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Managing Wisconsin Fish Ponds

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About this publication

This publication was written in response to the growing interest in managing ponds for both recreational and commercial fishing. Its purpose is to provide a source of reliable, up-to-date information for those interested in building new ponds or managing existing ones. The reference section is designed to serve as a guide to the vast body of information that deals with fish pond management. This publication replaces *Wisconsin Farm Fish Ponds* published by the University of Wisconsin–Extension in the late 1960s.

Throughout this manual we explain processes and principles for you to choose from, rather than specific management practices that you must follow. Adapt the information here to your own specific interests and needs, and use it as a guide for planning pond construction and management for either sport or commercial aquaculture. Most of the general information here focuses on sport fishing ponds, but the sections on ponds and fish management apply to both sport and commercial pond aquaculture (Chapter 9 deals specifically with commercial pond aquaculture).

Whether your pond is a commercial enterprise or is used for recreation, our hope is that this manual will help you achieve better results.

The authors

Acknowledgments

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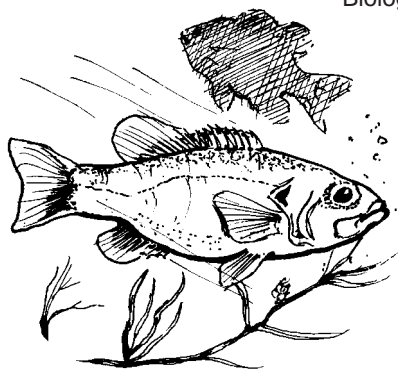


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chapter 1

Overview

This publication provides an overview of ponds as aquatic systems and tells how to manage ponds to achieve different goals. It is designed primarily for current or prospective pond owners with an interest in sport fishing, but it is also valuable to those interested in commercial pond aquaculture. Chapter 9 provides an introduction to this topic and much of the material from other sections also applies to commercial enterprises. Those interested in managing ponds for waterfowl, swimming or irrigation, where fish production may be a side benefit, will also find this publication useful.

Another of the publication's main goals is to help pond owners achieve better results from their ponds, and to aid aspiring owners in understanding a pond's potential and problems before they commit to building or buying one.

Though the emphasis here is on pond management under typical Wisconsin conditions, much of the information also carries over to other areas of the north central United States.

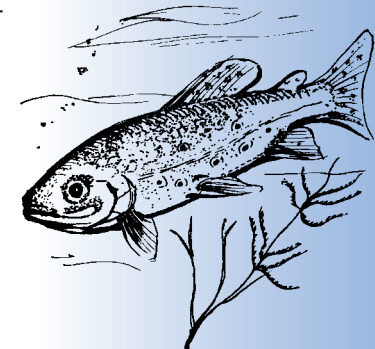
The resource

Approximately 15,000 inland lakes provide Wisconsin with roughly 1.27 million acres of surface area. Portions of Lakes Michigan and Superior lie within Wisconsin's boundaries as well, adding nearly 8.5 million acres of water to the state.

In spite of the many lakes and easy access to fishing in public waters, many private landowners want their own ponds. Having your very own fishing spot, close at hand on the farm or vacation property, or even in a suburban setting, offers convenience and control—though not without cost and added responsibilities.

Interest in commercial fish production is increasing in Wisconsin due in part to the growing demand for fish, a decline in production from wild stocks and improved opportunities for diversified aquaculture brought about through research. The management and educational challenges involved in owning a pond also attract many people.

Many ponds are constructed primarily for sport fishing. Other reasons to build a pond include commercial aquaculture, swimming, wildlife habitat, water for livestock, irrigation, hunting dog trials, fire protection, water quality improvement and scenic enhancement. If a pond is designed and managed for another purpose, do not expect it to provide the same fishing quality as one designed specifically for fishing. For example, a pond that provides good duck habitat



may be too shallow and choked with plants to provide enough oxygen for fish during hard winters.

How does a pond differ from a lake? The fact is that there are no sharp differences between the two. Most people think of a pond as being smaller than a lake, but opinions vary on what size constitutes a pond. This publication deals primarily with ponds that range in size from a quarter acre to 10 acres (0.2 to 4 hectares).

Regardless of their size, sport fishing ponds often provide a few years of good fishing when new or renovated; fishing often deteriorates as fish populations change. Occasionally, ponds may be dismal failures right from the start, usually because of faulty design, improper location or poor water quality.

When is a pond a “success” or “failure”?

In commercial pond culture, profit is typically identified with success. However, the level of profit and other rewards considered “successful” varies with each owner. An owner’s or user’s level of satisfaction is the ultimate measure of a pond’s success.

Much of this publication is geared to the many pond owners and users who *aren’t* satisfied with their fishing success. But if the fishing in your own pond *does* satisfy you, enjoy it, and don’t pay much attention to someone else’s idea of what makes a successful pond.

Because satisfaction is a matter of personal preference, we try not to tell owners and users what kind of pond or management is the “right” kind. Instead, we explain principles and describe alternatives from which you can choose.

Caution! Are you sure you want a pond?

Creating and managing a pond requires substantial time, effort and money. In addition, there are some risks involved such as potential legal liability from injuries or drowning. Another problem can be an overabundance of aquatic weeds. Trying to prevent or control weeds can be frustrating, but we offer information here to make the job easier.

Maintaining a prime fishing pond is like striving to keep a racing car in good condition. Performance depends on attention to details. You need to ask yourself: *Do I really have time for this?*

Natural and artificial ponds

The landscape contains many ponds that have formed naturally. Most often, these ponds have marshy, gradually sloping edges, and are only a few feet deep at their deepest points—not enough to maintain good fishing, but fine for wildlife. Marshy or swampy ponds can be extremely enjoyable just for their sights and sounds, and sometimes for the hunting they offer. If they provide some fishing, it’s a bonus. If a natural pond is deep enough (15 feet or more) to furnish proper habitat for a flourishing fishery, the owner is fortunate indeed. Many shallow ponds are suited for production of fish bait or fingerling game fish.

This publication can help you increase fish production from a natural pond whether it has high or low potential. However, we caution owners that radical management, especially in the form of reshaping the basin or altering plant life to benefit fish, may destroy some wildlife habitat or damage other valuable features. Natural ponds are often protected by state laws to preserve the wildlife values of wetlands.

The artificial pond, designed for maximal sport fish abundance and minimum maintenance, is quite different from most natural ponds. It has steeply sloped banks, an average depth of more than 8 feet, and a maximum depth greater than 15 feet, no matter what the surface area.

General considerations

Good fish pond management involves more than just putting in some fish. Ponds, like gardens, need proper design and management. Just as in gardening, many questions must be answered before management can be effective. Some of the important ones are:

- What is my goal in having the pond? Fishing? Profit? Swimming? Wildlife? Irrigation? Water for livestock? Nature study? Scenery?
- If there are several goals, which is the main one, and how do the others rank in priority?
- What, roughly, is the pond's potential for producing fish in terms of space, water fertility and other aspects of pond quality?
- How deep should I build (or rebuild) the pond?
- What kind(s) of fish should I stock? What sizes? How many? When?
- When can I start fishing (or harvesting) the pond?
- How many fish should I expect to be able to harvest each year and at what sizes?
- How can I prevent or remedy fish overpopulation and stunted growth?
- How can I prevent or control aquatic weeds and algae?

- Am I willing and able to spend the time, money and effort needed to achieve the results I want?

Goals

Lack of a clear goal is often at the root of unsatisfactory pond construction and management. Changing goals frequently can also be a problem. Select and work toward a single primary goal based on careful assessment of a pond's potential. Write down your goal and keep sight of it. Stick to it long enough to see whether it works.

Satisfactory fishing is undoubtedly a primary goal, or at least a secondary one, for many pond owners. Write this goal down in terms of the kinds of fish you want. Also create a list of your other goals. Record your goals on the first page of your pond management log book (see page 26). Once you decide to build or manage a pond, a log book is an invaluable tool for keeping track of your management efforts.

Trying to accomplish too many things with your pond might mean that none works well. For example, maintaining schools of large fish along with flocks of ducks and geese in a clearwater environment and also using the pond as a livestock watering area are not compatible goals. Concentrate on one major benefit and a few pleasant side effects. For example, a soundly managed bass or trout pond might also offer a little swimming and skating, as well as an emergency water supply. It can also serve as a scenic asset frequented by

songbirds and visited occasionally by migrating ducks.

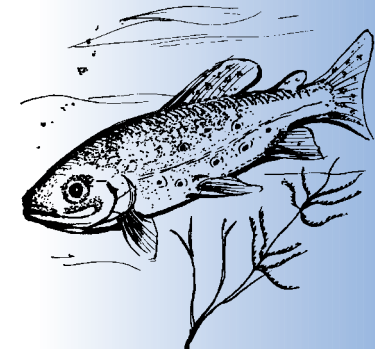
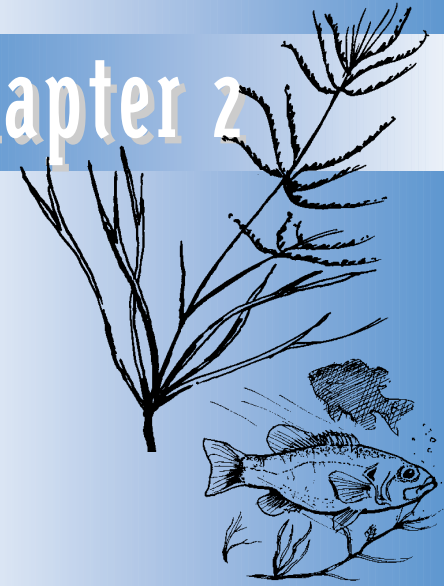
A reasonable goal for a sport fishing pond in Wisconsin would be to obtain a moderate amount of angling for medium-sized fish. Angling fun and a meal of fish now and then are reasonable expectations. Whether you are interested in sport or commercial fish pond management, you should understand that northern ponds cannot produce as many large, fast-growing fish as warmer ponds in southern states.

Investigate and plan

Undertake pond construction and management only after carefully studying the situation. After reading about ponds, examine your pond (or potential pond site) in as much detail as possible. Several sections of this publication suggest characteristics of ponds and their fish populations that can be measured and analyzed. Consider hiring a professional to analyze the pond and assist you with a management plan.

Pond design and construction are highly important to a successful fishery. If you intend to build a pond, see Chapter 3 and contact the U.S. Natural Resource Conservation Service (NRCS) office in your county about engineering design services. Your county Land Conservation Department may also be able to provide technical advice. The county Extension office can help you identify design services or develop a business plan if your interests lie in commercial aquaculture.

chapter 2



Management overview

Knowing when to leave things alone is important. Overmanaging and applying management techniques simply because you've heard of them are common management mistakes.

The usual steps in managing a pond for sport fishing are:

1. Building or rebuilding for the best depth and slopes (Chapter 3)
2. Assessing and modifying fish populations (Chapter 10)
3. Stocking suitable fish (Chapters 5, 6 and 7)

If you manage a trout pond, you generally need to restock it each year. If you manage a warmwater pond, natural reproduction usually maintains the fishery.

The interrelated ideas of **balance** between predators and food organisms and of a **happy medium**, or consistently maintaining the right amounts of certain elements in the pond, are important for sustained quality fishing. To maintain the pond as a good place for fish to live, water fertility, chemical characteristics and temperature need to stay within certain limits.

Water fertility ranges from too little to just right to too much. With too little fertility, not enough plant and animal life grows to feed resident fish. With excessive fertility (often the case), plants clog the pond, organic matter accumulates on the bottom and the pond becomes unsuitable for most desirable fish.

Fish grow well and produce good yields as long as there is enough breeding stock and food. Too many fish ruin the food supply, resulting in undernourishment and poor growth. For example, if you stock two small, identical ponds with unequal numbers of fish—1,000 in one and 10,000 in the other—each pond will have about the same total weight of fish a year later. But the fish in the pond stocked with 1,000 will be larger. Don't overstock, and don't let the fish become too numerous!

In ponds managed as trout or bass fisheries, angling harvest must be limited if fish are to live long enough to reach a good size. On the other hand, where panfish are present, severe cropping of small fish may be needed to avoid overpopulation. Keeping panfish populations in check by fishing alone is difficult in northern ponds.

For the best bass fishing, it may be best to exclude panfish. This contrasts with management in southern states where, due to warmer water and longer growing seasons, bass prey heavily on panfish, control their populations and maintain a productive predator-prey balance. Bass in northern ponds usually don't eat enough panfish to maintain such a balance, and bass are often overfished. The result of having panfish in a northern pond, with or without bass, is often panfish overpopulation and stunted growth. Adequate numbers of **large** bass are needed to exert effective panfish control.

Managing panfish in our climate is difficult but various options exist. You can treat the pond to eradicate or reduce fish populations, use sterile hybrid panfish or simply accept and enjoy fishing for smaller panfish. Such fishing is ideal for children who like to catch lots of fish.

Commercial aquaculture

Some pond owners envision financial profit, either by raising fish to sell or by charging anglers a fee to fish. Ponds for commercial purposes should be designed specifically for that purpose (see Chapters 3 and 9). Both "fish farming" and "fee fishing" are risky ventures that require managerial skills and considerable investments in facilities. To be competitive, producers have to market their product at a profit. We strongly suggest "entering the business" via effective in-depth planning before

investing in commercial aquaculture (see Chapter 9).

Meeting state environmental regulations

The construction and management of ponds can cause safety and environmental problems. State laws regulate the following activities (see Chapter 15):

- Damming and diking
- Excavating and dredging within 500 feet of any surface water
- Filling wetlands and any land within 500 feet of surface water
- Discharging fish food and wastes into streams or lakes
- Stocking fish

Federal regulations administered by the state Department of Agriculture, Trade and Consumer Protection (DATCP) and the Wisconsin Department of Natural Resources (DNR) also regulate the use of chemicals to control plants and fish. Before undertaking any of these activities, consult the nearest DNR office on how to proceed within the law.

Various permits may be needed. Proper application for a permit may not only spare you future grief but might result in tips from state officials on the best ways to accomplish your objectives.

Designing and building fish ponds

Types of ponds

There are three main types of fish ponds (figure 1):

- 1) Excavated ponds
- 2) Impoundments
- 3) Levee ponds

Each has different land requirements and applications. Excavated ponds and impoundments are used primarily for sport fishing, while levee ponds are more appropriate for commercial aquaculture.

Excavated ponds are often built in fairly level terrain where the groundwater table is close to the surface. An excavated pond is made by digging a pit deeper than the groundwater level. The pit fills when groundwater seeps in, or when water flows in from nearby springs. Because the excavated pond is dug below the water table (usually with a dragline), it is typically one acre or less in size.

Less commonly, pits are dug that catch runoff water from surrounding land or receive water diverted from a stream. These sources of water are generally less desirable than groundwater springs

or seepage because they can introduce unwanted species and chemical contaminants. Diversion can also change the temperature and flow in these systems, adversely impacting native fisheries.

Because excavated ponds cannot be drained, they can be difficult to manage and are most suited to sport fish production. However, they can be designed and are often used for commercial production of bait or fingerling game fish.

Impoundments or watershed ponds are appropriate for rolling or hilly areas. They are formed by constructing earthen dams. Impoundments are most appropriate in areas with steeper land slopes and low-permeability soils. Where possible, material is excavated from the future pond bottom to form the dam and deepen the pond. If the dam is properly constructed, a watershed pond can be drained. This enhances fish management options.

Pond water quality is generally better if the water is impounded from springs rather than from runoff or streams. Impoundments are not recommended if their construction calls for damming a stream. Impoundments on streams can become settling basins for silt, sediment and debris, causing the streams to fill in and become less suitable for fish. In addition, it may be difficult to stop undesirable fish from entering the pond, making fish management extremely difficult.

Damming streams of any size is strictly regulated in Wisconsin and is generally not permitted.

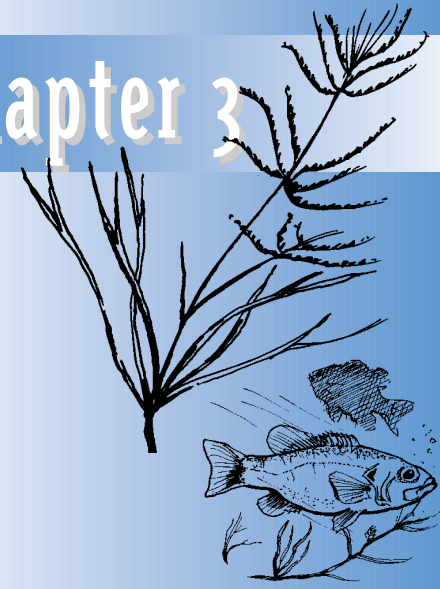
A **levee pond** is usually built on level ground by removing 1–4 feet of material from what becomes the pond bottom. The excavated material is used to build levees, or embankments, around the pond's perimeter. The end result is that most of the water stays above the groundwater level.

Clay soils are best for levee ponds because they hold water and the above-groundwater construction reduces construction costs. Suitable 3- to 5-acre levee ponds can be built for approximately \$3,000 per acre.

Levee ponds are appropriate for commercial aquaculture because construction costs are low. The ponds are shallow, drainable and responsive to intensive management because of their regular shape. Levee ponds are not good candidates for sport fishing because they require pumping and filling from wells or surface water and maintenance costs are high.

Selecting the right site and planning construction carefully plays a large part in a pond's overall success. Contact your county office of the U.S. Natural Resources Conservation Service (NRCS) for information about soils and additional advice on site selection. Also contact the nearest Wisconsin Department of Natural Resources (DNR) office early in the planning stage. Find out what restrictions may apply to your situation and what permits you need. Fish managers often possess valuable expertise with pond management and can help assess your plans.

chapter 3



Stocking fish may require that you obtain a fish stocking permit (see Chapter 15). This process involves a visit to the site by the DNR fish manager. You should also try to identify contractors with previous experience and good reputations by talking with some of their customers. Experienced contractors and pond owners serve as good sources of information.

Key considerations in designing a successful fish pond are:

- Water depth
- Water supply
- A properly formed basin and surroundings that will help avoid an overabundance of nutrients and aquatic plants

These design considerations are interrelated, and changes to one can influence one or more of the others. Landscaping details are somewhat less important.

Water depth

Water depth is one of the most important elements in achieving satisfactory fish habitat in ponds. No matter how large the pond's surface area and how it was formed, a better fish population usually results when most of the pond is at least 15 feet deep. This depth helps avoid winterkill and summer oxygen depletion that stresses fish and can cause die-off or poor growth.

Shallow ponds are more subject to winterkill, especially in cold winters. They usually have fewer, smaller and less desirable kinds of fish because of near winterkill conditions.

Shallow water will do where a sufficient flow of well-oxygenated spring water moderates temperatures and prevents depletion of dissolved oxygen. This is the case in trout ponds with large inflow.

Aeration is used to prevent winterkills and summer oxygen depletion in shallow ponds. You need power at the pond site but periodically operating a good aeration system need not be cost prohibitive. In general, greater depth is better for sport-fish ponds, providing more room and a greater range of living conditions for the fish and their food organisms.

Two main problems can prevent establishment of a 15-foot water depth: 1) excavation costs (which become disproportionately higher as depth increases); and 2) soil conditions.

Before you begin construction, NRCS staff or other knowledgeable individuals should investigate the potential pond's soil structure and profile. In some situations, excavation to the desired depth may perforate the clayey soil layer that seals the bottom, allowing the pond water to drain away. If the natural clay seal is broken, the pond bed can be resealed with clay or commercial plastic liners, which can be expensive. It is better to avoid breaking the seal. The soils may also be unstable and the side slopes will not hold up.

Water supply

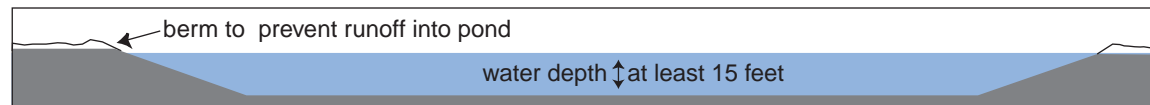
Groundwater, either from wells, springs or seepage, provides a better water supply than runoff or stream water. Groundwater tends to be well-filtered, while runoff and stream water temperatures vary and bring excessive amounts of nutrients, sediment and other materials into the pond. Even stream water that appears clear and "pure" often carries nutrients into a pond.

Excessive nutrients create the overabundance of plants and other organic matter that deplete oxygen for fish. Avoid runoff from barnyards, pastures and fertilized or eroding cropland. Fertilized lawns and gardens are other sources of unwanted nutrients.

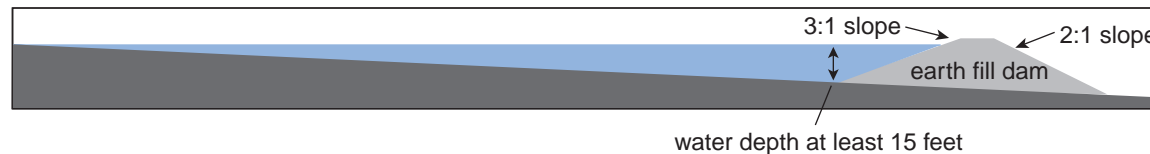
Even with seepage and spring water, you should take precautions. As it emerges from the ground, such water might be very high in iron or too low in dissolved oxygen for fish. Aeration alleviates the problem but adds to the oper-

Figure 1. Three types of pond construction.

Excavated or dug pond



Impounded pond



Levee pond



ational cost. Test the water before you invest in a pond fed by wells, springs or seepage.

Designing for control of aquatic plants

While a moderate amount of rooted aquatic plants benefit fish, too many can produce an overabundance of small fish and impede fishing and management. You can significantly reduce this problem with good pond design and construction.

Rooted aquatic plants need light and nutrients, and grow best on level pond beds. Minimize aquatic plant nuisances by:

1. Minimizing inflow of nutrients
2. Keeping the bottom too deep and dark for plants to survive (15 feet)
3. Constructing steep side slopes

In commercial aquaculture ponds, fertility is sometimes increased to promote adequate phytoplankton levels to restrict light penetration and the growth of rooted aquatic plants. However, this is not recommended for sport fishing ponds.

One way to minimize nutrients flowing into groundwater- or spring-fed ponds is to situate the pond where as little land as possible slopes toward it. This helps reduce the amount of surface runoff entering the pond.

Excessive runoff can also be diverted by means of earthen berms or water diversion ditches. A filter strip of unmowed grass and other low plants along the pond banks is another way to reduce nutrient inflow. Other aspects of erosion control are discussed in the section on landscaping.

If the pond is formed by a dam, an outlet structure that allows discharge from the bottom enables draw-off of nutrient-rich water that accumulates there in summer and winter. Rapid water exchange from groundwater also reduces these problems.

Safety

Side slopes that extend 3 feet into the pond per foot of drop (a 3:1 slope) are sufficiently steep to reduce plant growth while not being so abrupt as to cause *unreasonable* danger to wading children. However, a slippery clay incline of 3:1 or greater *can* be a great hazard to people or animals that might wade or stumble into the pond.

It is recommended that escape ramps of 5 feet horizontal distance per foot of drop (a 5:1 slope) be installed periodically around the pond for escape in situations where soil type and slope pose a danger to humans or animals. If the incline is made of fine sand, it is likely to be unstable and slump if steeper than 3:1. It is recommended that all other soils have slopes no steeper than 2 feet horizontal distance per foot of drop (a 2:1 slope) for stability. If your objectives are plant control and a maximum amount of deep water, the steeper the side slopes the better.

Wildlife pond/fishing pond system

Some sites may be better suited for wildlife ponds. A pond built in an area of heavy erosion or nutrient runoff will have a short life as a fishing pond. Erosion will fill in areas of the pond and, combined with the extra nutrients, bring increased aquatic plant growth. Under these conditions, it may be better to first provide erosion control and then build a wildlife pond or a wildlife pond/fishing pond system.

Wildlife ponds or marsh ponds typically have a maximum depth of about 6 feet with the average depth being about 1 to 2 feet. The pond bank should slope gradually (8:1 or flatter). These conditions encourage aquatic plant growth that will be consumed or used for cover by various types of wildlife. Marsh plants remove the nutrient input from runoff.

A wildlife pond can serve as a settling pond to cleanse water of excess nutrients and sediments when built in conjunction with a fish pond. Use berms to divert runoff water away from the fish pond and into the wildlife pond.

Separate the wildlife pond from the fish pond by a dike. The dike prevents sediments from moving into the fish pond and prevents fish from escaping predation in the shallow weedy areas of the wildlife pond (see Chapter 5). Install an overflow tube, concrete or sheet piling or a rock-lined channel in the dike to prevent over-topping and dike washout during heavy rains.

Surface area

As a rule, the larger the pond, the more stable its fish population. While trout ponds of only a quarter acre may support adequate fishing if they have strong spring flow, most ponds don't provide satisfactory fishing unless they are a half acre or more—and preferably much more.

Small ponds usually need much more intensive care than large ones. Their disadvantages may be somewhat alleviated by making them very deep. Also, if something goes wrong it is easier and quicker to fix the problem in a small pond. Make your decisions based on your goals.

Landscaping and erosion control in the pond's surroundings

With a little planning, a fish pond and the area around it can be made very attractive. Decide whether you want a natural setting or the look of a manicured lawn. In a natural landscape, logs, stumps, rocks and uneven ground may be fitting. If much of the area will be mowed, you may need to smooth the ground and eliminate obstacles during pond construction.

To prevent erosion, establish plant covers quickly on exposed areas. Sod or a heavy stand of grasses prevent soil from washing away. Some recommended grasses include Kentucky blue-

grass, smooth brome grass, creeping red fescue and timothy.

Don't plant deep-rooted plants such as alfalfa, sweet clover, shrubs and trees on earthen dams or embankments. Deep roots weaken these structures and cause leaks. Some ponds may need reinforcement, called "rip-rap," with stone of 8–10 inches diameter piled 1½ to 2 feet thick along the shoreline. Rip-rap protects against wave erosion, especially in the case of dam and fill embankments.

Mixed clumps of evergreens and deciduous trees, bordered by shrubs, provide food and cover for wildlife and give pond surroundings a pleasing appearance. Don't plant trees on embankments. Roots cause structural problems, and dense shade suppresses cover and encourages soil erosion.

Shrubs shouldn't be planted so near the pond that leaves or twigs fall or blow into the water. Leaves use up oxygen when they rot and create layers of litter on the pond bed. They also furnish nutrients for excess water plants. Keep shrubs at least as far back from the water's edge as the greatest height the tree or shrub will reach—and preferably much farther. It isn't necessary to set evergreens back quite as far. Trees and shrubs on the shore area may also interfere with fishing.

Fence livestock away from the pond. Animals destroy vegetation in the pond-bank buffer strip, and their droppings add nutrients to the water. Grazing and trampling also weaken dams, embankments and spillways. If livestock watering is one of the pond's functions, pipe the water to an area where the animals won't harm the pond.

Construction of excavated or dug ponds

Many parts of Wisconsin provide favorable terrain for dug ponds because they are fairly flat, with soft, porous soils and groundwater that lies close beneath the soil surface. These are usually areas where sand and gravel are at or near the surface. Groundwater percolates easily through sand and gravel.

However, many areas which seem suitable may be designated wetlands or may adjoin designated wetlands. Under these conditions strict restrictions apply. DNR water quality specialists and NRCS staff can help you understand the regulations and evaluate the site to determine if it is designated as a wetland.

Peaty, acidic soils characteristic of many wetland areas are not suitable for pond construction. The decaying organic material in these soils depletes dissolved oxygen levels in pond water. The characteristically low pH of waters draining from many wetlands can retard growth or even kill fish.

The water level may fluctuate significantly in seepage ponds as the groundwater table rises and falls—higher in wet years and lower during drought. Plan to excavate more than 15 feet below the lowest level that the groundwater table reaches in a very dry year. Consult NRCS or other experienced people about how to make test borings to find the water table in late summer of a dry year. Depending on soil conditions, groundwater can be pumped into ponds from nearby wells. Sometimes windmills are used for this.

Catchment pits for overland runoff can be dug if soils are clay or other fine material that will hold water, or if clay or other sealants can be obtained to line the pond bed. Because there is usually less water exchange and more potential to pick up sediments and other pollutants, using runoff water to fill ponds is generally less desirable for ponds built to support sport fishing.

The type of equipment that is best for digging ponds depends largely upon the pond's size, site characteristics and desired depth. Draglines or bulldozers are generally used. Bulldozers are more adapted to the drier pond beds. Ponds dug by draglines are seldom wider than about 90 feet but may be much longer. Excavation width is governed by the distance a dragline can move back before it is blocked by its spoil piles—unless the spoil can be moved.

The material dug out of the pond, called the "spoil," should be graded back away from the pond edge and landscaped to

improve overall appearance. Using some of the spoil to build a gentle berm around the pond can help divert unwanted overland runoff.

Construction of impoundments

In impoundments or "fill-type" ponds, water is impounded by an earthen dam containing a core of watertight material such as clay. It is best to build on a site where a great volume of water can be stored by constructing an embankment with a small amount of fill.

The most desirable location is in a valley that is narrow at the dam site. The pond area should be wide and flat with steep sides. Excavation is usually required to deepen the site and also provides the earth for the dam. Wave erosion on the dam embankment can be a problem in large ponds. If possible, try to choose a site where the prevailing wind doesn't blow along the length of the pond toward the dam.

A properly designed impoundment will have two water outlets; a trickle tube or mechanical spillway and a vegetated earthen emergency spillway (figure 2). The emergency spillway is for flood flows. To manage fish and control weeds it is very desirable for the pond to have an outlet designed with a draw down capability for drainage. Contact a professional engineer to design the proper size and type of spillway.

It is best for fish if the water supply comes from groundwater rather than from runoff. If the impoundment must be designed to catch runoff water, situate it so that the drainage basin is large enough to provide sufficient runoff to fill and to maintain water levels even in drought conditions.

You can calculate surface runoff according to the area of land draining into the pond, the amount of precipitation, and runoff characteristics involving land slope, soil porosity, vegetation and human disturbances of the land.

Generally, for a Wisconsin pond that depends entirely on runoff water, five acres of runoff basin land is needed per acre/foot of pond water. An acre/foot is defined as the volume in 1 acre of water, 1 foot deep.

Clay and silty-clay are good soils for impoundment basins. Sandy-clay is suitable only if the cost of extra materials for sealing the pond is acceptable. Be careful not to excavate through the soils that best hold water. Sites in some areas of limestone or dolomite are especially unsuitable—even hazardous—for impoundments. There may be crevices allowing water to drain very quickly from the pond. To get a good bond between the earth and fill material, you must remove all vegetation (including stumps and roots) and topsoil from the dam site prior to construction.

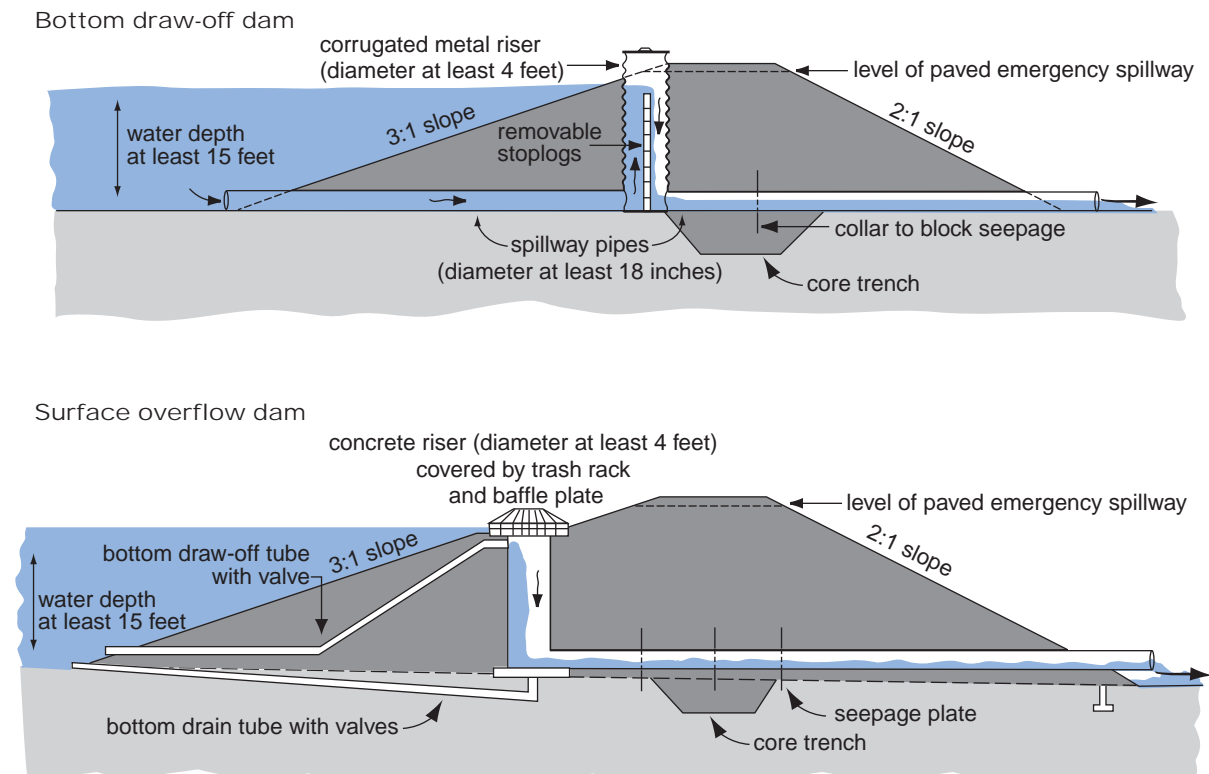
Soils for earthen dams should be at least 20% clay by weight and contain a wide range of particle sizes up to coarse sand or gravel. Fine-grained silts and clays are best to limit seepage. Place the most impervious material in the upstream two-thirds of the embankment. The earth must be compacted to minimize seepage through the dam. Sheepfoot compactors or loaded rubber-tired scrapers are used to compact each layer. Typically, fill is placed in 9-inch layers and compacted.

To ensure proper compaction, you must control soil moisture during construction. Soils that are too wet or too dry will not compact adequately. Carefully compact the soils by hand around any pipes in the dam. For the dam's vegetated spillway, clay, sandy-clay and silty-clay are suitable. Avoid loose sand and other easily erodible soils. Dam cross-sections, side slopes and wave protection are part of site-specific design.

Construction of levee ponds

Levee ponds are best suited for commercial aquaculture. Prior to starting construction make sure the site is suitable for the facilities being planned. An adequate water supply must be available in terms of volume, water quality and pumping ability. The soils should be tight enough to prevent water loss through the pond bed or levees and they should not have high levels of chemical contaminants. The site should not be subject to flooding and should be easy

Figure 2. Two common types of outlet structures for dams that form fish ponds.



Riser-and-stoplog construction is the simplest design that allows controlled bottom draw-off. A drop-inlet spillway can accommodate greater variation of flow. It is needed where runoff from a large land area supplies the pond and where sudden high water is expected.

to drain. Generally less earth will have to be moved and the cost will be lower in level areas than on hilly or rolling areas.

Decisions on the number and size of ponds will depend on what fish you want to raise, the land available and other variables. You should look at the cost of building ponds of different sizes and configurations. Typically commercial levee ponds are built in sets of four. Square or rectangular ponds reduce construction cost and increase accessibility and ease of management. The levees should be at least 8 feet wide at the top and extend at least 1½ feet above the intended water level. If possible they should be constructed with a 3:1 or greater slope. However, the actual slope will depend on the soil type.

As with impoundments, all vegetation and topsoil must be removed from the site prior to starting levee construction to allow a good bond between the foundation soil and fill material.

Self-loading earth movers are the most efficient equipment to use in building levee ponds. They give the best compaction of fill material when complete wheel track coverage is made over each layer of fill placed in the levee. Vibrating or sheepsfoot compacters are also frequently used. For proper compaction the soil must have at least a 15% moisture content.

Leave open the area of the levee where the drain is to be placed to serve as a drain for storm water until construction nears completion. Install the drain pipe

of appropriate diameter as soon as the pond bottom is graded. Dig a small sloped ditch, approximately one third the diameter of the pipe, to give uniform support for the pipe (figure 3).

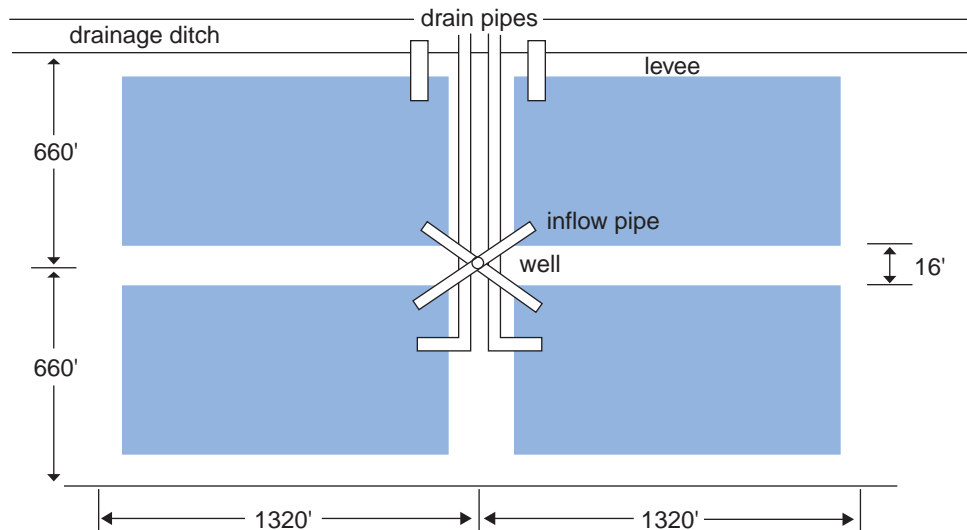
Place moist fill materials along the sides and over the top and compact it by hand to a distance of at least two feet above the pipe. The hand-compacted fill provides protection from heavy equipment while the levee is being completed. In some situations the pond drainpipe should be installed first, so that storm water can drain through the pipe during construction. In either situation, install at least 2 anti-seep collars around the drain pipe to avoid seepage along the outside of the pipe. Such seepage can cause erosion and even failure of the levee.

The ponds should be built with a 0.1–0.2 foot drop per 100 lineal feet from the shallow to the drain end. The level of the pond bottom at the drain must be high enough to drain to a ditch which carries water away from the site by gravity.

To prevent unwanted fish from entering the pond through the pipe during draining, elevate the drain pipe 2 feet above the ditch. Several types of draw-down structures can be used; simple turndown pipes are recommended for large fish production. More elaborate structures with harvest kettles can be used for fingerlings or small fish, but these are quite expensive.

Don't forget Wisconsin's winter ice conditions. If you are using a simple turndown pipe and keeping the pond full during winter, aeration or continuous water input should be installed next to the drainpipe to keep water from freezing around the pipe and heaving or breaking it. The drain system must be secure enough to prevent unintentional draining and large enough to allow the pond to be drained completely in 5–7 days, preferably less. Typically a 6" pipe is used for a 1-acre pond and an 8" pipe for a 3-acre pond.

Figure 3. Layout of typical levee type ponds.



Ponds as places for fish to live

Basic pond characteristics for fish production

The ideal Wisconsin sport fishing pond possesses the following attributes:

- A surface area of at least one acre
 - Steep side slopes (about 1 foot vertical per 3 feet horizontal)
 - At least one quarter of the pond more than 15 feet deep
 - Water comes exclusively from groundwater seepage rather than streams or runoff from land
 - Dissolved carbonate mineral concentration (hardness) of 150–250 parts per million (conductivity of 200–500 $\mu\text{mhos/cm}$)
 - pH between 7–8
 - Inflow with only moderate amounts of nutrient chemicals—amounts that would naturally enter the pond from an undisturbed landscape
 - Less than $\frac{1}{4}$ of the pond bed covered by dense plant growth
- Concentrations of dissolved oxygen not much below 5 parts per million during the growing season, even in the deepest water
 - A balance between the amount of fish and the amount of natural food so that fish grow rapidly

Few ponds are ideal in every respect and different characteristics in any of the categories can still produce worthwhile fishing. In many locations, some of the ideals cannot possibly be met, even with considerable management. For example, regulating the hardness of groundwater is usually not feasible, and you should not hesitate to own a pond just because hardness is not optimum. Throughout the state, ponds with a maximum depth of 7–10 feet produce good fishing for many years.

An ideal coldwater pond for trout differs from a warmwater pond primarily by having a good seepage of groundwater (springs), which keeps water temperature lower in summer.

This chapter explains why the pond characteristics listed above are important to the well-being of fish. The functioning of ponds is complex—but understandable and predictable enough to help you manage for quality fishing.

The pond ecosystem

A pond is an organized system of water, soils, dissolved substances, solar energy and living organisms. These elements comprise the pond ecosystem.

The parts of the ecosystem continually change and interact. Material and energy enter and leave the pond continuously (figure 4). Most minerals and organic materials that enter the pond are trapped and stored there. In contrast, most water and gases that flow in soon flow out again. The pond captures solar energy to produce food and warm the water.

The pond is part of a larger land-and-water ecosystem called the watershed. The watershed includes all the land area that drains into the pond either through surface or groundwater. What goes on within the watershed greatly affects what happens in the pond. For example, disturbance of vegetation in the drainage basin may increase rainwater runoff and soil and nutrients that wash into the pond.

Some mineral and organic material enters the pond in solid form (dirt) that settles to the bottom. This material accumulates in the pond. Other minerals and organic matter enter the pond already dissolved. Plants can readily use dissolved nutrients to grow.

chapter 4

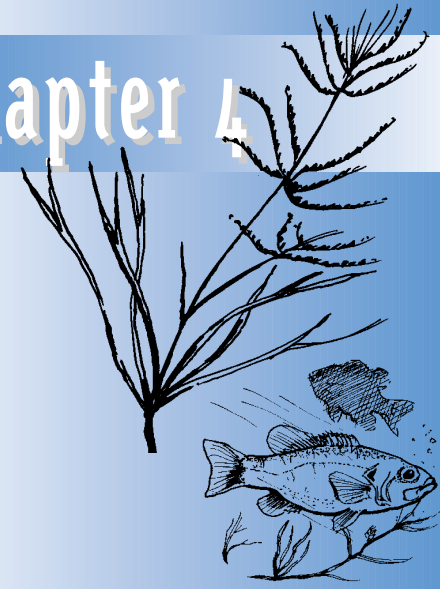
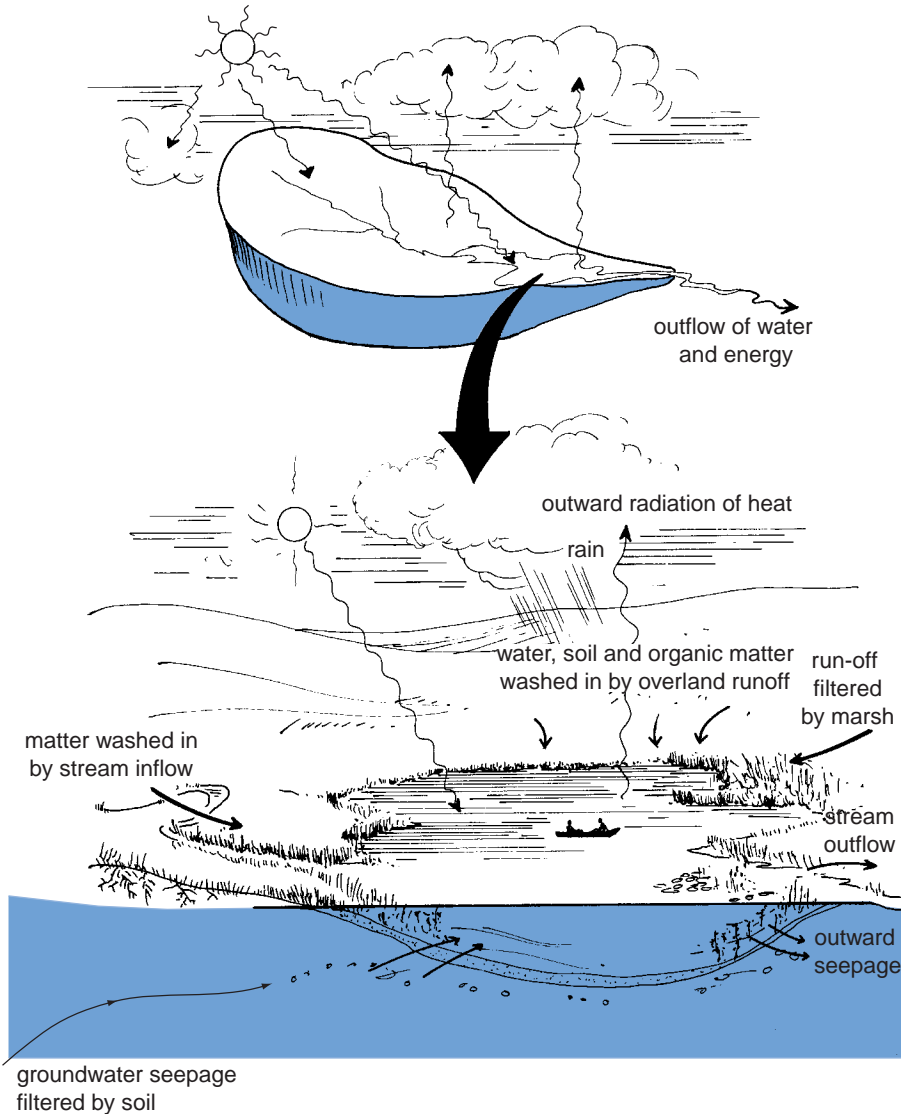


Figure 4. Flow of energy and matter into and out of the pond and its drainage basin.



Some plants are eaten by animals; others die and settle to the pond bottom. The plant-eating animals die and drift to the bottom or are eaten by other animals—which in turn may be eaten by still others. The plant and animal material that animals consume is either stored in their bodies or passes into the water as solid or dissolved wastes.

The dead plants and animals, wastes and solid materials washed into the pond partially decompose and redissolve due to scavenger animals, microorganisms and chemicals (figure 5). The redissolved material serves as nutrients for further plant growth. Materials not completely decomposed accumulate on the pond bottom and so the cycle continues (figure 6).

Figure 5. The food pyramid of a pond.

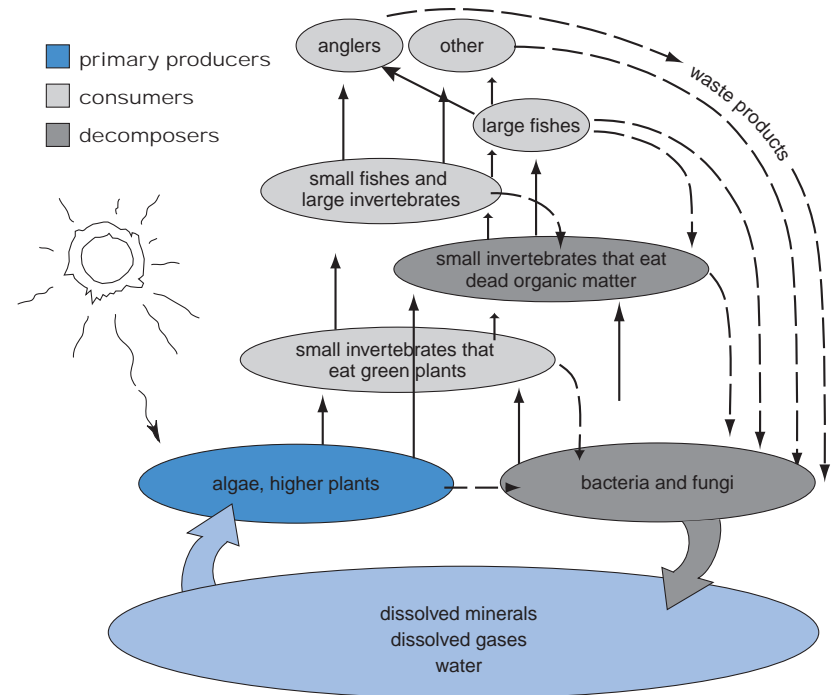


Figure 6. Inner working of a pond in rough outline.

This sketch of the movement of energy and matter looks complicated, but the real situation is far more complex. Most mineral and organic matter entering the pond becomes trapped in it and is, to some extent, recycled. Most energy that enters from the sun leaves again rather soon. Water also flows through.

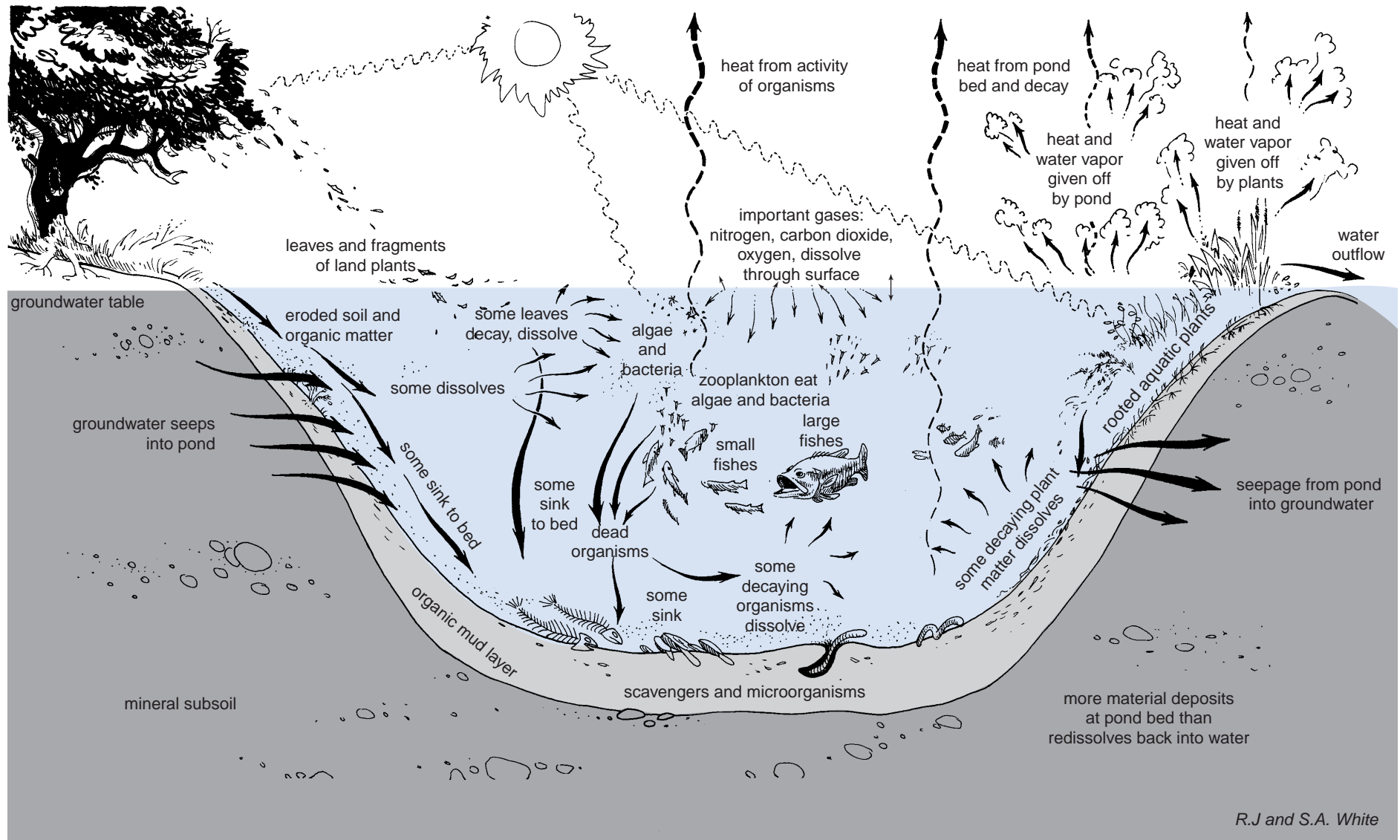
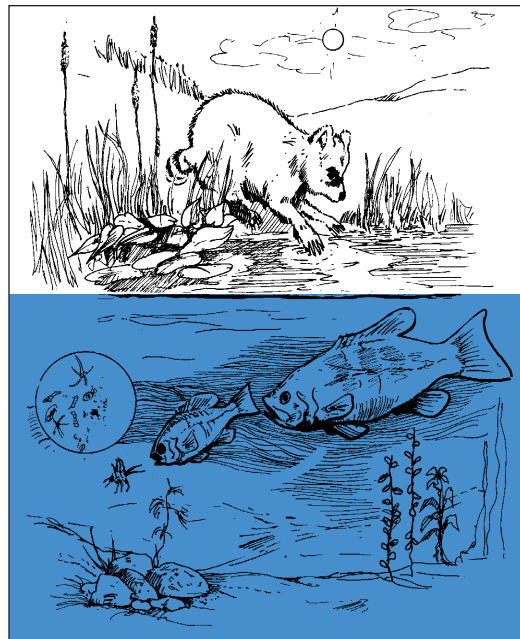
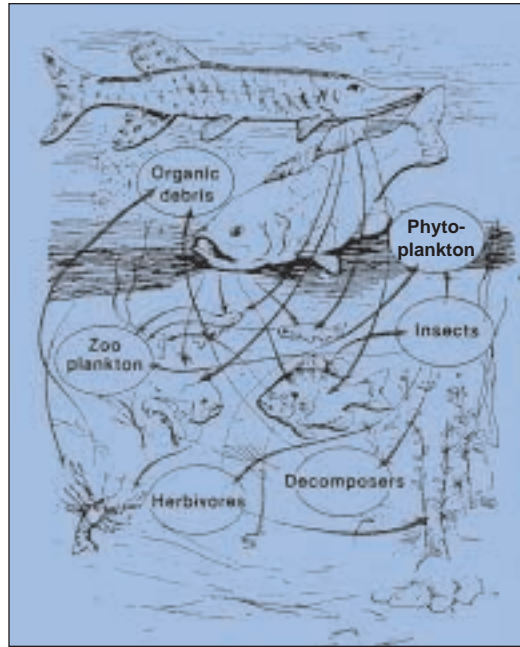


Figure 7. **Food web and food chain contrasted.**

The arrows point in the direction of predatory or “grazing” pressure. A chainlike system may produce more of certain fish that we want, but a break in one link may severely disrupt production. The web-like system has many more parts and is therefore more stable and more productive overall.



Much of the mineral and organic matter that enters a pond stays there, even if water flows out. Some nutrients are carried away by emerging insects or in fish taken by natural predators or anglers.

The food relationships that link organisms form a “food web” (figure 7). The web-like structure provides a stable food supply to fish and other pond creatures. When a part of the web changes, for example, when disease reduces the numbers of one animal, other creatures still remain to serve as food for fish.

When we manage a pond to produce one or several kinds of fish, we often reduce the kinds of habitats and organisms in the pond. This removes many links from the food web and may make the pond ecosystem less stable.

We purposely build ponds with little habitat diversity so that only a few kinds of organisms can thrive—the fish we want and a few food organisms for them. We build uniformly steep pond side slopes to discourage plants that interfere with fishing and provide habitat for too many young fish. We dredge smooth, deep pond bottoms suited for maximum fish growth and for seining to remove fish. We try to ensure a short, efficient food chain by stocking only one or two kinds of fish.

Such artificially simplified and shortened food webs boost production of the desired fish. This is usually what the pond owner wants, rather than an “interesting” and diversified natural community of fish that doesn’t provide as much angling.

However, keep in mind that this simplified community is less stable and may not be able to bounce back from occasional catastrophes such as disease, cold snaps and drought. Substantial and repeated management is often needed to keep a pond community the way you want it. There is a saying in pond management: “Once you start managing, you have to keep managing like mad.”

Another problem occurs when there are insufficient predator fish (bass). Small fish (bluegills, other sunfishes, minnows) may become so abundant that they significantly reduce the “water flea” population, which consumes algae. This leads to an overabundance of algae, which is not only unsightly and foul smelling but also harms the pond’s oxygen levels.

Consequences of overenrichment

A pond's suitability for fish deteriorates severely if the pond contains too many nutrients. This happens when topsoil, leaves, fertilizers, or human and livestock wastes flow in—or if too much fish food is added. Algae and other plants then become overabundant. Stagnant, deep areas may lose dissolved oxygen and develop such a buildup of toxic gases in summer and winter that fish become sick or die. This problem is especially acute in winter under ice cover. Mass die-offs of fish, termed “winterkills,” are common in shallow ponds with much organic matter. “Summerkills” may occur with prolonged periods of hot, still weather (figure 8).

Facts about water and the chemicals dissolved in it

Water travels, carrying along substances that dissolve in it. Algae, dissolved material and other substances in the water affect the amount of light entering the pond, which in turn affects the amount and depth of rooted plant growth.

Pond water can be rich or poor in plant nutrients (calcium, potassium, phosphorus and others) depending on their abundance and solubility in the surrounding land. Many ponds grow only small or moderate amounts of aquatic vegetation because few nutrients enter from the watershed. A well-vegetated landscape reduces nutrient inputs to the pond.

Depending upon their amounts, the key nutrients nitrogen and phosphorus can determine growth levels in many ponds. Algae form the base of the food web and increasing the amount of nutrients increases total production of algae. This can become a nuisance. More algae does not always result in more fish since not all of the algae is useful to fish or fish food organisms.

Alkalinity is a measure of the acid-neutralizing capacity of water. The main constituents of alkalinity are carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) dissolved from limestone (CaCO_3) and dolomite in Wisconsin's soils and bedrock (figure 9).

In water with low alkalinity, a small amount of phosphorus yields the kinds of algae that water fleas and other fish food organisms eat. At higher phosphorus levels, the added production may be “bluegreen” algae—a type that algae-eating animals don't like. Thus, rather than supporting the food web that promotes fish production, bluegreen algae proliferate without being eaten. As nuisance algae develop, die and decay, they draw excessively on the pond's supply of dissolved oxygen. The result is oxygen stress that may harm fish.

Ponds with more alkalinity have greater potential for producing fish. But the fulfillment of that potential will be seen only if there is just the right balance of nutrients and if other conditions, such as temperature, are right.

Figure 8. Hazards of pond overenrichment.

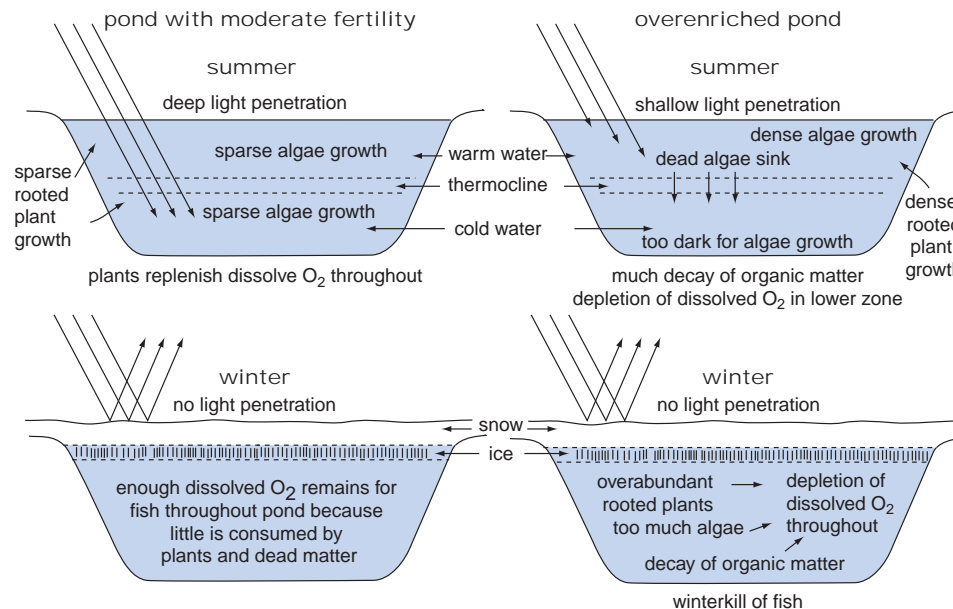
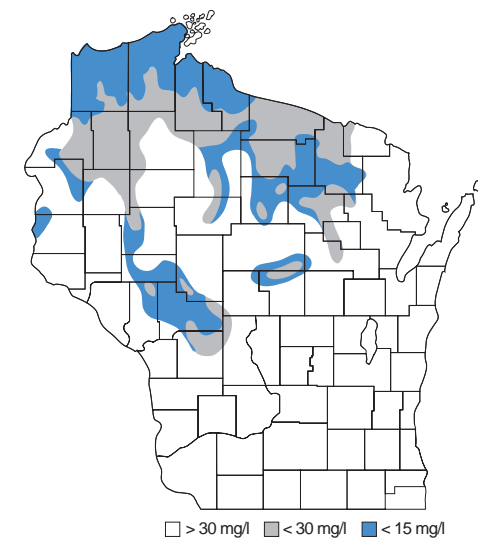


Figure 9. Alkalinity of Wisconsin lakes.



Another benefit of moderate to high water alkalinity is the action of a variety of chemical conditions unfavorable to fish and other aquatic life. The dissolved minerals provide a buffer against extreme changes in pH. In addition, fish need the nutrients associated with alkalinity to grow.

Ponds range in alkalinity from less than 10 parts per million (ppm or mg/L) to over 300 ppm. Most are between 50 and 240 ppm. An alkalinity of 40 ppm seems to be a pivotal value below which fish production declines and above which it is moderate to high. There is no steady trend of increased production with increased alkalinity because of variability in other key conditions (table 1).

Table 1. **Pond carrying capacity related to alkalinity of the water.**

These are very rough indications of how much fish can be supported by naturally occurring food in a pond. Particularly for trout, much greater amounts can be sustained in the pond by artificial feeding, which has certain drawbacks.

Alkalinity of water	Approximate carrying capacity (lbs/acre)			
	Warmwater ponds			Coldwater ponds
	Bass or catfish	Bluegills or other panfish	Total**	Trout**
More than 100 ppm*	50–100	200–400	250–500	150 or more
40 to 100 ppm	25–50	75–200	100–250	25–150
Less than 40 ppm	under 25	under 75	under 100	under 25

*parts per million

**In warmwater ponds, much of the total poundage will be in the form of young fish that are too small for angling. In coldwater ponds, all or most of the trout will usually be large enough for angling—and the poundage shown may provide about as much fishing as that shown for warmwater fishes on the same line.

Water changes in density as it changes in temperature and chemical content. Water is nearly unique among substances in being lighter as a solid than as a liquid. The fact that ice floats atop ponds in winter rather than growing upward from the bottom (or falling there after forming at the surface) is profoundly important to pond life.

Pond breathing, circulation and stratification

A pond exchanges gases with the air above it. This is a form of “breathing.” Gases and other dissolved and drifting materials are moved about the pond by water circulations caused by wind and gravity. In winter, ice greatly reduces circulation and almost completely blocks pond breathing. In both summer and winter, the pond water may stratify into layers representing a gradation of tem-

perature, hence different density. The heaviest water lies on the bottom and the lightest at the top.

During summer stratification, or layering, wind circulates only the upper part of a deep pond. In shallow ponds that are exposed to the wind, summer stratification may occur for only a few days under extremely still conditions. In deeper protected ponds, stratification may last all summer. Generally, ponds less than 8 feet deep will not stratify for long periods in the summer unless they are well-protected from the wind.

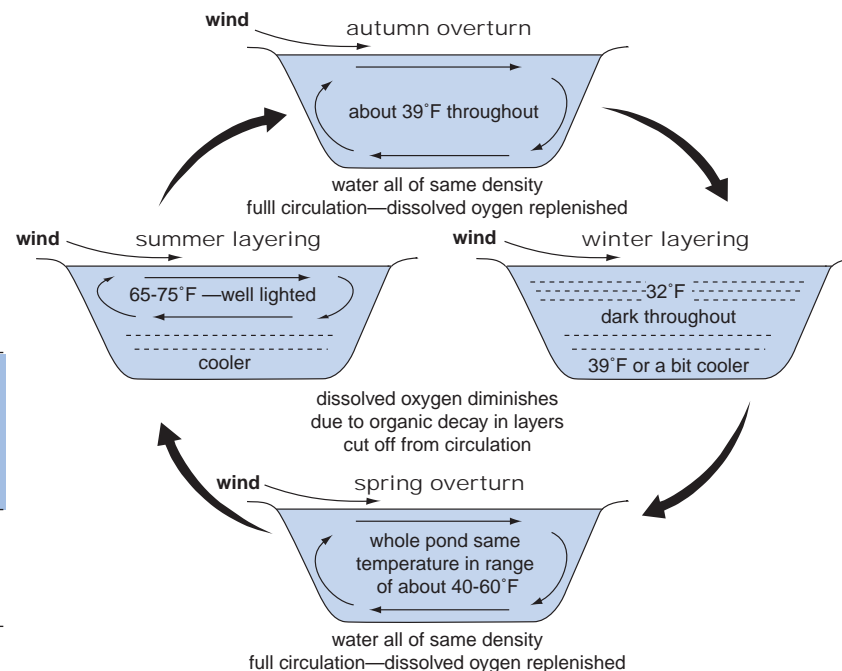


Figure 10. **Circulation and thermal layering of water in ponds.**

Not only temperature but the amount of oxygen available to fish is strongly influenced by the seasonal cycles of circulation and layering. Very shallow ponds (not shown) may have complete circulation for much of the summer, but are much more likely to be oxygen-depleted in winter.

In fall and spring when cooling or warming change all the water to an equal temperature and equal density, the water mixes easily and stratification does not occur. These events are described in figure 10.

Investigating a pond's suitability for fish

Pond owners often ask whether water can be simply tested for fertility and other chemical characteristics to evaluate its fish-producing capacity or to find out why fish haven't thrived. These determinations are far more involved than just sending water samples to a laboratory.

As previously described, ponds are complex, and their conditions change continually. The foremost need is to be alert for land disturbances, water runoff coming into the pond and the entry of human or livestock waste that could cause overenrichment. Such observation of the pond's surroundings, combined with a program of water temperature, water clarity and dissolved oxygen measurement in the pond, provides enough information for basic pond management.

Alkalinity, pH, inorganic nitrogen and phosphorus are additional tests that can help you manage your pond. Some pond testing equipment is relatively inexpensive to purchase or make, or you

may consult a professional biologist for advice.

Judging a pond's productive capacity or diagnosing its problems is best done by a professional. Properly trained aquatic biologists can evaluate conditions of the pond site and surroundings and can interpret temperature and oxygen data.

You may be able to participate with a professional in pond investigation—or, after doing some research, undertake measurements on your own. Much depends on your knowledge of science, the amount of time you can spend and the equipment available. Various handy analysis kits for dissolved oxygen and other determinations are commercially available.

Working with a professional is especially valuable in designing the investigation and interpretation of results. Design involves planning the right sampling at the right times, while interpretation involves judging what the data mean in terms of pond biology and what the implications are for management.

Knowing maximum water depth and calculating mean depth are important, as is observing the abundance of aquatic plants and keeping records of the fish caught (species, length and weight). It is essential to identify possible sources of nutrient overenrichment, such as septic systems, livestock wastes, soil and fertilizer erosion and roadway runoff.

Dissolved oxygen and temperature are crucial to fish and should be systematically monitored. Electronic or chemical kits for dissolved oxygen measurement and sampling devices (dissolved oxygen samplers) should be used. Contact the DNR or your county Extension office for possible sources of these items.

Important times to analyze water temperature and dissolved oxygen (DO) are: 1) in mid-or late summer after a week or more of very hot weather; and 2) in winter after ice and snow have covered the pond for a month or more. For a more detailed picture, monitor the complete annual cycle of pond temperature and DO by sampling every week or two (table 2). A specialist can assist you in developing a schedule for tests at a variety of depths.

Table 2. **Water temperature at various depths¹ over time.**

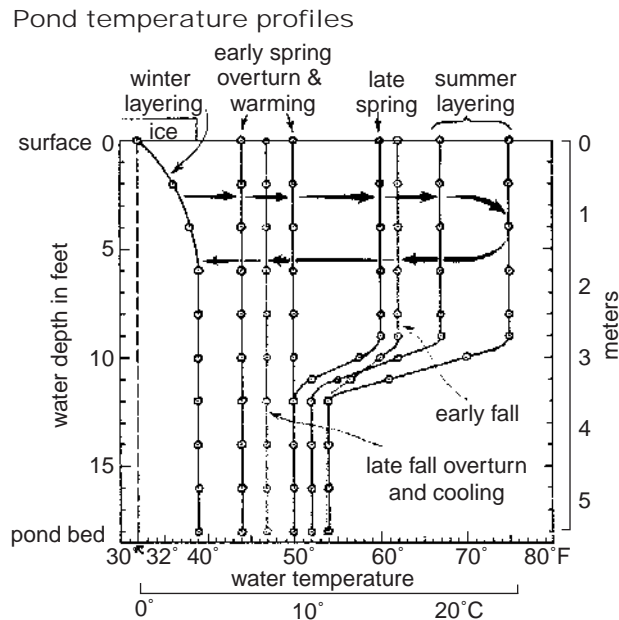
This is an example of a pond measured on the 15th of each month at the deepest point (18½ ft deep).

Water depth (feet)	temperature (°F) at mid-month											
	Jan ²	Feb ²	Mar ³	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec ²
surface	32	32	44	50	60	67	71	75	62	51	46	32
2	36	33	44	50	60	67	71	75	62	51	46	39
4	38	36	44	50	60	67	71	75	62	51	46	39
6	39	38	44	50	60	67	71	75	62	51	46	39
8	39	39	44	50	60	67	71	75	62	51	46	39
9					60	67	71	75	62			
10	39	39	44	50	58	62	65	70	60	51	46	39
11				52	55	58	61	57				
12	39	39	44	50	50	52	53	54	54	51	46	39
14	39	39	44	50	50	52	53	54	54	51	46	39
16	39	39	44	50	50	52	53	54	54	51	46	39
18	39	39	44	50	50	52	53	54	54	51	46	39

¹Measurements made at regular 2-ft intervals, except at 1-ft intervals in areas of rapid temperature change.

²Pond covered by ice. ³About 1 week after ice has melted.

Figure 11.
Water temperature change during the year in a small, fairly deep warmwater pond.



Great temperature variations exist from pond to pond and even within the same pond depending on the water depth, wind strength, air temperature and other factors. Temperature affects water density. Water is heaviest at 39°F (4°C). Thus, water nearest 39°F tends to be at the bottom with warmer—or in winter, cooler—water floating on top of it. This vertical layering, when it occurs, causes a gradation of temperature from top to bottom. Fish can choose the depth with their preferred temperature—as long as there is enough oxygen for them.

Winter layering—Ice covers the surface. Water is 32° just under the ice and progressively warmer at greater depths. Deepest water is near 39°. Warming by groundwater seepage may alter the curve.

Spring overturn and even warming—After ice melts in March or April, wind mixes water evenly throughout as the pond warms. Temperature stays equal from top to bottom as warming occurs.

Late spring and summer layering—Does not often occur in many ponds, especially not in ones shallower than shown here. Layering takes place if upper water becomes, by intense warming, so much lighter than lower water that wind cannot overcome the density difference and can no longer mix all the way to the bottom. Then mixing occurs only in upper water. The well-mixed upper layer has a thinner layer of water with rapidly decreasing temperature between it and the cooler water below.

The upper layer usually extends deeper than shown. Wind may become strong

enough to destroy layering. Very cool groundwater seeping into the pond may make layering more distinct and stable.

Autumn overturn—Surface water cools, becomes denser and sinks, mixing with warmer water just beneath. Thus, the upper layer is cooled to a density near that of the lower layer and wind can remix the whole pond. Complete fall mixing can occur only when the upper water sinks as the weather gets colder; wind is not needed. Fall overturn halts when ice blocks wind action and the upper water becomes colder, hence less dense, than water beneath it, which is nearer 39°F.

Figure 12. **Dissolved oxygen at different depths in the same pond, as affected by the wind mixing and thermal/density layering.**

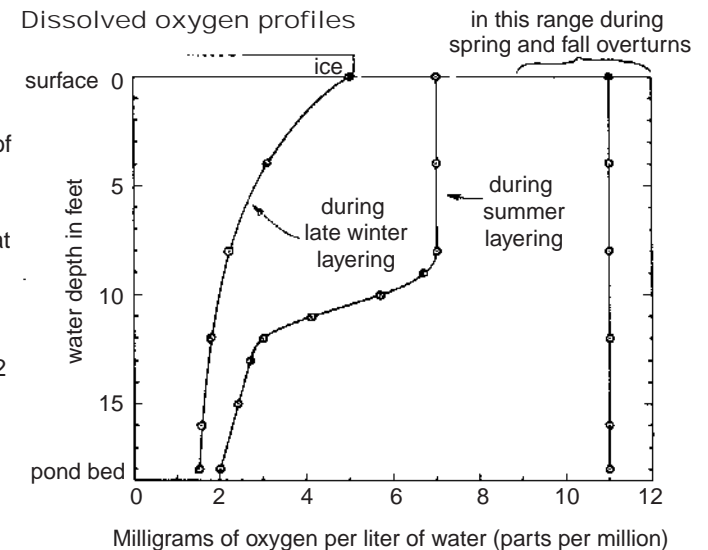
During spring and fall overturn—

Large amounts of oxygen can dissolve into the pond from the air because water that is cooler can hold greater concentration of dissolved gases. Amounts of dissolved oxygen are the same at all depths because water is well circulated throughout. Concentrations of 9–12 ppm commonly occur.

During summer layering—Warmer water in the upper layer cannot hold as much

dissolved oxygen as could the cooler water in springtime. Cool water of the deep layer could hold more dissolved oxygen, but decay of organic matter consumes oxygen and the lower water cannot obtain more because density layering prevents it from being circulated into contact with the atmosphere. Therefore, dissolved oxygen decreases in the lower layer and it may become unfit for fish.

During winter layering—Ice and snow block light and oxygen from entering. Plants have too little light to produce oxygen and oxygen from the atmosphere cannot dissolve in the pond. Respiration and decay consume dissolved oxygen. Concentrations decrease the most near the pond bottom where there is more organic matter. Fish are forced upward into layers with enough dissolved oxygen.



Types of fish to raise in Wisconsin sport fishing ponds

It's important to know something about the lives of the fish you choose to raise in your pond. Species differ in their requirements for feeding, growing, reproducing and surviving. If the pond is unsuitable for the kind of fish stocked, be prepared for reduced growth and poor reproduction or survival rates.

There are two basic categories of pond fish—warmwater and coldwater. Warmwater fish such as bass, bluegills, other panfish or catfish, do best in ponds where summer water temperatures are more than 70°F. A pond may be suited for coldwater fish (various kinds of trout) if summer water temperatures remain below 70°F.

Temperature should be measured a foot below the surface near the center of the pond. Most species do best when dissolved oxygen concentration remains above 5 ppm, but warmwater fish can survive lower levels of dissolved oxygen and all fish can survive lower levels during the winter. The so-called “coolwater” fish such as northern pike, muskellunge, walleye and perch, generally don't thrive in small bodies of water without intensive management (see Chapter 9).

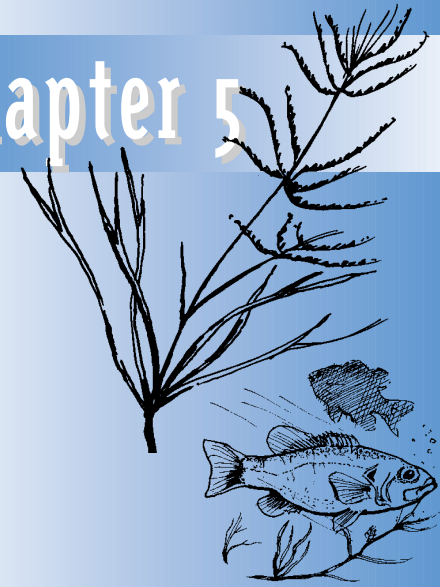


Table 3. Summer length ranges at various ages for fish in Wisconsin ponds.

Growth may be somewhat greater where fish are uncrowded and temperature and food supply are ideal. Growth can be much slower, especially where ponds are overpopulated.

Kind of fish	length in inches					
	first summer (age 0)*	second summer (yearling)	third summer (2-yr-old)	fourth summer (3-yr-old)	fifth summer (4-yr-old)	sixth summer (5-yr-old)
Rainbow trout**	4–6	9–14	14–17	15–19	***	***
Brook trout	2–4	6–8	8–12	9–14	11–16	***
Largemouth bass	1–4	6–8	8–10	10–12	12–14	13–17
Smallmouth bass	1–4	4–7	7–10	10–12	12–14	13–17
Channel catfish	1–4	5–7	8–10	11–13	13–15	15–17
Bluegill	½–2	3–4	4–5	5–6	6–7	6½–7½

*Fingerling **From fall-spawning stock in hatcheries ***Very few survive to this age, and growth is extremely variable.



Coldwater fish

The coldwater fish include trout and their relatives (salmon, whitefish). Trout are most suited for coldwater sport fishing ponds or small lakes (figure 13). Trout eat a wide variety of organisms. They prefer zooplankton, insect larvae and crayfish. Supplementary feeding is not recommended unless the fish are stocked in large numbers.

Trout spawn on gravel beds in streams. Typically, they do not spawn successfully in ponds. Therefore, populations are maintained by periodic stocking. Brook trout can sometimes reproduce in gravel or coarse sand where springs well up in the pond bottom. As with other fish, trout growth varies greatly between ponds, depending on oxygen levels, food supplies, crowding and fish size.

Rainbow trout (*Oncorhynchus mykiss*). Rainbow trout are the most adaptable of the species and are readily available from dealers. They also grow fast and are easy to catch. Generally they can withstand warmer water than other kinds of trout, and do well in all parts of the state. Rainbow trout grow best when the water is between 54°–66°F. They commonly reach a size of 15 inches in about three years. Few live long enough in a pond to reach 20 inches.

Brook trout (*Salvelinus fontinalis*). Brook trout do best in spring-fed coldwater ponds with water temperatures of 48°–60°F. Brook trout are also easy to catch and can provide especially tasty table fare. They may grow as well as rainbow trout up to a size of 10 inches, after which their growth slows. A 15-inch brook trout is an exceptionally large one. For fishing variety, stock rainbow trout together with brook trout.

Brown trout (*Salmo trutta*). Brown trout tolerate slightly higher temperatures than other species. However, they are relatively hard to catch and therefore may be less desirable. Brown trout usually produce a far lower total harvest over the years than rainbow or brook trout. Brown trout can live 5–7 years, despite heavy fishing even by skilled anglers.

The way 18–20 inch browns are cannibalistic which may make further stocking with fingerling or yearling trout unrealistic unless the large brown trout are removed. This may require use of fish toxicants.

Hybrid trout. Hybrids between various kinds of trout are sometimes available and can be interesting to raise. They are unusual and often grow faster than pure-bred trout, but may be hard to catch. They usually aren't practical for the pond owner who is simply interested in recreation and a few fish on the table.

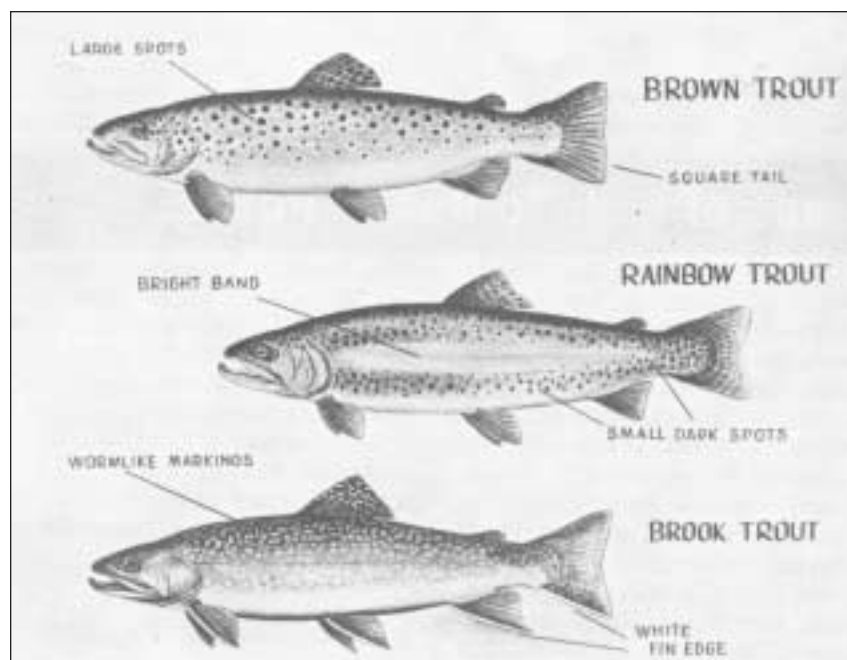


Figure 13. Three kinds of trout that can be used in coldwater ponds. The brown trout is usually not advisable, however.

Warmwater fish

The primary warmwater fish raised in Wisconsin ponds are members of the sunfish or bass family. They include the predatory largemouth and smallmouth bass (figure 14) and smaller sunfish, such as bluegills, pumpkinseeds and green sunfish (figure 15). Black crappie have also been managed successfully in some instances. Another commonly raised warmwater fish is the channel catfish. Various minnows are also classified as warmwater fish. Some species make excellent forage fish.

Largemouth bass (*Micropterus salmoides*). Largemouth bass are the most commonly stocked species in warmwater ponds. They adapt to a wide range of pond conditions, can grow quite large and are a very popular game fish. Their growth rates are influenced by food supply, competition with other fish and water temperature. They grow fastest when the water is above 75°F.

Bass prefer minnows as forage over bluegills and other panfish. They tend to grow and reproduce better where they are stocked with minnows.

Largemouth bass may live for 10–13 years, though the average pond has very few older than 5 years. Most female largemouth bass first spawn when they are 2–4 years old, or about 10 inches long. Spawning occurs in May or June when the water is between 60°–70°F.

To form a nest, the male either sweeps a shallow circular depression in the bottom or cleans off a clump of grass-like aquatic plants by fanning with his tail. Males select nest sites at depths between 2–6 feet. The nests usually are developed near overhanging logs or other cover.

The male fertilizes the eggs as the female scatters them on the nest. He guards the embryos and newly hatched fry, which school near the nest until they are well developed (about one week).

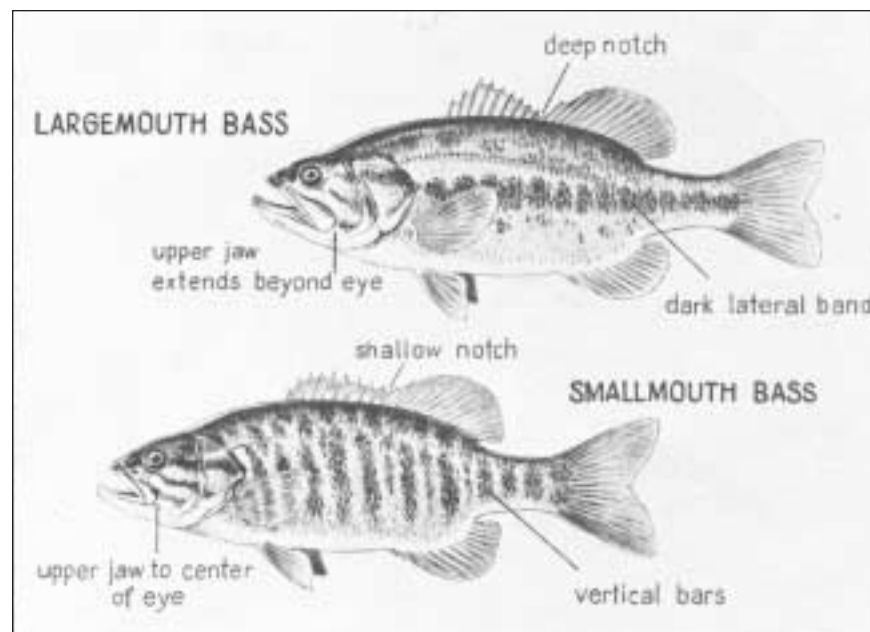
Numbers of fry hatched per nest vary considerably. An average of 4,375 was found in one study. Young bass eat water fleas, insects and very small fish and crayfish. An adult will prey on almost any available animal that fits in its mouth, such as fish, crayfish, tadpoles, frogs, worms and insects. Young bass make an excellent forage for adults. By preying on their own young, largemouth bass can live successfully in a pond or small lake without other species. They also hold their numbers in check reducing the risk of overpopulation, stunting and poor fishing.

Figure 14. **Largemouth and smallmouth bass. The latter is especially suited to water where the temperature is a bit too cool for largemouth bass but too warm for trout.**

Survival of largemouth bass embryos and fry in the nests may be reduced by sudden drops in water temperature during the spawning period. Smaller adult males are also less successful in defending their nests against predation. They can be overwhelmed by large numbers of bluegills or other species. Competition for food, predation, reduced winter pH and starvation during winter all influence first year survival.

Food competition with other fishes such as young bluegills can cause mortality by reducing the growth of first year largemouth bass. Those that do not get big enough starve or are killed by predators during the winter. Young bass are extremely inactive during the winter and do not feed even if food is plentiful.

Smallmouth bass (*Micropterus dolomieu*). Smallmouth bass are best-suited for ponds that have clean gravel beds for spawning and somewhat cooler water than is best for largemouth bass. For these reasons, old gravel pit ponds often furnish excellent smallmouth bass fishing. Smallmouths are sometimes classified as a “coolwater,” rather than warmwater, fish. Many anglers like smallmouth bass better than largemouth because they fight harder. Their feeding, growth, reproductive habits and management are roughly similar to those of largemouth bass. Their young are probably more susceptible to mortality by predation in systems overpopulated with bluegills. The fry are black and conspicuous. Smallmouth young are also subject to winter pH stress and starvation.



Bluegill (*Lepomis macrochirus*). The bluegill is probably the fish stocked most frequently in warmwater ponds. Bluegills are caught easily, are good scrappers on light tackle and are very tasty. They also provide fast action for kids.

However, pond owners who wish to stock bluegills should be cautioned that, although several years of good fishing will probably follow the initial stocking, intensive management is required to maintain desirable body growth. Bluegills breed prolifically, overpopulate the pond and severely overgraze the food supply, decreasing growth. Even when stunted, they remain prolific.

Bluegills feed on a wide variety of organisms, including insects, water fleas, fish eggs and small fish. Rooted aquatic plants and algae have also been found in their stomachs. However, plant material provides little if any of their nutritional needs. Bluegills, like all other northern game fish, must meet their nutritional needs by feeding on other animals. Growth varies, depending largely on how crowded they are. Under favorable conditions, they reach 6 inches in 2–3 years but in many ponds, they reach this size only after 4–6 years.

Female bluegills reach sexual maturity by the second to fourth summer of life and produce 6,000–27,000 eggs per year, depending on their size. Bluegills spawn over almost any type of bottom in water 1–3 feet deep, starting in May or June.

Spawning occurs at slightly higher temperatures than in largemouth or smallmouth bass and continues into early summer. As with bass, the male bluegill builds and guards the nest. Nests are usually shallow depressions in the bottom, 6–12 inches in diameter and close together. The average nest contains about 18,000 fry which may come from more than one female.

Females mature at different times, and the eggs from a single fish ripen gradually. A female may deposit eggs in batches over a period of several weeks. The long spawning season assures that there will be offspring even if adverse conditions occur during parts of it.

Black crappie (*Promoxis nigromaculatus*) and white crappie (*P. annularis*). Black and white crappie possess many of the characteristics of other members of the sunfish family (figure 15). Crappies have been managed successfully in some ponds and small Wisconsin private lakes.

Under the appropriate conditions, crappie grow faster and larger than bluegills. They spawn earlier than bluegills and their spawning period is more restricted, reducing the probability of overpopulation. They eat water fleas, insects and minnows and feed in more open water. Therefore, they do better in waters with fewer rooted aquatic plants. They are not generally suitable for smaller ponds (less than 6 acres).

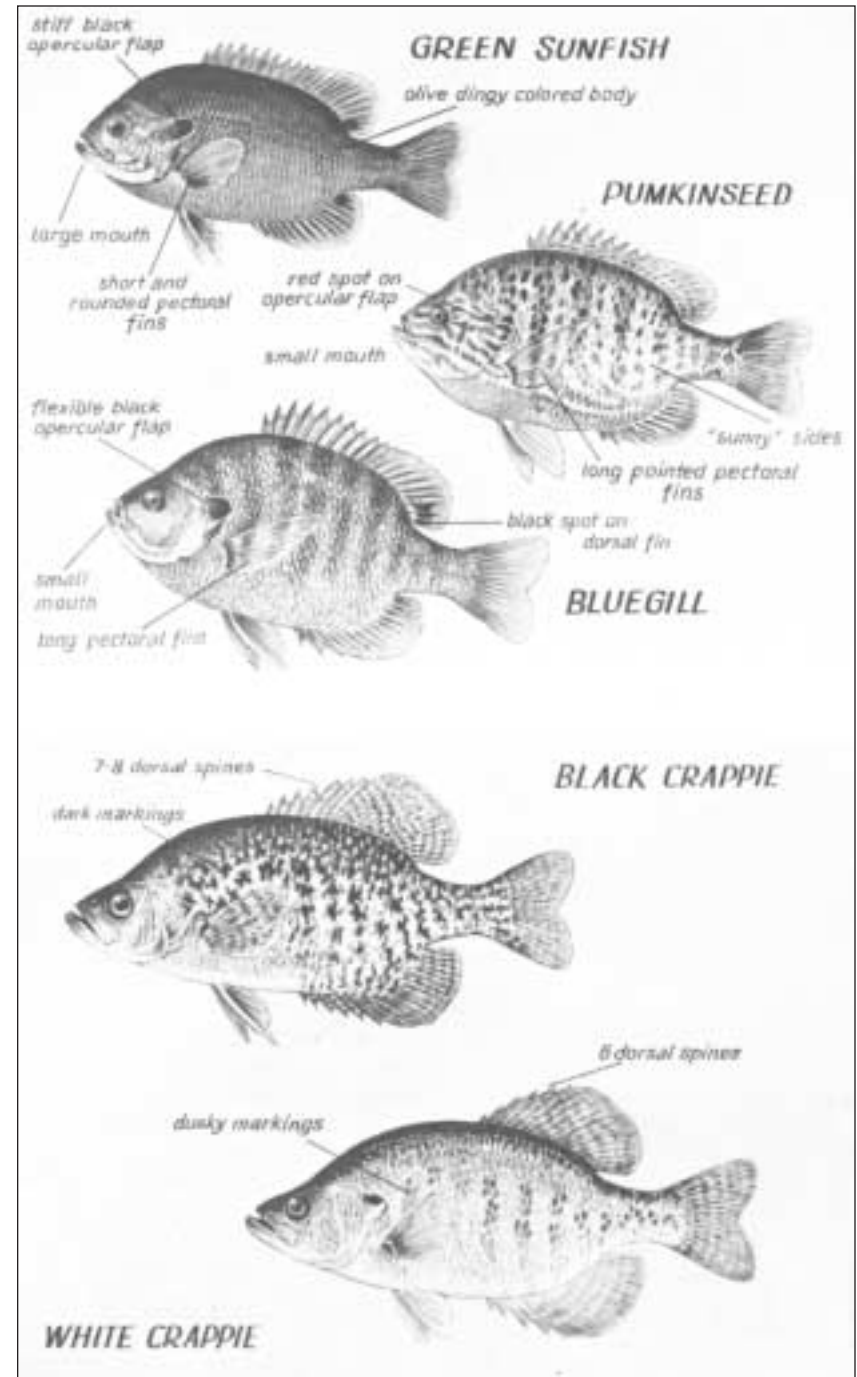


Figure 15. Panfishes.

Hybrid sunfish. Hybrid sunfish are artificial crosses, usually between green sunfish females and males of other species like bluegills or redear sunfish. If the fish farmer producing the hybrids is very careful in selecting the parents so that only female green sunfish and only males of other species are present in the breeding pond, the resulting offspring should range from 65% to nearly 100% males.

Since most hybrid sunfish are male, reproduction is reduced in ponds that contain only hybrids. Under these conditions the hybrid sunfish may grow faster than normal bluegill sunfish.

Do not stock hybrid sunfish under the following conditions:

- If normal bluegill or green sunfish are already in the pond. The hybrids can back-cross with their parent types since the hybrids are fertile.
- If the ponds already have a stunted sunfish population. They will compete for the same food and will not grow very fast. They will also breed with the stunted fish.
- If the pond is shallow and weedy. The weeds will provide places for the young of the hybrids to avoid predation. Overpopulation will be forestalled by only a few years.

Channel catfish (*Ictalurus punctatus*) (figure 16). Interest in stocking catfish in Wisconsin ponds has increased. This is due largely to extensive catfish farming that developed in southern states in the 1960s.

Catfish have certain drawbacks in northern ponds. They do not generally spawn successfully in these ponds unless special spawning structures are installed. They also grow slowly compared to their counterparts in the South.

The catfish is a truly warmwater fish that grows fastest in water over 80°F. But catfish will still grow large enough to provide recreational fishing in many southern Wisconsin ponds because they normally reach 12 inches after 3–4 years. Females usually mature at 13–16 inches in length.

When the water temperature reaches 75°F, catfish spawn in cavities such as those found beneath undercut banks or in hollow logs. The male guards the embryos and fry until they school and leave the cavity.

Catfish eat many types of food, both living and dead: insect larvae, crayfish, snails, worms, clams, fish and various items that fall into the pond.

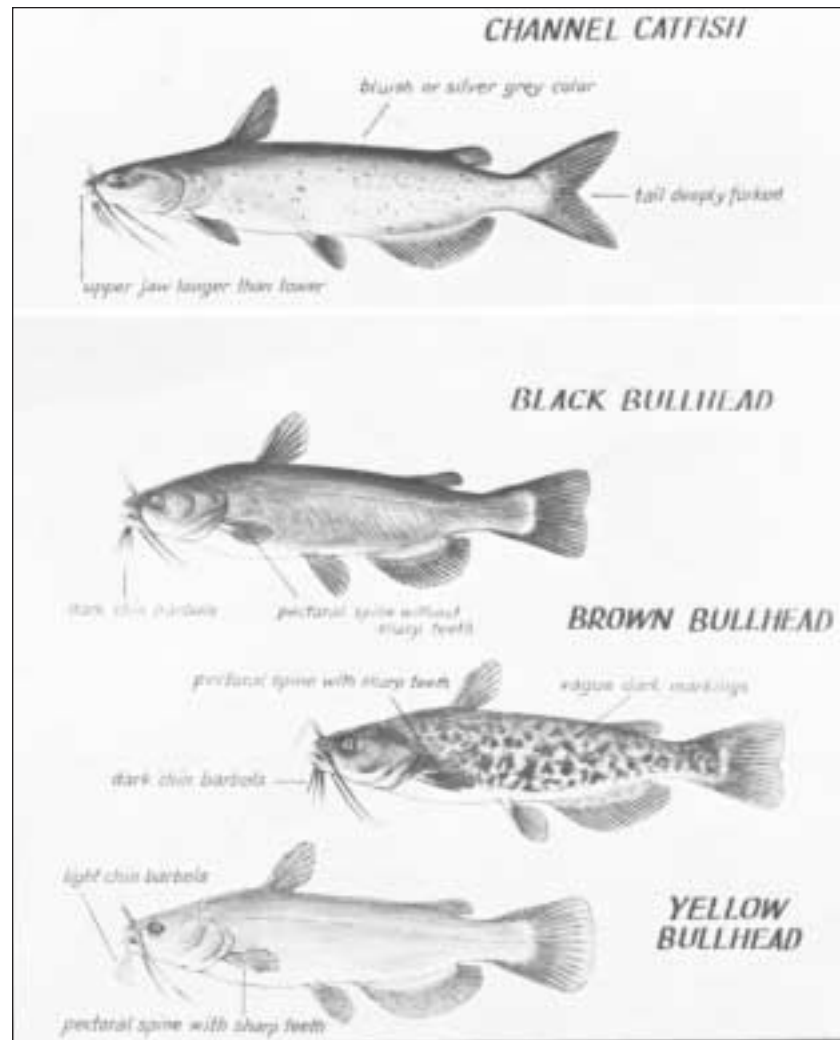


Figure 16. Channel catfish and bullheads.

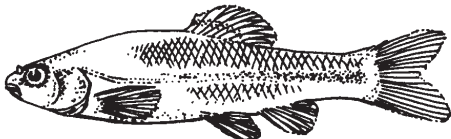
Forage fish

Small fish, such as minnows and shiners, may be stocked as forage for bass and catfish, though this won't always be necessary. Trout don't need the forage and the small fish usually compete for food with the trout.

Therefore, planting forage fish in cold-water ponds is not recommended.

The most suitable bass forage species are the fathead minnow (*Pimephales promelas*), the bluntnose minnow (*P. notatus*) and the golden shiner (*Notemigonus crysoleucas*). These all feed on plankton and insects and will reproduce in ponds if there is suitable spawning habitat.

Fathead minnow

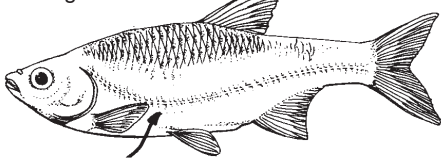


olive gray color

Golden shiner

large scales

silvery gold color



deeply dipping lateral line

Bluntnose minnow

olive back above dark stripe

black spot

spot



All three species spawn when they are 2–3 inches long. Normally, they spawn several times throughout spring and summer. Spawning starts when the water warms to 65°F in areas 1–2 feet deep. Golden shiners deposit their eggs on aquatic plants and sometimes in bass nests. Fathead and bluntnose minnows lay eggs on the undersides of rocks, tiles, boards or logs. Fathead and bluntnose minnows are repeat spawners and males protect the embryos during development, thus increasing survival rates and the forage supply.

Although these forage species are prolific, bluntnose minnows seldom exceed 4 inches in length, and fatheads, 3 inches. They are easy prey for largemouth and smallmouth bass which can wipe them out if the bass population is not held in check or there is not enough dense cover to protect reproductive populations.

Golden shiners attain a maximum length of about 10 inches so their populations are less likely to be depleted by predation. But if many golden shiners in the pond reach 6 inches or larger, they may compete with young bass for food.

Fish not recommended for Wisconsin ponds

The most common problems for Wisconsin pond and small lake management are the presence of too many fish and undesirable species (figure 17). If you are managing a pond for sport fishing, there are two important things to remember:

1. The food resources of ponds are very limited. Placing too many fish in a pond destroys the food supply.
2. Fish have the capacity to multiply quickly. Introducing a small number of a new species "to see what will happen" often results in the expensive task of removing and disposing of thousands of unwanted fish a few years later. In addition to the costs of removal (if removal is feasible) fishing can be harmed for many years. To produce a usable crop the focus should be on managing for one or a few species.

Unwanted species can be introduced in a variety of ways. Well-meaning children or neighbors may transfer fish from nearby ditches or lakes. Fish may also enter from nearby waters during periods of flooding. They may be introduced inadvertently when stocking game or forage fishes. Pond owners should learn to readily identify undesirable fish and try to keep them out of their ponds. Any fish not included as part of the management plan should be viewed as undesirable.

Some species present special problems. The spines of bullheads (*Ictalurus melas*, *I. natalis* and *I. nebulosus*) protect them from predation, allowing them to take over a pond within a few years. Young bullheads are often mixed in with forage fish or fingerling game fish being stocked. Inspect these carefully to weed out bullheads.

Carp (*Cyprinus carpio*), suckers (*Catostomus* spp.) and various native minnow species can also be mixed in with fish destined for stocking. They compete for food and prey on the eggs of gamefish. Carp are bottom feeders which stir up the water, hampering sight-feeding by gamefish.

Fish such as walleye (*Stizostedion vitreum*) and northern pike (*Esox lucius*) are often introduced to control an abundance of stunted bluegills. This approach is seldom effective because bass are very susceptible to predation by these species. Therefore, introducing them often results in fewer bass but no change in bluegill population numbers or growth rates.

Yellow perch (*Perca flavescens*), pumpkinseed sunfish (*Lepomis gibbosus*) and green sunfish (*Lepomis cyanellus*), like bluegill, tend to overpopulate ponds and become stunted. Use these fish only in lakes or larger ponds where largemouth bass over 12–14 inches are present and their numbers are maintained through catch and release fishing. Additional controls may also be required to prevent overpopulation and stunting, such as destruction of nests, trapping and removal of young (see Chapter 10).

Exotic species

Many species of fish exist in the world which are not native to Wisconsin and most would not survive here in the wild. However, certain species have the potential not only to survive, but to reproduce. They become a nuisance, often destroying populations of native fishes. To protect the state's resources, Wisconsin has passed laws that prohibit importing and transporting species not native to the state either as eggs, larvae, juveniles or adults.

The common carp is the best example of an exotic fish species that produces adverse effects. The European ruffe is also established in Wisconsin waters of the Great Lakes and is doing extensive damage. The grass carp (white amur), Japanese weatherfish, ide, rudd, bitterling and tench are other exotics that are present in U. S. waters and could reduce the abundance of native fish.

Besides fish, two exotic plants— curlyleaf pondweed and Eurasian water-milfoil—invade Wisconsin ponds and can cause serious nuisances. Purple loosestrife, a wetland exotic plant, invades wetlands adjacent to ponds and destroys wildlife habitat. A number of other exotic species like the zebra mussel, spiny water flea and rusty crayfish are present in Wisconsin waters, ready to invade ponds of the unsuspecting.

Introduction of unwanted species is a major problem in pond management. The pond owner should learn to recognize "exotics" and undesirable native species and take special care to guard against their introduction.

Pond owners also have a responsibility to ensure species are not released from their ponds into natural waterways. Even the release of native species could alter a natural system by increasing competition, changing predator-prey dynamics or introducing diseases or parasites.



Figure 17. **Some of the fish best kept out of ponds.**

chapter 6

Implementing pond management

Keeping records

A pond logbook is invaluable for recording and reviewing water quality conditions, the kinds of fish stocked, their source, weed treatments that worked, the costs of stocked fish or treatments, and the success of each management activity. Visits from wildlife, catches and fish sizes should also be recorded (figure 18).

In addition to a written logbook that you can carry with you in the field, a computer spreadsheet helps maintain records of water monitoring information, costs, the number and size of fish stocked, the numbers of fish caught, their size and the hours you and others spent enjoying the pond.

You are not likely to remember all of this information without good record keeping. In addition to being a key part of the management process, reviewing the pond records may be one of the rewards that you and other family members receive for your investment in pond management.



Dec. 15, 2001: Finished construction of pond. Figured total costs at \$3,000 on spreadsheet.

Dec. 17, 2001: Pond full. Water flowing over stop logs. Measured at 85 GPM.

Jan. 15, 2002: Pond $\frac{2}{3}$ frozen over. Oxygen 8 ppm at surface pH 7.5.

April 10, 2002: Finished smoothing area around pond and seeded with grass and cover. Installed fish screen at stop logs.

April 25, 2002: Stocked 125 $1\frac{3}{4}$ -2-inch rainbow trout.

June 20, 2002: Algae forming along edge of pond. Removed with rake.

Aug. 15, 2002: Temperature at surface 58°F; bottom 52°F; air temp 90°F. Trout visible along shore around 6 in long. Muskrats in pond.

Oct. 1, 2002: Stocked 100 6-in trout from Fairweather Hatchery.

Oct. 20, 2002: A lot of muskrat activity.

Figure 18. **Pond logbook.**

Selecting the best fish for the pond

The best pond will not produce a good crop of fish if the species is not suited to the pond's conditions. Evaluate your pond conditions before you select fish to stock. Record your observations in a logbook so that you can make sound judgements.

Water temperature is probably the most critical factor in determining the kind of fish to manage. The water source should give some indication of whether the pond is suitable for trout or warmwater species. Unless you are sure, it is best to measure water temperature on a hot summer afternoon a foot below the surface near the center of the pond. Try to read the thermometer at that depth (the reading can change rapidly if it is brought to the surface) or collect a larger volume of water and immerse the

thermometer in it, or use a sampler for dissolved oxygen measurements. If the near surface temperature is more than 70°F, the pond is probably best suited for warmwater fish.

Similarly, you can obtain a bottom temperature by lowering a screw-top jar or can full of water, with a thermometer protruding through the lid to near the bottom for two to three hours (figure 19). Read the bottom temperature when you bring the jar to the surface. If the bottom temperature is the same as that on the surface, you know that the pond is mixing and there should be oxygen at all levels. If it is above 74°F, the pond is too warm for trout.

In the case of borderline temperatures, try trout. They often do well in a borderline pond for several years until the dissolved oxygen content of the water falls too low (under about 5 parts per million) from accumulated organic matter.

Since trout are not likely to reproduce in the pond, it will be easy to switch to a warmer water species if the trout planting fails. This is not true of warmwater species that will live and reproduce in colder ponds but do not grow well. Try trout only before you stock any other kind of fish. This will avoid competition from warmwater species.

In borderline cases you can economize by using only a token stocking of a dozen or so fish per acre; then follow their progress by catch-and-release fishing. If they survive and grow well the first year, stock more.

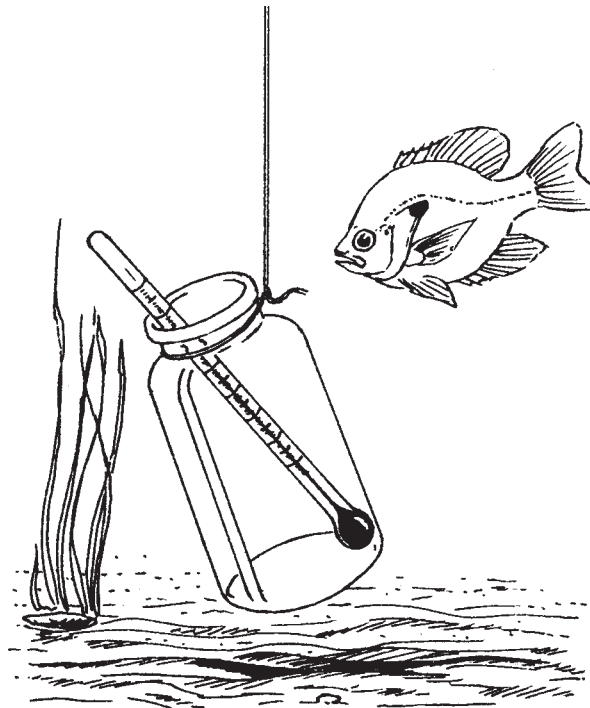
Dissolved oxygen should be above 5 parts per million (ppm) for coldwater fish but can be as low as about 3–4 ppm for warmwater species during summer. Cold water holds more oxygen than warm water; therefore the higher levels required by trout are not generally a problem if the water is cold enough and stock densities are not high.

Oxygen is more plentiful in deeper ponds and in those where plant nutrients are low to moderate. Dissolved oxygen will probably not remain at or above 5 ppm during winter months under the ice in Wisconsin ponds. However, the metabolism of fish is lower during winter. Coldwater fish should survive at 2–3 ppm. Warmwater species will generally survive in ponds even when dissolved oxygen falls to 1–2 ppm during late winter.

In some Wisconsin ponds, **pH** may be a problem. Few fish grow well in acidic systems at pH 6 or below. You should suspect low pH if the water is bog-stained or if the pond was constructed in an area that was previously a bog.

Low pH can also occur in ponds in sandy areas fed primarily by rain water. Liming is sometimes used to raise the water's pH and alkalinity to counteract acidity problems. Liming also allows the pond to handle phosphorus fertility in ways that boost production of fish rather than of nuisance bluegreen algae (see Chapter 4). High pH can also be a problem in some fertile ponds. On a sunny afternoon, pH can reach 9.5 because of carbon dioxide depletion. This can aggravate problems with ammonia toxicity.

Figure 19. Bottom temperatures can be obtained by lowering a screw-top jar or can of water to the bottom and leaving it until its temperature is the same as the surrounding water. Then take the temperature of the contents when it is brought to the surface.



Where to get fish for stocking

Carefully consider and investigate the source of fish for your pond. Purchasing fish from a licensed game fish breeder (licensed hatchery) is usually the easiest, most economical and safest in the long run. You can get the fish at just about any time, in the numbers you need and at the appropriate sizes. You will also reduce the chances of introducing unwanted plant and animal species.

For coldwater ponds, purchasing trout represents the obvious choice. A list of licensed Wisconsin game fish breeders is available at no cost from the Wisconsin Department of Agriculture, Division of Trade and Consumer Protection (see Chapter 16). Check with several hatcheries. In addition to comparing prices, you may wish to visit them to see how the fish were raised and to evaluate their quality. Some breeders are registered as “disease free” and this may be a factor to consider. Record prices and other relevant information in your logbook.

It is possible to catch fish for planting in a warmwater pond. However, bear in mind that you will want the fish to be free of unwanted parasites and in good condition. The stress that fish undergo when they are caught, held in a cooler or on a stringer and transported to your pond could make them unsuitable for stocking.

You might also obtain fish from someone else’s pond or from public waters. In the latter case, you must adhere to all state laws. You are also required to register your pond as a fish farm to catch and transport game fish to plant in your own warmwater pond (see Chapter 15).

Anticipating fish management activities and costs

In addition to assessing what kind of fish to plant and the costs and benefits of various stocking options, you will want to estimate the need for other management activities and their costs. Subsequent chapters will help you determine the fish management activities that will probably be required to promote the success of your pond project. Developing an understanding of the alternatives and their costs will be facilitated by the same kind of careful assessment required to build a good fish pond. Keeping careful records in your pond logbook will help you make good choices.

Determining whether aeration is needed and how much it will cost are questions you should evaluate before beginning your pond management. If dissolved oxygen levels are at or near the minimum required for the desired species, aeration can increase oxygen concentrations.

The most common and inexpensive method is to circulate the water by an air-lift system. A stream of air bubbles is injected near the pond bed in the deeper part of the pond. Rising bubbles draw bottom water toward the top, creating a vertical circulation of water. At the surface, the oxygen-poor water takes on oxygen from the atmosphere. Surface water circulates to the bottom to replace it. The bubble stream can be produced by a compressor powered by electricity. In some instances wind-powered compressors are used. Air passes through a hose along the pond bed to an air stone or other dispenser. A variety of air-lift circulation systems are sold for lake and pond use.

Aeration systems should be designed to meet the specific needs of each pond. One risk with circulating a trout pond in summer is that the entire pond may be warmed beyond trout’s tolerance limit. There are special devices for aerating only the deep, cool part of the pond, without mixing it with warm surface water. Aeration may also keep part of the pond’s surface unfrozen in winter. This can help protect the outlet pipe from damage by freezing. However, the open water and thin ice increase a pond owner’s liability. If aeration is needed, part of the assessment process should include determining how you will protect people, livestock, pets or wildlife from the open water and thin ice areas caused by winter aeration.

For occasional use, consider cascade aeration (pumping water over a cascade box), using a power take-off or engine-driven pump.

Knowing the costs of getting power to the pond site, aeration equipment, the time the equipment will be running and related operating costs will help implement successful fish management on ponds that need aeration.

Managing coldwater ponds for sport fishing

The main steps in managing coldwater fish ponds include:

1. Stocking small trout
2. Fishing for them when they grow to a desirable size
3. Restocking as the population diminishes

Restocking is usually done annually, but can be done less often if you don't fish much and the trout survive other hazards. Annual stocking with fingerlings or yearlings is often good because it creates an interesting population with fish of different ages and sizes. Keep in mind that trout do not reproduce in most ponds, so replenishing the population depends on stocking. See Chapter 5 for information about the different kinds of trout.

Trout usually grow best on a diet of invertebrates such as freshwater shrimp (*Gammarus*), water fleas, insect larvae and crayfish. They do not thrive when there are other kinds of fish in the pond. Bass, pike and catfish eat large numbers of trout. Panfish, bullheads, suckers, carp and even the smallest kinds of minnows compete with trout for food. When competitor fish are in a pond, trout growth and survival is poor.

Before stocking the pond, refer to Chapter 6 to determine whether the pond can support trout.

Stocking

Preparing the pond for stocking is usually not necessary for a new, properly built pond (Chapter 3). If you are converting an old pond to support trout or readying a renovated trout pond, you may need to do certain things before you begin stocking.

If other kinds of fish are in the pond, remove them (Chapter 10). Screen inlets and outlets to prevent the smallest fishes from entering. Maintaining screens can be quite a problem, so it is far better to build the pond without connections to other surface waters that harbor fish. Caution children and friends not to introduce minnows, panfish, goldfish or any other fish.

You may wish to combine a re-digging operation with a fish-removal drawdown. Dragline digging with the pond bed exposed and somewhat dry may be much cheaper than suction dredging or draglining when the pond is full.

Even if you don't dig the pond deeper during a drawdown, take advantage of the situation to rake out aquatic plants and debris. Reducing organic matter usually improves a pond for trout. See Chapter 11 for plant control methods.

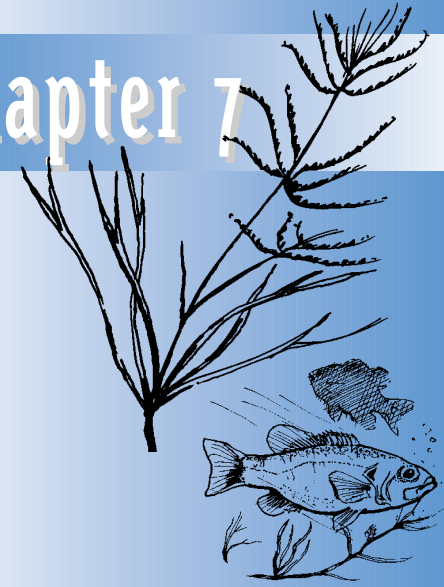
The best times to stock are April, May and possibly June because water temperatures are still moderate and natural food organisms are increasingly abundant. Fish planted at this time tend to do better and start growing sooner.

You can also stock trout in September and October when the pond is becoming cooler. However, there is less chance for growth because the pond soon becomes too cold. Fall stocking is usually done only in new or redredged ponds—or where unwanted fish have been eradicated during the summer.

Fall-stocked fish that live on natural feed generally look and taste better than newly stocked fish. Fall-stocked trout may die during harsh winter conditions, but the losses may be outweighed by the much lower cost of fall fingerlings.

Stocking trout in summer is inadvisable due to the risk of thermal shock that can kill many or all of the planted fish.

chapter 7



Suggested numbers and sizes of trout to stock for populations that will grow well on natural food supplies are suggested in table 4. Only *one* of the types listed should be stocked in one year, although “adult” trout can be restocked as often as they are fished out.

A common mistake is stocking too many trout, which results in poor growth. The current recommended stocking rates are conservative and lower than often suggested in the past. We believe it is far better to risk starting with too few trout than to risk ruining the food supply. If the trout are fast-growing and stay plump all year, stocking can be done at a somewhat higher rate the next time.

The number and size of trout to stock depend on an individual pond’s condition: the amount and size of trout already present, how fast they are to be harvested, the food supply and whether natural reproduction occurs. Adjust stocking from year to year according to past experience and current conditions.

Infertile ponds may support only about 20–25 pounds of trout per acre. Very fertile ponds may sustain upwards of 150 pounds per acre on the natural food supply.

Pond capacity for trout production can be increased several fold by supplemental feeding, and then you may raise the stocking rate. However, feeding can cause various problems (see page 31).

As a rule, the larger the trout stocked, the greater the percentage that survive to be caught—and, of course, the sooner there will be fishing for big trout. Whenever you stock, consider using the largest fish that the budget allows. Price per stocked fish rises sharply with increasing size, but the number needed to adequately stock the pond decreases.

Experimenting in the pond over the years should reveal the best sizes and numbers to stock. Your logbook records will be extremely useful in assessing which size to stock and how well fish from different sources grow. You can compare growth rates with regional averages using figure 20 (see page 32). Calculate the cost per-pound-caught, or per-fish-of-desirable-size caught. You may find that these costs decrease if you stock fish somewhat larger than the smallest, cheapest ones available.

The first time you stock a new or renovated trout pond, it may be most economical to use spring fingerlings. Plan not to fish them until the next spring when they should be 7–8 inches long. However, you may want to do some test fishing in the interim.

If you want an initial springtime stocking to provide more immediate fishing, use 6- to 7-inch yearlings. In excellent ponds, they will grow an inch a month during spring, summer and fall.

For restocking in ponds with established trout populations, don’t use fish smaller than fall fingerlings (5–6 inches). There will be fewer losses to cannibalism by trout that have survived from previous stocking. Annual restocking may provide far more consistent fishing than restocking at greater intervals.

Inspect the trout before planting them to be sure that they are healthy. Don’t accept fish that are obviously diseased, that appear weak or behave abnormally. Fish stressed by improper handling and transport will die soon after stocking. Even under the best conditions, 10–20 percent of the stocked fish may die in the first 2–4 weeks.

Table 4. **A guide for stocking trout to achieve maximum growth without additional feeding and aeration.**

Type of trout	Size in inches	Number to stock per acre	Time to stock	Comments
Spring fingerlings	2–3	200–300	April–May	Least expensive. May be hard to get. Only for initial stocking of new pond or one which has had all fish removed.
Fall fingerlings	5–6	50–150	Sept–Oct	For initial stocking or restocking.
Spring yearlings	6–7	50–150	April–June	For initial stocking or restocking. More expensive than fingerlings.
“Adults”	over 7	25–50	spring or fall	For initial stocking or restocking. Can be very expensive.

*The lower number is for ponds with alkalinity less than 50 ppm or that will be lightly fished. The higher number is for ponds with alkalinity over 150 ppm and/or will be heavily fished; hence, more rapidly “thinned out.”

You may need a special hatchery license to transport your own fish. If you decide on this approach, keep the water at a rather constant low temperature (50–60° F). Cool weather greatly reduces handling stress. Besides being cold, the water must be well-oxygenated and unchlorinated. You may use small aeration devices that operate on batteries or automobile current—or you can attach a tube with a clamp valve and airstone to a spare tire. Cool the container of water (plastic trash cans work well) with ice. However, never place ice made with chlorinated tap water in with your fish. It is usually most convenient and reliable to let the dealer deliver the fish.

As mentioned, stocking trout in summer is not advisable. Since trout must be transported in water that is much colder than the summer surface water of most ponds, they may undergo lethal temperature stress in the warm upper layers of the pond and oxygen stress in the cool water below. Resulting deaths may not be evident immediately, but may occur over several hours or days.

If more than a 6°F difference exists between transport water and the pond, “temper” the trout to the new water gradually. To do this, add small amounts of pond water to the transport tank until its water is at pond temperature. If you transport the fish in plastic bags (oxygen packs), trash cans or other small containers, set them in the pond until the water inside is the same temperature as in the pond. If the transport bags have been filled with oxygen and tied off, do not open the bag (unless fish are in dis-

stress) until tempering has been accomplished and you are ready to release the fish into the pond.

Flushing the trout through a large tube from the transport truck directly into the cold pond depths is another way to reduce thermal shock, but few dealers have such equipment. All in all, it is best not to stock in summer.

When to start fishing and how much to harvest

Do some catch-and-release fishing periodically to see how the trout are growing. Recording their sizes in your logbook allows you to estimate their growth rates. Start keeping fish as soon as you start catching some of desirable size. A reasonable size at which to start harvesting is 7–10 inches. If you delay harvest until the fish are much larger, your total return may be severely reduced. This is because loss of fish by non-fishing or “natural” causes usually occurs rapidly, especially in the case of rainbow or brook trout and few live to be over 3 years old.

The more fish that are taken by angling, the fewer that can be lost to other causes. The greatest yield of fish and enjoyment is usually obtained by doing most of the harvesting in the season when the trout reach 7–10 inches. Review your records over the years to see how best to spread out the harvest to get the desired results.

Under a “put-grow-and-catch” management scheme, trout grow while the harvest is spread out over the season each year. You should be able to harvest an amount of trout about equal in weight to the total poundage that exists in the pond at the start of summer. This is because the remaining trout grow enough to compensate for mortality.

A put-and-take fishery may be appropriate for ponds where temperatures are suitable for trout only in spring and fall. Under “put-and-take” management for rapid catch-out of stockings of trout, many times more pounds of trout can be caught than the pond can support. But you will never catch as many pounds of trout as were stocked. There isn’t time for the trout to make use of the food supply and to grow enough to compensate for post-stocking mortality. The cost per pound of fish caught will be higher than in a put-grow-and-catch management program.

Supplemental feeding

Supplemental feeding shouldn’t be needed if you follow the stocking rates in table 4. At these densities, the trout should have enough natural food to sustain desirable growth.

Higher population densities can be maintained if feed is added. Some people keep as much as 5,000 pounds of trout per acre in hard water ponds with artificial feeding—and harvest that amount annually. This can only be done where a strong supply of spring water keeps temperatures low and rapidly

replenishes the oxygen consumed by decaying feed and fish wastes.

However, there are disadvantages to such intense management. Once the population is built up to the level needing feed, the trout must be fed almost daily during the growing season. “Feedlot” conditions may be created, and the pond’s appearance could become unpleasant. Excess feed and the unavoidable large amounts of trout feces raise water fertility to levels that can cause undesirable algae growth. The accumulation of unused feed, trout waste, living and dead plant matter and decayed microorganisms in the pond consume large amounts of dissolved oxygen. Having too little oxygen hampers trout growth and can kill them if the problem is severe enough. In soft-water ponds especially, excess enrichment can cause fluctuations of pH which are intolerable for trout. High trout densities also attract predators, particularly birds.

If you must feed supplementally, give no more feed at one time than the trout eat immediately. This minimizes the residue of unused feed and reduces cost.

Convenient pelletized dry feed is available. However, use only food especially made for trout. Feeds for other animals (such as chickens) don’t have the ingredients in the right proportions and won’t work. In most cases, floating pellets are best. They stay up where trout can find them longer—and where you can see when they have had enough.

Special aquatic plant control in trout ponds

Keep the amount of algae and rooted plants in trout ponds moderately low. While water plants produce oxygen in daylight, they consume it at night. An overabundance of plants, together with decaying dead plants, may reduce dissolved oxygen levels below the trout's needs, especially on hot summer nights or under winter ice cover. See Chapter 10 for information on aquatic plant control.

CAUTION: Trout are generally more sensitive to chemicals used to kill algae (algicides) or rooted plants (herbicides) than are warmwater fish. Some of these chemicals kill trout at the concentrations needed to kill plants. Be very careful with the common algae control chemical, copper sulfate, in trout ponds. You need to know the water hardness to determine whether copper compounds can be used safely. Other copper compounds such as Cutrine (chelated copper) also require extreme care. *Before buying any chemical for killing aquatic plants in a trout pond, obtain the appropriate permits and determine the effect on trout.* It is safer to remove plants by mechanical means (see Chapter 11).

Trout—*inches*

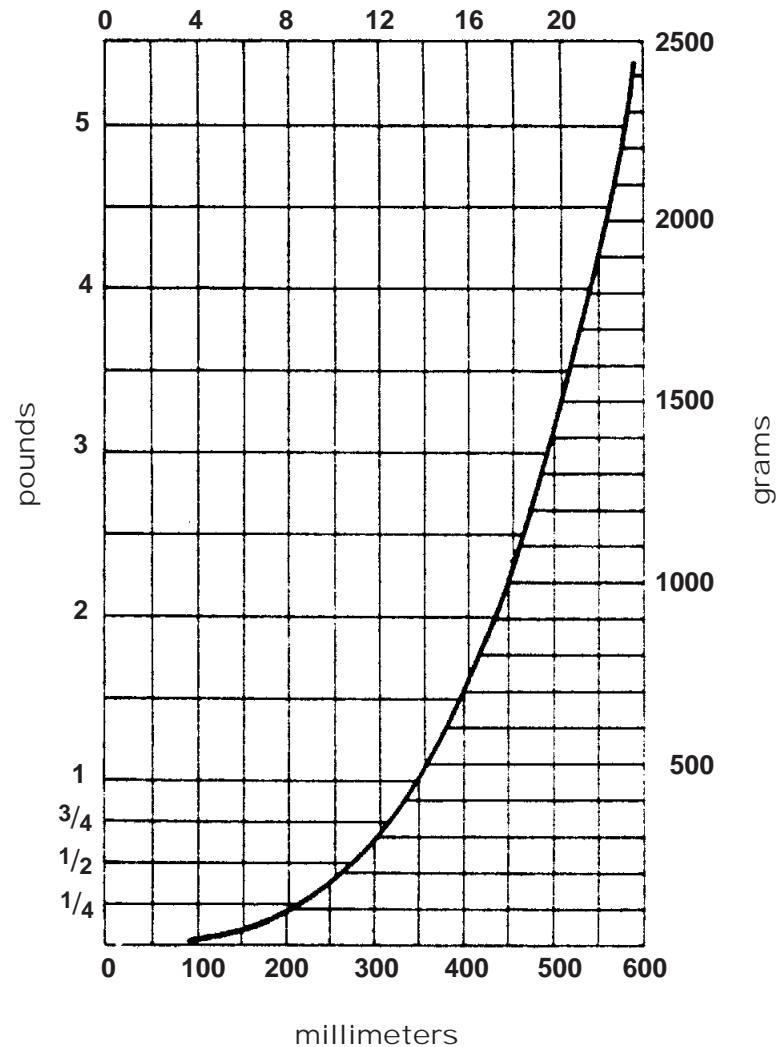


Figure 20. **Determining** whether a trout is the proper weight for its length.

Weigh the fish to the nearest half ounce or 10 grams, if less than $\frac{1}{4}$ pound. If heavier, it may be weighed a bit less accurately. Measure length to the nearest $\frac{1}{8}$ inch. Plot length on the horizontal scale and lightly pencil a vertical line there. Plot weight on the vertical scale and draw a light horizontal line there. If the point where the two lines intersect lies on the heavy curved line, the fish is of standard weight for its length. If the point lies above the curve, it is heavier than average. If it lies below the curve, the fish is underweight.

Managing warm-water ponds for sport fishing

Selecting the right fish species

Most warmwater fish do well at summer dissolved oxygen concentrations of 5 ppm and temperatures between 70°–80°F. Typically these warmwater ponds have less water flow; therefore they need greater depth (15 ft) to sustain oxygen concentrations above the level required for winter survival. Managing warmwater ponds is made more difficult by many species' high reproduction rates. Overproduction of small fish and stunting are major problems, though less so in larger ponds or small lakes (6–10 acres). Managing for one or two species also greatly increases your chances of avoiding problems.

Stocking

While stocking is not the only important aspect of management, the type of fish, the number stocked, their body size, and the time of stocking will do much to determine fishing quality, especially in the first 3–5 years. Special details on stocking various kinds and combinations of fish are given and summarized in table 5. For more information on the biology of each species, see Chapter 5.

Largemouth bass, bluegill and other panfish usually won't need restocking, since they reproduce well in most ponds. Adding to established populations of these fish generally results in loss of the newly stocked fish due to competition and poor growth. You may have to restock smallmouth bass, and will likely need to restock channel catfish.

Bass (largemouth or smallmouth) without other fish. In ponds lacking other fish that compete for food, bass thrive on worms, insect larvae and crayfish. They also feed heavily on their own young which helps keep their population under control. We strongly recommend trying bass alone. If their growth is unsatisfactory, you can always add forage fish.

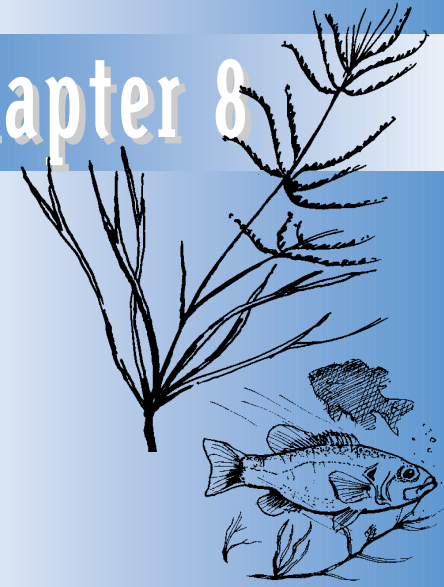
Smallmouth bass work better than largemouth bass where water is on the cool side. Smallmouth bass may also do better than largemouth in new or renovated ponds that haven't yet developed much forage. Smallmouths often don't spawn successfully, because they prefer gravel and the young seem to require more dissolved oxygen than largemouth fry.

Bass with forage minnows. Stocking fathead minnows before stocking bass is safe if you carefully remove all unwanted species beforehand. Fathead minnows are recommended, since they don't grow larger than 3 inches. You can also use bluntnose minnows.

Golden shiners also work well, but sometimes grow too big for bass to eat. If large bass are not maintained in the pond as recommended in this publication, golden shiners may become too abundant and compete with young bass for food. If bass deplete the minnow populations in a few years, you can stock more and reduce the size of the bass population by fishing.

Restocking minnows should always be done carefully so that unwanted species like bullheads are not unintentionally introduced. Scattering the minnows when stocking serves to reduce immediate predation. A moderate amount of rooted plants in the pond gives minnows cover from bass predation and usually allows enough to survive and reproduce to maintain their populations. Installing tile pipes or raised spawning boards also aids minnow reproduction.

chapter 8



Channel catfish and minnows.

Channel catfish grow slowly and seldom reproduce in Wisconsin ponds. They must usually be restocked for continuous fishing. If shelters such as milk cans, kegs or closed pipes are provided, they may occasionally breed. Use the same kinds of minnows recommended for bass forage. Sometimes, for variety, channel catfish are added to a pond containing bass and/or panfish. If adult bass are present, use catfish larger than 7 inches to minimize predation. Bass and panfish will prey on any catfish fry produced.

Largemouth bass and bluegills or crappies. Largemouth bass in combination with bluegills is a favorite in southern states, where it works in small ponds (0.5–3 acres), but it has been less successful in the North. Bass are supposed to control bluegills by predation, but it doesn't work that way in our climate, particularly in smaller ponds. Bluegills overpopulate the pond, resulting in stunted growth of both bass and bluegills. If you want bass and bluegills, give the bass a 1- to 2-year headstart on growth. The combination works better in larger ponds and small lakes if the bass harvest is greatly restricted.

In Wisconsin, crappie may be a better choice than bluegill in combination with bass. Because crappies spawn earlier and their reproduction period is shorter, there is less chance for overpopulation. In addition they tend to use the open water of a pond where they are more available to bass. However, too few pond owners have tried this combination

for it to be fully evaluated. Some owners have had good success with crappies in larger ponds.

Bluegills or other panfish without bass. This results in overpopulation and stunting even sooner than the bass-bluegill combination. If a bluegill-only pond is desired, consider stocking only fingerlings. This delays the onset of stunting by giving the initial population some time to grow before it produces offspring which compete with the parents for food.

Hybrid sunfish with or without bass. Artificial crosses between green sunfish females and other species of sunfish (for example, bluegill and redear) may have the advantages of hybrid vigor and are predominately male. With reduced reproduction, the food supply and room to grow are maintained. But beware—**purebred sunfish** are usually included among the hybrid fingerlings stocked. These purebreds and the hybrids can spawn and start the pond on its way to overpopulation. Their offspring typically grow much slower than native sunfish. Still, overcrowding can be delayed for several years—with excellent fishing in the meantime. The advantages can be extended if the hybrid sunfish are stocked with largemouth bass because the bass prey upon the limited number of sunfish offspring. *Hybrids are of little or no value when stocked in the presence of existing panfish populations or in shallow weedy ponds.*

If large (6 inches or more) hybrids are stocked, they may improve fishing by changing the size structure of the sunfish population, particularly if you practice catch and release fishing.

You should check with your area DNR fish manager before stocking hybrid sunfish. Because green and redear sunfish are not found in some areas of Wisconsin, and the offspring of hybrids grow slowly, stocking is restricted.

Exotic species include fish and other organisms such as crayfish not native to Wisconsin that are sometimes desired by pond owners. All of these, such as grass carp, tench and Japanese weath-erfish, are illegal and have the potential to damage your pond and adjoining public waters (see discussion in Chapter 5).

Table 5. **Stocking guide for Wisconsin warmwater ponds to achieve maximum growth without supplemental feeding and aeration.**

Kind of fish	Number to stock per surface acre	Length (inches)	Time of year
Largemouth or smallmouth bass alone	100 fingerlings*	2–4	July–August
	25–50 yearlings	6–10	April–October
	6–8 adults (both sexes)	12	October or May
Bass with minnows	500 adult minnows, then, after minnows spawn, stock bass as above	2–3	April–May
Channel catfish with minnows	500 adult minnows after minnows spawn	2–3	April–May
	-100 fingerling catfish	2–4	July–August
Largemouth bass** with bluegills or crappie	Stock bass as above; after 1 or 2 years 500 fingerling bluegills	1–2	July–August
Bluegill or other panfish with NO bass	500 fingerlings THIS ALTERNATIVE IS NOT RECOMMENDED	1–2	July–August
Hybrid sunfish	400–800 fingerlings	1–3	July–October

* Reduce by half if water alkalinity is less than 50 ppm

**Don't use smallmouth bass; they eat very few bluegills.

Angling harvest

Delay **bass** harvest until the fish have spawned once. This ensures that they are well established before other fish (especially panfish) disrupt the food supply. It may mean waiting 2–3 years if you stock fingerlings; 1–2 years if you stock yearlings; or until mid-June of the year following stocking of adults.

If you stock 100 bass fingerlings per acre, expect around 25–30 adults per acre after 2 full summers in the pond. The original bass stocked as fingerlings must support the first 5 years or more of the pond's bass fishing. Therefore, harvest them lightly!

Light harvest means not removing more than 20–25 pounds of bass per acre each year. Recording the length and weight of all fish taken in your pond logbook is essential to determining when this level of harvest is reached. After the year's quota is taken, you can still enjoy the pond by changing to catch-and-release fishing. Recording information about caught-and-released fish is also useful in estimating growth and changes in growth.

There are many ways to manage harvest in an established Wisconsin bass pond, especially if panfish have also been stocked. Since panfish can easily overpopulate and stunt in Wisconsin ponds, it is important to protect the bass that are panfish predators. Bass 12- to 16-inches prey on 3- to 5-inch panfish effectively .

The easiest way to ensure that these panfish predators are available is to release all 12- to 16-inch bass. When the pond contains a healthy population of this size bass, you can harvest a few 10- to 12-inch bass (25–30cm) as well as those over 16 inches. Harvesting some of the 10- to 12-inch bass will help select for the fastest growing fish. Since slower growing fish will be 10–12 inches for a longer time than the faster growing fish, they are more likely to be caught than the faster growing fish.

Any time that bass of a certain size appear thin and poorly fed, harvest bass of that size more heavily. If a bass weighs less than 95% of the standard weight for its length, it is too thin. Use figure 21 to check whether your bass are of standard weight. Here again, keeping good records of the length and weight of the fish you catch is essential.

Channel catfish. If you stock channel catfish as fingerlings, start harvesting them in the second or third year after stocking, after they have reached 9–10 inches. If the catfish population is one of those rare ones in Wisconsin that sustains itself by natural reproduction, remove only 10–15 fish per acre each year. Usually, however, replenishment is accomplished by annual restocking, and all fish caught above whatever size pleases the owner can be harvested.

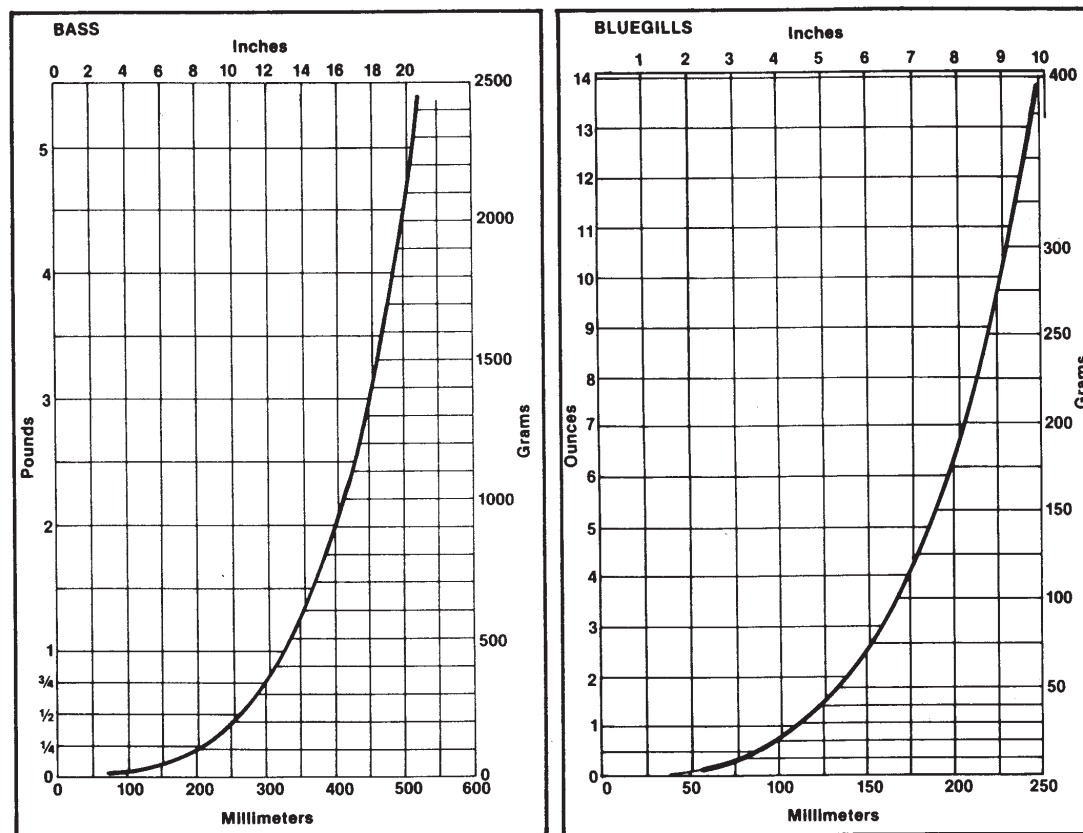


Figure 21. Determining whether a bass or bluegill is the proper weight for its length.

Weigh the fish to the nearest half ounce, if less than $\frac{1}{4}$ pound. If heavier, it may be weighed a bit less precisely. Measure length to the nearest $\frac{1}{8}$ -inch or millimeter. Plot weight on the vertical scale and length on the horizontal scale. Draw a horizontal line lightly with pencil at the fish's weight and a vertical line at its length. If the point where the two lines intersect is on the heavy curved line, the fish is of standard (or average) weight for its length. If the point lies above the curve, it is heavier than average. If it lies below the curve, the fish is underweight.

Bluegills and other panfish. Start harvesting as soon as they are a size you like. In new ponds or those where fish have been eradicated, some bluegills stocked as fingerlings should exceed 4 inches the next summer and 6 inches the summer after that. Follow two harvest rules:

1. Remove as many fish under 6 inches as you can.
2. Greatly restrict the harvest of fish over 6 inches. This works against overcrowding and helps superior brood stock survive. Just as with bass, the biggest, fastest growing bluegills bite most readily and tend to be caught first.

Figure 21 shows how much bluegills should weigh at each length. If the bluegills are thin or growing too slowly, suspect overcrowding. Apply increasing catch rates and other population control techniques (see Chapter 10).

The bass-bluegill combination. Follow the procedures outlined in the above sections on bass and bluegills. Harvest at least 4 pounds of bluegills for each pound of bass harvested. This helps bass keep the upper hand longer. It is especially important to restrict harvest of bass over 16 inches. At that length, they may be nearly 2 pounds and are probably just beginning to eat enough bluegills to have an effect in controlling their numbers. Have fun catching large bass and releasing them alive. Try to build up a substantial population of bass weighing 3, 4 and 5 pounds.

No matter how intensively you manage the bass-bluegill pond, bluegills may still simply take over. Bass spawning success will decline, large bass and bluegills will disappear, and there will be hordes of small bluegills—all about the same size. When this occurs, the owner is often tempted to plant more and bigger fish—maybe even walleye or northern pike. Resist such impulses! Walleye and northern pike are generally not suited to life in small warmwater ponds (Chapter 5), and the only cure for stunted panfish is a sound program of population control (Chapter 10).

Not recommended: higher stocking levels and fish feeding

Adding pellets, bread or other fish food may increase fish growth in a pond—but it can also accelerate the growth of algae and other aquatic plants to excessive amounts. The result may be not only unsightly and interfere with fishing, but a build-up of organic matter in the pond may cause oxygen depletion and fish die-off.

If you wish to do some supplemental feeding, use demand or ring feeders to reduce food loss. Because you are adding nutrients, supplemental feeding should be done in moderation and in combination with other population control measures. Higher stocking levels may lead to the fish outstripping the natural food supply. Although many fish will eat pelleted fish feeds, it is usually best for pond health, appearance and your pocketbook to manage so that the fish are sustained by the food that occurs naturally in the pond.

Pond fertilization and liming

Fertilizing and liming are generally not recommended for Wisconsin sport fishing ponds. Fertilization here usually causes excessive weed and algae growth, resulting in plant control problems (Chapter 11) and a lack of dissolved oxygen for fish.

Never use fertilizer to create algal growth to stifle rooted plants, as is done in the South and in commercial aquaculture ponds. Such enrichment is so strong that it poses the grave risk of winterkill of fish.

Liming is sometimes used to raise the water's alkalinity to counteract acidity problems or to allow the pond to handle phosphorus fertility in ways that boost fish production rather than that of nuisance bluegreen algae (Chapter 4). Fertilizing and liming ponds should be done only under the direction of a water chemistry expert who understands the proper balance between alkalinity and phosphorus content and who can determine the right dosage of phosphorus or lime.

Emergency aeration of the pond

Chapter 6 describes ways of injecting a stream of air bubbles at the deepest part of the pond to circulate the water and keep sufficient dissolved oxygen in the deep zone. This procedure can be used to rescue fish from a temporary oxygen crisis, such as on hot summer nights or during an especially hard winter.

Aerators are particularly useful in preventing winterkill of fish. The circulation achieved by the bubble stream or a pump and cascade aerator system maintains an open area of ice-free water through which the pond can take on oxygen. However, an aerator should not be needed in a properly designed sport fishing pond. The open water resulting from winter aeration can represent a safety and liability problem.

Managing ponds for commercial fish production

General considerations

The four basic methods commonly used to raise fish for profit are:

1. **Flow-through systems**, which generally consist of a set of tanks, concrete or earthen raceways or pools with a large volume of fresh water continuously flowing through them. This is how most Wisconsin trout are raised.
2. **Water reuse or recirculation systems**, which are normally built indoors and rely on continuous water pumping and filtration. (These work in a manner similar to that of most tropical fish aquariums.)
3. **Open-pond culture**, in which fish are raised unconfined, and in ponds that are usually designed and built specifically for commercial aquaculture.
4. **Net-pens**, in which fish are confined in cloth or plastic mesh cages; generally located in large bodies of water or ponds.

Regardless of the method used, commercial aquaculture in Wisconsin is regulated by both the Department of Agriculture, Trade and Consumer Protection (DATCP) and the Department of Natural Resources (DNR).

DATCP is responsible for the annual registration of fish farms, import permits for live fish and eggs and for all matters related to fish health and processing. DNR regulates fish stocking into public waters, water use, water discharge and importation of non-native fish. Both of these agencies should be contacted early in the planning stage. You should also contact the University of Wisconsin Sea Grant Institute, which supports a great deal of aquaculture research.

Of the four methods used for commercial aquaculture, open pond culture is usually the most economical way to raise fish if you can meet a given species' environmental requirements. Primarily because of this economic advantage, pond culture is responsible for more than 60% of total worldwide fish production. A good example of a successful large-scale industry based on pond culture is the production of channel catfish in the southern U.S.

In Wisconsin, commercial aquaculture has traditionally used a combination of flow-through and pond culture techniques to raise coldwater trout. Most open-pond aquaculture currently involves raising coolwater and warmwater game fish fingerlings and baitfish. Production of food fish, particularly yellow perch, has also begun. Net pen culture is being explored and may have potential.

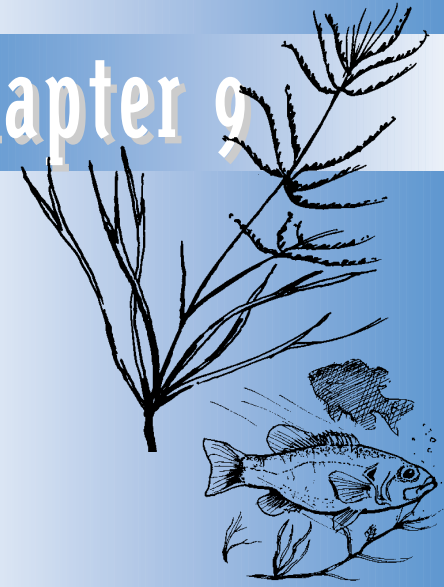
In contrast to many other uses of ponds, such as recreational fishing, swimming or scenic enhancement, the primary goal of commercial aquaculture is to make a profit. The importance of careful planning cannot be overstated for a successful commercial aquaculture venture. The planning process includes an accurate business prospectus and enterprise budget.

Planning

Careful planning may take years, but it should be viewed as a mechanism by which you can develop much of the knowledge and skill essential to making your business a success. It is a way to enter the business before you actually invest in it. Planning helps you learn about the species you plan to grow, the market for your products, what is required in terms of time and money, as well as potential rewards and problems, both short- and long-term.

The planning process helps you decide if commercial aquaculture is the best investment of your time and resources. Entering any business without the knowledge and skills developed through careful planning usually leads to business failure and financial loss. It can also result in the loss of self-confidence, friends and even family.

chapter 9



The planning process (figure 22) should help you develop understanding and skills in:

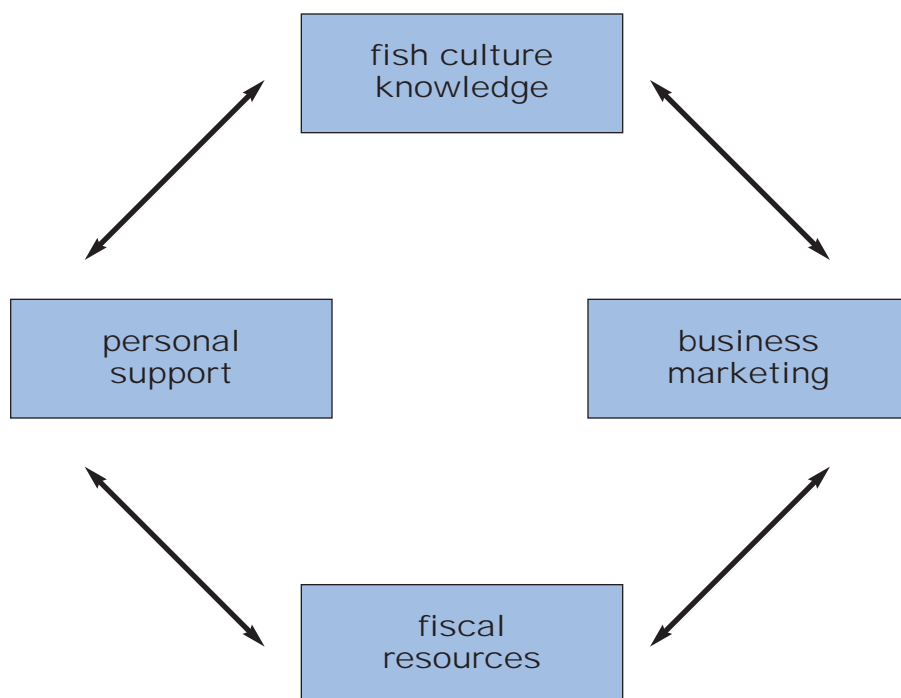
1. Producing the product(s)
2. Operating a business, including marketing the product
3. Developing the financial resource base
4. Developing the personal support base

Throughout the process you should maintain good records of the information you have reviewed. These records will serve as a guide in developing the business prospectus and for implementing your plan.

Planning production of aquaculture products. For many, an interest in aquaculture starts with a strong desire to rear a preferred species. The important questions to ask yourself are:

- Can I rear the species in commercial quantities?
- Can I sell the product at a price that will earn an acceptable profit?

You may find that the probability of success would be higher with other species or a combination of species, or by combining aquaculture with marketing the products of other producers. You will then need to decide if you have the interest to go ahead with the project.



We suggest starting with a broad perspective and investigating a variety of aquaculture alternatives. For example, starting with the idea of bait culture is better than focusing on one species of bait. This approach will increase your breadth of knowledge about aquaculture as a business, and thereby increase your chances of success.

Efficient production of large quantities of fish or other aquaculture species requires detailed knowledge of the species. Unless you have previous training with the species and the aquaculture industry, you will need to start gathering *reliable* detailed information on the group or species you may be culturing.

Figure 22. **Aquaculture planning.**

Careful consideration to the four areas identified below will help you determine the feasibility of an aquaculture business and develop the knowledge required to make good decisions regarding commercial aquaculture.

You also need to develop enough experience to *correctly interpret* how the information applies to your potential business venture. Although most of the chapters in this publication focus on pond management for sport fishing, the information provides a good starting point for developing a basic understanding of pond management.

After reviewing this publication you will need to develop much more detailed information about the culture of appropriate species at the high densities characteristic of commercial aquaculture. You will want to study information on temperature-oxygen requirements and management, growth under different feeding regimes, mating behavior, egg incubation techniques, the various sources of stock, diets, feeding behavior and techniques, potential diseases and their control. The reference section lists sources of more detailed information.

In addition to reading, getting up-to-date information on commercial aquaculture requires interacting with those already in the business. Contacting or joining the Wisconsin Aquaculture Association (see the list of references, p. 76) is an excellent starting point. Members, the group's meetings and its newsletter, the *Creel*, provide invaluable information on aquaculture in Wisconsin. In addition, the newsletter is an excellent way to learn about state, regional or national meetings that introduce the most recent information on aquaculture techniques and products. Having up-to-date information on culture techniques and products is critical to your business plan.

Presentations at aquaculture meetings can provide key information essential to making your business a success. However, you must know how to *interpret the information correctly*. For example, a researcher's success in growing a certain species under research conditions should not be interpreted as evidence that the fish can be grown under less controlled conditions at a profit.

Investors should continually remind themselves that the researchers developing better aquaculture techniques are often enthusiastic about their new findings. Also, research presentations are usually narrow in scope so one or even a few presentations are not likely to tell you everything you need to know to rear the species successfully.

Presentations and published information is often provided by for-profit consultants and persons selling equipment and supplies to the industry. Although such information may be honest and accurate, keep in mind that the livelihood of the source depends on your purchases. It is essential to get the latest information from several sources covering the range of important topics.

After you have gathered, summarized and reviewed the information, ask another key question: Is anyone else operating this type of business successfully? If the answer is no, you will want to find out why. If the answer is yes, it suggests the species can be raised profitably in Wisconsin. The next step is to find out all you can about how the successful businesses operate.

Business planning and marketing.

There is a saying: "You cannot make money raising fish." Aquaculture is like dairy farming—you not only need to produce the product, you have to sell it for more than it cost to produce.

Each individual must decide how much profit is acceptable. To determine profit, you will need to evaluate production costs, the costs of marketing the product (including getting it to market) and its value in the marketplace. You need to understand that aquaculture is a relatively new agricultural business in the U.S. and definitive information is not readily available on the production costs (dollar investment) and/or market values (dollar return) for many fish species. Accordingly, rough estimates of investments and returns are often used for planning purposes. When using such estimates, a sound business plan should be conservative; that is, the cost figures should range toward the high side and the returns should range to the low side.

You will want to look at alternative production methods not only in terms of the amount and quality of the product produced but in terms of production costs. Production costs include the expense of pond construction, water management (pumping and aeration), animals for stocking, feed, harvest equipment, chemicals or fertilizers and outside help. Do not overlook insurance, office supplies, technical services and equipment maintenance. For most businesses, there are start-up costs to cover the operation's expenses before the first crop is brought to market. For example,

if you are growing yellow perch in Wisconsin, you could expect a minimum of two years before you produce any product.

Carefully assess accurate information on the product's market and current market trends. Do not rely upon figures quoted by those promoting the industry. Find out what people will pay for your product.

Generally speaking, one of the advantages of aquaculture is that relatively few people are involved in it. But the market in your area may be highly competitive or may need to be developed. Because aquaculture is a small industry, many producers do their own marketing and transport their product to the market.

Developing a market takes some skill and may require considerable time. In fact, skill in developing the market may be just as critical to success as producing the product. Before investing you'll want to know who will buy the product and what price they are likely to pay. You will also want to learn about the long-term market projections for your potential product.

Plan ways to develop the market for the various products you could raise. The cost of transport equipment, marketing materials and the time, travel and other costs associated with market development should be included in the business prospectus. You will want to develop a plan to expand production and the product's market over a several year period. Contact your county Extension office for help in developing a business plan.

Planning the personal support base.

While commercial aquaculture is promoted by the Wisconsin Department of Agriculture, Division of Consumer Protection (see the references listed at the end of this publication) it is important to clearly understand the kind of government and private support available if you invest in such an enterprise. Those involved in traditional agriculture know that appropriate feeds, a neighbor's plow, the local vet and the county agricultural Extension agent are available to assist them as needed. That level of infrastructure is not yet available to those investing in aquaculture.

You may need to contact individuals across the state or country to obtain the same kind of help available locally to those in traditional agriculture. Touch base with the many people with whom you will need to work before you invest. Getting to know people in the business well enough to work with them on marketing, buying large quantities of food at a lower price or sharing equipment helps reduce your costs, increases production and the price you get for your product. In addition to Wisconsin Aquaculture Association members, get acquainted with other producers in your area, those who sell products you may need, aquaculture research scientists in the region and local UW-Extension, DATCP and DNR staff. You will also find a wealth of information on the Internet (see references).

Like traditional agriculture, the success of many aquaculture businesses in Wisconsin depends on the commitment of an entire family. If the kind of operation you envision involves other family members, it is important to include them in the planning process, making sure they understand the business and their roles in it *fully*.

Approaching the planning process as a family promotes development of opportunities that might otherwise be overlooked. For example, one family was interested in buying a property equipped with a coldwater fish pond. However, the pond could not make a profit if it was managed for food fish production. After some careful planning, the family realized that the property could be commercially profitable if fee-fishing on the pond was paired with the operation of a bed and breakfast. The *family members* decided this was something they could commit to together. Approaching the planning process in this manner is important to success.

Planning the financial needs. The soundness of a business plan and prospectus will considerably influence the financial resources available to you. Contact the Wisconsin Department of Commerce for information on low-interest loans. The amounts to be borrowed, the interest rates and the risk associated with borrowing should all be assessed carefully as part of the planning process. To reduce risks and the cost of borrowed money, investigate a variety of scenarios. It is not uncommon for someone new to aquaculture to start small by initiating a low investment pilot project before making a major investment. This approach reduces risk and start-up cost while increasing the aquaculturist's hands-on experience.

Water temperature and species selection

The choice of fish species to raise is usually dictated by market; in other words, select species you can sell at a profit. From a biological perspective, the most important criteria for selecting pond species is water temperature. Simply put, the temperature of a pond dictates which species will survive and grow well.

Ponds in most locations have an annual temperature cycle that depends on the climate. For example, the water temperatures in most Wisconsin ponds are below 45°F from December through March and range from 65°–85°F from June through September. The growth rate of fish depends largely on temperature, so it follows that the growth of fish depends on the season and does not occur uniformly throughout the year.

When considering species and climate, a primary goal should be to keep water temperatures as near as optimal for the species' growth as possible. A general rule of thumb for commercial aquaculture is that the growing season should be at least 180–200 days per year. However, each fish species has a maximum temperature that cannot be exceeded for even a short time without causing serious disease problems and heavy losses. Some warmwater fish also have a minimum temperature below which they cannot survive.



In Wisconsin, only very deep ponds or those with substantial groundwater input remain cold enough to raise coldwater species like trout and salmon throughout the year. Most other Wisconsin ponds simply get too warm in the summer to support coldwater fish. Cool water species, such as yellow perch, walleye, northern pike, muskellunge and some types of baitfish are probably the species best suited for Wisconsin pond culture.

For these coolwater fish, the water temperature should never exceed 80°–85°F. Well-designed ponds should be able to meet this criteria, and a growing season of 180–200 days is possible for coolwater fish, at least in the southern part of the state. You can raise some warmwater fish, such as catfish and bass in Wisconsin ponds, but the growing season for warmwater fish is much shorter than in southern states. Accordingly, pond culture of warmwater fish is more economical in the South than in Wisconsin.

Site selection

The source of the water is a main consideration in selecting a site for pond aquaculture.

Compared to the other methods of fish culture, ponds require a moderate amount of water. On average, pond culture requires about 50 times more water to rear each pound of fish than recirculation systems. Flow-through systems, in turn, require about 50 times more water to rear each pound of fish than do ponds. To estimate the amount of water needed for pond culture, keep in mind the following calculation: At a continuous flow rate of 50 gallons per minute it will take approximately 22.6 days to fill a one-acre pond to a depth of five feet, assuming that no water is lost through seepage or evaporation and none is added via rainfall or runoff.

The two primary sources of water for ponds are groundwater and surface water; either can be used. Ground- or well water has the advantage of a relatively constant temperature (ranging from about 44°F to 52°F in Wisconsin); therefore it can be used to cool ponds in the summer and to warm ponds and minimize ice buildup in the winter.

Groundwater also contains relatively few nutrients, pollutants or unwanted organisms. In many or most locations, however, groundwater must be pumped into ponds, adding additional expense. Permits are needed from the DNR to operate high-capacity wells.

Surface waters such as rivers and lakes can often be used without pumping, but can vary greatly in temperature throughout the season, and may contain unwanted chemicals and organisms. You should also consider that diverting too much water from a stream can alter its temperature and flow, thus changing the species that it supports.

A third source, which has yet to be used in Wisconsin, is the heated discharge from industry, particularly facilities that generate electric power. This source has the potential to extend the growing season to 365 days per year.

Water discharge is another major factor to consider when you select a site for a commercial fish pond. Most commercial ponds discharge water from time to time, or at a minimum must be drained occasionally (such as at harvest time). The DNR regulates these discharges. The regulations vary and depend on the species and quantity of fish produced, the amount and type of nutrients discharged, and the water quality of the receiving waterway. For example, the regulations and restrictions for discharging into trout streams with outstanding water quality are generally much more stringent than for discharging into large warmwater rivers. Wetlands and crop-

lands can also be considered potential water discharge sites.

Regardless of the factors above, all new ponds should be subject to the best reasonable management practices to minimize the discharge of potential pollutants. Settling ponds are very effective at minimizing the chemical and biological effluents discharged from ponds and are relatively inexpensive to build.

The land itself is an important consideration for selecting a site for pond aquaculture. Before discussing the relationship between the land and ponds, however, it should be emphasized that the cost of building a pond is often the largest single capital investment made in the development of a pond-based fish farm—more expensive even than purchasing the land. Accordingly, the cost of constructing the pond will have a major impact on the farm's ultimate profitability.

Pond construction costs are directly related to the amount of material that must be moved, as well as how often and how far it is moved. The cheapest way to move earth is with a bulldozer or a self-loading earth mover, which might typically cost \$0.75–\$1.50 per cubic yard. It is more expensive to use a backhoe, and it costs even more if the soil has to be moved long distances with dump trucks. This may cost upwards of \$3–\$5 per cubic yard.

Land requirements vary greatly depending on the type of pond you want to build. Construction of the three types of ponds—excavated ponds, impoundments or watershed ponds, and levee ponds—are described in Chapter 3.

Excavated ponds are being used successfully for commercial aquaculture in Wisconsin, but they may not be the best choice for commercial fish farming. They are expensive to build and difficult or impossible to drain, thereby impeding a number of pond management strategies important to commercial fish culture.

Watershed ponds are currently used to raise fish in some parts of the country, but are not commonly found in Wisconsin. They can be built only in specific locations, and usually have an irregular shape that can make them difficult to manage. Construction costs, however, can be quite low.

Levee ponds are the most common type of pond used for commercial fish farming. They are well-suited for aquaculture because of their relatively low construction costs and because they can be built with regular shapes and sloping bottoms to permit complete and rapid draining. The best location for a levee pond (those where construction costs are lowest) is a flat area with a deep layer of clay subsoil. For any type of pond, plastic liners can be used instead of clay to prevent seepage, but pond liners typically cost \$10,000–\$20,000 per acre or more. In

Wisconsin under appropriate conditions, a 3- to 5-acre levee pond suitable for aquaculture can be built for \$3,000 per acre or less; a 1- to 2-acre pond can be built for approximately \$6,000 per acre.

Pond design and construction

Ponds used for aquaculture in Wisconsin can range in size from less than $\frac{1}{4}$ acre to more than 5 acres. Larger ponds are less expensive to build per acre, but ponds larger than 5 acres get progressively more difficult to manage. One problem with very small ponds is that water quality and other factors change more rapidly than in large ponds (see Chapter 3). On the other hand, problem conditions in small ponds can be more rapidly corrected than in large ones. Normally, smaller ponds are best suited for raising fingerlings, small or bait fish, while large ponds are better suited for growing large fish.

The exact shape of a pond is often determined by the topography and property boundaries of the land. Most aquaculture ponds are rectangular. Square ponds are somewhat less expensive to build than rectangles, but rectangular ponds, particularly if they are large, are easier to manage.

Ponds built for commercial aquaculture are generally shallower than recreational ponds, primarily to reduce construction costs. If aquaculture ponds will be used year-round, they should be a minimum of 7 feet deep. This helps prevent winterkill and also reduces excessive warming during summer hot spells. Smooth-bottomed ponds with an adequate slope from the shallow to the deep end allow for complete drainage and easy fish harvest. See Chapter 3 for more detail on levee pond construction.

Managing for different types of fish

Trout. Wisconsin's aquaculture has historically revolved around trout production. Most trout production takes place in areas with high water flow using flow-through raceway systems. These systems allow high densities of trout to be raised using intensive artificial feeding programs because the water flow removes waste rapidly. Ponds are used for grow out, holding fish and fee fishing. Pond management for commercial fee fishing operations is somewhat similar to the techniques described in Chapter 7 and will not be treated further here.

Fingerling game fish. Small fish fry and fingerlings of many species depend on zooplankton and/or phytoplankton as their initial food source. Fingerling ponds are often fertilized to increase the amount of plankton available and thereby the number of fish that can be raised.

Inorganic fertilizers including liquid or soluble phosphorus and nitrogen stimulate phytoplankton growth. Organic fertilizers, such as alfalfa, soybean meal or manures stimulate phytoplankton growth to some extent, but also promote the growth of bacteria and protozoans, which in turn are consumed by zooplankton. Often a combination of organic and inorganic fertilizers are used.

The optimum amount and frequency of fertilization varies greatly from pond to pond, depending on the pond's natural fertility. Ponds used by the University of Wisconsin Aquaculture Program at the Lake Mills State Fish Hatchery are fertilized weekly with 50–250 pounds of soybean meal and 5–10 pounds of 54% inorganic phosphorus and 46% inorganic nitrogen per acre. Take care not to over-fertilize ponds, as this will deplete dissolved oxygen.

The number of fingerlings or small fish that can be produced depends on the species as well as fish size at harvest. For yellow perch, 200,000 fingerlings per acre can be produced if the fish are harvested at $\frac{3}{4}$ inch. Many walleye hatcheries average 80,000–120,000 fish per acre if the fish are harvested at $1\frac{1}{4}$ inch. When perch and walleye are harvested at 2 inches or more, the number of fish drops to 30,000–50,000 per acre or less. The fingerlings of walleye, largemouth bass, smallmouth bass and other species are usually marketed to organizations that plant them in public and private lakes.

Grow-out. When the fish are $\frac{3}{4}$ inch to $1\frac{1}{2}$ -inch long, some species learn to accept commercially available formulated feeds. For larger fish, a floating diet is a great advantage in pond culture because you can readily observe the feeding response of the fish and avoid overfeeding. Some fish species, like yellow perch, readily accept floating feeds only if they are fed when there isn't much daylight (near dusk and dawn).

Currently there is little definitive information on how many pounds of fish can be raised per acre in Wisconsin ponds. These limits are determined by the maximum amount of food that can be put into a pond before dissolved oxygen is depleted. Catfish farmers in the South typically raise 4,000–5,000 pounds of catfish per acre.

In several trials, University of Wisconsin researchers successfully raised 4,000 pounds of yellow perch per acre while limiting the amount of water added to the pond to the minimum needed for temperature control. In another trial they raised 10,000 pounds per acre using sufficient flow-through to exchange the entire volume of the pond every 2–3 weeks.

Bait. Fish bait production represents the largest aquaculture business in the state. Bait producers grow approximately one-third of commercially sold bait fish. Two thirds is harvested from the wild. Baitfish that are grown may have several advantages, such as increased uniformity and better health and “shelf life,” compared to those that are harvested from the wild. The amount of wild harvest versus production varies with the species. For example, suckers are hatched from eggs and the fry planted in coolwater ponds or raceways. Fathead minnows are typically harvested from wild ponds but the ponds are managed somewhat similarly to those used for fingerling gamefish. The potential for using existing ponds lowers the cost of bait production.

Water quality and harvest

Oxygen and aeration. One of the most important routine management procedures of pond culture is to regularly measure dissolved oxygen concentrations just before sunrise, particularly when potential dissolved oxygen depletions are anticipated. Because of high fertility in commercial ponds, regular oxygen monitoring is much more critical than in recreational ponds.

Many types of mechanical aerators are used in pond culture. Some devices are used primarily to circulate the water in a pond, others provide continuous active aeration and others are of the stand-by type, used only under emergency conditions when dissolved oxygen is depleted.

In general, intensive aeration devices are becoming more popular in pond culture because they can increase fish production. It is important to recognize, however, that most oxygen in a pond is not used directly by the fish but rather by bacteria, plankton and plants.

Aeration and water circulation systems provide several significant benefits to pond culture. First, because of the large quantities of nutrients added to them, ponds used for intensive aquaculture occasionally suffer from dissolved oxygen depletion. During extreme situations catastrophic fish losses result if remedial action is not taken. Second, without top-to-bottom water circulation, ponds frequently stratify. Although stratification can be desirable in recreational ponds to increase habitat variety, in highly fertile commercial ponds the water at the pond bottom often loses all



its oxygen. Under these conditions, aerobic decomposition of waste products, which is essential for maintaining the high productivity of aquaculture ponds, does not occur. Third, in northern climates aeration is used to keep ponds partially ice-free and to prevent winterkill.

Adding water. At a minimum, some water is added to aquaculture ponds to make up for water lost through seepage and evaporation. Water flow-through is also used to minimize ice formation and thickness in the winter. In summer, it is used to reduce pond temperatures during hot spells. Depending on the amount of water available, flow-through can also be used to reduce the overall nutrient loads in ponds.

Harvest methods. Several methods are commonly used to harvest aquaculture ponds. For a complete harvest, conduct a drawdown along with seining or capture in internal or external catch basins. Catch basins are used to harvest small fish or fingerlings. The use of internal basins is usually restricted to small fish or fingerlings. Ponds that remain full can be partially harvested using seines, trap nets or gill nets. A common technique to selectively harvest large fish from ponds is to use a size-selective seine in a partial pond draw-down.

Regardless of the method used, it is important to recognize that harvesting procedures are very stressful for fish, due to physical and mechanical abrasions as well as rapid changes in water quality. If harvested fish are to be kept alive, every effort should be made to minimize the stresses of harvest.

For several reasons, commercial fish ponds should be completely harvested, drained and allowed to remain dry for a period of time at least once every several years. First, complete harvest allows for an accurate inventory of fish. Second, drying eliminates many disease and other organisms such as snails, salamanders and crayfish, that spread disease or can otherwise be detrimental to fish culture. Third, the organic material accumulated on the pond bottom decomposes quickly when exposed to air. If the buildup is excessive it can be mechanically removed.

Fish population control

Pond owners sometimes need to reduce or eliminate fish populations before moving forward with management plans. Older ponds may contain undesirable fish, such as carp, suckers or bullheads. A trout pond may contain unwanted warmwater fishes. A pond that has suffered a winterkill may have a predator-prey imbalance. Or perhaps panfish are overabundant and stunted. When such situations occur, various methods exist to alter fish population structure or to remove fish populations completely.

Angling intensively

A common perception is that intensive angling brings fish populations into balance. That idea is fine in theory, but it seldom works except in very small ponds. The overabundant fish are usually not large enough to catch, or else they are an undesirable species that no one wants. The time required for intensive angling is also substantial. To prevent overabundance or reduce the chances that undesirable species will be introduced, follow the harvest suggestions outlined in Chapters 7 and 8.

Stocking predators

Some people reason that stocking northern pike, muskellunge or walleyes controls stunted panfish. After numerous attempts however, there are no well documented success stories with this approach.

Bluegills and other sunfish have deep bodies with a spiny fin along their backs. Predators need large throats to swallow them. Even largemouth bass that attain the necessary throat size at an earlier age than other predatory fish usually do not keep bluegill populations in check in Wisconsin ponds.

All piscivorous (fish-eating) fishes, including the largemouth bass, prefer to eat cigar-shaped forage fish without spiny fins. Thus, they tend not to eat many panfish until more favored prey, such as minnows, or young largemouth bass become scarce. Having northern pike in bass bluegill ponds often results in more predation on bass than on bluegills. Even though they also have spines, bass are easier for pike to swallow.

Introducing large predators rarely controls carp and suckers in ponds. By the time these fish become a problem, they are usually too large and numerous to be controlled by piscivorous fish.

Destroying spawning beds

Some people control sunfish populations by destroying the fish embryos, either by raking or trampling the nests. A large percentage of the nests must be destroyed for this technique to be effective. Because most sunfish species are prolific and spawn over a long period, this method requires considerable effort. It is simple, however, and can be effective in delaying or reducing overabundance problems, particularly when used with other methods such as properly managed largemouth bass populations and/or seining, trapping or electrofishing.

Seining

Fish can be removed by drawing a seine, or large vertical net, through the water (figure 23). Seining is usually done by two people, each holding an upright that supports the ends of the net. Floats keep the seine top at the water surface, and weights hold the bottom edge on the pond bed. The seine must stay tight along the pond bed, or fish will escape underneath. Therefore, the seine should be deeper than those portions of the pond where it is to be used so that it will “belly” without being pulled away from the pond bed as it is drawn along.



For seining, the pond bed should be smooth and free of snags such as rocks, logs and brush. Dense weed beds also impede seining. Water-level drawdown (described later in this chapter) can aid seining by drawing the water away from weed beds and other shore-zone obstructions, as well as decreasing the area and depth to be seined.

Small seines are especially useful on panfish during the spawning period. Minnow seines, 15–40 feet long and available at sporting goods shops, are used along shorelines to remove panfish fry and fingerlings which concentrate there. Longer, deeper seines allow greater coverage. Ready-made or custom-built seines can be ordered from various suppliers.

Use nylon netting. It is most rip-resistant and lasts a long time with little maintenance. However, sunlight rots nylon quickly so do not leave it exposed to the sun. For removing small panfish, use netting with mesh $\frac{1}{4}$ - to $\frac{1}{2}$ -inch long. Smaller mesh isn't necessary; in fact, it is harder to draw through the water.

If the seine spans the pond's width, two people can draw it the length of the pond in one sweep. This is the most efficient method. If the pond is too wide for that, pull the seines out from shore in an arc—using a boat if needed—and back to shore. Draw the arc tighter and into shallow water or on to the shore. Draw the seine so that the bottom edge stays ahead of the upper edge. Many fish escape if a seine rolls up at the bottom as it is pulled along.

To salvage bass, large panfish or minnows and return them to the pond uninjured, leave a pocket in the seine in shallow water at the end of the haul, rather than dragging it ashore. Rolling or sandwiching the net can bruise fish and remove their slimy covering and scales, thus increasing their susceptibility to disease. Minnows are very prone to such injury—especially in hot weather.

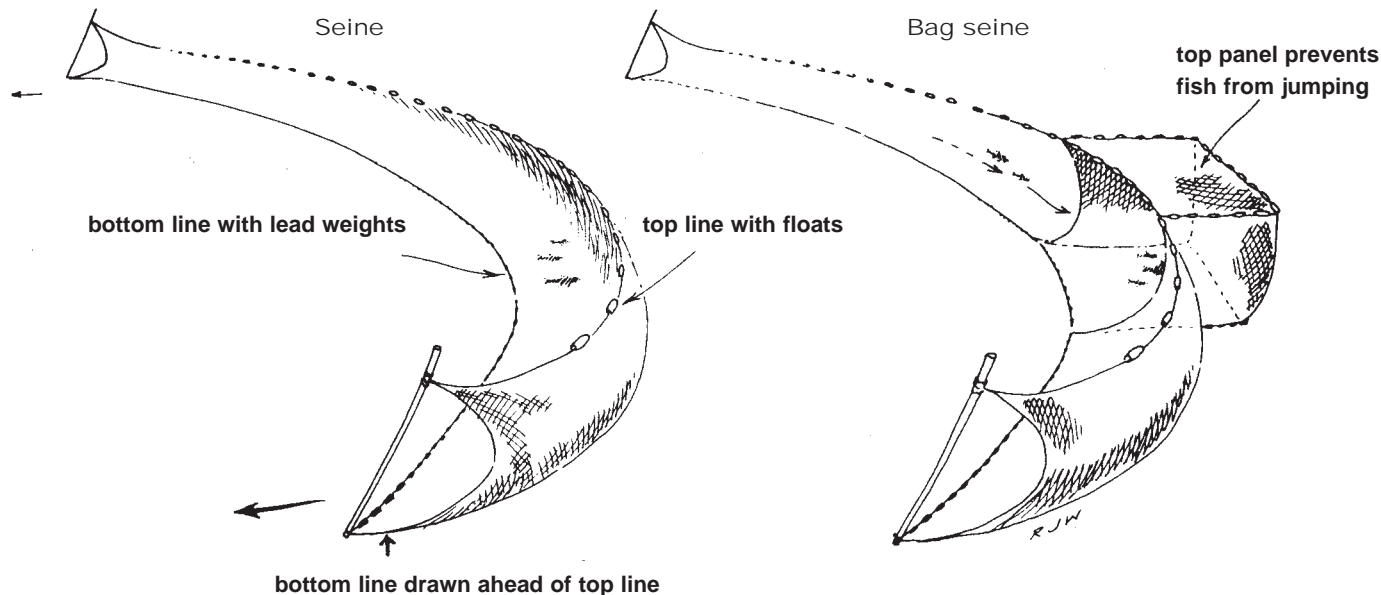
To “thin out” populations of bluegills or other sunfish, seine frequently in the warm season but after the young bass have developed enough so that they can withstand capture without injury (when they are approximately 1 inch long). Remove panfish that are less than 6 inches long, and return those larger than 6 inches plus any bass or channel catfish (not bullheads!). This amounts to

selecting for fast growing fish while making room for growth to occur. Subsequent generations of fish should grow faster if you use this strategy.

If possible, keep seining until about 80% of the pond's estimated summer poundage of panfish is removed. Estimating the total weight of panfish in a pond is difficult, and you may wish to consult a professional biologist for assistance.

Seining is hard work but can be fun. It provides useful information about the fish population. In your pond logbook, record the effort invested and the numbers of fish removed. Also record the numbers of young and adult bass and larger panfish that were released, along with information on the forage base. Remember that bass and carp, especially older ones, are adept at avoiding nets. When you seine up only small bass or carp, don't conclude that big ones aren't there.

Figure 23. A seine and bag seine.



Live-trapping

Fish traps may be useful for reducing populations in ponds where seining is difficult. You can make an effective trap using ¼- to 2-inch hardware cloth on wooden framing (figure 24).

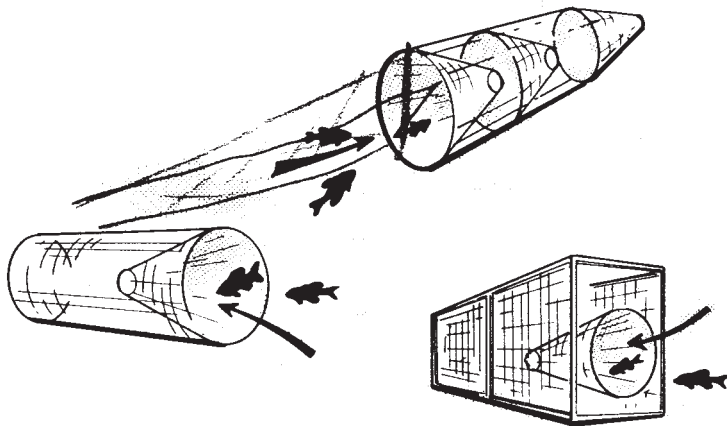
Use traps with or without a “lead.” A lead is like a fence that typically extends from the center of a trap’s mouth to the shore. It guides fish moving along shore into the trap. A seine or seine material (with floats and weights attached) can be attached to the mouth of your wooden-framed traps to make a lead. Hanging gauze bags of bait, such as bread, oatmeal, dog food, soybean cake or cottage cheese in traps increases the catch. You can experiment with bait to determine whether it improves on your

trapping success. This method adds nutrients and is often not necessary.

Place traps in shallow areas where small fish gather. Set the traps at right angles to the shore in water that is just deep enough to cover them. Run the lead into shore. Fish moving along shore will follow the lead to the opening and enter the trap. For panfish thinning, up to 10 traps per acre may be needed.

Remove the same amounts and sizes of fish as described in the section on seining. Remove the fish from the traps daily to avoid stress and turtle predation on the desirable fish that you will want to return to the pond.

Figure 24. Various kinds of fish traps.



Electrofishing

Fish are sensitive to electricity and are “galvanotactic.” That is, they move in the direction of direct current (DC) electricity. Modern electrofishing equipment, operating on this principle, makes it possible to capture large numbers of fish with electricity without injuring them. The fish swim towards the probes of the shocker where operators capture them in dip nets. Because electrofishing works in areas of relatively heavy cover and is effective in collecting small or large fish, it can be very useful in population control.

Bear in mind, however, that the electrical current required for electrofishing can be *lethal* to humans. This technique is not effective in soft water and should *not* be attempted by the pond owner using homemade equipment. We recommend contacting one of the many private consulting companies to evaluate your situation and carry out the task. In addition, be sure that whomever you hire uses modern, safe equipment and is covered by insurance.

Drawing down the water level

Draining represents a good method of population control in ponds that can be drained easily. Not only are undesirable fish easily destroyed but desirable fish can be saved and restocked. If the pond is formed by a dam with a proper water control structure, draining should be easy. With the appropriate bottom slope the fish will come to the outlet area where they can be seined and sorted as the water level drops.

Low head pumps or a siphon can be used in some ponds. Even if the pond cannot be completely drained, reducing the water level in late fall so the pond freezes to the bottom serves to control unwanted fish populations. Seining can be used to capture wanted fish. The length of time needed for the pond to refill should be carefully considered before a drawdown.

Contact the DNR district fisheries expert whenever you are considering a drawdown or other water release from your pond. Permission from the DNR may be required to drain or refill a pond.

Fish cannot be discharged with the pond water to other waters except under special permit from the DNR, as this constitutes stocking. Unauthorized introductions of fish can disrupt natural fish populations to the detriment of the public interest.

Screening the outlet and/or the pond discharge to prevent fish from escaping is often necessary. Take care to ensure that downstream waters or properties are not damaged by flooding, erosion or sedimentation. It is the owner's responsibility to release the water in a judicious, reasonable and prudent manner.

Total drawdown is used to eliminate all fish from the pond. A special effort must be made to find fish that may take refuge in residual puddles. Spot applications of fish toxicant chemicals may help attain a complete kill. Desirable fish, such as large bass, can usually be salvaged and kept alive for restocking if other water for holding them is available.

Partial drawdown can concentrate fish so that predators like bass can become more efficient. This tactic depends on having enough predators to consume a large portion of the unwanted fish. With drawdown, seining is also more efficient. Conducted properly, a partial drawdown destroys overabundant aquatic plants. Predatory reduction of small fish is most effective if the partial drawdown is done for a month or more in July or August. Carefully consider whether a partial drawdown will increase the danger of oxygen depletion and whether a summer drawdown will aggravate aquatic weed problems.

Fish toxicants

Another method of reclaiming ponds from panfish overpopulation or the presence of undesirable fishes is to kill all fish with a specially formulated chemical—a fish toxicant* or piscicide. Then start anew by restocking after the water has detoxified. Some fish can be salvaged before or during treatment and kept alive in other water for restocking. The amount of chemical used and the cost can be reduced if the chemical treatment is made in combination with a partial drawdown. Because discharge of fish toxicants into public waters is unlawful, partial drawdown may be required for ponds that discharge into public waters.

Partial treatments to remove only certain species or sizes of fish, or to merely reduce rather than eradicate the population, can be done by applying special dosages or by treating a portion of a large pond. However, partial treatments are usually very difficult and generally ineffective.

Only two chemicals, **rotenone** and **antimycin**, are legally registered for use as fish toxicants. The commercial brand names and best local sources can be obtained from your DNR district offices (see references). Federal law requires that only legally registered fish toxicants be used—and that they be applied in strict accordance with instructions on the product label. In Wisconsin, only a licensed applicator may apply these chemicals. A DNR fish farm environmental permit coordinator will be able to help you identify licensed applicators.

The amount of toxicant needed for total removal of fish may depend on several factors, including the kind(s) of fish to be killed, the pond volume, water temperature, water hardness, light conditions, abundance of aquatic plants and amount of other organic matter present.

* The chemical is absorbed into the fish's gills and kills by interfering with respiration. This does not mean that the pond is made poisonous for humans, for any vertebrate animals other than fish, or for most invertebrates when used at the dosages prescribed for killing fish.

Aquatic plants and their control

Aquatic plants play essential roles in a pond. They provide oxygen and produce the pond's food web. They also furnish cover for fish and support organisms that fish eat.

A few well-spaced plant beds provide some prime fishing spots and certain types of vegetation attract waterfowl and other enjoyable wildlife.

Plants easily become overabundant. The disadvantages of too many pond plants include:

- Unfavorable build-up of organic matter on the pond bed
- Nighttime depletion of oxygen
- Daily changes in pH that are unfavorable to fish and other organisms
- Too much cover for small fish to hide from predator fish, resulting in small fish overpopulating the pond
- Interference with fishing, swimming, boating and other activities—including seining to control fish populations

If less than a fourth of the pond's surface is covered by plants, there is likely no problem unless they interfere seriously with use of the pond. Even more vegetation may pose no threat to the welfare of the fish.

Kinds of plants

It is important to know the kinds of plants in your pond so you can interpret changes and prescribe the appropriate plant management measures. Pond plants are separated into two general groups: **algae** and **rooted leafy plants**.

Algae are single-celled plants or colonies of cells lacking true roots, leaves or flowers. There are three types of algae:

1. **Planktonic algae** drift free in the water, are usually microscopic and, when abundant, make the water look murky. Their coloration ranges from blue-green to green, to yellow and brown, or even gray.
2. **Filamentous algae** are threadlike or netlike. They may be small and free-drifting, but often occur as "mossy" growths on rocks or thick mats floating on the pond surface. Most scums and mats contain bacteria and fungi as well as algae.
3. **Chara algae**, also called muskgrass or stonewort, grow attached to the pond bed without true roots. They have clustered needle-like projections and are often mistaken for leafy plants. The two common kinds are chara and nitella. When mashed between the fingers, they feel gritty and give off a skunk-like odor. There is often a white or brownish crust of lime or "scale" on the plants. Chara

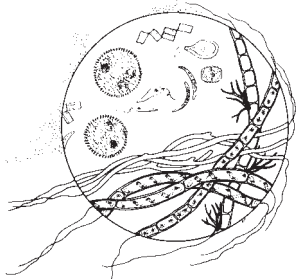
occurs under natural conditions as small clumps about 6 to 8 inches tall. Under some conditions it forms a continuous stand several feet high. Overabundant chara is a common pond problem.

Rooted, leafy plants occur in three general forms:

1. **Submergent (or submersed) plants** grow rooted in the bottom with most growth beneath the water. Some have a few leaves floating on the surface. Many thrust blossoms above the water. Common submergents are pondweeds (*Potamogetons* in many varieties), coontail and waterweed (*Elodea*).
2. **Floating plants** are characterized by having all or most of their leaves and flowers at the water's surface with free-dangling roots in the water or attached in the pond bed. Duckweed and water lily are examples.
3. **Emergent plants (or emersed plants)** such as bulrush, cattail and arrowhead, have stems and leaves thrust above the water. These grow at pond margins and may extend into the water several feet deep.



Algae



Planktonic algae (many species)—free-floating, usually minute, may be single-celled or found in colonies. When abundant, may color the water murky green to brown—or in extreme cases, pea-soup green.

Filamentous algae (many species)—long strands, filaments or nets. Often form floating mats.

Chara algae (muskgrass or stonewort)—Upright plants attached to the pond bed. Roughly resemble rooted, flowering plants, but are really algal colonies with stems and whorled branches. Each joint of the stem consists of a single cell. Even-lengthed branches are clustered at each joint. Chara algae occur in shallow water having high alkalinity. They are rough to the touch. Feels gritty and gives off a skunk-like odor when crushed between the fingers.



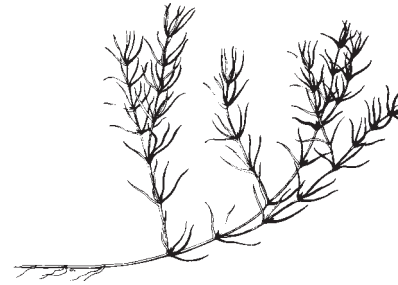
Submergent plants



Bladderwort (*Utricularia* species)—Tiny oval bladder near bases of finely divided leaves. Often floats free under the surface without roots. Found in cold, acid water. Flowers yellow or purple.



Hornwort or coontail (*Ceratophyllum demersum*)—Whorls of leaves at joints of stems. Leaflets forked once or more, have toothed edges. Leaves densely crowded near tip of stem. Grows in hard water.



Naiad (*Najas* species)—Leaves occur as opposite pairs or whorled, very narrow, toothed on edges. Commonly grows in water 1–4 feet deep but sometimes much deeper.



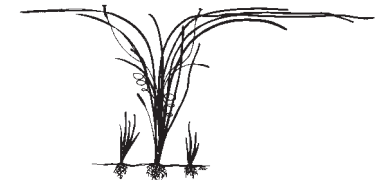
Water milfoil (*Myriophyllum* species)—Leaves whorled on stem and divided feather-like, not forked as in coontail.



Waterweed or elodea (*Elodea canadensis*)—Flat, thin leaves grow in opposite pairs or whorled. Commonly used in home aquaria.



Water star grass (*Zosterella dubia*)—Looks like some narrow-leaved pondweeds (*Potamogeton*), but leaves lack a mid-vein. Flower is yellow, star-like.



Wild celery (*Vallisneria americana*)—Light green, ribbon-like leaves may be up to six feet long (but usually much less), with tips floating on the surface.



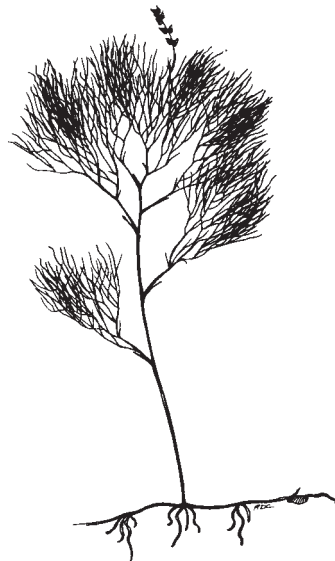
Curly leaf pondweed (*Potamogeton crispus*)—Leaves alternate; has finely toothed, crinkled or puckered edges. No floating leaves. Flowers and seeds in spike at tip extend above water for fertilization. Grows in fertile hard water. Introduced from Europe.



Leafy pondweed (*Potamogeton foliosus*)—Leaves, ribbon-like, about $\frac{1}{16}$ -inch wide. Lacks sheath at base.

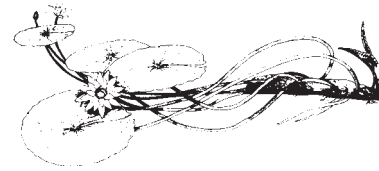


Floating leaf pondweed (*Potamogeton natans*)—Two types of leaves. Underwater leaves are narrow, grasslike and appear as stalks. Floating leaves are oval to heart-shaped, each with a notched base. Flowers and seed on a spike.

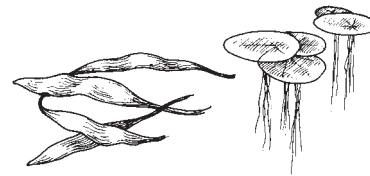


Sago pondweed (*Potamogeton pectinatus*)—Fine, thread-like leaves that fan out with a sheathed base. No floating leaves. Stems usually multi-branched. Tubers grow from horizontal roots.

Floating plants

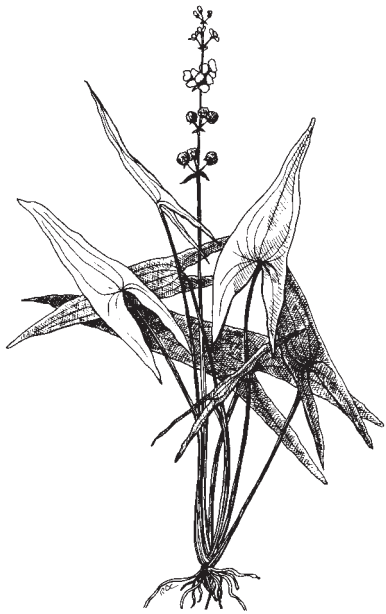


White (fragrant) waterlily (*Nymphaea odorata*)—Round, floating leaves grow to ten inches in diameter, split to stem at center, often purple on the underside. Flowers are showy, usually white but sometimes pink. Flowers open from morning until shortly after midday.



Duckweed (*Lemna species*)—Tiny, free-floating bodies are flat and round or lobed, oatmeal-sized or smaller; often mistaken for algae. Barely visible roots dangle thread-like. Sometimes several plants are attached. Masses of this plant accumulate as a scum blanketing quiet shallows. As scum dies, it turns yellowish or whitish.

Emergent plants



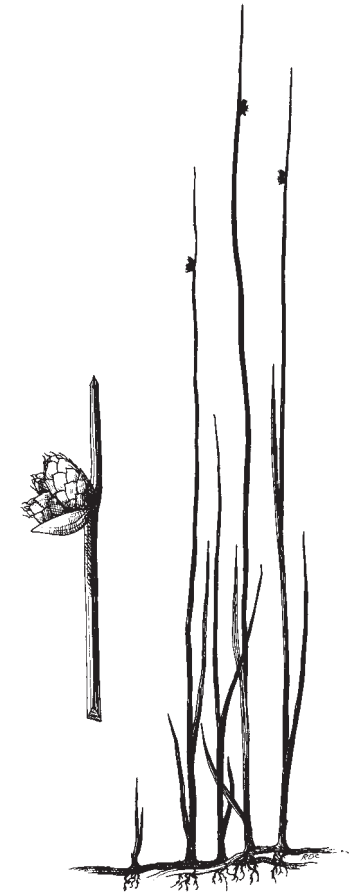
Arrowhead (*Sagittaria* species)—Leaves usually arrow-shaped, but some may be tongue-like or ribbon-like, especially at base of plant or underwater. Flowers white, petaled, whorled and grow near tip of a stalk. Fruits are tightly packed balls of seeds.



Burreed (*Sparganium eurycarpum*)—Leaves, long, erect, ribbon-like, usually 1–3 feet high. Stems bear male flowers at tip; female flowers below. Fruiting heads are 1-inch round balls with many seeds.



Cattail (*Typha latifolia*)—Leaves reach to 6 feet tall, ribbon-like, tapering to a point. Flowers on stalks taller than leaves. Male flowers at tips, female flowers below. The plants grow at the water's edge, but commonly also to depths of 3–4 feet.



Chairmaker's rush (*Scirpus americanus*)—Horizontal rootstocks give rise to stems with triangular cross section (but round in some bulrushes). Height usually 2–3 feet. Flowers and seeds on spikes along stem near tip. The plants may form dense stands after several years.

Pond plant biology

Understanding how pond plants grow helps in managing nuisance plant problems. All plants need water, light, a place to be, nutrients (fertilizers) and the right temperature. If any of these elements are in short supply, plant growth will be reduced or eliminated.

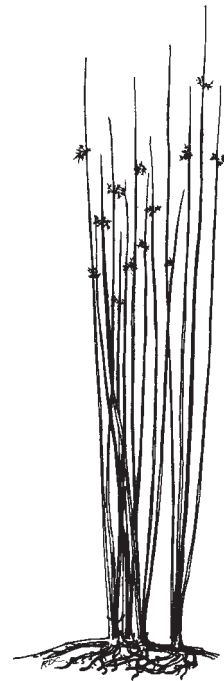
Water is usually not a limiting factor in ponds. Although, as discussed in other parts of this publication, if a pond is designed so it can be drained, draining or dewatering it can offer a useful plant management option.

Light diffuses rapidly in water, so plant growth decreases as the light gets dimmer. The water's clarity determines how quickly light dissipates and thus affects plant growth. In clear lakes and ponds, rooted plants might grow in water up to 30 feet deep. In very turbid or muddy water, rooted plants may not grow in water deeper than 18 inches. Rooted plants rarely reach the water's surface where they become a nuisance in water deeper than 15 feet. Pond design as it relates to depth is important to managing the area where rooted plants grow.

Although some green, rooted plants can be found under the ice, rapid growth usually doesn't start until water temperatures reach about 60°–65°F. Algae are more tolerant of broader temperature ranges. Different species of algae may dominate the pond depending on water temperature.



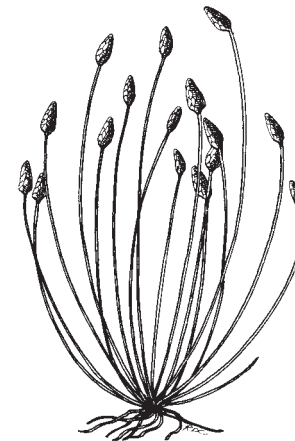
Water smartweed (*Polygonum amphibium*)—Leaves elliptical, up to 4 inches long. Stems upright or sprawling in water or on mud banks. Deep pink flowers in spike at tip of plant.



Rush (*Juncus effusus*)—Clumps of stems rise from stout horizontal rootstocks, grow 3–4 feet tall resembling grasses and sedges. Greenish-brown flowers near tip of stem.



Pickerelweed (*Pontederia cordata*)—Leaves heart-shaped, similar to those of arrowhead but rounded at tip and corners. Curving veins follow leaf margin. Blue flowers that grow in a spike.



Spikerush (*Eleocharis species*)—Clumps of stems rise from shallow roots, remain much shorter than rushes. Oval fruiting spike at end of stem.

Although not much can be done to manage temperature in an outdoor pond, temperature is important for chemical weed control. Herbicides work best when plants are growing. Water temperatures should be 60°–65°F before you use herbicides.

There is a direct relationship between nutrient levels (primarily nitrogen and phosphorus) in water and algae growth. Generally speaking, the more nitrogen and phosphorus in the water, the greater the algae growth. Any method of reducing nitrogen and phosphorus in the pond will limit this growth.

Proper pond design and land management around the pond is essential to prevent excessive nutrient input. Chapter 3 discusses these techniques.

The relationship between nutrient levels in the water and rooted plant growth is not as direct. Rooted plants get the majority of their nutrients from the pond bottom. Therefore, it is more difficult to control nutrient availability to rooted plants. Limiting nutrients in the water may cause rooted plants to spread because the clearer water will allow deeper light penetration and thus provide more area for plants to grow.

The type of plants in ponds often changes even when the plants aren't managed. One type of plant replaces another. By this process a pond vegetation problem may alleviate itself or get worse depending on the species involved. Nuisance growths of chara, for example, have been replaced by other plants that are less bothersome—with no control needed.

Managing the growth of nuisance plants

The best way to avoid plant problems is to design the pond so that there is little area suitable for plant growth. This usually means making the pond deep enough so that rooted plants can't grow and nutrients don't get into the pond to stimulate algae and other plant growth.

Assuming you already have a pond with a problem, the next best thing is to try to adjust one critical factor—light, nutrients and sometimes water—to limit growth of the nuisance plants. These techniques provide the most long-lasting control.

If your options are limited, you may have to control plants by physically removing or chemically killing them. You will usually need to do this on a regular basis. Consider it part of pond maintenance much like mowing is a part of lawn maintenance.

Certain control techniques are more effective for certain species. Some techniques are best suited for algae control and others for rooted plants. This re-emphasizes the importance of knowing the species that are causing problems.

Eliminating one type of vegetation may make room for some equally bothersome replacement. This phenomenon takes place soon in some cases. For example, less than a month after cutting or poisoning rooted plants, the area may be clogged with stringy algae. You should keep records of vegetation changes because your management

strategy may change as new problems occur.

When deciding on a plant management technique, consider not only how well and for how long the technique works, but also the environmental impacts, the use limitations imposed by using or not using the technique and the costs in terms of both time and money.

Physically disrupting and removing plants

This method is one of the simplest and most practical, akin to weeding a garden or mowing a meadow. Most aquatic plants are more fragile than garden weeds, so physical control may be easier for water plants than for land plants.

You can keep areas free of weeds by causing frequent disturbances, such as raking the pond shallows, or letting swimmers trample beach areas. Cattails

are easily killed by trampling or cutting the new shoots in springtime. Cutting cattail shoots in the fall so they freeze under the ice is another effective control technique. Both techniques may work on other emergent plants.

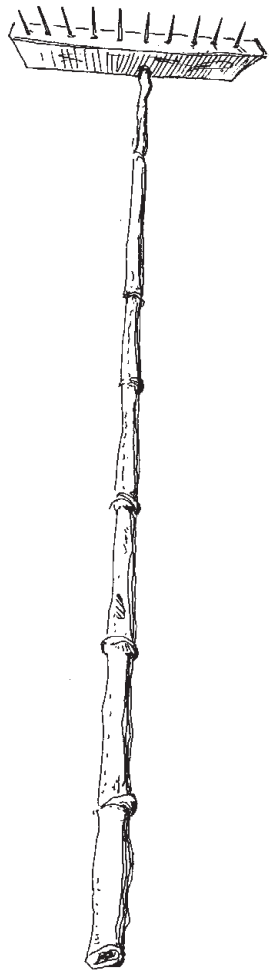
You can simply wade in and uproot many plants by hand. This works for cattails, rushes and other emergents when they are growing as isolated plants, as well as for submergent plants that you can reach. The first “weeding” of a well-established plant bed may be hard work, but repeated follow-ups prevent the situation from developing again.

A scythe or hoe is useful for cutting aquatic weeds in shallow areas.

Caution: Wielding a blade underwater can be dangerous! Always wear protective boots!



Pulling plants out by hand is often the simplest way to control vegetation in shallow water.



A floating rake.

Cut plants will float and should be removed from the pond as soon as possible. Deposit them where the nutrients will not run back into the pond as the plants decay.

A rake can be used for uprooting, tearing loose and dragging out plants. The head of a garden rake, fitted with an extra-long handle and manipulated from a boat or while wading is suitable for reaching into deep water. A floating rake is less tiring for work near the surface.

You can construct a floating rake from an 18- to 20-inch, 2x2 board by driving a row of spikes two or three inches apart, then cutting off the heads. A bamboo pole makes a good handle. It can be long, yet light. Hand-operated and power-operated weedcutters designed for underwater use are available from commercial sources, as are floating rakes.

For weed growth too extensive to cut with a scythe or rake, a log wrapped loosely and stapled with barbed wire can be dragged through the pond behind a tractor driven along the shore. A heavy chain connecting the log to the tractor helps sink the log to the pond bed. Add more weight as needed. The log can be guided with a rope manipulated by someone on the opposite shore. The barbed wire log seems to be an improvement over the often recommended method of dragging bed springs. Weeds are difficult to remove from bed springs.

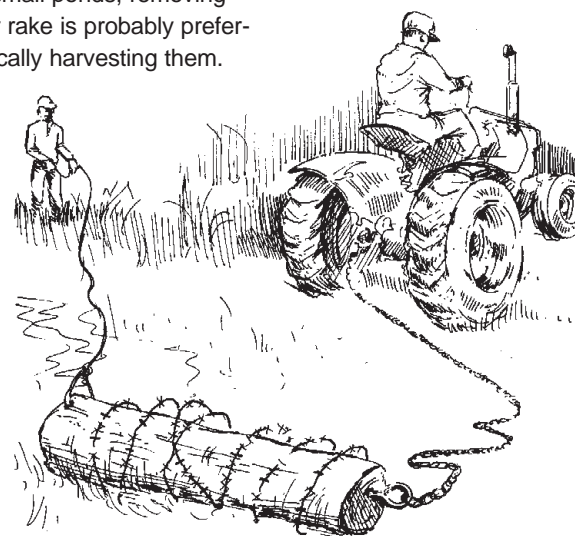
Mechanized harvesters are available in a range of sizes. Small models, costing about \$1000, can be mounted on a rowboat. These have cutter bars like those on hay mowers. With this type of boat-mounted unit, weeds can be cut to a depth of about 4 feet. After the weeds are cut, they are raked to a removal point on shore. Other weed cutters are manufactured as mower bars on small paddlewheel barges. These can operate in very shallow water, as well as to depths of 5 feet or so. They range in price from \$2000–\$20,000. Large harvester units which draw plants onto the barge as they are cut are available for upwards of \$50,000.

Some plants are difficult to control with mechanized harvesters. Chara sinks when cut and is therefore hard to pick up. Milfoil, coontail and elodea are also hard to collect once they are cut. These kinds of plants spread by fragmentation. Each piece cut and not picked up may become a new plant. In small ponds, removing them by hand or rake is probably preferable to mechanically harvesting them.

It is best to remove plants during the spring or summer because you can remove the largest number of plants and still allow full recreational use of the pond. The timing depends on your knowledge of the growth habits of the plants in your pond and your plans for the pond's use. Often, the best approach in a small pond is periodic trimming as in caring for a lawn or garden. In new ponds, control plants by frequent hand or rake removal before they become abundant.

Harvested plants make good garden mulch, soil conditioner and composting material. The thin cell walls of aquatic plants break down rapidly and the resulting fine-textured matter is also suitable for spreading on lawns.

A log and barbed wire drag for removing vegetation.



Deepening the pond to control vegetation

You can renovate a plant-clogged pond by dredging out the pond bed, or if it is dammed, by raising the water level to deepen the pond. One effect of greater pond depth on aquatic vegetation is to put more of the bed at a level that is too dark for rooted plant growth. It is hard to say what water depth will be critical to prevent nuisance growth of rooted plants. That depends on the water clarity, the kinds of plants present and nutrient supplies. Maintaining a depth of 15 feet should greatly reduce problems.

Dredging reduces the amount of nutrients available to plants from organic deposits in shallow water, and can create steeper side slopes where plants seem to grow poorly.

Increasing the depth and volume of the pond can have other beneficial effects on nutrient levels and suitability for fish. Consider these in deciding whether the expense is justified. See Chapter 3 for a discussion of the techniques, relative cost and environmental impacts of pond deepening.

Water level drawdown

Lowering the pond's water level and exposing all or much of the pond bed to air can have several favorable effects and may cost little. Table 6 lists common aquatic plants that are susceptible to summer and winter drawdowns. Drying kills many kinds of aquatic plants. It is preferable to conduct the drawdown in winter when the freezing of plant tissues, including the roots, gives more extensive and lasting control. Summer drawdown is particularly ineffective on plants such as coontail and elodea which grow as free-floating fragments. Other plants increase as a result of summer drawdown, and cattails or other emergents can invade exposed mud flats.

Where sediments are composed of soft organic material, drying consolidates them, and you may gain several inches or feet of pond depth. Drawdown can also facilitate dredging. See Chapter 10 for a discussion of drawdown techniques.

A word of caution: If shallow water remains in the pond for much of the growing season, the extra light may permit seeds or plant fragments to sprout and take root. When the pond is refilled, especially if the water level is raised too slowly, the plants may continue to grow and become a nuisance. To prevent this, draw the water down as far as possible, and when the drying and/or freezing has had its effect, raise the water level rapidly. If plants have begun to grow in shallow pools, it may be advisable to destroy them by raking or other means before refilling the pond.

Table 6. Plant susceptibility to drawdown

Scientific name	Common name	Summer drawdown	Winter drawdown
<i>Bidens beckii</i>	water marigold	-	I
<i>Brasenia schreberi</i>	water shield	D	D
<i>Carex</i> sp. or spp.	—	I	-
<i>Ceratophyllum demersum</i>	hornwort	V	V
<i>Chara</i> sp. or spp.	muskgrass	V	V
<i>Eleocharis acicularis</i>	needle spike rush	I	D
<i>Elodea canadensis</i>	common waterweed	V	V
<i>Lemna</i> sp. or spp.	—	V	V
<i>Myriophyllum heterophyllum</i>	various leaved water milfoil	V	V
<i>Myriophyllum sibiricum</i>	spiked water milfoil	V	V
<i>Myriophyllum spicatum</i>	eurasian water milfoil	V	V
<i>Najas flexilis</i>	slender naiad	V	I
<i>Najas guadalupensis</i>	southern naiad	-	D
<i>Nelumbo lutea</i>	american lotus	V	V
<i>Nuphar advena</i>	yellow pondlily	D	-
<i>Nuphar variegatum</i>	bull-head pondlily	V	D
<i>Nymphaea odorata</i>	fragrant waterlily	V	D
<i>Polygonum amphibium</i>	water knotweed	I	V
<i>Potamogeton amplifolius</i>	large leaf pondweed	-	V
<i>Potamogeton diversifolius</i>	water thread pondweed	-	I
<i>Potamogeton epihydrus</i>	ribbon leaf pondweed	-	V
<i>Potamogeton gramineus</i>	variable leaf pondweed	-	V
<i>Potamogeton natans</i>	floating leaf pondweed	D	I
<i>Potamogeton pectinatus</i>	sago pondweed	-	V
<i>Potamogeton richardsonii</i>	clasping leaf pondweed	-	V
<i>Potamogeton robbinsii</i>	fern pondweed	-	D
<i>Potamogeton zosteriformis</i>	flatstem pondweed	-	V
<i>Scirpus americanus</i>	chairmaker's rush	-	I
<i>Scirpus validus</i>	softstem bulrush	I	I
<i>Sparganium chlorocarpum</i>	—	V	V
<i>Spirodela polyrhiza</i>	great duckweed	-	D
<i>Typha latifolia</i>	broadleaf cattail	V	V
<i>Utricularia purpurea</i>	purple bladderwort	D	-
<i>Utricularia vulgaris</i>	great bladderwort	-	D
<i>Vallisneria americana</i>	eel grass	-	I

I = increases with drawdown D = decreases with drawdown V = variable response
- = indicates information unknown or unreported

Discharging selectively

In a pond formed by a dam, designing the outlet facilities so you can vary the depth from which water is released may help control water fertility. At certain times of the year when dissolved nutrients are more concentrated, discharge water can be drawn from those depths to reduce the pond's total nutrient supply. Possible adverse effects of nutrient-rich discharge on downstream waters should be considered.

Flushing and diluting the pond

It is sometimes feasible to remove nutrient-rich pond water and replace it with "sterile" water. If enough water is available, continual flushing keeps planktonic algae population low. Diluting nutrient-rich water may also alleviate algae blooms. To accomplish this, truly nutrient-poor water must be available from a well or elsewhere. The benefits of this strategy will be brief, however, if the source of the nutrients that caused the problem remains.

Inactivating phosphorus

Introducing certain chemicals can change dissolved phosphorus to forms less available to plants or can trap and carry it down to the pond bed. The effect of this action may be brief. Various compounds of aluminum, iron, calcium and other elements can be used. The chemicals are typically broadcast as a powder or injected as a slurry into outboard motor wash. Sodium aluminate and

alum, used in combination (to maintain pH) may be available to the pond owner, as may zeolite, fly ash, powdered cement and clay.

Aerating the pond

Pumping air into the depths of a pond and creating a rising stream of bubbles helps aerate a pond. You can do this with an on-shore compressor that passes air through a hose to the deepest part of the pond. There a special dispenser, such as an air stone, plastic foam block or metal baffle, breaks the air into fine bubbles. The rising bubbles draw water upward, causing the pond water to circulate from bottom to top and take on oxygen from the atmosphere. More oxygen is gained through the pond surface than from the stream of bubbles. With the water at the pond bottom oxygenated, the surface of the pond mud is kept oxidized, holding phosphorus in an insoluble form and making it less available for growing plants.

In the case of deep trout ponds, special equipment (the hypolimnetic aerator) is available. This brings the cool water of the deep zone to the surface and back during summer without allowing the cool water to mix with the upper layers. Thus, an undesirable warming of the deep waters is avoided.

It may be especially important to aerate the pond in winter. This keeps the area ice-free and allows oxygen to move continually from the atmosphere to the pond depths. It also reduces transfer of phos-

phorus from mud to water which occurs during winter stagnation. Running aerators in the winter causes safety hazards from thin ice and open water—*use care*.

Selective discharge, pond flushing, nutrient inactivation and aeration are techniques designed to reduce algae blooms by limiting nutrients in the water. They will probably have little impact on rooted plants and may aggravate the problem of nuisance rooted plant problems by increasing water clarity. These techniques usually require a close estimate of the nutrient "budget" in the pond. Before spending time, effort and money on these techniques, you should consult a competent limnologist to decide if they will work in your pond.

Sealing and blanketing the pond bed

To control rooted plants, pond beds can be covered with black plastic sheeting weighted with gravel or rocks. However, research shows that the results of this technique are short-lived. As soon as sediment accumulates on top of the plastic, weed growth resumes. Black plastic isn't recommended unless you are willing to continually manage the area.

Newer products made of fiberglass screening are commercially available and effective. It is recommended that these products be removed periodically, usually annually, and cleaned for them to remain effective.

Shading or coloring the water

Sheets of black plastic supported by a floating wooden or styrofoam framework can be used to cover parts of the pond surface. Such a covering is anchored in one spot for the 3–4 weeks needed to shade out plants beneath it, then moved to a new place. Shading with plastic is apparently effective on most submergent plants (except chara) but not on emergents, and the device may be cumbersome and unsightly.

Special dyes are available (for example, "Aquashade") that temporarily color the water to cut off light and control plants. For dyes to be effective, you must maintain the recommended concentration in the water. This can be difficult in ponds with streams or a lot of groundwater entering the pond. Dyes should be applied early in the growing season before plants reach the surface. Sediment in the water reduces the effectiveness of some dyes. Dyes should not be applied to ponds where the water is used for human consumption.

Another method of shading portions of the pond is by planting trees on the south and east sides of the pond so that they shade the water. Conifers are preferred because they provide year-long shade and don't drop leaves into the pond.

Herbicides and algicides

Killing pond plants with chemicals is another form of treatment. Substances toxic to algae are called **algicides**.

Those for poisoning rooted, leafy water plants are **aquatic herbicides**. You may need a permit from the Wisconsin DNR or be certified by DATCP to use herbicides and algicides in your pond (see Chapter 15 on permits and licenses).

Chemical treatments have the advantage of convenience, but consider the following drawbacks:

- Poisoning kills plants without removing them from the pond. After they die, plants sink, consuming oxygen, creating odors and releasing nutrients for new plant growth.
- Poisoned plants disappear only slowly from the treated area. One to several weeks may pass before the masses of nuisance plants sink away.
- Since each herbicide kills many kinds of plants, beneficial species may be killed along with the nuisance plants.
- Localized treatment is difficult. Even ponds that appear placid have currents that can carry poison from a problem area to one where plant beds should be preserved.
- There is risk of harm to other life in the pond and the surrounding area.

- Most chemical treatments require that pond use be restricted afterwards (for example, no swimming, irrigation or fishing). Make sure you can abide by these restrictions.

To use chemicals effectively and present the least hazard to other life, you must identify the kind of plant you wish to destroy, obtain the proper chemical, calculate the volume of the pond and apply the proper dosage. Also, for personal safety, wear proper protective clothing. Use safe procedures for handling pesticides and disposing of empty containers.

A list of chemicals generally used for weed control, their trade names and use restrictions are provided in tables 7, 8 and 9. These recommendations and restrictions change rapidly so check with the DNR at least annually for current regulation. *Using chemicals other than those on this list may be illegal and dangerous!* Use only chemicals labeled for use in lakes and ponds so you have complete instructions on their use and know of any special precautions.

Dosage rates will be shown on the product label. Follow these closely. *Do not overtreat!* Avoid thinking "If a teaspoonful is called for, then a whole shovelful will do the job better." This not only wastes money, but may cause plant decay so rapid that dissolved oxygen becomes depleted and fish suffocate. A chemical overdose may poison fish and other life. Distribute the chemical evenly over the area to be treated, whether using spray, powder or granular plant poisons. Too much applied in one place

increases the risk of killing fish and other organisms. Most plant poisons work best when water temperature is above 65°F.

Carefully follow safety precautions printed on the product label. Don't let the chemical reach crops and other desirable plants or trees. Choose a calm day to avoid wind drift. Don't use the treated water for irrigation, agricultural sprays, livestock watering or swimming until the time period advised on the label has elapsed.

Most emergent plants have a waxy outer surface. For chemical treatments to work, an adjuvant or surfactant must be added to the herbicide so it "sticks" to the plant and penetrates the waxy surface to vital parts. Check with the DNR's or DATCP's aquatic nuisance control specialists for adjuvant and surfactant recommendations and use restrictions.

Copper sulfate is widely used to kill algae and is commonly available from agricultural supply outlets. Extreme care is needed when using copper sulfate or other copper-based chemicals in fish ponds. Even though it is frequently described as suitable for use in human drinking water supplies or where fish will be consumed, a high copper content harms fish food organisms and kills fish.

Copper sulfate is difficult to use properly. Its effects vary greatly depending on water hardness and other factors. In extremely softwater ponds, very little copper sulfate may kill the algae—but also may kill the fish. In very hard water,

it may take much more copper sulfate to kill the algae, yet the danger to fish may be much less. See your nearest DNR biologist for locally recommended dosages.

Copper sulfate is best applied by dissolving the crystals in water and spraying the pond's surface or by placing the crystals in a burlap bag and pulling it through the pond until the crystals dissolve. Simply throwing copper sulfate crystals into the water may result in their accumulation on the bottom where they have little effect on the algae problem.

If you wish to poison algae with copper, you may lower the risk somewhat by using chelated copper. It achieves the same algicidal effect as copper sulfate with a much lower concentration of copper. This is less likely to harm fish and other pond life and is much more effective in hard water ponds.

Chara algae can be particularly hard to control with toxic chemicals because it often has a crust of lime (calcium carbonate scale). Therefore chara should be chemically treated only in the spring before a heavy crust forms. The amount of copper sulfate needed to kill chara is more than for other algae. Additional caution is advised because copper concentrations could be hazardous to other pond life.

Biological control

Controlling aquatic vegetation with plant disease organisms, plant-eating fish, waterfowl or other animals has been tried in many parts of the world, but holds little promise for northern ponds. The plant-eating Asian grass carp (*Ctenopharyngodon idella*), also called the white amur has been imported into the southern U.S. to control weeds in fish ponds. In addition to eating problem plants, it eats beneficial plants that are used as breeding habitat by some desirable fish, serve as cover for young game fishes or that supply food for wildlife, especially waterfowl. Since grass carp do not eat all aquatic plants and algae, the plants they don't eat grow in place of the plants they do.

It is illegal to bring grass carp into Wisconsin or to possess them, including the sterile, triploid grass carp.

The rusty crayfish (*Orconectes rusticus*) has invaded some Wisconsin lakes and eliminated aquatic plant growth.

Although this may sound appealing to some pond owners, the crayfish causes problems because it eats fish eggs and burrows into pond banks. Furthermore, it requires some gravel substrate to reproduce and achieve abundance levels required for plant control. Planting crayfish in ponds to control plants is not recommended and it is illegal to possess or transport live crayfish in Wisconsin.

Plant-eating waterfowl have also been tried for controlling leafy aquatic plants. One pair of domesticated swans and their one or two offspring can keep an acre of pond plant-free. However, the swans must be provided with some open water and shelter in winter (or kept in a barn), and they may need supplemental feeding which adds nutrients to the pond.

Ducks and geese that eat plants aren't suitable for pond weed control. They obtain much food through supplemental feed or by foraging outside the pond, bring nutrients to the pond as feces, and increase the plant problem.

Algae typically replace the higher aquatic plants consumed by animals used to control pond plants. In some cases, dense blooms of planktonic algae may be more tolerable than large weeds.

Often in a pond, rooted plants and algae compete for nutrients and light. One problem acts as a biological control over another. You may be able to choose your problem, but managing both at the same time is difficult.



Table 7. **Susceptibility of aquatic plants to herbicides***

Scientific name	Common name	Endothall	Diquat	2,4-D	Glyphosate	Fluridone
<i>Acorus calamus</i>	sweetflag	N	N	C	-	-
<i>Brasenia schreberi</i>	water shield	N	N	C	-	N
<i>Ceratophyllum demersum</i>	hornwort	C	C	C	-	C
<i>Chara</i> sp. or spp. (1)	muskgrass	?	N	N	N	N
<i>Eleocharis acicularis</i>	needle spikerush	-	-	-	-	?
<i>Eleocharis palustris</i>	creeping spikerush	-	-	-	-	?
<i>Elodea canadensis</i>	common waterweed	?	C	N	-	C
<i>Juncus pelocarpus</i>	brown-fruited rush	-	-	-	-	C
<i>Lemna</i> sp. or spp.	—	N	C	N	-	C
<i>Lemna minor</i>	small duckweed	N	C	N	-	C
<i>Myriophyllum</i> sp. or spp.	—	?	C	C	-	-
<i>Myriophyllum heterophyllum</i>	various leaved water milfoil	?	-	-	-	?
<i>Myriophyllum sibiricum</i>	spiked water milfoil	?	-	-	-	C
<i>Myriophyllum spicatum</i>	eurasian water milfoil	?	C	C	N	C
<i>Najas</i> sp. or spp.	—	C	C	-	-	?
<i>Najas flexilis</i>	slender naiad	?	C	N	N	C
<i>Najas guadalupensis</i>	southern naiad	C	C	N	-	C
<i>Nelumbo lutea</i>	american lotus	?	?	C	?	-
<i>Nitella</i> sp. or spp. (1)	—	-	-	-	-	-
<i>Nuphar</i> sp. or spp.	—	N	N	C	C	C
<i>Nuphar variegatum</i>	bull-head pondlily	?	-	C	C	-
<i>Nymphaea</i> sp. or spp.	—	?	N	C	C	C
<i>Nymphaea odorata</i>	fragrant waterlily	?	-	C	C	C
<i>Phragmites australis</i>	common reed	-	-	-	C	?
<i>Polygonum</i> sp. or spp.	—	?	N	C	C	?
<i>Potamogeton</i> sp. or spp.	—	?	-	-	?	-
<i>Potamogeton amplifolius</i>	large leaf pondweed	C	?	N	-	-
<i>Potamogeton crispus</i>	curly leaf pondweed	C	C	N	-	C
<i>Potamogeton diversifolius</i>	water thread pondweed	C	?	N	-	C

For use as a general guideline only. C = plant generally controlled. ? = questionable control; results highly dependent on chemical formulation or environmental conditions. N = plant generally not controlled. (1) = plant usually controlled with copper compounds. - = information unknown or unreported.

Table 7. (continued)

Scientific name	Common name	Endothall	Diquat	2,4-D	Glyphosate	Fluridone
<i>Potamogeton filiformis</i>	thread leaf pondweed	C	-	-	-	C
<i>Potamogeton foliosus</i>	leafy pondweed	C	C	N	-	C
<i>Potamogeton illinoensis</i>	illinois pondweed	-	-	-	-	?
<i>Potamogeton natans</i>	floating leaf pondweed	C	C	?	-	C
<i>Potamogeton nodosus</i>	long leaf pondweed	C	?	N	-	?
<i>Potamogeton pectinatus</i>	sago pondweed	C	C	N	-	C
<i>Potamogeton pusillus</i>	small pondweed	C	C	N	-	-
<i>Potamogeton richardsonii</i>	clasping leaf pondweed	C	N	N	-	C
<i>Potamogeton strictifolius</i>	stiff pondweed	C	C	N	-	-
<i>Potamogeton zosteriformis</i>	flatstem pondweed	C	N	N	-	-
<i>Ranunculus</i> sp. or spp.	—	?	C	?	-	-
<i>Ranunculus tricophyllus</i>	white water crowfoot	?	C	-	-	-
<i>Ruppia maritima</i>	widgeon grass	N	C	N	-	-
<i>Sagittaria</i> sp. or spp.	—	N	N	C	-	?
<i>Sagittaria latifolia</i>	common arrowhead	-	-	-	-	?
<i>Scirpus</i> sp. or spp.	—	N	?	C	-	C
<i>Scirpus acutus</i>	hardstem bulrush	-	-	-	-	?
<i>Scirpus americanus</i>	chairmaker's rush	-	-	-	-	?
<i>Scirpus validus</i>	softstem bulrush	-	-	-	-	?
<i>Sparganium</i> sp. or spp.	—	C	N	N	-	-
<i>Spirodela polyrhiza</i>	great duckweed	-	C	?	-	?
<i>Typha</i> sp. or spp.	—	N	C	?	C	?
<i>Utricularia</i> sp. or spp.	—	N	C	N	-	-
<i>Utricularia gibba</i>	humped bladderwort	-	-	-	-	C
<i>Vallisneria americana</i>	eel grass	?	?	-	-	N
<i>Wolffia</i> sp. or spp.	—	N	C	N	-	-
<i>Wolffia columbiana</i>	common watermeal	-	-	-	-	?
<i>Zannichellia palustris</i>	horned pondweed	C	?	N	-	?
<i>Zosterella dubia</i>	water star grass	C	C	N	-	-

For use as a general guideline only. C = plant generally controlled. ? = questionable control; results highly dependent on chemical formulation or environmental conditions. N = plant generally not controlled. (1) = plant usually controlled with copper compounds. - = information unknown or unreported.

Table 8. Aquatic herbicides commonly used to control weeds in ponds

Common name	Trade name
Copper Sulfate	Copper Sulfate Medium Crystals
	Triangle Brand Copper Sulfate
	Copper Sulfate Instant Bluestone
	Copper Sulfate Superfine Crystals
	Kocide Copper Sulfate Crystals
Copper Chelates	Algimycin PII-C
	Aquatrine Algaecide
	AV-70 (also AV-70 plus)
	Cutrine-Plus Algaecide/Herbicide
	Slow Release Algimycin
	Stocktrine II
	Komeen
K-Tea Algaecide	
Endothall	Aquathol
	Aquathol K
	Hydrothol 191 ^a
Diquat	Reward
2,4-D	Weed R-64
	Aqua-kleen
	Navigate
Glyphosate	Rodeo
Fluridone	Sonar A.S.
	Sonar S.R.P.

^a Fish will be killed by dosages greater than 0.3 ppm.

Table 9. General restrictions on use of treated water (number of days)

Herbicide	Human			Animal		Irrigation	
	Drink- ing	Swim- ming	Fish con- sumption	Drink- ing	Turf	Food crop	Forage
Copper sulfate	0	0	0	0	0	0	0
Copper chelate	0	0	0	0	0	0	0
Endothall	0	0	3	7-25	7-25	7-25	7-25
Diquat ^a	1-3	1	14	1	5	14	14
2,4-D ^b	14	0-2	^c	14	14	14	14
Glyphosate ^b	0	0	0	0	0	0	0
Fluridone ^b	0	0	0	0	7-30	7-30	7-30

^a = A drinking water tolerance of 0.01 ppm has been established for Diquat.

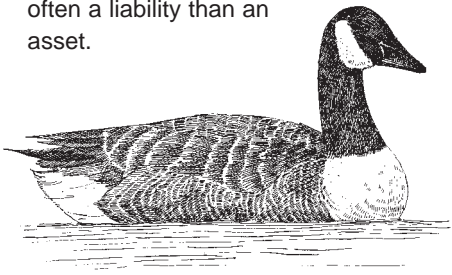
^b = Although no waiting period is established for recreation or domestic purposes, a drinking water tolerance of 0.07 ppm has been established for 2,4-D, 1 ppm for glyphosate and 0.15 ppm for fluridone.

^c = No established waiting period.

Wildlife around the pond

Ponds are an excellent way to enhance wildlife habitat on your property. For many species, a source of water provides much more than just a place to get a drink. To reproduce, most amphibians (frogs and toads) must make a seasonal move to water. Waterfowl (ducks and geese) feed, rest and nest in, on or near water. Turtles and aquatic mammals such as muskrat and beaver all depend on water for a home. Thus, if you have a pond, you can expect these animals to be present.

However, there is a difference between wildlife ponds and ponds constructed to propagate and harvest fish. Any water will attract some animals, but wildlife ponds are generally shallower and more vegetated with sides that slope more gradually than fish ponds. Resource agencies may provide technical assistance and cost sharing for construction of wildlife ponds, but usually not for fish ponds. In the case of ponds designed for fish production, the presence of abundant and diverse wildlife is more often a liability than an asset.



Because this publication focuses on ponds for fish production and fishing, wildlife here is discussed primarily in the context of nuisance and damage problems. If you are interested in creating or managing a pond for wildlife, refer to your local Wisconsin DNR office, NRCS office, Extension wildlife specialist or one of the many informative print materials available.

Controlling wildlife problems

The mere presence of wildlife does not necessarily mean you will have problems. Furthermore, you and your guests will likely enjoy the opportunity to observe the wildlife around a pond. However, it is very important to be aware of the problems that can occur and be prepared to take the necessary steps to control them should they arise. Many mammals and birds eat fish, several mammals can do significant structural damage to dikes, dams and shorelines, and some species (such as Canada geese) can be a nuisance on grassy shorelines.

Animal damage problems are usually much more complicated than aquatic weed or insect control. Wild animals are mobile, often wary, usually protected by state and/or federal law—even on private land—and are often highly valued by society. In addition, problems are confounded by differences in site, weather, season and other factors. Consider the following general guidelines, techniques and sources of assistance. Advice specific to individual species is presented for the major problem species.

Also, don't expect animal damage control to be totally effective or permanent. The control techniques described here will reduce or eliminate losses, but in most cases you will need to repeat them from time to time.

Wildlife control considerations

Keep these things in mind as you attempt to resolve conflicts with wild animals.

- **Anticipate rather than react.** Try to anticipate a problem and take steps to prevent it. For example, if fish-eating birds are common, remove potential perches before damage occurs. Wildlife problems are much easier to avoid than stop after an animal has established a behavior pattern.
- **Understand wildlife laws.** You must find out what you can and cannot do with regard to harassing, relocating or killing any wild animal. A few species (rats, mice, some other small mammals and a few birds like pigeons and starlings) are not protected by laws. Most, however, are protected by state and/or federal law. Although there are some special provisions for landowners, you will not be able to kill or capture certain species, no matter how serious the problem. Permits, licenses or other forms of permission may be required. Laws also vary from state to state and even within some

chapter 12



municipalities (use of firearms, for example). The sections of this publication dealing with problems caused by certain species contain basic legal information *but check first with your local DNR office or warden.*

- **Be sensitive to values other than your own.** A problem for you may be a delight to your neighbors or vice versa. Neighbors may have differing opinions about killing or relocating “pest” species or the use of pesticides. This is especially true in the case of fish-eating birds.
- **Know your adversary.** Your efforts to control a wildlife problem can be greatly enhanced by an understanding of the animal’s basic life history. What does it eat (helps with bait choice)? Where does it live (helps with trap placement or habitat modification)? How prolific or mobile is it? Furthermore, better knowledge of the wildlife in question may lead you to decide your problem is really not so bad given the benefits the animal may provide.
- **Understand the basic tools and techniques of wildlife damage control.** Wild animals are much different than weeds or insects. Few chemical pesticides are registered (available) for animal control (that’s good!) and cookbook solutions (apply X to Y, wait 3 days, problem is gone) are rare for wildlife problems.

The following general options are used in wildlife control:

1. **Exclusion.** Prevent the animal from getting to a site where it may cause damage. Examples: a fence, a mesh cover over a small rearing tank or pond, or monofilament lines strung in parallel rows over a raceway for bird exclusion.
2. **Removal.** Remove the animal from the scene. Examples: remove live animals—capture and relocate via wire live trap, net, hand, etc.; kill animals—shoot, use toxicants, kill-traps (like a wooden-base rat trap).
3. **Repellents.** Prevent the animal from doing damage or gaining entry by using olfactory or taste-based repellents. Examples: Rejex-it® applications on grass to discourage Canada geese.
4. **Scare tactics.** Frighten the animal away. Examples: gunfire over a pond, owl decoys, mylar or plastic streamers, other noisemakers, “scare-eye” balloons, propane cannons, radios.
5. **Habitat modification.** Eliminate a key component of the animal’s habitat thus causing it to leave the area. Examples: eliminate dead snags or posts used as perches by fish-eating birds; riprap a bank used by muskrats.

6. **Increased tolerance.** Rethink the situation! Examples: The sounds or sights provided by the animal in question may be worth the hassle or loss, or maybe there are more fish than you really needed anyway.

Problem species

Muskrats and woodchucks

Muskrats and woodchucks dig burrows that may cause pond bank cave-ins, weaken dams or result in leaks. They prefer to dig in steep banks. Muskrats tunnel from beneath the pond surface while woodchucks typically tunnel into the high portions of the banks or dams.

Muskrats make burrow entrances 6”–18” below the water line, sometimes deeper. Burrows may penetrate banks or dams 9 feet or more, but the average length is 5–6 feet. The tunnel leads to a dry nest chamber above water level. Frequently muskrats also burrow upward from the nest chamber tunnel to the surface, thus creating a second burrow entrance high on the bank or dam.

Woodchucks, also called groundhogs, burrow into pond dams and banks well above the waterline. The burrows may penetrate 50 feet or more and rise to the surface creating a second burrow entrance on the other side of the dam, or well away from the pond. The tunnels lead to underground nesting chambers and chambers for food storage, body waste and traps for water that enters the burrows.

Habitat management. Eliminating or reducing habitat reduces or eliminates the attractiveness of banks and dams to woodchucks and muskrats. Maintain dams and banks in grasses such as fescue and brome. Eliminate all broad-leaved plants, especially legumes like clover, alfalfa and trefoil. Eliminate muskrat food, such as cattails, arrowhead and other emergent plants. If the pond is not properly constructed, consider regrading the banks, and deepening the pond to reduce the zone where emergent plants grow (see Chapter 3).



Remember, habitat modification will help to solve problems, but will also reduce the attractiveness of your pond to other more desirable species. To completely eliminate the possibility of muskrat and woodchuck damage to bank and dam, reinforce banks and dams with materials that will prevent burrowing. Reinforcing these embankments is the only way to completely prevent muskrat and woodchuck damage when the pond is located near other waterways, wetlands or uplands that are in unmowed meadows, hay fields or other agricultural uses.

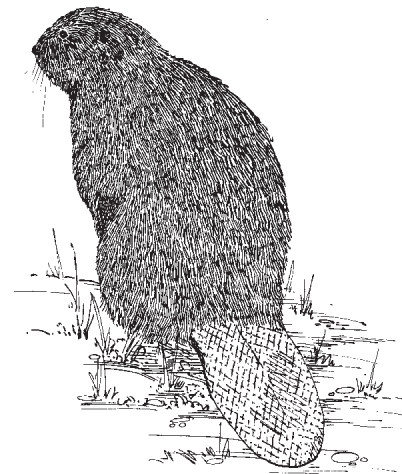
Reinforcing the shore and dam. The shore and bank can be reinforced to deter muskrat or woodchuck burrowing in one of the following ways.

- Cover with at least 2 layers of rocks (called riprap) at least 6 inches in diameter from 3 feet below the low waterline to 3 feet above the normal waterline for muskrats. For woodchucks, cover with 2 layers of riprap from normal waterline to the top of the dam or to the top of the bank.
- Use soil cement in the top 6 inches of earth from 3 feet below low waterline to 3 feet above normal water level for muskrats and from the normal waterline to the top of the bank or dam for woodchucks.

- Cover with vinyl-coated chicken wire from 3 feet below low waterline to 3 feet above normal water level for muskrats and from the normal waterline to the top of the dam or bank for woodchucks.

Reducing muskrat and woodchuck populations. If the pond is not adjacent to extensive muskrat or woodchuck habitat, damage caused by muskrats and woodchucks can be greatly reduced by eliminating as many of the animals as possible. If the area surrounding the pond has extensive wetlands or meadows, hayfields or agricultural lands, the animals that are eliminated will be replaced very quickly by new ones from the surrounding habitat and damage will be reduced only slightly, if at all.

Because these regulations change occasionally, check the annual hunting and trapping regulations and consult your local conservation officer about special provisions for damage control.



Beavers

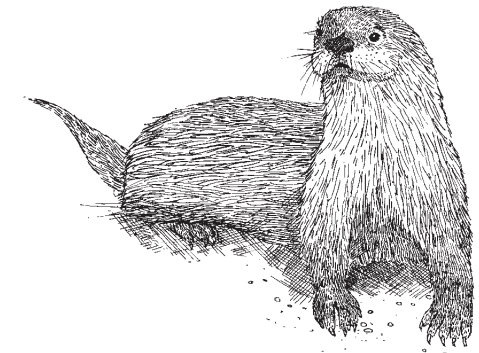
Beavers may cause problems by felling trees, plugging culverts and spillways and digging bank dens. Major revisions in Wisconsin regulations in 1990 changed private landowners' beaver control options. Consult your local DNR office and request a copy of *Beaver Damage Control*. In general, you may shoot or trap beaver on your own property and remove dams without a special permit. In northern Wisconsin the USDA Wildlife Services office in Rhinelander runs an intensive beaver control program.

Beaver are most likely to be attracted to moving water where they can engineer their own flowage. In this case, there are several devices that utilize PVC pipes installed through the dam with intakes and outflows well above and below the dam. For some reason, the animals do not seem to figure out the "leak" in their pond and water continues to flow. Look for information on the "Clemson Beaver

Pond Leveler" if this idea sounds useful. There is an excellent chapter on beaver control in the *Handbook of Wildlife Damage Control* published by the University of Nebraska. Most Wisconsin county UW-Extension offices have a copy, or you can request a copy of the section on beavers from your Extension wildlife specialist.

Otters

Otters are playful creatures but fish are the main component of their diet. A family of otters in a fish pond is a major problem. The otters should be captured and removed as soon as possible. Mink may also take some fish but they earn their keep by preying on muskrats.



Moles

Mole burrows cause erosion by destroying patches of sod on dams or pond banks. Applying any mole damage control method to inactive mole burrow systems is futile. In all cases, treat only active tunnels. To see if a tunnel is being actively used, gently flatten a short section of the ridge above the tunnel. If the tunnel is in use, the ridge will be raised again within 24–48 hours.

A new repellent, Mole-Med® can be applied directly to grassy areas, for 1–2 months of relief from burrowing activity. For further details contact your local UW-Extension county office for a copy of the publication *Mole Control* (G3200). Pocket gophers could be confused with moles but they are found only in the west-central and southwestern parts of Wisconsin. Gophers are rodents (moles are not) and can be controlled with poison baits.



Birds

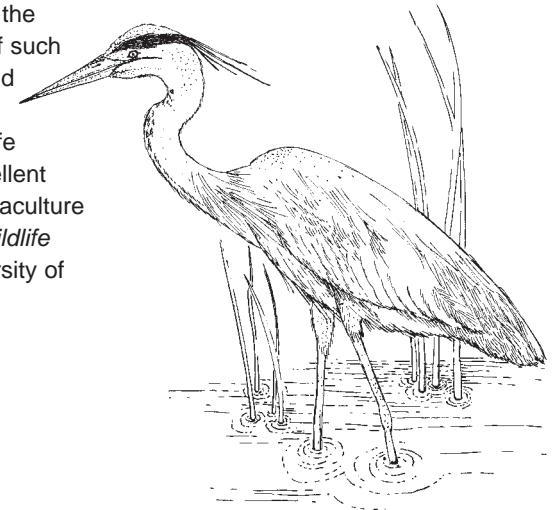
Several kinds of fish-eating birds consume fish from ponds, especially kingfishers, herons, osprey, mergansers and domesticated ducks. Fish-eating birds may also carry parasites that infect fish. All of these birds can be scared away by noise-making devices, such as gas-powered automatic cannons and bird-scaring shotgun shells that fire explosive charges designed to detonate 50–100 yards away. Use exploders and scare shells in combination. You must vary the locations, firing intervals and firing times at least every third day or the birds soon become accustomed to these techniques. Use of these devices requires a federal permit if endangered or threatened species are involved. Noise ordinances may also be a factor if you are near a developed area.

Scarecrows, artificial snakes, hawk or owl decoys and special balloons that frighten birds can also be used to scare birds away. These devices must be positioned imaginatively and moved frequently, at least every other day, or they will soon become ineffective. They are most effective if used together with scare shells and automatic explosion cannons.

Discourage herons by grading the pond's edges to form steep underwater side slopes. Three feet of horizontal distance per foot of slope is the maximum slope recommended for safety (see the information on pond construction in Chapter 3). If necessary, suspend chicken wire horizontally at or near the water surface along the shallow parts of the pond edge. Discourage kingfishers by removing all perches, such as posts and dead tree limbs, close to the pond. If Muscovy ducks are kept in the pond, confine them to a small part of it.

All birds that may cause potential problems around ponds are protected by federal (and often state) law. In extreme cases, a permit may be issued to shoot offending birds. But be aware of the public relations consequences of such actions. For more information and necessary control permits, contact the nearest USDA Wildlife Services office. There is an excellent chapter on "Bird Damage at Aquaculture Facilities" in the *Handbook of Wildlife Damage Control* from the University of Nebraska mentioned earlier.

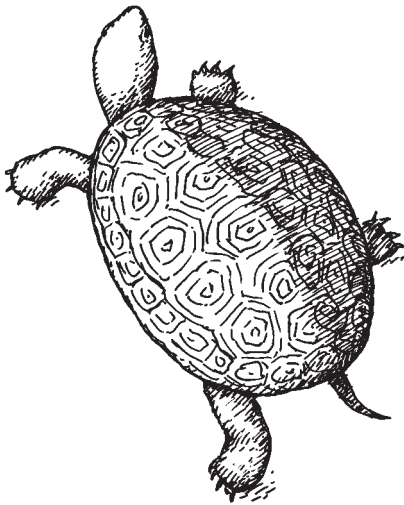
A pair of Canada geese and their goslings may be a welcome addition, but large flocks of local or migrating geese can be a major nuisance if your pond is surrounded by a well-maintained turf. Geese defecate profusely which leads to a visual and sanitation problem. Persistent grazing by geese can damage turf. Scare tactics such as bird screamers, shell crackers or gunfire will help. Hunting pressure during the appropriate open season is very useful. A relatively new repellent called ReJex-It® (a formulation of methyl anthranilate) can be applied directly to the turf to discourage geese.



Turtles and snakes

In recreational fish ponds, turtles and snakes rarely eat enough fish to affect the fish population. Unlike mammals and birds, turtles and snakes may not feed daily and they concentrate on minnows and other small fish.

Some pond owners want to remove turtles and snakes simply because they are afraid of them or don't like them. Snake and turtle populations can be reduced by mowing pond bank vegetation and removing logs, tree roots, branches and large stones from the shoreline. Mowing this habitat reduces the opportunity for these animals to survive, but it also reduces the effectiveness of a vegetated buffer strip for nutrient and sediment control.



Indiscriminate killing of all snakes regardless of species accomplishes little and may create or intensify other problems, such as rodents. In recognition of the value of many reptile species, laws and regulations change rapidly. Be sure to check with your local DNR office before taking action.

If it becomes necessary to remove turtles from a pond, they are easily caught using a trap constructed of chicken wire. Commercial turtle traps are also available. To make a trap, roll a piece of one-inch mesh chicken wire 60 inches wide and 60 inches long into a cylinder 60 inches long. On both ends of the cylinder, make four cuts, 15 inches apart. Each cut should be 12 inches deep. Next fold these ends of the cylinder inward and reattach the cut ends to each other to create funnels pointing inward with a small end opening of approximately 12 inches by 6 inches. A trap of this size will catch all but the largest snapping turtle.

To trap a very large snapping turtle that weighs more than 20 lbs., start with a piece of chicken wire that is 6 by 8 feet.

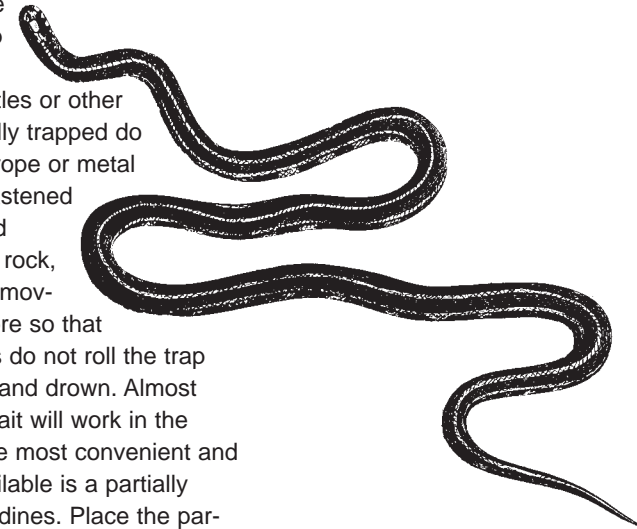
Follow the previous directions, but this time make the opening of the small end of the funnel leading into the trap approximately 10 inches by 18 inches.

Cut a door panel in the side of the trap and wire it tightly closed.

To use the trap, place it in shallow water where turtles are most likely to feed.

Make sure that the top part of the trap is above water so that entrapped turtles or other animals accidentally trapped do not drown. Nylon rope or metal cable should be fastened to the trap and tied securely to a tree, rock, stake or other nonmovable object on shore so that entrapped animals do not roll the trap into deeper water and drown. Almost any meat or fish bait will work in the trap, but one of the most convenient and effective baits available is a partially opened can of sardines. Place the partially opened can into the trap before putting the trap in the pond. Captured turtles can be removed by hand or with a dip net through the door panel.

Check with the local DNR office for regulations on trapping turtles in your pond.



For more information or on-site assistance

Wisconsin Cooperative Extension —

County extension offices or state wildlife specialists have a wealth of information available. Extension wildlife damage control publications contain the details needed for most problems and most county offices have a copy of the *Handbook of Wildlife Damage Control* (University of Nebraska, 1995).

State Natural Resource Management Agencies (DNR) —Agency staff can provide information, legal advice and permits.

U. S. Department of Agriculture-Animal and Plant Health Inspection Service-Wildlife Services—This agency's role varies from state to state but Wildlife Services staff can be a great help in agricultural and aquacultural problems. The agency maintains district offices in Waupun (800-433-0663) and Rhinelander (800-228-1368) and a statewide office in Sun Prairie (608-837-2727).

Private contractors—There has been a recent proliferation of individuals who will handle wildlife damage problems for a fee. Check the Yellow Pages or the county Extension office for a reference.

Self reliance—With some good information, a little thought and good equipment you *can* solve most wildlife problems yourself.

Other problems

Swimmer's itch

Swimmer's itch is caused by a minute, free-swimming parasite that burrows into and irritates the skin. This parasite develops only in certain kinds of snails before it attacks humans. Ducks also assist in the life cycle of the parasite but any attempt at duck control is likely to be undesirable and ineffective. Feeding ducks at pondside will only exacerbate potential swimmer's itch problems and should be avoided.

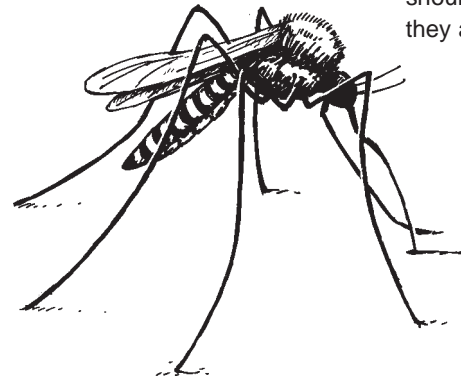
Ridding a pond of swimmer's itch means controlling the snails. To control snails with least harm to the pond's fish, remove plants and pondbed debris, which provide the snails' habitat. Sowing pea-sized copper sulfate crystals onto the pond bed (2 lb/1000 sq ft or 87 lb/acre) poisons snails but also kills many other fish food organisms, and possibly some fish, especially trout. To avoid chemical control, simply be sure all swimmers quickly and vigorously towel dry themselves immediately upon leaving the water.

Mosquitos

In general, mosquitos don't thrive in fish ponds because fish eat mosquito larvae. Moreover, mosquitos need calm water to develop. Any spot where a breeze can ripple across a pond's surface is unsuitable for mosquitos. Only very shallow, protected pond edges support them, and small fish usually dispose of mosquito larvae in these places.

Most mosquitos that cause problems come from temporary puddles. Maintaining a stable pond level prevents flooding of shoreland which creates isolated puddles for mosquito breeding. Don't try to control mosquito breeding unless you have found exactly where it occurs. Then confine your control efforts to those sites.

A safe, effective and pleasant mosquito control is to install a purple martin house near the pond or at the area of human activity. One colony of martins will help keep mosquitos at a tolerable level during daytime and early evening. Beware of using insecticides to control mosquitos near ponds. These chemicals are very likely to kill the fish.



Leeches

Most leeches feed on animals, such as turtles, or on dead matter. Only four species attach to humans. Therefore, the first thing to determine is whether leeches are attaching themselves to people or whether they have merely been sighted in the water. No control is needed unless the leeches are definitely causing a human problem.

Often, the most effective way to reduce leech populations is to reduce the amount of organic debris on the pond bed. Leeches dwell in accumulations of twigs and leaves at the bottom of the pond and they swim up or reach out to attach to host animals. Some leeches attach to aquatic plants and stretch to amazing lengths in search of passing food. Controlling beds of dense vegetation may also help control leeches.

Another method for controlling leeches is to have plenty of bass or trout in the pond. These fish prey on most of the troublesome leeches. In fact, some kinds of leeches are highly effective fishing baits, and they are a hot-selling item at bait shops. Stocking 25 to 50 yearling (6- to 8-inch) bass per acre should reduce leech populations so that they are no longer a problem.

Fish health management

Factors influencing fish health

The health of fish, whether they live in the wild, in a hatchery or in a pond depends upon the interactions of the fish (the susceptible host), the presence of disease organisms (bacteria, viruses, parasites or fungi) and the living environment (figure 25).

Fish and disease organisms can co-exist without causing significant fish health problems or mortality. But health problems occur when one (or some combination) of three conditions exists.

1. Something happens to affect the fish's susceptibility to a disease or parasite. For example, when fish populations reach a high density, fish can become stressed, and disease can occur and spread quickly. Over time, the genetic makeup of a fish population can change so that the fish are more or less susceptible to certain pathogens.

2. Increased environmental stress directly or indirectly causes fish health problems. Decreased oxygen in the water, increased ammonia levels and low pH can directly affect the gill structure, leading to bacterial or environmental gill disease. Exposure to poor water quality, pesticides or limited food supply can indirectly affect fish health by suppressing the immune system.
3. New fish stocked into a pond may carry new disease organisms that can result in significant fish health problems. Or disease organisms already present can mutate to more virulent forms and cause disease outbreaks.

Managing fish health

Pond design specifications, stocking rates and other fish management recommendations in this manual were developed to promote healthy fish populations. But some health problems may occur even when these recommendations are followed. Close attention to pond conditions, oxygen, temperature and the relative growth of fish, coupled with regular observation of fish behavior is important to assessing the health of fish. Fish that are lethargic, pip for air at the surface, or "flash" against rocks or the pond bottom may have underlying health problems. In general, make sure fish introduced into your pond are not stressed or carrying heavy loads of fish parasites or disease organisms.

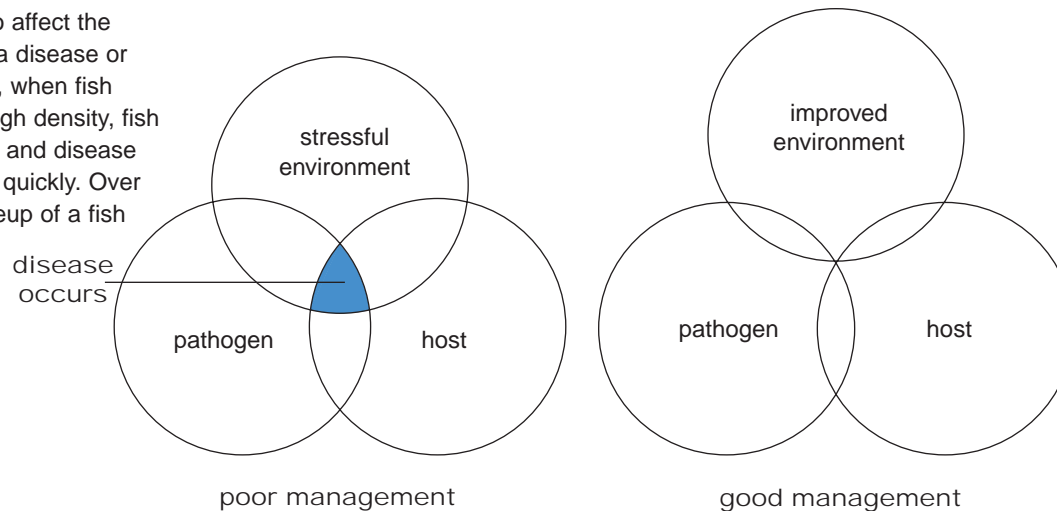
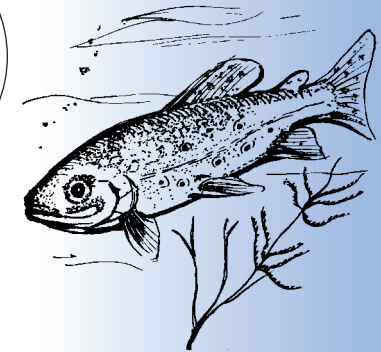


Figure 25. Relationship of management to disease problems.



Your understanding of fish parasites and disease organisms will help you evaluate the status of the fish intended for planting and those already present in your pond. Establishing that a group of fish are disease free requires the skills of a trained professional.

If you plan to raise trout or salmon, it is always a good idea to ask potential fish suppliers for a copy of the most recent fish health inspection report for their facilities. Results from an inspection indicate the disease organisms that were detected at the time of the inspection. To minimize the introduction of new disease organisms, it is always best to receive eggs (that are surface disinfect-

ed) rather than fish. Fish cannot be “disinfected” and may carry any combination of fish pathogens.

Introduction to common fish parasites and diseases

Table 10 gives an overview of some of the more common organisms that can make fish sick and explains how you can tell if those organisms are present. Parasites and bacterial infections are most common in pond fish.

Table 10. **Common fish diseases and their symptoms.**

Name of disease (and fish affected)	Causative agent	Symptoms
Skin fungus or water mold (all fish)	Saprolegnia fungus (often results from injury to skin)	Tufted growths of fine white or gray threads radiating 1/3 inch or more from body.
Columnaris (all fishes)	<i>Flavobacterium columnare</i> bacterium	Grayish-white spots surrounded by red on parts of head, gills, fins or body.
Red sore (northern pike)	<i>Aeromonas hydrophila</i> bacterium	Open bleeding sore from which scales are lost.
Furunculosis (trout and salmon)	<i>Aeromonas salmonicida</i> bacterium	Boils or furuncles on skin, inflammation of inner body walls, many small internal hemorrhages, bright red spleen and swollen kidneys.
Black spot or black grub (mostly warmwater fish*)	Digenetic trematodes	Small black spots just under skin and in muscle. These are cysts containing a microscopic stage of this parasite.
“Ich” or white spot (mostly warmwater fish)	<i>Ichthyophthirius multifiliis</i> protozoan	Tiny white spots on body.
Lymphocystis (perch, walleye, sunfishes)	a virus	Raised nodular masses of light-colored tissue resembling warts on skin.
Fish lice (warm and coolwater fish and brook trout)	Injuries, dietary problems, genetic causes, etc.	External and internal tumors of various sorts, spinal deformities, shortened or flattened heads.

*Also trout where the water is unfavorably warm.

Parasites

Parasitic infections are common in pond-reared fish and can be difficult to control. Some parasites live their entire life on the same fish, while others require a variety of intermediate and final hosts (figure 26).

The life cycle of the parasite causing “black spot” is typical of most fish parasites. Adult flukes live in the intestines of kingfishers and shed eggs that are passed in the bird’s feces. Once in the water, the eggs hatch, releasing a larvae that infects certain species of snails. Larvae develop in the snail and then emerge and “swim” until they encounter

a fish. The larvae then burrow into the skin or muscle of the fish and secrete a protective wall around themselves. The fish also secretes a protective layer around the parasite and we see this as the black spot. When the kingfisher eats an infected fish, the larvae mature to the adult stage and the cycle repeats. Since the parasite spreads via free-flying kingfishers, susceptible fish and resident snails, it is very difficult to eradicate it from a pond.

Other birds and mammals carry similar types of parasites that spend part of their life cycle on fish. Therefore, wherever there are abundant wildlife populations, it is very likely that parasites will infect fish that are reared outdoors. In general however, these types of parasites do not pose a threat to the fish or those who eat them. By keeping the fish population at low densities, you may be able to reduce the number of encysted larvae per fish, but this may not be acceptable if low fish densities are not part of your pond management plan.

Columnaris is a disease caused by the bacteria *Flavobacterium columnare*. This bacterium is very common in lakes and ponds. The bacteria invade gill and skin tissue and sometimes infect the internal organs. Signs of this disease include yellow to grey mucus on the gills, erosion of the skin on the head and body and erosion of gill filaments. Trout or salmon tend to develop “saddle back” lesions that look like grey patches of skin on either side of the dorsal fin. Under certain conditions the disease can cause high levels of mortality. The bacteria

thrive at temperatures above 65° F. Fish can develop an immunity to this bacterium if they survive the initial infection.

Columnaris bacteria increase on fish under stress and pose a particular problem in commercial ponds with high fish densities. Stress caused by low dissolved oxygen, high temperatures, high ammonia levels, an inadequate diet or insufficient space or water flow increases the likelihood of mortality when disease organisms are present.

Depending upon the situation, Columnaris disease and parasitic infections are controlled by a variety of treatments. Guidance for treatments can be obtained from other fish farmers, some veterinarians, the U.S. Fish and Wildlife Service, DATCP, the DNR and fish health reference books. The U.S. Food and Drug Administration regulates fish therapeutants. Anyone who treats fish must follow U.S. FDA guidelines.

If your pond has an outlet, you should be aware that fish health problems will be passed downstream to other fish. Responsible natural resource stewardship will minimize fish health problems at your pond and in fish downstream. The key to successfully raising fish in a pond is to remember that fish are living organisms. If you can provide an adequate food supply and a quality environment for your fish, the chance for disease problems to occur will be small.

There are many opportunities to learn more about fish health. The U.S. Fish and Wildlife Service conducts a week-long course entitled "An Introduction to Fish Health." The course is usually held in February in LaCrosse. Contact the U.S. Fish and Wildlife Service LaCrosse Fish Health Center for more information about this course. See the references on page 77 for the address for the LaCrosse Fish Health Center and a list of reference materials on fish diseases.

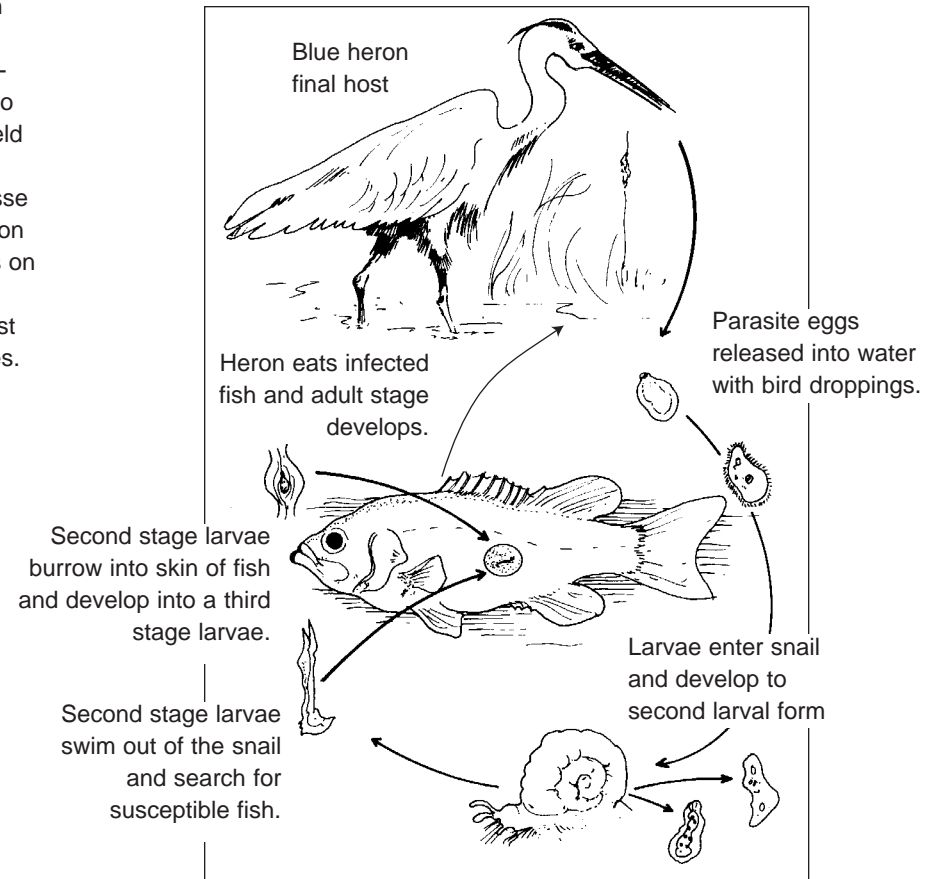
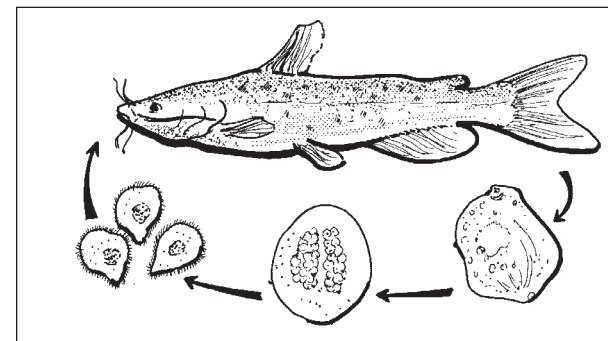
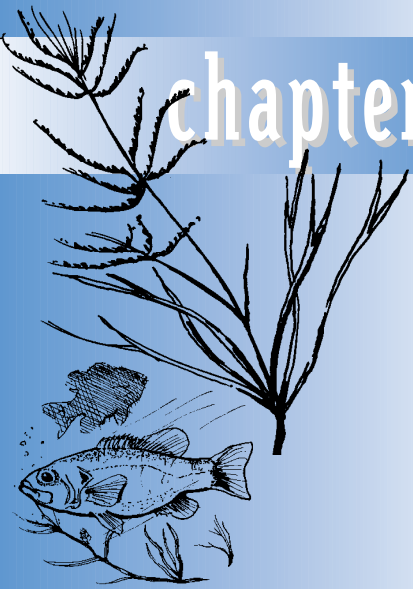


Figure 26. Life cycles of the yellow grub (above) and the "ich" skin parasite (below).





Pond safety and liability

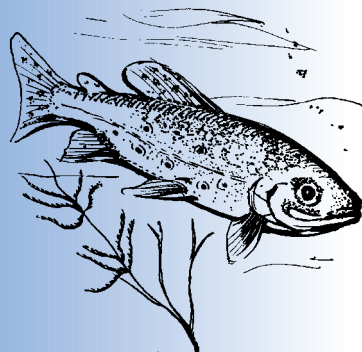
A fishing pond may furnish some swimming, boating, hunting, ice skating, wading and picnicking, even though it may be designed primarily for fish. It will be a special attraction to children.

Because ponds attract people, they present an accident hazard. Drownings are second only to motor vehicle mishaps as a cause of accidental death among people in the active age groups, particularly children.

Each pond owner has moral and legal obligations to family, friends, neighbors and even trespassers to make the pond as safe as possible. Providing certain safeguards can prevent an incident from becoming an accident or even a fatality.

Simply posting a notice prohibiting trespassing at a pond does not relieve an owner of responsibility.

Legal liability is often based on whether an owner has taken **all reasonable precautions** against mishaps. **Pond owners should consult their attorneys and insurance companies** about liability for serious accidents or death, as well as about the legal requirements for safety precautions at the pond.



Find out about both community and state liability laws regarding injury or death resulting from use of the pond. Local laws may vary greatly. This is especially important if an owner intends to open the pond to the public and charge user fees.

Here is a list of fairly economical safety measures.

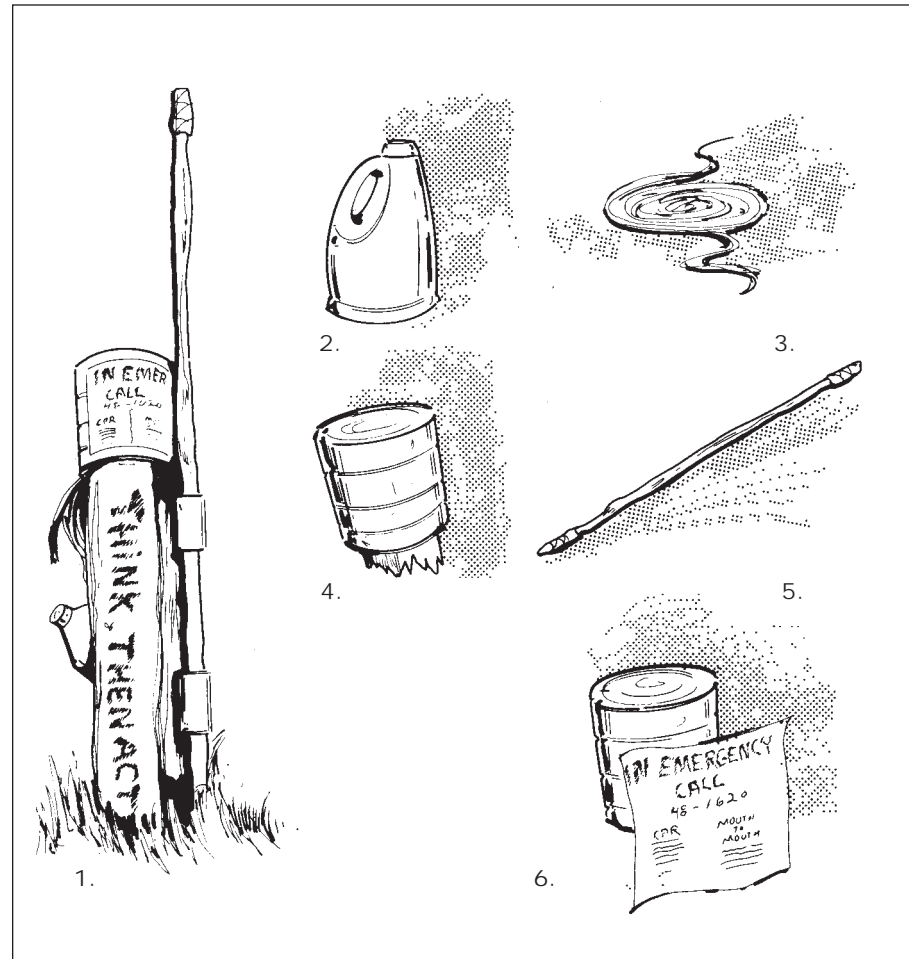
- Grade the pond bed to eliminate steep slopes or drop-offs.
- Remove broken glass and other sharp objects, stumps, logs, large rocks and trash that could pose a hazard to waders, swimmers and boats.
- Place warning signs near specific danger areas, giving the depth of the water and the location of the nearest telephone.
- If you permit swimming, mark a safe special area for it with buoyed lines.
- Install life-saving equipment on the pond bank where it can be easily seen and used.
- Be sure that piers, rafts and landings are well-constructed and braced.
- Erect adequate fencing and locked gates to prevent unauthorized entry—especially by children.
- Keep boats used on the pond in good condition. Never overload them. Instruct passengers never to stand up in the boat. Provide one Coast Guard approved life preserver or personal flotation device (PFD) for each person on board. Use common-sense safety in all other respects!
- Beware of thin ice! Test the strength of the ice with a spud or auger, and actually measure its thickness before venturing over deep water. Don't walk or skate on freshly formed ice that is less than three inches thick. If the ice is thawing, it may need to be much thicker than that. Snowmobiles should not be driven onto ice less than five inches thick.
- Keep a wooden ladder at the pond's edge in winter. This can be shoved out to someone who has fallen through the ice.
- Never let a child play at the pond alone, no matter what the season.
- Everyone who lives, works or plays near a pond should know how to swim and how to give cardiopulmonary resuscitation. Find out more about it from your local Red Cross.

Installing a rescue station

Use the materials and process described below to install a rescue station.

- Post**—A 6-ft two-by-four or four-by-four, preferably painted yellow. Set the post about 2 ft into the ground, standing no more than 4 ft out of the ground, near the water at any point where swimmers might get into trouble. Paint “THINK, THEN ACT” down the length of the post on all sides. About 1 ft from the top, attach a metal shelf bracket, wooden arm or 60-penny spike to use as a hook for coiled rope and the jug float.
- Jug**—A gallon plastic jug with an inch of water inside to be thrown to a person in trouble. Paint “FOR EMERGENCY USE ONLY” on the side.
- Line**—A 40-ft length of $\frac{3}{8}$ inch polypropylene. Tie one end to the handle of the plastic jug. At the opposite end, fasten a 4-inch piece of two-by-four to prevent the line from slipping completely through hands or from underfoot when thrown.
- Pole**—A 10- or 12-ft bamboo pole or sapling. Since the pole will be extended to anyone struggling in the water, its tip and butt should be wrapped with friction tape to reduce slippage. Paint the pole white. Hold it in an upright position by placing it in two 6-ounce tin cans, nailed near the bottom of the post about 6 inches apart.
- Tin container**—A 46-ounce juice can or a 2- or 3-lb coffee can. Remove one end, then slide the can over the top of the post. Fasten it down with one nail through the center of the top so it is impossible to rotate.
- Poster**—A sheet of safety tips, rescue methods and emergency telephone numbers. After applying a coat of varnish to the can, attach the poster to the can and mount the can at the top of the post. Let dry thoroughly; then varnish the poster to protect against weather.

Note: Add a ladder to the rescue station if the pond is likely to be used in winter.



Steps in making a rescue station.

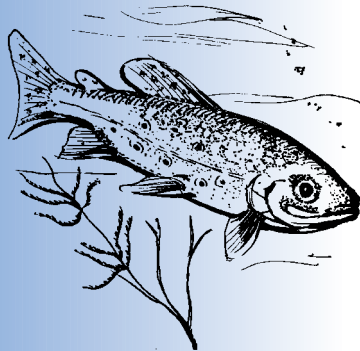
chapter 15



Regulations

To protect Wisconsin's priceless natural resources for future generations, legislation has been enacted that regulates pond construction and management. While the permit process may seem cumbersome, it serves to remind those interested in pond construction and management of their responsibility to the state's natural resources and the potential liability that may be involved. You can start the process by requesting a fish farm information packet from DATCP.

In Wisconsin, all navigable waters are public property and are protected to promote the public interest. In addition, because over 50% of Wisconsin's and the nation's wetlands have already been destroyed, both state and federal laws protect existing wetlands.



Pond construction regulations

The type of pond and its placement determine the regulations that concern you. As suggested earlier, ponds that might affect public navigable waterways or wetlands are of particular concern.

A navigable waterway is any body of water large enough to float a canoe at any time of the year. Generally, a stream 3 feet wide and 8 inches deep at any time of the year is classified as a navigable waterway. A wetland is any area with water at or near the surface that supports wetland plants.

The DNR determines whether the water is a navigable waterway or a wetland. Your county or local units of government may also have designated sites as wetlands. The U.S. Army Corps of Engineers reviews permits involving wetlands.

You should contact your DNR fish expert at the nearest local or district office (see references) to find out which permits apply to your project. You should also contact your county, city and village zoning office or building inspector to find out whether local permits are required.

Any pond to be located within the floodplain of a navigable waterway may require a permit. A permit is always required if you are planning to build a pond within 500 ft of a navigable waterway. A special permit is also required if the project involves changing the course of a navigable waterway or diverting water from or discharging water to a navigable water.

Navigation and safety are a consideration for impoundments. Federal as well as state regulations prohibit construction of dams on navigable waterways. If your plans call for placing a dam on a non-navigable waterway, the law requires that the plans be reviewed and approved by the DNR to protect public safety as well as the public's natural resources. Some county land conservation departments have professional staff who can assist in the pond design and the permit processes.

Registration as a tool to regulate pond management

The destruction caused to waterways by the European carp illustrates why fish pond management is regulated.

Registration is used to implement many regulations related to fish pond management, and the collection of wild animals for sale by the bait industry.

The state gains a way to keep track of who is involved in fish management and the specific sources of fish being stocked in public waters through the natural waterbody permits and stocking permits issued by the DNR.

Fish farms are registered by DATCP. If you choose to register your pond with DATCP, you may:

1. Fish on your pond without a state fishing license
2. Stock fish into the pond without obtaining a DNR stocking permit
3. Ignore state fishing regulations on size, bag limits or open/closed seasons

If you do not register your pond with DATCP, anyone older than 16 must have a state fishing license to fish there; they must abide by state fishing regulations; and you must obtain a stocking permit from DNR to put fish in your pond. There is no fee for the stocking permit.

DATCP has the right to inspect private fish farms and to revoke a registration if violations are observed. The Fish Farm Registration Law is provided in Chapter 95.60 of the State Statutes.

Bait dealers are regulated by the DNR and are required to obtain a Class A license (\$49.25) if they sell more than \$2,000 worth of bait per year, or a Class B license (\$9.25) if their sales are less than that.

The license allows for the sale of any species of minnow (the state lists specific native species as bait) or frog used as fish bait. Crayfish may only be sold *dead* in Wisconsin. The gear that can legally be used to collect bait by the license holder is specified by the state. For example seines to capture bait from public waters cannot exceed 35 ft except for smelt seines which may be 75 ft. The law governing bait harvest is found in Chapter 29 of the Wisconsin Statutes.

Wisconsin residents who hold a bait dealer's license can import *bait* into the state. All fish imported into the state require an importation permit from DATCP. If the imported species are exotic, DNR and DATCP will co-issue the import permit. Licensed bait dealers file annual reports and wardens may inspect their businesses at any reasonable hour to ensure compliance with the terms of the license.

Permits as a way to regulate pond management

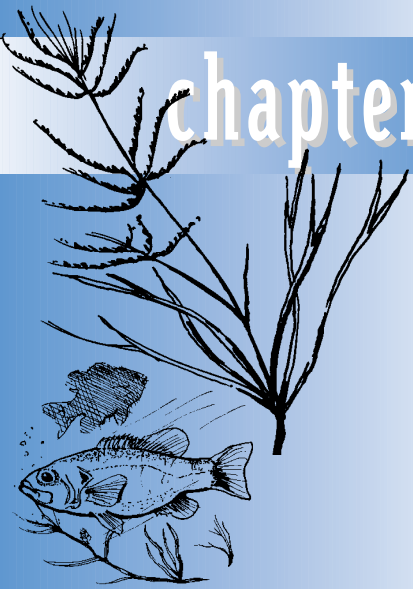
A permit process is used to regulate the importation of all plant and animal species for the purpose of introducing or stocking. The purpose of the regulations is to protect the native animal populations of the state from foreign species or disease organisms that might be carried by species coming into the state.

Under the new statutes, if a fish farm is self-contained, it does not need an aquatic pesticide permit to use toxicants. If the fish farm discharges to surface water, a permit is needed to use the chemicals unless the discharge of that chemical is allowed under a (WPDES) Wisconsin Pollution Discharge Elimination System permit.

Liability

Certain pond management operations may affect other people. If this effect is detrimental, the parties involved may bring legal action. In this respect it makes little difference if the pond is a registered private fish hatchery. Fish poisons or plant toxicants that damage public resources may result in legal action. Damage to another's property during construction or as a result of an uncontrolled discharge may initiate a lawsuit. Drowning of pets, livestock or people can occur and result in legal action. Always manage your pond with thorough consideration of its effects on the surrounding area.

chapter 16



References

Major sources of information

General

Wisconsin Department of Natural Resources

Aquaculture, fish health
608-266-7715, 608-266-2871

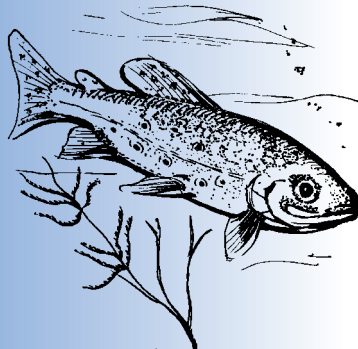
Regional offices

Contact the nearest Wisconsin Department of Natural Resources (DNR) regional office or your local DNR Service Center about permits for the following pond management activities: damming; pond digging or dredging within 500 ft of any navigable water; fish stocking; pond draining; use of algicides or weed-killing chemicals; use of fish toxicant chemicals; and aquatic weed cutting or harvest.

Northern Region
Box 309
Spooner, WI 54801
715-635-2101
or

Northern Region
Box 818
Rhineland, WI 54501
715-365-7616

North-Eastern Region
Box 10448
Green Bay, WI 54307
920-492-5800



West-Central Region
Box 4001
Eau Claire, WI 54701
715-839-3700

South-Central Region
3911 Fish Hatchery Road
Madison, WI 53711
608-275-3266

South-East Region
Box 12436
Milwaukee, WI 53212
414-263-8500

Wisconsin Cooperative Extension

Your Cooperative Extension county office is listed in the phone book under "county government." The county agent can put you in contact with state fishery, wildlife or plant specialists, local people who can assist in planning and managing your pond, or, if you are interested in commercial aquaculture, with one of the UWEX Small Business Development Centers.

Aquaculture Information Center, National Aquaculture Library, 10301 Baltimore Blvd, Room 111, Beltsville, MD 20705, 301-344-3704

The Internet

Many companies that produce aquaculture products advertise and conduct business on the Internet. All aspects of pond aquaculture are represented by various home pages and mail groups. Listservers and web pages can provide you with much valuable information.

Listservers are automated e-mail listings and can be very useful in getting answers to specific questions. When subscribers to the listserver group send a message, the message is distributed to all subscribers. PONDS-L is an example of a listserver that deals with pond aquaculture. To subscribe, send the e-mail message: "subscribe ponds-l" to listserv@execpc.com. Many listservers offer summaries of messages for you to review before you join.

The World Wide Web offers access to a whole universe of information in the form of web sites. One web site typically links to others with related information. You can select the various links to find information you want. You can get to a particular web site by knowing its address, or URL (uniform resource locator). Two examples of URLs for aquaculture sites are the AquaNIC homepage (<http://ag.ansc.purdue.edu/aquanic/>) and the The Aquaculture Health site (<http://geocities.com/capecanaverallab/74901>).

You can also find information on the Internet by conducting a search using key words like "aquaculture," "recreational pond," "fisheries," "bass," or other terms that might take a search engine to sites of interest. When you find a good web site, save it as a "bookmark" so you can return to it quickly.

Commercial aquaculture

AquaNic homepage

<http://ag.ansc.purdue.edu/aquanic/>

Provides access to information on commercial aquaculture.

Aquaculture Institute

Great Lakes Research Facility
600 E. Greenfield
Milwaukee, WI 53204
414-382-1700

A research center that focuses on aquaculture.

Aquaculture Magazine

P.O. Box 2329
Asheville, NC 28802
704-254-7334

A trade magazine with articles on all subjects of aquaculture; issued bi-monthly; \$19/year.

Aquaculture News

P.O. Box 416
Jonesville, AL 71343
318-339-4660

A monthly newspaper providing information on aquaculture, especially in the U.S.

Fish Farming News

P.O. Box 37
Stonington, ME 94681
207-367-2396

A bi-monthly newspaper that provides information on all aspects of aquaculture; \$10/year.

North Central Regional Aquaculture Center

Office of the Associate Director,
Department of Animal Ecology
124 Science II, Ames, Iowa, 50011
515-294-5280

More than 100 specialized publications and videotapes on most aspects of commercial aquaculture.

University of Wisconsin Aquaculture Program

123 Babcock Hall
1605 Linden Drive
University of Wisconsin–Madison
Madison, WI 53706
608-263-1242

A research center that can provide up-to-date information on pond aquaculture.

Wisconsin Aquaculture Association

Box 115
Lewis, WI 54851
715-653-2271
<http://www.wisconsinaquaculture.com/>

Meetings and the newsletter, *Creel*, provide key information on aquaculture in Wisconsin.

Wisconsin Department of Agriculture, Trade and Consumer Protection

2811 Agricultural Drive
Madison, WI 53704
608-267-9644
Information on planning, grants and loans.

Videos

The videos listed below provide either **general** or **detailed** information on pond culture. Most titles are available through the North Central Regional Aquaculture Center. For more titles, see the AquaNic web site.

Kulka, K. and E. Norland. 1993. *Weed Control in Ohio Ponds* **Contact:** Ohio State University Extension Piketon Research and Extension Center, 1864 Shyville Road Piketon, Ohio 45661 614-289-2071 **(Detailed.** 30 minutes, *Note: Fifteen titles covering a range of topics available).*

Swann, L. 1993. *Investing in Freshwater Aquaculture* North Central Region Aquaculture Center Video Series 103 **Contact:** Aquaculture Extension Office. Dept. of Animal Science Purdue University West Lafayette, IN 47909 317-494-6264 **(Detailed.** 95 minutes *Note: Other titles available).*

Swenson, W. A. 1999

Fish Farming: Some Industry Perspectives.

Contact: University of Wisconsin–Extension county Extension offices **or** Media Resources Center University of Wisconsin–Superior Superior, WI 54880 715-394-8340 **(General.** 22 minutes).

Swenson, W. A. 1990

Managing Ponds

Contact: University of Wisconsin–Extension county Extension offices **or** Media Resources Center University of Wisconsin–Superior Superior, WI 54880 715-394-8340 **(General.** 22 minutes).

Further Reading

Pond planning and construction

- Gibson, G. R., Jr. 1979. *A riparian's guide for self-help inland lake water quality management*. Extension bulletin E-1117 Michigan State University East Lansing, 67 pp.
- U.S.D.A. Soil Conservation Service (revised 1997). *Ponds—Planning, Design, Construction*. Agriculture Handbook No. 590. U.S. Dept. of Agriculture. Washington, D.C., 85 pp.

Pond fishery management

- Bennett, G.W. 1971. *Management of Lakes and Ponds*. Van Nostrand Reinhold New York, 375 pp.
- Eipper, A. W., & H. A. Regier. 1962. *Fish Management in New York Farm Ponds* Extension Bull. 1089. Cornell Univ., Ithaca.
- Lopinot, A. C. 1972. *Pond Fish and Fishing in Illinois*. Fishery Bull. No. 5, Illinois Dept. of Conservation, Division of Fisheries, Springfield, IL 62706, 72 pp.

- Marriage, L. D., A. E. Borell, & P.M. Schaefer. 1971. *Trout Ponds for Recreation*. *Farmer's Bulletin No. 2249*, U.S. Dept. of Agriculture Soil Conservation Service, Washington, D.C., 13 pp.
- Schrouder, J.D. et.al. 1994. *Managing Michigan Ponds for Sport Fishing* (E1554). Michigan State University, Lansing, 67 pp.

Prospects for commercial aquaculture

- Cain, K. and D. Garling. 1993. *Trout culture in the North Central Region*. North Central Regional Aquaculture Center. Fact Sheet Series # 108.
- Chopak, C.J. 1992. *Promoting fee fishing operations as tourist attractions*. Michigan State University Extension bulletin E-2409
- Chopak, C.J. 1992. *What consumers want: advice for food fish growers*. Michigan State University Extension Bulletin E-2410.
- Chopak, C.J. 1992. *What brokers, wholesalers, retailers and restaurants want: advice for food fish growers*. Michigan State University Extension Bulletin E-2411.
- Garling, D.L. 1992. *Making Plans for Commercial Aquaculture in the North Central States*. North Central Region Aquaculture Center, Fact Sheet Series #101.

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Fish health

- Richard Nelson, Director
U.S. Fish and Wildlife Service
LaCrosse Fish Health Center
555 Lester Ave.
Onalaska, WI 54650
608-783-8444

Further reading on fish parasites and diseases. Note that there are numerous free pamphlets available on this topic.

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