approximately 300 herbicide active ingredients are registered in the U.S., only 14 of those are labeled for aquatic use. All herbicides come with a label describing the product form with instructions for safe handling and effective use. Aquatic herbicides are not harmful to fish as long as the label instructions are followed. It cannot be stressed enough: the label is the law, and not using herbicides according to their labeled instructions can lead to serious legal ramifications for the applicator.

Herbicide Selection

Selecting the most effective herbicide begins with correctly identifying the nuisance plant species. Each herbicide active ingredient has a particular mode of action. Some interrupt a certain biochemical pathway, while others stimulate selective growth or cause cell contents to leak out of the cell. As a result, a particular herbicide may kill one species of plant while not harming another species. Once the species is identified and the proper herbicide options are known, final herbicide selection can be based on the water conditions, time of year, water-use restrictions and whether the entire pond or only a section are to be treated. University of Arkansas Cooperative Extension Service county agents can assist with aquatic plant identification and herbicide selection (Appendix B-3).

Herbicide Types

Herbicides can be classified by the manner in which they kill plants: on contact or systemically (Table 6).

Table 6. Types of herbicides commonly used for controlling aquatic plants.

Types of Herbicides	
Contact	**Systemic**
Copper and Copper Products	2,4-D
Diquat	Glyphosate
Endothall	Fluridone
Carfentrazone	Triclopyr
Sodium Carbonate Peroxyhydrate	Imazapyr
Flumioxazin	Imazamox
	Penoxsulam
	Bispyribac Sodium

This classification refers to whether the herbicide is chemically active where it contacts the plant or if it is translocated within the plant to its action site. This has implications on herbicide effectiveness, application methods and how quickly it acts on the plant.

Contact herbicides only kill the parts of the plant they contact. Contact herbicides tend to work faster than systemic herbicides but require more complete spray coverage of all plant tissues during application. If a contact herbicide is used on submersed plants, the chemical must remain in the treatment area long enough for the entire plant to be exposed to a lethal concentration. Contact herbicides are risky to use in ponds heavily infested with aquatic plants, especially in warm water. Rapid plant death, common with contact herbicides, consumes a great deal of oxygen and can lead to fish kills. It is best to avoid using contact herbicides during the summer and only treat one-half to one-third of the pond at a time. Having supplemental aeration available is also a good idea during contact herbicide treatments.

When using contact herbicides, only treat one-half to one-third of the pond at a time to avoid oxygen problems.

Systemic herbicides move within the plant's vascular tissue to their action site. This gives systemic herbicides the ability to affect the entire plant, not just what it touches. Systemic herbicides tend to take longer to kill plants than contact herbicides. This allows for whole pond treatments because plants decompose more gradually, thus reducing the chances of oxygen problems. Entire plant coverage is also not typically needed if a system herbicide is used. If applications are timed correctly, systemic herbicides can be stored within the plant's root tissues. The next growing season, sugars and the herbicide stored within the roots are moved upwards in the plant. This can lead to a second season of control.

None of the aquatic herbicides labeled for use in Arkansas require a restricted-use pesticide applicator's license (at the time of this document's publishing). However, pond owners are encouraged to participate in pesticide applicator training, offered through the University of Arkansas Cooperative Extension Service, to ensure effective and safe use of herbicides (Appendix B-3).

Why Treatments Fail

Herbicide treatments for submersed plants do not always produce the desired results. This can be the result of incorrect plant identification, leading to incorrect herbicide selection. Another potential cause for unsatisfactory results is using herbicides under suboptimal conditions. For example, using diquat for a submersed plant in a muddy pond is a waste of money. Diquat binds with suspended particles in muddy ponds, rendering it inactive. Copper sulfate, often used as an algaecide, can be toxic to fish in water with less than 50 mg/L of alkalinity and ineffective at treating algae in water with more than 250 mg/L of alkalinity. Water temperature can also alter herbicide effectiveness. Most herbicides should not be used when the water temperature is below 60ºF; although plants may be growing, they are not metabolizing rapidly enough to take in lethal concentrations of herbicide.

Dilution is the most common reason for treatment failure. Every herbicide and target plant has a unique concentration and duration of exposure requirement. Underestimating a pond's volume can reduce herbicide concentration. Chemical degradation due to bacteria, sunlight, high pH or water current can reduce herbicide contact time. The result is a plant that survives because it was not exposed to a lethal concentration of herbicide long enough. Following herbicide label instructions and correctly estimating the pond volume and condition will help herbicide treatments succeed.

Know and understand EPA restrictions for the herbicide before applying it.

Summary

Nuisance aquatic plants are almost inevitable in ponds. If they are to be treated, it is easier and cheaper to treat them early. If an aquatic plant species becomes a problem one year, it is likely that same species will be a problem the following year. Early detection and treatment will ultimately save money and effort in the future. Best management practices will involve advanced planning, early detection and rapid implementation of multiple control methods early in the growing season.

Fish Kills and Other Problems

The most common cause of major fish kills in ponds is low dissolved oxygen. Fish kills from infectious diseases, pesticides or chemical contamination are extremely rare in private ponds. Minor fish kills in the form of a few dead fish per day are usually due to water quality problems other than dissolved oxygen.

In the event of a fish kill, compile information about the pond, the fish and the recent weather, then contact local University of Arkansas Cooperative Extension Service county agents, or one of the University of Arkansas at Pine Bluff Fish Disease Diagnostic Laboratories (Appendix B-3, B-1). These specialists will help identify the likely cause of the fish kill and suggest methods to avoid future fish kills. If more information or samples are needed, they will provide instructions on how to collect them. If a pesticide is suspected, contact the Arkansas Plant Board (Appendix B-6).

In the event of a fish kill, record the following information:

- Weather conditions before and after the kill
- Water temperature and water quality data, if available
- Color, appearance and smell of the water before and after the kill
- Size and average depth of the pond
- The time of day the fish are dying
- Whether the fish died all at once, or gradually over days
- How the surviving fish are behaving
- Whether the surviving fish have visible sores or lesions
- The species, sizes and numbers of fish currently stocked in the pond
- The species, sizes and numbers of fish that have died

Oxygen Problems

Turnovers are a common cause of low dissolved oxygen in ponds and can potentially lead to fish kills. Warm water is less dense and floats on top of cold water. This physical barrier to mixing, called stratification, is very strong and can essentially lock cold water in the bottom of a pond until the weather cools. Turnovers are the result of water temperatures within a stratified pond balancing and mixing. The cooler bottom layer of water, especially in deep ponds, is often lacking dissolved oxygen. When the warm oxygen-rich layer of water mixes with the oxygen-poor bottom layer, dissolved oxygen can be diluted to dangerously low levels and fish can be killed. Additionally, the decomposition of organic material that is released from the pond bottom during a turnover consumes oxygen as well. Ponds undergoing a turnover often turn milky grey or look muddy and can release hydrogen sulfide, a rotten-egg smelling chemical that is toxic to fish. Ponds more than 12 to 14 feet deep and protected from the wind are more prone to severe turnovers. Ponds typically recover from turnovers within a few days and return to their normal appearance.

The most common cause of major fish kills in ponds is low dissolved oxygen.

Signs of oxygen depletion include:

- Fish piping at the surface, especially in the morning
- A sudden fish die off, especially in the morning
- Most of the dead fish are large
- More than one species dead

Planktonic algae bloom die-offs are another common cause of low dissolved oxygen. Planktonic algae is often the primary producer of oxygen during the day and the primary consumer of oxygen at night in productive ponds. These blooms are highly susceptible to water quality changes and viruses. This can lead to sudden and rapid planktonic algae die-offs, resulting in large amounts of decomposing organic matter and insufficient oxygen production. Ponds experiencing a bloom die-off will abruptly change color. The before and after colorations are variable, but the change in appearance is usually obvious.

The first sign of low dissolved oxygen in ponds is fish "piping" at the water surface. Piping fish are sucking on the uppermost layers of water that contain the most oxygen. Piping fish that startle and dive when approached may be saved if aeration is provided quickly. Those that remain at the surface and lie listlessly when approached are usually beyond saving. Although fish are normally able to seek out areas containing higher dissolved oxygen, overly stressed fish are not likely to move towards aerators. Fish growing in commercial ponds containing permanent aerators learn to congregate around the aerators at night for oxygen. Sick fish sometimes show behavior similar to fish that are experiencing oxygen stress by congregating at the edges of the pond and the water surface. Diseases that

affect gill functionality can cause these behaviors even if oxygen is plentiful.

Factors that contribute to oxygen problems:

- Dense planktonic algae blooms or excessive plant growth
- Sudden planktonic algae die-offs
- Improper herbicide treatments
- High water temperatures
- Hot, calm and cloudy weather
- Strong storms triggering turnovers
- Excessive stocking and feeding
- Input of organic material such as hay, cotton-seed meal, manure or sewage

Early detection of oxygen problems is critical if emergency aeration is to be provided. Most fish die within hours in water containing less than 1.5 mg/L of dissolved oxygen. Prolonged exposure to sublethal oxygen concentrations, less than 5 mg/L, can lead to stress-induced diseases. Oxygen problems can be particularly painful for pond owners because the largest, and often most prized, fish are the first to die from low oxygen.

The only reliable means to quickly combat low dissolved oxygen in ponds is aeration. Some aerator designs work better than others, and there are differences in cost. Refer to Southern Regional Aquaculture Center publication 3700, *Pond Aeration* for more information (Appendix B-10) or contact University of Arkansas Cooperative Extension Service county agents for advice on aeration or where to locate aerator manufacturers (Appendix B-3). Purchasing an aerator is not required in order to have a successful fishing pond. However, aerators provide insurance against oxygen problems that can ruin several years of management efforts and expensive fish stockings.

There are several ways to reduce the chances of oxygen problems. Do not build ponds deeper than 12 to 14 feet. Deep ponds are useful for storing water but they do not produce more or bigger fish just by being deeper. In southern ponds, much of this deep water becomes unproductive during summer stratification and can lead to more severe turnovers in the fall. Monitor pond fertility to avoid excessive planktonic algae blooms, and do not feed in excess of 30 pounds per acre per day. Where the expense can be justified, place a small aerator on an all-weather timer and run it nightly from mid-May through mid-September. Allow buffer strips of vegetation to grow around the pond. This will slow and filter incoming water. If possible, prevent livestock from entering the pond. Muddy water and nutrient input from the livestock can substantially reduce water quality.

Muddy Ponds

Planktonic algae provide the base of the food chain in ponds. However, planktonic algae cannot grow in muddy ponds because sunlight does not penetrate far enough into the water. This is why fish production is usually poor in muddy ponds unless the fish are fed a complete diet.

In some ponds, bottom sediments are constantly stirred up but the pond stays clear because the particles quickly settle out. Other ponds experience very little disturbance or mixing but clay particles stay suspended in the water. The difference is usually because of water chemistry. Clay particles are small flakes with negative charges. They repel each other and are far too small to settle by gravity alone. In ponds with moderate to high water hardness, positively-charged calcium and magnesium ions are plentiful. These metal ions cause clay particles to stick together into larger clumps that settle to the bottom of the pond. Other charged particles that help clay settle come from the decomposition of plant material. In contrast, clay particles often remain suspended in water with low hardness.

Common ways that ponds become muddy:

- Rain washing mud in from non-vegetated shorelines and watersheds
- Wave-action that erodes shorelines
- Bottom-feeding fish such as common carp and bullhead

When faced with a muddy pond, the first step is to take a jar of pond water and set it aside for several days. If the mud settles and the water clears, it is likely that erosion on the watershed or something stirring up bottom sediments is responsible for keeping the pond muddy. Common carp and bullhead agitate bottom sediments searching for food. Livestock can also keep a pond muddy. If the water in the jar

Two important factors contributing to muddy ponds:

- The rate at which clay is agitated by bottom-feeding fish or wave-action, or washed into the pond by erosion on the watershed
- The rate at which clay particles settle out of the water

remains cloudy with suspended clay particles for several days, the water is likely very low in hardness. For more numerical results, water pH, hardness and alkalinity test kits can be purchased from pet stores and pool supply stores. Or, University of Arkansas Cooperative Extension Service county agents can test the water (Appendix B-3).

Preventing livestock from entering the pond, planting wide buffer strips of grasses along the shoreline and removing bottom-feeding fish species from the pond helps to reduce sources of muddy water. Chemical methods to clear ponds will help settle clay particles, but the effects are usually short-lived if the sources of the muddy water are not addressed first.

Most water-clearing treatments are only temporary unless the source of the muddy water is addressed.

Applying lime is one way to increase calcium and magnesium levels in ponds with low alkalinity and hardness. These ions will bind some of the clay particles together and sink them to the bottom. Although liming provides long-term benefits to ponds containing water with low alkalinity and hardness, agricultural lime is not very soluble, and applying it is unlikely to immediately clear a pond. Very finely crushed limestone dissolves more quickly than coarse forms. Other forms of lime, such as hydrated lime, are much more soluble but dangerous to apply in ponds that already contain fish. Refer to Pond Environment Management: Liming for more information.

Water quality conditions that slow clay settling:

- Low hardness
- Low pH
- New ponds with little algae or organic material

The addition of plant material may help to clear muddy water. Decaying organic matter creates weak acids that neutralize the charges of clay particles. This helps the clay settle to the pond bottom. However, the decomposition of organic matter also consumes oxygen. If too much organic matter is breaking down at once, dissolved oxygen can reach dangerously low levels and fish can be stressed or even killed. For this reason, treatments of organic matter should only be done in the spring or fall. Past studies suggest scattering two broken-up bales of green hay per acre, with two additional bales per acre every two weeks until a total of 10 bales per acre have been added. Alternatively, broadcasting 75 to 100 pounds per acre of cottonseed meal has also been recommended. These organic options do not always succeed and can introduce a high risk of oxygen problems.

Gypsum (calcium sulfate) and alum (aluminum sulfate) are used to clear muddy ponds. These chemicals are commonly used in water treatment facilities. They work by coagulating mud particles and forming clumps that settle to the pond bottom. Effective rates of alum are between 150 and 250 pounds per acre. However, alum destroys alkalinity and will likely kill fish if it is applied by itself into a pond with low alkalinity water. Simultaneously applying hydrated lime at one-half the rate of alum will counteract the alkalinity-destroying nature of alum. Both alum and hydrated lime can kill fish by themselves, so caution is advised when applying these chemicals. Gypsum is safer to use in low alkalinity ponds but a greater quantity is required, typically 1,000 to 2,000 pounds per acre. For further information on water-clearing methods, refer to Southern Regional Aquaculture Center publication 460, *Control of Clay Turbidity in Ponds* (Appendix B-10).

If the pond has a great deal of water flowing through it, limestone and organic matter will be flushed from the pond before water can clear. If this is the case, a diversion ditch to channel some of the water around the pond may be needed before any of these water-clearing treatments will work.

After the pond water has cleared, fertilization can help establish a planktonic algae bloom. Planktonic algae will help keep the pond clear and boost productivity. Only fertilize after the water has warmed to above 65ºF and never add fertilizer to a pond that is still muddy or to ponds that contain aquatic plants.

If all attempts to clear water have failed, or the recommendations are too expensive, there are ways to have a great fishing pond without clear water. Channel catfish and/or hybrid sunfish can be stocked into muddy ponds and provided floating fish feed. These ponds can be quite enjoyable and can even be less trouble than managing multi-species fisheries such as largemouth bass and bluegill ponds.

pH and Mineral Problems

After oxygen problems, the next most common cause of fish kills in private ponds is poor water chemistry. Ponds located in areas of acidic soil will usually have acidic water. Generally, if crop or pastureland near the pond requires limestone to be productive, the pond probably does too. Fish in acidic and low mineral water typically do not grow well and

Ponds in Arkansas that stay very clear usually have water chemistry problems.

are more vulnerable to environmental stressors, especially in the winter after rainstorms. Ponds that are consistently muddy or clear, and ponds that contain a few dead fish of various size and species each day, likely have poor water chemistry.

One of the best recommendations for any pond owner is to have the pond water tested for alkalinity. Test kits are available at pet stores, pool supply stores or University of Arkansas Cooperative Extension Service county agents can test it (Appendix B-3). Ponds with less than 20 mg/L water alkalinity can usually benefit from liming. The best time to lime is in the fall, and most ponds will need re-applications of lime about every four years. Refer to Pond Environment Management: Liming for more information.

Signs of water chemistry problems:

- Pond is in a region with acidic soil
- Pond water is very clear, tea-colored or always muddy
- Fish die in the winter, especially after rainstorms
- Various sizes and species of fish are dead

Leaky Ponds

As the heat of summer arrives, water levels begin to drop in most ponds. Owners often get suspicious that their ponds are leaking when it is simply evaporation. A plastic ruler attached to a rigid structure within the pond can be used to measure water level changes. Record the initial level, then measure the level again after a week without rain. Summertime evaporation rates are usually around ¼ inch per day. Normal seepage into the soil will also be around ¼ inch per day in most ponds. Ponds with very high amounts of clay in the soil may not lose any water to seepage. When evaporation and seepage are combined, the typical Arkansas pond will lose about ½ inch of water per day during the summer.

The typical Arkansas pond will lose about half an inch of water each day during the summer.

If a pond is truly leaking, inspect the dam for obvious signs such as wet spots and holes. Ponds built too deep, through outcroppings of porous rock, over soil with too little clay or over soil that was not properly compacted are at risk of leaking.

Fixing a leaking pond can be extremely expensive. Simply reworking and properly compacting a pond can cost $300 to $1,000 per acre. Adding the minimum rate of bentonite clay will cost $3,500 to $4,000 per acre for the clay alone. For more information on addressing leaky ponds, refer to Southern Regional Aquaculture Center publication 105, *Renovating Leaky Ponds* (Appendix B-10). The Natural Resources Conservation Service is another resource to contact for experienced pond engineers (Appendix B-4). Private pond construction companies are another option for assistance.

Chemicals

Accidental overspray of chemicals is not likely to kill fish in ponds. It would take an applicator spraying directly into the pond or allowing strong wind to blow a great amount of the chemical into the pond for there to be a problem. While certain insecticides are quite toxic to fish, very few herbicides will kill fish even if the pond is sprayed directly. Large amounts of runoff from a large land area treated with insecticide into a small pond might cause problems. If a chemical is suspected, contact the Arkansas Plant Board and describe the problem and what chemicals may have been involved (Appendix B-6). Accidental overspray from an adjacent cropland is also the responsibility of the Arkansas Plant Board (Appendix B-6). Although pesticides can kill fish, they are one of the least common causes of fish kills in ponds.

Parasites

Parasites can disfigure fish and make them unappetizing. Although unsightly, these parasites are only harmful to fish at very high concentrations. They also pose no danger to humans as long as the fish are cooked properly. Chemical treatments to remove the parasites are not practical in private ponds. Maximizing water quality, controlling aquatic plants and only stocking fish from reputable fish hatcheries will help to reduce parasite loads.

Grubs

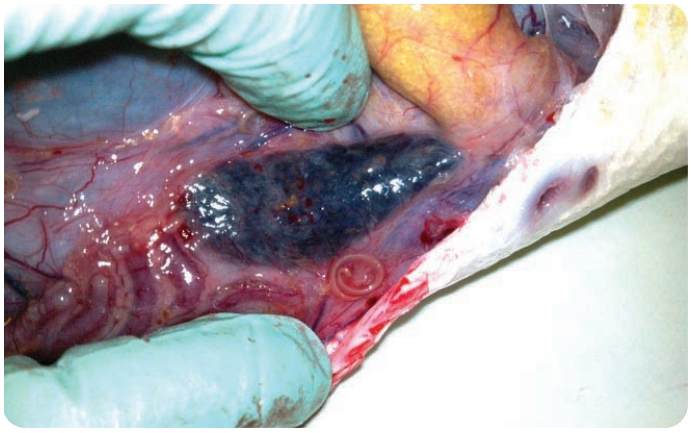
White, yellow and black grubs are parasites that insert themselves into the skin, muscle or internal organs of fish. Grubs tend to form circular cysts. These parasites have a complex life cycle requiring fish,

Image courtesy of Andrew Goodwin, U.S. Fish and Wildlife Service.

snail and bird hosts to survive. The only practical way to deal with grubs is to break their life cycle. Redear sunfish feed heavily on the snails that grubs require to survive. Stocking about 100 redear sunfish per acre can help control the snails. Controlling aquatic vegetation can also help reduce snail populations. Once these control methods are in place, the number of grubs in fish will begin to decline. Grub problems are most common in clear ponds with plentiful aquatic plant growth.

Nematodes

Nematodes are small round worms that can be from ¼ to 1 inch long. They are commonly found coiled up around the fish's internal organs or in the liver. Some species can inhabit the skin or muscle. There are no practical treatments for nematodes. Methods to maximize water quality and fish health will help to prevent nematode problems.



Anchor Worms

Anchor worms are actually crustacean relatives of crab and shrimp, not worms. They typically look like short, stiff, black or green/gray threads protruding from red spots on the fish's skin. They are more common in ponds that contain high numbers of susceptible species, such as carp, minnows and green sunfish. Anchor worms rarely cause problems with largemouth bass or catfish. There are no practical treatments for anchor worms. Luckily, these parasites have short and simple life cycles, usually disappearing within a few months of the onset of a severe infestation.

Other Diseases

Bacterial and viral infections rarely cause major fish kills in private ponds. Sick fish tend to get eaten before they can spread potentially dangerous pathogens to other fish. However, if fish are dying for any reason, it never hurts to give local University of Arkansas Cooperative Extension Service county agents or the University of Arkansas at Pine Bluff Fish Disease Diagnostic Laboratories a call to help determine the cause (Appendix B-3, B-1).

Stocking wild fish into private ponds can sometimes introduce pathogens that hatchery-raised fish are not familiar with. This can potentially lead to fish kills or unappetizing parasite infestations. It is best to only stock fish from certified fish hatcheries to ensure healthy fish populations, especially when a great deal of time, money and effort has been spent to build a certain type of fishery.

Mosquito Control

Mosquito larvae live in water and many pond owners worry that their backyard ponds increase mosquito numbers. In truth, most small fish love to eat mosquito larvae. Therefore, ponds with healthy populations of bluegill, fathead minnows and other small fish are not likely to produce a great number of mosquitoes. The majority of mosquitoes are born in small temporary puddles that do not support fish.

Acknowledgements

The authors recognize the contributions of the authors of previous Arkansas farm pond management guides:

Goodwin, A., J. Jackson, N. Stone, T. Burnley, J. Farwick and M. Armstrong. 2004. *Farm Pond Management for Recreational Fishing*, MP360. Cooperative Extension Program, University of Arkansas at Pine Bluff.

Killian, H. S., M. Armstrong, J. Hogue and S. Lewis. 1999. *Farm Pond Management for Recreational Fishing*, MP360. Cooperative Extension Program, University of Arkansas at Pine Bluff.

Killian, H. S., M. Armstrong, J. Hogue and S. Lewis. 1996. *Farm Pond Management for Recreational Fishing*, MP360. Cooperative Extension Program, University of Arkansas at Pine Bluff.

Cline, D. J. and H. S. Killian. 1992. *Farm Pond Management for Recreational Fishing*, MP360. Cooperative Extension Program, University of Arkansas at Pine Bluff.

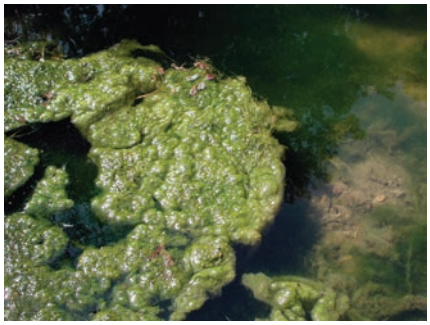
Gray, D. L. 1987. *Farm Pond Management*, EL248. Cooperative Extension Service, University of Arkansas.

Brady, P. M. 1981. *Pond Management for Sport Fishing in Arkansas*. USDA Soil Conservation Service, Little Rock, Arkansas.

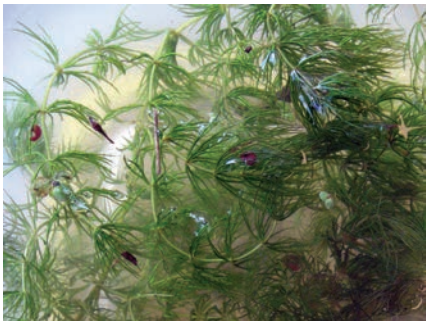
Appendix A – Common Aquatic Plants in Arkansas

This section contains photographs and descriptions of aquatic plants common to Arkansas. Many of these plants may look slightly different in person than the photos representing them below. It is best to use this section as a quick reference guide before contacting University of Arkansas Cooperative Extension Service county agents to confirm the identification (Appendix B-3). More aquatic plant identification resources can be found online (Appendix B-11-12). Several photos were donated courtesy of John Boyd and Jerry Roach. Photos labeled with asterisks were used with permission from Texas A&M AgriLife Extension Service, http://aquaplant.tamu.edu. Red labels indicate that the plant is nonnative. Efforts should be made to prevent the spread of nonnative species.

1. Planktonic algae



2. Filamentous algae



3. Chara

4. Nitella

5. Alligator weed

6. Water primrose

7. Parrot feather

8. Water pennywort

9. Sedges

10. Bulrushes

11. Cattail

12. Water willow


13. Smartweed

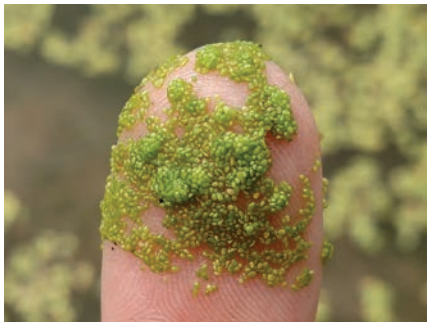

14. Arrowheads


15. Lizard's tail

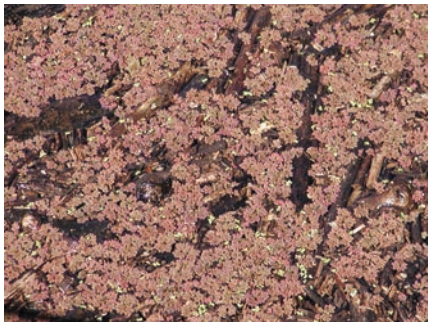

16. Waterleaf


17. Common reed


18. Duckweed


19. Watermeal


20. Water hyacinth


21. Water fern

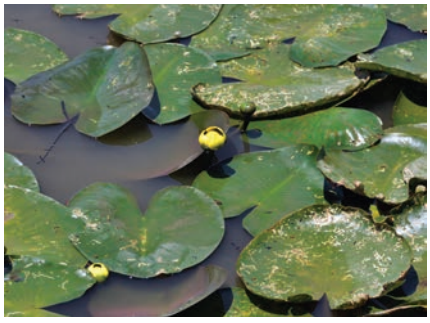

22. Giant salvinia


23. Frog's bit


24. American lotus


25. Fragrant water lily


26. Watershield


27. Spatterdock

Appendix A – Common Aquatic Plants in Arkansas *(cont.)*

28. Hydrilla

29. Canadian elodea

30. Egeria

31. Coontail

32. Southern naiad

33. Slender naiad

34. Eurasian watermilfoil

35. Eelgrass*

36. Fanwort

37. Sago pondweed

38. Illinois pondweed*

39. Variable leaf pondweed

Algae

1. **Planktonic algae** are the microscopic plants that at high concentrations can make water appear green. Planktonic algae blooms can be red, black or green. These blooms can also leave an oily or scummy appearance on the water surface.
2. **Filamentous algae**, also called moss, can blanket pond bottoms and clumps of it can float to the surface, creating dense dark to lime green mats.
3. **Chara**, also called stonewart, often mimics higher aquatic plants but it is actually an alga. Chara forms widespread submersed beds. It is rough to the touch and typically has a garlic-like musty odor.
4. **Nitella** can be distinguished from similar-looking chara by its smooth bushy branches and lack of musty garlic-like odor.

Emergent

5. **Alligator weed** is a nonnative plant that often forms very dense stands or mats that can make shoreline access difficult. The hollow stems can be single or branched. The leaves are opposite, long, oval or lance-shaped, ¾ inch wide and 5 inches long with a prominent midrib. The flowers are small (about ½ inch in diameter), white and fragrant on long branches resembling white clover.
6. **Water primrose** stands erect along the shoreline but can form long runners that float out across the water surface. Leaves range from willowlike to round or oval, 1 to 2 inches in diameter. The leaves range from green to reddish, depending on the species. The single flowers are yellow with four or five petals.
7. **Parrot-feather** is a nonnative plant that gets its name from the pale green to gray-greenish thickly bunched leaves that emerge from the water. The exposed leaves are in whorls of three to six and are divided into narrow frilly segments, giving it a featherlike appearance.
8. **Water pennywort** usually forms dense mats along shorelines, but it can form large floating mats or islands. Leaves are up to 2½ inches in diameter, dark green and round with blunt indentations rising from a center stem. Tiny white to greenish-white flowers with five petals arise from a single point on the stalk.
9. **Sedges** are difficult to identify without using detailed botanical keys. Sedges resemble grasses, grow in shallow water or moist soil and can reach 4 feet in height, often growing in thick clusters. Sedges usually have solid triangular stems and have sheathed or bladed leaves.
10. **Bulrushes** are grasslike plants that can grow to 10 feet tall. Bulrushes have a soft, round and pointed stem that is light gray-green in color with no obvious leaves.
11. **Cattails** get their name from their brown cylindrical flower spikes that can be more than 6 inches long. Stems can grow to 9 feet tall. The leaves are bladelike with rounded backs and sheathed together at their base to appear flattened.
12. **Water willow** often forms dense colonies along shorelines. The stems do not usually branch and have prominent whitish lines. The leaves are opposite, long and narrowly tapered (up to inches 6 long and ½ inch wide) with smooth edges and a distinct whitish midvein. The flowers have long stems starting at the base of the leaves. Flowers are orchidlike with five white petals featuring purple/violet streaks on the lower petals.
13 **Smartweed** can grow up to 3 feet tall and form dense colonies in shallow water or in wet areas. Stems are jointed at internodes surrounded by a tubular sheath. Roots can develop from the leaf nodes. Leaves are alternate, lance-shaped and up to 4 inches long but usually less than ½ inch wide. Flowers are green and then turn white or light pink as they mature. Flowers are spike shaped and drooping.
14. **Arrowheads** grow in shallow water or in wet areas. Leaves grow in clusters from rhizomes and can be over 4 feet tall. Leaves range from narrow and grasslike to the three-pointed arrowhead shape. Leaves are long and spongy with a milky-like fluid when broken. Flowers grow on separate stalks above the water in groups of three. Flowers have three white to light pink petals.

15. **Lizard's tail** forms colonies from spreading rhizomes. Stems are hairy with few or no branches growing up to 4 feet tall. Leaves are usually heart-shaped, 2 to 5 inches long and 1 to 3 inches wide. Flowers grow on long hairy stems opposite the top leaf. The flowering structure consists of a spike of many small whitish flowers that forms an arching, tail-like shape. Lizard's tail has a distinctive orangelike smell.

16. **Waterleaf** can reach 3 feet tall, growing from shallow water and moist soil. These plants have large thorns growing from the bases of their oval to lance-shaped leaves. Flowers often grow in clusters with deep blue to purplish-blue petals.

17. **Common reed** is a canelike grass that commonly grows from 12 to 16 feet tall, forming dense stands. Stems are round and hollow with flat leaves along their length. Leaves are up to 24 inches long, 2 inches wide and gradually taper to a point. The multi-branched flower is at the end of the stem and can be up to 16 inches long. The flower is brown, purplish or silvery with silky hairs along the axis giving the flower a silky appearance.

Floating

18. **Duckweeds** form dense blankets that cover the surface of still water. Duckweeds range in color from light green to dark green and they have flattened leaflike structures with hanging roots.

19. **Watermeal** is the smallest and simplest aquatic plant. Watermeal is a rootless plant that looks and feels like green cornmeal. Watermeal forms dense blankets that cover the surface of still water and is often associated with duckweed.

20. **Water hyacinth** is a nonnative plant that forms large floating masses. Water hyacinth has deep green leathery leaves with inflated spongy stems and feathery roots. The flower consists of 5 to 20 light purple to blue flowers with the upper petals having a pronounced yellow spot.

21. **Water fern** fern is a true aquatic fern. It has small clusters of overlapping velvety leaves with slender unbranched roots. The color varies from grey-green to reddish-green when mature.

22. **Giant salvinia** is a nonnative fern that forms mats that can be 3 feet thick. The leaves are generally seen in whirls of two with two opposite leaves that lie flat on the surface and a third submersed leaf that is highly modified into feathery roots. The leaves are light to medium green with long brownish hairs on their surface.

23. **Frog's bit** has several forms ranging from small rosettes to small ½- to 1¼-inch heart-shaped leaves with reddish-purple spongy cells on the underside of the leaves to emergent leaves 2½ to 8 inches long when mature. The mature form of frog's bit is often mistaken for water hyacinth.

24. **American lotus** is a native plant with large round leaves that may be floating or emergent arising from a single stem. The leaves are bluish-green to grayish-green in color. The flowers are pale to golden yellow, 4 to 10 inches wide, solitary and usually several feet above the water's surface.

25. **Fragrant water lilies** have round leaves with a deep notch. The top of the leaf is green and the underside is usually purplish. The flowers float on the water, are yellow or white and are very fragrant.

26. **Watershield** has a football- or kidney-shaped green leaf with a reddish-purple underside. All submersed parts of the plant are covered with a thick jelly-like substance.

27. **Spatterdock**, also called yellow cow lily, can have leaves that float, are submersed or emergent. The leaves are spade shaped with a deep notch and can range in color from dull to bright green. The flowers are small, round and yellow in color.

Submersed

28. **Hydrilla** is a nonnative plant. The leaves are oblong with sharply serrated edges; the underside usually has one or two toothlike structures on the midrib making the leaves rough to the touch. The leaves are green and grow in whorls of three to eight. The flowers grow from upper branches, are less than ¼ inch in diameter and are translucent to white in color.

29. **Canadian elodea** is similar to Brazilian elodea and hydrilla. The leaves are oblong, bright green, grow in groups of three and are smooth to the touch. Flowers are small with white petals on a single long stem.

30. **Egeria** is nonnative and similar to Canadian and Brazilian elodea and hydrilla. The leaves are oblong, bright green, grow in whorls of four (but may have whorls of three to six) and are smooth to the touch. The flowers have three white spreading petals.

31. **Coontail** is a rootless, submersed plant that can grow 15 feet tall, or more, and form large dense colonies. The stems are elongated, branched, readily fragmented and very rough to the touch. The leaves are in whorls of five or more that get closer together towards the tip of the branches, resembling the tail of a raccoon.

32. **Southern naiad** stems are branched and can grow several feet long. The leaves are opposite, narrow, linear and the bases sheathe the stem. The stem sheath has five to eight teeth along each side.

33. **Slender naiad** is similar to southern naiad. The leaves are opposite, linear, 1 to 1½ inches long with 7 to 15 marginal teeth and bases sheathe the stem with five to eight teeth on each side.

34. **Eurasian watermilfoil** is a nonnative plant and is distinctly different from other watermilfoils. The leaves are usually bright to dark green in whorls of four, with at least 12 segments resembling a feather.

35. **Eelgrass** is a rooted plant with ribbonlike basal leaves that can grow 7 feet long. The leaves are thin and veined, lacking a midrib. The white flowers grow from the base of the plant and rise to the surface on long, slender and coiled stems.

36. **Fanwort**, sometimes called Cabomba, has many flattened stems winding alternately from side to side. The leaves are soft, opposite and repeatedly divided into equal parts resulting in a fanlike shape. The color of the stems, leaves and flowers ranges from green with cream or white flowers to reddish-purple with pink to light purple flowers.

37. **Sago pondweed** has no floating leaves. The stems are thin, long and highly branched with very thin and filament-like leaves (about 1/16 inch wide) and can grow over 12 inches long, tapering to a point. The leaves grow in thick layers and originate from a sheath.

38. **Illinois pondweed** has mostly submersed leaves. A few floating leaves may be present in an alternate pattern but are absent most of the time. The leaves are bladelike. Submersed leaves are 1 to 7 inches long and 2 to 3 inches wide.

39. **Variable leaf pondweed** has both floating and submersed leaves. Floating leaves are leathery, elliptical and grow up to 1½ inches long and ¾ inch wide. Submersed leaves are much thinner and threadlike, usually up to 2¼ inches long and only ⅛ inch wide.

Appendix B – Helpful Resources

Online Resources and Directories

1. University of Arkansas at Pine Bluff Aquaculture and Fisheries Center
   http://aqfi.uaex.uada.edu/

2. University of Arkansas at Pine Bluff Farm Pond Management Website
   http://aqfi.uaex.uada.edu/extension/farmponds/Pond_Management/default.htm

3. University of Arkansas Cooperative Extension Service County Offices
   http://www.uaex.uada.edu/counties/

4. USDA Natural Resources Conservation Service Centers
   http://offices.sc.egov.usda.gov/locator/

5. Arkansas Game and Fish Commission
   http://www.agfc.com/

6. Arkansas Plant Board
   http://plantboard.arkansas.gov/

7. Arkansas Natural Resources Commission
   http://anrc.ark.org/

8. Arkansas Department of Environmental Quality
   http://www.adeq.state.ar.us/

Downloadable Publications

9. University of Arkansas Cooperative Extension Service
   Publications http://www.uaex.uada.edu/publications/

10. Southern Regional Aquaculture Center Publications
    https://srac.tamu.edu/

Online Aquatic Plant Identification Resources

11. Texas A&M University AQUAPLANT
    http://aquaplant.tamu.edu/

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

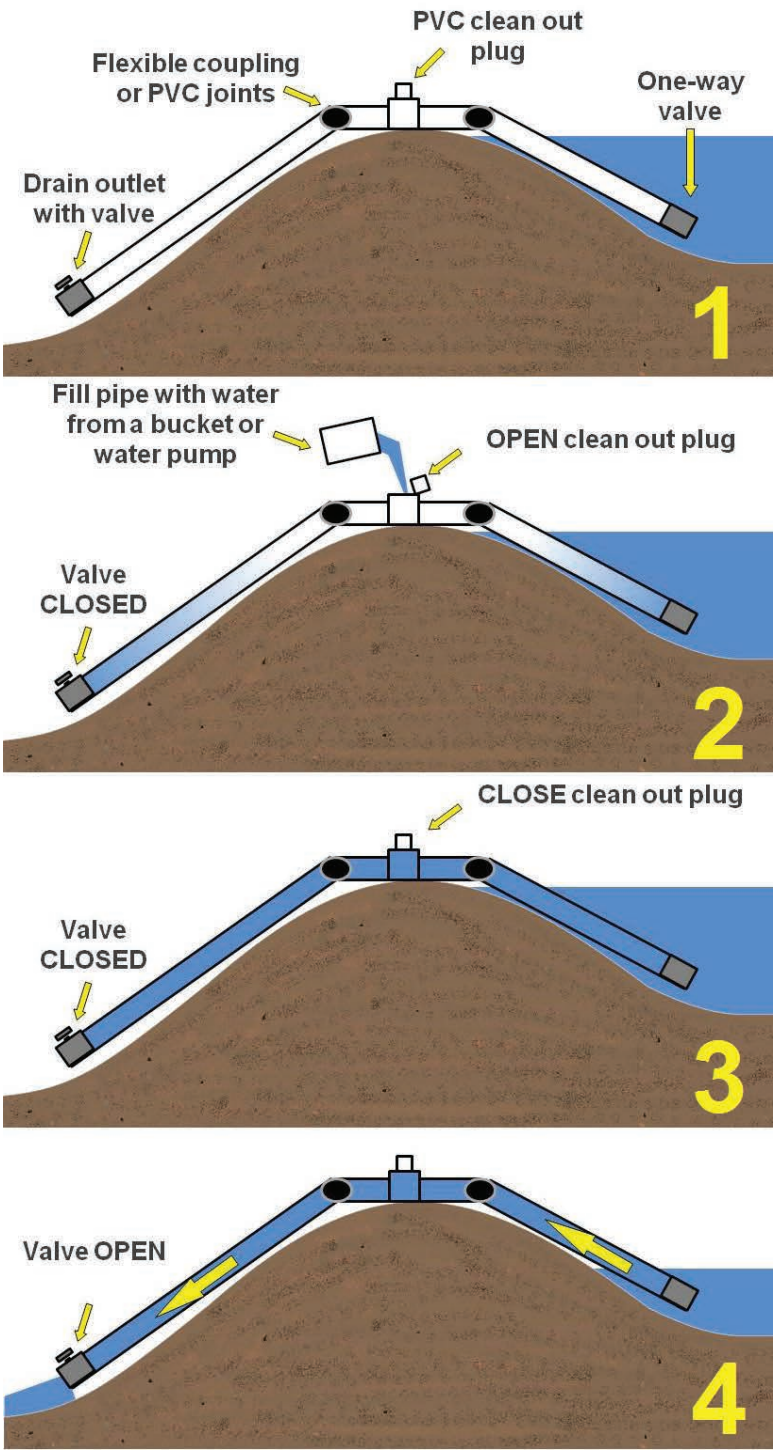
Appendix C – Homemade Pond Siphon

Few older ponds have draining systems installed, or they are in disrepair and are no longer functional. Many pond management activities can be greatly simplified by being able to regulate water level. For ponds that do not have functioning drain systems, there are alternatives. Owners can either rent water pumps, or they can build their own siphon systems with simple PVC plumbing parts.

This diagram describes the needed parts and how to assemble them. It is a good idea to install a trash guard around the one-way valve that will be submerged in the pond to prevent clogging from large debris. The system must be completely airtight to function properly. Also, be mindful of erosion below the drain valve. Place a plastic sheet, rocks or other hard surface on the ground beneath the drain outlet to protect exposed soil from erosion.

Siphon drains rarely empty ponds completely. If the pond is being drained for total renovation, a fish poison will be needed to eliminate fish from the remaining puddles. This design is meant to be inexpensive and for temporary use. If a permanent, automatic siphoning system is desired, it is best to contact the Natural Resources Conservation Service for advice and designs on building one into the dam (Appendix B-4).

Homemade Pond Siphon



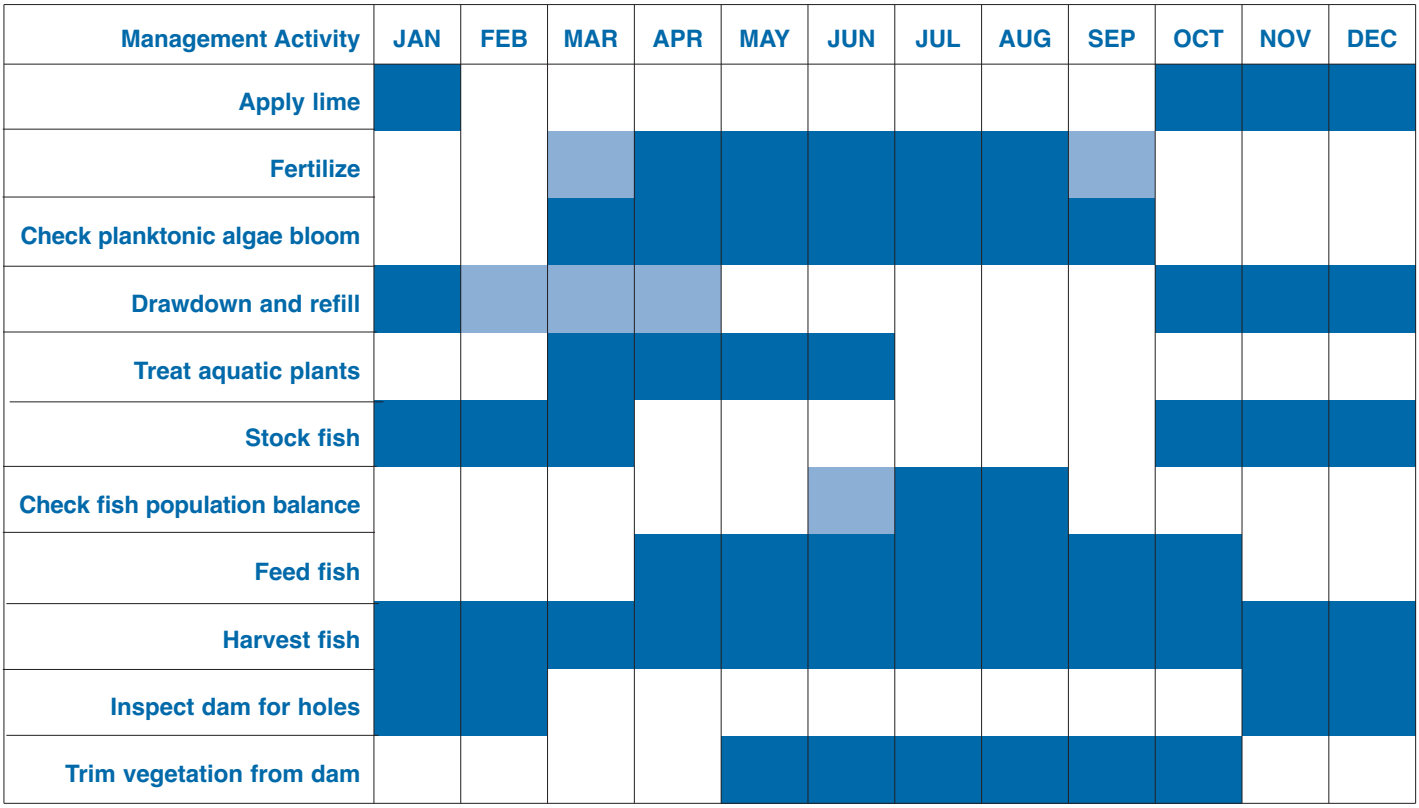
Appendix D – Angler Catch Log

All fishing effort should be recorded. Provide date, length of time fished, number of people who fished and initials for every trip. If no fish are caught, record a zero under species. If fish are caught, record how many fish were either harvested (H) or released (R) for each species size group.

Date	Length of time fished	Number of people who fished	Initials	Largemouth Bass						Bluegill				Catfish			Other Species Caught	
				< 12”		12 to 15”		> 15”		3 to 6”		> 6”		# Caught				
				H	R	H	R	H	R	H	R	H	R	Length	H	R	Species	# Caught

Appendix E – Arkansas Farm Pond Management Calendar

Managing a pond for good fishing is a year-round task and timing is often critical to the success of management activities. This calendar can help pond owners schedule management activities for the entire year. Not all of these activities need to be performed every year, and some may not be appropriate for all ponds. Dark-shaded areas are the months when management activities should be performed. Lightly-shaded areas indicate when management activities may be performed during years with abnormal weather. Drawdowns should begin around October and begin refilling around February.



UNIVERSITY of ARKANSAS AT PINE BLUFF 1873™

School of Agriculture, Fisheries and Human Sciences

Cooperative Extension Program

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MP360-PD-3-2016RV

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