Penn State **Extension**

Management of Fish Ponds in Pennsylvania

PENNSTATE
1855
Cooperative Extension
College of Agricultural Sciences

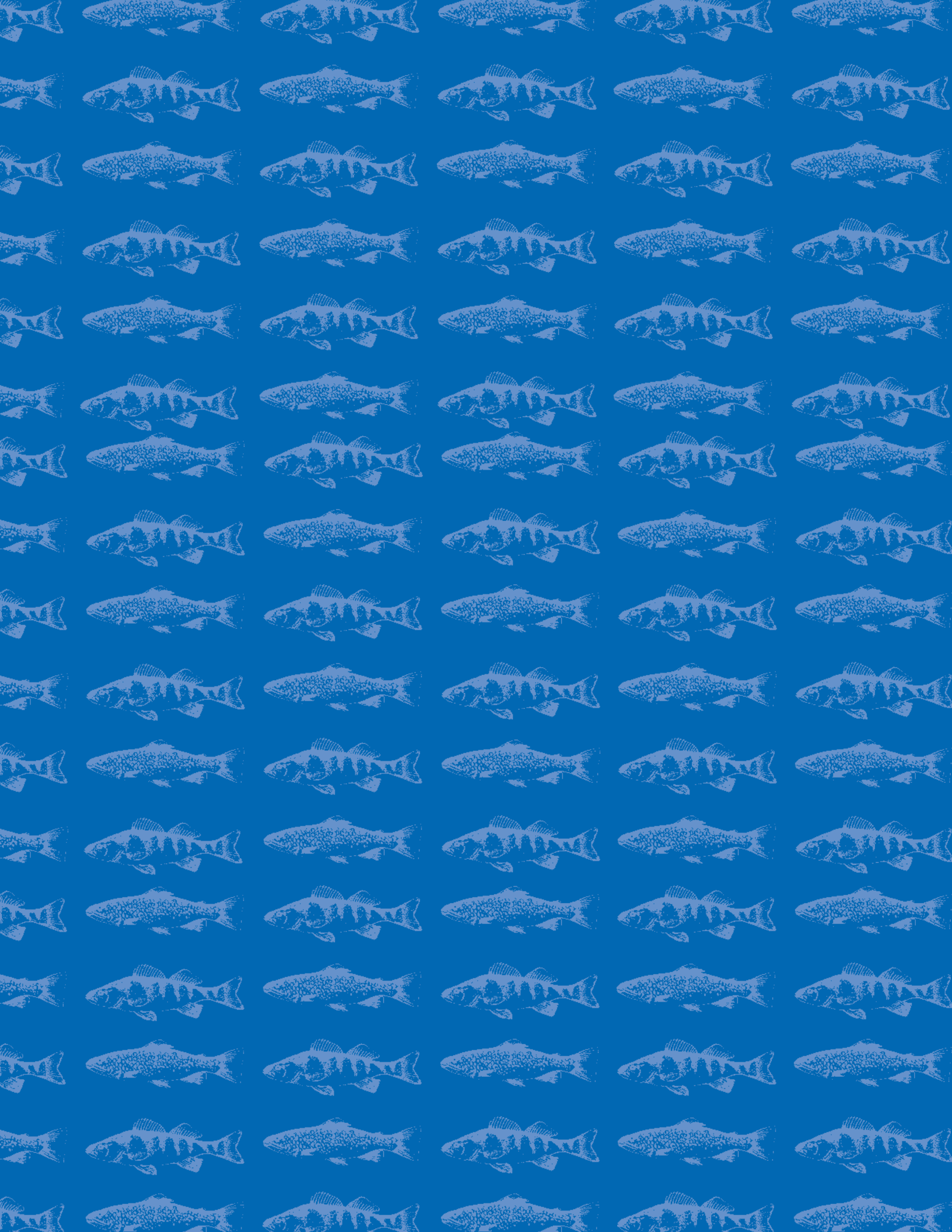


Table of Contents

About This Publication

Ponds are a common feature of Pennsylvania's landscape. Although they occur naturally in some parts of the state, thousands also have been constructed for a variety of purposes. Many were built under the technical supervision of the United States Natural Resources Conservation Service (formerly the Soil Conservation Service), largely to assist farming operations. In more recent years, the recreational uses of ponds have become more important to pond owners.

Regardless of a pond's intended use, its management can be difficult and complex. Even with careful planning, many ponds do not meet the objectives of their owners or serve their intended purposes. Fortunately, management techniques are available to help you deal with almost any pond problem.

The purpose of this publication is to provide general information about a wide variety of pond management principles applicable to Pennsylvania. It is not intended to be a complete or exhaustive guide. References are given in the text to more comprehensive publications and web pages where they are available.

Although some generalizations can be applied to pond management, each pond is unique and may require specific treatment to achieve a desired result. When the general recommendations of this publication appear to be inadequate, you are encouraged to seek additional professional assistance.

Where to Get Help with Pond Management

Assistance with pond management is available from a variety of sources. In addition to local extension offices, local offices of the Natural Resources Conservation Service (NRCS), Pennsylvania Fish and Boat Commission (PFBC), and Pennsylvania Department of Environmental Protection (DEP) may be able to advise pond owners. Often, consultants are hired to implement major pond management practices. The agencies listed below or your local Yellow Pages may be able to direct you to local pond consultants.

Sources of Assistance

PA Fish and Boat Commission
Phone: 717-705-7800
Check phone book for local number.
www.fish.state.pa.us

PA Department of Environmental Protection
Phone: 717-783-2300
Check phone book for regional office.
www.dep.state.pa.us

Natural Resources Conservation Service
Phone: 717-237-2200 (Pennsylvania office)
Check phone book for local office.
www.nrcs.usda.gov

Penn State Extension
Check phone book for local office.
extension.psu.edu/water/ponds

Developing Objectives for Your Pond

You may have a wide variety of reasons for building or owning a pond. The first and most important step of proper pond management is choosing your primary objective or use for your pond and understanding the limitations this will place on other uses of the pond. For example, small ponds today are commonly used to aesthetically enhance the landscape, but their relatively simple construction may not provide the best facilities for other activities like swimming, boating, and fishing. The importance of establishing objectives for the projected uses of a given pond cannot be overemphasized. Careful consideration of use compatibility and use priorities is essential in planning a new pond.

In dealing with an existing pond, you will need a slightly different approach. Make an appraisal, or have one made, that describes the existing pond and its potential for management. For example, if the water quality is unacceptable for trout, it would be pointless to spend a great deal of time developing a plan with a trout fishery as the objective. Recognize the limitations of the resources available, then develop objectives and plans that fall within these limitations. This will make management of the pond easier, less costly, and more satisfying and rewarding.

Ponds are frequently used in several ways to satisfy more than one objective. For example, having water available in the pond for fire protection usually does not conflict with other objectives such as swimming or fishing. Multiple-use ponds are fine as long as the uses are compatible. When conflicting or incompatible uses are desired, you must assign priorities to your objectives. For example, the objective of providing for swimming may conflict directly with the objective of having water available for irrigation. Irrigation needs may lower the water level to a point where swimming is impossible, at a time when it is most wanted. If this occurs, you must decide which objective is most important. Sometimes planning and management can eliminate or at least reduce these conflicts. This is one reason for listing and prioritizing specific objectives.

Table 1. The most common primary uses of ponds, from a survey of 557 pond owners throughout Pennsylvania.

Pond Use	Percent of Respondents
Aesthetic Beauty	45
Fishing	21
Wildlife Habitat	11
Swimming	7
Animal Drinking Water	6
Fire Protection	6
Irrigation	1
Other	3

Planning a New Pond

When deciding where to locate a new pond on your property, you should consider several critical factors. These include topography, land use, soil texture, and water supply. In some cases, these factors may limit the pond location to one site. Where these factors are equally satisfactory at several locations, appearance and convenience will play a role in site selection.

For example, a pond located near a house, where it can be observed frequently and conveniently, is safer and more desirable for family recreation. It can be used as a source of water for fire protection or for irrigating a small garden. Road access to the pond is important if it is to be used for fire protection, so fire trucks can drive to within 15 feet of the water.

The size of the pond will be determined by the site characteristics and money you want to spend on construction and maintenance. Keep in mind that small ponds are not easy to manage for fish. Normally, ponds of less than ¼ acre in surface area are too small for effective management of warmwater fish. Ponds as small as $\frac{1}{10}$ acre in surface area may be suitable for trout, however, if they have appropriate water quality.

The Pond Watershed

The area of land surrounding the pond that contributes water to it is known as the pond watershed. Understanding the pond watershed is important, because anything that occurs within this area can affect the pond. Locating a pond in an undisturbed area or minimizing disturbance and land use changes within the pond watershed are important components of managing a pond.

The ideal topography for a pond watershed is a natural depression or a broad drainage with a narrow neck at its lower end where only a short dam will be needed. The most economical site is one that will require the smallest dam and the least amount of work for the size of the pond created. Small ponds collecting runoff from large drainage areas require expensive overflow and spillway systems to handle water safely.

Soil texture must be considered when selecting the pond site. The bottom of the pond, the banks, and the earth fill placed in the dam must contain enough clay or silt to prevent seepage and make the reservoir hold water. Normally, areas that include exposed bedrock or beds of sand or gravel are not satisfactory. Anyone who is considering building a pond should have the soils and geological conditions in the area checked by a professional consultant knowledgeable and competent in making site investigations.

Water Supply

Springs, seeps, and small streams are typically the best sources of water for ponds. They usually provide cool and relatively clean water suitable for most pond uses. If an obvious water supply is not available, direct surface runoff from the surrounding land can be the primary source of water to maintain the level of a pond. The drainage area should be large enough to ensure that the combined surface runoff and subsurface seepage are adequate during even the driest years. Normally, a drainage area of 10 to 20 acres yields sufficient water for a one-acre pond in Pennsylvania.

Land use around the water supply is critical in determining the water quality of the pond. All sources of water contributing to the pond should be free of sediment, pesticides, and other forms of pollution. It is generally a good idea to establish a buffer strip of vegetation around the pond to trap sediment and keep it out of the water. Ponds also commonly suffer from excessive amounts of nitrogen and other nutrients. These nutrients often originate from animal or human waste or fertilizers from nearby barnyards, crop fields, and septic systems. Drainage from these areas should be diverted away from the pond, since too much nitrogen and other nutrients will cause excessive growth of weeds and algae.

Construction Permits

Permits for the construction of ponds or dams may be required, depending on the size of the drainage area, the height of the dam, and the capacity of the impoundment. A permit is required for the construction of any dam that impounds the runoff from a drainage area that exceeds 100 acres or provides a maximum storage capacity of 50 acre-feet of water (about 16.3 million gallons). A permit also is required for any pond with a dam more than 15 feet high, even if the pond's only source of water is a spring, a well, or a small pipeline from a stream. Permits are not required for ponds that do not exceed these specifications.

Contact your local Pennsylvania DEP office for more information and to obtain the necessary permit application. The office telephone number and location can be found in the state government pages of your local phone book.

Safety and Liability Concerns

Safety and liability are legitimate concerns of all landowners, and ponds create an additional reason for concern. Ponds may pose a downstream threat, and consequently the aforementioned permits are required to ensure proper construction.

Ponds, like any body of water, attract people. When the two come together, accidents sometimes can occur. Consider safety features when planning your pond. Remove trees, stumps, and brush that may be a hazard to swimmers. Keep the pond and banks free of rubbish, wire, cans, bottles, and other debris. After the pond is built and filled with water, mark the swimming area and post safety rules for all permitted water uses. Place warning signs at all known danger spots. If boating and swimming are permitted, consider building a dock or pier. Place lifesaving devices such as ring buoys, ropes, or long poles near swimming areas.

Although many pond owners willingly allow use of their land and water areas for varied recreational purposes, liability for accidents is a justifiable concern. To address this issue, Pennsylvania enacted a law that has as its purpose "encouraging landowners to make land and water areas available to the public for recreational purposes by limiting liability in connection therewith, and repealing certain acts." This law generally limits landowner liability, except for "willful or malicious failure to guard or warn against a dangerous condition, use, structure, or activity." Liability also is not limited when fees are assessed for recreational uses such as fishing, regulated shooting, campsite rentals, and other for-fee activities.

In addition to the protection offered by this law, most landowners carry comprehensive liability insurance on their property. Some pond owners also choose to restrict access to their pond by posting signs prohibiting tresspassing. You should consult with an attorney and an insurance agent for proper legal interpretation and protection for the specific circumstances involved with your pond.

Design

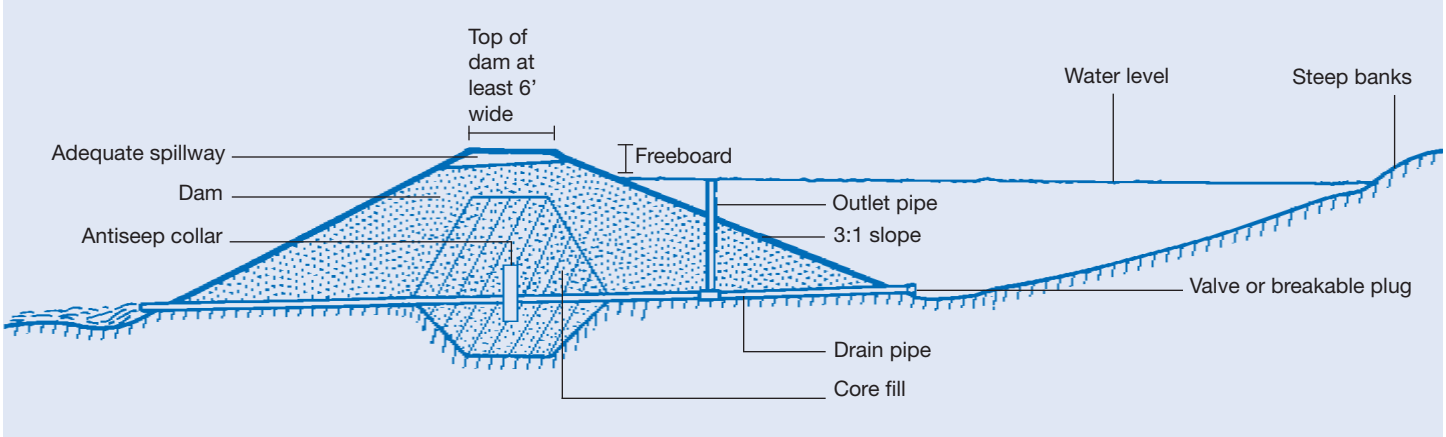
Ponds designed and constructed according to recommended standards are relatively safe, easy to manage, and fairly economical to build. Ponds constructed haphazardly are unsatisfactory and difficult to maintain. It pays to obtain information and expert advice before you start construction. This section briefly discusses the basic components of a well-designed pond.

For More Information on Pond Design, Construction, and Maintenance

Look in the U.S. Government pages of your phone book for your local Natural Resources Conservation Service office. Request Agriculture Handbook Number 590, *Ponds—Planning, Design, Construction*. This 85-page color publication gives detailed information on proper pond design and construction, including detailed illustrations.

This publication is also available online at the Penn State Extension pond website, **extension.psu.edu/water/ponds**.

Figure 1. Pond construction.



Top Width and Side Slopes of Dam

The top width of the dam depends on the height of the structure. In most cases, the dam should be wide enough to permit limited use as a roadway for vehicles. The minimum top width should be 6 feet if the dam is less than 10 feet tall. The minimum top width increases to 14 feet for a dam that is over 25 feet tall.

All earth dams should be constructed with side slopes stable enough to prevent erosion and keep the earth fill in place. In most instances, a slope of 3 feet horizontal to 1 foot vertical (3:1) on both the upstream and downstream faces of the dam will be satisfactory. Under no circumstance should either face of the dam or any excavated slope be steeper than 2:1. Proper slope is especially important in the shallow edges of the pond. Water should be at least 3 feet deep at a point 6 feet out from the shoreline to discourage growth of algae and aquatic weeds. Experience indicates that it is best to slope the banks properly at the time of construction.

Emergency Spillway

An emergency spillway is necessary to provide a safe overflow outlet for floodwater. Be sure that your pond has one. The spillway should be constructed in the undisturbed bank at one end of the dam. It should have a flat-bottomed channel large enough to handle the overflow caused by a 10- to 50-year rainstorm, depending on the size and watershed area. Pennsylvania DEP requirements must be met for dams that are large enough to require a permit (see permit section).

The spillway, including the side slopes and channel bottom, should be planted with a mixture of grass seed that will produce a thick, tough sod. Good sod prevents rushing floodwater from scouring deep ruts in the channel. The pond should not be filled with water until the sod becomes well established and the spillway is ready for use.

Freeboard

The crest, or top, of all earth dams must be higher than the normal water level to keep waves and high water from breaking over the top and cutting channels through the structure. After settling, the top of the dam for a one-acre or smaller pond should be at least 1.5 feet above the high water level or the elevation of water designed to flow through the emergency spillway (see above). The interval between the water level and the top of the dam is called the freeboard. The freeboard interval is maintained by the emergency spillway and the outlet pipe.

Outlet Pipe

A drop- or hood-inlet pipe should be installed through the dam to provide an outlet for the normal flow of water. The pipe, which governs the depth of water in the pond, should be positioned at a level about 12 inches below the bottom of the emergency spillway. The pipe should be large enough to drain the full pond down to normal water level within 24 hours after the flow through the emergency spillway ends. These pipe sizes vary with drainage area and pond storage characteristics and should be determined by an engineering professional.

Drain

A combination outlet pipe and drainpipe is highly desirable for pond management. It can be used to drain the pond for various fish management practices, pond repairs, or emergency situations.

The drainpipe can be closed with a valve or plugged with a bell-end clay tile partially filled with cement. Even a glass jug will work. The plug should be sealed in the inlet end of the pipe with asphalt cement or cement mortar. If a breakable plug is used, the pond can be drained whenever it becomes necessary, but it will be difficult to stop the flow without draining the pond completely.

Antiseep collars or drainage diaphragms should be placed around the drainpipe to prevent water from seeping along the outside of the pipe and eroding a channel through the dam. When steel pipe is used, the collars should be metal plates welded to the pipe. Prefabricated drains with antiseep collars and drain valves may be available where culverts and large corrugated pipes are sold. A drainage diaphragm consists of sand and gravel surrounding the downstream sections of the outlet pipe.

Dry Hydrants

A dry hydrant is a nonpressurized, low-cost pipe system installed along the bank of the pond at a location accessible by fire trucks to provide easy access to pond water during an emergency. It is constructed from 6-inch or larger PVC pipe that extends from at least 2 feet below the water surface through the pond embankment and above the ground next to the pond. Dry hydrants usually can be installed for less than $1,000 and often pay for themselves over time in insurance premium savings.

Construction

The construction site should be cleared of all large rocks, trees, brush, roots, and other debris. The topsoil should be removed and stockpiled for later use.

Most earth dams should have an antiseepage core built into the structure. (See Figure 1.) A trench for this core should be dug along the centerline of the dam and then refilled and packed with the best fine-grain soil available. This trench should extend the full length of the dam and be at least 3 feet deep, preferably deeper. The core is necessary to prevent seepage and to establish a good bond with the undisturbed foundation.

Dry hydrant

Pond construction

The earth fill used in the dam should be free of boulders, stumps, roots, tree limbs, and decaying vegetation. Organic material buried in the dam will eventually decay and leave channels through which water can seep and cause the dam to fail. Earth fill should be spread in 6- to 8-inch layers and compacted with a heavy roller. The top of the dam should be built about 10 percent higher than the designed height, to allow for settling.

The emergency spillway and exposed faces of the dam should be planted with a grass mixture to make the pond attractive and to prevent erosion. Trees should not be planted on the dam, because their root growth may cause leakage from the pond.

Precautionary measures at the time of construction may avoid some management problems that commonly occur after the pond is completed. Riprap should be applied to the upstream face of the dam to control wave erosion and discourage muskrats. If livestock are nearby, a fence should be constructed to keep them from tramping along the banks and polluting the water.

Selecting a Contractor

Attention to the details of construction and adherence to specifications are as important as adequate investigation and design. Careless and shoddy construction can make an otherwise safe and adequate design worthless and can cause failure of the dam. Adherence to specifications and prescribed construction methods are the responsibility of the contractor, who should have a reputation for high standards of workmanship. Your local NRCS office may be able to provide you with a partial list of local contractors experienced in pond construction. Additional contractors may be found in the telephone directory. It may prove worthwhile to go to several ponds the contractor has constructed to see if the work completed appears satisfactory and the pond owner is satisfied with the work.

The type of equipment to be used is also important. With proper construction equipment, the cost can be reduced and a safer dam constructed. The contractor should have a backhoe to conduct soils investigations at the proposed dam site and borrow area. A bulldozer can be used to clear and grub the area. If the borrow area is immediately adjacent to the dam site, a bulldozer is also satisfactory for excavating, backfilling, and placing the fill. For dams over 20 feet high, special equipment such as a sheepsfoot roller may be needed for fill compaction. As with all construction, the landowner should understand the type of work that is to be performed and regularly inspect the construction to help ensure that the contractor is doing a good job.

Construction Costs

The cost of building a pond is highly variable, depending on site conditions and specific features of the desired pond. Costs can range from several thousand dollars per acre to over $30,000 per acre for a more unique design. Although cheaper contractors may seem appealing at first, many cheaply built ponds end up costing their owners more in the long run after costly repairs are made.

Maintenance

A popular misconception is that a completed pond provides immediate benefits to the owner that last forever with little maintenance. Nothing could be farther from the truth. A pond certainly requires as much or more attention than does any comparably sized piece of land.

Many older ponds, or those that were not constructed properly, may have fallen into disrepair. They may be partially silted in, develop leaks, or have unsafe dams with trees growing on them. Repairs to ponds are possible, but you should obtain professional assistance. Consult your local NRCS office or a consulting engineer for help. If pond renovation is going to involve modifying or enlarging any dam covered under a permit issued by the Pennsylvania DEP, a written permit is required to make these changes.

Inspection

Routine inspection and frequent maintenance protects a pond, keeps it attractive, and extends its useful life. Lack of inspection and prompt repair of problems may cause more severe damage that is either irreparable or more expensive to fix.

The dam structure should be checked to ensure it has complete grass cover and has not eroded. Soil should be added and re-seeded at the first sign of erosion. Cut the grass and keep weeds, brush, and trees from growing on the dam. Trees growing away from the dam and pond embankments are usually acceptable. Check for signs of minor leaks along the dam so they can be repaired before they become more serious.

Remove floating debris that can clog the overflow pipe and emergency spillway. Also, check the overflow inlet and outlet to ensure that flow is unrestricted. Check for and repair any erosion in the spillway. Inspect and repair any fences that are used to keep livestock from accessing the dam embankment.

Be sure that any roads provided for fire trucks are maintained for the passage of heavy vehicles and are plowed following a heavy snowfall. To maximize fire protection benefits from a pond, you must ensure that fire trucks have access to the pond during all seasons of the year and that the dry hydrant is readily accessible.

Muskrat Damage

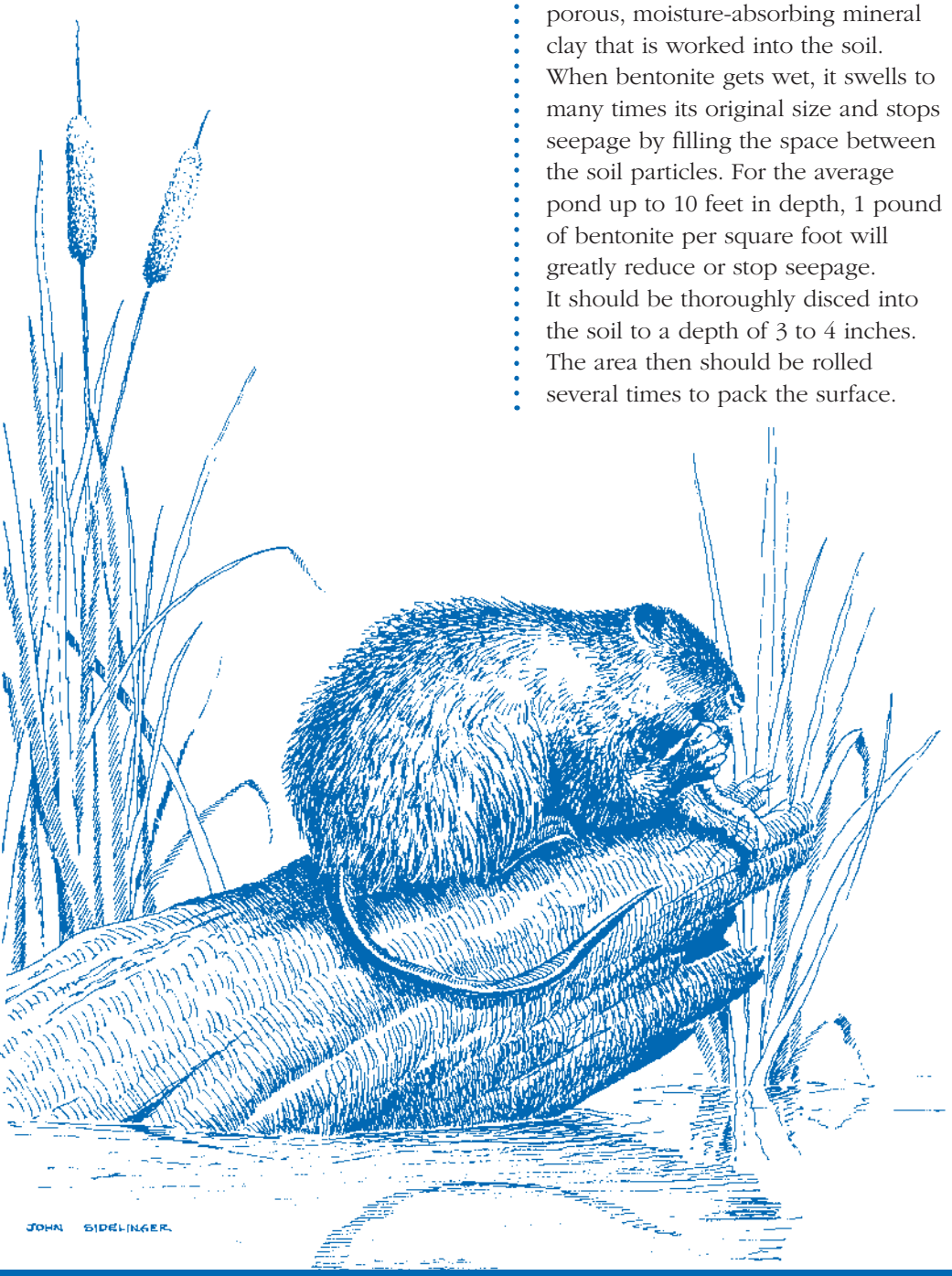
Muskrats may damage a pond by building dens in the banks. They begin burrowing 6 to 18 inches below the waterline and angle up into the bank, where they construct living quarters in dry soil above the water line.

The best defense against muskrat damage is a properly designed pond. A wide top and sufficient freeboard will make a dam relatively safe from damage. There is little danger of leaks in dams with adequate top widths, because muskrats usually will not burrow completely through. If sufficient freeboard is provided, the den usually will have enough ground cover over it to prevent a cave-in.

Despite construction precautions, muskrats are likely to take up housekeeping in even the best-designed ponds. They are especially attracted to areas of emergent and submergent vegetation such as cattails. Removal of this vegetation is one way to reduce muskrat activity in the pond.

Burrowing can be stopped by riprapping the shoreline with large gravel or small stones. These materials should be placed in a layer at least 6 inches thick, and should extend from at least 1 foot above the normal water level to at least 3 feet below it. Riprapping also protects the shore from erosion caused by waves.

Muskrats are furbearers that can be trapped legally during parts of the year. The Pennsylvania Game Law further provides that any person may kill or capture alive, at any time, any furbearing animal (except beaver) in the act of destroying personal property. Poisons legally may not be used in muskrat control, but various repellents may be used. Contact your local Wildlife Conservation Officer for further details.



Fixing Leaks

Seepage is less likely when precautions are taken at the time of construction. If leaks develop after the pond has been filled, it will be necessary to drain the pond, let the bottom dry, then apply a sealant. Leaks usually cannot be fixed without draining the pond. Before attempting any sealing, consult a soils professional to ensure that the treatment is suited to the pond conditions.

Several products are used for sealing pond leaks. One is bentonite, a soft, porous, moisture-absorbing mineral clay that is worked into the soil. When bentonite gets wet, it swells to many times its original size and stops seepage by filling the space between the soil particles. For the average pond up to 10 feet in depth, 1 pound of bentonite per square foot will greatly reduce or stop seepage. It should be thoroughly disced into the soil to a depth of 3 to 4 inches. The area then should be rolled several times to pack the surface.

Sodium polyphosphate is the name of a group of chemicals used to seal pond leaks. The chemicals are similar to some household detergents and usually are obtained in a white, granular form. Treated lumpy soils break down into fine particles that pack together and hold water better. Small channels and voids in the untreated soil fill with these dispersed particles. The result is a relatively stable, impermeable blanket over the treated area.

Ten pounds of granulated sodium polyphosphate will adequately treat 200 square feet of pond bottom. Thoroughly mix the soil to a depth of 8 inches. Apply the polyphosphate by broadcasting or drilling. Compact the treated area with a rubber-tired roller or a steel roller before filling the pond. Do not use a sheepsfoot roller.

Sodium polyphosphate works best in a limestone soil with a high silt and clay content. It does not work as well with coarse-textured soils. Bentonite works well on coarse-textured sods, but is not effective on highly acidic soils.

Leaks in an established pond sometimes may be eliminated by applying a 6-inch blanket of clay to the pond bottom. If clay is not available at the pond site, it may be transported from a nearby area. The clay should be compacted and the water should be returned to the pond as quickly as possible to prevent the clay from cracking because of excessive drying.

Dredging Pond Sediment

Ponds that are filled with sediment can be renovated, but the process is expensive. The least expensive method is to drain, pump, or siphon the water from the pond and use a bulldozer to remove the sediment. The more expensive but quicker method is to remove the sediment with a dragline. If the pond is small enough, a backhoe may be used.

A pond with a high inflow and without a drain may require a cut through the dam at a depth lower than the pond bottom to drain the water from the sediment. Drain the pond before cutting through the embankment. After removing the sediment, you may want to consider constructing a bottom drain through the cut and then repairing the dam.

Sediment removed from the pond, or "spoil," should be spread to promote drying. To prevent silt from washing into the pond or stream, place the spoil away from water bodies and establish a vegetative buffer or sediment trap between the spoil and the water's edge. Once the spoil dries, it can be permanently seeded.

If the pond receives excessive amounts of silt, implement erosion control practices in the watershed. If you do not own upstream land, a small settling basin just upstream from your pond could be built to intercept silt or debris.

Water Quality

Water quality is critical to the beneficial use of ponds, but the parameters and levels of concern will vary depending on the intended use of the pond. For example, water quality criteria are much different in ponds used for animal watering or human drinking water compared to ponds used for irrigation or fishing. Water quality also plays a critical role in determining the types and number of fish species that can live in all ponds, as well as their growth and survival rates.

Water quality is complicated by the fact that many parameters will vary seasonally and from year to year and by differences in water quality between the source and the pond. Changes in water quality are normal and acceptable provided that drastic changes do not occur in a very short time period, changes do not exceed extreme limits, and changes are not caused by pollutants that are directly or indirectly problematic.

Most ponds have not been tested for water quality, and most pond owners are unaware of the important water quality parameters for which they should be testing. This section discusses some of the most important water quality parameters for typical pond uses and describes how water testing might be accomplished.

Physical Water Quality

Temperature and dissolved oxygen

Temperature and dissolved oxygen are the most important physical water quality concerns for pond fishes. It is desirable to check these water quality parameters when they are likely to be least satisfactory (usually July through September).

Trout require cool water and high levels of dissolved oxygen to survive. They grow and survive best when water temperatures are between 55 and 60°F and can withstand only short time periods when temperatures exceed 75°F. Trout also require water that is high in oxygen content; 5 parts per million (equivalent to 5 milligrams per liter) is considered the safe minimum.

Warmwater fish, like bass and bluegill, prefer water temperatures in the 70s and 80s. They reproduce and grow well if the temperature remains in the low 70s for several weeks during early summer. The dissolved oxygen concentrations should be at least 3 parts per million (3 milligrams per liter) for warmwater fish.

Temperature and dissolved oxygen measurements must be made before deciding which fish species will be stocked in a pond. It is difficult or impossible to change the physical characteristics of pond water to make it more suitable for the types of fish you prefer.

Fish kills from a lack of dissolved oxygen or excessive water temperature occur occasionally in Pennsylvania ponds. Refer to the "Miscellaneous Troubles and Treatments" section on page 29 of this publication for more details about this problem and other causes of fish kills in your pond.

Muddy water

Muddy or cloudy water is perhaps the most common pond water quality problem. Newly constructed ponds nearly always have muddy water until grass is established around the pond. In older ponds, muddy water is aesthetically undesirable, makes swimming displeasing, reduces fish growth, and interferes with fish reproduction. It may be caused by erosion from a cultivated or unprotected watershed, by livestock wading in the pond, by wave action eroding the banks, and by the feeding action of some bottom-dwelling fish. Attempts should be made to determine the cause of the muddy water before resorting to treatment.

Correcting the problem may be as simple as diverting muddy surface runoff away from the pond. Muddy water from bank erosion can be corrected by adding 3 to 4 inches of stone or gravel riprap to exposed banks. Occasionally, muddy water will result from an overabundance of bottom-dwelling fish such as catfish. In this case, take steps to reduce their population through fishing, trapping, or draining the pond.

When muddy water results from the action of waves stirring up the bottom sediments, the situation may be corrected by spreading a layer of hay or straw over the bottom of the pond from the edge to a few feet from shore. This measure will have the greatest beneficial effect in shallow areas or where wave action is especially heavy. The mat prevents the waves from picking up fine sediments and provides food and cover for aquatic organisms. Introducing too much hay or straw, however, could cause oxygen depletion that could result in a fish kill.

Sometimes the problem of clearing muddy water is not easy to solve, especially when colloidal particles become suspended in the water and must be precipitated by chemical action. In these cases, one of the following chemical additions may be effective in clearing the water: (1) Broadcast 1,000 pounds of ground agricultural limestone (calcium carbonate) or 740 pounds of hydrated lime per surface acre of water. This treatment should clear a pond and keep it clear for two years or more. Do not use burned lime or quicklime (calcium oxide), because it may kill the fish. (2) Broadcast 1,000 pounds of agricultural gypsum per surface acre of water. It may be necessary to repeat this treatment several times a year to keep the pond clean. (3) Broadcast 250 pounds of aluminum sulfate (commercial alum) per surface acre. Apply treatments weekly until the water clears. Both gypsum and alum treatments will lower the pH of water and may reduce yields of fish.

In some cases, cloudy water is actually caused by growth of microscopic organisms called plankton. This can be easily determined by holding a glass of pond water up to a strong light. Plankton can be observed moving around the glass of water. Plankton blooms can be reduced using chemical applications (see "Chemical Controls" section), but these treatments may reduce the overall productivity of the pond.

Plankton

Nutrient runoff

Chemical Water Quality

Chemical water quality in ponds is important not only for fish but also for other pond uses like animal watering and swimming. Changes in chemical water quality also are usually responsible for excessive growth of aquatic plants and algae. Brief descriptions of some of the most important parameters are given below.

pH

The pH of a pond is a measure of the water acidity. The pH scale runs from 0 to 14, with values less than 7 indicating acidic water and values greater than 7 indicating alkaline water. Most fish species prefer a pH in the range of 6 to 9, although values as low as 5 may be suitable for brook trout. Ponds with a pH less than 6 are common in northern Pennsylvania and may result in stunted or reduced fish populations. Ponds used for animal watering also should have a pH between 6 and 9.

Nutrients

Excessive nutrients such as nitrogen and phosphorus are a common problem in Pennsylvania ponds. These nutrients usually originate from fertilizers or animal wastes applied within the pond watershed. They cause excessive growth of aquatic plants and algae that plague many ponds during summer months. Nutrient levels in pond water can be measured by testing for ammonia, nitrate, and phosphate. Measurable amounts of ammonia or phosphate may be problematic. Nitrate levels in excess of 100 mg/L may be dangerous for animal watering.

Nutrient management techniques and best management practices such as vegetated buffer strips and limited use of fertilizers and manures near ponds are necessary to reduce nutrient levels and restore the pond ecosystem.

Hardness

Hardness is a measure of the mineral content of water, especially calcium and magnesium. Ponds with hard water have a high mineral content and are usually more fertile. These ponds are more likely to support a dense growth of aquatic plants and algae. Soft water has a low mineral content, which results in low fertility. Ponds or lakes containing soft water often have sparse vegetation and clearer water.

Hardness measures are especially important for the use of some aquatic herbicides, especially the copper compounds used for algae control. Hardness concentrations above 50 mg/L as $CaCO_3$ can interfere with the effectiveness of some of these chemicals, requiring increased dosage.

Hardness also may cause a buildup of a whitish solid known as scale in pipes, watering troughs, and plumbing that use pond water. This is an aesthetic problem that will not harm animals drinking the water.

Pesticides

Ponds that are located near farm fields, golf courses, or yards may be susceptible to pesticide pollution from surface runoff or drift during application. Many pesticides, especially insecticides, are highly toxic to all forms of aquatic life and could also be dangerous for ponds used for animal watering. Pond owners should be especially cautious about using pesticides near ponds or streams. A fish kill from pesticides may be difficult to detect, and minute amounts of a pesticide can cause losses over a long period. Read and follow pesticide labels carefully and apply them as far away from ponds as possible. Since fish are generally much more susceptible to pesticides than livestock are, fish kills are often apparent before problems occur with animals.

Aquatic herbicides

A variety of herbicides are registered for use in Pennsylvania ponds to reduce or eliminate aquatic plants and algae. The use of aquatic herbicides is generally compatible with other uses of the pond, but limiting certain uses for specific time periods may be recommended. *Always read and carefully follow product labels.* Warnings regarding other uses of the water should be taken seriously. Some herbicides, especially the copper-based algaecides, are highly toxic to fish and other aquatic life if applied in doses higher than those indicated. Others may require that swimmers or animals be denied access to the water for some period of time to allow the herbicide to break down naturally. The repeated use of copper-based algaecides also may lead to excessive concentrations of copper in pond sediments.

Acid mine drainage

Ponds in western Pennsylvania also are susceptible to pollution from acid mine drainage. Runoff from mined areas can carry high concentrations of iron, manganese, aluminum, and sulfate. Metals like iron and manganese impart an objectionable taste to water that may cause intake problems for livestock. Iron concentrations above 0.3 milligrams per liter and manganese levels above 0.05 milligrams per liter may be sufficient to reduce water palatability to livestock. Iron is also toxic to fish at low concentrations. Aluminum is toxic to fish species, especially trout, when the concentration exceeds about 0.2 milligrams per liter.

Biological Water Quality

Coliform bacteria

Coliform bacteria are a large group of many species of bacteria that can originate from animals, plants, and soil. A subgroup, fecal coliform bacteria, represent species that originate from animals, including humans. Many of the bacteria in this group are harmless, but their presence indicates the potential for disease-causing bacteria also to be present.

Some coliform bacteria are present in all ponds, but bacteria levels are highest in ponds that receive runoff containing animal or human waste. Ponds located near barnyards or septic systems are most vulnerable. High densities of waterfowl also can contribute to excessive bacteria levels. Pond water cannot be treated efficiently to reduce excessive bacteria numbers. Rather, reduction must be accomplished by removing the source of the bacteria, whether by diversion of polluted runoff or reducing direct access by animals and waterfowl.

The acceptable levels of bacteria will depend on the intended use of the pond. Ponds used for swimming should contain fewer than 2,000 total coliform bacteria and 200 fecal coliform bacteria per 100 milliliters of water. Adult livestock should not drink pond water with fecal coliform bacteria above 10 per 100 milliliters, and calves should have water free of fecal coliform bacteria.

Toxic algae

Algae growth is common in many ponds when nutrient and temperature conditions are favorable. Algae growth normally occurs between May and October, with a peak in late summer. At least six species of blue-green algae that occur in Pennsylvania may produce toxins that are harmful to animals.

Toxic algae poisoning of livestock and pets is rare in Pennsylvania. Symptoms include muscle tremors, diarrhea, lack of coordination, collapse, labored breathing, and death. If these symptoms appear, animals should be denied access to algae-contaminated water.

Toxic algae blooms can be treated using applications of copper sulfate as described later in this publication. Again, this is a rare problem in Pennsylvania, but it should not be overlooked if symptoms appear in animals with access to a pond with algae.

Parasites

The most common parasite problem in ponds is swimmer's itch. It is caused by a small, free-swimming parasite that burrows under skin, where it dies. This causes an itching that lasts for about a week. A brisk rubdown with a towel immediately after the swimmer emerges from the water will minimize the irritation caused by this parasite. The most practical way to control these parasites is to control the snails that serve as their intermediate hosts, by draining the pond and letting it dry for several months. Stocking of redear sunfish also may be effective, since they are a natural predator of snails. No chemicals are registered for controlling snails.

Water testing

Testing Your Pond Water Quality

Your pond water can be tested easily and inexpensively for many of the parameters listed above. Temperature, dissolved oxygen, pH, ammonia, hardness, and various other water quality parameters can be tested using kits available at most local pet stores for less than $10 each.

Measurement of total coliform bacteria, fecal coliform bacteria, pesticides and metals, and identification of toxic algae would require more sophisticated testing by certified laboratories. Tests for total and fecal coliform bacteria normally cost $10 to $30 each at a certified lab. A list of certified labs by county is available from your local Penn State Extension office.

Routine water testing for pollutants that are important for your pond will help identify problems before they become too serious. The following guidelines provide some testing recommendations for the most common pond uses in Pennsylvania. They indicate only the most common pollutants that should be tested for. When doing additional testing, pond owners should evaluate the symptoms of their pond, keeping in mind the other special water quality problems described above.

Fishing—test the water frequently, especially during the summer, for temperature, dissolved oxygen, and pH. Test kits from a local pet store are adequate.

Animal drinking—test the water annually for pH, nitrate, and fecal coliform bacteria at a certified water-testing laboratory.

Swimming—test the water annually for total and fecal coliform bacteria at a certified water-testing laboratory.

Penn State recently developed a pond and lake water testing program. Contact your local Penn State Extension office to obtain a pond and lake water testing kit. Costs for testing range from $42 to $70.

Pond Fisheries Management

Whether for fishing or for aesthetic enjoyment, most pond owners are interested in developing and managing a pond fishery. The success of fish in a pond depends on the water quality, the pond's construction, and the management of the fish populations. The following sections give some guidelines for the stocking and management of some common fish species in Pennsylvania ponds.

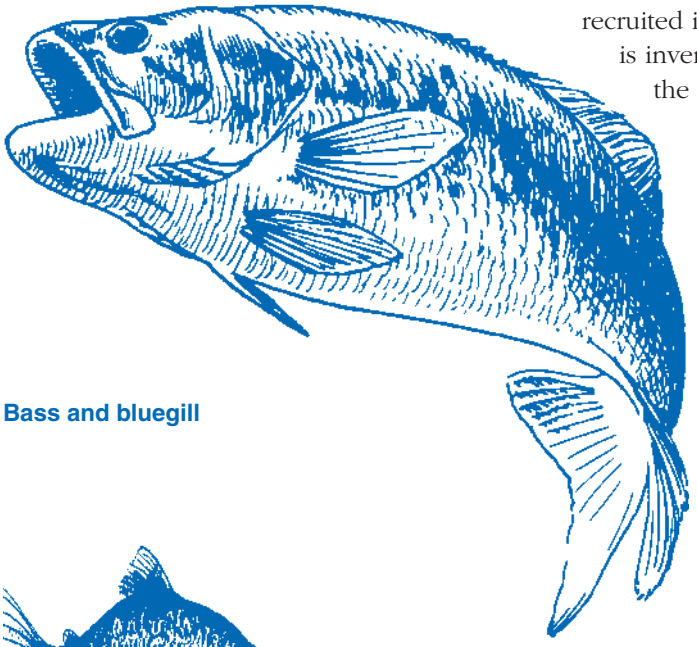
Warmwater Versus Coldwater

Ponds may be stocked with warmwater fish such as largemouth bass and bluegills, or with coldwater fish such as trout. The decision of which type of fish to stock is determined primarily by the temperature regime of the pond and the desire of the pond owner. Other water quality factors such as pH may be important to fish survival and reproduction. Consult the water quality section of this publication for more information about other water quality concerns for fish.

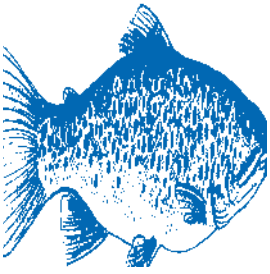
Coldwater fish like trout grow and survive best when water temperatures are 55 to 60°F. Trout may be able to withstand temperatures of 80°F for a few hours, but long periods with temperatures exceeding 75°F will cause death. Many ponds get too warm during the summer months to support trout, but they may still support a put-and-take trout fishery during cooler months. Most ponds in Pennsylvania are better suited to the temperature requirements of warmwater species like bass and bluegill. These species will grow well when water temperatures remain above 80°F for several weeks in the summer.

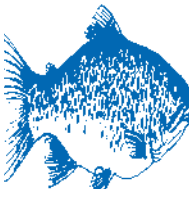
Warmwater Pond Management

Many fish species combinations have been tried in small artificial ponds, but largemouth bass and bluegills have been the most successful in all parts of the country. Pennsylvania experiences with largemouth bass and bluegill sunfish range from outstanding successes to complete failures. The difference is in the management. Recent investigations at Mansfield University of Pennsylvania have confirmed that this species combination is capable of providing excellent sportfishing in Pennsylvania.



Bass and bluegill





Basic ecology

Largemouth bass spawn the first spring that they reach 9–10 inches in length and the water temperature reaches 60°F. Bluegills spawn at a younger age than bass, but not until later in the summer when the water temperature reaches 67 to 80°F. Unlike bass, bluegills may spawn several times during the summer in fertile ponds if they are not too crowded.

Bass feed effectively on bluegills as large as one-third their own body length. Although bass guard their eggs and fry, bluegills prey upon them in a density-dependent manner; that is, the number of young bass recruited into the population is inversely proportional to the number of bluegills present. Thus, bass and bluegills control each other by their predatory habits. If bluegills are too numerous, they can totally eliminate bass reproduction, resulting in elimination of bass from the pond. In the absence of bass predation, bluegills become overcrowded and stunted. When bass are able to spawn successfully, bluegills will be adequately controlled. When bass become too dominant, very few bluegills survive their predation and the bass become crowded and stunted.

Population structures

Bass are often stocked alone in farm ponds in Pennsylvania. The result is a self-sustaining population of small bass. In bass-only ponds, the fish stop growing, regardless of age, at lengths from 9 to 12 inches, depending on the fertility of the pond. Very few small bass and no large bass are present in bass-only ponds.

A population that contains about 3 pounds of bluegills for every pound of bass is bass-crowded and results in relatively slow-growing bass but very large bluegills. The adult bass in this situation will be larger than in the bass-only pond because of the forage provided by the bluegills when they spawn, but still rather small because nearly all the young bluegills produced will be eaten soon after they hatch. The few bluegills that survive predation will grow very rapidly because the invertebrate food supply will be divided among relatively few individuals. The bass-crowded condition provides excellent bluegill fishing. Many bass will be caught, but few will be larger than 2 pounds.

A community containing about 8 pounds of bluegills per pound of bass has relatively few large bass present, but a more equal representation of different size classes than in the bass-crowded situation. The bluegills are crowded, and few will exceed 6 inches in length. This condition provides a great deal of bass forage and allows them to achieve their maximum growth potential. Bass in Pennsylvania ponds like this often grow a pound per year, resulting in real trophy fishing.

Table 2. Average bass and bluegill size in ponds.

	Years after stocking				
	1	2	3	4	5
Bass					
Length (inches)	8	10	12	14	15
Weight (ounces)	5	10	15	20	24
Bluegill					
Length (inches)	5	6	7	8	8
Weight (ounces)	2	4	6	7	8

Stocking bass-bluegill ponds

When small bass and bluegills of the same age were stocked simultaneously in Alabama, balanced populations always resulted. When this stocking strategy was followed in the North, the result nearly always was a stunted bluegill population and a bass population unable to spawn successfully. Research at Cornell University showed that to achieve successful bass-bluegill populations in northern states, the initial stocking must consist of bass that are at least 1 year older than the bluegills. This can be achieved by stocking yearling bass 1 year ahead of yearling bluegills or combining 2-year-old bass (over 6 inches) with yearling bluegills less than 2 inches long. Researchers currently believe that the proper number of fingerling fish to stock is 100 bass and 200 to 500 bluegills per surface acre. This stocking strategy has been shown to be successful in Pennsylvania ponds.

Bass and bluegill fingerlings usually grow quickly during the first few years after stocking (Table 2). Actual growth rates will vary considerably depending on food availability, population structure, and many other pond characteristics. The numbers in the table above are given only as broad averages and should not be expected in any given pond.

Pond owners in Pennsylvania commonly stock their ponds with adult fish obtained from other ponds. At least 6 bass over 10 inches and 100 bluegills over 5 inches should be stocked per pond, or per acre in ponds larger than 1 acre. This stocking strategy has been very successful. Properly stocked ponds should result in balanced populations that will become bass-crowded if the ponds are not fished. Removal of bass (and their predation on the bluegill population) allows the bluegill population to increase. Excess harvest of bass by angling will shift the population toward the bluegill-crowded condition. In this case, bluegills eventually become so numerous that the few remaining bass are unable to spawn successfully and the abundant bluegill are stunted in their growth.

Determining the bass harvest

Little was written about the possibility of bass overharvest before 1970, possibly because of the slowly changing notion that fisheries must be consumptive to be successful. Today, nearly all biologists working with largemouth bass recognize overharvest as a chief reason for unsuccessful bass-bluegill ponds. Regulation of bass harvest is applied to maintain an adequate bass population which, in turn, regulates the abundance of small bluegills. The remaining bluegills then grow to a harvestable size while converting forage biomass in smaller bluegills to valuable bass flesh. In most small ponds under private ownership, the fishing can be closely monitored. As a result, a pond manager can easily implement a quota to regulate numbers of bass removed from the pond and stop bass harvest when the quota is reached. A 15-inch size limit, in addition to a quota, appears to be necessary to protect bass in small ponds. Since enforcing a quota on public lakes with uncontrolled access is very difficult, if not impossible, the bass harvest is controlled with a size limit.

Based on research from other states, it appears that a proper quota for bass harvest in Pennsylvania is about 30 percent of the adult bass per year. If this figure is exceeded, the population shifts toward crowded bluegills, and if the harvest is less than 30 percent, the population shifts toward crowded bass. If the bass harvest exceeds 50 percent per year, irreversible bluegill crowding is likely to occur.

Bass-bluegill ponds in Pennsylvania will contain 50 to 300 pounds of fish per acre, depending on the fertility. Suppose a 30 percent quota of bass is sought for a pond of average fertility containing 250 pounds of fish per acre. The ratio of bass to bluegills is defined by the population structure. A pond containing small bass and large bluegills would contain approximately ¼ bass and ¾ bluegills, by weight.

Therefore, the total weight of bass in the pond would be: 250 x 0.25 = 62.5 pounds. The average size of the adult bass in this bass-crowded pond would be about 1.5 pounds. Thus, the annual bass quota would be: 62.5 pounds of bass ÷ 1.5 pounds each x 30 percent = 13 bass per acre of pond per year.

In a bluegill-crowded pond, the proportion might be 1/9 bass to 8/9 bluegills, or only 28 pounds of bass in our example of 250 pounds of fish. The average adult bass is probably 3 pounds. The annual harvest quota is then calculated as: 28 pounds of bass ÷ 3 pounds each x 30 percent = 3 fish per acre per year.

Calculating these harvest rates reveals the importance of carefully monitoring the number of bass removed from farm ponds, especially small ponds. Catch-and-release fishing for bass and fishing bluegills for an occasional meal of fresh fish is appropriate management for small warmwater ponds. It should be remembered that even with catch-and-release fishing, some of the released bass may die. Those fish must also be counted in any harvest quota for bass.

The pond manager can fine-tune the fish populations by regulating the bass harvest to provide the desired type of fishing. Increasing the bass quota will make the bluegills more numerous, but smaller, and the bass fewer, but larger. Decreasing the quota will provide larger bluegills and smaller bass. Satisfactory fishing is defined differently by different people. Catching many small bass rather than occasional large ones may be desirable for one angler but not another. Bass-only ponds do not provide satisfactory fishing for most anglers because of the small size of the fish caught. Research at Mansfield University has shown that stocking of adult bluegills in these ponds can successfully establish bluegill populations. Bluegill-only populations and ponds that are irreversibly bluegill-crowded are generally drained to remove all the fish and then re-stocked. It may be possible, however, to obtain enough adult bass from another pond to establish bass in bluegill-only populations, especially in very small ponds.

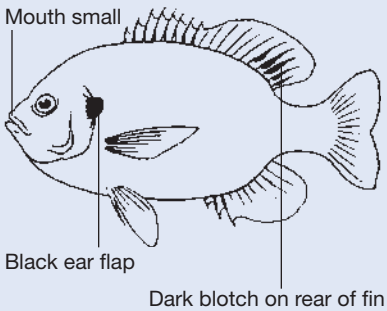
Other fish species for warmwater ponds

Many pond owners stock several species of fish in their ponds; in fact, some people stock every fish they can get their hands on. This practice is undesirable, because the resulting species interactions make management much more difficult and unreliable. However, some other fish show promise as candidates for pond management. Many ponds in Pennsylvania contain bullheads. While they do not seem to interfere or compete with bass or bluegills, bullheads can become stunted and overcrowded in ponds containing few bass. In some bass-crowded ponds, bullheads have been eliminated by bass predation. If bullheads are desired, they should be stocked.

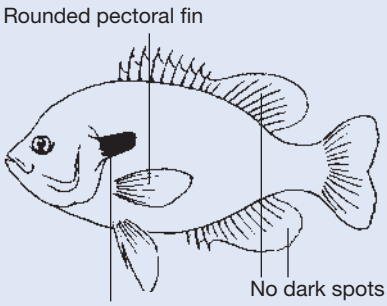
Some biologists recommend stocking golden shiners or fathead minnows with bass. These forage species give bass a good start in a pond, but experience has shown that such forage fish are soon eliminated by bass predation. The forage fish never grow large enough to avoid being consumed by the bass, and eventually the population of these fish declines to a very low level.

Other sunfish species are not as satisfactory as bluegills for pond stocking. The common and colorful pumpkinseed does not grow as large as the bluegill, and the redear, popular in the South, cannot reliably survive Pennsylvania winters. Green sunfish should be avoided.

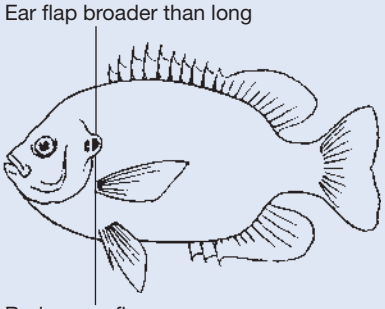
Bluegill



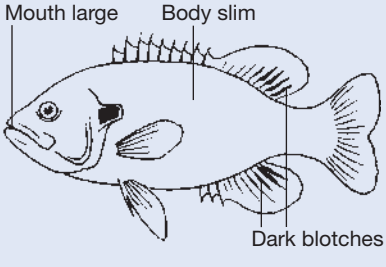
Redbreast sunfish



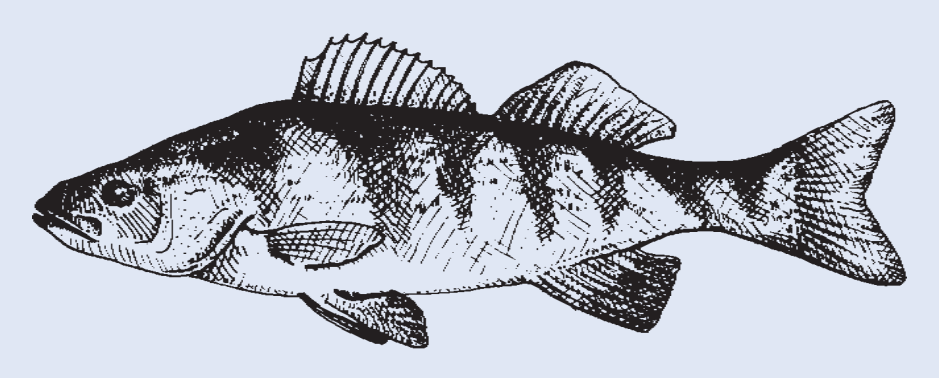
Pumpkinseed sunfish



Green sunfish



Yellow perch



Yellow perch may be a suitable substitute for bluegills as a forage for bass, especially for anglers who like to icefish. Researchers have found ponds where perch successfully coexisted with bass and other ponds where they were crowded and stunted. Further research is necessary to evaluate yellow perch as a pond fish in Pennsylvania.

Although both white and black crappie are often of interest to pond owners, these species seldom are successfully managed in a small impoundment. The typical end result of their stocking will be stunted crappie and decreased success of largemouth bass reproduction. Crappie spawn before bass in the spring, and both the adults and young compete for food with similar sizes of bass. Crappie below about 7 inches also compete with bluegills to some degree. Because of these characteristics, introducing crappie into farm ponds is discouraged.

For several reasons, it is generally more economical to manage ponds for warmwater species than for coldwater species.

- Warmwater species are not as exacting in their water quality requirements as trout. All ponds that will support fish life permanently will support warmwater species, but not necessarily trout.

- Most properly managed warmwater species develop a self-sustaining population. Trout usually must be maintained through periodic restocking.

- Warmwater species are generally more tolerant of herbicides for aquatic vegetation control when the herbicides are used correctly. Trout are very sensitive to copper sulfate, a herbicide often used for algae control, and may be killed by the chemical.

Nevertheless, many pond owners are still interested in managing their pond as either a seasonal or annual trout fishery. Tips for managing trout in ponds are discussed in the next section.

Management of Trout Ponds

Trout occupy a highly favored position among Pennsylvania game fishes. They are generally easy to catch, making them an outstanding sportfish, and they make great table fare. Water temperature constraints normally determine whether a pond owner desiring trout should implement put-and-take versus year-round trout management.

Put-and-take versus year-round

In Pennsylvania, most ponds are able to support trout in spring and fall, and some pond owners may choose a put-and-take trout program. This is not necessarily efficient, economical, or recommended for most ponds, but it is discussed here for completeness. Such a program is governed more by economics than by biology. The pond owner acquires trout of an acceptable catchable size, stocks them in the pond, and begins to fish for them immediately. The number of fish stocked should not exceed the number needed to provide the desired level of sportfishing until the water temperature is no longer suitable for trout (usually sometime in June). Under such a program, it is desirable to harvest as many of the stocked trout as possible if they cannot survive through the summer.

The pond owner should bear in mind that adult trout will compete for food with other insect-eating fish (including young bass) present in the pond. This is true even though the trout will be present for a relatively short period of time. Artificial feeding of trout may alleviate the competition for natural food, but care must be exercised so that artificial feeding is not overdone. Excessive amounts of feed could result in water quality deterioration. Minnows should not be stocked as a food source for trout.

Some ponds in Pennsylvania can support a year-round trout fishery. These ponds may be supplied by a groundwater spring that supplies cool groundwater even during the summer months or may be small and shaded during most of the day. When free from competition with other species, trout thrive in an insect-rich pond that remains cool during the summer.

Species of trout

Brook trout and rainbow trout are best suited for small lakes or ponds. This is especially true if the pond owner wants to establish a permanent fishery of trout only, but also true if occasional put-and-take trout fishing is an objective.

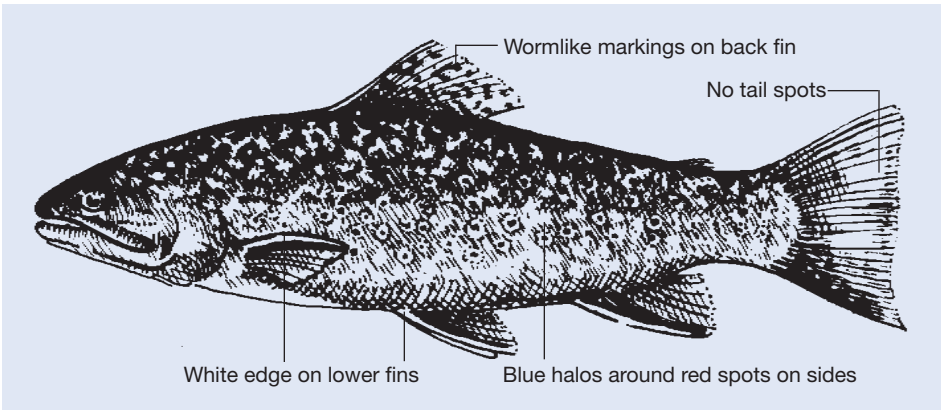
Brook trout are easier to "fish out," making them a good option for a put-and-take trout pond. Rainbow trout are generally considered to be more spectacular fighters. A mixture of these two kinds of trout can be stocked in a pond to provide variety in fishing. If both species are stocked, they should be about the same size so one group will not prey heavily upon the other. Brown trout are generally more difficult to catch than brook or rainbow trout.

Stocking year-round trout ponds

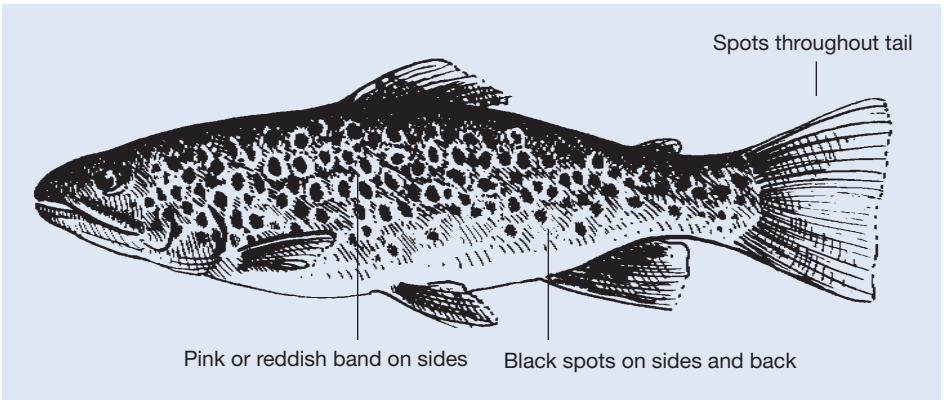
Either spring fingerlings (2 to 3 inches long, 2 to 3 months old) or fall fingerlings (5 to 6 inches long, 7 to 8 months old) may be used in stocking trout ponds. Both types reach catchable size about the same time; that is, in the spring following stocking. However, results with spring fingerlings are much more variable and unpredictable than with fall fingerlings.

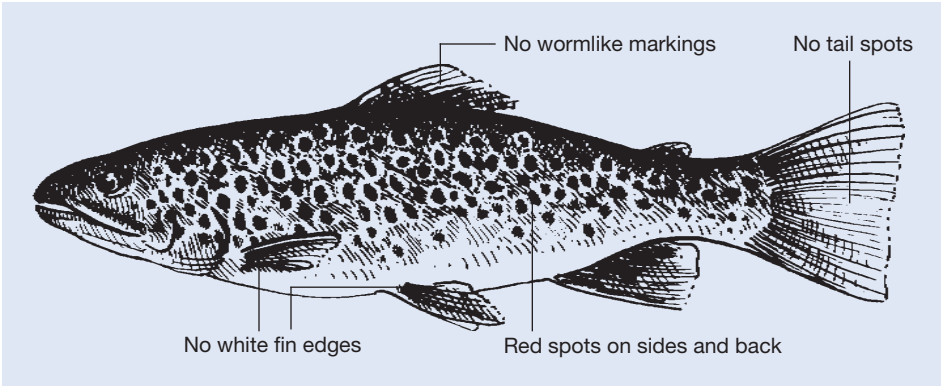
When trout are obtained from commercial hatcheries, fall fingerlings usually provide considerably more catchable-sized trout per dollar than spring fingerlings. It is economically unwise to purchase trout longer than about 6 inches for pond stocking, unless they are to be fished out within a year.

Brook trout



Rainbow trout





A stocking rate of 600 fall fingerlings (or 2,000 spring fingerlings) per surface acre of pond should produce the best yield and satisfactory growth. Highly productive trout ponds on limestone soils may accommodate 700 fall fingerlings per acre, while ponds located on more acidic soils probably will support fewer fall fingerlings per acre.

To minimize losses, stock trout only in the cool or cold weather of spring and fall. If the weather is warm, ice should be packed around the transporting tank to keep the water below 55°F. Do not put ice made from chlorinated water in with the fish, because chlorine is toxic to fish. Oxygen-producing tablets, available in sport or bait shops, may be used when transporting trout. Do not release the fingerlings near the overflow structure of your pond.

Fishing trout ponds

Natural losses of trout will reduce the population of unfished ponds by 90 percent in two years. For this reason, pond owners should harvest as many trout as possible during this period. The time interval between stocking and initial harvest is a matter of owner preference, but the longer the owner waits before harvesting trout, the lower the total harvest.

Pond trout generally are much easier to catch in spring and fall than in the summer. Successful methods of fishing may vary with the season and with the skill of the angler. Minnows should not be used as bait when fishing trout ponds. If they escape and reproduce, they may eventually ruin the pond for trout production.

Table 3. Average trout size in ponds after stocking as fall fingerlings (5–6 inches).

	After 1 year	After 2 years	After 3 years
Length (inches)	10	12	14
Weight (ounces)	8	14	22

Restocking and feeding trout

Because trout have a relatively short survival time, a pond should be restocked with trout every 2 years to maintain adequate fishing. Fall fingerlings should always be used for restocking. "Holdover" trout are less likely to prey on them than they are on spring fingerlings, because fall fingerlings are larger than spring fingerlings. Fall fingerlings for pond restocking must be purchased from commercial sources.

At stocking rates of 600 fall fingerlings or 2,000 spring fingerlings per acre, trout grow rapidly on natural food produced in an established pond. Supplemental feeding may increase the growth rate an inch or two per year, but it is expensive.

Some pond owners feed trout as a hobby or to maintain much larger trout populations than the 600 per acre recommended for stocking. Feeding is one way to increase the fishing potential, especially in a small pond. Pelleted trout food is available through farm supply stores. Trout usually come to the surface for pellets and become conditioned to feeding at the same area of the pond.

Use only as much food as the trout will eat immediately. Excess food will settle to the bottom and decompose, removing dissolved oxygen from the water and possibly causing fish kills. Feeding should be done only in ponds that have a year-round supply of good water.

Growth, survival, and spawning

Brook and rainbow trout in ponds grow at about the same rate, although growth may vary considerably from one pond to another. Growth generally slows as fish become older, and usually is faster in summer than in winter. Growth may be slower in newly constructed ponds, since aquatic insect life may be limited, and in soft (acid) water. Table 3 illustrates average growth rates.

In general, it is best not to fertilize trout ponds. A single application of 10-10-10 fertilizer at 300 pounds per acre may hasten the establishment of a natural food supply in newly constructed ponds. Heavier fertilization may harm the trout and cause summer or winter fish kills.

Pond trout survival rates depend on the size of fingerlings stocked and many environmental factors. Survival rates may vary considerably from pond to pond and from year to year. Larger fish generally have better chances for survival. During the summer immediately following stocking, the survival rate of spring fingerlings in ponds averages 30 percent. In each subsequent year, the rate averages about 50 percent. At the end of the second year, only 5 to 10 percent of the original number remain. Few trout remain in a stocked pond after 3 years. Fish death from natural causes is a gradual and continuous process, even though dead fish seldom are seen.

Total poundage of trout in a pond at any time following stocking depends on two opposing processes: growth, which increases poundage, and death or fish losses, which reduce the poundage. Total poundage rises rapidly the first year after stocking, then decreases. In an unfished 1-acre pond stocked with 600 fall fingerlings or 2,000 spring fingerlings, an average of 230 trout will remain after 1 year. They will weigh a total of about 110 pounds. Two years later, only 45 trout will remain and they will weigh a total of about 41 pounds.

Most ponds lack suitable spawning sites, so trout rarely reproduce in Pennsylvania ponds; however, they may go through the act of spawning. A suitable spawning site for trout is a gravel area through which well-oxygenated water circulates during the incubation period. In ponds with exceptionally large, heavily flowing springs, limited trout reproduction may occur naturally or may be achieved by development of gravel beds in suitable locations. Reproduction is usually limited to brook trout because rainbow and brown trout require tributary streams for spawning. So far, no economical method has been developed to achieve adequate natural reproduction in the average spring-fed pond.

Sources of Fish for Stocking Ponds

Ponds may be successfully stocked with fish caught from other water. If this is done, it must be in accordance with all state regulations. Both warmwater and coldwater fish species also can be purchased from dozens of private commercial hatcheries throughout Pennsylvania. A list of licensed private fish hatcheries showing the addresses and the species each has available can be obtained from the Pennsylvania Department of Agriculture. Hatcheries should be contacted directly for other specific details.

For a list of commercial fish hatcheries, visit the Penn State Extension pond website at **extension.psu.edu/water/ponds**.

Once the pond, either warmwater or coldwater, and its fish populations are established, it is important to regulate activities involving the pond. Regulations probably constitute the pond owner's most valuable management tool.

Regulations and Laws Affecting Fish Ponds

The Pennsylvania Fish and Boat Commission has the chief regulatory and legal responsibility for fishery resources of all waters in the state. For the most part, anglers over the age of 16 are required to have a valid Pennsylvania fishing license to fish in any Commonwealth water, including privately owned ponds. The Fish and Boat Code does contain a provision allowing landowners and their families to fish in private ponds on their own lands without a license. This license exemption does not apply to guests, employees, temporary residents, or tenants on the land.

A separate statute applies to "farm fish ponds," which are defined as artificial ponds on a farm holding "water, the source of which is wholly within the limits of the farm." On farm fish ponds, the resident owner or lessee of the farm, members of his or her family, and persons who are regularly employed on the farm, all of whom must permanently reside there, are exempt from license requirements and other fishing regulations (including season, size, and creel limits) when fishing in the farm fish pond.

In addition to existing state regulations, pond owners should carefully manage the harvesting of fish from their pond. Ponds have a finite capacity to produce fish biomass. The amount that can be harvested by anglers is controlled and determined by the amount of fish production in the pond, and the two processes must be in balance. The need for pond owners to regulate harvest cannot be overemphasized. State regulations provide pond owners with a framework for effectively managing the harvest of the pond's fish resources, but owners may establish their own regulations and restrictions on fishing, as long as they are not more liberal than the state laws. Enforcement of personal regulations is the

responsibility of the pond owner. Pond owners especially might want to consider additional regulations for ponds with a great deal of fishing pressure.

If fish are transported from a pond during a closed fishing season, the pond owner must provide a written statement including the date, place, and by whom the fish were taken; the number and species of fish; the name and address of the person transporting the fish; and the date they were transported.

Special permits

Regulations require pond owners to obtain appropriate permits before using traps, seines, or chemicals for weed or fish control. Propagation permits are required for fish culture in ponds as a whole or in cages. A permit is also necessary to operate a fee-fishing pond. Applications for permits may be obtained from regional offices of the Pennsylvania Fish and Boat Commission or at its home page (**www.fish.state.pa.us**).

Remember:

State regulations relevant to fish ponds are always subject to change. Consult your local Pennsylvania Fish and Boat Commission office or visit the commission's web page for up-to-date regulations.

Aquaculture

Aquaculture is the husbandry of aquatic organisms. Fish culture, a specific form of aquaculture, varies from raising baitfish for sportfishing to producing fish for human consumption. Certain kinds of fish culture can be conducted without interfering with other planned pond uses, while others require the pond to be dedicated to aquaculture.

Commercial fish culture, like any other commercial venture, has rewards and risks. Both should be investigated thoroughly by a prospective entrepreneur. Persons contemplating commercial fish culture will need a basic understanding of biology and water chemistry, as well as business skills. Fish culture has too many ramifications for detailed treatment in this publication.

For more information on aquaculture, contact:

Pennsylvania Department of Agriculture
2301 North Cameron Street
Harrisburg, PA 17110
Phone: 717-787-4737
agriculture.state.pa.us

For applications to start a fish culture operation, contact your local Pennsylvania Fish and Boat Commission office or download the application from its home page, **www.fish.state.pa.us**.

Aquatic Plants and Algae

Aquatic plants and algae occur to some degree in most Pennsylvania ponds. Under normal circumstances, they are beneficial to the pond ecosystem in many ways. They take up carbon dioxide and release oxygen during photosynthesis, and they provide food and cover for a variety of microscopic organisms, fish, amphibians, and wildlife. In many cases, however, pond plants and algae can become overabundant, creating unwanted or undesirable pond conditions.

The desirable level of aquatic plant and algae growth depends on the point of view of the pond user. For example, a pond that is overrun with plants and algae may be desirable to waterfowl enthusiasts for attracting ducks and geese, while the same pond would be displeasing for swimmers who want clean, clear water. Pond owners need to evaluate their objectives when deciding how to manage their pond's aquatic plants and algae.

Pond plants can be either planted or reduced to the level desired by the pond owner. In recent years, the aquascaping business has grown in response to pond owners interested in creating aquatic "gardens." Several commercial nurseries have opened to provide many types of aquatic plants, and many can be accessed on the Internet. More often, pond owners are interested in controlling or eliminating unwanted or overabundant plants and algae, especially during the summer months. This is a complex subject that is given proper detail in other publications. The remainder of this section gives a brief overview of identification and control of aquatic plants, along with references to these more detailed resources.

Identification of Plants and Algae

Algae

Algae are the most common and widely distributed of all aquatic plants. They occur in some form in all ponds. Algae can be separated into three categories, including plankton algae, filamentous algae, and attached-branched algae. Plankton algae are the most important plants in all natural bodies of water because they serve as the beginning of food chains that support higher forms of aquatic life. Plankton algae may "bloom" under the right conditions, turning the pond water brown, yellow, pea-soup green, or even red.

Filamentous algae are especially familiar to many pond owners in Pennsylvania. They usually occur in large floating masses, filaments, mats, or scums that can quickly cover the pond surface.

Attached-branched algae are often mistaken for an aquatic plant. They have an erect central main stem with whorls of branches at various intervals. Chara and Nitella are types of attached-branched algae that have a strong, musky odor and are sometimes encrusted with rough, gritty, calcium deposits.

Algae

Aquatic plants

Flowering aquatic plants usually are divided into submergents, emergents, and floaters, based on their growth characteristics. Submergent plants generally grow underwater (except at flowering time) and are attached to the muddy bottom. Flowers protrude a short distance above the surface, where wind and insects aid in pollination. Pondweeds, common elodea, coontail, and watermilfoils are among the common submergents. Emergent plants grow along the shoreline in shallow water and are sometimes called marsh plants. The most common emergents include cattails, arrowheads, rushes, reeds, and sedges. Floating plants have much of their structure floating on the surface of the pond, but most are rooted to the bottom. Common attached floaters are waterlilies, watershield, and spatterdock. Other floaters such as duckweed have small dangling roots that obtain their nutrients directly from the water.

Submerged aquatic vegetation

Emergent plants

Floaters

Identification of the plants and algae in your pond will be necessary before they can be properly managed. Dozens of aquatic plants and algae occur in Pennsylvania ponds. Specific identification can be very difficult and is beyond the scope of this publication. For help in identifying specific plants and algae, consult the following resources:

Aquatic Plant and Algae Identification

- Experts at your local extension office may be able to help identify aquatic plants.
- Penn State Extension publication AGRS-110, *A Field Guide to Aquatic Plants in Pennsylvania* ($11.00), provides pictures and descriptions of some of the most common aquatic plants in Pennsylvania.

Causes of Plant and Algae Growth

Excessive plant and algae growth is usually caused by nutrients entering the pond from the surrounding pond watershed. The primary materials that stimulate growth are nitrates and phosphates from agricultural fertilizers, lawn and golf course fertilizers, animal wastes, and septic system discharges.

In addition to available nutrients, ponds with dense aquatic plant and algae growth usually have several of the following characteristics: shallow depth, gently sloping shoreline, stable bottoms, warm water, clear water, and high fertility. In contrast, factors that inhibit aquatic plant growth are deep water, moving water, steep shoreline slopes, unstable bottoms, cold water, colored or muddy water, and low fertility. Ponds with soft water (low mineral content) tend to have low fertility and sparse vegetation while hard water ponds (high mineral content) often support a dense growth of many species. The composition of the mud on the lake or pond bottom influences the number and species of plants that will grow. Most aquatic plants grow best in a mixture of sand and organic soils. Soft, mucky soils may be unfavorable to aquatic plants.

Drawdown

Preventing Plant and Algae Growth

Like most problems, preventing excessive aquatic plant and algae growth is more desirable than attempting to control it after it has become a problem. Prevention can be accomplished in several ways. Deepening shallow ponds or lakes offers the most permanent method of preventing aquatic weeds. In ponds where most of the water is over 10 feet deep, submerged vegetation seldom becomes a serious problem. Sunlight penetration at this depth usually is not sufficient to stimulate vigorous growth of aquatic plants. Pond embankments and steep sides that slope rapidly into deep water usually limit aquatic plant growth to the very edges of the pond, where emergent plants may be cut or removed easily by other mechanical means. Steep sides, however, may create a safety hazard to small children, equipment operators, and swimmers.

Drawdown

Drawdown or partial draining can be used to prevent the growth of some species. This is achieved by partially draining the pond beginning in late fall or early winter. Plants usually are killed or rootstocks frost-heaved if the bottom mud freezes to a 4-inch depth for a period of 3 weeks or longer. Use caution in prolonged drawdowns, because oxygen depletion is more likely to occur when fish and organic debris are concentrated in a smaller volume of water.

Nutrient management

Nutrient management practices are desirable for controlling aquatic plant and algae growth because these activities attempt to reduce or limit nutrient entry into the pond. Reducing nutrients will not immediately reduce plant growth, but it will have a long-term benefit. Nutrient reductions can be accomplished by reducing fertilizer and manure applications near the pond, diverting nutrient-rich runoff away from the pond, or creating vegetative buffer strips to trap nutrients. If surface waters entering the pond are passed through a vegetated drainage channel or buffer strip, nutrients, turbidity, and many chemical concentrations may be reduced.

Although in some cases an initial application of a balanced fertilizer will help new ponds become productive faster, it will also make a pond more susceptible to later problems with surplus nutrients.

Barley straw for algae

In recent years, the use of barley straw has been suggested to prevent growth of algae in ponds. Although this practice is still not completely understood, enough evidence appears to exist to suggest that it is beneficial.

Remarkably little straw is needed—approximately two to three bales per surface acre of water. Too much straw can deoxygenate the pond and possibly cause fish kills. The straw should be applied loosely or in cages at several locations in the fall or spring. It is important to note that barley straw does not kill existing algae, so it must be applied before the algae appears.

One of the greatest difficulties with this technique can be locating barley straw. Your local Penn State Extension office or another farm-related organization may be helpful in finding a local barley straw supplier.

Control of Plant and Algae Growth

Although prevention techniques are preferable, it is often necessary to control existing aquatic plant and algae growth. No easy cure-all exists for controlling undesirable aquatic vegetation. Each of the methods described below can be effective, but many factors—including cost, effectiveness, side effects, and difficulty—must be considered when deciding which technique to undertake.

Mechanical removal

Mechanical removal methods consist of cutting, mowing, raking, digging, or pulling plants and algae. As you might expect, these methods are physically demanding but inexpensive if you do them yourself. They are most efficient for small quantities of plants near shorelines. Mechanical treatments often must be repeated several times during a year to eliminate new growth as it appears. Cutting or pulling may be undesirable for some submerged plants, because stem fragments left in the water may establish new plants. If you are physically able, consider mechanical removal methods because they may be safer, less expensive, and longer lasting than chemical controls.

Chemical controls

Herbicides offer a solution to many otherwise difficult aquatic weed problems. But chemical control of aquatic weeds must be undertaken with adequate planning and considerable care. The correct chemical must be selected for the identified problem plant, and precise measurements of water volume and chemicals must be made. Small errors in application rates can cause inadvertent damage to fish and other aquatic life in your pond. As a result, *permits are required before you apply algaecides or herbicides to your pond*. These permits are issued with joint approval of the Pennsylvania Fish and Boat Commission and the Pennsylvania DEP.

You can obtain a permit to apply aquatic herbicides from the following:

- Your local Fish and Boat Commission office
- Your local DEP Office
- Some local Penn State Extension offices
- Downloadable form available online at **www.fish.state.pa.us**

Once you've obtained a permit, *carefully follow the label instructions on the herbicide*, including any water use restrictions. The following tips and cautions may be helpful.

Many herbicides are toxic to fish and other animals, including human beings, but the amounts needed to kill aquatic weeds are usually tolerable to fish and animals. Newly hatched fish appear to have less tolerance to herbicides than do older fish. In some areas, minor fish kills may occur when safe dosages are inadvertently exceeded because of an uneven distribution of the chemical.

A fish kill also may occur as an indirect result of chemical weed control, because oxygen is consumed by the rapid decay of plants. To minimize this danger, treat only one-third of the pond at any one time, even when plants are present in the entire pond. Make applications at least 1 week apart, or as specified on the label, so that rapid plant decay will not reduce oxygen content of the water to a dangerously low level.

Waters should be treated for aquatic weeds in late spring or early summer when plants are young and actively growing. Treatment at this time of year usually gives best control with the least amount of chemical. Applications in late summer or early fall require more chemical and usually give slower, erratic control. If a problem becomes apparent during the late summer, treat it the following spring, rather than immediately. This probably will reduce your cost and increase the effectiveness of the application.

Aquatic plant control with chemicals can be successful and satisfactory. Once a weed problem is under control, diligent treatment of regrowth is necessary to maintain control. It is much easier and less expensive to conduct periodic maintenance or to make spot treatments than it is to wait until treatment of the entire area is necessary. Using chemicals for control of certain plant species, even though successful, is not likely to end all plant problems.

For more detailed information on chemical control of aquatic plants and algae, see Penn State Extension publication AGRS-102, *Management of Aquatic Plants*, available for $4.00 from your local Penn State Extension office.

Grass carp

Biological control (grass carp)

In recent years, grass carp have become a popular choice for controlling some types of aquatic plants. Grass carp can be very effective in controlling many species of submergent plants. They generally are not effective at reducing filamentous algae or emergent plant growth.

Because grass carp are not native to Pennsylvania, their sale and use are regulated by the Fish and Boat Commission. All grass carp sold and stocked must be triploid, meaning they cannot reproduce, and pond owners must obtain a permit before stocking them. A permit and list of commercial hatcheries that sell triploid grass carp are available from your local Fish and Boat Commission office. Take care not to overstock the pond with grass carp; too many can strip a pond of all vegetation and muddy the water as they search the bottom for more plants. The permit process will be helpful in determining the correct number for your pond. Pond owners should purchase grass carp at least 8 inches and preferably 12 inches long. These large fish usually can avoid predation by other pond fish and will be large enough to begin consuming unwanted plants immediately. Stocking rates for grass carp range from 1 to 15 fish per acre depending on the amount and type of unwanted plants. Other types of fish such as koi or other species of carp are not recommended for aquatic plant and algae control, since they are relatively ineffective in controlling aquatic plants and tend to produce muddy water problems.

Miscellaneous Troubles and Treatments

Fish Kills

Fish kills resulting from a lack of sufficient oxygen occur occasionally in Pennsylvania ponds. Ponds that are poorly constructed, shallow, overpopulated, or have excessive aquatic vegetation are most likely to suffer from oxygen depletion. Most die-offs are observed during an extended period of hot, calm, and cloudy days in summer. Die-offs may also result from the decay of plants and algae after an application of an aquatic herbicide. Occasionally, fish kills from oxygen depletion occur during extremely cold winters when a pond is covered with ice and deep snow for prolonged periods.

The best insurance against a fish kill from oxygen depletion is a well-constructed pond. Spring-fed ponds or ponds with running water where long cold winters are not the rule should have depths of 6 to 8 feet over at least one-fourth of their total area. Ponds without running water or those located in areas with long cold winters should have depths of at least 10 to 12 feet over at least one-fourth of the total area.

Occasionally, fish kills occur from other water quality problems. Most notable among these would be runoff and drift from terrestrial applications of pesticides. Although most of the chemicals degrade quickly, they can be highly toxic to all forms of life, especially fish.

By following a few basic guidelines, you can reduce the likelihood of a fish kill occurring in your pond. Stock only fish that are capable of surviving the water temperatures in your pond. Obtain a permit before using an aquatic herbicide in your pond, and carefully read and follow the label directions. Do not treat more than one-half of the pond with an aquatic herbicide. In ponds where fish kills occur frequently because of low dissolved oxygen levels, installing aeration devices may be helpful. Finally, be especially cautious using pesticides on land adjacent to the pond.

Turtles

Snapping turtles occasionally inhabit larger ponds. They seldom cause problems, but are considered undesirable by many pond owners. Other kinds of turtles are usually desirable. If snapping turtles become a problem, they may be removed by fishing. Use large turtle hooks (1 inch between shank and point) attached to a wire leader and heavy cord. Bait the hook with dead fish or other meat. Place baited hooks in shallower parts of the pond.

Ducks and Geese

Many pond owners wish to attract waterfowl to their pond for viewing pleasure. For example, wood ducks can be encouraged by building nesting structures. However, while small numbers of waterfowl may be desired, large flocks can create numerous problems. In recent years, the large resident population of Canada geese has been especially problematic in Pennsylvania. The waste associated with a large concentration of waterfowl can degrade water quality by increasing both nutrients and bacteria concentrations. To prevent problems, no more than a few waterfowl should be permitted per acre of pond. Short-term visits by larger flocks during spring and fall migration are generally not a problem.

Waterfowl can be discouraged for a short period of time using decoys of natural predators such as hawks and owls. Vegetative barriers of tall grasses or cattails around the pond may provide a longer-term solution. Since geese like to eat most lawn grasses, planting the pond perimeter with less desirable grasses such as tall fescue may discourage geese from inhabiting your pond. A mowing schedule that allows somewhat taller grasses and weeds to grow in the vicinity of the pond will also reduce the use of that area by Canada geese. Tall weeds can create other problems, though, such as attracting water snakes (see next paragraph). Maintaining a relatively small closely mowed area immediately adjacent to the pond will reduce the area attractive to geese, thereby reducing their numbers around the pond.

Snakes

The most practical way to eliminate snakes from a pond is to make it unattractive to them. Keep the pond free of weeds and debris in which they can hide. Keep the banks closely mowed and clean. A few water snakes may occasionally inhabit the pond, but these do little or no harm.

Leeches

Leeches are flat, dark-colored parasites that attach themselves to animals in the water and suck blood through punctures made in the skin. They will attach to swimming humans, but their bite is normally painless. Leeches are rarely abundant enough in Pennsylvania ponds to warrant any concern, but they can be eliminated, if desired, by treating the pond with a very high concentration of copper sulfate (5 parts per million). It is important to note that such a treatment will likely kill all of the fish in the pond and will require a permit from the Pennsylvania Fish and Boat Commission. Spot treatment of only the swimming areas in the pond may be possible to avoid a large fish kill, but the leeches will slowly return from the untreated portions of the pond. Any chemical treatment to eliminate leeches is a drastic step that will greatly affect the pond fish and other aquatic life. Given the side effects of treatment, elimination of leeches can be justified only where fish are already absent from the pond.

Prepared by:

Bryan R. Swistock, extension associate, Department of Ecosystem Science and Management, Penn State

Richard W. Soderberg, professor, Department of Biology, Mansfield University of Pennsylvania

Harry Blanchet, county extension director, Forest County, Penn State Extension

William E. Sharpe, professor emeritus, School of Forest Resources, Penn State

Adapted from R. D. Heaslip, Hesser, R. B., Hock, W. K., Rader, T. D., Soderberg, R. W., and Wingard, R. G., 1985. *Pennsylvania Fish Ponds*. Penn State Cooperative Extension. 40 pp.

For more information on all aspects of pond and lake management, visit the Penn State Extension pond website at **extension.psu.edu/water/ponds**.

extension.psu.edu

An OUTREACH program of the College of Agricultural Sciences

Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

This publication is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. For information telephone 814-865-6713.

Produced by Ag Communications and Marketing

Code UH137 1.5M10/13mpc