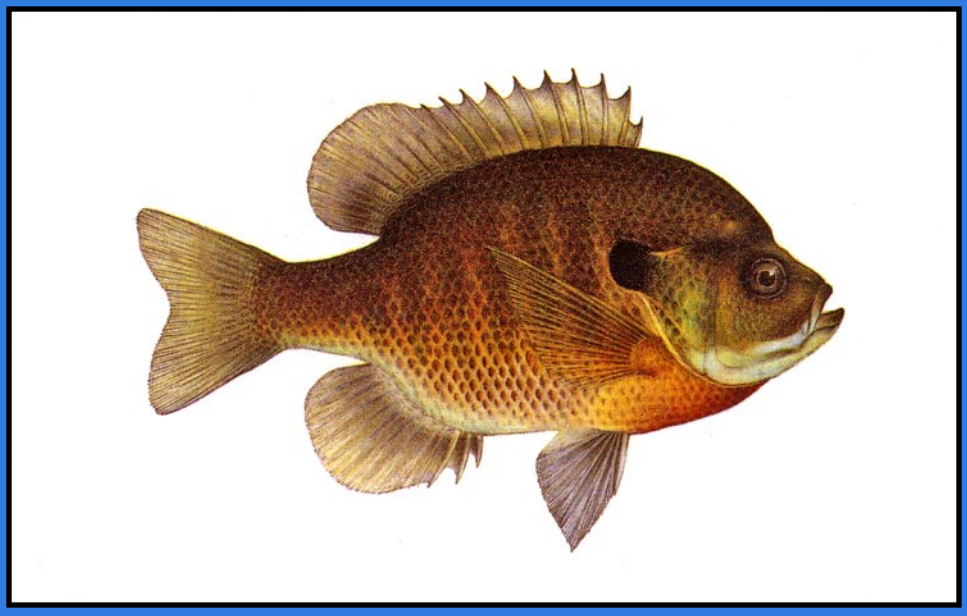
Managing South Dakota Ponds for FISH AND WILDLIFE



South Dakota
Department of Game, Fish and Parks

MANAGING SOUTH DAKOTA PONDS FOR FISH AND WILDLIFE

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FOREWORD

South Dakota pond owners have long sought a publication that would help them plan and manage their fish ponds. Recognizing that need, the South Dakota Department of Game, Fish and Parks and the Department of Wildlife and Fisheries Science at South Dakota State University have put together this booklet. It provides information for all aspects of pond management from construction to rehabilitation. Most of the research and experience were obtained in South Dakota and are applicable to the state's farm and ranch ponds.

Maintaining a good fishing pond is not easy. It requires sufficient attention from the manager to know how many and what sizes of the predatory fishes are being removed from the pond. That is the key to sustaining good fishing. The guidelines are simple and easy to follow. If ranchers, farmers and other landowners want to sustain good fishing in their ponds, strict rules must be established for themselves and their guest anglers. Enforcement of the rules is important because the bass population in small ponds can be harmed quickly by intense harvest.

Enjoyment no longer means keeping all you can catch. Take what bass you need, but put back the rest. Catch and release of bass is the by-word in pond fishing. The medium-sized predators are the mainstay of the population. In ponds where harvest rates are unknown, releasing the 1 1/2 to 3 pounder should be the rule. Taking the very large and the small normally will not harm the population structure in a pond with good reproduction.

We all enjoy the solitude of fishing a good pond back away from the busy highways. Summer mornings on a pond when the bass are knocking your spinner out of the water or when the half-pound bluegills will not let your child's bobber rest on the surface are the best days in one's outdoor life. With the individual principles and guidelines contained within this booklet, most ponds will produce and sustain good fishing for a long time.

Robert L. Hanten, Chief of Fisheries, Retired
South Dakota Department of Game, Fish and Parks

ACKNOWLEDGMENTS

We would like to gratefully acknowledge the assistance provided by Donald Gabelhouse, Jr. His pond booklet, *Producing Fish and Wildlife from Kansas Ponds* (reference on page 67), was used as a template for much of this booklet. In fact, much of the sections on "Pond Ecology," "Area Management," "Pond Problems" and parts of the "Fish Management" section were taken from that booklet, with his gracious permission. In addition, the concept of providing pond owners with management options was first espoused by Mr. Gabelhouse, and his ideas were set in a South Dakota context for this booklet.

We would like to thank a number of people who reviewed preliminary drafts of this booklet, including Bruce Coonrod, Christopher Guy, Stephen Flickinger, Allen Knapp, and Charles Scalet. Charles Scalet also provided much of the incentive to develop such a booklet. Connie Vicuna reviewed the booklet for the U.S. Soil Conservation Service, and her efforts are gratefully acknowledged. Richard Ford assisted with the section on "Trout Pond Management," and his efforts are appreciated. Bobbi Gaukel provided the artwork for the figures.

We would also like to acknowledge the pond research undertaken by Timothy Modde and Charles Scalet at South Dakota State University. Funding for many of those projects was provided by the South Dakota Agricultural Experiment Station and the South Dakota Department of Game, Fish and Parks.

Finally, we would like to recognize the efforts of the graduate students who undertook much of the pond research and the landowners who allowed access to their ponds over the years.

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INTRODUCTION

Ponds and pond fisheries are an important recreational resource across the United States. In a 1980 national survey of fishing, hunting, and wildlife-associated recreation, the U.S. Fish and Wildlife Service found that 36.4 million people fished in fresh water. Of this number, 23% (that's 8.4 million!) fished in man-made lakes and ponds less than 10 acres in surface area. South Dakota enjoys an extensive pond fisheries resource—of the 100,000 ponds in the state, 43,000 contain fish populations.

The purpose of this booklet is to provide South Dakota pond owners with the information necessary to properly manage their ponds. Pond management requires a knowledge of diverse topics, and we urge interested pond owners to read the entire booklet. For those without as much time or interest, we have provided a special "key" on pages 29-30. This key can be used to identify the desires of the pond owner, and indicates specific sections of the booklet that will discuss those desires.

At times, we have had to use technical terms. We have attempted to define those terms when used and have also provided a glossary on page 69.

Under good conditions, ponds can provide high-quality fishing. However, poor fishing often occurs because (1) ponds were not built for fishing, or (2) pond owners and anglers don't understand the appropriate fish management techniques. One of three problems typifies poor pond fishing: (1) no fish are present, (2) fish are present, but are of the wrong species, or (3) fish of the right species are present, but are of the wrong size. We will address these problems throughout this booklet.

POND PERMIT REQUIREMENTS

When building a pond, a landowner should file a "Location Notice for Dam/Dugout" with the Water Management Board of the State of South Dakota. Copies of this form are available from:

Water Rights Division
Department of Water and Natural Resources
Foss Building
Pierre, SD 57501 *Phone: (605) 773-3352.*

If the storage of the proposed structure at the spillway crest or overflow exceeds 25 acre-feet, a water permit from the Water Management Board is required. One acre-foot of water covers one acre to a depth of one foot. Thus, a 3-acre pond with an average depth of 8 feet would store approximately 24 acre-feet of water. In most ponds, the average depth is approximately one-half of maximum depth.

Landowners also need to consider threatened and endangered species before constructing a pond. In most cases, this will not be a problem for ponds constructed on uplands with a watershed drainage. However, we recommend that the area Conservation Officer be contacted before construction of a dam on any type of flowing water.

In addition review the current list of threatened, endangered or candidate species in South Dakota by going to the following website: www.state.sd.us/gfp/Diversity/TES.htm

A cost-sharing program for pond construction is administered by the U. S. Department of Agriculture's Agricultural Stabilization and Conservation Service (ASCS). Application forms can be obtained at an ASCS office. The amount of assistance is determined after an eligibility review by the U. S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

Pond construction costs may also be shared by the South Dakota Department of Game, Fish and Parks through the Conservation Partners program, if public access to the pond is guaranteed. The amount of assistance is determined after consultation and review by the area Conservation Officer.

POND ECOLOGY

A basic understanding of the biology of fishes and their interactions with their environment is helpful in understanding how to manage fish. Knowledge is useful in all aspects of pond management from initial pond construction to salvaging a problem pond.

The basic needs of fishes are (1) food, (2) good-quality water, (3) shelter, and (4) a spawning area. The first two items are generally the most critical, but all are important to varying degrees. Each of these items will be briefly discussed to give the reader a basic understanding of the reasons for management recommendations contained in this booklet.

FISH FOOD

The natural foods of fishes are either produced in the pond or are washed or fall into it from the surrounding area. Food produced in the pond has its origin in the nutrients that are dissolved in the water and in the pond bottom. A variety of plants use these nutrients to grow. These plants may be microscopic algae that give a green color to the water, or they may be rooted plants that grow in shallow water. Plant material, in turn, is food for a variety of small animals such as insects and microscopic zooplankton. These small animals are eaten by fish such as bluegills and young bass. Large bass will feed mainly on small fish, crayfish, and tadpoles. The chain of events leading to the production of large fish can follow different routes. It can follow a "food chain" from nutrients, to algae, to zooplankton, to small fish, to large fish. In reality, food chains have more links or steps than mentioned here, and there is considerable crossing over between the various chains. Thus, what really exists is a "food web."

All ponds contain nutrients that ultimately produce food for fish. The amount of nutrients present depends upon the productivity of the watershed. The amount (pounds) of fish that the pond can support is called the "carrying capacity." This is comparable to the capacity of a pasture to support only a certain amount of cattle or a garden's ability to produce only a certain amount of vegetables. In South Dakota, mixed-species ponds may support 100-400 pounds of fish per surface acre if supplemental feeding is not provided. The average pond probably supports 200-300 pounds of fish

per acre. Populations can comprise many small individuals or fewer large individuals, but the total poundage of fish depends upon what the pond can support. The amount of fish food a pond will produce is limited by the amount of nutrients available. All food will be shared by the entire fish community. By managing for fewer fish, larger fish can be produced.

WATER QUALITY

Fish require good-quality water to survive, grow, and reproduce. Good-quality water is free of pollutants such as toxic materials, excessive organic matter, and silt. Water should also have a high oxygen content. Oxygen enters the water from the atmosphere and is also produced by plants (including algae) during daylight through the process of photosynthesis. Oxygen deficiency is a common water-quality problem encountered in ponds. Most fish species require at least 5 parts per million (ppm) of dissolved oxygen for good health and vigorous growth. They can tolerate 1 or 2 ppm for short periods, but they become stressed, cease feeding, and become more susceptible to diseases.

The amount of oxygen contained in the pond depends upon water temperature and depth. During late winter and early spring, the water in a pond will have the same temperature from top to bottom. In late spring, increased air temperatures begin warming the pond from the surface down. Water in shallow ponds and ponds in open areas exposed to much wind may continue to mix throughout ice-free periods. However, by summer, the surface water in deeper, less wind-swept ponds is considerably warmer (and much lighter) than the bottom water, so thermal stratification occurs. This is a fairly stable condition with the warm upper layer (epilimnion) floating on the cool bottom layer (hypolimnion) separated by the transition zone (thermocline). As the wind blows, only the upper layer is mixed and oxygenated. The lower layer does not receive additional oxygen and slowly loses its oxygen due to the decay of organic matter on the bottom. By midsummer, oxygen is consumed in the lower layer so fish are confined to the upper layer and thermocline.

In late summer and fall, the surface water cools until its density is similar to the bottom water. Strong winds are then able to mix the water from top to bottom. This carries oxygenated water to the bottom, and fish are again able to inhabit the entire pond.

After ice forms in the winter, water on the bottom of the pond is slightly warmer than water just under the ice. Fish prefer to locate near the bottom for this reason. Because the ice prevents a mixing action, organic wastes settle to the bottom, much like in the summer when a pond stratifies. Decomposition of organic wastes uses oxygen, and excessive decomposition can drive fish off the bottom, up the water column, in search of oxygen. Severe cases of decomposition, in combination with lack of oxygen production by plants because of snow cover, result in an oxygen deficiency throughout the pond and eventually winterkill. This subject is discussed in more detail in the "Winterkill and Summerkill" section.

SHELTER

Fishes are eaten by a variety of mammals, birds, reptiles, amphibians, other fishes, and even invertebrates (some insects eat small fish). To survive, fishes have evolved various behavior patterns. Pond fishes always try to hide when danger threatens. They can hide by swimming to deeper water or by moving behind a rock, stump, brush, or plant. In a pond, fish communities will exist without physical structure, but fish are sure to concentrate near a structure if it is present. In fishing ponds, structures benefit fishermen more than the fish because anglers know the most productive areas for angling are near areas with habitat structure. This is why fish attractors are recommended for ponds containing largemouth bass and panfish. Attractors are also useful in trout ponds, because the cover helps decrease predation by birds such as herons, pelicans, and cormorants.

SPAWNING

Some species of fishes require specific bottom material to reproduce. Largemouth bass and bluegills are generalists and will spawn on about any type of bottom material, but the channel catfish is more particular. It requires some type of cavity such as a hole in the bank or solid structure in the form of a stump or rock for nests. In most cases, catfish reproduction is not desired in catfish-only ponds because the catfish tend to overpopulate and stunt when no predators are present, so nesting structures should not be provided.

Trout do not reproduce successfully in ponds. Reproduction is most likely in streams where running water provides oxygen to eggs buried in the gravel. The only time reproduction might occur in a pond is when a continually flowing spring provides an area of clean gravel with sufficient oxygen.

When other species are desired in a pond, it is necessary to know their reproductive requirements to determine whether they will be able to maintain a population.

WINTERKILL AND SUMMERKILL

Fish kills are common during the winter in South Dakota. Mass mortalities are noticed in late winter when ice cover disappears. However, if the winterkill was early, it may not be noticed by pond owners. Winterkills are caused by oxygen depletion under the ice and the accumulation of toxic gases like ammonia and hydrogen sulfide (rotten egg odor). A long period of snow cover on the ice increases the risk of winterkill. Ice is usually clear enough to allow sufficient sunlight penetration so that algae and other plants can produce some oxygen, but snow cover greatly reduces the amount of light penetration so plants are unable to produce oxygen. Instead, there is a steady decline in oxygen due to the decay of organic matter and respiration by bacteria and other organisms (both animals and plants use oxygen

during respiration). If ice and snow persist long enough, severe oxygen depletion will occur. Winterkill ponds are typically shallow and have a high organic matter content, commonly in the form of decaying vegetation or livestock wastes.

The likelihood of winterkill can be reduced by controlling aquatic vegetation and reducing the amount of livestock or other wastes that get into the pond. Water depth in South Dakota ponds should be at least 15 feet in the southern part of the state and 20 feet in the northern part of the state. These water depths going into winter should hold enough oxygen to carry fish through a normal period of ice cover. Because South Dakota is affected by periodic drought, quality fish ponds should be built with an additional 5 feet of depth to provide extra capacity for drier times. Removal of even a strip of snow from ice in a northwest-southeast direction may also help to prevent winterkill. Another effective way to prevent such kills is to place an aeration device in the pond or to install a water circulator to keep an area free of ice. Water is then exposed to the air for oxygen absorption. Just cutting a hole in the ice is not effective because too little water gets exposed to the air. For a further discussion of circulation methods, see the "Aeration Systems" section on page 21.

Summerkills are fish mortalities that occur during the summer, and are also due to oxygen depletion. They occur most often after periodic die-offs of dense algae or aquatic vegetation, which usually occur after periods of calm, cloudy weather, when the water is muddy after a rain, or at the end of the plant growing season. Oxygen is consumed by bacteria that decompose these dead plants. Low oxygen levels cause stress in fish so they do not feed and grow, become susceptible to disease, and often die. Fish mortality due to summerkill usually occurs early in the morning when the dissolved oxygen in the pond is at its lowest level.

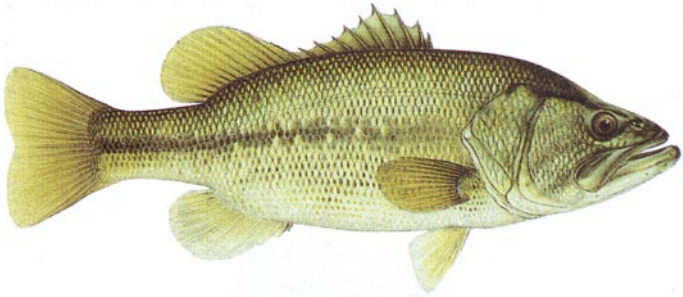
Summerkills can be prevented by keeping aquatic vegetation from becoming too abundant. Excessive nutrients should also be prevented from entering the pond. Proper pond construction with few shallow areas will also help minimize aquatic plant growth. If a fish kill is occuring or about to begin (fish are gulping for air at the surface), heavy mortality can often be prevented by pumping fresh aerated water into the pond, spraying water onto the pond, or by installing an aeration device.

Summerkills are more common in ponds with supplemental fish feeding programs. The addition of the organic matter in the form of feed can deplete the oxygen content in the pond, depending on the number of fish fed and the amount of food used.

COMMON SOUTH DAKOTA POND FISHES

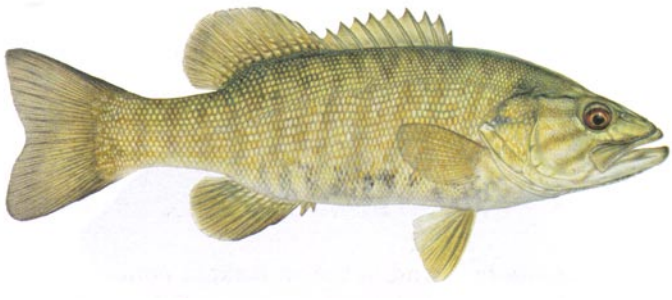
Many fish species can be found in South Dakota ponds, but only a few lend themselves to effective management for sport fishing. The most common species stocked in ponds are largemouth bass, bluegill, and rainbow trout. Other species can be used for specific management objectives. A brief description of life histories for useful species follows.

Largemouth Bass



The largemouth bass is a large predatory fish that belongs to the sunfish family. It is greenish on the back, with a white belly and a dark horizontal band along its side. Its mouth is large, with the upper jaw extending beyond the eye when the mouth is closed. Common food items include insects, crayfish, frogs, and fish. In the southern United States, largemouth bass commonly attain weights over 10 pounds, but anything over 5 pounds is considered a trophy in South Dakota. Previous pond research in South Dakota indicated that largemouth bass will spawn after reaching a length of about 10 inches. This usually corresponds to an age of at least two years. Spawning occurs during spring when water temperatures reach 60-70^{o} F. The male makes a large saucer-shaped nest on the bottom in shallow water by fanning an area free of debris with his tail. The female deposits eggs in the nest, and the male fertilizes them. The male protects the eggs from predation and maintains good water quality by fanning with his tail. If the male bass is removed, the eggs will die. If the male fish is caught and released, he generally will return to the nest. The male guards the eggs until they hatch and the young until they are large enough to swim and find food. This takes about 1-2 weeks.

Smallmouth Bass



The smallmouth bass is another large predator that belongs to the sunfish family. The mouth of the smallmouth bass does not extend beyond the back of the eye, differentiating it from the largemouth bass. Its coloration is also somewhat different, with sides and back a rather uniform greenish brown

with faint dark mottlings. If stripes are present, they will be vertical rather than horizontal. Common food items include insects, crayfish, and fish. Smallmouth bass can surpass 7 pounds, but anything reaching 3 pounds is a trophy in South Dakota. Spawning habits are similar to largemouth bass, although smallmouths tend to spawn earlier. Most nesting activity occurs after water temperatures have reached 60° F.

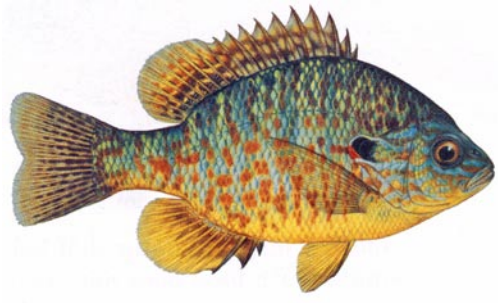
Bluegill

Breeding male

The bluegill is a saucer-shaped sunfish with a small mouth. With an increase in size, the fish changes from a silver lavender color to greenish brown, with an orange or yellow breast. All sizes of bluegills possess a blue-black gill cover flap. Bluegills feed primarily on insects, both aquatic and terrestrial. Pond research in South Dakota has shown that bluegills typically mature at a length of 3-5 inches. They normally reach a length of 6-8 inches, but larger fish can be produced if properly managed. Large fingerling bluegills stocked in the fall will spawn the next summer. Bluegills spawn from May to August when water temperature reaches 70° F, with a peak in June. The male makes a saucer-shaped nest on the bottom in shallow water like the bass and guards the eggs and young. The prolific spawning of the bluegill makes it a good food fish for largemouth bass, but also allows it to overpopulate if sufficient predatory fish (such as the bass) are not present to control bluegill numbers.

Pumpkinseed

Breeding male



The pumpkinseed is a sunfish native to the northeastern United States

and southeastern Canada. Pumpkinseeds complete spawning activities by June, otherwise their reproduction is similar to the bluegill. Pumpkinseeds primarily feed on invertebrates, particularly snails. They can be distinguished from the bluegill most easily by the reddish orange spot on the rear of their gill covers.

Green Sunfish
Breeding male

The green sunfish is also a member of the sunfish family, along with the largemouth and smallmouth bass, bluegill, pumpkinseed, and crappies. It is greenish in color and has a medium-sized mouth (larger than the bluegill but smaller than the basses). It feeds on a variety of small animals and seldom grows over 6-7 inches in length. Green sunfish are common in small streams, and often get into ponds by swimming over spillways. They can be a nuisance in a pond if bass are not abundant. Green sunfish reproductive behavior is similar to that of bass and bluegill. This fish is not normally part of a pond management program, nor is it purposefully stocked.

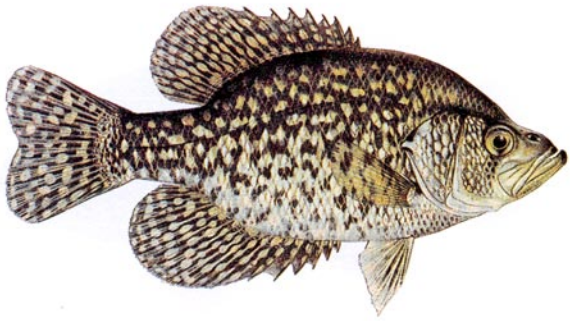
Hybrid Sunfish
Bluegill male-Green Sunfish female hybrid

The three sunfishes previously described, along with some others, have all been hybridized with one another in an effort to produce offspring that do not overpopulate, grow larger than either parental species, and are easier to catch. These crosses between sunfish species generally result in offspring that are predominantly male. Stocking hybrid sunfish in a pond will result

in little or no reproduction, and thus no overpopulation problems. However, hybrid sunfish need to be restocked to maintain the population. Hybrid sunfish also provide little prey to help support largemouth bass populations.

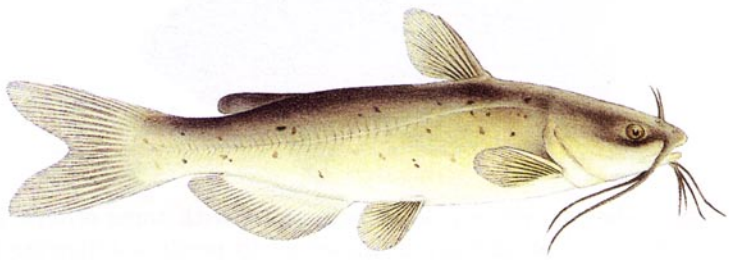
Crappies

Black Crappie



There are two kinds of crappies, the black and the white. The black crappie generally performs better in clear water. It has 7 or 8 dorsal (back) spines, and black spots scattered randomly over its body. The white crappie is slimmer than the black, has 5 or 6 dorsal spines, and its spots tend to form vertical bars on its sides. In muddy water, the white crappie usually predominates. Both kinds of crappies feed on invertebrates and small fish. Their reproductive behavior is similar to that of the bass, although they generally spawn just before the bass. The minimum length at maturity is 6-7 inches. Crappies will overpopulate if there is not enough predation on the young. In combination with a high density of largemouth bass, they grow rapidly and often reach lengths of 10-12 inches. The black crappie is the superior pond fish, and should be used for pond stocking. Black crappies are not dependent on small fish as prey for them to reach larger sizes, while white crappies are.

Channel Catfish



The channel catfish is a native stream fish with a forked tail, gray back,

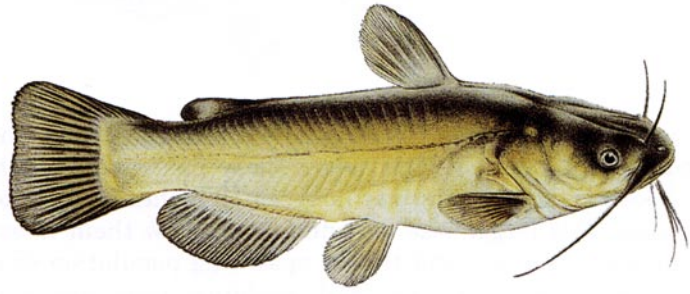
white belly, and 8 barbels around the mouth. It has serrated spines in three of its fins. Young fish have some black spots, but these are lost with maturity. The diet of the channel catfish consists mainly of invertebrates and small fish. Channel catfish grow rapidly if enough food is available and often exceed 5 pounds. They spawn in the summer when the water temperature reaches 75-80^{o} F. The male makes a nest in a hole in the bank, under a log, or next to any material that will provide protection for the young. The male also guards the eggs and young fish. Male channel catfish develop a bluish color that often causes them to be misidentified as blue catfish. The anal fin of blue catfish has 30 or more rays, and channel catfish have 24-29 rays.

Flathead Catfish

The flathead catfish is a common fish in the south-central United States, but is not as common in South Dakota. It is slender with a broadly flattened head and a projecting lower jaw. Its tail is slightly notched, but not forked as is the tail of the channel catfish. Flatheads commonly exceed 40-50 pounds in more southerly states, but would rarely reach that weight in a South Dakota pond.

The flathead is a large predatory catfish. While the flathead eats primarily fish, it cannot control bluegill populations. However, the flathead has been shown to effectively prey on bullheads, and may have potential for increasing the quality of bullhead populations in muddy water where largemouth bass densities are low.

Black Bullhead



This bullhead is a common catfish in South Dakota lakes and streams. Its

back is gray or black, and its belly is yellow or white. The tail is not forked but slightly indented, and the chin barbels are dark. The bullhead also has spines in three of its fins. It feeds on a variety of small animals and seldom gets over 15 inches long. Bullheads often gain access to a pond by swimming over the spillway. This species quickly becomes overpopulated if a pond is muddy or contains few bass. Reproduction takes place in the summer, with the male building and guarding a nest much like the bass and bluegills. After hatching, young bullheads will travel in a compact school accompanied by one or more adults.

Fathead Minnow

Female *Breeding male*

The fathead minnow is a common baitfish in South Dakota, and can be stocked in ponds to accelerate initial bass growth rates. It is a dull silvery color and reaches a length of 2-3 inches. Fatheads feed on small invertebrates and plant material and are hardy and prolific spawners. Spawning occurs all summer, with eggs deposited on rocks or other objects.

Golden Shiner

The golden shiner is a deep-bodied minnow, and all but the smallest specimens tend to be a bright golden color. These fish reach lengths of over 8 inches in South Dakota, but get as large as 12 inches in some of the southeastern states. This larger size for adults can allow them to escape predation by smaller predators, and thus a spawning population can sometimes be maintained to provide prey for small predators. Generally, golden shiners are most likely to maintain a population in ponds with substantial amounts

of submerged aquatic plants. In ponds without plants, it is very vulnerable to largemouth bass predation, and its population is usually eliminated.

Common Carp

The common carp is the largest member of the minnow family. It has a relatively deep body, a brown or bronze color, relatively large scales, a subterminal (sucking) mouth, and serrated spines in its dorsal (back) and anal (ventral) fins. It feeds on bottom organisms and tends to stir up the mud. Thus, it is undesirable in ponds if sight-feeding fish such as the largemouth bass are desired. Carp usually get into ponds when they are seined from creeks for bait and released or lost in the pond. All efforts should be made to ensure that this fish does not gain access to a pond.

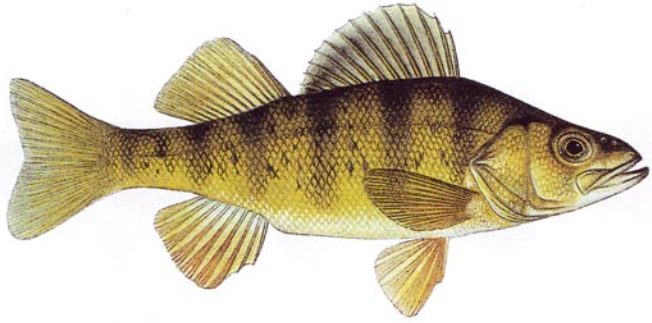
Northern Pike

The northern pike is a large predator not easily confused with any other fish common in South Dakota. The closest relative in the state is the muskellunge. Northern pike are elongated, with duckbill-like jaws having numerous canine teeth. The sides and back are greenish, and the belly is white or cream. The sides are covered with round or elongated light spots. Northern pike spawn soon after ice-out, and are most successful when they can spawn on flooded terrestrial vegetation. They feed primarily on fish. Although they reach sizes of 30 or more pounds, 5-pound fish would be considered large in a pond. Northern pike are not normally used in pond management programs.

Walleye

The walleye is a predatory fish belonging to the perch family. It has two distinct dorsal (back) fins, one with a series of spines and the other with soft rays. Large canine teeth are present, and the eye has an opaque appearance that is responsible for its name. The walleye tends to be brown or greenish on its sides and back, with white on the belly. Walleyes spawn after ice-out. In standing water, they spawn most successfully when gravel shoals are available. Smaller walleyes feed on insects, with fish becoming more important in the diet as they grow. They can surpass 15 pounds, but a 3-pound fish would be a large pond specimen. Walleyes are not normally used in pond management programs.

Yellow Perch



The yellow perch is the "panfish" of the perch family. They have two distinct dorsal (back) fins, as do walleyes. Yellow perch generally have golden-yellow sides with dark vertical crossbars. Spawning activity begins when water temperatures reach 45-50° F. Eggs are deposited in a gelatinous, ribbonlike band that is several inches wide and folded or pleated. These egg masses may be several feet in length. Perch are predacious, and feed on insects, snails, crayfish, and small fish. Yellow perch that surpass 1 pound would be considered large.

Yellow perch are quite prolific, and have a tendency to overpopulate and stunt. However, a high density of largemouth bass can control yellow perch populations so that perch will reach harvestable size. Yellow perch can be a good pond fish, but pond owners should consult their area Conservation Of-

ficer to determine if such stockings have proven successful in that area.

Rainbow Trout

The rainbow trout is bluish or olive green above and silvery on the sides, with a broad pink lateral stripe. The back, the sides, and the dorsal (back) and caudal (tail) fins are dotted with small dark spots. Rainbow trout feed primarily on insects. It does not require a source of fish, such as minnows, as prey, although large rainbows will eat fish. Some varieties of rainbow trout reach 50 pounds, but 2- to 3-pound rainbows would be large in a pond.

Rainbow trout require water with temperatures below 70° F and with a high oxygen content. Thus, they are not suited to many waters in South Dakota.

Brown Trout

The brown trout is olive brown or greenish, shading to a yellowish white on the belly. The sides are covered with rather large dark spots, often interspersed with red or orange spots. The caudal (tail) fin has spots only on the upper portion. Brown trout can survive in water temperatures reaching 70° F, or perhaps slightly higher for short time periods. Large individuals tend to eat fish, and minnows might be desirable in a pond containing brown trout. Brown trout are not usually included as part of trout pond management programs in South Dakota.

Brook Trout

The brook trout has a dark olive back with light marbled streaks. The sides are also dark green, sprinkled with light spots and numerous red spots. Brook trout require colder water than do rainbow or brown trout. It does best in waters that do not warm beyond 60-65^{o} F. This fish is not normally included in pond stockings made by the South Dakota Department of Game, Fish and Parks.

POND CONSTRUCTION

Many factors play a role in determining the suitability of a pond for recreational fishing. This section will take the approach of someone planning to build a new pond, but many of the points covered can also be applied to the evaluation of existing ponds. For detailed advice about the design and construction of ponds under local conditions, the reader is advised to contact a local Soil Conservation Service office. An excellent source of information on pond construction is the SCS booklet, *Ponds—Planning, Design, Construction*, listed in the "Reference Materials" section on page 67.

Two major types of farm and ranch ponds can be found in South Dakota. "Hill ponds" (hereafter referred to as ponds) are those formed by building a dam across a ravine or draw. These are often called "stock dams," and are usually filled by surface runoff, springs, or a combination of the two. In general, this is the least expensive type of pond to build because it requires the least earth moving. "Excavated ponds" (hereafter referred to as dugouts) are found in flatter regions of the state where they are most often used for watering livestock. Because dugouts are more expensive to construct and usually cannot be drained, they are less desirable than ponds but may be the only choice available. In addition, dugouts tend to be too shallow and too small to provide recreational fisheries. This discussion of construction will focus on ponds, but will also be useful to those managing a dugout for recreational fishing.

THE WATERSHED

An obvious but often overlooked fact in selecting a site for a pond is that everything above the pond has a tendency to end up in the pond. Most land in South Dakota is used for farming or ranching, so agricultural practices in the watershed should usually be considered when evaluating a site. Land under heavy tillage is more likely to erode and add silt to a pond. The added turbidity (muddiness) will decrease the food available to fish by shading the plant life on which the food chain is based. In severe cases, ponds built in erodible watersheds will fill with silt within a few years. If the only site available is in an eroding watershed, you may wish to consider constructing

check dams (small dams above the main dam) to allow suspended sediments to settle before entering the pond. This will prolong the life of a pond. A vegetated area above the pond will also filter water before it enters the pond.

Pesticide use in the watershed should also be a matter of concern to the pond owner. Fish from ponds subject to heavy runoff from recently treated fields should not be eaten unless you know that the pesticides used are specifically approved for food fish. A list of chemicals approved for fish is given in the booklet, *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management*, listed in the reference section.

Sites receiving runoff from feedlots, pastures with large numbers of livestock, or heavily fertilized fields should be avoided. Nutrient-rich runoff into a pond will lead to oxygen depletion and fish kills.

Wild fish in ponds higher in the watershed are apt to move into your pond during heavy rains. It is a good idea to eliminate wild fish from all higher ponds, if feasible. If not, problem species may make effective management difficult or impossible.

SOILS

The water-holding capacity of the soil should be determined before the decision is made to begin pond construction. Generally, a soil needs 20% or more clay to be suitable for pond construction. Soils can vary within the proposed pond site itself, so it is important to have a number of samples tested. Soils also vary with depth, so samples should be taken from depths lower than the expected excavation depth. The Soil Conservation Service can suggest how best to go about sampling soil and where to have samples tested. You may be tempted to skip soil testing, but remember it is the best insurance against building a pond that will not hold water.

PEOPLE FACTORS

A fishing pond should be designed to maximize recreational pleasure. Keep landscaping in mind when planning the earth moving so that pleasing features such as trees or hillocks are preserved or created. Picnic or other special sites can be created near the pond. Usually the pond should be within walking distance of a road to ensure easy access.

Ponds have an unfortunate tendency to attract uninvited guests who help themselves to fish without so much as a thank-you. Having the pond within view of a dwelling helps to discourage such visitors, although this is not always feasible.

POND SIZE

If your goal is to construct a quality warmwater fishing pond, build one that is at least 2 surface acres in size. Smaller ponds are usually too shallow

to avoid winterkill, prone to excessive plant growth, and more likely to have fish overharvest. Coldwater trout ponds with constantly flowing springs can be much smaller because they are less prone to winterkill or vegetation problems.

The actual size and design of a pond will depend upon several factors that are best considered in consultation with someone experienced in pond construction, such as the local Soil Conservation Service engineer. The watershed must be evaluated to determine runoff characteristics so that the water supply is adequate to replenish losses due to evaporation and seepage without being so great that flooding and dam failure are likely. As a general rule, 10-20 acres of watershed are recommended for each acre of pond surface, but this varies with expected rainfall, watershed slope, and type of vegetative cover. Well-vegetated watersheds with a gentle to moderate slope are superior because they act like a sponge to soak up rainfall and release it gradually. The problem of having too large a watershed can sometimes be overcome by building a diversion ditch to channel excess runoff waters around the pond.

Local topography is an important consideration in minimizing construction costs. It is most economical to choose a site where the lay of the land is such that a fairly short dam will impound a large amount of water. Sites that require movement of more than 1600 cubic yards of earth per surface acre of water are not recommended.

If a spring is present, another set of factors must be considered to determine the best pond size. In this case, the first step is to measure the flow volume, preferably at different times of the year. If the measurements are taken during a period when rainfall has been above average for several years, be aware that the flow may be overestimated. A conservative estimate of spring flow, together with estimated evaporation and seepage rates for the site, will allow the Soil Conservation Service engineer to arrive at a pond size that meets your needs. For warmwater fish ponds, the objective will probably be to build the largest pond that will stay adequately filled. For trout ponds, the objective will be to maintain water temperatures below 65-70^{0} F during the summer. One hundred gallons per minute of spring flow is usually sufficient to maintain cold water conditions for a half-acre pond.

SITE PREPARATION

Once the site has been selected and a plan of construction made, the first step in building a pond is to remove all trees and other plants from the area to be excavated. Trees in unexcavated areas should be retained as important fish habitat. Next, remove all topsoil and stockpile it in a location where it can easily be spread over the pond bottom after all other construction is completed. Topsoil is usually unsuitable for dam construction but will be spread on the new pond bottom later to promote fertility and reduce seepage.

POND DEPTH

To be confident that winterkill will not be a problem, a pond should be at least 15 feet deep over one quarter of its surface area. An additional 5 feet should be included as a safety factor for drought years so that there will always be 15 feet or more of water before the pond freezes. On most sites it will be necessary to deepen the pond area, resulting in fill dirt that can be used for dam construction or other purposes.

BUILDING IMPROVED FISH HABITATS

From a fisheries standpoint, the least desirable type of pond is one in which the bottom is bowl-shaped with no irregular features. Pond deepening offers a good excuse for considering the construction of special features that will enhance the fishability of the pond. Excess fill dirt can be bulldozed into fingers of land that jut into the pond or to build a small island. This not only will allow shore fishermen access to more of the lake but may benefit fish populations by providing more habitat. Deep pools close to shore are another desirable feature that a pond owner may add to make shore fishing more productive. Fish tend to congregate in such pools, especially when water temperature is high. Pond owners should consider safety when constructing deep areas near shore. Such areas can be dangerous for children. Finally, ponds should be built considering the direction of prevailing winds. Try to have the long axis of the pond oriented at a right angle to the winds to decrease the impacts of waves. In South Dakota, we suggest that ponds be constructed in an east-west orientation, when possible.

BLOCKING POTENTIAL SEEPAGE ROUTES

As earth moving proceeds, pond owners should watch for potential seepage points on the pond bottom. Veins of sandy soil will lower water levels unless they are completely excavated to a depth of several feet and replaced with clay soil. Large trees may have been removed from the site but their roots may still remain, providing another seepage route. Heavy chisel plowing is recommended to break tree roots. Rock outcroppings should be covered with a foot or more of clay soil.

DAM CONSTRUCTION

To overcome the tendency for water to seep under or through the dam, a core trench is required. After the dam site is staked out, a trench 6 or more feet wide and several feet deep is dug along the midline of the dam. It is then successively filled with soil layers of the highest clay content available and compacted in the manner discussed below. This core is often extended upward into the dam when there is concern about the possibility of seepage

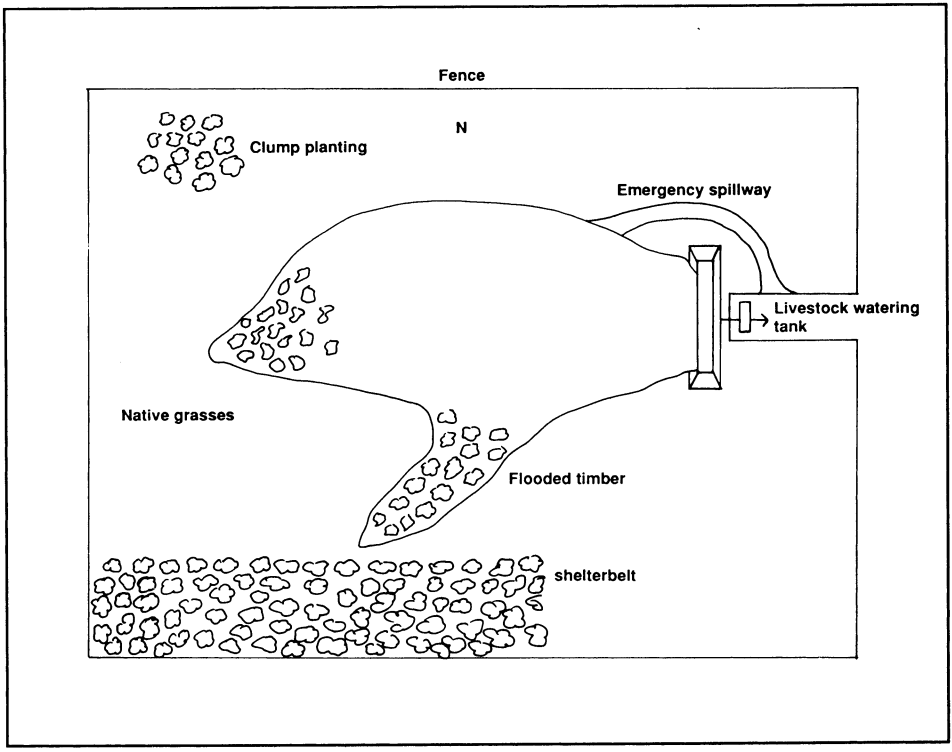


Figure 1. A well-designed fishing pond also includes the surrounding land, which should be fenced to keep livestock out.

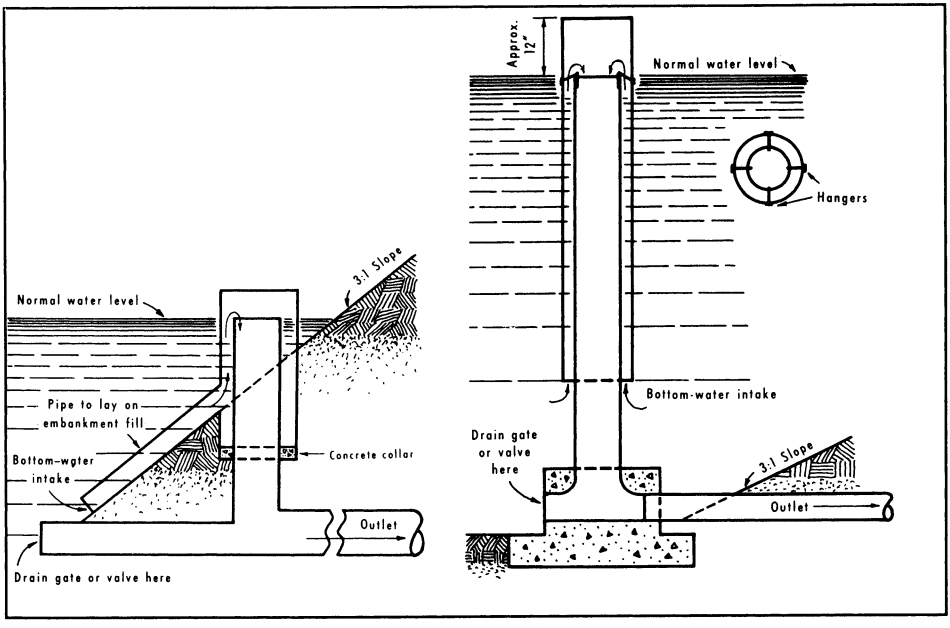


Figure 2. Examples of trickle tubes that allow the automatic removal of poor-quality bottom water during the summer.

through it.

The best method of dam construction is to lay down layers of soil about 6 inches deep, compacting them with a sheepsfoot roller until the feet of the roller no longer sink into the soil. This construction method may require the use of an earth mover in addition to a bulldozer. For adequate compaction, the soil must have the proper moisture content. This can be determined by rolling a small amount in your hand. If it crumbles, it is too dry. If you can roll it down to the diameter of a pencil, it is too wet. Soils must have at least 5% clay content to be tested. Dams compacted as described have a much longer useful life than those built cheaply by pushing up a large pile of soil and running the bulldozer over it.

Fishing ponds should have drains installed for two major reasons. First, they make eliminating undesirable fish easy, if they become established in the pond. Second, a drain with a trickle tube will automatically keep water levels a little lower than the spillway elevation, thereby allowing a wide (safe) and inexpensive earth spillway with a grass cover to be used instead of a narrow (unsafe) and expensive concrete one. Trickle tubes can also be modified to release poor-quality bottom water from the pond as fresh runoff enters. See Figure 2. Siphon drains can also be used to make an existing pond more manageable, but are not recommended when a new pond is built.

If there is only one time in the pond construction process when the owner can be present, it should be during the installation of the drain. The pipe must be properly sloped, fitted with anti-seepage collars, and surrounded by well-compacted soil. Shortcuts at this stage will result in serious problems later.

POND EDGES

The practice of grading pond edges to a gentle slope, "feathering," should be avoided as rooted plants thrive in shallow water where light can penetrate to the bottom. Pond edges should be excavated to a depth of 3 or 4 feet and graded to a slope of 3:1 (30 degrees). This will discourage the growth of rooted plants that would otherwise make fishing from shore difficult and perhaps lead to oxygen problems. If the decision is made to fill some areas instead of deepening them, be sure that a proper slope is achieved to allow complete drainage. Steep bank dropoffs are a drowning hazard and should be avoided whenever possible.

SPILLWAYS

A wide emergency spillway is good insurance against flood damage. In addition, the wider the spillway, the less likely fish are to escape during overflows. By installing a trickle tube, wide spillways can be inexpensively protected against erosion by planting grass. If a trickle tube is not used, the water level will be at the spillway elevation, and may require the use of expensive concrete surfacing. A 1:1 slope is recommended below the spillway

to prevent undesirable fish from swimming upstream into the pond.

FINAL STEPS

The last earth-moving task is to spread the stockpiled topsoil over the pond bottom and the face of the dam. The dam and all areas above the waterline that have been cleared of vegetation should be fertilized and seeded with a grass seed mixture recommended by the Soil Conservation Service. Do not plant trees or shrubs on the dam or allow them to become established. Their roots will eventually weaken the dam and may lead to its failure. Tree roots penetrate the dam and allow avenues for seepage when they die and rot. Windstorms can topple live trees, and this uprooting creates caverns that are likely to weaken the dam structure and cause the structure to fail.

AERATION SYSTEMS

Aeration can allow use of shallow ponds, which would otherwise winterkill, for fishing. A wide variety of aerators are commercially available. They work by keeping a portion of the pond free of ice, allowing light and oxygen to enter the water, and allowing phytoplankton (microscopic plants) to generate adequate levels of oxygen naturally. Most popular are shore-mounted blower units that pump air to diffusers located in the pond. Care must be taken to mount air diffusers well off the bottom to avoid stirring up sediments. Prices can vary widely, so shop around. Do not operate an air blower system during periods other than winter without first consulting with a knowledgeable biologist, because there is a danger of fish kills in some ponds where bottom waters lack oxygen during the warmer months. More information on pond aeration can be obtained from the South Dakota Department of Game, Fish and Parks.

POND AREA MANAGEMENT

Regardless of how a pond is built or managed, fish are not the only animals that will benefit. Creatures such as frogs, salamanders, turtles, and many birds may begin using a new pond immediately, often before fish are established. While it is true that we rarely go to a pond just to watch wildlife, a brood of wood ducks or a deer coming to drink can highlight a fishing trip. A pond is not just a "fish" pond. It is a community of many living things, most of which depend on one another for survival. The pond itself forms a connecting link between the aquatic and terrestrial worlds.

Development around the pond can influence use and maintenance of the pond itself. The dual usage of fishing and wildlife can even cause management conflicts if consideration is not given in the development stage.

FENCING

When possible, all fish ponds with impounded areas less than 2 acres need to be completely fenced if livestock are present. Larger ponds should also be fenced, if physically possible. Even partial fencing of large ponds provides some benefits, especially near highly erodible areas. The amount of fenced area required for any given pond will vary with adjacent land uses and pond owner desires. A minimum might be to set the fence back 40-50 feet from the maximum high water level of the pond. The shoreline, dam and spillway must be protected from as much livestock access as possible. On existing ponds with no easy means to provide water except from the pond itself, livestock access should be restricted to one or two watering areas.

When considering the enhancement of wildlife habitat around a pond with nearby livestock, the first thing to do is to start driving fence posts. Fencing is an important, if not the most important, measure needed on most ponds to protect and enhance wildlife habitat. The effects of livestock grazing and trampling around concentration areas like ponds has been well documented in many scientific and popular publications. Livestock may make a pond edge more attractive to mourning doves, but the bare mud will offer little to any other wildlife.

ESTABLISHING VEGETATION

Permanent native vegetation should be planted on the dam, spillway, terraces, waterways, and other construction areas as soon after construction as possible. Native grasses planted in combination with forbs and legumes provide cover for wildlife and protection from erosion. Local Natural Resources Conservation Service (NRCS) personnel and South Dakota Department of Game, Fish and Parks wildlife biologists can provide recommendations on species, seedbed preparation, fertilization, and planting times.

Planting a cover crop in the area to be flooded is recommended for new ponds over 5 acres. Planting rye, oats, wheat, sudan grass, or other cover crops before flooding helps hold the bottom soil and keeps the water clear, provided the plants have sufficient time to grow before being covered with water. Flooded vegetation also supplies substrate on which fish food organisms develop. Ponds less than 5 acres may fill too rapidly for planted vegetation to establish.

The dam should be protected from wave erosion with either rock riprap or special grasses. A dense cover of grasses may adequately protect the dam where wave action is minimal. Contact the NRCS for recommended grasses. Trees should not be planted or allowed to grow on the dam because their roots can cause water leakage problems.

The banks and a buffer area around the pond should be planted to permanent vegetation. Native vegetation, including water-tolerant grasses, should be used. This buffer strip provides wildlife habitat and prevents silt from entering the pond from adjacent areas. Vegetated banks also provide a pleasing setting for fishing and other pond uses.

Pond owners should also be aware that vegetative cover will largely influence what types of wildlife regularly use the pond. In native rangeland, merely fencing the grasseed area around the pond will provide the low cover needed to benefit ground-nesting birds and mammals. If the pond is to be located in cropland or tame grass pasture, a native grass mixture should be planted within the fenced area. The NRCS can provide specifications for such plantings.

Depending on the land available, tree and shrub plantings should be considered. A windbreak of trees on the south and west sides of the pond will provide cover for birds and small mammals and help reduce wave action and turbidity (muddiness) in the pond. In South Dakota, 8-10 rows of trees are recommended to provide suitable wildlife habitat.

Random clump plantings of trees and shrubs can also be incorporated if sufficient space is available. Plants that are adapted to the site conditions and have proven wildlife values should be used. Some woody plants known to be attractibe to wildlife include wild plums, red cedar, and Russian olive. Other plants can be substituted and still achieve similar results. The pond owner may want to consult local NRCS personnel, county extension service personnael, or wildlife biologists for species suitable for soils surrounding the pond.

WATERFOWL MANAGEMENT

Ponds will attract a variety of birds ranging from tiny shorebirds to an occasional goose. Most pond owners enjoy seeing waterfowl use their ponds, and most ponds can be enhanced to increase chances for their usage. However, the decision to manage a pond for waterfowl must be made before the pond is built. No matter which management technique is eventually used, a water-control valve or structure must be included in the dam. Nearly all successful waterfowl efforts on impoundments require some water-level manipulation.

Some potential problems must be considered before a pond is managed for waterfowl by using water-level fluctuation. Water supply often is a limiting factor in pond management, especially in South Dakota where periodic drought can be expected. Unless sufficient inflow is available for reflooding, lowering water levels should not be attempted. If a pond cannot be refilled, the decreased water depth may result in winterkill. Another problem exists even if enough water is available for refilling. Decomposition of large amounts of flooded vegetation may result in a rapid loss of oxygen in the water and can cause substantial fish kills. Lastly, a pond built to maximize waterfowl use would contain extensive areas of shallow water with large amounts of aquatic vegetation desired. Fish ponds, on the other hand, minimize shallow-water areas so that excessive aquatic vegetation is avoided.

Where possible, the most suitable method for attracting waterfowl during migration is to provide a flooded food source. This can be accomplished by lowering the water level of the pond by 2-3 feet during June or July, and allowing annual weeds and grasses to develop naturally on exposed mud flats. Reflooding should begin in September or October. This technique assumes a water supply is available to reflood the pond.

If land is available, a more suitable way to provide waterfowl habitat without intefering with fish management potential is to construct a 1- to 3-acre shallow-water area below the pond dam. Water from the pond can then be used to seasonally flood the area, creating a man-made marsh. Timely drainage during the spring or early summer should result in a dense stand

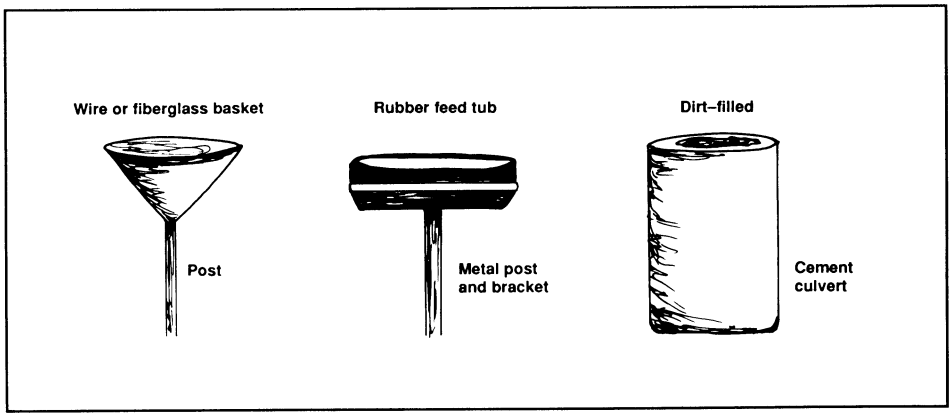


Figure 3. Nesting structures for geese and ducks.

of desirable wetland plants, such as smartweed, that can be flooded in the fall. Such shallow-water areas offer many more wildlife options than trying to rely on water-level manipulation within the pond itself. The pond-marsh combination provides for much more efficient use of water since only a 12- to 15-inch average depth is needed in the marsh. To further enhance such shallow-water areas, openings should be mowed in dense, tall vegetation before flooding. A good rule of thumb is to provide a marsh habitat with half open water and half emergent vegetation. *Once again, this technique requires that water be released from a pond, and may enhance the likelihood of winterkill in the pond itself.*

Nesting structures can also be installed in ponds. These may attract the giant Canada geese that are being re-established in the state, and may also attract ducks.

HABITAT MAINTENANCE

All too often it is assumed that once plantings are established, the job is done. This overlooks the fact that habitat is always changing due to plant succession. Consider an abandoned cropfield. For the first several years, it is mostly annual grasses and weeds. Gradually, it grows into perennial grasses and weeds. In some regions, such fields may eventually be dominated by brush and trees.

The secret of encouraging wildlife utilization of a habitat is to maintain a stage of succession that will benefit the kinds of wildlife desired. Because it is impossible to hold vegetation in just one stage for any great length of time, it becomes necessary to set back succession and allow the process to occur again, thus recycling the most beneficial successional stages. Controlled burning, mowing, plowing, discing, and grazing can all be valuable habitat maintenance tools. Even chemicals, with careful use, can be of value. Contact the area Conservation Officer or the Soil Conservation Service for more information on habitat maintenance procedures.

FISH ATTRACTORS

Trees and brush that must be removed to obtain fill for the dam should not be burned. A beneficial use is to relocate this material within the pond basin to serve as fish attractors. Fish attractors do produce some food and provide cover for fish in the pond, but their ultimate purpose is to concentrate fish for angling.

Fish attractors can benefit all fish species. Bluegills, minnows, and other prey use fish attractors as a place to hide from predators. While hiding there, they generally find an increased food supply of aquatic insects. Bass will find an attractor a good place to feed on bluegills or to rest.

Any type of tree will work as a fish attractor. Hardwoods tend to be long-lasting, and the multibranched red cedar also makes an ideal attractor.

These trees can be tied together in any number of configurations or placed separately with preformed or custom-made concrete blocks as anchors. A tree can be secured to an anchor with heavy gauge wire or polypropylene rope that has been passed through a hole drilled in the tree trunk, or by standing the tree trunk in a concrete block and filling the hole with cement.

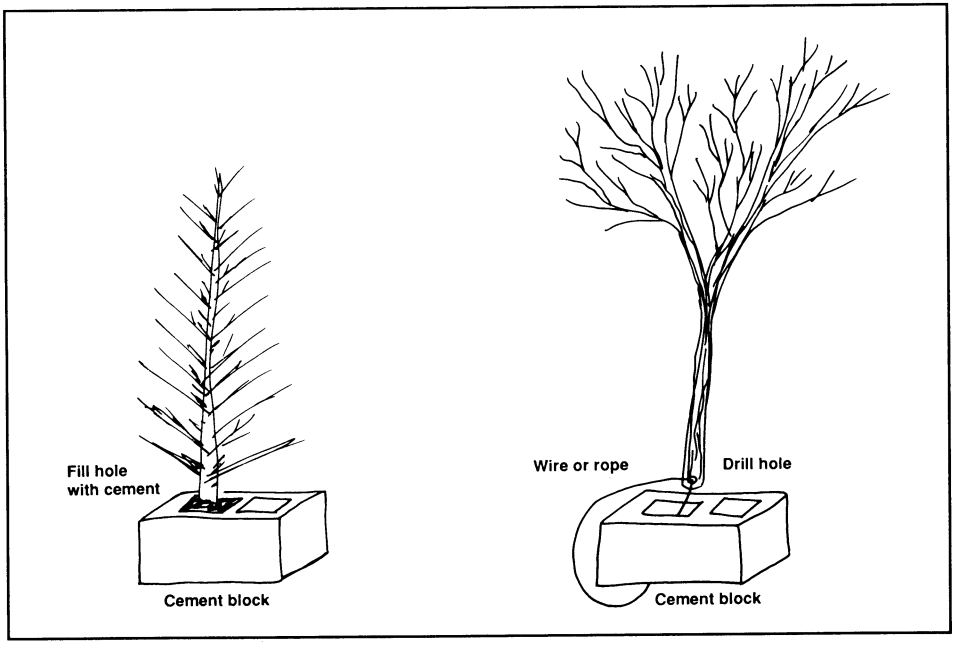


Figure 4. Fish attractors constructed from trees and cement blocks.

Other materials for fish attractors include tires, piles of old or broken concrete blocks, and piles of old clay tiles or pipes. Tires can be tied together in any design that suits the pond owner. A group of tires generally works better than single tires. Several holes should be drilled in each tire to allow air to escape so the tire will sink easily. None of these alternative attractors are as aesthetically pleasing as trees. In addition, pond owners need to be certain that such materials are not contaminated with dangerous chemicals.

The best attractor locations in a pond are near natural gathering places for fish or in areas where fish are to be attracted for angling. Attractors congregate fish in a particular area, but do not necessarily attract fish from great distances. Therefore, logical locations for habitat attractors would be off points, at the edges of creek channels, in the mouths of coves, or near boat docks and fishing piers. Brushpiles can be constructed at any water depth and may protrude from the shoreline into deep water. Tires, blocks, and sewer tiles are generally unsightly if exposed above the surface, so these will need to be placed in water deep enough to cover them. There is no particular depth that is most conducive to concentrating fish, so the depth of structures can be varied. Shoreline attractors can be made by cutting two-thirds of the way through a tree that is growing next to the shoreline, and felling it into the water, leaving it attached to the stump.

Fishing brushpiles is a challenge. Skill is needed to avoid the loss of lures and bait. The angler should fish straight down or near the edges of the brushpile. Bluegills and bass will move out of brush to feed if they are hungry. If the brushpile is holding catfish, the angler may have to get the bait fairly close. Strong line may be necessary to pull a good-sized bass or channel catfish away from the protection of the cover provided by an attractor.

No type of fish attractor should be placed in catfish-only ponds. Any type of structure may provide catfish a nesting site. If catfish spawn in the absence of bass, overpopulation of small catfish is likely.

MANAGEMENT OPTIONS

A common misconception by many pond owners is the belief that their pond can "have it all." They believe they can stock any and all species of fish, and have quality fishing for each of those species. This is not the case. Pond owners must decide what they would prefer and choose a management option for their pond. For example, research at South Dakota State University has shown that as the number of panfish species in a pond increases, the quality of the fishing declines. Therefore, we have provided the following key to help pond owners focus their thoughts on pond management. After choosing a management option, pond owners should carefully read the discussion of that option on the pages indicated to see if such an option is feasible for their pond.

1. Is the pond at least 15 feet deep in the fall and 2 acres in area?
   Yes—Go to 2.
   No—The pond is susceptible to winterkill and should be managed for short-term production or managed to reduce the chances of winterkill. See page 30.

2. Is the pond clear most of the year? Is transparency greater than 15 inches (elbow to fingertip) for most of the year, excluding a summer algae bloom?
   Yes—Go to 3.
   No—The pond should probably be managed for channel catfish only. See page 34.

3. Are there fish already present in the pond?
   No—Go to 4.
   Yes—See page 37.

4. Does the owner want to produce a trout fishery?
   No—Go to 5
   Yes—See page 35 for necessary conditions to stock trout. No stocking of warmwater species such as largemouth bass, northern pike, and bluegill can be made in trout ponds.

5. Does the pond owner intend to actively manage this pond, realizing that considerable time, effort and expense may be involved?
   No—Go to 6.
   Yes—Go to 7.

6. Pond owners preferring not to spend time managing their ponds should choose the "safe" management option of largemouth bass only (see page 31). Stocking a panfish species such as the bluegill in a pond that is not well-managed usually results in a large number of stunted bluegills.

7. Pond owners willing to spend the necessary time managing their ponds can choose one of these management options.
   a. The "balanced" or all-purpose largemouth bass-bluegill option (production of moderate sizes and numbers of both largemouth bass and bluegill). See page 31.
   b. The panfish option (production of large panfish such as bluegill). See page 32.
   c. The big bass option (production of larger sizes of largemouth bass). See page 33.
   d. A crappie fishery (really a panfish option). See page 32.
   e. Other species desired:
      Smallmouth bass. See page 36.
      Northern pike. See page 37.
      Walleye. See page 37.

WINTERKILL-PRONE PONDS

Winterkill is a common occurrence in South Dakota, especially in shallow ponds or during drought. To understand the process that results in a winterkill, be sure to read the "Winterkill and Summerkill" section on page 3 before continuing this discussion.

In ponds that are likely to winterkill, the best management strategy may be to get as much fishing as quickly as possible, and be prepared to start over when winterkill occurs. In ponds that will support rainbow trout (see "Trout Pond Management" on page 35), they will reach harvestable size by their first fall in a South Dakota pond, and can be harvested as soon as the pond owner finds their size acceptable. Rainbow trout are quite vulnerable to ice fishing, so harvest can continue into early winter. If the pond happens to make it through the winter without a winterkill, then larger fish would be available the next year and could be considered a bonus. Pond owners should realize that shallow ponds are also more likely to have warm water temperatures in the summer.

In warmwater ponds, the best management strategy would probably be simultaneous stocking of largemouth bass and bluegill, with harvest occurring as soon as the pond owner finds the fish to be an acceptable size. We

recommend that 100 largemouth bass fingerlings (2-3 inches) and 500 bluegill fingerlings (1-2 inches) be stocked per acre of water. Fish can be harvested without size or number restrictions (remembering legal daily creel limits, of course), because the main objective would be to obtain as much fishing as quickly as possible before winterkill occurs.

When a complete winterkill occurs, no fish will be left in the pond, and the management process can be restarted. However, winterkills are frequently partial. "Rough fish" such as bullheads and carp, which are more resistant to winterkill, likely will comprise the remaining fish population. In these cases, pond owners have two options. They can wait for a complete winterkill before restarting their management program, or they can eliminate the fish population as described in the "Improving Undesirable Fish Populations" section on page 45. Restocking desirable fish into ponds that contain these undesirable species is not recommended because it is rarely successful.

Ponds that are susceptible to winterkill may not meet the criteria to qualify for stocking by the South Dakota Department of Game, Fish and Parks (see page 40 for a description of this stocking program). The remaining options all assume that the pond is not susceptible to winterkill under normal circumstances.

LARGEMOUTH BASS-ONLY OPTION

Largemouth bass can be managed as the only fish present in a pond. They do not require other fish species as prey, because they will feed on smaller bass, crayfish, frogs, and tadpoles. This is undoubtedly one of the safest management options for South Dakota ponds, and may be the best option for pond owners that have little time or desire to actively manage their ponds. Fathead minnows can be stocked with largemouth bass, but they will eventually be eliminated from the pond by bass predation. In clear, weedy ponds, golden shiners can be used as prey. If vegetation is sparse or lacking, largemouth bass predation will greatly reduce or eliminate golden shiner populations.

In some ponds, especially those that are clear, have abundant aquatic plant growth, and are protected from the wind, largemouth bass may overpopulate when stocked alone in a pond. Such populations are generally characterized by high densities of 8- to 11-inch bass, with bass over 15 inches being nearly nonexistent. These populations produce good fishing, but few large fish are caught. Modification of this condition is discussed under the "Big Bass Option" section, or these ponds can be managed under the "Panfish Option."

ALL-PURPOSE OPTION

This option affords the opportunity to catch fish of a variety of sizes. To catch bass over 15 inches long with any consistency in ponds that are clear,

have abundant aquatic plant growth, and are protected from the wind, the number of 8- to 12-inch bass must be reduced. In a pond of average fertility, no more than about 30 8- to 12-inch bass can be harvested per acre per year after the fourth year from stocking. The removal of these small bass reduces competition and makes it possible for some fish to attain lengths over 15 inches.

To ensure that at least 10% of the catchable-size bass survive to lengths of 15 inches and longer, all 12- to 15-inch bass that are caught should be released. A good supply of 12- to 15-inch bass will also reduce densities of smaller bluegills so that some individuals grow to sizes of interest to anglers. This management option will produce bluegills of several sizes, with a few reaching 8 inches. However, most South Dakota ponds managed under this option do not produce high numbers of large bluegills. Intermediate-size bluegills tend to be quite abundant. However, such bluegill populations are often desirable in fishing ponds for kids.

Bluegills can be harvested as desired, and channel catfish can be included in the pond stocking complement. Catfish that are harvested must be replaced with 8-inch or longer individuals to maintain a sizable catfish fishery. Without periodic supplemental stocking, few catfish will be caught because few young catfish can survive bass predation.

The all-purpose option is not as safe as the largemouth bass-only option. In some South Dakota ponds, largemouth bass populations may not reach densities high enough to control bluegill populations, and stunted bluegills may result. Recruitment (reproduction and survival to adulthood) of largemouth bass tends to be high in clear ponds that have abundant aquatic plants and are somewhat protected from the wind. In ponds that are somewhat muddy, or have little aquatic vegetation, or are shallow and/or windswept, recruitment of largemouth bass may be low. Such ponds are probably best managed with the largemouth bass-only option. If bluegills are present in a pond with low bass recruitment, no bass less than 15 inches long should ever be harvested.

Northern pike can be stocked in these ponds, especially larger ponds, as an additional sport fish and predator, as long as the pond owner realizes the limitations of this species as described in the "Northern Pike" section on page 37. Rapid northern pike growth rates present a threat to survival of originally stocked bass if pike are stocked too soon. Fingerling pike (6-10 inches) can be stocked at a density of 10 per acre two or more years after bass have been introduced. Walleyes can also be stocked in all-purpose option ponds, but pond owners should realize that bluegills are not an ideal prey source for walleyes. Once again, northern pike and walleyes are not normally part of a stocking program provided by the South Dakota Game, Fish and Parks Department and are not commonly available.

PANFISH OPTION

Ponds that have or likely will have high recruitment (reproduction and survival to adulthood) of largemouth bass can be managed under the pan-

fish option. Ponds that are clear, have abundant aquatic vegetation, and are somewhat protected from the wind are good candidates for this management option.

The panfish option should be utilized if catching big panfish is more important than harvesting bass or catching big bass. High densities of 8- to 11-inch largemouth bass are more effective at controlling bluegills and other panfish than moderate numbers of bass of several sizes. By purposefully overpopulating bass, the panfish option will produce more 8-inch and longer bluegills. Other species of panfish may be useful as variations on this option. High-density largemouth bass populations will thin reproduction by bluegills, crappies, bullheads, and yellow perch, such that surviving panfish grow to sizes of interest to anglers. However, it is best to *choose only one of these species* for each panfish-option pond. The reproductive capacity of several species of panfish is generally too high for the largemouth bass to control through predation, especially in South Dakota ponds.

In the past, these panfish species were usually not recommended for ponds because they have a tendency to overpopulate if bass numbers are low or if the pond is muddy and the bass cannot see to feed. Thus, some pond owners may wish to begin their pond program by stocking only largemouth bass to be sure that a high-density population does indeed develop. Such a population can be recognized by high angling catch rates, with most bass caught being 8-11 inches long. At this time, adult panfish can be introduced into a pond by stocking approximately 20 adults per acre of water. After adult panfish spawn, it will take 3-4 years for their offspring to reach sizes of interest to anglers.

For pond owners desiring the "safest" panfish option, all largemouth bass that are caught should be released. Few, if any, bass over 15 inches long would exist in such a pond. If pond owners would like to harvest an occasional bass, only those at least 15 inches long should be taken.

Northern pike stocked as described in the "All-purpose Option" section can be included in this management option. The pike can provide some additional predation on panfish.

It is *essential* to prevent overharvest of largemouth bass in any pond managed under the panfish option! If the bass are overharvested, the panfish species present will undoubtedly overpopulate. The pond will then contain high numbers of small panfish, and few bass.

BIG BASS OPTION

Larger sizes of largemouth bass can be produced in ponds stocked with largemouth bass only and in ponds stocked with both bass and bluegills. In ponds containing only largemouth bass, the sizes of bass present can be increased by harvesting some of the smaller bass. For ponds of average fertility, approximately 40 bass that are 8-12 inches long should be harvested per acre per year. Perhaps 5 12- to 15-inch bass might also be harvested per

acre per year, but all other bass should be released. Eighteen-inch bass (4 pounds) can be produced in a pond with such a management strategy, and these larger bass can be harvested as *occasional* trophies if so desired. A similar harvest strategy for bass can also be used in ponds containing both bass and bluegills. It must be realized that the quality of bluegills in such ponds will be sacrificed to produce fewer, larger bass. In fact, ponds managed in such a fashion might reach a point at which bluegills become overpopulated and bass recruitment ceases. Correction of such problems is discussed under the "Improving Undesirable Fish Populations" section on page 45. Management of a bass-bluegill pond with the "Big Bass Option" is not a safe option in South Dakota, and should only be attempted by extremely interested pond owners.

Table 1. Appropriate harvest of bass in a pond of average fertility given the management option followed [modified from Gabelhouse et al. (1987)].

Option	Years after stocking	Length (inches) 8-12	12-15	15+
All-purpose	0-4	none	none	as desired
	4+	20-30/acre	none	as desired
Panfish	0-4	none	none	as desired
	4+	none	none	as desired
Big bass*	0-4	none	none	none
	4+	30-50/acre	5/acre	trophies

**largemouth bass only*

CHANNEL CATFISH-ONLY OPTION

It is advisable to stock only channel catfish in muddy ponds where sight-feeding fish like bass and bluegills would do poorly. Large, clear ponds will produce about the same weight of catfish whether or not they contain bass and bluegills.

Ponds managed under this option should be free of any structure such as sewer tiles, stumps, large rocks, or tires that would provide seclusion for spawning. Ponds that contain only catfish are often characterized by excessive numbers of small catfish when suitable spawning sites exist. If reproduction can be avoided, replacement fish will have to be stocked periodically to maintain the population. Fathead minnows can also be stocked to provide additional food for catfish and a ready source of bait for the pond owner.

This option is the easiest of the five options to manage as long as natural reproduction does not occur. Harvest can begin as soon as fish reach a size considered to be harvestable, and no restriction need exist on the overall number harvested (remembering, of course, to follow applicable daily creel

limits). As catfish numbers decrease, fishing success will decline, so additional stocking will be required to maintain catfish at a density of approximately 100 fish per acre. Catfish at least 8 inches long should be stocked in the fall or spring when water is cool. The number stocked should equal the number harvested in previous angling seasons with an additional 10% per year to replace those fish lost to natural causes.

Channel catfish are truly a warmwater species. In South Dakota, they have a short growing season, and growth rates are slower than in the southern United States. However, pond owners can expect to have harvestable fish within 2-3 years if fingerling fish are stocked and within 1-2 years if 8-inch fish are stocked.

In the southern United States, channel catfish commonly receive supplemental feed from pond owners. Generally, this is not a good technique to use in South Dakota waters without careful consideration and planning. Please refer to the "Feeding Fish" section on page 44.

TROUT POND MANAGEMENT

Rainbow trout require water with temperatures below 70° F and with a high oxygen content. Thus, they are only suited to some waters in South Dakota. Water temperature should be monitored throughout the summer before stocking trout. Generally, only deep ponds in western South Dakota or the Black Hills are suitable for trout. However, the presence of a large spring may maintain sufficiently cool water temperature in all parts of the state. In addition, larger ponds without excessive aquatic vegetation may retain sufficient oxygen in the cool bottom waters (see the "Water Quality" section on page 2) to allow trout survival. Pond owners should consult an area Conservation Officer or fisheries biologist before stocking trout.

Trout reproduction generally is not expected in ponds (see the "Spawning" section on page 3). Thus, they need to be restocked as they are harvested. We suggest an initial stocking of approximately 250 fingerling (3-4 inches) trout per acre of water. Restocking can occur at the same densities, and generally should be done every second or third year. Growth of rainbow trout in South Dakota ponds is often quite rapid, with fish ranging from 8 to 12 inches by the end of their first growing season.

We do not recommend stocking fathead minnows with rainbow trout. While larger rainbows will indeed eat the minnows, they do not require fish as prey. In fact, the fatheads may actually compete for food (zooplankton) with the small rainbow trout that are stocked as replacements.

Brown trout can survive in water that is slightly warmer and somewhat lower in quality than can rainbow trout. Thus, they may have a place in South Dakota pond management. They are, however, more difficult to catch than rainbow trout. Pond owners might take advantage of this lower catchability by stocking a few brown trout in the hopes of producing a trophy some years later. Large individuals tend to eat fish, and minnows might be desirable in a pond containing brown trout. This predatory nature causes problems when stocking replacement fingerling trout (brown or rainbow). If a

pond contains a large population of brown trout, it might be wise to consider stocking larger sizes of replacement trout, perhaps as large as 6-8 inches. Brown trout should not be used in ponds unless pond owners truly desire to produce this species. They are not normally available from the South Dakota Department of Game, Fish and Parks for pond management.

Brook trout require colder water than do rainbow or brown trout. They do best in waters that do not warm beyond 65° F. Therefore, brook trout should not be stocked except in some Black Hills areas. One exception might be in a pond that has a sufficiently large spring to maintain the necessary water temperature. However, such a spring must flow with sufficient quantity (and sufficient dissolved oxygen) to maintain a good environment for the brook trout.

Strains of warmwater trout are presently being investigated by the fisheries profession. If such fish are able to withstand warmer water temperature, they may allow development of pond fisheries for trout in many more parts of South Dakota. We would like to repeat that trout ponds can contain only trout. None of the other warmwater species such as largemouth bass, bluegill, walleye, or northern pike can be added. Predators such as bass and pike will prey on the trout. Panfish such as bluegills will overpopulate and compete with the trout for food.

SMALLMOUTH BASS

Smallmouth bass have been used in South Dakota pond management for only a few years. Thus, their population dynamics are not yet well understood. However, results to date have been quite positive.

Smallmouth bass can be stocked as the only species in a pond. Small ones will eat mostly insects, and larger ones can eat insects, crayfish, and perhaps some small bass. Larger sizes of smallmouth bass could be produced much as was described for largemouth bass under the "Big Bass Option" section on page 33. Certainly, fathead minnows or golden shiners could be added as a source of prey. The fathead minnows may eventually be eliminated by bass predation. However, the golden shiner has great potential to provide a source of prey for smallmouth bass, especially if some aquatic vegetation is present.

Smallmouth bass should *not* be stocked with bluegills. Smallmouths are not as efficient as largemouth bass are as predators, and in most cases the bluegills will overpopulate. In addition, smallmouth bass and largemouth bass should not be stocked in the same pond. In most cases, the largemouth bass is more suited to the pond environment, and will likely out-compete the smallmouths. Eventually, few, if any, smallmouth bass will remain. One exception might be in "gravel-pit" type ponds, where the smallmouths often do quite well.

NORTHERN PIKE

Northern pike have already been discussed in the "All-purpose Option" and "Panfish Option" sections. Certainly, northern pike can be part of a pond management strategy in South Dakota.

Northern pike tend to have a maximum biomass of 10 pounds per surface acre of water. Thus, even though they may reproduce and maintain a population in South Dakota ponds, they do not control bluegills and few are available for angling in most ponds. A pond stocked with bluegills and northern pike will likely result in a stunted bluegill population. It is possible to utilize both largemouth bass and northern pike as predators in a pond, with the bass being the primary predator.

The success of northern pike reproduction will vary from pond to pond. Reproduction is more likely in ponds that have some type of marshy area. In steep-sided ponds that vary little in water level, the pike may not be able to reproduce. Fingerling (6-10 inches) northern pike can be stocked at a density of 10 per acre two years after largemouth bass have been introduced. Northern pike are not normally available from the South Dakota Department of Game, Fish and Parks for pond management.

WALLEYE

Walleyes are a popular game fish in South Dakota, and pond owners often desire to have them in their ponds. While walleyes do not cause problems in a pond, they are not particularly well-suited to the pond environment. Reproduction is not likely, although it may occur in larger ponds having gravel shoals or rocky shoreline areas. Likely, they will not reproduce adequately in ponds to maintain their own numbers. They are costly to stock, difficult to obtain, and a pond cannot support many of them. If a pond owner truly desires to have walleyes, he can add some, but must realize that catches will be occasional bonus fish. They can be part of the predator component in most pond management strategies (with the exception of trout ponds), as long as the pond owner realizes they will need to be restocked every few years. Walleyes stocked into established pond communities should be at least 6-8 inches long so they can avoid predation by fish such as largemouth bass and northern pike. Stocking density can be approximately 20 fish per acre. However, walleyes are not available for pond stocking from the South Dakota Department of Game, Fish and Parks.

ESTABLISHED FISH COMMUNITIES

If a pond already has a fish community (a fish community includes all species of fish in the pond) present, we suggest that the pond owner read through all the management options. If any of these situations seem to de-

scribe the pond, then it can be managed accordingly. However, if the pond is dominated by a high density of small sunfish or bullheads or if common carp are present, the pond owner is referred to the "Improving Undesirable Fish Populations" section on page 45.

The South Dakota Department of Game, Fish and Parks will assist pond owners with the management of their ponds. Assistance can be received by contacting the area Conservation Officer. If the owner wishes, the Conservation Officer will inspect the pond and make recommendations for the type of management that would be best suited to the pond and the needs of the owner. Cooperative Farm Pond Agreements are available to landowners who desire management assistance and fish and who allow reasonable public access.

STOCKING

WHAT TO STOCK INITIALLY

In warmwater ponds, initial stocking densities for a largemouth bass-only pond would be 100 fingerling (2-3 inch) fish per acre of water. These bass are generally available in July or August. These fish usually will not be of catchable size for two years. Stocking rates less than the recommended levels will delay the development of the pond community and necessitate a longer waiting period before fish can be harvested. Higher stocking rates could slow growth and delay the development of quality fishing. If larger fish are stocked, stocking densities should be reduced. Approximately 50 8- to 12-inch bass per acre of water would be sufficient. To accelerate initial bass growth rates, 3 pounds of fathead minnows can be stocked per acre of water when fingerling bass are introduced or a year before adult bass are stocked. Similarly, golden shiners can also be introduced at this time, if desired.

For management options that include bass and bluegills, largemouth bass fingerlings (2-3 inches) should be stocked at a density of 100 fish per acre of water. Once again, these fish are generally available in July or August. Largemouth bass are not expected to reproduce for two years. Thus, intermediate-size bluegills should be stocked *two years after the bass*, preferably in the spring. Bluegill stockings could also be made the previous fall (a year and several months after the bass), because no reproduction will occur until the next spring. The intent of this stocking method is to provide small bluegills as prey for largemouth bass that are hatched that year. One hundred intermediate-size bluegills should be stocked per acre of water. Channel catfish can be added to a pond by stocking 100 channel catfish fingerlings (2-3 inches) per acre when fingerling bass are stocked. If larger bass are present in a pond, 8- to 12-inch channel catfish must be stocked to avoid bass predation. When only catfish are stocked in muddy ponds, 50 channel catfish fingerlings should be stocked per acre. In muddy waters, not as many fish can be supported per acre of water.

If a pond owner has a pond that contains a high density of largemouth bass (recognizable by high angling catch rates with most fish being 8-12 inches), a panfish species can be added to create a panfish-option pond. In

these situations, 20-50 adult panfish per acre should be introduced. Recommended species include bluegill, black crappie, black bullhead, or yellow perch. We do *not* recommend introducing more than one panfish species. Unless the bass population has an extremely high density, reproduction by several panfish species can overwhelm the ability of the bass to control reproduction.

These adult fish stockings will be more successful in the spring or fall when water temperatures are lower. Stocking in midsummer may result in low survival of stocked fish.

Northern pike and walleyes should not be added to a largemouth bass or largemouth bass-bluegill pond until two years after the bass have been stocked. Then, 10 6- to 10-inch northern pike or 20 6- to 8-inch walleyes can be stocked per acre. If natural reproduction does not occur, these stockings can be repeated every second or third year, assuming the pond owner wishes to maintain these fish species in the pond community.

Smallmouth bass introductions can be made at the same densities as largemouth bass—100 fingerlings per acre or 50 6- to 10-inch fish per acre.

Rainbow trout can be stocked at 250 fingerlings (3-4 inches) per acre of water. Such stockings can then be repeated every second or third year. Trout should be stocked in the spring or fall when water temperature is below 60° F, if possible. Survival will be greater at lower water temperatures.

THE SOUTH DAKOTA POND STOCKING PROGRAM

The South Dakota Department of Game, Fish and Parks provides fish stockings for private waters. Applications may be obtained at any Game, Fish and Parks Wildlife Division office or from your area Conservation Officer. Both trout and warmwater fish are available.

To qualify for trout stocking, a pond must be a minimum of 1 acre in area or 1/2 acre if flowing springs are active throughout the year. Ponds must be at least 15 feet deep over one-fourth of the pond area or at least 10 feet deep with continual spring flow. The rainbow trout is the only species available, and is generally stocked on alternate years.

To qualify for warmwater fish stocking, a pond must be at least 1 acre in size and have a depth of 12 feet or more over one-fourth of the pond. Species available may include largemouth bass, bluegill, channel catfish, black crappie, and yellow perch. The number of species available may increase as various options are studied. Most fish are stocked as fingerlings, and only a single stocking is usually provided. However, sizes of fish stocked and frequency of stocking may vary if special circumstances warrant such changes. Fingerling stockings of warmwater fish are generally most successful and most likely to be approved when no other fish are present in the pond.

In most cases, your area Conservation Officer will inspect your pond as part of the approval process for stocking. Fish will not be furnished for waters that are subject to commercialization. In addition, pond owners must sign an agreement allowing reasonable public access and optimum harvest of resultant fish populations. The department will supply suitable fish

stocks in sufficient quantity and quality needed to adequately manage the waters and will assist the pond owner in managing the pond.

Stocking applications can be returned to your area Conservation Officer or the Wildlife Division headquarters in Pierre. Requests for warmwater fish received through March of a calendar year will likely result in stocking that same year. Trout stocking must be requested by September 1 of the year preceding the desired stocking date.

PRIVATE SOURCES OF FISH

The state stocking program may not meet the needs of all pond owners. Thus, a list of private fish producers is available from Wildlife Division offices of the South Dakota Department of Game, Fish and Parks. The supplier will be able to assist you in determining the best way to transport fish to your pond. Pond owners should determine whether or not live delivery is guaranteed. If possible, fish should be inspected before shipment to ensure that no obvious signs of disease or poor condition are present. Such signs may include thinness, bulging eyes, swollen stomach, red spots, white spots, or strange swimming patterns. In addition, be certain that unwanted species are not included with your fish. Rainbow trout and other salmonids must be certified disease-free before they can be imported into South Dakota. Contact a Game, Fish and Parks Wildlife Division office for details. Purchasing fish changes the rules as to what you can do with them.

WHEN AND HOW TO STOCK

Chlorinated water should not be used to transport fish because it will kill them. Water taken directly from the pond is best. It should be obtained just before picking up fish. Water collected the day before may cool substantially during the night, causing fish to die when transferred from a delivery truck into the container.

Before fish are stocked into a pond, the temperature of the water the fish are being transported in should be equalized with the temperature of the pond. A sudden change in water temperature will cause fish to go into shock and will often result in death. Even if the fish swim away, delayed mortality may cause a complete loss of the stocked fish. Half the water in the container used to transport fish should be poured out and replaced with water from the pond. The fish should then be given 5-10 minutes to adjust to the temperature change. This procedure should be repeated until the water temperature in the container is within 3^{o} F of that in the pond. The fish can then be released into the pond without going into shock.

New or renovated ponds are commonly stocked with fingerling (1 1/2- to 4-inches) fish. Because these fish are small, there should be no salamanders or other fish (besides fathead minnows) in the pond before stocking. If fish or salamanders are present, the stocked fish will quickly be consumed or will be unable to compete for food. To prevent wild fish from becoming estab-

lished, a pond should be stocked as soon after it fills as possible. It is, however, best to avoid stocking during hot summer months because high temperatures and low oxygen content weaken fish.

FISH MANAGEMENT

Proper pond construction, development, and fish stocking will not guarantee sustained good fishing. A correct start must be followed by periodic management. Some of the techniques described in this and the following sections seek to affect fish populations directly, while others modify habitat within the pond, affecting fish indirectly.

REGULATING FISH HARVEST

Improper fish harvest ruins future fishing in more potentially good ponds than any other cause. Pond owners and other anglers are eager to fish a newly stocked pond, and they frequently overharvest the bass population in the first season of fishing. This allows the bluegills to overpopulate, and is partially responsible for the bad reputation of bluegills. Generally, this overharvest of largemouth bass is unintentional. Few pond owners realize how little time it takes an angler to affect a bass population. Two anglers fishing for a few days during the spring (when the bass are really biting) in a 3-acre pond that has never been fished *can actually harvest 75% or more of the catchable bass!* Thus, the pond never has a chance to develop a desirable fish community. Without a doubt, the bluegills will overpopulate in that pond, and a high density of 3- to 5-inch bluegills will result.

A pond owner can reduce the likelihood of bass overharvest by not letting anyone fish the pond. This practice is not encouraged, however, because underfishing as well as overfishing can cause problems. Pond owners are urged to let others fish their ponds as long as the rules of the owner are followed.

One way to prevent bass overharvest is to release all bass less than 15 inches long for a period of four years from stocking, even though bass may be large enough to catch after one or two years. This means that few bass can be harvested for four years from the time of stocking, unless adult fish were introduced. If 8-inch bass were stocked, the 15-inch minimum length limit would be needed for only three years. Catch-and-release fishing could be allowed, but no fish should be removed.

After four years from stocking, a management decision must be made. The choice of management options will depend upon what numbers, sizes, and

kinds of fish are desired. At this time, harvest guidelines should follow those listed in the table on page 34 for each of the management options.

Some ponds receive little bass fishing pressure and harvest due to their remote location (such as many of the West River ponds in South Dakota), because few people fish the pond or because area anglers do not like to catch small bass. Such ponds eventually contain high numbers of small bass. If bluegills are present, they will usually be large as described in the "Panfish Option" section. The results from low bass harvest due to low fishing pressure or angler preferences are the same as those that occur with a 15-inch minimum length limit and high fishing pressure (assuming adequate habitat and largemouth bass reproduction). Ponds that normally receive minimal bass harvest can withstand the harvest of an occasional 12-inch bass and even periodic high bass harvest without change because bass reproduction soon returns the pond to crowded bass and large bluegills. Other than habitat changes, annual harvest of 30 or more 8- to 12-inch largemouth bass per acre is the only way to increase numbers of larger bass. If harvest of small bass and 12- to 15-inch bass continues each year, the fish population will eventually become dominated by small bluegills.

We suggest that interested pond owners keep catch records for their ponds. The number of fish caught per hour of angling can be monitored over the years. Substantial changes in the catch rate will warn pond owners of potential problems. The size of fish caught can also be monitored, and changes could again signal developing problems.

FERTILIZATION

While widely recommended in warmer parts of the country, fertilization of fish ponds should not be done in northern states due to the increased danger of winterkill. Fertilizers promote the growth of plant life, resulting in higher levels of organic materials that decay during the winter and use oxygen. In South Dakota, low water temperatures and short growing seasons are more likely to limit fish growth than low fertility, while the reverse is true in the South. Certain ponds with low fertility may benefit from small applications of fertilizer at regular intervals, but an on-site visit by a knowledgeable biologist is recommended first.

FEEDING FISH

Limited feeding of fish can increase growth rates, but is expensive, time-consuming, and the added nutrients increase the chance of winterkill. Adequate studies have not been completed to determine how much feeding is safe under South Dakota conditions. Some feeding is probably safe in larger ponds or those in which winter aeration is used. Feed should be used as a supplement to the natural foods available in the pond and not as a total replacement. A conservative guideline is to never distribute more than 5 pounds of feed per surface acre per day, or more than the fish will eat in

one-half hour.

Fish must be fed at the same time every day and observed while feeding to ensure that feed is not left uneaten. Uneaten feed is not only a waste of money but also pollutes the water. Do not attempt to feed all that the fish will eat. A floating type fish feed is best if it can be obtained. It may be necessary to special order fish feed. Pellets should be 1/8- to 1/4-inch in diameter. If you must purchase a large amount, be sure that it can be used within 90 days. Floating feed should be dispensed inside a floating ring that has a platform suspended below it at a 25-degree angle. This arrangement will prevent feed from blowing to shore and will keep pellets that sink from getting lost on the bottom.

The amount to feed each day should be based on how actively fish feed during a 30-minute period for bass and bluegill and for a 10-minute period for trout. The upper limit should be reached in midsummer and then reduced as fall approaches. For warmwater fish, such as bass and bluegill, begin feeding on alternate days when water temperature is from 55-70° F. For higher water temperature, feed each day. Trout should be fed each day when water temperature is above 40° F.

IMPROVING UNDESIRABLE FISH POPULATIONS

Undesirable fish populations can develop if bass (predator) numbers are low, if bass were never stocked, or if the pond has turbidity or vegetation problems. If anglers catch mainly 3- to 6-inch bluegills and few or no bass, it is likely that (1) bass overharvest has occurred, (2) bass are not present, (3) bass cannot see to feed, or (4) excessive aquatic vegetation has made bluegills unavailable to bass. The first two problems can be rectified by stocking 50 8- to 12-inch bass per acre. If the pond has an underwater visibility of less than 12 inches or if over 50% of the surface area of the pond is covered by vegetation, these problems must be treated before bass are stocked. Procedures for dealing with problem ponds are discussed in the next section. If the problem with muddy water cannot be solved, the pond owner might consider stocking only channel catfish in the pond, and forget about bass and bluegill. After 8-inch bass have been stocked in a clear pond, no bass less than 15 inches long should be harvested for a 3-year period. Then, one of the management options should be chosen and followed, as described beginning on page 29.

If only small bass and no bluegills are caught, and the pond owner desires a bluegill fishery, 20-50 adult bluegills can be stocked per acre. Then, appropriate bass harvest restrictions and stocking strategies should be followed as outlined in the "Management Options" section. If bluegills are not desired, then larger bass can be produced by selectively harvesting some 8- to 12-inch bass and releasing most 12- to 15-inch bass, as described in the "Big Bass Option" section on page 33.

If the pond contains neither bass nor bluegills and small bullheads and green sunfish are present, 50 8- to 12-inch bass should be stocked per acre and no bass should be harvested. This stocking can be repeated a second

year, if needed. Once the bullheads or green sunfish are controlled, bluegills can be stocked, if so desired. Once again, the pond in question must be relatively clear.

In the absence of bass, bullheads and carp sometimes develop such dense populations that their bottom-feeding activities muddy the water severely. Even if bass were stocked in such ponds, they could not see to feed, and their impact on bullheads and carp would be negligible. Draining the pond is the most economical alternative for removing unwanted fish, given these circumstances. Before a pond is drained, check with the area Conservation Officer. Other private and public waters downstream could be damaged by the carp and bullheads from the pond. In essence, the releases would be stocking these other waters. In South Dakota, it is illegal to stock public or private waters without permission.

If the pond cannot be drained, the fish community can be chemically removed. Liquid rotenone (5% or 2.5% synergized) is the chemical most frequently used. This chemical kills only animals with gills and is not harmful to any warm-blooded animals except pigs. It should be mixed at a rate of 2 gallons per acre-foot of water. However, if any springs enter the pond or if aquatic vegetation is abundant, we recommend that 2.5 gallons be used per acre-foot. The total amount of rotenone required may be reduced if the water volume of the pond can be lowered through siphoning or pumping. This is desirable because the chemical is expensive. Local fisheries biologists and area Conservation Officers can provide information on purchasing rotenone.

Treatment should occur when the water temperature is 60^{o} F or above. In ponds smaller than 2 acres, the chemical should be mixed into the water using the prop wash of a stationary outboard motor. The front end of a small boat should be pointed into the pond bank, and the motor should be run in forward gear. The rotenone is then poured slowly into the prop wash. It is best to dilute the rotenone with water before it is poured into the pond so that the treatment is done gradually. The prop wash circulates the chemical to all depths of the pond. The motor must be run as fast as safely possible to assure maximum circulation. The front and sides of the boat should be tied to stakes driven into the pond bottom to keep the boat from running up the bank.

It is important to change the location of the boat several times so that the mixing action reaches all areas of the pond. Shallow areas not reached by the prop wash should be treated with a hand sprayer or by carrying in the chemical by bucket. The mixing action is ineffective when the boat is only driven around the pond. While the upper 3 feet of water may be well mixed, little chemical will reach lower depths.

Rotenone may not reach all areas of large ponds or ponds deeper than 10 feet when the chemical is mixed with an outboard motor, especially during warm weather. The chemical should be pumped into areas not reached by motor mixing and into the deepest portions of such ponds. In ponds that are stratified (see "Water Quality" on page 2 for a discussion of stratification), rotenone will need to be pumped into the cold bottom water if the pond is treated in the summer. If treated in the fall after the pond is circulating thoroughly, this pumping will not be necessary. Fish can be stocked into a

pond within three weeks after rotenone has been applied in the summer. It is best to wait until the following spring to stock ponds treated in the fall. The pond can be tested by putting a few fish in a cage in the pond to check toxicity. Testing before stocking might prevent the loss of stocked fish.

AQUACULTURE

Aquaculture is the farming of aquatic animals or plants. It can be used as a means of earning additional income, producing fish for home consumption, or improving the fishing in a pond. Certain types of aquaculture can be done in recreational fishing ponds with no negative effect on sport fishing. Other forms can be practiced in ponds unsuitable for recreational fishing. Pond owners interested in a broader introduction to aquaculture possibilities for this region may want to obtain the publications listed in the "Reference Materials" section.

Shallow natural ponds that winterkill and are never more than one-third covered by aquatic vegetation make good culture sites for fish that can be grown in one season or less. Golden shiners, fathead minnows, crayfish, and white suckers can be grown in such ponds, harvested by seines or traps, and marketed as bait. Such ponds may also be suited to the culture of walleye fingerlings that can be purchased from private sources and stocked as newly hatched fry. Walleye fingerlings are generally harvested with fish traps.

Good bass-bluegill fishing ponds located near cities may be suitable for lease fishing. Under such an arrangement, a flat yearly fee is charged, giving a limited number of people the right to fish. A more intensive option is the stocking of catchable-size fish, such as channel catfish, into a pond where customers are charged by the pound for everything they catch. Such ponds require a special state license and constant on-site supervision. They are usually drainable and seineable to allow removal of uncatchable fish. Additional services such as fish cleaning usually provide a major part of the revenues generated. Some fish species, such as rainbow trout and channel catfish, can be grown in floating cages, thereby allowing the pond to be used for two purposes at the same time. Fish can be grown to a size suitable for direct consumption. Four-inch rainbow trout can be grown in cages to a length of 11 inches in 5 1/2 months at a constant temperature of 60^{o} F. Six-inch channel catfish fingerlings require two years in a typical South Dakota pond before reaching the same length (11 inches), and an aeration system is required to keep the cage free of ice.

Cage culture of rainbow trout in eastern South Dakota dugout ponds has been investigated by South Dakota State University researchers. Trout did not reach marketable size because water temperature and dissolved oxygen

content limited the dugout growing season to spring and early summer. However, the trout had excellent survival, good-eating quality, and although small were of usable size.

Alternatively, cages can be used as a means of growing fingerlings to a large enough size so that they can escape predation when released into the pond. This is a good technique to replenish channel catfish in a pond containing largemouth bass.

Caged fish must receive specially formulated fish feeds at a rate equal to about 3% of their body weight daily. As discussed in the "Feeding Fish" section, there is an increased chance of winterkill when fish are fed. Thus, feeding should only occur in large, deep ponds or those that have aeration systems.

Many of the activities discussed in this section will require a permit. Contact the South Dakota Department of Game, Fish and Parks for permit applications.

Finally, there are a host of other aquaculture possibilities that may have potential in South Dakota. Some examples include salmon, tiger salamanders, leeches, sportfish fingerlings such as smallmouth bass and hybrid bluegill-green sunfish, and the use of geothermal waters for striped bass or tilapia. These possibilities should be thoroughly investigated for the amounts of capital investment, potential economic gain, environmental limitations, and legal requirements before any financial investments are made. Special fish hatchery or bait dealer licenses are required. Check with the area Game, Fish and Parks representative for more information.

POND PROBLEMS

Pond owners can encounter numerous problems when attempting to manage their ponds for fish production. Many of these problems can be prevented or at least lessened by proper planning before pond construction and in the initial stages of area development and fish stocking. While it is usually easier to prevent potential problems earlier than it is to treat symptoms later, the following information may help pond owners deal with established problems.

MUDDY WATER

Pond water needs to be reasonably clear for production of desirable sight-feeding fish populations. Clear ponds produce several times the amount of fish as muddy ponds. Most ponds will be muddy after a heavy inflow, but in good ponds silt should settle within a week. Water clarity should be at least 15 inches during most of the year. If underwater visibility is reduced, fish production will be decreased. Water clarity is necessary for the production of algae, an important component of the food chain or web. In addition to limiting food production, muddy water can reduce the success of fish reproduction, particularly for bass.

To cure the muddy water problem, the source needs to be identified. An easy way to determine the cause is to collect a jar of water from the pond and put it on a shelf. If the suspended silt settles out within a week and the water above it is fairly clear, the problem is probably due to wind action or the activities of animals like livestock, fish like carp or bullheads, or crayfish. If the water in the jar remains muddy after a week, the problem is due to the chemistry of the soil type suspended in the water. Often the problem is a combination of factors.

Muddiness Caused by Soil Type

This is the most difficult muddy water problem to cure. The turbidity (muddiness) is caused by the suspension of clay particles that electrically re-

pel each other and will not clump together to form a particle large enough to settle. This problem can be treated by adding material that will cause these particles to clump together and settle.

Agricultural grade gypsum (hydrated calcium sulfate), available from most fertilizer dealers, can clear colloidal clay problems temporarily. It should be scattered evenly over the surface of the pond at 12 pounds per 1,000 cubic feet of water or 525 pounds per acre-foot of water. An acre-foot contains 43,560 cubic feet. To calculate the pond volume in acre-feet, the surface area of the pond should be measured in square feet and multiplied by the average depth in feet. This figure is then divided by 43,560. Some ponds built with Soil Conservation Service assistance have acre-feet volumes calculated and on file, but be aware that old ponds may have silted-in. If the pond does not clear within four weeks and there is no other source of turbidity, one-quarter the original amount of gypsum should be added.

Another material that can be used to clear clay turbidity is aluminum sulfate (filter alum). This material will cause the clay to flocculate and settle. An application of about 50 pounds per acre-foot of water will clear most ponds within a week. Alum should be dissolved in water and then quickly sprayed over the entire pond surface. This should be done on a calm day because wave action will break up the floc and it will not settle. Alum has an acid reaction with the water. If the pond is acidic (low pH) or has very soft water, about 20 pounds of hydrated lime (calcium hydroxide) should first be added per acre-foot of water. Sometimes the liming itself will cause the clay to settle. Very few ponds in South Dakota have acidic or soft water.

Organic matter can also be added to water to settle clay particles. This treatment technique is preferred to the addition of gypsum or alum because organic matter increases pond productivity rather than decreasing it. Organic matter provides food for desirable bacteria. As the bacteria break down the organic matter, by-products cause the clay particles to clump together and settle. Manure, weeds, hay, and cottonseed meal all work. When organic matter decays, oxygen is consumed. Too much organic matter can cause oxygen deficiency in the pond. If organic matter is added, it is best to use something that decomposes rather slowly, such as dry hay. It should be applied at a rate of two small bales per surface acre at 14-day intervals. The bales are pulled apart and scattered in the shallow water around the pond. No more than 4 or 5 applications should be made per year. Solid bales can also be placed along the shoreline, just into the water, every 40 feet.

The above-mentioned methods are only temporary measures. These treatments will probably have to be repeated each year (usually at lower application levels) and after periods of heavy water inflow. Ponds with chronic clay turbidity may be best managed by stocking channel catfish, in which case treatment of the turbidity problem is unnecessary.

Muddiness Due To Wind and Erosion

Strong winds often cause shoreline erosion and wave action that keep soil particles in suspension. The effect of wind can be minimized by the use of

windbreaks and shoreline protection. A windbreak can be planted on the upwind side of the pond to dissipate the prevailing summer winds. If the dam is eroding badly, it should be protected by rock riprap. Erosion of the rest of the shoreline can be lessened by deepening the shoreline during construction, thus eliminating mud flats. Eroded shores and/or mud flats on existing ponds can be stabilized by planting a water-tolerant grass such as reed canary grass.

Muddiness Due To Animal Activity

Livestock having access to a pond trample shoreline vegetation and wade in the water, especially during the summer. These activities stir mud that can then be carried over the entire pond by wind and wave action. Livestock should be fenced out of a pond if fish production is important. If livestock water is needed, a pipe through the dam to a tank below the dam will supply it. If this is not possible or feasible, all but a small corner of the pond should be fenced. This limited livestock access may cause some muddy water, but less than if livestock had access to the entire pond.

Fish such as bullheads and carp cause water to be muddy because of their feeding activities. Removal or control of these species has been described previously in the "Improving Undesirable Fish Populations" section on page 45.

A dense crayfish population causes pond water to be muddy due to their burrowing and bottom-feeding activities that stir up the mud. The introduction of predatory fish such as largemouth bass or channel catfish will solve this problem. Ponds with a good population of predatory fish will not have crayfish problems.

SEALING LEAKY PONDS

Leaky ponds are common in some areas, and almost all ponds leak to some extent, especially new ponds. However, pond owners should realize that evaporation from a pond can be substantial. During the summer, especially in hot, dry, windy periods, about a half inch of water can be lost to evaporation each day. Water loss greater than this can usually be considered leakage. The pond owner can determine his pond's leakage rate by measuring the water level drop during a period of cold or very humid, calm weather.

Leaks in ponds may be the result of permeable sand, gravel, or fractured rock layers that either exist throughout the basin naturally or were exposed during pond construction. Improper bonding of the embankment to an impermeable foundation soil can also lead to leakage. Some ponds are constructed in areas where all the soil in the basin is permeable, so the leak cannot be pinpointed. Deeper ponds tend to leak more because of the increased water pressure on the porous areas.

Techniques are available to seal leaky and potentially leaky areas. Most sealing techniques are expensive and require considerable work.

Soil layer

If a small gravel or rock area is causing leaks, a bulldozer can be used to remove some of the problem material. The area can then be covered with a layer of soil high in clay (at least 10% clay) from some part of the basin. The added soil should be at least 1 foot thick and preferably 2 feet thick. This soil should be compacted as it is being deposited. A sheepsfoot roller is recommended for serious leaks.

Bentonite

Bentonite is a clay material that expands greatly when wet. Mixed with sand or permeable soil and water, it seeps into pores, making an impermeable layer. Bentonite is usually applied at 1-2 pounds per square foot of pond bottom (more in areas over 10 feet deep). The dry powdered form creates a protective barrier when placed in a thin layer and covered with several inches of soil. Powdered bentonite can also be uniformly applied on the pond bottom and then mixed into the top 4-6 inches of soil with a disc and then compacted. This method is quite successful in sealing a pond, but the seal can be punctured if cattle walk on the muddy pond bottom. A leaky pond that contains water can also be sealed by pouring a slurry of bentonite or spreading granular bentonite over the surface of the pond. This technique is usually not as successful as applying bentonite to the dry pond bottom because it is difficult to achieve an even application of the material. Bentonite is available from most feed mills or well drillers.

Livestock

Trampling a pond basin with cattle or hogs will sometimes seal permeable soil. Livestock should be fenced into the pond area and fed in the dry pond basin for several months. The combination of the compaction of many hooves and manure and waste feed being worked into the soil sometimes makes a seal. This is especially effective if the pond basin occasionally becomes wet. However, the pond could fill before the basin has been completely sealed.

Gleization

For ponds with rock 2 1/2 feet or more below the surface, organic matter can be used for sealing. The soil surface should be covered with about 6 pounds (dry weight) of livestock manure, straw, grass, leaves, or sawdust per square yard. An 8-inch protective layer of soil should then be placed over the organic matter. A biochemical reaction takes place between the soil

and the organic matter to seal the basin.

Liners

Plastic membranes that can be placed over pond basins are available. They are expensive and must be protected from rupture. If livestock are present, their access to the pond must be prevented. In addition, muskrat burrowing can create holes in the liner.

Salt

In the past, salt was used to seal pond bottoms because sodium disperses clay particles, causing them to plug pores in the soil. This technique is no longer recommended because of possible ground-water contamination.

AQUATIC VEGETATION

All vegetation is not bad. In fact, fish benefit from far more vegetation than anglers typically tolerate. A certain amount of vegetation is needed for good fish growth and protection. Fish communities comprised of largemouth bass and bluegills function best when aquatic plants cover 25-30% of the pond surface during the summer. Plants produce food for many insects that are, in turn, eaten by fish. They also provide habitat for many fish food organisms and cover for small fish. Plants produce oxygen, protect the shoreline from wave erosion, and serve as feeding and nesting habitat for wildlife.

Aquatic plants can become so abundant that they interfere with fishing, swimming, and boating. Excessive vegetation can also provide too many hiding places for small bluegills so bass have difficulty controlling their numbers. This often leads to overpopulated bluegills. Periodic die-offs of dense vegetation, which usually occur after periods of cloudy weather, or when the water is muddy after a rain, or at the end of their growing season, can also threaten fish. Oxygen is consumed by bacteria that decompose dead plants. Low oxygen levels cause stress in fish so they do not feed and grow, and often die (summerkill and winterkill). Decayed plant material also produces offensive odors and imparts undesirable flavors to water.

To control aquatic plants, it is essential to know what type is causing problems. Aquatic plants can be grouped into four general categories: algae, floating plants, submergent plants, and emergent plants. Pond owners should either obtain the plant key listed in the "Reference Materials" section or have a reliable person identify the plant.

Algae

Algae are small plants that do not have true leaves or flowers. Microscopic, single-celled, free-floating algae are called phytoplankton. Individual plants cannot be seen, but they give the water a greenish brown tint. Filamentous algae is commonly called "moss" and consists of masses of long, stringy strands that float on top of or just under the water surface. One type of algae, Chara or muskgrass, looks very much like a submergent plant. Filamentous algae and Chara may be considered undesirable when they reach nuisance proportions.

Floating Plants

These plants have leaves that float on the water and have roots that hang down without being connected to the bottom. A common type of floating plant in South Dakota is duckweed, often seen in the marshes of our state. Rarely does this plant cause a problem in ponds.

Submergent Plants

These plants grow under the water, are rooted to the bottom, have stems, leaves, and produce seeds. Generally, they have long flexible stems with clumps of narrow leaves along those stems. Some species do have leaves that reach to the surface that are a different shape than those below the surface. Common examples of such plants are the various pondweeds, coontail, and milfoil. This category of plants generally produces most of the problems in ponds.

Emergent Plants

These plants generally grow around the margin of a pond, are rooted to the bottom, and have parts extending above the water surface. Emergent plants generally grow in shallow water. Common examples of such plants are the cattails and bulrushes.

AQUATIC VEGETATION CONTROL

Control of aquatic vegetation really should *not* be considered until plants cover more than a third of the pond area. Four different control methods can be considered.

Preventive Control

Prevention is always the best control method. Plants are common in ponds that have clear water, high fertility, and extensive shallow areas. Plant problems can be minimized through proper pond construction. All shallow mud flats should be eliminated by digging the shore area to at least 3 feet deep with a 3:1 slope. Existing ponds with extensive shallow areas can be dug deeper during periods of low water.

High fertility can cause a plant problem if nutrients increase the amount of plant growth. It is desirable to avoid rich sources of nutrients, such as runoff from livestock holding areas, septic tank drainage, or row crop fields.

Mechanical Control

Vegetation around the shore can be controlled by hand pulling, cutting, or mowing. Hand pulling is effective for cattails, willow trees, and cottonwood trees when they are small. Most submergent plants can be partially removed by raking or pulling a chain or cable through the pond between two tractors. If a small open area is desired, perhaps to allow access for easy fishing by kids, then raking a small area is a good technique.

Submergent vegetation can also be controlled by shading with dark plastic screen, similar to screening used for shade in greenhouses. A large piece of screen should be weighted down on the patch of plants. After two weeks, the screen can be moved to a new area. The advantage of this method is that fishing, swimming, and boating can take place over the screen.

All mechanical methods of vegetation control are temporary and normally affect only a portion of the pond's vegetation. They must also be used frequently during the growing season.

Chemical Control

Chemical control is expensive and temporary, but effective if properly executed. It is important to identify the problem plants, because there is no all-purpose chemical for aquatic vegetation control. Different herbicides are effective on different types of plants. Because the status of chemical regristration is always changing, specific chemical names will not be listed. However, references on plant identification and control can be found in the "Reference Materials" section of this booklet. Aquatic herbicides are available at most dealers that handle agricultural chemicals. Personnel from the South Dakota Department of Game, Fish and Parks and the Department of Water and Natural Resources can provide recommendations on which specific chemical to use.

Chemicals are registered for specific uses. Directions on the label must be followed explicitly, and precautions must be observed. Many chemicals have restrictions on the use of the water for a period of time after application. With some chemicals, fish should not be eaten for a period after application

and livestock should not drink the water for some time. These restrictions will determine which chemicals can be used.

Most chemicals are applied at a certain dosage per acre-foot of water in the affected area. Dosages are generally listed on the label of the herbicide container. Volume of the area to be treated can be calculated as described in the "Muddiness Caused by Soil Type" section on page 51.

Most aquatic herbicides do not harm fish if applied according to label directions. They are most effective if applied as the vegetation begins to grow. If applied after mid-June or if the growth is heavy, bacterial decomposition of the dead vegetation could consume all the dissolved oxygen, resulting in a fish kill. Spot treatment with a granular herbicide is an effective method to provide openings in vegetation to allow easier shore fishing.

One chemical treatment per year is usually sufficient, but in some cases, a partial treatment is needed later in the summer. Chemical control is only temporary and must be repeated almost every year. Permits may be needed for chemical treatment. Pond owners should check this requirement with their area Conservation Officer.

Certain chemical dyes can be added to the water to shade out the plants. These also are temporary, impart an unnatural tint to the water for a period of time, and are largely ineffective.

Biological Control

A common method of biological control in some areas of the United States is the use of an herbivorous fish, called the grass carp. Once the grass carp reaches a length of 6-8 inches, its diet consists almost entirely of aquatic plants. This fish is a native of the large rivers of China and Siberia. Because the grass carp is an exotic fish, its use is not presently allowed in many areas of the country, including South Dakota.

Grass carp require large rivers for spawning, and they do not reproduce in ponds. However, they are quite mobile, and often escape from ponds through emergency spillways when water flows are high.

A sterile form of the grass carp (triploid) is being evaluated as a possible means of vegetation control in South Dakota. Results to date are promising, and this sterile fish may be a useful tool for vegetation control in the future. However, they are not recommended for use at this time, and approval by the South Dakota Department of Game, Fish and Parks is required when they are used.

Fertilization can also be used as a means of biological control. Fertilization favors phytoplankton, and high densities of these microscopic plants shade the pond bottom and decrease plant growth. However, as stated previously, fertilization can cause oxygen depletion and is not recommended in South Dakota.

Ducks, geese, and swans have also been used to control aquatic plants. They are aesthetically pleasing, but can be messy, especially at the densities needed to control plants.

OLD, FILLED-IN PONDS

Many 20- to 30-year-old ponds have filled in so extensively that they have vast shallow areas choked with aquatic vegetation. Ponds are temporary features on the landscape because they accumulate silt, debris, and decaying vegetation, eventually becoming marshes and even dry land. Although filling-in is inevitable, some measures can be taken to slow the successional process.

If a pond is reclaimed that has received excessive amounts of silt from erosion, soil conservation measures such as terraces, grassed waterways, and minimum tillage can be implemented. Small dams can also be built just upstream from large impoundments to act as settling basins for silt.

Livestock trampling the shoreline can cause pond banks and the dam to slough in. In addition to benefiting fish and wildlife, the practice of excluding livestock from the pond (or providing watering areas or troughs) also increases its life. Ponds that are filled in can be renovated, but the process is expensive. It is often easier to build a new pond if other good sites are available. If the pond is located on the only good site available, it can be deepened by dredging with a drag line. A cheaper method is to drain or pump the water out of the pond and let the bottom dry. If the bottom muck is deep, it will dry very slowly, and the pond may fill with water before the bottom gets a chance to dry completely. In most cases, it is best to break the dam with a backhoe down to a level below the pond bottom. After drying for about a year, the pond bottom should be firm enough for a bulldozer to push out the sediments. This material can be pushed out to the back side of the dam and the break can be patched and packed with clay soil. It is important to "stair step" both sides of the break from bottom to top and compact each layer of added clay separately. The pond side of the dam should also have a new layer of soil pushed up against it and packed to be sure the dam is resealed. The Agricultural Stabilization and Conservation Service has a cost-share program available for cleaning out existing ponds.

MUSKRATS AND BEAVERS IN PONDS

Muskrats

Muskrats damage ponds by burrowing into dams and banks to make dens, thus increasing the chance of seepage and erosion. Den openings are about 4-6 inches in diameter and are usually near the surface, though in ponds with frequent water-level fluctuations they may be in deeper water. In clear water, dens are usually visible, but in muddy water, they must be detected with hands, feet, or a pole. When ice appears, trails of bubbles and chewed vegetation will lead to active dens.

Muskrat damage is unlikely in ponds where the dam is sodded, ungrazed, and built to Soil Conservation Service specifications. Hard clay should be

used in construction to discourage burrowing. To control burrowing after it has begun, all muskrats in the pond should be trapped and affected areas riprapped. Wire mesh or fencing can also be used, but these materials yield to corrosion after several years. If all muskrats are not removed, survivors will find a way to reopen their traditional burrows. In any case, reinvasion from outside sources may occur.

Beavers

Beavers burrow into dams and banks, cut trees, and plug outlet tubes. Their work is conspicuous, and they are extremely persistent. Bank dens are 12-18 inches in diameter and will be present whether a lodge is present or not. In fall and winter, a pile of fresh cuttings is evident near the lodge or main den.

Beaver burrows are large enough to damage even well-built dams. Riprap discourages initial burrowing, but all beavers must be trapped if burrows are to be sealed. If burrows break through the surface of the dam, the opening should be collapsed as far back as possible and filled with clay.

To keep beavers from plugging outlet tubes, the pond owner can string electrified fence wire around the tube and connect it to a fencer and battery. Wood or fiberglass posts should be used or the system will not work. After beavers have been shocked a few times, the power can be turned off until problems recur. Outlet tubes are easier to keep free of debris if they are covered with a heavy trash rack of welded metal that is periodically cleaned. Chicken wire should not be used, as it cannot be cleaned. To prevent cutting of ornamental trees, bases should be wrapped with 1/4-inch wirecloth or similar fence material. No effective repellent is commercially available.

Population Control

Sustained population control is the best method available for both animals. Small, stable populations of muskrats and beavers do little damage and are aesthetically pleasing. Pond owners should not wait until furbearers become overabundant before initiating control, because by then the damage has been done.

For most pond owners, the most feasible method of population control is to have a local trapper work the pond every year during trapping season (or the pond owner can do the trapping). Everyone benefits from this arrangement. The pond owner keeps problems to a minimum, and the trapper earns money from pelts. If muskrat or beaver problems occur during the nontrapping season, pond owners should contact their area Conservation Officer. These officers will request the State Extension Trapper to assist with the animal damage problem.

Both muskrats and beavers can be live-trapped, although equipment costs may be prohibitive. Beavers can be taken in suitcase-style Bailey or Hancock traps, and muskrats can be taken in wire box traps (Havahart type)

that are set on a float made from 2- by 8-inch boards.

CRAYFISH, TURTLES, AND FROGS IN PONDS

Crayfish

Crayfish can provide an important part of the prey base in ponds that contain predatory fish such as largemouth or smallmouth bass, and channel catfish. In fact, pond owners may consider stocking crayfish at the time fish are introduced. Crayfish may cause leaks in ponds, but only rarely when populations are extremely high. Crayfish numbers are easily controlled by predatory fish, and a good-quality pond will not have sufficient crayfish to cause problems. Crayfish populations are higher in ponds with fluctuating water levels than in more stable ponds. Crayfish can be harvested in wire basket traps or lift nets baited with meat.

Turtles

Most pond owners and anglers view turtles as a threat to fish communities in ponds. Such is not the case. Turtles are primarily scavengers, feeding on dead or dying fish and other aquatic organisms. They serve to clean the pond more than cause harm, and should not be indiscriminately destroyed. Turtles may cause problems by stealing bait and even fish from stringers. In addition, an occasional snapping turtle may capture a few live fish, but will not impact the fish populations.

Frogs

Frogs are found at all ponds, as they need water in which to lay their eggs. Tadpoles then use the water to complete their first life stage. Frogs are seldom a problem in ponds because predatory fish usually keep populations low. In fact, high numbers of tadpoles in a bass pond are a good indicator of severe problems in that fish community.

FISH PARASITES AND DISEASES

There are many parasites found in South Dakota fish. However, very few fish parasites or diseases can be transmitted to humans, and all are killed by cooking. If only one or two parasites are discovered while cleaning a fish, a little quick work with the fillet knife will get rid of the problem; do not be afraid to do so.

Grubs are the most commonly encountered parasite in South Dakota fish. These "worms" are usually found just under the skin or encysted in muscle. There is no effective chemical treatment to rid fish of grubs. The best strate-

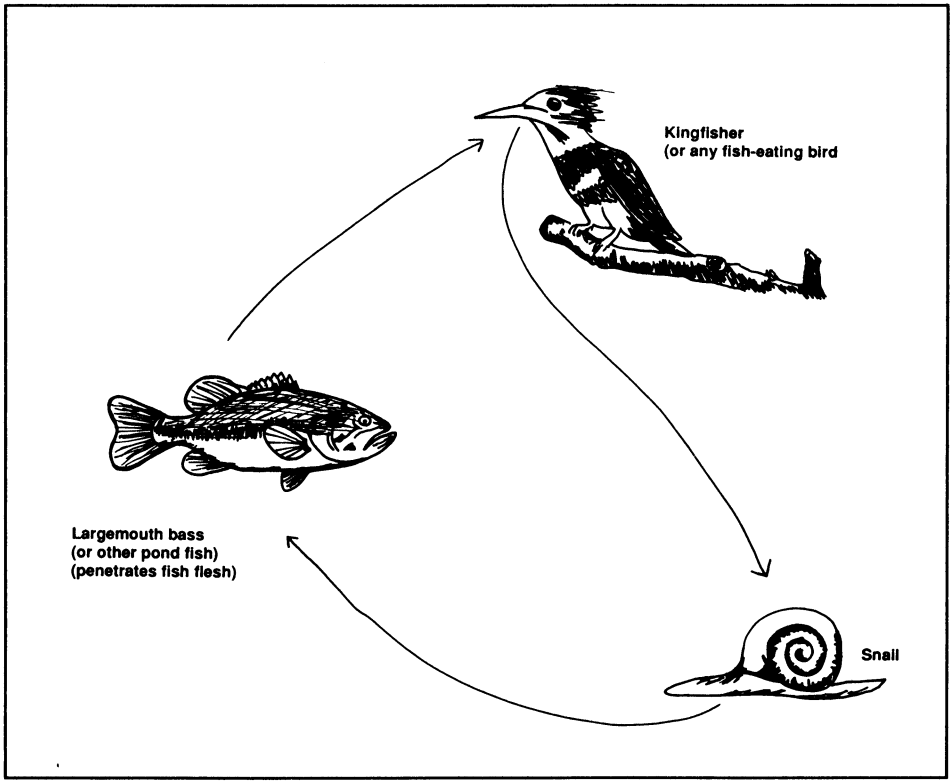


Figure 5. Life cycle of the yellow grub.

gy for dealing with them is to understand and break their life cycle. Grubs have two other animal hosts besides fish (Figure 5). By eliminating either snails or fish-eating birds, the problem can be eliminated.

Snails can be dealt with by pond draining, snail-eating fish, or applications of copper sulfate. The stocking of pumpkinseeds, a close relative of the bluegill, has been recommended as a means of reducing snail populations. Unfortunately, availability in South Dakota is doubtful at present. Copper sulfate should only be used after consultation with a knowledgeable biologist, and a permit is required for its use.

Fish-eating birds, such as herons, kingfishers, and cormorants, are protected by law, so methods other than hunting must be used to discourage them. Trees, wires, and other perching areas near ponds should be eliminated, when possible. Silhouettes of hawks have sometimes been used to scare unwanted birds from fish ponds. Some fish farms plagued by fish-eating birds have found that playing recordings of the same birds in distress is much more effective than the use of propane cannon noisemakers. Large, colorful beach balls will eyes painted on them can also be suspended over and around ponds. These beach balls act as scarecrows and fighten birds.

LEGAL CONSIDERATIONS FOR SOUTH DAKOTA PONDS

TRESPASS

Most ponds are located on property of private landowners, and permission must be obtained to fish those ponds. If a pond has been stocked by the South Dakota Department of Game, Fish and Parks, the landowner has agreed to allow reasonable access to the pond. However, that landowner maintains control over who can enter. The bottom line is: always get permission before fishing any pond on private land.

REGULATIONS AND LICENSES

State regulations, such as creel limits and seasons, apply at all ponds, except the fish-for-fee ponds that are properly licensed. These regulations apply to both visitors and pond owners. A fishing license is required to fish in a South Dakota pond, except that resident land occupants do not need a license to fish in private waters on their own land.

COMMERCIAL VENTURES

A special license is required to undertake a commercial venture of any sort on your pond. Examples of such ventures include raising bait, raising food fish for sale, or operating a fish-for-fee pond. Pond owners should contact the South Dakota Department of Game, Fish and Parks before starting any such operation.

RIGHTS AND RESPONSIBILITIES OF THE CONSERVATION OFFICER

Area Conservation Officers are always available to help pond owners with securing fish, managing ponds, or enforcing laws. These officers do have the right to enter private property in the performance of their duties.

REFERENCE MATERIALS

Fish Identification

The Fish Book, Nebraska Game and Parks Commission, P.O. 30370, Lincoln, NE 68503. Fee required.

Iowa Fish and Fishing, Iowa Department of Natural Resources, East Ninth and Grand Avenue, Wallace Building, Des Moines, IA 50319. Fee required.

Aquatic Plants

Aquatic Weeds: Their Identification and Methods of Control, Illinois Department of Conservation, 600 North Grand Avenue West, Springfield, IL 62706.

Chemical registration

A Guide to Approved Chemicals in Fish Production and Fishery Resource Management, MP 241, University of Arkansas Cooperative Extension Service, P.O. Box 391, Little Rock, AR 72203.

Pond Construction

Ponds—Planning, Design, Construction, U.S. Department of Agriculture, Soil Conservation Service, Handbook Number 590. Available from your local SCS office.

Pond Management

Producing Fish and Wildlife from Kansas Ponds, 2nd Edition, by D.W. Gabelhouse, Jr., R.L. Hager, and H.E. Klaassen. Kansas Department of Wildlife and Parks, RR 2, Box 54A, Pratt, KS 67124. Fee required.

Trout Ponds for Recreation, U.S. Department of Agriculture, Farmer's Bulletin No. 2249. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Aquaculture

Fish Farming? by M.D. Beem, Extension Extra 12001, Cooperative Extension Service, South Dakota State University, Brookings, SD 57007.

Building Cages for Fish Farming, by M.D. Beem, Extension Extra 12002, Cooperative Extension Service, South Dakota State University, Brookings, SD 57007.

Rainbow Trout Culture in South Dakota Lakes and Ponds, by M.D. Beem, Extension Extra 12003, Cooperative Extension Service, South Dakota State University, Brookings, SD 57007.

Bait Vendors Handbook, by G. Van Eeckhout, North Dakota Game and Fish Department, 100 North Bismarck Expressway, Bismarck, ND 58501.

Parasites/Diseases

Parasites of Fish in South Dakota, Bulletin 484, Agricultural Experiment Station, South Dakota State University, Brookings, SD 57007.

Periodicals

Farm Pond Harvest, Quarterly Magazine, Professional Sportsman's Publishing Company, RR 2, Momence, IL 60054. Fee required.

Muskrat and Beaver Control

Identifying and Managing Aquatic Rodents in Texas: Beaver, Nutria and Muskrats, by D.A. Wade and C.W. Ramsey. Publication B-1556, Texas Agricultural Extension Service, Texas A & M University, College Station, TX 77843.

GLOSSARY

Acre-foot–Term used to describe storage capability of an impoundment; an acre-foot of water has an area of one acre covered with water to a depth of one foot.

Algae–Minute plant life living in a body of water; in addition, two types of algae resemble more complex aquatic plants.

Anal fin–Fin on the bottom of a fish, behind the anus.

Carrying capacity–Maximum poundage of organisms a given area can support throughout the entire year.

Caudal fin–Tail fin.

Dorsal fin–Fin on the back (top) of a fish.

Emergent aquatic plants–Rooted aquatic plants that grow beyond the surface of the water.

Epilimnion–Warm upper layer in a thermally stratified lake.

Fish community–All fish in a given body of water.

Fish population–All members of a single species of fish in a given body of water.

Food chain–A relationship of animals and plants, in which one is the food of another; food chains usually start with photosynthetic organisms and end with predators.

Food web–A complex food chain; a more realistic view of nature.

Hypolimnion–The cool lower layer of a thermally stratified lake.

Photosynthesis–The process whereby green plants manufacture food using light as an energy source and carbon dioxide and water as raw materials; oxygen is released as a by-product.

Phytoplankton–Minute plant life living in a body of water.

Recruitment–Reproduction and survival to adulthood.

Respiration–The process by which animals and plants release energy in cells; involves the intake of oxygen and the release of carbon dioxide.

Standing crop–The total weight of a given population of organisms at any given time.

Submergent aquatic plants–Aquatic plants that grow from a pond bottom to the surface of the water.

Summerkill–Complete or partial kill of a fish population in ponds or lakes during warm months; caused by excessively warm water and a depletion of dissolved oxygen.

Supplemental feeding–Supplying a prepared diet to supplement the natural food of fishes in a pond.

Thermal stratification–The layering of water masses owing to different densities in response to temperature.

Thermocline–The transition zone between the epilimnion and hypolimnion where water temperatures decline at least 1^{o} F per foot of water.

Turbidity–The cloudy condition caused by suspended solids in a liquid.

Winterkill–Death of fish in a pond during a prolonged period of ice and snow cover; caused by oxygen depletion due to respiration and a lack of photosynthesis.

Zooplankton–Minute animal life living in a body of water.