NEBRASKA POND MANAGEMENT

second edition

NEBRASKA GAME PARKS

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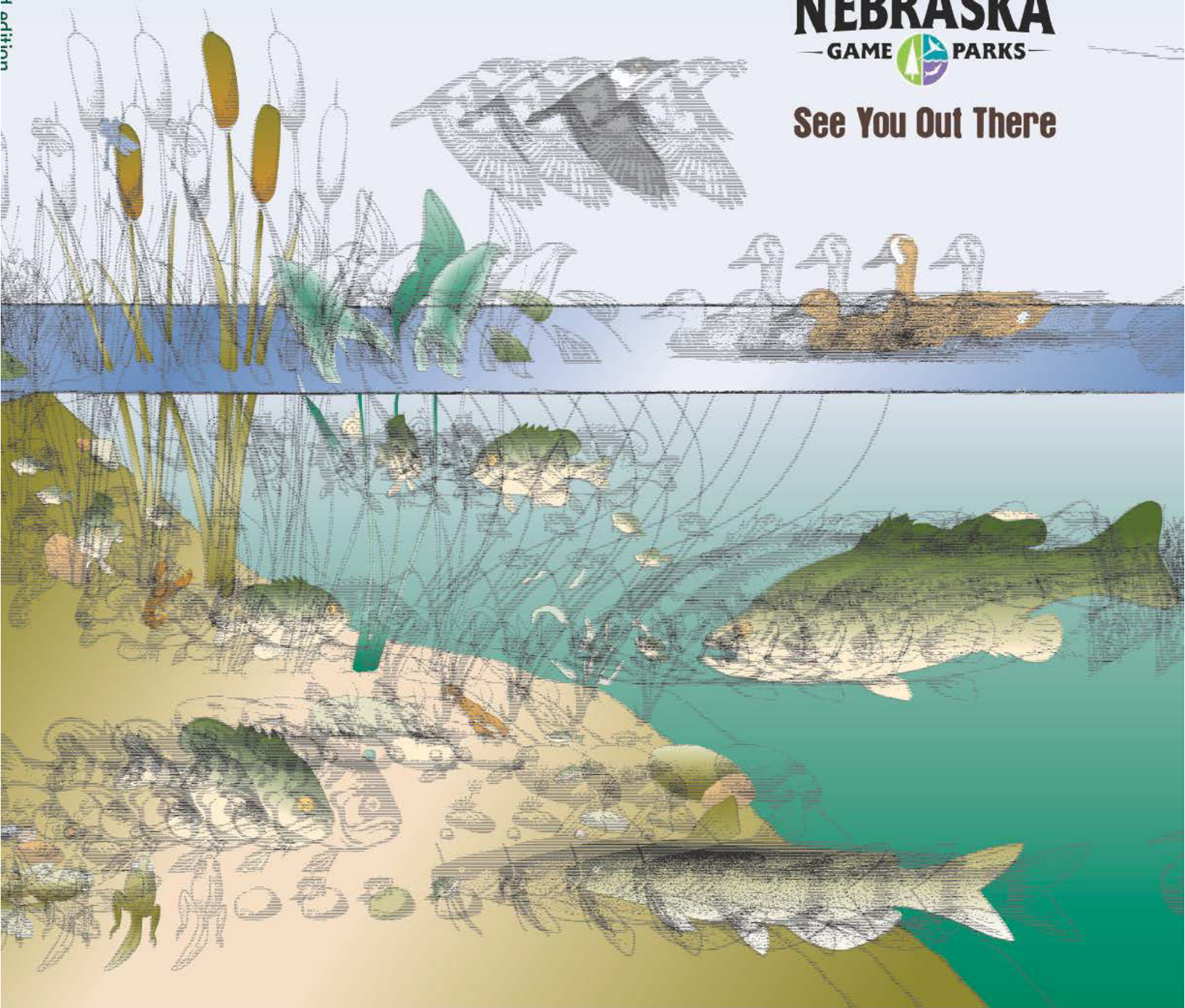

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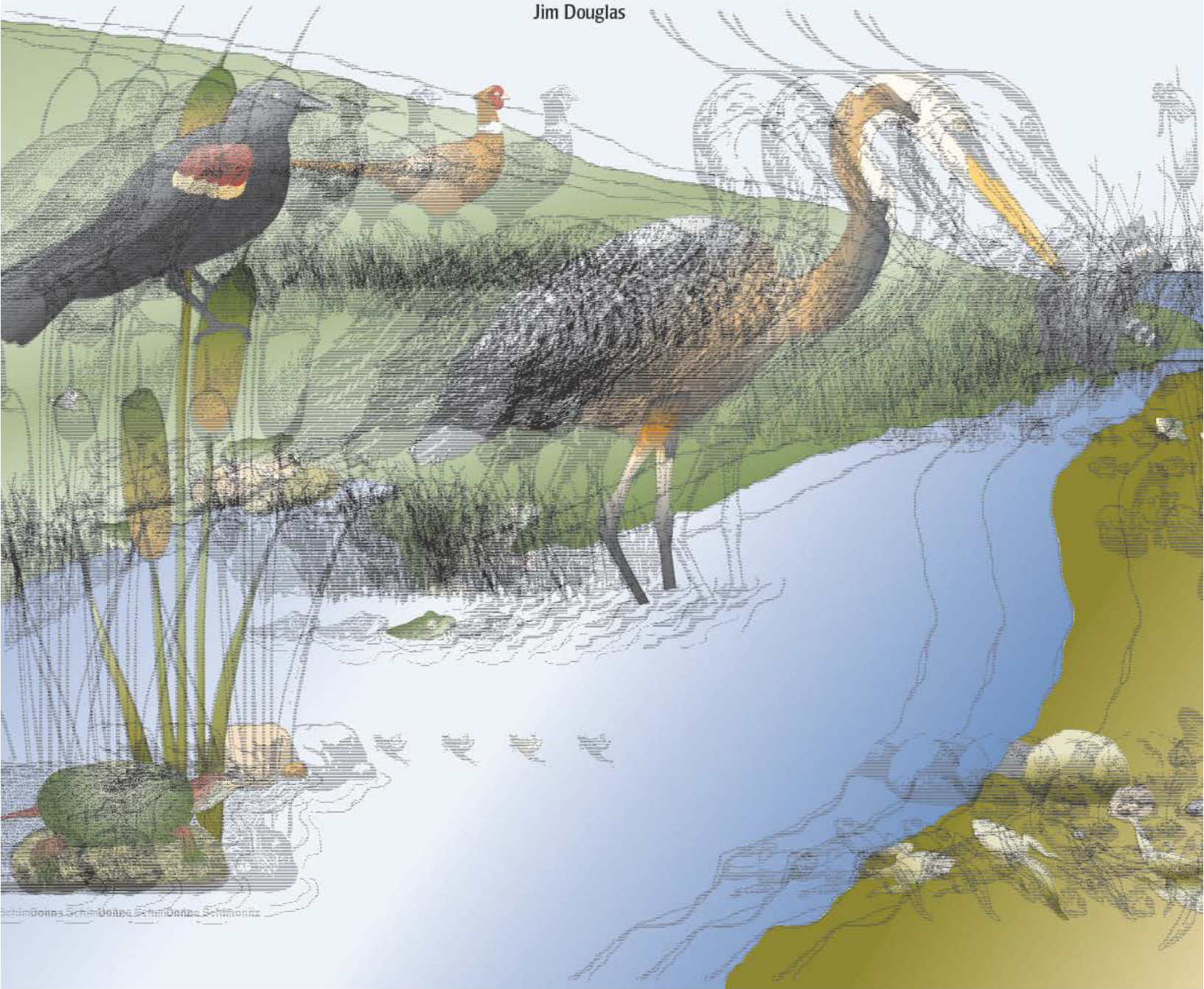

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NEBRASKA GAME PARKS

See You Out There

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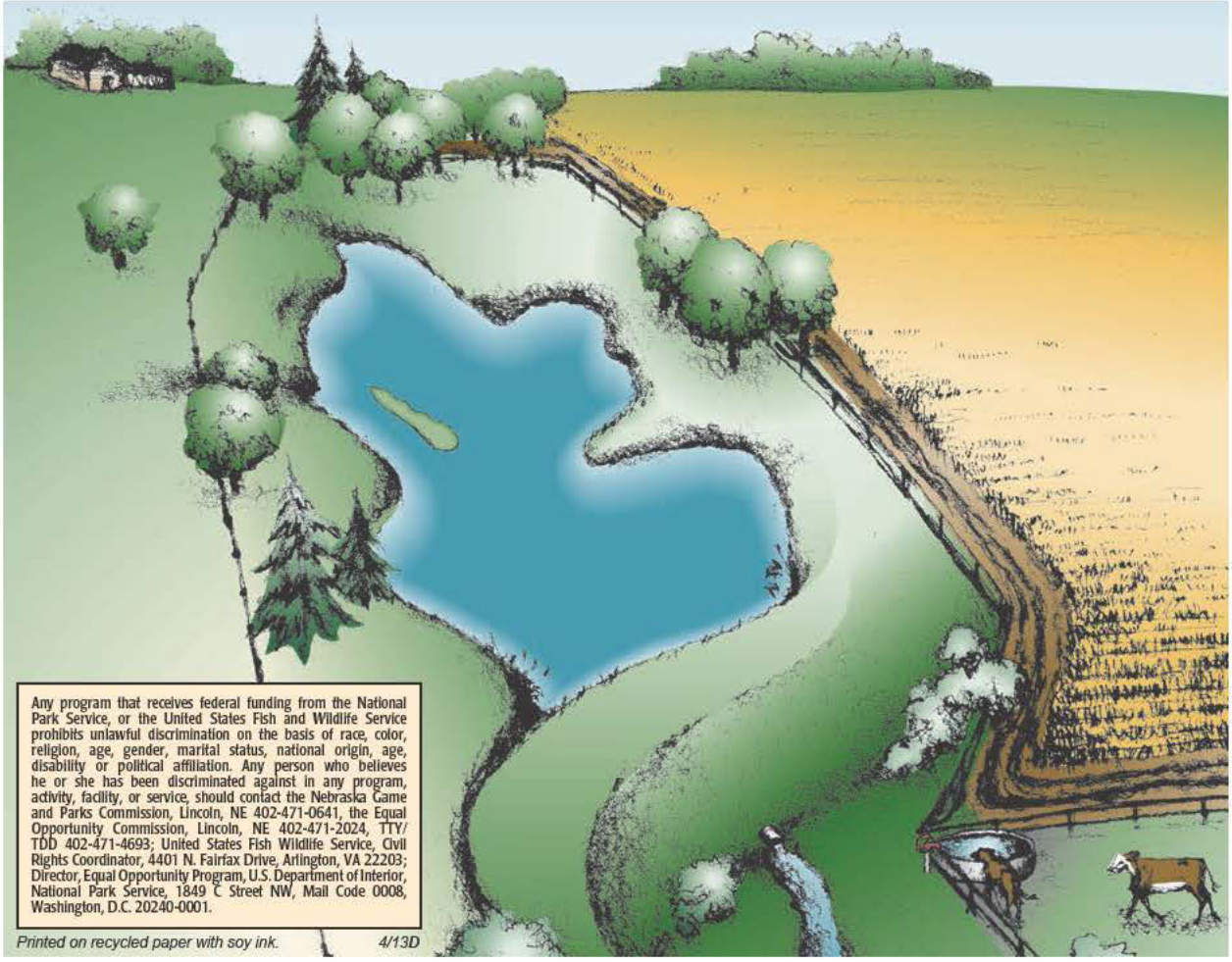

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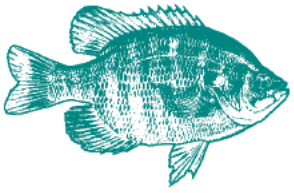

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INTRODUCTION

Many ponds have been constructed in Nebraska over the years, most in the eastern third of the state. Several surveys have found that about 25% of licensed anglers fish in private impoundments, primarily farm ponds. Although many ponds provide good fishing, some do not. Poor fishing can result from improper pond construction or management, or uses that conflict with fish production.

Ponds need to have good water quality, favorable aquatic habitat, and proper management in order to develop and maintain desirable fish populations. They must also have adequate water depths to prevent excessive growth of aquatic vegetation and to support aquatic life during periods of adverse environmental conditions. Finally, they need to have the correct balance of fish populations to achieve desired angling goals.

This handbook is intended to help owners of both new and old ponds, and those who plan to build a pond, to maximize the fishing potential of their pond. Information is provided on pond construction, stocking, environmental modifications, management, and maintenance. By understanding the conditions that can lead to problems, the pond owner can correct them, or even prevent them from occurring in the first place. If after reading this handbook you still have questions or would like to discuss any topics in greater detail, contact the fisheries or wildlife biologists at your area Nebraska Game and Parks Commission district office, or the Commission's Private Waters Specialist in Lincoln (see Appendix A for a list of technical assistance contacts).

Whether you enjoy fishing for bluegills with a child or catching a lunker bass, searching the thick shoreline vegetation for a late season rooster pheasant, or just listening to a bullfrog serenade, we hope this handbook will help you maximize the enjoyment you receive from your pond.

POND CONSTRUCTION

Developing a good fishing pond involves more than just pushing up some dirt to impound water and stocking fish. By building a well designed pond, an environment can be created that will support a multitude of organisms, both plant and animal, important to fish. With proper stocking and management, a pond can produce a quality fishery, benefit terrestrial wildlife, and be relatively maintenance-free.

Pond Types

There are two types of ponds: embankment and excavated. An embankment pond, hereafter referred to simply as a pond, is made by building a dam across a ravine or draw to impound flowing waters. An excavated pond, hereafter referred to as a dugout, is made by digging a pit in a flat area that is usually wet for extended periods of time or near a stream/river, keeping in mind flooding potential. Dugouts are normally sustained by groundwater and/or springs. Water depths must be monitored during the excavation process to ensure sufficient depths for fish are available when completed. Attaining proper depths may be very difficult in some wet areas. Information for ponds provided throughout the remainder of this handbook, except for dam construction considerations, can also be applied to dugouts.

Site Selection

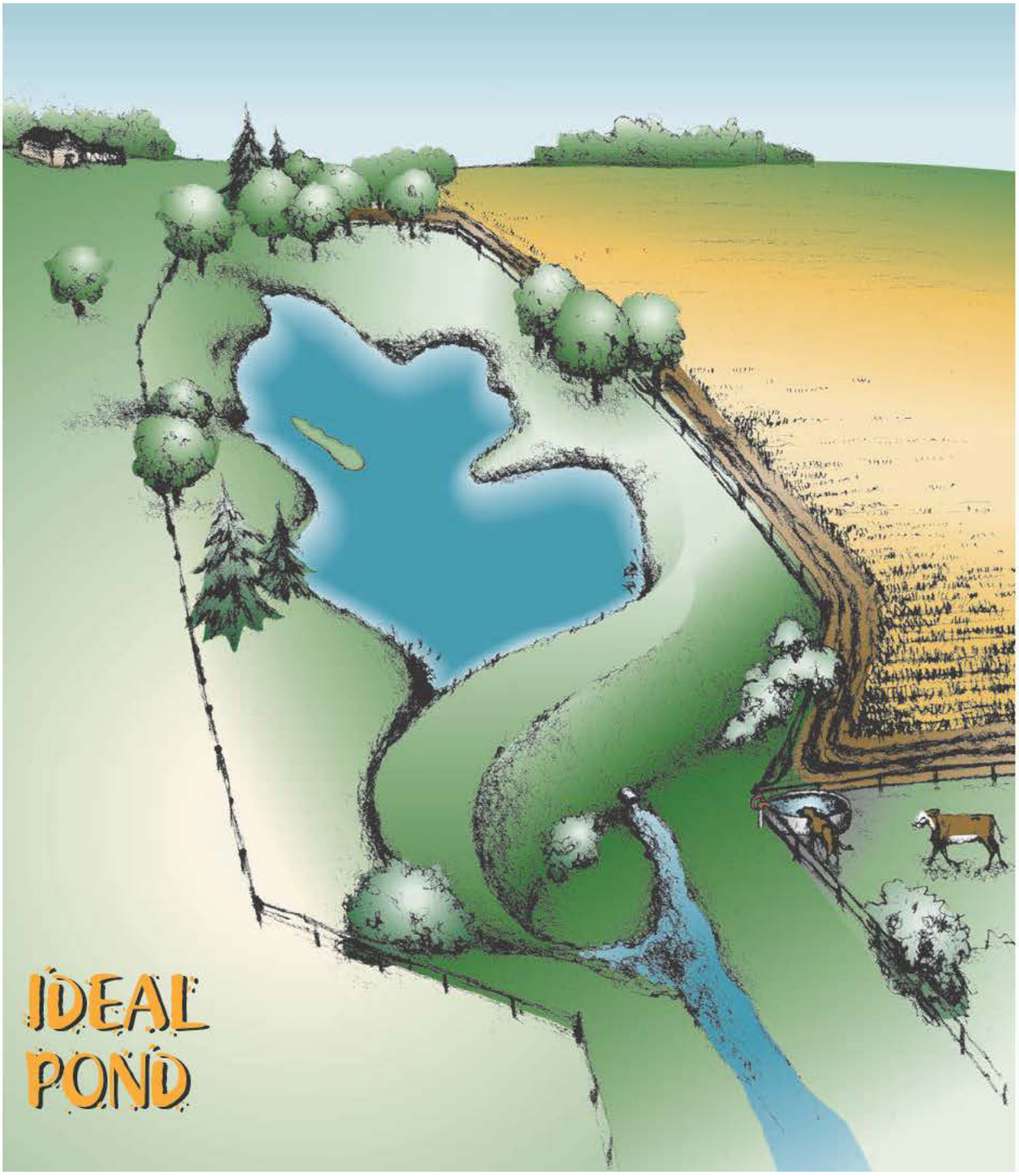
The success or failure of a pond may depend upon the site you choose. Careful site selection can reduce construction and maintenance costs, and increase the benefits you receive from your pond. Although most potential pond sites have some features that are less than ideal, many deficiencies can be overcome with good planning and design. When thinking about location, don't forget about convenience. A well planned pond that is close to home and easily accessible will be used more often and provide more enjoyment than one that is far away and hard to reach. In addition, it is more likely to be properly maintained.

Watershed

The size of the **watershed**, or drainage area, is an important aspect of site selection. The watershed includes the immediate pond site and all land that drains to the pond. This may include land belonging to other people.

The minimum watershed area needed for each acre of pond surface is called the watershed ratio. The ideal watershed ratio varies from 20:1 in southeastern Nebraska to in excess of 50:1 in the Panhandle. This means a 1-acre pond containing 5 acre-feet of water built in the southeast needs 100-acre watershed to maintain water levels, while a similar pond in the Panhandle would need a 250-acre watershed. The exact ratio for a specific location depends on annual precipitation, soil type, the amount and types of vegetation in the watershed, pond uses, and the slope of the watershed.

Watershed ratios vary across the state. Personnel from the local U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) office can help determine that ratio as well as the total annual yield of surface runoff for a particular site.


IDEAL
POND

Ponds with large watersheds typically require a larger dam and therefore cost more to build. Ponds with very large watersheds, or very high watershed ratios for their part of the state, are often unsuitable for fish production. Major runoff events from heavy rains may cause flooding and erosion in the pond or spillway area. They may also bring in heavy sediment loads that fill in the pond and muddy the water. The added turbidity, or muddiness of the water, affects fish, their food organisms, and aquatic plants. Even runoff from normal rainfall can slow fish growth by causing temporary food shortages if most of the food items, particularly microscopic plants and animals, are flushed out.

When possible, check dams, terraces, and vegetated buffer areas should be established in the watershed before a pond is built. These practices will slow runoff and allow suspended sediment to settle out before entering the pond, thus reducing sediment problems and prolonging the life of the pond. Terraces can also be used to divert excess water away from the pond.

See page 58 for additional information on effects of muddy water and ways to resolve turbidity problems.

Another potential problem associated with major runoff events is fish movement. Fish may swim out of a pond or enter it from either the watershed or downstream areas during high water. Any undesirable fish in the pond's watershed should be eliminated, if feasible, prior to construction, or they may hamper fishery management efforts. Installation of an overflow structure (see pages 16-21) in the dam will prevent most fish movement into the pond from downstream.

It is difficult to maintain good fish populations in ponds with small watersheds. Water levels may drop so low during prolonged hot and dry periods that all aquatic life could be jeopardized. The smaller the volume of water, the faster it warms and the less oxygen it can hold. Less water also means a reduction in the pounds of fish the pond can support. With decreased water levels, aquatic vegetation can become more abundant. If this vegetation dies, its decomposition can reduce oxygen levels and cause a fish kill. Terraces can be used to divert more water to a pond with a small watershed.

An important aspect of site selection is the immediate **topography** (land elevations and slopes). Since earth moving is one of the biggest construction costs, select a pond site that requires the smallest dam to impound the largest amount of water and that has an adequate volume of soil for dam construction on site or close by. An ideal site would be a natural draw, or low area with a moderate slope, that narrows at the dam site. This would result in a pond that contains adequate amounts of deep and shallow water. Steep-sided sites should be avoided because they will not contain sufficient shallow water for fish spawning and nursery areas and may become unstable and slump into the pond once it fills. Sites that have extensive flat areas should also be avoided because they may result in high evaporation rates and excessive aquatic vegetation growth.

To ensure your pond will hold water, it is very important to determine the water holding capacity of the **soils** present at your site prior to construction. This will help you avoid building a pond that doesn't hold water. Soils containing sand or gravel are typically not suitable for dam and spillway construction. Since soils can vary at surface and subsurface levels, a number of core samples must be collected within the site to depths deeper than the expected excavation depth. NRCS personnel should be contacted about soil suitability and testing.

The best soils for a pond site are those that allow water to penetrate very slowly. These include clay, silty clay, loams, and sandy clay/loams. When compacted and moistened, particles in these soils swell and seal the bottom. If there isn't enough clay at the site to build a reliable dam, it may have to be imported from a nearby source. Keep in mind, some clay soils are easily suspended in water and do not readily

settle out, causing the water to remain turbid. Soils containing very porous components, such as sand or gravel, or those containing bedded materials, such as shale or limestone, can allow impounded water to flow under or around the dam and should be avoided. Soil suitability can also be determined by checking nearby ponds for clarity and seepage problems.

The quality of the fish community in a pond is a reflection of the quality of the watershed.

Land use in the watershed is another important consideration when selecting a pond site. The vegetative cover in the drainage area greatly influences the quality, quantity, and flow of water that enters a pond. Ideally, the best cover for a drainage area would be undisturbed grassland. Thick vegetation will slow runoff, acting like a sponge to soak up rainfall, and then gradually release clear, filtered water to the pond. Land with grass cover has minor erosion problems. If possible, the pond should be located near established wildlife cover, which would encourage immediate use by various wildlife species. Land with row crops or construction sites can have major erosion and sedimentation problems if proper soil conservation practices or buffer strips are not in place. A pond with watershed disturbances can fill with sediment in just a few years. Sediment-laden runoff from row crops may contain agricultural chemicals and nutrients that can result in fish kills, reduced fish numbers or growth rates, and excessive aquatic vegetation.

If a pond's watershed must include cultivated land, the amount should be as small as possible. Soil conservation practices, such as terracing, minimum or no-till farming, strip-cropping, and buffer strips, should be established before a pond is built in a cultivated watershed. A vegetated buffer strip at least 100 feet wide should be established and maintained between the pond and any nearby cultivated land.

Consult NRCS and Commission Wildlife Division personnel about the various buffer programs that are available. Most of the programs provide cost-share and even payments to establish and maintain buffers.

Another site selection consideration is whether there are potential **pollution sources** in the watershed. The fish community will be negatively affected if a pond constantly receives runoff from high nutrient sources, such as a barnyard or feedlot, domestic sewage, or heavily grazed or fertilized pastures. Runoff from such areas promotes excessive growth of aquatic plants. Any potential sources of pollution should be eliminated prior to pond construction. Cattle should be excluded from the pond and dam to prevent their excrement from entering the pond. An alternative is to construct a check dam large enough to contain the contaminated runoff, or to divert it around the pond, if legal. Contact the Nebraska Department of Environmental Quality (NDEQ) regarding barnyard or feedlot runoff and domestic sewage. Use caution when applying chemicals, particularly insecticides, in the watershed. Misuse could result in contaminated or dead fish.

See page 23 for additional information on livestock related problems and how they can be solved.

Water Sources

The water supply for your pond should be adequate to replenish water lost to evaporation and leakage, but not so excessive that erosion and flooding are problems. Constructing a pond on a perennial (always flowing) stream should usually be avoided, particularly in eastern Nebraska, where most watersheds include cultivated land. Streams and major drainages generally have large watersheds with numerous potential problems, as mentioned earlier.

Damming a stream usually requires an expensive dam and an extensive spillway structure to control the volume of flow during high runoff events. In drier parts of the state, constructing a pond on a small or intermittent (not always flowing) stream may be the only way to obtain sufficient water to maintain a pond. A portion of a stream's flow might be diverted into a pond constructed off-channel, with steps taken to keep out sediment and unwanted fish. Contact your local NRCS office to determine the feasibility of this approach and what permits would be needed.

Dugouts can sometimes be built near a flowing stream or river to utilize groundwater, instead of surface water. The excavated soil can then be used to make a berm around the dugout if the area is prone to flooding, reducing the chance of unwanted fish entering the pond.

Springs may be considered as a potential water source if flows are sufficient. First obtain a flow estimate by measuring the flow volume several times during the year. This estimate, along with estimated seepage and evaporation rates for the site, can then be used to determine what size of pond can be built. NRCS personnel can help determine site feasibility.

Depending on the surface area and volume of a pond, a well or domestic water source may be used to supplement the water supply. Determine the amount of water needed, and then determine if it is economically feasible to maintain the pond level with a well, particularly during dry periods. When a well is used to fill a pond, the delivered water should be piped to the pond to eliminate erosion problems. Most wells need to be registered with the Nebraska Department of Natural Resources (DNR) and permits may be required by the local Natural Resources District (NRD).

Ponds filled by springs or small, coldwater streams may be able to sustain trout if water temperatures stay below 70 degrees year-round. Water temperature should be monitored before trout are stocked, particularly during the summer months. Such ponds may have water too cool for good growth of largemouth bass, bluegill and channel catfish, but still too warm to sustain trout. Since these types of ponds typically have good water clarity and stable water temperatures, they may have excessive growth of aquatic vegetation, especially if they are shallow. Pond construction on most cold-water streams should be avoided, especially if a naturally-reproducing trout population is present or the stream needs to be an open system to facilitate trout movement.

Pond construction on most coldwater streams should be avoided. Contact a local Commission fisheries biologist for advice.

Pond Size

An ideal fishing pond would cover 1 to 5 surface acres. Although ponds larger than 5 acres would provide fishing for more anglers, they can be more difficult and expensive to manage if problems arise. While fish populations can be managed in properly constructed ponds of any size, smaller ponds, particularly those less than one-half surface acre, have a number of disadvantages. They are more susceptible to water level fluctuations and may even go dry during droughts. Since smaller ponds are also typically shallow, they are likely to have excessive growth of aquatic vegetation and are more susceptible to summer and winter fish kills. Smaller ponds are also easier for anglers to overharvest, so harvest restrictions, especially for bass, will likely have to be applied. For ponds smaller than one-half acre, it is best to allow no fish harvest at all (catch-and-release only). Ponds less than one-half surface acre are also not eligible to receive fish for initial stocking from the Commission.

Pond Depth and Slopes

Ponds need to have both deep and shallow areas to benefit fish and fishing. Deep water protects fish from winterkill, discourages

excessive growth of aquatic vegetation, helps withstand water losses due to evaporation and leakage, and reduces the negative effects of sedimentation. Some shallow water is necessary for fish spawning and nursery areas and to produce food, especially aquatic insects, for fish. As a general rule, 25% of the pond should be at least 10 feet deep in southeastern Nebraska and at least 12 feet deep in western and northern Nebraska. No more than 25% of the pond should contain water less than 4 feet deep. Ponds should also have about 50% of the impounded area at least 8 feet deep to prevent excessive growth of aquatic vegetation, especially those with good water clarity. The slope from the shoreline to a water depth of 4 or 5 feet should be no flatter than 1 foot vertical drop for every 3 horizontal feet. Then create several benched flat areas to facilitate placement of structure (rock piles, weighted trees, pallets etc.) for fish habitat (see page 41 regarding artificial habitat). The slope should then taper to at least 8 feet in depth for two-thirds of the distance from the dam to the upper reaches of the pond. Although the shoreline may have to be graded to attain a 3:1 slope, grading may be cheaper than the future costs of aquatic vegetation control. Slopes greater than 2:1 should be avoided because of safety hazards and the likelihood of shoreline slumping into the pond.

Having deeper water doesn't necessarily mean more fish can be produced in a pond because fish production is based primarily on microscopic plant and animal growth occurring in the upper 3 to 5 feet of water. Also, water greater than 15 feet deep may not be used by fish during summer months due to low oxygen levels usually present at those depths.

Site Preparation

Once a site has been selected, all trees, vegetation, roots, stumps, and large rocks must be removed from the dam site. If they aren't, the decay of organic materials will create passages that will allow water to seep through the base of the dam. Large rocks may prevent the soil from being properly compacted, which also could result in seepage. All topsoil containing organic material removed from the pond site should be stockpiled close by. Once construction is completed, the topsoil should then be spread over the dam and spillway to promote grass growth, and over the excavated basin to promote fertility and sealing.

Trees and brush should also be removed from areas that are planned for swimming and wading. Small ponds will likely need to have all brush and trees removed since the majority of the fill material for construction of the dam will likely have to come from the basin.

Catfish-only ponds should have all debris removed and the bottom left smooth to reduce spawning sites and lessen the likelihood of the pond becoming overpopulated with small catfish.

Some of the trees and brush that are removed can be stockpiled and then placed back in the pond basin or the upper reaches when construction is done. They will provide fish habitat, enhance production of fish food items, such as zooplankton and aquatic insects, and help trap sediment and debris. Trees and brush in non-excavated areas of the pond bottom should be left intact, especially in larger ponds. They will also provide fish habitat and become a substrate on which aquatic organisms can grow.

To minimize impacts to wildlife, existing cover in draws and waterways leading into the pond site should also be left undisturbed. This will also help to enhance water clarity and lessen shoreline erosion and sediment problems as the pond fills. Decomposition of flooded vegetation will also improve water clarity by facilitating settling of suspended soil particles.

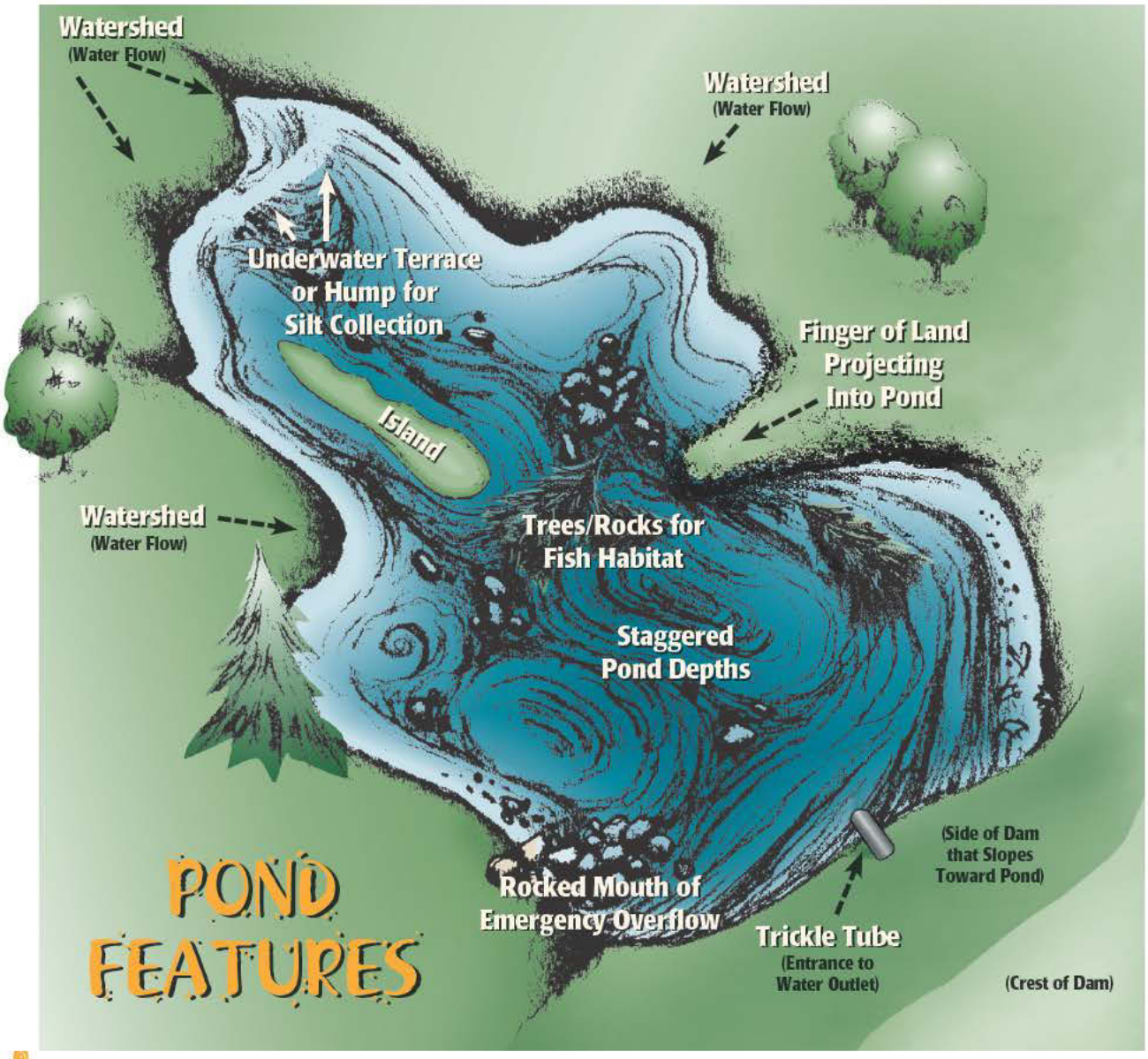
See page 39 for additional information on establishing and improving fish habitat.

Dam Construction

It is important that the material in the dam be tied to the soil in the foundation. A cutoff or core trench should be cut lengthwise, along the dam's centerline. This trench should be deep enough that all soil, sand, gravel, and loose rock is removed down to either solid rock or clay. The trench should extend a minimum of 3 feet into impervious subsoil or be anchored into solid rock the length of the dam and into the valley walls at each end of the dam. It should have a minimum base width of 8 feet. This trench should be backfilled with clay, compacted in layers to the top of the dam, creating a clay wall within the dam. Failure to install a core trench and wall can result in seepage through, or even loss of, a dam.

The dam should be constructed of impervious moist material that is compacted in continuous horizontal layers as it is installed. Dams pushed up with a bulldozer and not compacted have a greater chance of failing. All material should be compacted by either a sheepsfoot roller or an earthmover with rubber tires.

The recommended dam top width is 12 feet for a dam less than 20 feet high. For taller dams,



the width should be increased an extra 2 feet for each additional 5 feet of height. The actual dam height depends on pond size, along with the size, slope and usage of the watershed. All dams should have at least 3 feet of extra height, or freeboard, to prevent flood waters and waves from overtopping them.

The dam should be constructed with slopes that will not slump or slide. The steepness of the slope on the pond side of the dam should not exceed 3:1 and the steepness of the slope on the downstream side should not exceed 2.5:1.

Muskrats and beavers sometimes burrow into a dam. These holes may eventually cause the dam to fail due to erosion. An adequate freeboard and width is needed to eliminate leakage or dam failure. Since beavers and especially muskrats prefer steeper slopes for burrowing, another option is to construct steeper banks on the nearby pond banks than those found along the dam. Lining the dam face with rock 2 feet above and 3 feet below the water surface will also deter burrowers.

Additional information on beavers and muskrats is provided on page 78.

Pond Bottom Design

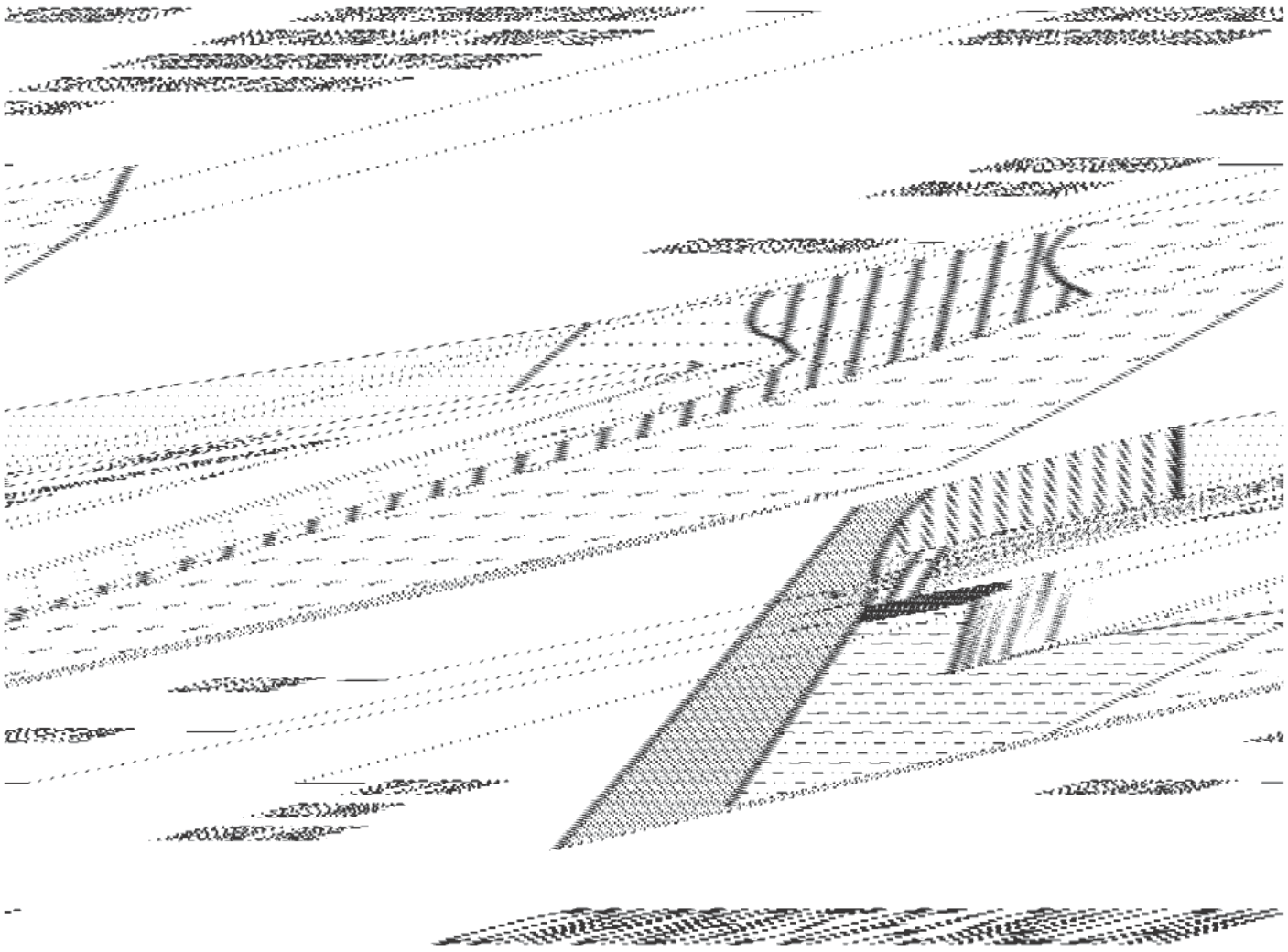
The least desirable design for a bass-bluegill-catfish pond is one with a bowl-shaped bottom, with no irregular features. If core samples indicate soil is suitable (will not leak), bottom features can be made that will benefit fish production as well as angling opportunities. Trenches and drop-offs can be built to diversify basin fish habitat. Deeper water near shore will benefit fish and shoreline anglers, but should be avoided in wading and swimming areas. Underwater terraces and humps can also be incorporated, particularly in the upper reaches of the pond. They will provide additional structure and slow incoming water, allowing sediment to settle out in the upper reaches of the pond. Those underwater structures should be considered when it isn't feasible to install sediment/nutrient entrapment structures above the pond. Excess fill soil can be used to create additional shoreline by building fingers of land that extend into the pond (either below or above water surface), or small islands. This will increase shoreline access and produce additional fish habitat. Make sure adequate depth is present adjacent to these structures to prevent excessive growth of aquatic vegetation.

Water Control Structures

Ideally, the pond owner should have complete control of the water entering and leaving the pond. Inlet and outlet structures are two of the most important structural features of a pond. When incorporated into new pond designs, they will help prevent and control many common problems. An outlet structure enables the owner to drain the pond to make repairs, manage fish populations, control nuisance aquatic plants, and encourage desirable aquatic plants. Most waterfowl management efforts require some water level manipulation and a flooded food source, so a water control structure needs to be included in the pond design. Installing only an earthen overflow spillway not only prevents water control, it can also result in erosion and dam failure if it is not properly designed and maintained.

An inflow or inlet control structure may be necessary to prevent waters containing pollutants or undesirable fish from entering the pond. When streams are used as a water supply, the stream should be diverted around the pond and an inlet pipe, which can be screened or closed as needed, should be installed.

One type of outlet control structure is a trickle tube. The upper opening is installed at the planned water level. The tube is then sloped downward with the lower opening at or near ground level at the back of the dam. The tube should be large enough to carry most of the runoff, or at least large enough to draw the water level down in a short period of time once storm flows subside.



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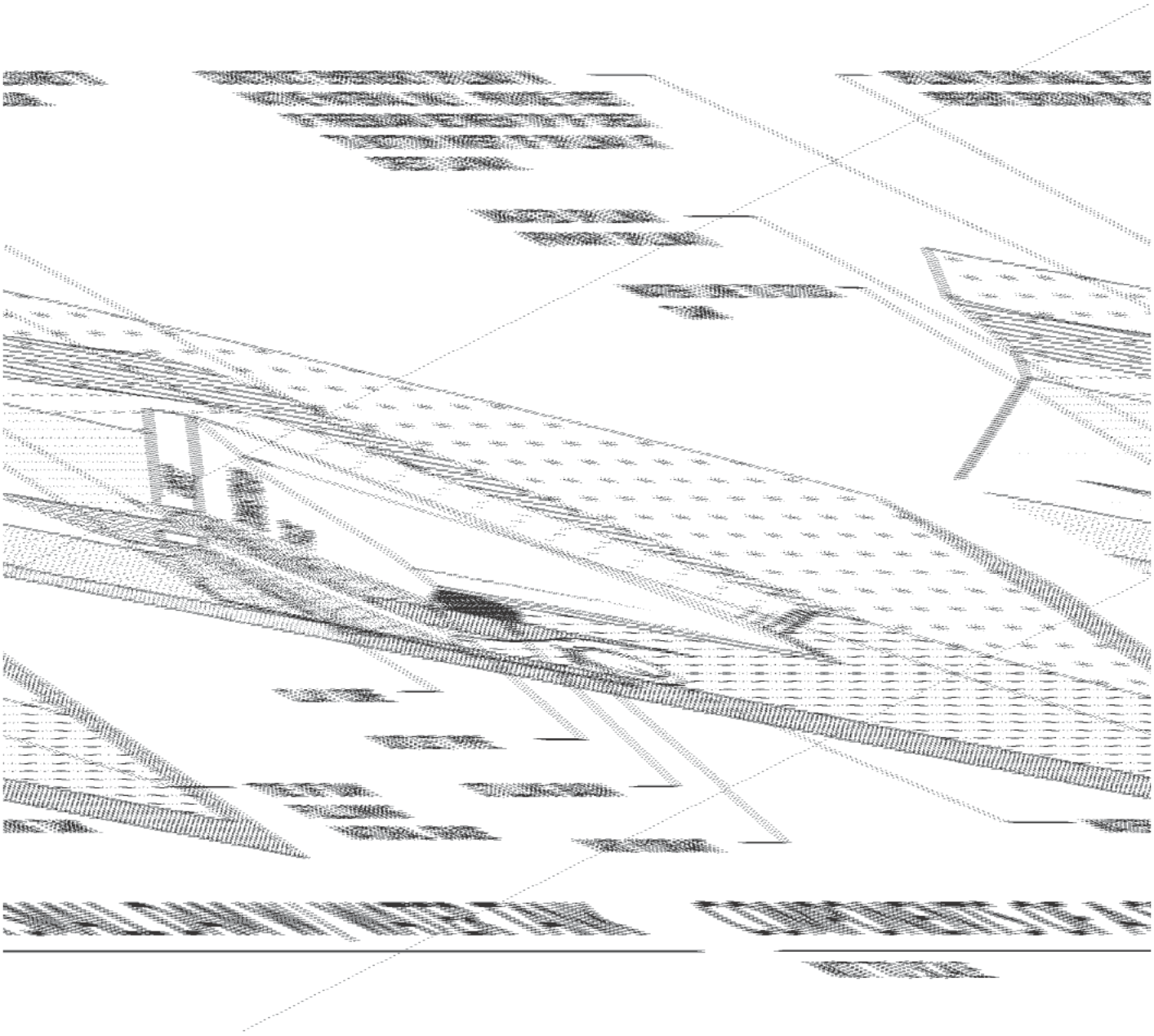
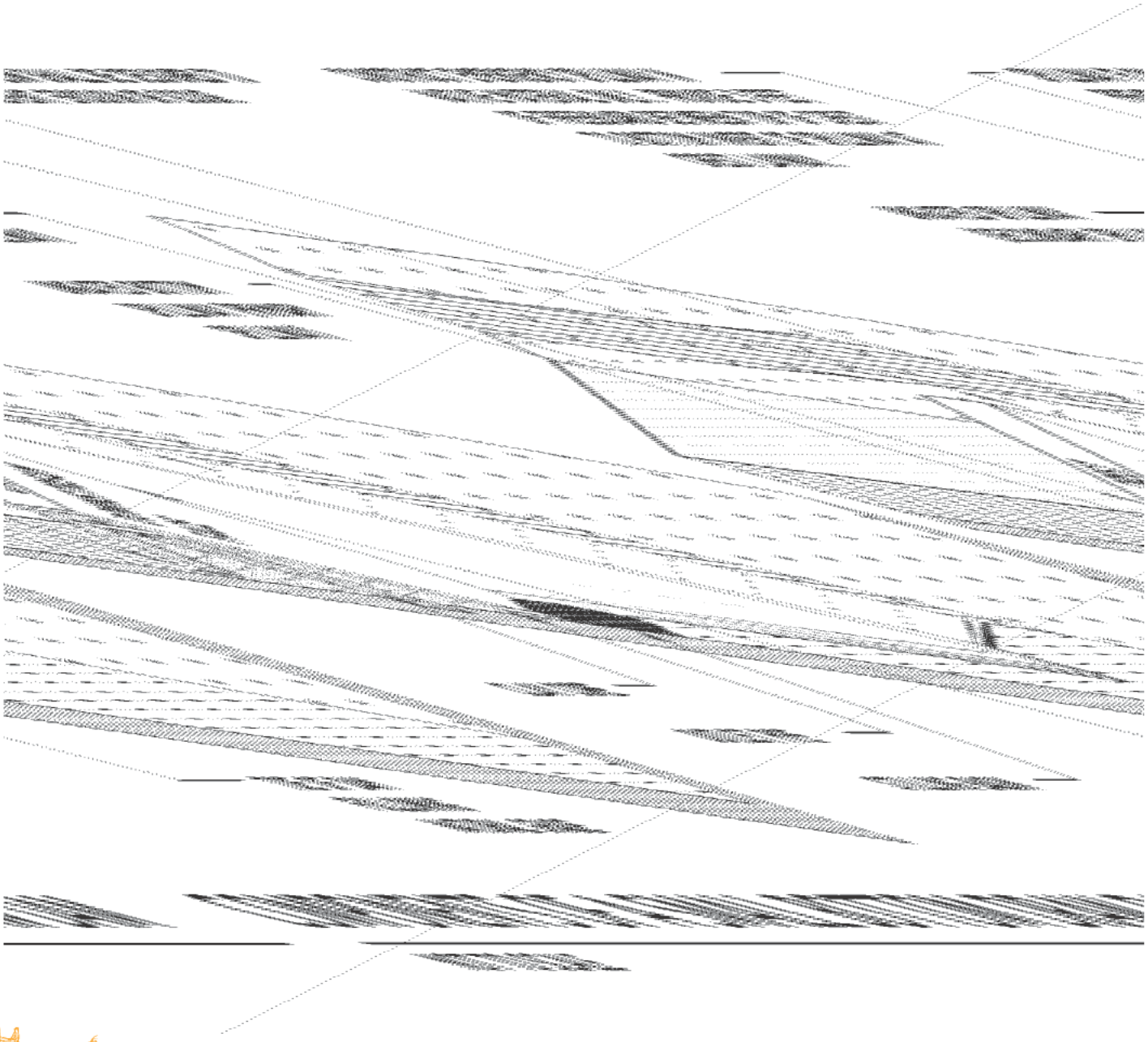
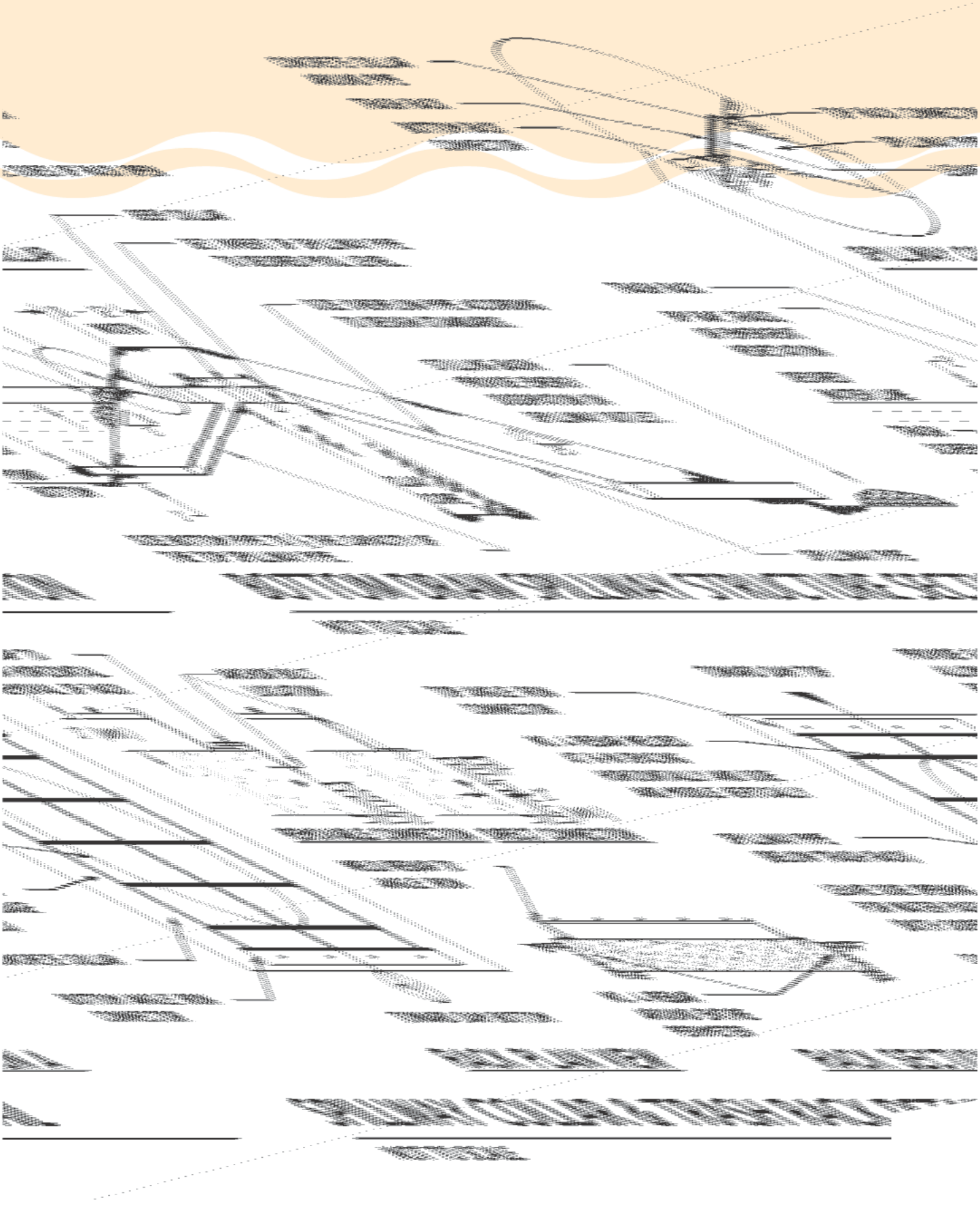
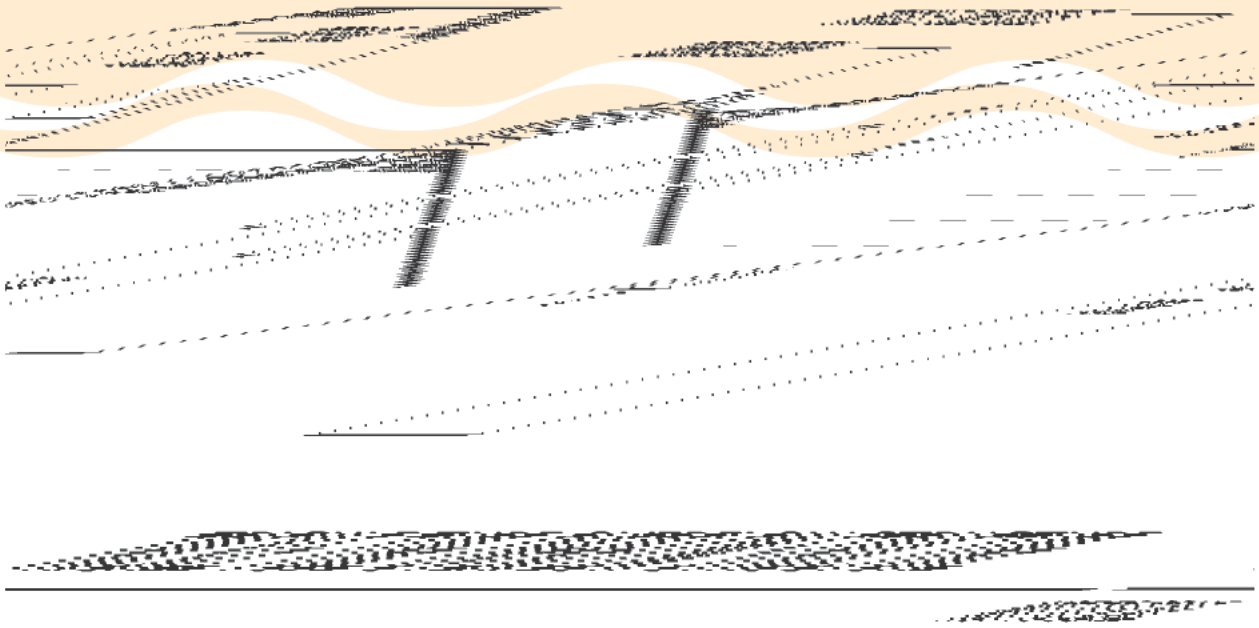








Another option for ponds with a large watershed is a drop outlet structure which allows water to drain quickly. It allows water to trickle over the rim of an open, vertical pipe with the rim set at the desired water level. Water is then drained from the drop structure through a horizontal pipe through the dam.

Ponds with these two types of outlet structures can be drained, either partially or completely, by either installing a gated valve or stop logs inside the drop outlet structure, or by installing a drain tube near the bottom of the dam. An accessible valve can then be installed on the drain tube, below the frost line in the earthen toe at the back of the dam. Water levels also can be manipulated by pumping or siphoning, but this can be time consuming and expensive. An optional watering line can be installed with the drain tube to provide water for livestock below the dam.

Another type of outlet structure is the bottom withdrawal spillway, which discharges water from the bottom of the pond. This device is designed to carry much of the incoming muddy water through the pond, dam, and then downstream, resulting in a minimal rise in the pond water level. It also maintains good water quality by removing stagnant water, sediment and organic materials from the pond bottom. This will improve the productivity of the pond and extend the life of the pond by 50%. An optional livestock watering line can also be installed through the dam to facilitate livestock watering below the dam.

Outlet structures, particularly drop structures, can prevent unwanted fish from entering the pond from downstream. Regardless of the type of outlet used, anti-seep collars should be installed around the pipe that passes through the dam to prevent the pipe from washing out. Trash guards or hooded inlets should also be installed on drain pipes, both for safety and to prevent them from becoming clogged with debris.

Another necessary feature for water overflow, especially for ponds having outlet structures, is an emergency spillway. While the drainpipe carries water during normal runoff, an emergency spillway carries flood runoff away from the pond so the dam is not damaged or breached. The upper tube opening for outlet structures is generally set 12 inches below the earthen spillway

level. This keeps water from flowing across the earthen spillway for an extended period of time, which would otherwise leave it moist and vulnerable to severe erosion during heavy rains. The width of the spillway is determined by a complex set of calculations that takes into consideration local rainfall duration and intensity, the slope of the watershed, and the type of ground cover anticipated in the spillway.

NRCS and NRD personnel need to be contacted regarding dam construction, water control structures, and appropriate emergency spillways for various pond sizes and levels of dam hazard.

Vegetation Establishment

Permanent native vegetation should be planted on the dam, spillway, terraces, waterways, and other disturbed areas as soon as possible after construction is completed. Utilize higher seeding rates in areas prone to erosion during the filling process and on steep slopes, particularly the front and back sides of the dam. Use a seed mixture of native grass, with emphasis on rhizomatous, sod-forming species. Native grasses produce a rigid, above-ground growth that provides excellent cover for wildlife, as well as an extensive, deep-reaching, fibrous root system that helps prevent soil erosion. Plants which are adapted to the on-site conditions and have proven wildlife values should be used whenever possible. NRCS and Commission Wildlife Division personnel can provide recommendations on what and when to plant.

The pond banks should be planted with permanent vegetation to prevent erosion and provide an aesthetic setting for fishing and other activities. Emergent vegetation, such as cattails, bulrushes, and arrowhead, can be dug up in other ponds in early spring, when new shoots begin to show, and transplanted into shallow-water areas of your pond. Keep in mind the aggressive nature of these plants, particularly cattails, when considering transplanting them into your pond. They may spread more than you want and eventually require control methods.

See page 40 for additional information on aquatic vegetation establishment.

Establishing a cover crop of wheat, rye, oats, or sorghum, or allowing weeds to grow in the pond basin, is recommended before new ponds fill. This helps to stabilize the soil and keeps the water clear. When the cover crop and weeds are flooded, they provide a substrate on which aquatic organisms can grow. Subsequent

decomposition adds nutrients to the pond and improves water clarity by facilitating settling of suspended soil particles. The ensuing nutrient boost also facilitates initial establishment and expansion of fish food items (such as zooplankton, phytoplankton, and aquatic insects). New ponds generally have an abundance of nutrients so it is quite common for algae to become established in the first 2 or 3 years. Eventually, most algae is replaced naturally by more desirable emergent and submerged vegetation.

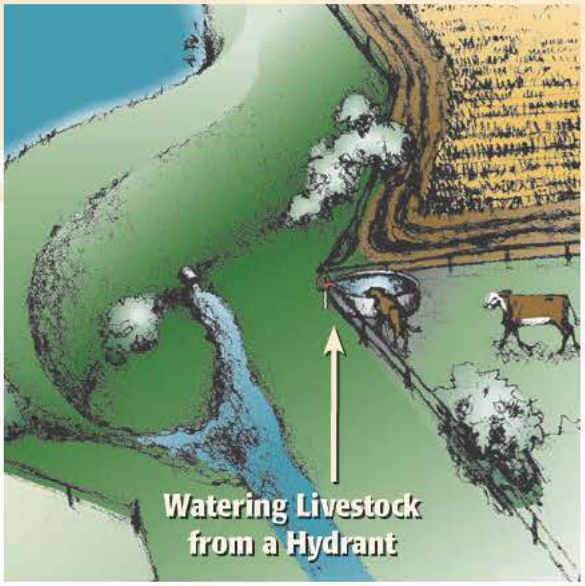
The dam should be protected from erosion due to waves with rock rip-rap or dense grass, such as prairie cordgrass. Trees should not be planted or allowed to grow on the dam as their roots can cause water leakage problems, nor should they be planted along the northwest corner of ponds. Prevailing northwest winter winds are needed to prevent excessive accumulation of snow on the ice, which can cause winter fish kills.

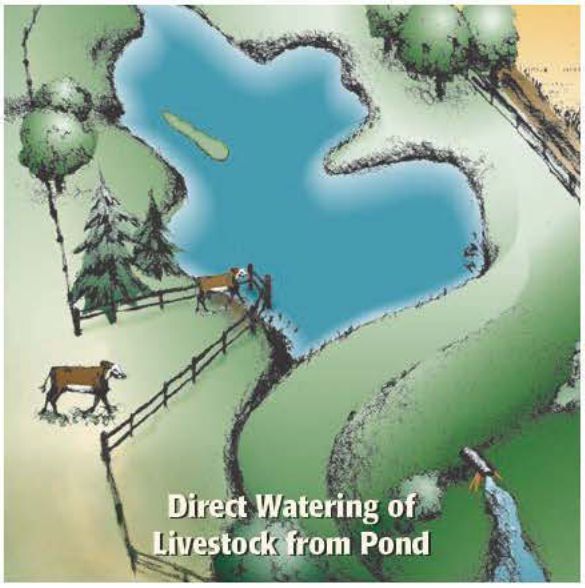
Other Pond Uses

The intended uses of the pond should be carefully considered before a pond is designed or the site selected. If you want a fishing pond, and the pond is designed specifically for fishing, it will be easier to manage and maintain and have greater recreational potential than if it were designed for an alternate use. Some uses will not be compatible with fish production, while some can be, with proper pond design.

Livestock watering will interfere with fish production if no precautions are taken to restrict their access. When livestock are allowed unlimited access to the pond shoreline and/or feeder stream, they trample the banks, resulting in shoreline erosion and the destruction of fish spawning and nursery areas. This can also weaken the dam and spillway, and shorten the life of the pond. Most importantly, livestock will muddy the water and increase nutrient inputs, which will prevent the establishment of desirable fish populations.

Ponds less than 5 acres should be fenced with a 100-foot minimum buffer, including the dam, emergency spillway, entire pond perimeter, and feeder stream, to exclude livestock. Auxiliary watering techniques can then be used. A pipe installed through the dam to a stock tank located outside the fenced area below the dam will provide cattle with clean, quality water, which can increase their weight gains. The 2-inch diameter pipe should extend into the pond and connect with a standpipe that has a top 4 feet lower than the water surface when full. Coarse gravel can be placed in the standpipe to filter the water and prevent fish from entering. A float valve can be installed in the stock tank to maintain a consistent water level.





If a pond or feeder stream has to be used for direct watering, both should be fenced to limit cattle access to small areas. Contact NRCS personnel about available buffer and cost-share programs regarding buffer establishment, fencing, and auxiliary watering. Keep in mind that prescribed grazing can be used to manage upland and wetland vegetation. Contact Commission wildlife staff for prescribed grazing information.

Livestock access to the pond and/or feeder stream has to be restricted to prevent environmental damages.

Fishing and **irrigation** are usually not compatible uses, especially if the pond is used as a return catch basin for irrigation runoff water. Using a pond as a source of irrigation water normally results in widely fluctuating water levels that will hinder fish reproduction and growth, and can cause fish kills. A pond can be used as a water source for small irrigation projects, such as gardens or lawns, provided inflows are sufficient to replace the water used and lost to leakage and evaporation. A permit is needed from the DNR before any water can be withdrawn from a pond. Ponds can provide water for **fire fighting**, provided precautions are taken to prevent fish and vegetation from plugging up the water intake system.

Flood control ponds designed to retain sediment and high volumes of runoff water generally do not make good fishing ponds. The water normally remains turbid for extended periods of time after runoff events and deposited sediment gradually fills in the pond. Although sight-feeding fish like bass and bluegill will do poorly under turbid conditions, channel catfish can produce a viable fishery. Catfish success will depend upon food availability, pond depth, and population density if natural recruitment (spawned fish survive to adult size) occurs.

Ponds less than 5 acres can provide many hours of fishing, swimming, boating, and **other recreational activities.** Power boating and skiing are not recommended due to the small size of these ponds. Wave action will cause shoreline erosion and resuspension of sediment, resulting in turbid water and reduced productivity. If the pond will be used for a variety of recreational activities, some safety precautions should be taken. Swimming areas should be marked and all obstacles removed. Have life saving devices, such as ring buoys, rope, and long poles, nearby to facilitate rescue operations during winter and summer activities. Pond owners should contact their attorneys and insurance agents about protection against a lawsuit if an accident should occur at their pond.

Permit Requirements and Environmentally Sensitive Areas

Whether you are building a new pond or restoring an old one, no permits are required if the finished structure has a low hazard dam less than 25 feet high, a storage capacity of less than 15-acre feet of water at the spillway crest or overflow, less than 50 acre-feet of total flood storage capacity at the top of the dam, and no diversion or withdrawal of water. It is always best to ask if you are unsure about whether or not you need a permit. Any questions on permitting should be directed to the DNR office in Lincoln. NRCS personnel can also answer questions about permit requirements. If a permit is required, it must be obtained before construction can begin; otherwise, the pond is subject to removal, or impounded water may have to be released for downstream water-right holders.

There are places where ponds should not be built and some places may require special permits.

Regardless of whether a DNR permit is required, there are places where ponds should not be built. Construction should be avoided

in areas where existing wildlife or habitats are unique or pristine, or where construction would negatively affect watershed functions below the pond. Threatened and endangered (T&E) species must be considered before construction begins. Usually, there are no concerns for ponds constructed on upland sites. Inquiries about known locations of T&E species should be directed to the Commission's Natural Heritage Program. If construction will affect a wetland or waters of the state, a U.S. Army Corps of Engineers (ACOE) Section 404 Permit will likely be required. The NRCS must also be contacted if a wet area is being considered for a site. They may require a permit, along with special construction considerations. Here again, ask if you are unsure. A Section 404 Permit is also required if habitat materials are added to any waters in the state. Questions can be directed to the ACOE regional offices in Omaha or Kearney. See Appendix A for the list of contacts.

While planning your pond, be sure to check your property deed for recorded easements for buried pipelines or power cables, and overhead lines. The restrictions in these easements and their locations may affect what you can do and where, and possibly change your site choice. Pond construction must not affect a public road or a neighbor's property.

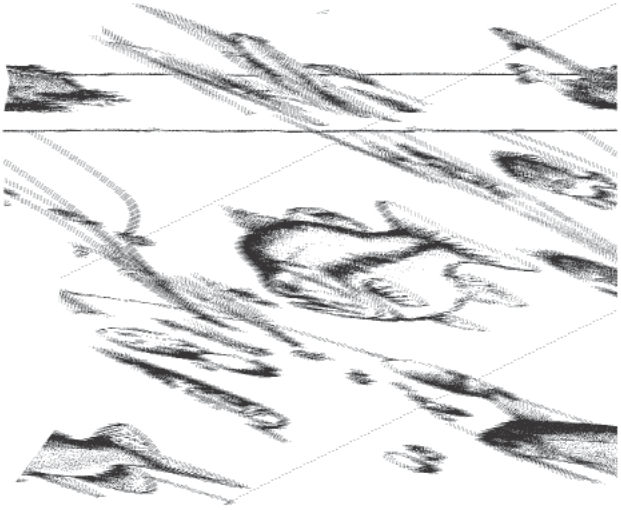
Technical Assistance (Construction and Cost-Share)

An important first step in building a pond is obtaining technical advice on construction that will maximize the pond's fishery potential and longevity. The primary sources for technical assistance are the Commission, NRCS, NRD, and UNL Cooperative Extension.

If you need additional information or would like to discuss any topics in greater detail, contact the Commission's district fisheries management staff in your area or the Private Waters Specialist at the Lincoln headquarters. The Commission's Wildlife Habitat Partners Section staff can provide information about establishment and management of wildlife habitat on property surrounding your pond. They can discuss their WILD Nebraska Program and various NRCS buffer programs that provide cost share funding for developing or enhancing wildlife habitat.

The local county NRCS office should be contacted regarding site selection, pond design and construction considerations, including what permits are required. They have programs that may provide cost-share funding for construction, particularly in high priority areas. They also have programs that provide cost-share or even payments for establishing buffers and set-aside (CRP) acres. They have a publication, "Ponds - Planning, Design, Construction," that is very informative.

The NRD's have cost-share funding for construction, with requests prioritized. See Appendix A for a complete list of technical assistance contacts. There also are private contractors and consultants who can be hired for various construction and management services. See Appendix B for a list of those services. Consult the yellow pages in your phone book or contact a local Commission fisheries biologist or the Private Waters Specialist to obtain a list of names and contact information for contractors and consultants.



POND STOCKING

Properly stocking a pond can make a world of difference in the quality of fishing it offers for years to come. The stocking strategy you choose should be geared toward the kind of fishing you want. If your primary interest is raising fish for eating, channel catfish or hybrid striped bass are a good choice. Both grow large on a diet of artificial feed and provide good fishing, too. If you just want to have something in your pond to catch, you could get by with almost any stocking combination. Most people, though, would like a low maintenance pond that provides good sport fishing, as well as an occasional fish to eat. After years of studies in ponds across the country, state fisheries biologists recommend stocking a combination of largemouth bass, bluegill, and channel catfish as the best choice for warmwater ponds.

The best stocking combination for warmwater ponds is largemouth bass, bluegill, and channel catfish.

Most Nebraska ponds are only capable of supporting warmwater fish species year-round. Trout require water temperatures below 70 degrees and high oxygen levels, and usually will not survive through the summer in most ponds.

Except for supplemental stocking of channel catfish, a pond that already contains bass and bluegill generally does not need to be restocked. Additional bass or bluegill should only be stocked after evaluating their relative abundance and size distributions. See page 50 for ideas on how to assess fish populations.

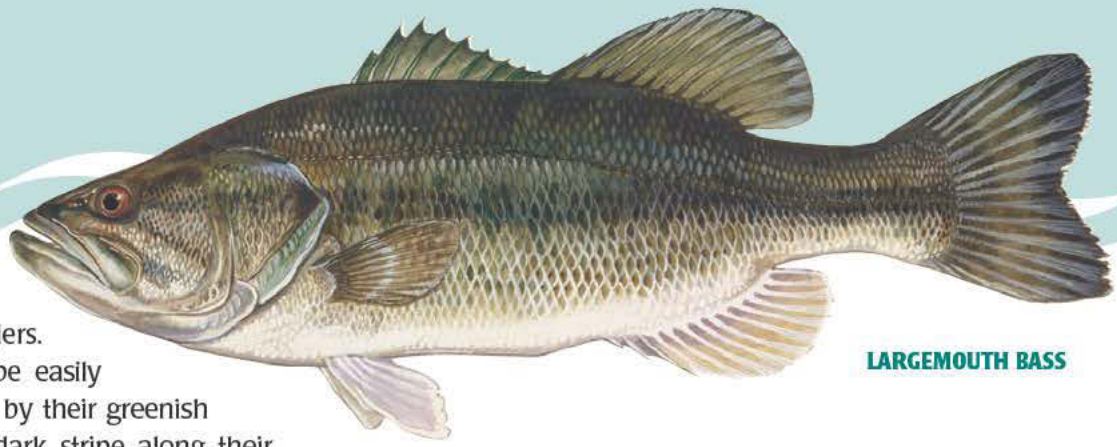
Moving fish from a neighbor's pond, a local lake, or nearby stream to your pond is not a good idea. It can even be illegal, especially if you do not follow bag, possession, and size limits. Many sunfish species are similar in appearance and you could accidentally stock green sunfish or other undesirable species. There is also the possibility of transmitting fish diseases to your pond. If you've invested a lot of money in building or renovating a fishing pond, trying to save a few bucks on stocking may sound attractive, but it is not likely to provide the return on your investment that you were hoping for. To reduce the risk of stocking undesirable fish species or diseased fish, obtain the initial stocking of largemouth bass and bluegills from the Commission, or purchase them and channel catfish from a licensed private fish hatchery.

Ponds should be stocked as soon as possible following completion of the dam to reduce the chance of undesirable wild fish species becoming established. Water in a pond that is still filling should be at least 8 feet deep to ensure over-winter survival of fingerling fish initially stocked in the fall. It normally doesn't take long for food items, primarily zooplankton and aquatic insects, to become established. It is usually best to avoid stocking in summer months because high temperatures and low dissolved oxygen levels could be present in the water and reduce survival of stocked fish.

Recommended Stocking Combination

Largemouth Bass

Largemouth bass are large predators that are well adapted to ponds. They are members of the sunfish family. Because of their growth potential and fighting ability, bass are sought by



LARGEMOUTH BASS

many anglers. They can be easily recognized by their greenish color, the dark stripe along their sides, and white belly. They also have a large mouth with an upper jaw that extends beyond the eye when the mouth is closed. Largemouth bass are voracious eaters and consume a variety of foods. Small fish, aquatic insects, crayfish, salamanders, and frogs make up the bulk of their diet. They will also eat other animals, such as mice, snakes, and leeches. Bass will grow rapidly when food is plentiful, and any fish weighing more than five pounds is considered a trophy in Nebraska. The state record fish weighed 10 pounds, 11 ounces. Many near record-size bass are caught in farm ponds. In healthy ponds, bass may reach a length of 3 to 5 inches their first summer, and 10 to 13 inches after 3 years.

Bass reproduce readily in ponds after reaching a size of about 12 inches at 2 to 3 years of age. Spawning occurs during the spring when water temperatures reach 60 to 70 degrees. The male uses his body and fins to fan a large saucer-shaped nest free of debris on the bottom in shallow water. A female is then enticed over the nest where she deposits eggs that the male fertilizes. The male guards the eggs until they hatch, then he protects the young for about two weeks, at which time they are able to swim and find food on their own. If harvest is carefully regulated, bass will maintain a population without restocking. Adequate prey must be available for bass to attain their growth potential. If stocked alone, they usually over-populate and do not grow large.

Bluegill

Bluegills are a small, but hard-fighting sport fish. They provide angling opportunities for people of all ages and are excellent table fare. They are prolific spawners and well adapted to pond life, which makes them suitable for stocking in combination with largemouth bass. Bluegills are a deep-bodied sunfish with a relatively short head and small mouth. They range in color from silver-lavender, when young, to greenish-brown with an orange or yellow breast, when older. They also have a blue lower gill cover, entirely black gill cover flap, and an irregular blackish spot at the base of the soft dorsal fin. Although they primarily eat insects, larger bluegills will also consume snails, small crayfish, and an occasional small fish.

Six- to 8-inch or even trophy-size bluegill in excess of 10 inches (over 1 pound) can be produced if properly managed. The state record fish weighed 2 pounds, 13 ounces. Bluegills mature at a length of about 3 to 4 inches, which is at 2 to 3 years of age in established populations. Bluegills can spawn from late May through August. Fingerling bluegills initially stocked in the fall will spawn the next summer. Nesting begins in the spring when water temperatures reach 60 to 70 degrees. The male constructs a nest, a small saucer-shaped depression, on the bottom in shallow water. Eggs are deposited by the female and fertilized by the male, who then guards the

BLUEGILL

eggs and young for one to two weeks. Spawning beds, consisting of many nests in close proximity, provide excellent fishing during the spawning season. Bluegills rarely need to be restocked.

CHANNEL CATFISH

Channel Catfish

Although channel catfish are native to streams and rivers, they do well in ponds and are favorites among many anglers. Channel catfish have a deeply forked tail, gray back, white belly, and eight barbels, commonly called whiskers, around their mouth. Young catfish have some black spots, which disappear as they mature. Large males develop a bluish color and are often misidentified as blue catfish. The anal fin of a blue catfish is straight along the bottom edge and has 30 or more rays; whereas, the anal fin of a channel catfish has a curved bottom edge and 24-29 rays. Catfish eat a wide variety of foods, including invertebrates, small fish, and aquatic plants. Fish eaten are usually dead or injured, and appear in the diet when catfish reach 12 to 14 inches. Channel catfish can be considered a bonus fish in the pond. Since they are not an important part of the predator-prey relationship, bass and bluegill will function just as well with or without them. But a pond's potential to produce fish is more fully realized if all three species are stocked. Channel catfish grow rapidly if sufficient food is available, and often attain a trophy size of 12 pounds or more. The state record fish weighed 41 pounds, 8 ounces.

Channel catfish spawn in early summer when water temperatures reach 75 to 80 degrees. The male makes a nest in a hole in the bank or in a hollow log, or next to any material that will provide protection for the young. The female deposits the eggs, which are then fertilized by the male. He then guards the eggs and young fish for about two weeks. Because bass and bluegill eat most of the eggs and young, periodic restocking will be necessary to maintain catfish populations in clear ponds. Restocked catfish should be at least 10 inches in length to ensure good survival.

10-inch channel catfish will have to be restocked periodically to maintain populations in clear ponds.

Other Potential Species

There are numerous other freshwater fish species that will live and grow in ponds. The following species can provide additional enjoyment or benefits; however, they can also create problems.

REDEAR SUNFISH

Redear Sunfish

Redear sunfish are native to the southeastern United States. They are sometimes stocked in place of, or in combination with, bluegills, because they can grow larger than bluegills, and have a low reproductive potential. Redears are a deep, slab-sided sunfish with a relatively small mouth. They are golden or light olive-green in color with a yellow or orange-yellow belly. The gill cover flap is black with a whitish border and, in adults, a prominent orange or red spot.

Redear sunfish spawning behavior is similar to that of bluegills. They typically have low population densities, especially north of their native range, where young-of-the-year are very sensitive to cold water temperature during the

winter. If stocking redears and depending on bass management goals, a mixed stocking rate of two-thirds bluegills and one-third redears is usually used to ensure bluegill become established and provide adequate food for the bass. Their availability is somewhat limited in the state and anglers may find them more wary and less aggressive than bluegill.

Redears feed primarily on snails, clams, and crayfish, and are commonly called "shellcrackers." They can help to control snails, which are a required host in the life cycle of yellow and black grubs. Although these grubs often show up in the fillets of fish, they are not harmful to humans (see page 73). Redears require clear water with abundant vegetation for preferred food items to flourish and sufficient depths to avoid winterkills.

Crappie

There are two species of crappies: black and white. Both are silvery colored with black markings. Black crappies have seven or eight hard dorsal spines with black spots scattered randomly over their bodies. White crappies are usually slimmer and have five or six hard dorsal spines with black spots arranged in vertical bars

BLACK CRAPPIE

on their sides. Spawning male white crappies become very dark and boldly marked, and are often mistaken for black crappies. Spawning behavior is similar to that of largemouth bass and bluegills. White crappies usually predominate in somewhat turbid waters, while black crappies

Crappies tend to overpopulate and grow slowly if predators do not reduce the number of young, especially when turbid water prevents their detection.

WHITE CRAPPIE

do better in clear water. Although crappies are very popular with anglers, they can become a problem in ponds. Since crappies feed primarily on small fish and invertebrates, they compete with bass for food.

In clear water with large numbers of bass present, black crappies can grow rapidly to lengths of 10 to 12 inches and provide quality fishing. A good rule of thumb is to avoid stocking black crappie unless your pond produces bluegills over 8 inches long. This is a good indication that the largemouth bass population is dense enough to control crappies as well.

HYBRID SUNFISH

Hybrid Sunfish

Hybrid sunfish are a cross between two sunfish species, generally green sunfish and bluegill. They produce offspring that typically do not overpopulate, grow larger than either parental species, and are easier to catch due to their aggressive feeding habits; however, the growth difference is usually slight without artificial feeding. Because hybrids do not produce enough offspring to support desirable largemouth bass populations, they should be stocked in combination with bluegills. Hybrids do not breed true, spawning produces second generation offspring that can be undesirable and exhibit a wide range of characteristics. Hybrids will have

to be periodically restocked, utilizing larger fish, in order to maintain a population when bass are present. For these reasons, hybrid sunfish are rarely recommended for stocking.

Black Bullhead

Black bullheads are a member of the catfish family. They are common in many small streams and often find their way into ponds. They are usually gray or black on top, with a yellow or white belly. The tail fin is almost square. Their bottom-feeding activities stir up sediment and can cause a pond to become muddy. This hinders sight-feeding fish such as largemouth bass and bluegills and reduces pond productivity. Bullheads become over-populated if stocked alone or a pond is muddy, or when very few bass are present. After hatching, young bullheads travel in compact schools called pods, often escorted by adults. In clear ponds with good bass populations, few bullheads survive. The ones that do, grow to a large size and are fun to catch and good to eat. As with black crappies, black bullheads should only be stocked in ponds that are producing bluegills longer than 8 inches.

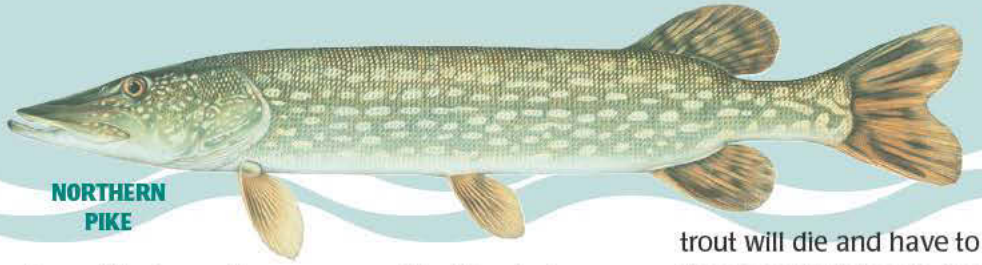
Bullheads are rarely recommended for stocking.

Northern Pike, Walleye, Flathead Catfish, Rainbow Trout, Wiper (Striped x White Bass Hybrid), Yellow Perch, and Smallmouth Bass

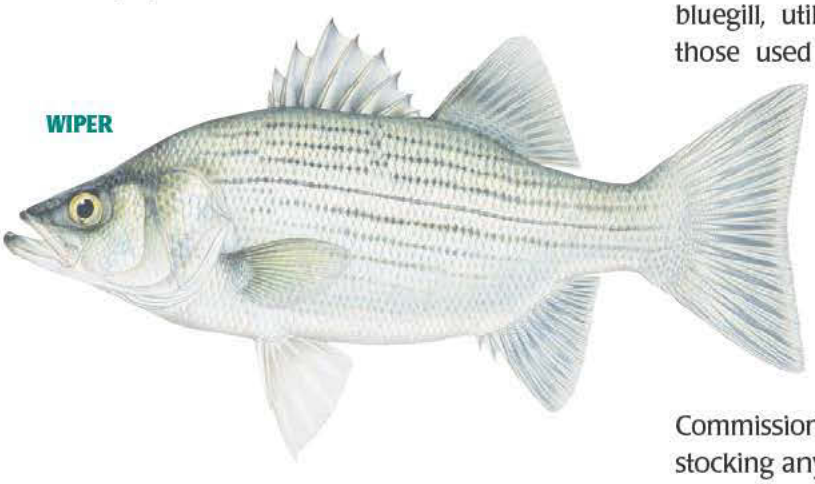
Although these fish are desired by some ponds owners and normally do not cause problems, they generally are not well suited for pond environments. Extra management efforts

will be required to maintain populations of these species, if they survive at all. These species typically do not reproduce adequately in ponds to maintain populations, are costly to stock, can be difficult to obtain, and most ponds cannot support many of them.

Very few ponds, particularly in eastern Nebraska, offer enough cool, clear water and/or aquatic vegetation to support walleyes, northern pike, yellow perch, smallmouth bass, and striped x white bass hybrid, also known as



wipers. Most ponds warm considerably during the summer, which can hinder the growth of these species and reduce survival of older fish. Although walleyes and northerns can survive in larger ponds or lakes in eastern Nebraska, they will likely have to be restocked periodically to maintain populations. While flathead catfish can



be stocked to produce a trophy fishery or as an additional predator, they will not effectively control bluegills as well as a properly managed largemouth bass population. Wipers generally require supplemental feeding in order to attain their full growth potential. See page 36 for additional wiper information.

Very few ponds are capable of supporting trout year-round. Trout require water temperatures below 70 degrees and a high oxygen content. If trout are desired in eastern ponds, they can be stocked to provide a seasonal fishery from fall through late spring. Unless a spring or aerated well water provides enough cool water for the pond during the summer, trout will die and have to be restocked each fall. See page 35 for more trout stocking information.

For ponds and lakes in western Nebraska that have adequate depth and moderate levels of submerged vegetation, yellow perch can be considered as an additional prey fish. If yellow perch are being considered for western waters, they should be stocked in combination with bluegill, utilizing stocking strategies similar to those used for redear sunfish. Some western and northern waters may be able to support smallmouth bass, provided the ponds contain clear, deep water, submerged vegetation, rocky substrate, and crayfish. Since they cannot compete effectively with largemouth bass, they should not be stocked if largemouth bass are already present. Consult a local Commission fisheries biologist for advice before stocking any of these species.

Grass Carp

Grass carp are native to Asia and were brought to this country as a means to control aquatic vegetation. They are members of the minnow family. They usually grow larger than the common carp, often attaining weights in excess of 50 pounds, and can live for decades.

The Commission does not recommend stocking grass carp; alternative vegetation control techniques should be used instead. The best solution for a vegetation problem is to

create more deep water to hinder the growth of submergent vegetation. If a pond owner insists, grass carp should only be stocked in ponds which have severe submerged vegetation problems that are negatively affecting fish populations. They will have no appreciable effect on algae species commonly referred to as moss or pond scum. Grass carp should only be stocked at a density of no more than 5 fish per vegetated acre to control plants or 15 per vegetated acre to eliminate them. Stocked fish should be at least 10 inches long to ensure high survival. Successful grass carp reproduction has not been documented in a pond or lake.

See page 63 for additional vegetation control information and page 65 for more about grass carp.

Species to Avoid

The following species should not be stocked in ponds. If undesirable fish are already established, they may have to be eliminated before the pond is stocked with the recommended stocking combination.

See page 55 for details on removing or controlling unwanted fish species.

Gizzard Shad

Gizzard shad are silvery colored with a dark spot near the head and a sharp, saw-like ridge on their bellies. Although shad can be the primary food source for large game fish in large reservoirs, they are not recommended for ponds. Shad spawn from spring into summer by scattering eggs randomly in shallow water. This produces very high numbers of young shad that feed on the same invertebrates as bluegills and small bass, negatively impacting survival, growth, and body condition of young-of-the-year bass and bluegill of all ages. An overabundant population of shad can also consume most of the zooplankton, which are capable of controlling nuisance algae species. This can lead to extensive algae blooms. Adult shad normally grow too large for most bass to eat.

Fathead Minnow

Fathead minnows are dull, silvery-colored baitfish that grow to about 3 inches in length. Fatheads feed on small invertebrates and plant material. They are hardy and very prolific. Eggs are deposited on the underside of submerged tree branches, aquatic vegetation, or boards placed in the water for that purpose. Since they spawn several times throughout the summer, they can produce very large numbers of young. An overabundant population of fatheads can remove most of the zooplankton and lead to extensive algae blooms.

Fatheads should not be stocked in ponds to accelerate initial bass growth. Extremely high populations of minnows have been found to directly compete with stocked fingerling largemouth bass and bluegills, resulting in poor survival of their offspring. Although the young bass that survive to eat the minnows grow well, they will be low in number. The bluegill population may not be able to expand until the fatheads are eliminated by disease and/or predators. Although fatheads are excellent prey for smaller bass, bluegills are a better suited prey for adult bass. Fathead minnows can be used in channel catfish-only ponds, see page 36 for details.

GOLDEN SHINER

Golden Shiner

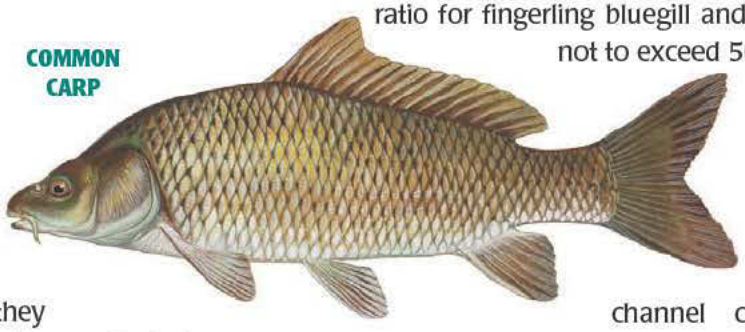
Named for their gold color, golden shiners have a small upturned mouth and an obvious downward curving lateral line – a series of sensory tubes and pores extending back from the head along both sides of the body. Golden shiners should not be stocked to accelerate initial bass growth rates because they will compete directly with bluegills and small bass for food.

GREEN SUNFISH

Green Sunfish

Green sunfish are often confused with bluegills and then mistakenly stocked into ponds. They have a stocky, tubular body shape, and their medium-sized mouths are considerably larger than a bluegill's. They are greenish in color and have a black gill cover flap with a whitish or yellowish margin. Green sunfish flourish in ponds that have not yet been stocked with desirable fish. If they get large enough, or have already spawned, they can be a serious threat to the survival of bass, bluegill, and channel catfish when they are initially stocked. They normally do not pose a serious problem if they enter a pond containing a well-established bass population.

COMMON CARP



Common Carp

Carp are members of the minnow family and can grow to be quite large. Like bullheads, they are bottom feeders and tend to stir up sediment and cause a pond to become muddy. They tend to overpopulate and grow slowly. A well-established bass population can control carp in ponds if good water clarity can be maintained.

Stocking Recommendations

Warmwater Ponds

The best approach for establishing largemouth bass, bluegill, and channel catfish populations in a new pond is to use YOY (young-of-the-year) fingerlings and stock 1- to 2-inch bluegills the first year and 2- to 3-inch bass the second year. Channel catfish fingerlings, ranging from 2 to 4 inches, can be stocked the same year as the bass. Bluegills should be stocked in late summer or early fall. This will allow them time to grow and spawn the following summer, with offspring providing prey for bass stocked the second year. Keep in mind a pond that is still filling should be at least 8 feet deep to ensure overwinter survival of stocked fish.

To determine the proper number of fish to stock, the surface area of the pond must first be determined. The recommended initial stocking ratio for fingerling bluegill and bass is 5 to 1, not to exceed 500 bluegills and 100 bass per surface acre of water. The initial stocking density for fingerling channel catfish is 100 per acre. This combination will begin to provide angling opportunities in about two years. If too few bluegills are stocked initially, an unusually high number of their first spawn will survive due to little competition for available

Warmwater Pond Stocking Recommendations (Fingerlings)

Species	Number Per Acre	Length (Inches)	When to Stock
Bluegill	500	1-2	Fall
Channel Catfish	100	2-4	Following Late Spring
Largemouth Bass	100	2-3	Following Late Spring
Largemouth Bass	50	3-4	One Year Later*

*Optional

Expected Lengths (Inches) of Fish Initially Stocked in a Typical Nebraska Farm Pond*

Species	Stocking Length (Inches)	Years After Stocking 1	2	3	4
Bluegill	1-2	4.5	6	7	7.5
Channel Catfish	2-4	10	14	16	17
Largemouth Bass	2-3	9	11	13	15

* Growth of subsequent year classes will likely be slower.

space and food. This can become a problem if bass are over-harvested, or are unable to effectively prey upon the bluegills due to poor water clarity or too much cover. Stocking at higher than recommended densities usually results in slow growth and poor fish populations.

If the surface area of a pond is unknown, consult NRCS or the pond contractor, or estimate it by using formulas in Appendix C.

When a pond is properly managed, bass and bluegill only need to be stocked once. Although not necessary, a second stocking of 50 largemouth bass fingerlings per surface acre can be considered in the third year. Since bass from the initial stocking usually would not spawn until the fourth year, this second stocking would provide the year-class of bass that would otherwise be missing in the pond. In order to maintain a population, 10-inch channel catfish should be restocked every 2 to 3 years; number stocked should equal the harvest

Warmwater Pond Stocking Recommendations (Adults)

Species	Number Per Acre	Length (Inches)	When to Stock
Bluegill	150-250	4-5	Spring
Channel Catfish	20-50	6-10	Spring or Fall
Largemouth Bass	30-50	8-12	Spring

plus an additional 10 percent to compensate for natural mortality.

If the pond is large, the cost of fish may be prohibitive at the densities recommended above. A pond larger than 5 acres can be stocked as if it was only 5 acres. This will save some money and still provide enough fish to establish populations. Keep in mind the likelihood of high survival of the bluegills' first spawn that could cause a problem if the bass don't become established or if bass are over-harvested. If cost is not an issue, you should stock more fish, just be sure to maintain the recommended ratios and do not exceed the maximum of 500 bluegill and 100 bass per acre.

Although more costly, another option is to stock adult fish. This option will provide angling opportunities sooner. While these fish are more expensive due to their larger size, their survival chances are higher, so fewer are needed to get a population established. Stocking adults will be necessary if the pond already has fish that are capable of consuming or out-competing fingerling bass and bluegill. Under this option, all three fish species are stocked the first year – the bass and bluegill during the spring and channel catfish either in the spring or fall. Catfish should be restocked every 2 or 3 years to maintain their numbers, depending on the amount of angler harvest. Stocked catfish should be at least 6 inches long the first year and 10 inches long in later years to reduce their chance of being eaten by largemouth bass.

Simply stocking a few adult fish to populate a new pond is risky and not advised. Production of young fish from these adults in the first year is unpredictable. Bluegills may spawn more successfully than bass and the pond can immediately become out of balance (see page 48). Fishing quality will become poor quickly, and will likely stay that way. Therefore, it is necessary to develop a high-density bass population the first several years following initial stockings.

For sand pits, quarries, and other steep-sided waters, the stocking recommendations are the same. Pits with very little water less than 4 feet deep may need supplemental stockings due to limited reproduction by bluegills and largemouth bass. New sand pits are usually infertile and will not be able to produce as many fish as a new farm pond.

Coldwater Ponds

For ponds able to support trout year-round, the suggested stocking rates are 100 adults, 8 inches or longer, per acre or 150 to 200 fingerlings, up to 5 inches in length, per acre. Smaller fish are cheaper and easier to transport. In ponds where large predators are established, only adult trout should be stocked to reduce the likelihood that the stocked fish will be eaten. Trout ponds will need to be restocked every 2 to 3 years, depending upon the amount of angler harvest. Ponds that only support trout on a seasonal basis can be stocked using 8-inch or larger trout at 100 per acre in the fall, when water temperatures stay below 70 degrees. Trout can be fed with commercial trout food, if desired.

Trout Stocking Recommendations

Species	Number Per Acre	Length (Inches)	When to Stock
Rainbow Trout	100	8 or Larger	When Water Temperature Is Below 70 Degrees
Rainbow Trout	150-200	5 or Smaller	When Water Temperature Is Below 70 Degrees

Small Fishing Ponds

Channel catfish are recommended for smaller ponds with adequate depth, particularly those less than one-half acre in size where it would be difficult to maintain balanced populations of bass and bluegills if angler harvest is high. Stocking only catfish is also recommended in muddy ponds since dirty water (clarity less than 12 inches) would hinder sight-feeding fish like bass and bluegill. Catfish can be stocked at an initial rate of 200 to 300 fish per acre with 4- to 6-inch fingerlings or 100 fish per acre with 8- to 12-inch sub-adults. Catfish can then be artificially fed to maximize growth and harvest. If the pond is already muddy and no feeding program will be used, the initial stocking densities should be cut in half.

If no reproduction occurs, catfish will have to be periodically stocked to compensate for harvest. They should be maintained at a density up to 100 fish per acre, 200 or more if supplemental feeding is provided, depending on the size of catfish present. Maintain a record of catfish harvest. Restock 8- to 10-inch catfish during the spring or fall when cooler water temperatures are less stressful. Again, the number stocked should equal the harvest plus an additional 10 percent to compensate for natural mortality. Fathead minnows can be stocked with catfish to provide additional food and a source of bait.

Ponds containing only catfish should not contain any structure that would facilitate spawning; otherwise, an overpopulation of small slow-growing catfish is likely and would worsen turbidity, due to their bottom feeding nature.

Another option for smaller ponds would be wipers, (striped bass x white bass hybrid), provided a feeding program will be used. Wipers can be initially stocked as 2- to 4-inch fingerlings at 100 per surface acre of water. Depending on the amount of harvest and natural mortality, supplemental stockings of 20 to 30 6- to 8-inch fish per acre will be needed every 2 to 3 years. Wipers, particularly those weighing more than 5 pounds, may not survive when water temperatures remain warmer than 85 degrees for extended periods, or when dissolved oxygen levels drop below 4 parts per million. Feeding should be discontinued until these conditions improve. Wipers larger than 5 pounds can be produced, provided adequate deep water and moderate levels of submerged vegetation are available, and high dissolved oxygen levels can be maintained. Aeration may be necessary to maintain oxygen levels. Wipers can also co-exist in ponds with largemouth bass and bluegills.

Sources of Fish for Stocking

The Commission will provide largemouth bass, bluegill, and possibly trout, for stocking new, privately-owned ponds or those where the Commission has recently authorized the existing fish population to be chemically removed. To be eligible for fish, private ponds must be one-half surface acre or larger in size. One-fourth of the pond must be at least 10 feet deep. There may be exceptions for spring fed ponds, natural lakes, and others at the discretion of the inspecting biologist. No other fish should be present at the time of stocking, with the exception of recently stocked channel catfish. Ponds must have a minimum water clarity of 12 inches. Fencing to exclude livestock will be required under most circumstances.

Although owners of state-stocked waters are not obligated to allow unlimited public fishing access, they cannot charge anglers a fee to fish and are urged to grant access to anglers who ask permission to fish. A valid Nebraska fishing permit is required of every person 16 years of age and older who fishes these ponds, and all anglers must comply with current state fishing regulations.

All applications for fish must be returned by August 1 to be considered for stocking during that calendar year. If a pond has multiple landowners, all landowners must concur with

the stocking request or the application will be denied. If a shortage of fish should occur, the owner will be notified and placed on a waiting list for the following year.

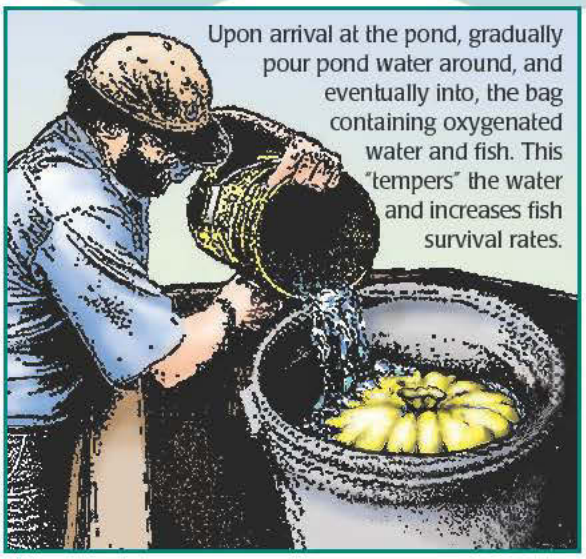
Young-of-the-year bluegills will be available during the fall and largemouth bass during the following late spring. Coldwater ponds capable of supporting trout throughout the year can be considered for an initial fall trout stocking. Owners who allow reasonable public access may also receive supplemental fingerling trout stockings.

Fish can be purchased from a licensed private aquaculturist or licensed nonresident fish dealer. Ponds that are stocked with purchased fish may be exempt from fishing license requirements and harvest restrictions. Consult Nebraska's fishing regulations or contact a local conservation officer for details. A list of licensed commercial fish dealers is available from the Commission. It is advisable to consult several suppliers to see who has the best prices and the most convenient delivery schedules.

Look for a copy of the fish application in the back of this handbook.

Stocking Process

If you are transporting fish to your pond, do not fill your container with tap water, especially if it contains chlorine or chloramines. Both can kill fish. It is best to take fresh water from your pond just before you pick up the fish. Water taken the day before may cool off significantly during the night. Water allowed to sit during the day may become too warm. Either situation can kill fish when they are transferred directly into the container. When fish are obtained from the Commission, your hauling container should have a trash bag liner and be half-filled with pond water. Upon arrival at the pick-up site, the water in your container is tempered to closely match the temperature of the water in the fish hauling tank. Fish are then added and the water oxygenated. Finally, the bag is sealed and the container is ready for the trip to the pond. A commercial supplier will often fill your container with oxygenated water when you get your fish, or he may provide fish already packaged in Styrofoam containers and/or plastic bags with water.



Upon arrival at the pond, gradually pour pond water around, and eventually into, the bag containing oxygenated water and fish. This "tempers" the water and increases fish survival rates.

Get the fish to the pond as quickly as possible to ensure their survival. Transportation delays can cause oxygen levels in the water to drop and water temperature to rise, resulting in stressed or even dead fish. If the water for transporting your fish wasn't taken from your pond, the water's pH, hardness, alkalinity and temperature will likely be different from that in your pond. Do not pour the fish into the pond right away. Fish must be acclimated to the changes in water chemistry first, or they can go into shock and die. This is especially important if the water temperature in your container is more than 5 degrees different from the water in your pond. Over the course of 15 to 30 minutes, mix pond water into the water in the container with the fish. Then place the container into the pond so that the fish can swim out when they are ready. Or, the hauling container can be partially submerged into the pond, allowing water to be slowly exchanged until the chemistry is similar to that of the pond. Be careful while handling the fish; any wound created may become infected with bacteria or fungi. Although the fish may swim away into the pond, they may die later from these infections.

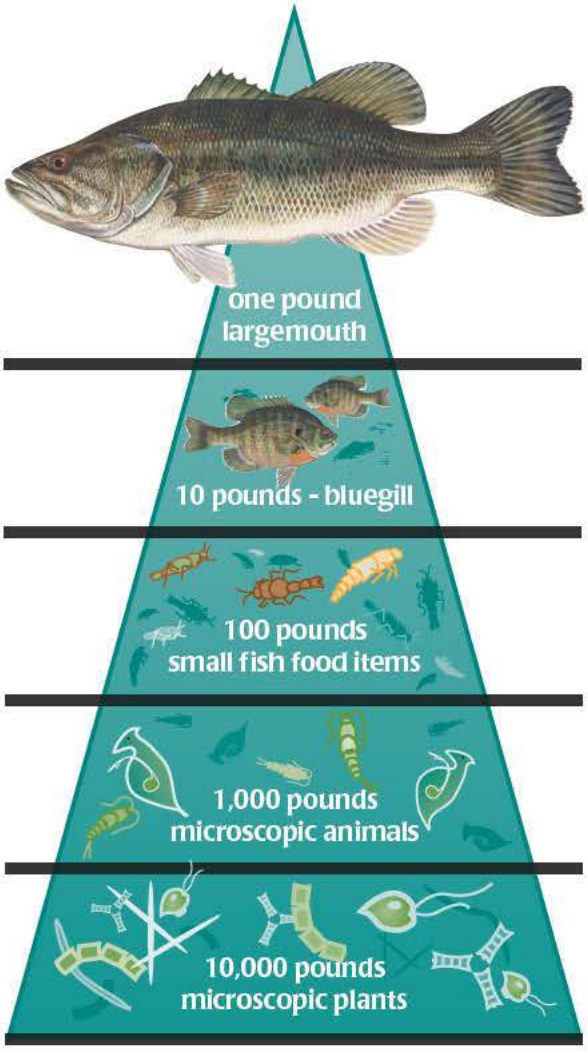
ENVIRONMENTAL MODIFICATIONS

The natural foods of fish are either produced in the pond, washed in by rain, or fall into the pond. Food produced in the pond has its origins in the nutrients found in the pond. A variety of plants, from microscopic algae to rooted plants, use these nutrients to grow. In turn, the plant material can be eaten by microscopic zooplankton or aquatic insects. These organisms are then eaten by bluegills and young bass. Bigger bass may then eat these smaller fish. Bass will also eat other items, such as crayfish and frogs, which also rely on plant material and insects in the pond for food. A pond has a series of food chains, or more accurately a food web, that starts with nutrients in the watershed and ultimately ends with big fish. Small fish concentrate the energy taken from the food they eat and, in return, become a high-energy food for larger fish. A pond will support 5 to 10 times as many pounds of bluegills as it does bass because bluegills are lower on the food chain.

The total weight of fish that a pond can support is called the carrying capacity.

Much like a pasture can only support so many cattle, or a garden can only grow so many vegetables, a pond can only support a certain biomass, or weight, of fish. A pond will achieve its maximum carrying capacity about 3 to 4 years after it is initially stocked. Without supplemental feeding, an average pond in Nebraska supports about 250 pounds of fish per acre: about 190 pounds of bluegill, 35 pounds of bass, and 25 pounds of catfish and/ or other species. Once the carrying capacity is reached, fish growth rates decline. Individual populations can be

AQUATIC FOOD CHAIN



comprised of many small fish, or a few large ones, but the total weight will be the same and equal what the pond can support.

The wildlife productivity of a pond and the immediate surrounding land can be increased by making beneficial environmental modifications, or supplementing what is already present, depending on management goals. These changes can involve manipulating aquatic and terrestrial habitats that will then benefit associated wildlife, whether it is a rabbit, a small catfish, or even a dragonfly.

Aquatic Habitat

Trees and brush removed during construction can be returned to the pond basin before the pond fills. After a new pond fills, the flooded trees, brush, grasses, and weeds become underwater structures and create an excellent, nutrient-rich environment for aquatic life. Underwater structures provide shade and cover for fish, substrate on which aquatic organisms, such as aquatic insects, can grow and feed, and concentrate fish. Small fish will come to the cover to eat the insects found there, and bigger fish will come to eat the small fish. However, as the pond ages, inundated vegetation eventually decays and disappears, reducing the amount of fish a pond can support. Some of the natural effects of aging and subsequent habitat loss can be counteracted by encouraging development of natural habitat and/or the addition of cheap, but sometimes labor-intensive, artificial habitat.

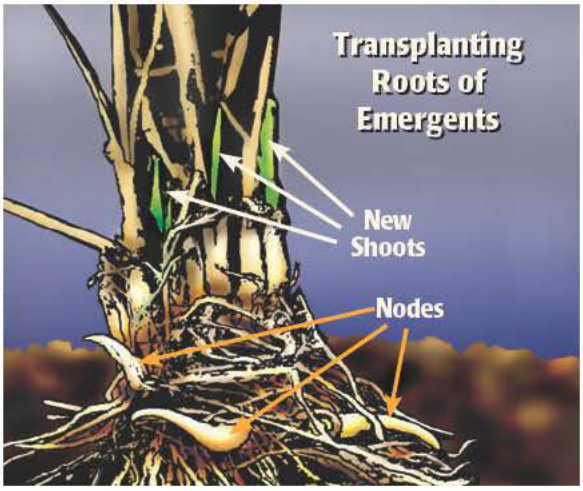
Natural Habitat

Aquatic vegetation is also considered structure and will eventually become established in most ponds. A good fishing pond usually will be about 40% covered with emergent and submergent aquatic vegetation. Aquatic vegetation is often considered a nuisance and removed by pond owners. It is, however, a natural and necessary component of a healthy pond. Aquatic plants provide cover, food, and

nesting sites for fish and other organisms. They also help to oxygenate the water, reduce nutrient levels, and improve water clarity by decreasing wave strength and minimizing shoreline erosion. Emergent and submergent vegetation tie up a portion of the nutrients present in a pond, which reduces the likelihood of nuisance planktonic algae blooms that can cause fish kills.

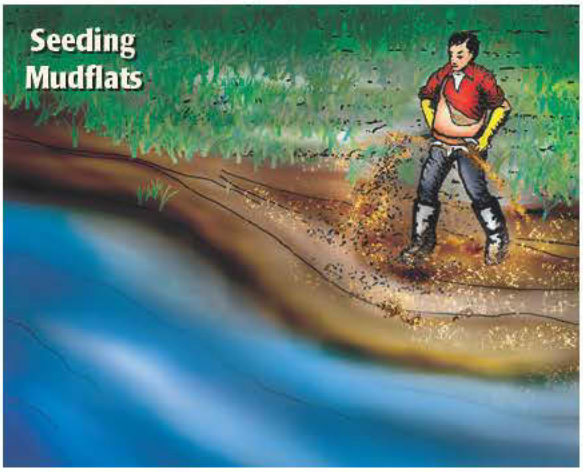
Although emergents – rigid plants which have the bulk of the plant above the water and grow along the shoreline – can become established naturally in a pond, they can also be transplanted to speed colonization. Most emergents, especially cattail, bulrush and arrowhead, are relatively easy to transplant. This should be done in the spring when new growth starts. Rootstock can be dug up and cut or pulled apart and planted along the shoreline. Make sure at least two new shoots/nodes are present for each section when utilizing cattails. Some of the transplants should be placed adjacent to and immediately above the water line, while others can be placed in water less than 10 inches deep. Cattails are very aggressive and can spread over extensive shoreline areas. Mechanical or chemical means may be necessary to eliminate them in wading, swimming, and some fishing areas.

Even though submergents – non-rigid plants which are normally completely submerged and attached to the bottom – can also be transplanted, they usually become established



See page 61 for additional information on identification, benefits, potential problems, and control of aquatic vegetation.

in the pond naturally by waterfowl transporting seeds and incoming water transporting seeds and plant fragments. Some types, including curleyleaf pondweed, Eurasian watermilfoil, and coontail, can colonize extensive shallow-water areas. The best way to restrict their growth is to make sure ponds contain adequate depths, as outlined on page 12. Although it is best to transplant locally acquired plants, some can also be purchased. Contact your area Commission fisheries personnel for a listing of aquatic vegetation dealers.



Some of the natural effects of aging and subsequent habitat loss can also be counteracted with water level manipulation. The water level of ponds with gated draw-down valves can be lowered 2 to 3 feet, provided adequate depth remains to prevent a summer fish kill, and maintained at the lower level for an extended period of time. Grasses and broadleaf plants will sprout naturally on the exposed pond bottom, or exposed areas can be seeded with sorghum or Japanese millet. Draw-down can commence in late spring. Hand seeding should be done when mud flats are initially exposed and still moist. The pond should be refilled to flood the established vegetation, either in the fall if a

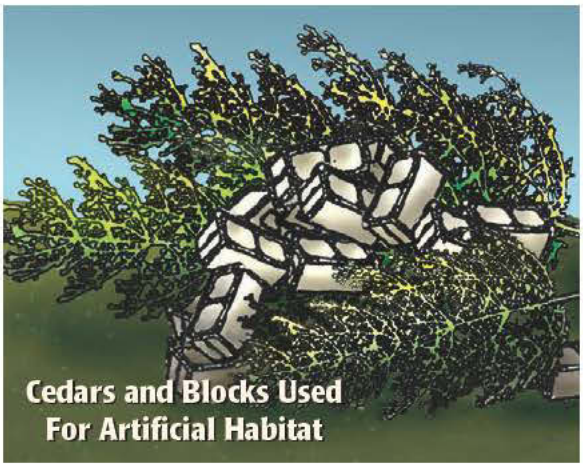
winter fish kill is possible or the following spring. Although pumps can be used to partially drain and refill ponds for water level manipulation, pumping costs can be considerable.

Water level manipulation can also be used to enhance emergents, with dewatering starting about mid-May and a slow, refilling process starting in September. It also crowds fish, which can make small bluegills more susceptible to predators. Water level manipulations should ideally be done every 4 to 5 years.

Artificial Habitat

A pond owner can install underwater structures, commonly referred to as artificial habitat, to enhance habitat available for numerous aquatic organisms. Research has shown that structures made of natural materials, such as brush and trees, are the most economical and effective types. Rocks, boat docks, wooden pallets, drain tiles, and piles of concrete blocks or bricks can all function as structure.

The easiest time to install structures is while the pond is being built. They can be built quickly by pushing downed trees together with a bulldozer and then anchoring them in place. Timber left standing in the pond basin creates natural structure that is very attractive to fish. Most small trees and brush will decompose in a relatively short period of time and will need to be replaced, but hardwoods, cedars, and large trees can last for decades. Trees can be tied together



Cedars and Blocks Used For Artificial Habitat

Pallets Used For Artificial Habitat

in various configurations or anchored separately with concrete blocks. Trees can also be kept in place by cabling them to existing stumps or steel posts driven into the pond bottom, as long as there is no concern about the posts causing the pond to leak or becoming a boating hazard.

Although any type of tree will work as habitat structure, hardwoods, osage orange, and especially red cedar, work best. Christmas trees can be used; however, they decompose rapidly and last only a few years. Large pines should be avoided because of their acidity. Plastic banding, polypropylene rope, or heavy, non-corrosive wire can be used to attach anchors directly to trees. Shoreline structure can be made by felling trees along the edge of the pond into the water. To keep these trees in place, cable them to the stump. Or half cut them, leaving a portion of the top connected to the stump.

Artificial habitat can also be added after the pond fills to intentionally attract and concentrate fish for anglers. The best locations for attractors are near natural gathering places for fish and in areas accessible to anglers. Good locations are off points, at the edges of drop-offs, in the mouths of coves, and near boat docks and fishing piers. The structures can be built on the ice during the winter over 4 to 10 feet of water or, if possible, the pond can be partially drained and the structures placed on the exposed bottom. Structures can also be built on the bank and pulled out into the water or hauled in a boat to the ideal fishing spot.

Structures placed in 5 to 10 feet of water can be used by fish year-round. Structures placed in water deeper than 10 feet may not be used during summer months if there is insufficient oxygen at those depths. Good attractors will be about 10 by 15 feet, or larger. Trees can be grouped together in several large piles, which is more effective than spreading individual trees across the entire pond bottom. A good rule of thumb for ponds larger than 5 acres is to build one large brush pile for every 2 to 3 acres of water. For safety's sake, do not place any structures in swimming or wading areas or within 100 feet of spillways or overflow pipes.

Before adding any structure into any surface waters of the state, you must first obtain a Section 404 Permit from the ACOE (see Appendix A for technical assistance contacts).

Spawning Habitat

Bass and bluegill are typically generalists, thereby eliminating the need to add spawning substrate such as sand or gravel. Some studies have shown bass prefer to spawn near a downed log, or similar structure, when available. There is the likelihood that excessive amounts of sediment in the older ponds can smother eggs in a nest if it is stirred up and then resettles. If an older pond can be partially drained, the exposed pond bottom will then dry out and become somewhat firm, making it better for nest builders. Or, once the pond bottom is exposed, equipment can be used to remove accumulated sediment in several areas. The operation of heavy equipment will also compact the bottom.

Channel catfish usually nest in a cavity. This can be a trash barrel on its side, a large piece of PVC pipe with one end plugged, or any other object that creates a "cave" the fish can lay in and defend. They will also nest alongside protective structure if no cavity is available. However, there will be limited survival of young catfish if the water is clear and bass are present.

Shallow-Water Habitat

If a pond owner desires, habitat can be further diversified by creating additional shallow-water areas. A small wetland area might be constructed below the dam, or a small pond can be placed above the main pond to provide sediment detention and additional habitat. Perhaps additional shallow-water areas can also be created in the upper reaches of the pond. All of these areas will eventually become vegetated and provide habitat for waterfowl, bullfrogs, and other wildlife.

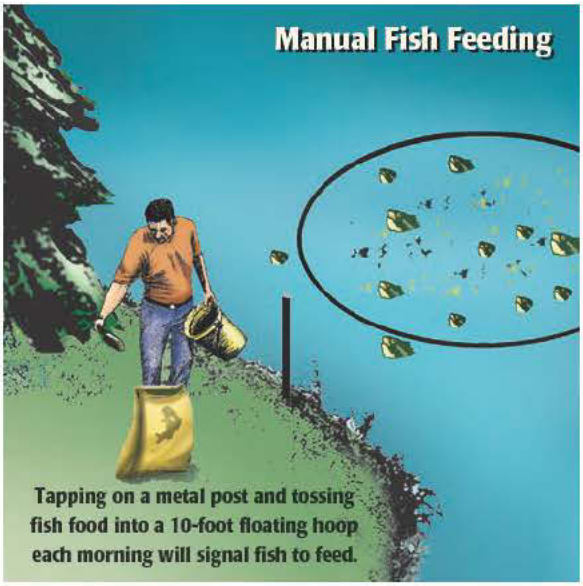
Fish Feeding

Feeding may be appropriate if the owner is willing to spend the time and money required to produce rapidly-growing, large-bodied bluegills, catfish, wipers, hybrid sunfish, or trout. However, fish must learn to eat commercial food pellets. Pellets should be provided at the same time and location each day. This can be easily accomplished with an automatic, timer-controlled, fish feeder placed on shore or on floats and anchored in the pond. Feeding only when you feel like it is usually a waste of time and money as most fish will never learn to eat the pellets, especially if there is no signal to indicate food is being provided. Fish will learn to react to signals, such as the whirr of the feeder as it turns on, or can be trained to come and eat dispersed pellets by banging on a pipe or post that has been driven into the nearby bank.

Nebraska ponds are usually fertile enough that fish feeding is not necessary.

Artificial feeding can increase the biomass of a pond beyond its normal carrying capacity. If a feeding program is discontinued, the pond may not be able to maintain the extra fish biomass, resulting in poor fish health and growth. Also,

the accumulation of nutrients from uneaten pellets and the increased waste output by artificially fed fish may age a pond quickly, consume oxygen, and stimulate algae blooms. When the algae die, their decomposition can lower dissolved oxygen levels, stressing or killing fish during the night or following several hot, calm, overcast days. When this occurs, fish can be seen at the surface gasping for oxygen early in the morning. An aeration system will help reduce the likelihood of fish kills due to low oxygen levels.



Tapping on a metal post and tossing fish food into a 10-foot floating hoop each morning will signal fish to feed.

If a pond owner insists on feeding fish, bluegills and/or hybrid sunfish should be provided about 5 pounds of pellets per acre, per day. Make sure the pellets are small enough for them to eat. Largemouth bass do not normally eat commercial pellets because they prefer to eat live aquatic organisms, but they may benefit from increased bluegill production. To increase bluegill and hybrid sunfish growth rates and produce large fish with feeding, there still has to be adequate bass predation on small bluegills and hybrids, unless the owner is willing to spend a fortune on food.

Channel catfish and wipers are practical to feed and quickly learn to eat pellets, resulting in increased growth rates. When catfish and wipers are present in relatively high numbers in multi-species ponds, they may consume the majority of the pellets, leaving little for other fish. Trout also readily accept dry pellets, and can be grown to larger sizes.

The amount and size of pellets to feed will depend on the fish species present, relative numbers and size range of target fish species, and the time of year. The following guidelines will help improve the success of a feeding program:

- Do not feed more than the fish will consume in 10 minutes. Keep in mind fish must first learn to come to the pellets, so start out with a small amount.
- If fish stop eating, stop feeding and check for low dissolved oxygen levels in the water, diseases, spoiled pellets, or other problems. Consumption of spoiled pellets can stress or even kill fish.
- Stop feeding catfish, wipers, bluegills, and hybrid sunfish when water temperatures are above 90 degrees or below 60 degrees. Stop feeding trout when water temperatures are above 70 degrees or below 50 degrees. Reduce the amount fed as water temperatures approach these temperatures.
- Do not feed after sunset or before sunrise.
- Feed only once and at the same time each day – preferably in the morning.
- Check automatic feeders periodically to make sure they are operating properly.
- Use floating pellets so you are able to observe fish while they are feeding and evaluate their health.
- Consider using a floating hoop to confine the pellets, which will prevent them from drifting to the bank.
- Only use pellets formulated for fish.
- Do not use old pellets – check the packaging date. Nutrient benefits decrease with time. Discard pellets if more than 6 months old.

- Store pellets indoors with room temperatures preferably under 75 degrees.

Contact a local livestock supply store for a source for commercial fish food.

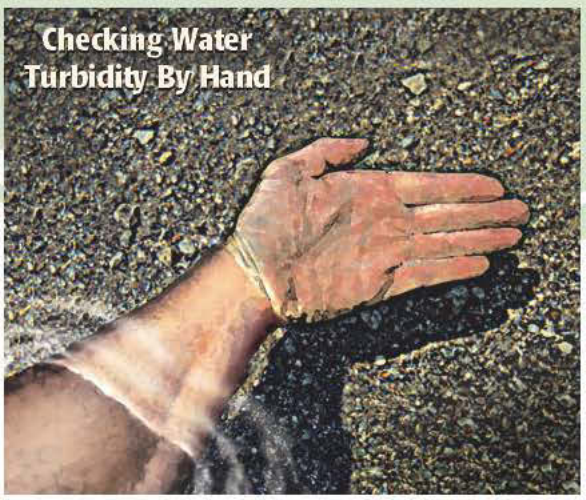
Pond Fertility

Water fertility determines a pond's productivity. A more productive pond will support more fish and a larger harvest than a less productive pond. A pond is considered about right for good fish production if you can see your

In general, fertilization is not needed in most Nebraska ponds, and adding agricultural fertilizer is prohibited.

fingers when you extend your arm 18 inches downward into the water while in direct sunlight or when a secchi disc is impossible to see at 18 to 24 inches below the pond surface. The level of visibility should be due to the density of existing fish food organisms (such as zooplankton, phytoplankton and aquatic insects), not suspended soil particles. Keep in mind most soils and pond water supplies in Nebraska are nutrient rich; therefore, adding more nutrients to ponds is typically not necessary. Exceptions could be newly created ponds. In Chapter 1,

Checking Water Turbidity Using a Secchi Disc



Checking Water Turbidity By Hand

we discussed the various benefits of placing removed organic-enriched topsoil, brush and trees back in the pond and establishing a cover crop in the basin, when construction was completed. One ensuing benefit was the likelihood of creating a nutrient boost that facilitates initial establishment and expansion of the aforementioned fish food items. With this in mind, the addition of agricultural fertilizer to increase fertility is not necessary and is actually prohibited since it would violate Title 117 Water Quality Standards set by the Nebraska Department of Environmental Quality. Also, if nutrients become excessive, there is the likelihood of excessive aquatic vegetation growth, especially algae, that could negatively impact fish populations.

Terrestrial Habitat

Although fish production is the primary interest for most pond owners, the impounded water will provide habitat for a multitude of organisms, ranging from aquatic insects to terrestrial wildlife. We have already discussed planting areas in and immediately around the pond to control erosion and sediment; however, the vegetative cover near the pond also greatly influences the types of wildlife that will regularly use the pond.

The basic needs of most upland wildlife species are simple: food and cover. Buffer strips

adjacent to ponds become important habitat that provide both. Cover is needed for nesting or denning, escape from predators, and shelter from harsh weather. The lack of any of these may limit populations. This cover can also improve water quality and lengthen the life expectancy of a pond by entrapping sediment from erosion on land surrounding the pond.

A pond is a community of many living organisms, with most of them depending on each other for survival. A pond forms a connecting link between the aquatic and terrestrial worlds.

In open rangeland and small pastures, fencing should be used to protect at least a 100-foot wide grassed buffer around the pond. A strip of this width provides excellent habitat, particularly for small mammals and ground-nesting birds, and makes it more difficult for predators to locate prey. If the pond is to be located in or near cropland or over-grazed pasture, a mixture of native grass and legumes, such as alfalfa and clover, should be planted within the 100-foot wide fenced buffer. Depending on the amount of land available, trees and shrubs can also be considered. Establishing windbreaks near the south and west sides of the pond will provide cover for a variety of wildlife and help to reduce wave action and turbidity. These various plantings will provide winter and escape cover, food production, and nesting areas for wildlife.

It is necessary to periodically set back plant succession to yield greater wildlife benefits and diversity.

The grassed buffer areas need to be periodically manipulated to produce a wide diversity of grasses and broadleaf plants, also known as forbs, that can be utilized as food and cover for the various kinds of wildlife desired. Wildlife utilization of a habitat can then be increased by maintaining a stage of plant succession. Since vegetation cannot be held at a particular stage for any great length of time, it becomes necessary to set back succession and allow the process to start over; thus, recycling the most beneficial successional stages. This can be accomplished by controlled burning, mowing, lightly discing and interseeding with legumes or forbs, grazing, or even careful use of chemicals. These practices, when done correctly, do not destroy the grass, but improve plant diversity and maintain vigorous growth within the stand, yielding greater wildlife benefits and diversity. Other wildlife requirements can also be met if there is a need to plant additional trees and shrubs. Contact your area Commission wildlife biologist or the NRCS about habitat planning and periodic manipulation.

Waterfowl Production

Most pond owners enjoy seeing waterfowl use their ponds and most ponds can be

enhanced to increase the chances that waterfowl will visit; however, the decision to manage a pond for waterfowl must be made before the pond is built. Guidelines for creating ponds attractive to waterfowl usually are different from those for fishing ponds. The ideal fishing pond, with deep water, relatively steep banks, and limited aquatic vegetation, is not the best for attracting waterfowl. While deep water areas of ponds provide loafing areas, waterfowl prefer to feed and raise their young in weedy, shallow water areas, away from human activity.

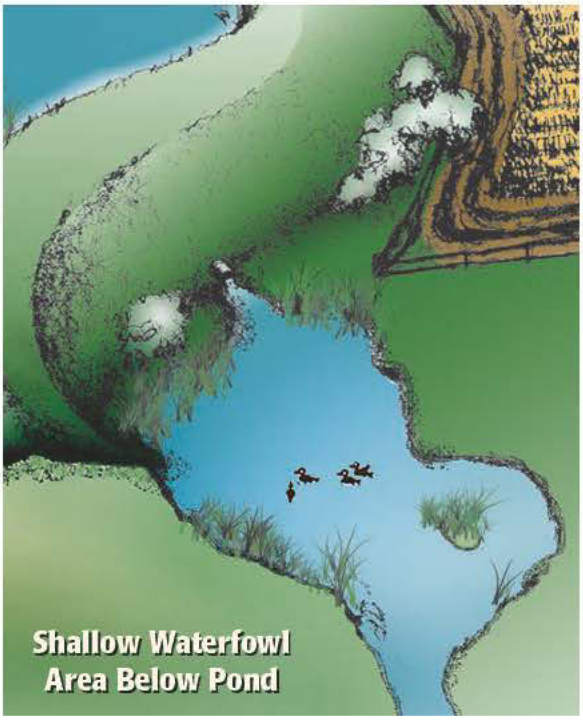
A water control structure needs to be included in a pond design if interested in waterfowl production.

Nearly all successful waterfowl management efforts require some water level manipulation and a flooded food source, so a water control structure needs to be included in the pond design. Keep in mind that a minimum water depth of 10 feet is needed in a portion of the pond to prevent fish kills, especially during the winter.

To create an annual flooded food source attractive to waterfowl and other migratory birds, lower the pond water level enough to expose mudflats, usually starting in late June or July. When water levels drop, wetland, seed-producing broadleaf plants and grasses, such as smartweed and barnyard grass, germinate and grow naturally on the exposed mud flats. Or, a grain crop, such as millet, can be broadcast seeded on them. Then, slowly bring the level back up, starting around September 1. This fluctuation in water levels often occurs naturally in some ponds, with evaporation reducing the levels in summer and fall rains refilling the pond.

Ponds having a consistent water level and an overflow control structure will have to be lowered periodically by removing boards from the control structure, or by opening the lower release valve if present, until the desired water level is reached. Again, start lowering in late June or July. Allow vegetation to become established naturally, or seed the mud flats with millet as they are exposed. Then, around September 1, slowly start bringing the water level up by putting one board back in the water control structure each week. The key is to allow the plants to germinate and grow and then gradually inundate about half their height each time a board is added. The plants will drown out if totally submerged for an extended period of time. The plants will also die or have limited growth if moisture is inadequate during the summer months. Emergent vegetation, such as cattails, bulrushes, and arrowhead, can be enhanced every 5 to 6 years. The dewatering should start about mid-May, with a refilling procedure similar to the one used for the annual flooded plantings.

If land is available, another suitable way to provide waterfowl habitat is to construct a shallow-water area below the dam, perhaps as large as three acres. Water from the pond can be used to seasonally flood this man-made marsh, provided pond inflows are sufficient and adequate depth remains. Such shallow-water areas offer many more wildlife options than trying to rely on water level manipulations within the pond itself. The pond-marsh



combination provides a more efficient use of water, as only a 12- to 15-inch average depth is needed in the marsh. A good rule of thumb is to provide a marsh with 50% open water and 50% emergent vegetation. Openings should be mowed, as needed, in dense tall vegetation before flooding.

Waterfowl can become a nuisance if populations become too high.

Truly wild, migrating ducks and geese cause few pond problems, nor do a few year-round resident birds. A large number of resident or domestic ducks and geese, on the other hand, can cause a whole host of problems on ponds. Go to many big city park ponds and you'll see people happily feeding bread crumbs to receptive ducks and geese. While this looks enjoyable, a large amount of bird droppings can create health hazards or poor pond water quality. In addition, the number of unattractive birds (feathers missing, deformed, or sickly) in the flock, the lack of shoreline vegetation in areas of high waterfowl use, and geese that may become quite mean and aggressive, are also potential problems. Population levels of these ducks, and especially Canada geese, have risen to nuisance levels in many areas. In fact, hand-feeding and nesting is now being discouraged, particularly in or near metropolitan areas across the state, and everywhere east of Highway 14.

Resident flocks sometimes attract thousands of migrating waterfowl during the winter. If a large concentration of waterfowl is present on a pond for a long period of time, their waste can increase nutrient levels. This could lead to an algae bloom that is detrimental to fish, especially on smaller ponds. Where aerators are needed during the winter to prevent fishkills, the open water that is created is very attractive to geese; therefore, if the geese numbers become too high, they should be hunted when/ where possible or they can be hazed as long as there is no physical contact or harm to them.

If you are in an area where waterfowl production is still being encouraged, mallards and Canada geese will likely nest at your pond if you construct small islands in the pond, at least 30 feet offshore. Nesting can be further assured by installing artificial nesting structures. Keep in mind waterfowl do not carry nest materials to nesting sites; therefore, manmade waterfowl nest structures require annual maintenance and replacement of nest material. A successful nesting structure may have less than the desirable amount of nesting material left. It will likely contain old down, feathers and possibly unhatched eggs or egg shell fragments, or, it may have gotten wet and contains moldy nesting material. These structures should be cleaned in late winter. Lack of proper maintenance is the number one cause of failure for most nest structures. It may take several years before new nest structures are used. But, once waterfowl successfully nest in structures, they and their offspring will very likely return to nest year after year, if structures are well maintained. As nest structures usage approaches 50 percent, more structures can be added, since few projects ever exceed 75 percent occupancy. Pond owners can also try to attract wood ducks to their ponds, by placing nest boxes on poles or nearby trees.

Plans for wood duck nesting boxes, and those for mallard or Canada goose nesting structures, are available from a variety of sources. Contact the Commission's Wildlife Education personnel for blueprints of various waterfowl nesting structures.

MANAGING A BASS - BLUEGILL - CATFISH POND

Very few perfect ponds exist. But with proper management, most ponds can provide good fishing. If you're catching 5-pound bass and 1-pound bluegills from your pond on a regular basis, put this handbook down and go back to fishing. Your pond is in great shape! If catching 5-pound bass and 1-pound bluegills from your pond sounds like a pipe dream, read on. While you'll find no magic or overnight solutions here, you will probably learn a few things you could do differently that will improve your fishing or give you more overall enjoyment from your pond.

1) Assessing Fish Populations

The most common complaints received from pond owners regarding the fish populations in their ponds are: 1) there are either too few or too many of a particular fish species present; 2) the fish are not of a desired size; or 3) undesirable fish species are present. Successful pond management requires more than just stocking fish and hoping the pond will produce the quality of fishing desired. We have already discussed how important it is to maintain proper aquatic and terrestrial habitats. It is also very important to monitor fish harvest, growth, and reproduction, and to keep out unwanted fish. By doing these things, you will be able to attain and/or maintain balanced fish populations in your pond.

What is a Balanced Pond?

Biologists commonly talk about pond balance or balanced fish populations. They are simply talking about the relationship between the abundance of predators and prey, such as largemouth bass and bluegills.

Fish Size Distribution in a Four-Year-Old Pond

Initially Stocked As Fingerlings In 1st Year (Now 4 Years Old)	No Largemouth Bass Stocked The 1st Year	No Channel Catfish Stocked The 1st Year
2nd Year Offspring	Initially Stocked As Fingerlings In 2nd Year	Initially Stocked As Fingerlings In 2nd Year
3rd Year Offspring	Not Necessary To Stock Largemouth Bass The 3rd Year No Offspring Produced	No Channel Catfish Stocked No Offspring Produced The 3rd Year
4th Year Offspring **BLUEGILLS**	4th Year Offspring **LARGEMOUTH BASS**	**4th Year:** Supplemental Stocking Of 10-Inch Channel Catfish: Number Stocked Depends On Harvest – See Pages 49-50 **CHANNEL CATFISH**

A good, balanced pond will contain about 250 pounds of bluegills and 50 pounds of bass per surface acre of water.

Generally, bluegills are the most abundant fish present in most fishing ponds. A good, balanced Nebraska pond will contain about 250 pounds of bluegills per surface acre of water. They provide the most angling opportunity and harvest can begin the second year after stocking. A good, balanced pond should also have about 50 pounds of largemouth bass per acre, or one-fifth the weight of bluegill. About 45 to 60 percent of the bass larger than 8 inches should be larger than 12 inches. In other words, about half the bass that you catch in the pond should be between 8 and 12 inches long and the other half larger than 12 inches. All bass less than 15 inches should be released for four years following the initial fingerling stocking. After that, no more than 15 to 30 adult bass or up to 20 pounds of bass should be harvested per acre annually, depending on pond fertility and management objectives. Greater harvest rates can reduce the quality of both bass and bluegill fishing.

For every pound of bass you harvest you will need to harvest five pounds of bluegills.

It is very important that the 5:1 ratio between bluegill and bass weight is maintained once fish harvest begins. If you take one 10-pound trophy bass out of a pond to hang on your wall, you'll need to harvest 50 pounds of bluegills to compensate for that. Given most bluegills you catch will probably be a quarter- to a half-pound in size, that's 100 to 200 bluegills you will then need to harvest. This is where many ponds fall out of balance: anglers do not take enough bluegills, causing a shift that will likely get worse.

When bluegills become overpopulated, growth rates decrease and they become stunted, with only a few fish growing to a large size. When this happens (usually as a result of bass being overharvested), it is almost impossible for anglers or remaining bass to remove enough small bluegills to get the pond back into balance. Even though a supplemental stocking of 50 adult largemouth bass per acre can be done to correct the situation, it may not work. The likelihood of bass overharvest can be reduced by requiring anyone who fishes the pond to follow strict harvest rules.

Fish Harvest Ratio for a Balanced Pond

Maintain a 5:1 Harvest Ratio

One 1-Pound Largemouth Bass **(1 lb.)**

Ten 1/2-Pound Bluegills **(5 lbs.)**

A good, balanced pond can also produce about 40 pounds of channel catfish per surface acre of water. Catfish can be introduced into established ponds by stocking 20 to 50 adults, 10 inches or longer, per acre. The higher rate can be used if there is significant harvest or a feeding program. Since channel catfish will have to be restocked in most ponds to maintain their fishery, you can harvest as many as you want. Of course if you want big catfish in your pond, you'll need to release some each year. Plus, harvesting everything you catch will mean you will have to restock more catfish, more often. If you only harvest 15 catfish per acre per year, you should be able to maintain a good catfish population and only have to restock

10-inch fish every three years. Number stocked should equal the harvest plus an additional 10 percent to compensate for natural mortality.

Is Your Pond in Balance?

The best way to tell how well your fish are doing is to go fishing! By catching fish, you can determine how well they are growing and reproducing, and whether any unwanted fish species have gained access to your pond. Fish with a variety of techniques, using artificial lures and natural baits suitable for all species and sizes present. The more fish you catch, the better you will be able to evaluate the fish population. Keep good records of the time spent fishing, dates, fish species caught, and accurately measure the length of each fish caught. A form for keeping catch records is provided in the back of this handbook (page 89).

Periodically review your catch records and ask yourself these questions:

1) Is the average size of bluegills decreasing?
2) Is the size of the largest bluegill caught getting smaller?
3) Are bass noted as getting skinnier?
4) Are fewer big fish and more little fish being caught per hour?
5) Are crappies, carp, bullheads, or other non-stocked fish showing up in the catch?

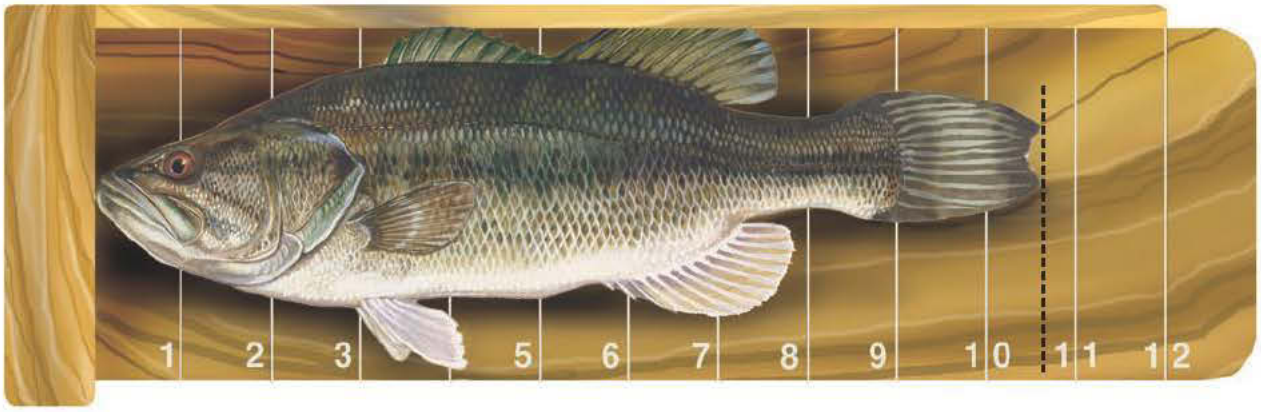
Answering yes to any of these questions may signal the pond is becoming out of balance.

How Can Balance be Maintained or Achieved?

Fish populations will naturally fluctuate from time to time and there's no need for concern if you have one or two fishing trips with poor success. If the quality of fishing in your pond appears to be declining, start collecting angler catch data. Spring is normally the best time to collect angling data; however, angling may have to be conducted several times during the year to collect enough pertinent data.

Although angling assessment is preferred, fish populations can also be assessed with a seine in mid-summer. Legal seines can only be one-fourth inch non-metallic square mesh

MEASURING A FISH



1. **Lay fish sideways, flat on measuring board/ruler.**
2. **Close the mouth.**
3. **Squeeze the tail lobes together.**
4. **See how long your fish is – this largemouth bass is just over 10 1/2 inches long.**

and not over 20 feet long and 4 feet deep. Use of larger seines must be authorized by the Commission. Seining may not be effective if submerged aquatic vegetation is abundant or if shallow water areas are limited.

Once angling and/or seining assessment data have been collected, choose one of the scenarios on page 52 or 53 that best fits your pond's situation.

Specific management options are presented starting on page 54, including several that intentionally keep a pond out of balance in order to produce trophy bluegills or largemouth bass.

Is Help Available to Assess Fish Populations?

Perhaps you are experiencing problems and are unable to collect fish, or you have already monitored your pond for a year, implemented the suggested management practices, and things don't seem to be getting any better. If you are unsure what to do, contact the Commission's Private Waters Specialist or your area district fisheries biologists and seek assistance. They may be able to resolve your problem(s) over the phone. If not, they will likely conduct a site visit, which may involve sampling the fish in your pond, and make recommendations.

The Commission's Private Waters Specialist or area district fisheries biologists can provide assistance.

The most effective way to quickly sample the bluegill and largemouth bass populations and determine if a pond is in balance is by electrofishing. Electrofishing is done by boat, so a pond must have good boat access. Electrofishing boats are rather large and heavy, so a smooth, solid shoreline and bottom is required. A water depth of at least 3 feet of water within 10 feet of the shoreline is required to launch an electrofishing boat. A sharp drop-off at the water's edge may present a problem.

Electrofishing boats send an electrical current into the water which stuns fish. Most of the stunned fish come to the surface in front of the boat by the electrodes, where they can be easily netted. Stunned fish recover from the shock within a few seconds to a few minutes, depending on their size, proximity to the electrodes, and water temperature. Netted fish are placed in a live well in the boat. Once an adequate number of fish are collected, the biologist will assess the sample, noting the species collected, their size distribution, and their relative abundance. Depending on the size of the pond and the number of fish initially collected, additional fish may need to be collected. From these samples and angler catch results, the biologist can determine whether or not the pond is in balance or if undesirable species have become a serious problem, and formulate a management plan.

While professional assistance would seem to be the easiest option for the pond owner, it may not be the most convenient. State biologists may be willing to sample your pond, but they do so on a time-available basis. Public waters take priority and electrofishing is most effective in the spring and fall. That means you may have to wait weeks or months for someone to visit your pond. You may also have to make some access improvements to your pond to accommodate launching a large boat. If a state biologist is not available, you may wish to contact a private pond management consultant. For a fee, they will sample your pond and make management recommendations. Contact an area Commission fisheries biologist or the Private Waters Specialist for a listing of consultants.

2) Managing Fish Populations

By the fourth year after stocking, you should decide how you want to manage your pond. Do you want balanced populations so you can catch good-sized bass and bluegills or is catching

ANGLING CATCH	WHAT IT MEANS	RECOMMENDATIONS
Most bass 12 to 15 inches, with some smaller and larger; most bluegills 3 to 6 inches, some over 8 inches.	Balanced population.	None. You're doing fine. Continue existing harvest philosophy, unless you want bigger bass or bigger bluegills.
Numerous small bluegills, most less than 5 inches; a few bass, most over 15 inches.	Overcrowded bluegill population; bass not reproducing or recruiting successfully.	None if managing for large bass; otherwise, stop bass harvest, stock 8- to 12-inch bass at 25 to 50 per acre.
Numerous bass, most less than 12 inches; most bluegills over 8 inches.	Overcrowded with small bass; most bluegills are eaten, but those that escape have little competition and grow well.	None if managing for large bluegills; otherwise, harvest 15 bass less than 12 inches per acre per year to reduce their competition for food.*
Numerous skinny bass, few over 12 inches; a few bluegills over 6 inches.	Severely overcrowded with small bass that compete with bluegills for food.	Harvest 30 bass less than 12 inches per acre per year.* If bluegills numbers remain low, may need to stock 4- to 6-inch bluegills at 50 to 100 per acre.
Aquatic vegetation covers more than 40% of pond; most bluegills less than 5 inches; most bass less than 12 inches.	Predator-prey interaction interrupted.	No bass harvest; control vegetation (see page 63).
Bullhead, green sunfish, carp; few bluegills and bass.	Undesirable species are competing with bass and bluegills; bass are unable to control them if water is turbid.	Drain the pond or renovate the fish population with rotenone* and restock with largemouth bass, bluegills, and channel catfish.

**** Authorization from the Commission is required before any bass less than 15 inches long can be harvested or removed from private waters or before a pond can be renovated. Consult Commission fisheries personnel for details.***

SEINE HAUL CONTENTS	WHAT IT MEANS	RECOMMENDATIONS
Small and medium size bluegills and some young bass.	Balanced population.	None. Keep the same management and harvest practices.
Numerous small bluegills, but no small bass.	Overcrowded bluegill.	None if managing for large bass; otherwise, stop bass harvest, stock 8- to 12-inch bass at 25 to 50 per acre.
Some small bass and no small bluegills.	Insufficient bluegill numbers, bass overcrowded.	None if managing for large bluegills; otherwise, harvest 15 bass less than 12 inches per acre per year.* If bluegill numbers remain low, may need to stock 4- to 6-inch bluegills at 50 to 100 per acre.
No small bass and no small bluegills, just green sunfish and bullheads.	Fish population has serious problems that require drastic measures to correct, especially if water is turbid.	Drain the pond and renovate it with rotenone* to eliminate fish and restock with largemouth bass, bluegills and channel catfish.
No fish, just tadpoles or salamanders.	No fish populations present or at low levels.	If only tadpoles present, pond may be too shallow to support fish or no fish have been introduced yet. If only salamanders present and pond has sufficient depth and good water clarity, stock larger largemouth bass, bluegills and channel catfish. Fingerlings would be eaten by salamanders.

**** Authorization from the Commission is required before any bass less than 15 inches long can be harvested or removed from private waters or before a pond can be renovated. Consult Commission fisheries personnel for details.***

large individuals of one species more important than the other? Quantity usually has to be sacrificed to grow larger fish. Regardless of which option you choose, the key to success is controlled harvest. Keep records of the fish caught in your pond and make sure anglers are only harvesting the species and sizes of fish suited to your plan. A lack of harvest may be a bigger problem than too much harvest and will likely result in your specialized management efforts not working.

Authorization from the Commission is required before any bass less than 15 inches can be harvested or removed from private waters.

When reading about the following harvest recommendations for the various management options, keep in mind anglers have to obey regulations set for private waters. Regardless of which option is chosen, any catfish harvest will require they be restocked periodically to maintain a viable fishery. Since bass are effective predators on small channel catfish, replacement catfish will have to be at least 10 inches long.

Management Option 1: No Harvest Restrictions

Although harvest without any restrictions requires no management effort by the pond owner, it will rarely provide more than one or two years of good fishing. Anglers are allowed to keep as many fish as they can catch within regulations set for private waters. Anglers will likely catch nice bass and bluegills during the first few years; however, the catch in succeeding years will usually consist of some small bass and numerous small bluegills. Once bluegills become overabundant and their growth slows, few will reach sizes most anglers like to catch for sport or keep. This option would be a choice for pond owners who are just interested in catching fish and are not concerned about size.

Management Option 2: All-Purpose (Balanced Pond)

If you are interested in catching fish of a variety of sizes, you can utilize the All-Purpose option to either maintain or get your pond back into balance. To catch some bass longer than 15 inches, the numbers of 8- to 12-inch bass must be reduced, especially if the pond has high bass recruitment (high survival of age 2 and younger fish). Removal of these smaller bass reduces competition and improves bass growth, which allows some bass to attain lengths over 15 inches. Most fertile ponds, particularly those in the southeastern part of the state, can have up to thirty 8- to 12-inch bass harvested per acre per year the fourth year after fingerlings are stocked. All 12- to 15-inch bass should be released in order to produce fish over 15 inches long. Having high numbers of bass, particularly 12- to 15-inch bass, also reduces the number of small and intermediate size bluegill. This will result in producing bluegills of various sizes, with some reaching 8 inches. Anglers can harvest bluegill and catfish as desired. You will need to monitor the level of submergent aquatic vegetation; too much vegetative cover will prevent bass from effectively controlling bluegills. See page 63 for various vegetation control techniques.

Management Option 3: Large Bluegill (Unbalanced Pond)

If you're more interested in catching big bluegills than big bass, anglers should release all bass caught less than 15 inches long. Bass over 15 inches long can be harvested, but few bass will reach that size, due to competition for food. By having a high density of small bass, bluegills will be effectively controlled. With overcrowded small bass, the few bluegill that avoid predation by bass will grow fast and reach a size large enough that the bass can't eat them. This will produce more 8-inch and larger bluegills than other management options.

Although there normally are no harvest restrictions on bluegill or catfish, some of the big bluegills should be returned to produce even

This option only works in water with visibility of at least 18 inches and when aquatic vegetation isn't excessive. This allows bass to easily see and capture their prey.

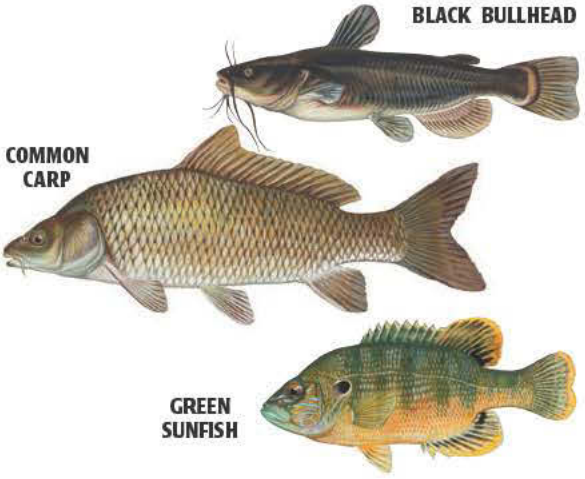
larger ones. If, after a couple of years, the bass become skinny or appear to be all head and very few 12- to 15-inch bass are caught, the removal of some 8- to 12-inch bass, about 15 per acre per year, may be necessary. This annual bass harvest may need to be continued or increased until 10 to 30 percent of all bass caught are 12 inches or longer. If small bass become too dense, they may remove too many bluegills or compete with them for food.

If your pond contains sufficient depth and clarity, has crappies, bullheads, or green sunfish, and you do not wish to drain the pond or kill all the fish in the pond, following the above management strategy would be your best bet. By purposely overcrowding bass in your pond, you may be able to control the numbers of these other species, possibly allowing you to eventually catch some of decent size, and maintain a good bluegill fishery. Stocking an additional predator, such as northern pike or walleye, might also help control the numbers of these other species provided the pond is of sufficient size and contains appropriate habitat. The important thing is the predators must be protected from angler harvest.

Management Option 4: Large Bass (Unbalanced Pond)

If you really don't care about bluegills and just want the chance to catch a big bass, this option is for you. After your initial pond stocking, do not harvest any bass for four years. After that, start harvesting 30 to 50 bass, 8- to 12-inches per acre per year and 5 bass, 12- to 15-inches per acre per year. By reducing bass numbers, survivors will have little competition and grow well. Release larger fish so they can continue to grow to trophy sizes. Remember, your pond can only produce a certain poundage of bass per surface acre. Whether it is ten 3-pounders or three 10-pounders depends on management, along with environmental and habitat conditions. But, if you want to catch a 10-pounder, you have to throw the 9-pounder back and keep the 1-pounders. That will give the 9-pounder a chance to grow and hopefully live long enough to reach record-size so you can reconnect. Since this management option produces high numbers of small bluegills, it may be a good option if you have young children learning to fish. They can enjoy catching lots of small bluegills while the adults go after trophy bass. There are no bluegill or catfish harvest restrictions with this option.

3) Removing or Controlling Unwanted Fish Species



If your new pond already has bullheads, carp, or green sunfish established, or you would like to restore an old pond containing these same species, it will be very difficult to establish or restore a balanced bass-bluegill fishery. The easiest and quickest way to resolve either problem will be to eliminate all the fish in the pond and start over with the appropriate pond species – largemouth bass, bluegill, and channel catfish.

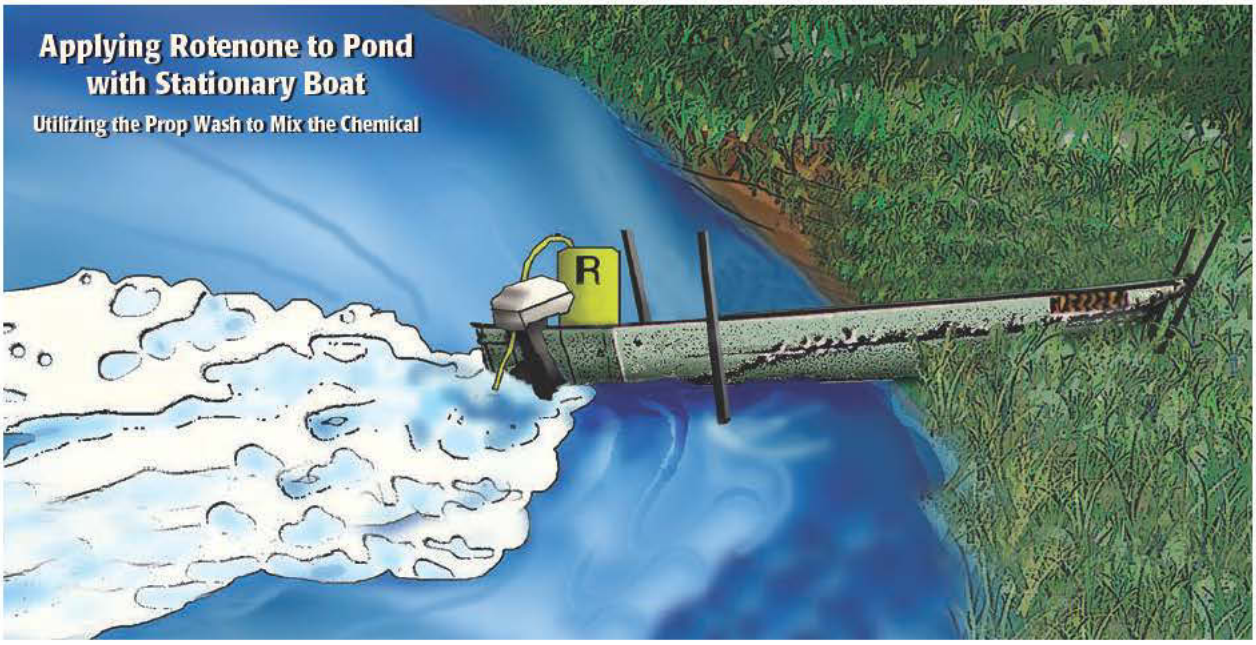
If there is no concern with contaminating downstream fish populations with the fish from your pond, the pond can be drained or pumped dry; however, keep in mind that your neighbor may not appreciate fish rotting on his land. Renovating your pond by killing fish with a chemical is another option. Even if a pond cannot be drained completely, lowering it a few feet will reduce the amount of chemical needed, saving you money if pumping costs are not considerable.

Fish renovations should be undertaken only in ponds with: adequate depth (10-12 feet), sufficient size (half acre or larger), controlled watersheds, and undesirable fish populations. Fish population improvements in ponds with marginal habitat or water quality would be short-lived. A new pond can be renovated as soon as the dam is completed if there is no possibility of additional unwanted fish entering before desirable fish can be stocked.

Rotenone is a chemical which kills fish by making it impossible for their gills to absorb dissolved oxygen from the water. Within a few minutes of application, fish can be seen struggling at the surface and dying. It is not toxic to most warm-blooded mammals (one exception is pigs) at prescribed concentrations. Rotenone is a naturally occurring organic compound extracted from the roots of certain tropical plants. It can be purchased either as a powder or liquid. The liquid is recommended because of its ease of application. Rotenone with 5% active ingredient, or 2.5% synergized, is recommended, especially for eliminating carp and bullheads. Since rotenone is a restricted use pesticide, it can only be purchased and applied by an applicator licensed through the Department of Agriculture. Contact Commission fisheries personnel regarding the permit process, chemical purchasing, and application.

Pond owners must obtain authorization from the Commission to use rotenone.

To determine how much rotenone is needed, you need to know the volume of your pond, which is calculated by multiplying the number of surface acres by the average depth of the pond. Average depth can be estimated by multiplying the maximum depth by 0.4. Volume is expressed as acre-feet of water. One acre-foot of water will cover one surface acre with one



foot of water. For example, a 5-acre pond with an average depth of 4 feet has a volume of 20 acre-feet. Liquid rotenone should be applied at a rate of one gallon per acre-foot of water.

See Appendix C for other examples of surface area and volume determinations.

One way to apply rotenone is to drive around on the pond in a boat with an outboard motor and slowly pour or spray diluted rotenone into the water near the prop wash. Be sure to cover the entire pond and make extra passes over deep water. If a large portion of the pond contains depths of 8 feet or more, a pump or portable sprayer with a weighted hose should be used to get the chemical down to the bottom.

A more effective method, particularly in smaller ponds, is mixing the chemical into the water by utilizing the prop wash from a stationary outboard motor. Point the front end of a small boat toward the bank. If there are no solid objects to restrain the boat, the front and sides can be tied to stakes driven into the pond bottom or shore to prevent the boat from running up the bank. Run the outboard motor in forward gear as fast as safely possible and slowly pour or spray diluted rotenone into the prop wash. This will circulate the chemical to all depths of the pond. The location of the boat should be changed several times so the chemical can be mixed into all areas of the pond. A portable sprayer should be used along the shoreline for applying chemical in shallow water areas where both prop wash techniques may not have distributed the chemical effectively.

The best renovation results are achieved in August. This is typically when water temperature is at its highest, and water levels are at their lowest so no treated water exits the pond. Wait at least two to four weeks before restocking. This will allow enough time for the chemical to detoxify. To ensure the pond has detoxified, leave a bait bucket containing some minnows in the pond overnight. If they survive, the pond is safe to restock.

As discussed earlier, you may not want to kill all the fish in your pond to get rid of undesirable fish. If your pond is spring-fed, rotenone may not be a viable option, due to the likelihood of chemical dilution; or in the case of large ponds, the chemical may be cost-prohibitive. In these situations, you may have to live with what you have.

To make the best of the situation, either learn to enjoy harvesting carp, bullheads, and green sunfish, or use management techniques to reduce their numbers as best you can. The best thing to do with all those little bullheads and green sunfish in a pond is to convert them into bigger, more desirable sport fish. Largemouth bass, northern pike, walleye, large catfish, and other predators all eat these unwanted species, and can be experimentally stocked if the pond is of sufficient size and contains appropriate habitat. Depending on availability and cost, the predators should be introduced by stocking 20 to 50 adults, 8 to 12 inches or longer, per acre of water. If protected from harvest, the predators should reduce the numbers of undesirable fish. Eventually your pond may even produce some trophy-size fish that you can enjoy catching. Once bullheads, carp, and green sunfish are controlled, or if bass appear to be getting skinny, stock 4- to 6-inch bluegills at 50 to 100 per acre if they are not already present. Bluegills will eventually provide adequate prey to support an expanded, desirable bass fishery.

While stocking predators can be a way to control carp, bullheads, and green sunfish, they have to be able to see these fish in order to eat them. In some cases, the unwanted fish may keep the water so stirred up that sight feeding predators can't detect their prey effectively. Turbid ponds are usually the best candidates for draining, excavating, and restocking. If that's not possible, you can try various techniques to clear muddy water, as discussed on page 59, or possibly stock adult flathead catfish, a very effective predator even in turbid water.

POND MAINTENANCE

RESOLVING COMMON POND PROBLEMS

There are many problems that can reduce a pond's potential to produce a desired fishery. Most can be prevented with proper pond construction, habitat development around the pond, and fish stocking, followed by proper management and maintenance. It is easier and less costly to prevent problems, rather than treat them later. But in some cases, such as decades-old ponds built with fishing as an afterthought, that is not possible.

Many pond problems are related to water quality. Whether the water is too green, too brown, or polluted, most water quality problems can be prevented by keeping sediment, nutrients, and pollutants out of ponds. Undesirable fish species, such as carp, bullheads, and gizzard shad, also need to be kept out of ponds since they can negatively affect water clarity and limit a pond's ability to produce sport fish.

The following information will explain the conditions that can lead to various pond problems, how to help prevent them, and how to resolve existing problems.

Water Clarity

The clarity of a pond is primarily determined by the abundance of individual, free-floating microscopic plants (phytoplankton/algae) and animals (zooplankton), organic materials, and suspended soil particles. If water is enriched with phosphorous, nitrogen, or animal wastes, a large algae bloom can occur, turning the pond green. See page 63 for vegetation control methods. If the pond was recently green in color, but quickly turned brown, the algae have died and are now decomposing. High populations of zooplankton or certain algae species can also give the water a brown color. A tannic acid buildup, resulting from the breakdown of accumulated organic materials from a marsh or wetland areas or from tree leaves in the pond, can stain pond water and give it the color of tea. When a pond contains non-transparent muddy water, it is the result of tiny particles of soil, especially clay soil, suspended in the water.

Extended periods of muddy water detracts from a pond's appearance, reduces food production for fish, eliminates aquatic vegetation and reduces oxygen.

Muddy water detracts from a pond's appearance and reduces its ability to produce food, especially for small fish, by shading the microscopic plant life on which the food chain is based. It also reduces the ability of sight-feeding fish, such as largemouth bass and bluegills, to capture prey. Extended periods of high turbidity can eliminate both submergent and emergent aquatic vegetation that provide important habitat for fish and other wildlife. Muddy water also has lower oxygen levels due to reduced photosynthesis. Sediment in the water can smother fish eggs and bottom-dwelling organisms. Although most ponds will be muddy following major inflow events caused by heavy rains in the watershed, the suspended sediment in good ponds should settle out within a week. Water in new ponds may be muddy until pond banks become vegetated; therefore, it is very important to establish and maintain vegetative cover around the pond as soon as construction is completed.

To correct a muddy water problem, the cause has to first be determined. Take a sample of pond water in a clear glass jar and set it on a shelf. If after one week the water is fairly clear and mud has settled to the bottom, the main cause of the problem is likely due to either soil erosion, wave action in shallow water, livestock, or an overpopulation of carp, bullheads, or even channel catfish; however, if the mud remains suspended, the problem is soil chemistry. Often the problem is a combination of several factors. In some cases the soil particles will stay suspended indefinitely.

Muddiness due to Soil Erosion

The best way to keep pond water clear is to prevent or reduce the amount of soil entering the pond from the watershed. This can be done by grading and terracing the land above the pond, installing sediment retention basins or soil traps at the pond inlet, routing muddy water around the pond through diversion ditches, and establishing buffer strips around the pond and in waterways leading into it. It is much easier to limit soil erosion and prevent excessive surface runoff than it is to remove sediment once it has entered the pond.

Reporting Excessive Runoff Problems:

If a landowner is experiencing excessive sediment runoff from a neighbor's property that may be in violation of Nebraska's Erosion and Sediment Control Act, the local NRD or NRCS offices should be contacted. If the excessive sediment runoff and/or suspected associated pesticides cause further environmental damages, such as crop loss or a fish kill, the U.S. Department of Agriculture's Plant Industry Section should be contacted within 24 to 48 hours at 402-471-2394. The Nebraska Department of Environmental Quality's Agricultural Section should be contacted at 402-471-4239 when problems arise from excessive runoff containing livestock waste.

Muddiness due to Wind and Animal Activity

If wind is causing shoreline erosion and waves are stirring-up bottom sediments in shallow-water areas, windbreaks should be planted to block prevailing summer winds and protect shorelines. Establish emergent aquatic vegetation, such as rushes, sedges, and cattails, and water-tolerant grasses, such as prairie cordgrass and switchgrass, along the shoreline and in shallow water areas, or by the dam if erosion is occurring there. These plants will facilitate healing of the shoreline and, in time, eliminate erosion. Rock rip-rap may have to be used along the dam if erosion is severe. Some of the shallow-water problems, including those on mudflats, can be resolved or avoided by deepening these areas, preferably during construction. Cover crops, such as millet, oats, or sorghum, can be planted in shallow areas or on excavated banks following construction or a drawdown to hold the soil in place during the filling process.

Turbid or muddy water in ponds is often the result of cattle activity in the pond or feeder stream. Cattle trample shoreline areas, causing the banks to erode. They also wade in shallow water, which destroys fish spawning and nursery areas and stirs up the mud. See page 23 on how to resolve water quality problems and habitat degradation associated with livestock watering.

When carp or bullheads are overpopulated, their feeding activity stirs up the bottom sediments. Eliminating the carp or bullheads and restocking with appropriate species will alleviate the problem. See page 55 for information regarding removal or control of unwanted fish species.

Muddiness due to Soil Type

Water that stays muddy is likely due to the type of soil in the watershed. This is the most difficult problem to resolve. Clay particles in suspension actually repel each other, rather than clumping together and settling out. Surface application of certain chemicals or organic matter causes a chemical reaction that makes the clay particles clump together and settle out. These treatments typically only provide temporary relief. The pond will likely become turbid again when the next major storm runoff event occurs. The sources of sediment should be eliminated through proper land management practices.

Ponds with chronic clay turbidity problems shouldn't be treated. Instead, they should just be stocked with channel catfish and minnows and provided with artificial feed, since turbid ponds produce limited natural food. See page 36 for further stocking and management information.

Chemical Treatments:

Alum (hydrated aluminum sulfate)

Alum is the most effective treatment to remove colloidal clay. Alum causes the clay to flocculate and settle out. It also produces an acidic reaction. Alum should be dissolved in water and then applied on a calm day. Windy conditions cause mixing that prevents formation of floc and settling out. Alum should be sprayed over the pond surface from boat or shore. On large ponds, a dissolved solution can be sprayed or poured into the prop wash of an outboard motor. If the water doesn't clear within a day after an initial application of 25 pounds per acre-foot of water, a second 25-pound application should be made. If the pond is acidic (pH below 7.0) or has soft water, a similar application of hydrated lime (calcium hydroxide) should be applied first to protect fish from the alum's acidic reaction. Occasionally, the liming process alone causes the clay particles to settle out. Avoid inhalation or eye contact with both hydrated lime and alum, due to their caustic and acidic natures respectively. Pumps operate under high pressure during alum application, which can cause them to rupture.

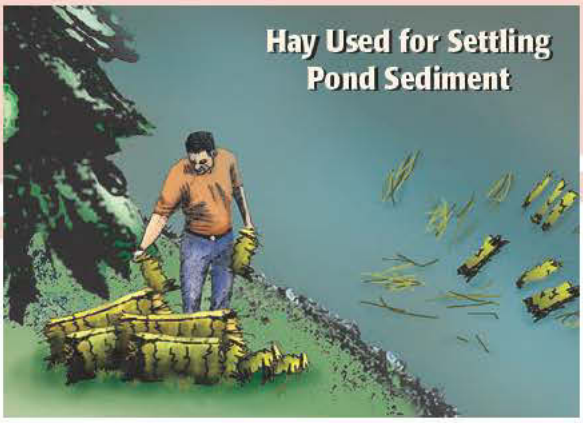
Agricultural Grade Gypsum (hydrated calcium sulfate)

Gypsum is also used to remove colloidal clay and is available at many fertilizer dealers; however, it is less effective than alum or hydrated lime. It can be applied at rates of 100 to 525 pounds per acre-foot of water. It can be applied in 100-pound increments, waiting a few days between applications, until the desired visibility is achieved. Gypsum should be applied by the same techniques described for alum. It has a neutral reaction in water and doesn't require a lime treatment. It also doesn't affect the use of treated water for livestock or aquatic plant and animal life in the pond. Finely ground agricultural limestone can be used as a substitute for gypsum and applied at a rate up to 500 pounds per surface acre. It can be applied using similar techniques as gypsum and it has a similar reaction and low environmental risks. Scrap sheet rock containing gypsum can also be used.

Organic Matter Treatments:

Hay Bales

Muddy water caused by suspended clay particles can sometimes be corrected by spreading broken bales of high-quality alfalfa, clover or prairie hay along the shallow, near-shore areas. About 100 pounds of hay (two small bales) should be applied per surface acre of water at 14 day intervals. As bacteria break down the hay, the resulting by-products form a weak acid, causing clay particles to clump together and settle out. Since decomposition uses up oxygen, this method shouldn't be used during the summer when water temperatures are high and dissolved oxygen levels are low or widely fluctuating, or late fall if hay will not be fully decomposed before winter. Dry hay bales should be used to facilitate a slower rate of decomposition. Monitor clarity changes. No more than 5 applications should be made



during a year. This treatment is preferred over the use of alum or gypsum since it can increase a pond's productivity instead of decreasing it. Hay bales shouldn't be used in ponds with a history of fish kills resulting from low oxygen levels unless an aeration system is present. Manure or weeds can also be used by utilizing similar application techniques and concerns as with hay.

Aquatic Vegetation Management

Although too much aquatic vegetation may interfere with fishing, boating, and swimming, vegetation is a very important component of the aquatic environment. It provides food, nesting sites, shade, and cover for a multitude of aquatic organisms. It also oxygenates the water and helps minimize shoreline erosion and wave action. Aquatic plants can become established naturally in a pond or they can be transplanted (see page 40).

The presence of aquatic vegetation is good for your pond.

In some cases, excessive amounts of aquatic vegetation can ruin fishing and upset the balance between bass and bluegill by providing too many places for young bluegills to hide and avoid predators. Insufficient bass predation on bluegills will ultimately result in an excessive number of small, slow-growing bluegills, which will raid bass nests and limit the number of bass produced. Some species of aquatic plants can become so thick that plant diversity and associated wildlife diversity are both drastically reduced. Occasionally, die-offs of overabundant vegetation occur following cloudy weather, run-off events that muddy the water, or at the end of the growing season. If these die-offs are substantial, decomposition of the dead vegetation can deplete oxygen levels, which can stress or even kill fish.

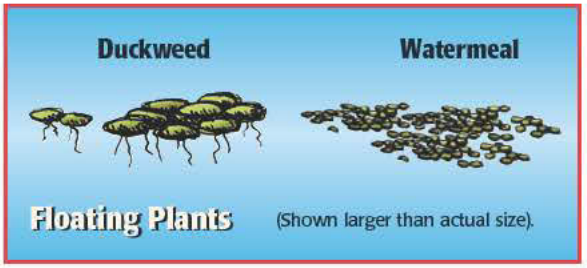
Aquatic Vegetation Identification

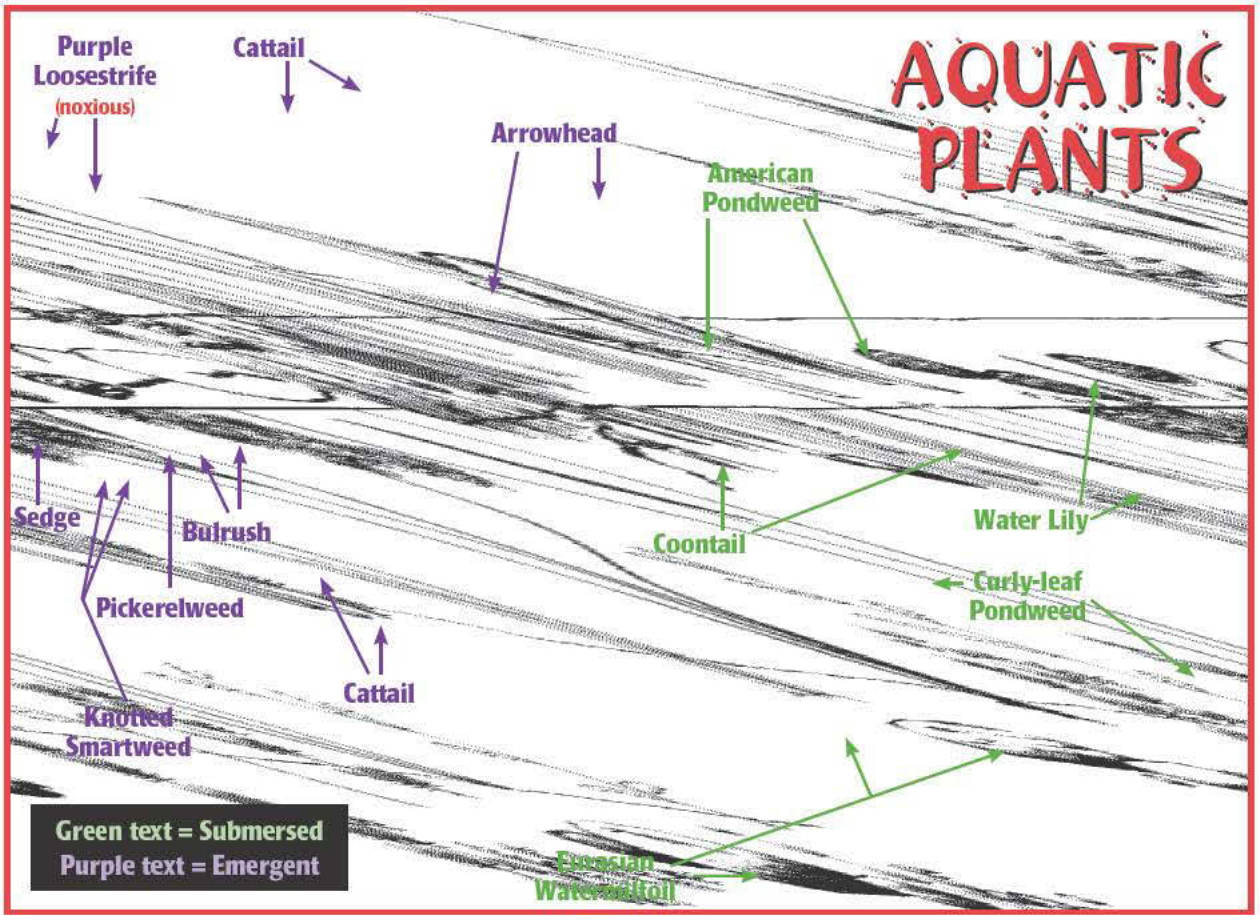
There are four major types of aquatic vegetation, classified by their growing patterns: algae, floating plants, submersed plants, and emergent plants. Since the effect each can have on a pond and the best methods of controlling them differ, it is imperative that you correctly identify the vegetation type(s) if a problem should occur. For some control methods, such as the use of chemicals, it is necessary to identify the plant species in order to purchase the correct herbicide.

Algae are primitive plants without true leaves or flowers. Many are individual, free-floating, microscopic plants (planktonic) that can turn a pond green, making it look like pea soup or as if paint is floating on the surface. Others (filamentous) are found together in clumps or strands that are often attached to the bottom or aquatic structure. Some species of planktonic algae can be toxic or cause water to have a bad taste or odor. Several blue-green, bloom-forming

planktonic algae species produce lethal toxins within the cell walls which are then secreted from living cells or released after death. These toxins can cause sickness, and even death, to pets, livestock, wildlife (especially fish), and humans. Filamentous green algae causes the most problems for pond owners. It is a stringy, hair-like plant, often called moss, that can form mats which can completely cover the pond surface. One type of algae, *Chara* spp., grows on the pond bottom and has stem and leaf-like features. They can be identified by their strong musty odor or gritty texture when crushed between fingers.

Floating plants are not attached to the bottom by roots. They float freely on the surface with roots hanging down in the water and move with the prevailing winds. Duckweed and the much smaller watermeal are common floating plants. They can become very abundant and cover the entire surface of smaller ponds protected from the wind.





Submersed plants are usually rooted to the bottom and grow upward to the surface of the pond. Their blossoms and seed pods extend above the water surface. The plant usually consists of a long flexible stem, with clumps of narrow leaves along it. Surface leaves of some species look quite different than lower leaves. These plants can form thick beds that interfere with fishing, swimming, and boating. Examples are pondweeds *(Potamogeton* spp.), coontail, water milfoil, and water lily. Depending on water clarity, some of these plants can grow in water depths exceeding 10 feet.

Emergent plants are rigid, rooted to the pond bottom and extend upwards out of the water. They usually occur along the shoreline and grow in water depths less than 3 feet. Many emergents reproduce by seeds and rhizomes. Cattails are probably the most familiar emergent plants. Although they provide excellent shoreline protection and sediment entrapment, they are notorious for rapidly filling-in shallow areas of ponds. This can result in elimination of other desirable aquatic plants and limit shoreline activities such as fishing, wading, and boating. Bulrushes, sedges, smartweeds, arrowheads, and pickerelweeds are other common emergent plants. Trees, such as willow and cottonwood, are also included in this group. Purple loosestrife is an exotic emergent that can take over extensive shoreline areas and entire wetlands.

Controlling Aquatic Vegetation

Aquatic vegetation can provide a variety of benefits. Although a particular level of abundance may be too much for one pond owner, it may be just right for another. As long as aquatic vegetation, primarily submersed type, isn't negatively affecting fish populations, especially largemouth bass, it can be allowed to cover 40% or more of the pond surface, depending on fish management goals. Once it gets above 40%, some may have to be removed to create open-water areas. Control for each vegetation type can involve one or more of the following techniques.

Depending on fish management goals, aquatic vegetation can cover 40% or more of a pond's surface.

Prevention

Prevention is the best control. Follow depth and slope guidelines presented earlier to reduce the amount of shallow-water areas where plants can grow. Utilize wise land use practices that prevent soil erosion and keep nutrients on the land and out of the water. Prevent animal wastes from entering – either construct a sewage lagoon to catch feedlot and barnyard runoff or divert it around the pond through a grass-lined ditch when permissible.

Physical or Mechanical Removal

The physical removal of aquatic vegetation from a pond is a valuable control technique. This is done by cutting or uprooting rooted plants and removing them from the pond. Floating plants can be collected with seines and removed, especially on windy days when the plants are concentrated along one shoreline. Plants can be removed by hand with simple tools or with special cutting machines. In shallow shoreline areas, plants can be pulled by hand, cut with a sickle, dug out with a shovel, or removed with a rake or a chain pulled through the pond behind a tractor or ATV. Undesirable plants should be controlled when they first show up, before they get a chance to spread extensively. Remove as much of the plant's roots as possible, when applicable.

For larger ponds or deep water, commercial power cutters are a more sensible option. The most important part of mechanical control is to remove the cut plants from the pond. Many aquatic plants can grow from plant fragments, so cutting one stem in half doubles your problem. Fragments that don't grow will decompose and release nutrients that stimulate other plants to grow. The decomposition process also uses up oxygen and can cause fish kills. Removing the vegetation from the pond removes all the nutrients stored in them, reducing the

likelihood of future problems. Removing plants mechanically or physically provides only temporary relief and may be practical for only a small portion of the pond. The processes will likely need to be repeated several times throughout the growing season and in subsequent years.

Chemical treatment should be kept to a minimum.

Chemical Treatments

If you are unable to determine a source of nutrients, or if you still have vegetation problems following nutrient reduction and removal efforts, chemical treatments can then be considered. Many herbicides that control aquatic vegetation in ponds are available from commercial distributors. Most are listed as restricted use and must be applied by a licensed aquatic pesticide applicator.

Some advantages of herbicides are:

- They generally produce fast results.
- They are usually easy to apply.
- They are often available locally.
- They are normally selective for a particular type of vegetation.
- They give the pond owner control over how much vegetation is eliminated.

Some disadvantages of herbicides are:

- They are expensive.
- They usually require multiple applications to maintain control.
- They can be dangerous to the applicator and aquatic animal life if applied incorrectly.
- The plants must be correctly identified, sometimes to species.
- The treatment area must be accurately measured.

Rarely does the entire pond need to be treated.

Typically, all that is needed is to open up some fishing and boating lanes or a few shoreline areas for bank fishing, swimming, and wading. If a large portion of the pond surface will eventually be treated, or the growth is extensive, treat only 1/4 to 1/3 of the problem area at a time, and wait about two weeks between subsequent applications. If too much vegetation is killed, its decomposition will deplete available oxygen which can stress or even kill fish. Most problem vegetation species should be treated early in the season when they first start growing, not during summer months when the dissolved oxygen levels in the pond may already be low or widely fluctuating. Some plants, such as cattails and water lilies, should be more mature when certain chemicals are used; otherwise, only the top will be killed and the rest of the plant and its roots will be unaffected and regrow. Keep in mind most aquatic plant species die-off naturally at the end of their growing season and regrowth of new plants from plant fragments, root stock, and seeds is likely.

Read and follow the directions and precautions on the herbicide label. The label will list what plants can be controlled, dosage recommendations, and when application should occur. Also listed on the label will be any restrictions on usage of treated water, including human contact (swimming, wading, or drinking the treated water), fish consumption, irrigation and livestock watering. Check the pond water temperature. Some chemicals will not work in cold water.

Try to avoid applying chemicals during fish spawning periods.

Some herbicides (contacts – such as copper algacides, endothall and diquat) work very quickly by killing the plant tissue they contact and can be used for "spot" treatment. Other herbicides (systemics – such as 2,4-D, triclopyr and glyphosate) can be used for spot treatments but work slowly and move from

sprayed leaf tissue into/killing other parts of the plant (underground rhizomes, tubers, etc.). One herbicide (systemic – fluridone) can't be used for spot treatment where water movement could transport it from a treated area before it has an effect.

Most aquatic herbicides will not harm fish if properly applied. Some chemicals can directly or indirectly kill spawning adult fish that refuse to leave treated areas, and they may kill fish eggs or fry. Some herbicides, such as copper sulfate used for algae control, should not be used extensively in fishing ponds. Because it is cheaper and perhaps easier to apply than chelated copper-based chemicals, there is a tendency to over-apply copper sulfate. This can negatively affect fish and their food organisms as it disperses through the water column. Chelated copper-based chemicals are less harmful to fish, less corrosive, and are more effective in hard water. They also persist longer in the water. This longer uptake period provides better control of algae and means less chemical is needed, as compared to copper sulfate.

Most chemical applications involve calculating a dosage per acre-foot of water that has a vegetation problem. Examples of surface and volume calculations are provided in Appendix C. If you are uncertain about plant identification or herbicide usage/sources, contact an area Commission fisheries biologist or the extension educator in your county.

Biological Control

The grass carp, also known as white amur, is a plant-eating fish native to Asia that has been introduced in the U.S. for aquatic vegetation control. Grass carp should never be stocked in a new pond, nor should they be stocked if there is only a narrow band of vegetation around the pond edge because they will eliminate critical habitat for bluegill and largemouth bass. They feed almost exclusively on aquatic vegetation, eating two to three times their weight each day during the summer months. Grass carp are grazers and prefer certain types of vegetation, eliminating them before they consume

Since grass carp are long lived, they should not be used; instead, spot treat with chemicals.

less-palatable or smaller species. They are not successful in controlling milfoil, coontail, watermeal, duckweed, pond lilies, or most algae species, especially *Chara* spp. Grass carp are very inefficient in converting food into body tissue. Their excrement is high in nutrients, which promotes the production of more vegetation. Too many grass carp can result in total elimination of the desirable submergent vegetation that was utilizing or tying up available nutrients. This can result in planktonic algae blooms.

Grass carp can live for decades. Once they are stocked in a pond, it is virtually impossible to remove them without killing everything in the pond or draining it. Since the pond owner has no control over which plants grass carp eat or how much they eat, they are rarely, if ever, recommended for vegetation control. Spot treatment with chemicals is a better option.

If a pond owner insists on stocking grass carp, they should be stocked at a density of no more than 5 per surface acre of vegetation coverage to control plants or 15 per acre to eliminate them. Always start at a low stocking density and add fish as needed. Stocked fish should be at least 10 inches long to prevent immediate predation by largemouth bass and birds. It may take two to three years before plant growth is reduced. Since grass carp require large rivers to spawn successfully, they may need to be restocked at less than 5 per surface acre every five years to compensate for natural mortality and the likelihood some may have been flushed-out during high water flows. Restock only when vegetation is causing a problem again.

Contact UNL Cooperative Extension staff about algae identification and control.

Barley straw can be used as a biological control for algae. It is normally applied at a rate of 225 pounds per surface acre of water. As the straw decomposes in the pond, it produces a growth-inhibiting chemical that will prevent new algae growth but may not kill off what is already present. For this reason, it should be applied in March or April, before the algae starts to grow. Barley straw doesn't work on all kinds of algae. The first step is to properly identify which species you have. If this isn't possible, experiment with a algae sample taken from your pond. Place it, along with an adequate amount of pond water, in a large tub or tank. Apply barley straw and determine if control occurs. It may take 2 weeks to see any results, longer if the water temperature is below 68 degrees. Depending on the availability and cost of barley straw and the size of your pond, it may be easier to just do the treatment if you had major algae problems in the past, and then monitor results. Keep in mind the decomposition process uses oxygen, which will reduce oxygen levels in the pond and stress or kill fish if the straw is over-applied.

Although many algae species are important food items for zooplankton, high density levels of algae are considered undesirable and somewhat difficult to control. If algae blooms keep recurring once control measures have been tried and gizzard shad are present in high numbers, the shad need to be controlled or eliminated. Shad are very efficient filter feeders and can decimate zooplankton populations that naturally feed on various algae species.

Pond Liners

Covering the pond bottom with perforated plastic sheeting or fine mesh landscaping fabric can effectively prevent rooted vegetation from growing. The fabric also limits nutrient exchange between the pond bottom and the water. Plastic sheeting 4 mm or thicker should be weighted to keep it in place and perforated to allow gases to escape from the pond bottom. Large sections of window screen can also be placed on top of submerged plants and weighted down. This will compress and shade the plants, which should cause them to die in a couple of weeks. The process can then be repeated in another area.

Water Level Manipulation

Lowering the water level of a pond can be an easy way to control unwanted aquatic

vegetation. Pond drawdown, especially during the winter, can dry out plants and expose them to harsh conditions, including freezing temperatures, wind, and sediment compaction. For winter control to be effective, the bottom mud should freeze to a minimum depth of four inches for at least a month. Dead plant material should be removed from the pond basin as soon as possible, definitely before refilling, so their nutrients are not released back into the water. Make sure the pond still has sufficient depth (10 to 12 feet) during the winter months to prevent a fish kill.

Cattails can be effectively controlled by lowering the water level, cutting or shredding the plants, and then flooding them during the winter. They will drown, provided the roots are kept completely submerged for an extended period of time, especially during the following growing season, and there is no attached top growth remaining to funnel air down to the roots.

Dredging and Deepening

Many vegetation problems can be eliminated by deepening shoreline areas. Creating a 3:1 slope to a depth of 4 to 5 feet, and then tapering off rapidly into greater depths will limit where vegetation can grow. At least 25% of the pond's surface area should contain a depth of at least 10 feet, 12 feet in northern and western parts of the state. Dredging, or partially draining the pond and excavating, reduces vegetation problems directly by removing the plants and bottom sediments, and their associated nutrients.

Shading

Limiting the amount of sunlight available to aquatic plants with dyes that stain the water is another vegetation control method sometimes used by pond owners. Too much chemical shading, however, can reduce the pond's overall productivity, including fish production. To be effective, the dye must persist in the water for several weeks. Ponds with constant flow may not be good candidates for this technique. For best results, dye should be used early in the spring before the vegetation starts growing. If the plants have already grown to the surface, it's too late to add dye. Floating objects such as piers or swimming platforms may shade a small area of the pond and prevent vegetation growth. Or, pond owners can anchor black plastic sheeting on styrofoam floats around swimming areas or boat launches to shade specific areas.

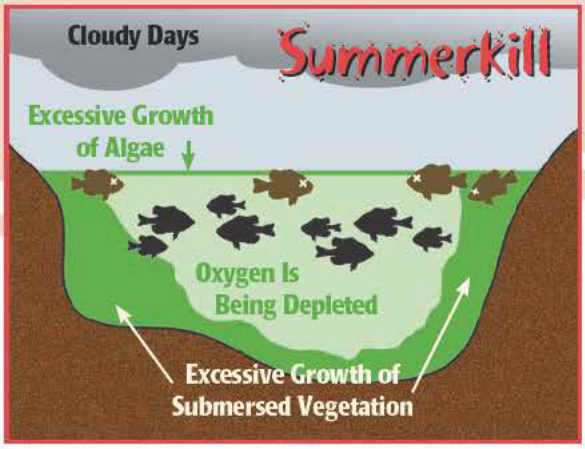
Fish Kills

Fish populations in a pond are constantly experiencing mortality. Some can have an annual mortality rate as high as 50%. Most of these deaths can be attributed to natural causes, with predation being the most common. It is also common to see some dead fish along shoreline areas. These fish likely died as a result of old age, minor disease outbreaks, handling, or spawning stress. Contrary to popular belief, fish kills are rarely caused by an overpopulation of fish. A pond will naturally stay within its capacity to support fish under normal conditions. Common causes of fish kills are suffocation due to lack of oxygen, poisoning, and disease or parasite infestations. Knowing about these causes can help pond owners prevent fish kills.

When large numbers and a variety of sizes of different species are found dead, a major fish kill has occurred.

Fish Kills due to Suffocation

Most of the dissolved oxygen in a pond is a product of plant photosynthesis. Oxygen can also enter the pond by absorption through the water surface, especially when there is wind and wave action. Dissolved oxygen levels can vary significantly throughout the year or even during a day. Critically low dissolved oxygen levels can result from certain combinations of environmental conditions and pond characteristics. Low dissolved oxygen is the most common cause of fish kills in ponds, often occurring in summer, winter, or as a result of seasonal water column turnover. Once levels



reach a critically low point, only aeration or the addition of fresh aerated water can prevent a fish kill.

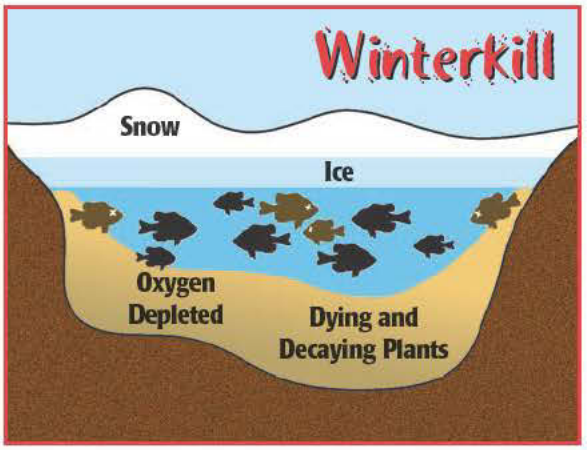
Summerkill

Summer fish kills can result in the total or partial die-off of a pond's fish community. This type of fish kill is most common in small, shallow, heavily vegetated ponds containing a large amount of decomposing organic material. Summerkills can occur when certain environmental conditions cause a substantial decline in dissolved oxygen levels.

The most obvious sign of an oxygen problem is fish gasping or gulping at the surface, particularly in the early morning hours.

Excessive vegetative growth, especially algae, in a pond can lead to a fish kill. Sunny conditions result in a long period of plant photosynthesis that produces high dissolved oxygen levels during late afternoon; however, during the night, oxygen is used for respiration by plants, fish, insects, and other organisms, and organic decomposition. If the oxygen produced during the daytime is insufficient to carry all pond life through the night, a fish kill will result. As long as the weather is sunny, oxygen production is usually adequate. However, several consecutive calm, cloudy days can result in vegetation dying (especially algae) and decomposing, reducing the pond's dissolved oxygen levels to the point that fish may not survive the night. These conditions are confounded during the summer when air and water temperatures are greater than 80 degrees and calm conditions prevail. A summerkill usually results in larger fish dying first, with minimal, if any, effect on other aquatic animal life, such as aquatic insects, frogs, and turtles.

Ponds can become stratified during the summer, particularly those protected from the wind. Water density varies according to temperature, with the colder, denser water occurring at the bottom. The surface water normally has sufficient dissolved oxygen, while the denser bottom water may contain little or no oxygen because it is depleted by bacterial decomposition of organic matter. This is especially true in ponds with excessive vegetation. The differences in water densities keeps the pond water from mixing. But, a rapid inflow of cool surface runoff from a summer thunderstorm, combined with strong winds and waves, can result in mixing the surface water with the oxygen deficient bottom water. During this thermal turnover, or inversion, a fish kill can result. Lightning strikes can also cause a fish kill in the immediate impact area.



Winterkill

Winter fish kills result when oxygen levels fall too low to support fish under the ice. Since ice acts as a seal and prevents the absorption of oxygen directly from the atmosphere, oxygen produced by plant photosynthesis is crucial. Clear, thick or even cloudy ice typically allows

enough sunlight penetration for plants. But, ice blanketed with snow allows very little sunlight penetration, so plants are unable to produce a sufficient amount of oxygen. Oxygen levels drop due to plant decomposition and respiration by the various aquatic organisms. If snow cover persists for an extended period of time, the oxygen will be completely depleted, resulting in a fish kill. This usually happens in shallow ponds which have large amounts of organic matter, such as decaying aquatic vegetation or livestock wastes. Winterkills can be severe enough to kill all the fish and other aquatic life, including frogs and turtles, in a pond. Often, bullheads and carp are the only fish to survive winterkills. In these cases, the pond should be renovated with rotenone and restocked with appropriate pond species, provided adequate depth is present.

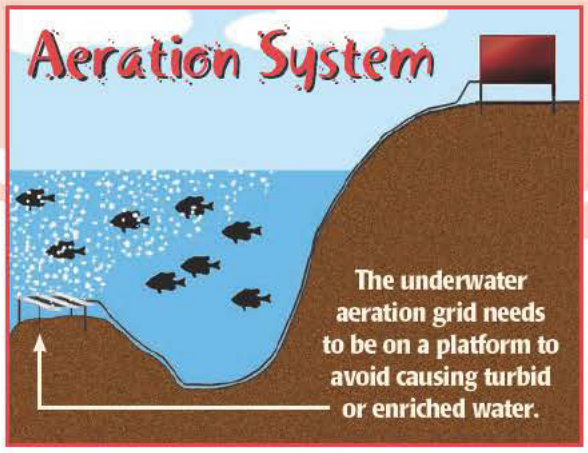
Seasonal Turnover Kill

Some ponds that contain relatively large amounts of deep water that annually stratifies can experience a fish kill when the pond turns over, producing conditions similar to an inversion. These ponds thoroughly mix in both spring and fall when surface and deep water temperatures are the same. Wind can facilitate the mixing.

Preventing Fish Kills due to Suffocation

Most of these fish kills can be avoided if a pond contains sufficient depths to prevent excessive growth of aquatic vegetation and to store enough oxygen during critical time periods, especially winter. Proper pond construction and management can prevent these fish kills.

These types of fish kills can also be prevented by installing an aeration or water circulating system that will oxygenate the water year-round. Do not allow the aerator diffuser (air stone) to rest on the pond bottom as this will stir up organic materials, accelerating their decay and increasing oxygen consumption. Algae blooms can result if large amounts of bottom nutrients are carried to the surface as the bubbles rise. Either place the diffuser on a pedestal or



in a weighted 5-gallon bucket, or suspend it at least two feet off the bottom. Both systems will maintain an open water area during the winter and facilitate oxygen absorption directly from the atmosphere. Cutting a single large hole in the ice during the winter isn't very effective because not enough water gets exposed to the air. See *Appendix D* for additional information on aeration.

Winterkills can also be prevented by removing snow from the pond. Three inches of ice, covered by five inches of snow, will block 99% of the incoming sunlight. Remove snow from 30 to 50% of the pond surface or just in shoreline areas where submergent vegetation would be located beneath the ice.

Fish Kills due to Poisoning

Fish kills can be caused by the improper use or spills of many chemicals, including insecticides, herbicides, fertilizers, and petroleum products.

Pesticides can enter a pond from an agricultural field, golf course, or lawn. Some pesticides can be very toxic to fish. Luckily, many are short-lived and usually break down and become non-toxic to fish before they enter a pond. Many pesticides can cause a fish kill when applicators are careless and allow the spray or its drift to enter the pond directly. A fish kill can also occur when storm runoff carrying pesticide-laden soil particles enters a pond immediately after an application.

Fish kills resulting from chemical poisoning can be extensive and affect all fish species. They are also characterized by small fish dying sooner than larger fish. Many species of aquatic vertebrates, such as turtles, frogs and tadpoles, and other aquatic organisms, can also be killed or adversely affected. If sub-lethal pesticide dosages continue to enter a pond for an extended time period, they can affect fish food production, alter fish reproduction, or become an additional stressor that decreases fish resistance to low dissolved oxygen levels and diseases. By choosing a proper site for pond construction, many of these problems can be avoided. Landowners also need to consider pond health when choosing chemicals to use in the watershed.

Fish Kills due to Diseases and Parasites

Fish kills can also result from disease and parasites. Although viruses, bacteria, and fungi can all cause disease outbreaks, they usually do not result in massive fish die-offs. Mortality can occur during early spring, when a fish's disease resistance is low due to winter and pre-spawning stressors. If fish populations are out of balance and there is a high density of one species of fish, particularly crappies, a disease outbreak can result in a substantial fish kill. Angler caught fish that are mishandled during the release process are more susceptible to infections and diseases. Environmental conditions, such as prolonged periods of low dissolved oxygen, extreme pH levels, and high temperatures, can also stress fish and make them more susceptible to diseases. Although most fish have some parasites, they are normally not a problem for healthy fish. Like diseases, parasites can cause mortality if fish are already stressed from other factors. Maintaining good water quality and balanced fish populations will keep fish healthy and less susceptible to disease and parasite problems. See page 73 for additional information on fish parasites and diseases.

Consequences of Fish Kills

Most fish kills do not result in elimination of the entire fish community. The severity of a fish kill depends on environmental conditions, the size and depth of the pond, and the type of kill. The adverse conditions that caused the kill may not have occurred throughout the entire pond, and unaffected areas will provide a refuge until conditions improve. For example, a partial kill caused by pesticides associated with storm runoff may occur in the area near the inlet and nowhere else, as a result of dilution.

Fish populations that have suffered die-offs should be assessed to determine what needs to be done to restore the pond's fishery. See page 50 for further details on assessing fish populations.

Depending on the severity of the fish kill and the species involved, the remaining fish populations may not return to previous levels or provide the same quality of fishing. If undesirable fish species, such as carp, bullheads, or green sunfish, were present prior to the kill and were not affected by it, they may then overpopulate the pond due to reduced competition and lack of predation by largemouth bass.

Diagnosing and Preventing Fish Kills

The following information can be used as a guide for troubleshooting fish kills in ponds. Knowing what can cause a fish kill will help you prevent or lessen the severity of one.

CAUSE of FISH KILL	SYMPTOMS	PROBLEM	RECOMMENDED SOLUTION(S)
Summerkill	Fish found dead and/or gasping for air at the surface, particularly in early morning hours; larger fish usually die first, little effect on other aquatic animal life (frogs, turtles, etc.).	Consecutive days and nights of cloudy, hot, still conditions; very high water temperatures (above 85 degrees) and not enough dissolved oxygen; cloudy skies prevent plants from producing oxygen; calm winds prevent mixing of oxygen into surface water; aquatic organisms' respiration and plant decomposition deplete available oxygen; shallow, weedy ponds are especially vulnerable.	Add fresh water and/ or agitate the water surface to facilitate oxygen absorption; deepen pond to limit vegetation growth and increase water volume so more dissolved oxygen can be stored and/or install an aeration system.
Inversion	Dead or gasping fish (larger fish affected first) found after a violent thunderstorm which produced heavy downpours and high winds.	Large sudden inflow of cool rainwater and strong winds cause bottom water (low in dissolved oxygen) to mix with the surface water, resulting in critically low oxygen levels throughout; can occur in shallow, weedy ponds or ponds that contain deep, stratified, stagnant water; both types in combination with large, steep drainage areas with high runoff rate; lightning can also cause a fish kill, affecting all fish species of all sizes in the immediate strike area.	Install an aeration system to circulate and aerate oxygen deficient bottom water and/or deepen shallow water areas to restrict vegetation growth.
Seasonal Turnover	Dead or gasping fish (larger fish affected first) found in spring and/or fall.	Stratified and/or unoxygen-ated deep water mixes with surface water in spring and fall when surface and deep water temperatures are the same, resulting in critically low oxygen levels; wind can facilitate the mixing.	Install an aeration system to circulate and aerate oxygen-deficient bottom water.

CAUSE of FISH KILL	SYMPTOMS	PROBLEM	RECOMMENDED SOLUTION(S)
Phytoplankton Die-off	Fish found dead and/or gasping for air at the surface (larger fish affected first); water has a green cast or looks like it has paint floating on the surface prior to or during fish kill, or water may have a brown color during or after kill.	Nutrient enriched ponds produce dense blooms of phytoplankton (algae) which can suddenly die-off following consecutive days and nights of cloudy, hot, still conditions; decomposition causes an oxygen shortage; dead and decomposing algae can release a toxin fatal to fish into the water and/or give a brown color to the water.	Reduce nutrient inputs by diverting nutrient enriched runoff from animal feedlots or cropland around the pond and/or install nutrient/sediment entrapment structure(s) above the pond, also consider an aeration system.
Dead Vegetation	Fish found dead and/or gasping for air (larger fish affected first) within a few days of a die-off of large amounts of aquatic vegetation.	Massive die-off of aquatic vegetation from aquatic herbicide overuse; or muddy water from storm runoff enters a pond and prevents sunlight penetration, resulting in suffocation and die-off of aquatic vegetation; large amounts of decomposing vegetation depletes available dissolved oxygen.	Shoreline should be sloped 3:1 and additional deep water areas created to limit vegetation growth; reduce nutrient inputs; consider an aeration system if unable to deepen or reslope shoreline areas.
Organic Pollution	Fish found dead and/or gasping for air (larger fish affected first) following inflow of large amount of organic matter after heavy rains.	Large amounts of decomposing matter (excess animal wastes, leaves and vegetation) deplete dissolved oxygen levels.	Prevent excess organic matter from entering or building up in the pond; use aeration to accelerate the decay process and reduce buildup.
Winterkill	Large numbers of fish of all sizes along with turtles, frogs, and other organisms found dead along shoreline soon after ice-out; few, if any, fish caught by anglers in spring as compared to the previous year.	Snow cover stays on the ice for an extended period of time, preventing sunlight penetration to plants that produce oxygen; aquatic organisms' respiration and plant decomposition deplete oxygen; shallow, heavily vegetated ponds are especially susceptible.	Remove snow if its depth is greater than 3 inches from at least 30% of pond surface and/or install an aeration system to prevent complete ice cover.

CAUSE of FISH KILL	SYMPTOMS	PROBLEM	RECOMMENDED SOLUTION(S)
Toxic Substances	Dead or dying fish (smaller fish affected first), frogs, tadpoles, and insects.	Pesticides, petroleum products, fertilizers, and other toxins enter the pond directly or when heavy rains wash recently applied chemicals into the pond; extent of the kill depends on the amount and dilution rate of toxins upon entry to pond (problem may be confined to just entry site).	Divert runoff coming from potentially toxic sources; install entrapment structures or buffer strips; if pesticide application is necessary for crop production, apply carefully.
Natural Causes	Some dead fish (usually larger and older fish) found along the shoreline in early or late spring.	Natural mortality caused by reduced disease resistance brought on by winter and/or spawning stressors.	Nothing, let nature take its course.

Reporting Fish Kills

Contact the nearest Commission district office, the Nebraska Department of Environmental Quality (NDEQ), 402-471-2186, or the 24-hour NDEQ/State Patrol pollution complaint hotline, 402-471-4545, regarding fish kills that may be due to toxic substances. Contact a district fisheries biologist or the Private Waters Specialist in Lincoln to discuss extensive fish kills and their consequences.

Fish Parasites and Diseases

A healthy fish can tolerate some parasites with little ill effects. Black spot and yellow grub are two common fish parasites found in ponds. Yellow grubs can be found beneath the skin of largemouth bass, bluegills, and other fish. Commonly found in bluegills, black spot are tiny flukes imbedded in the skin and flesh. Both of these parasites have no effects on humans, so infested fish are safe to eat. In addition, the parasites are killed when the fish are thoroughly cooked, hot smoked, or frozen. If grub infestation is low, the parasites can be removed from the flesh if family members are squeamish about eating them. If the flesh is heavily infested, it might be impossible to remove all the parasites; getting the cook to prepare it and the family to eat it may also be difficult.

It is not practical to remove parasites from a pond. Pond owners must simply learn to live with them. Of the more than 1,000 species of North American freshwater fish parasites, only a few are known to infect man and those have not been found in Nebraska. The life cycles of black spot and yellow grub involve different developmental stages that require host organisms such as fish, birds, and snails (see diagram). One technique that might reduce the abundance of these grubs is stocking snail-eating redear sunfish.

Pond fish are sometimes affected by a fungus *(Saprolegnia* spp.). This grayish, cotton-like growth is usually a secondary infection on fish that have experienced a disease or are stressed by some adverse environmental condition.

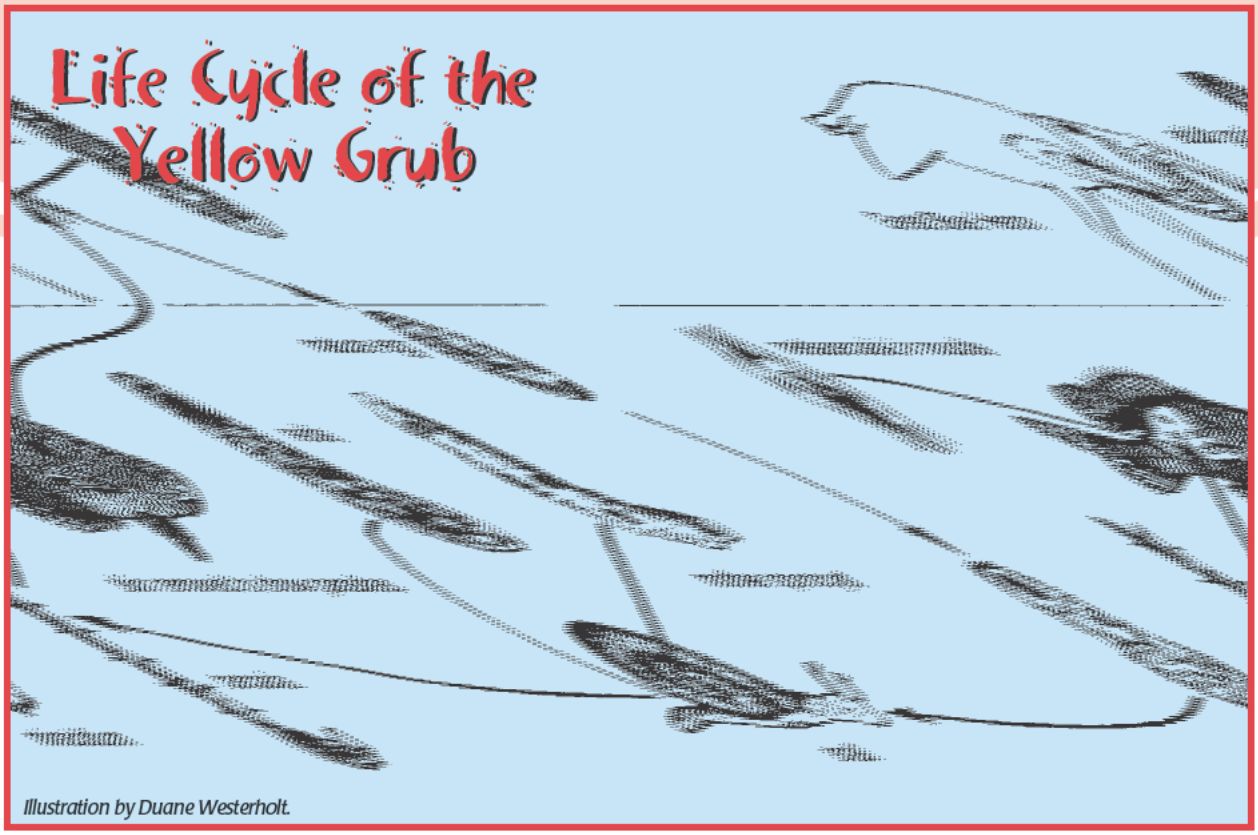


Illustration by Duane Westerholt.

Many times it is seen on the tail, sides, or belly of fish which have rubbed these areas while spawning or on fish that have been mishandled. Some affected fish will die, but most will recover.

A protozoan (*Ichthyophthirius* spp.), often called "ich," can be very harmful to fish. Many aquarium owners are familiar with this fish-killing parasite. The elimination of ich from a pond is virtually impossible, so prevention is important. By maintaining good water quality in the pond and only stocking healthy fish, ich should not be a problem.

Virus and bacteria are microscopic organisms that cannot be seen with the naked eye. However, an angler can see their symptoms, which range from "pop-eye" to swollen, bloody fins. Their diseases are common in all fish and occur most often when environmental conditions, such as water quality, are poor. Inadequate oxygen levels in the pond can stress fish and make them susceptible to infections. These infections are often associated with spring die-offs in ponds. As the water warms in the spring, fish weakened by the stress of winter can be affected by bacteria/virus and die. Spring spawning activity adds another stress to weakened fish that can increase the number of deaths. The loss of fish to these infections is fairly common in May and June. When a die-off does occur, it is often dominated by one species. If there is a high density of one species, particularly crappies, a disease outbreak can result in a substantial die-off. There is no economical treatment available for large scale bacterial/viral problems; fortunately, most are rarely severe. Keep in mind that viruses need fish to survive – they enter a pond via infected fish. Whereas, bacteria are present in the pond environment and severely infect fish that are stressed or mishandled.

Fish secrete a protective mucus coating which helps prevent fungal and bacterial/viral infections. If this coating is damaged during the spawning process or as a result of mishandling by an angler, the fish becomes more susceptible to infection. The mucus coating is less likely to be damaged if a hook is removed while the fish is still in the water, or if the angler wets his or her hands before handling the fish and

gently releases the fish, instead of tossing it into the water.

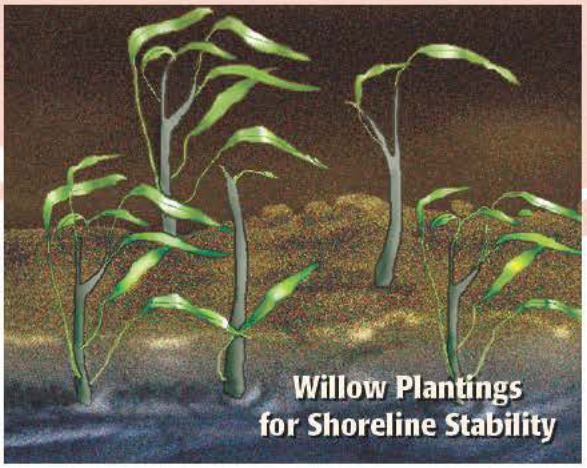
Extensive disease outbreaks or parasite problems are rare, usually occurring when a particular fish species approaches its carrying capacity. Follow recommended stocking rates and strategies and you shouldn't have any problems. In catfish- or wiper-only ponds and some backyard ponds, where fish are kept and fed at a high density, diseases are much more common. In these situations, special medicated feeds may prevent serious problems.

For more information on the state's more common fish diseases and parasites, contact the Commission and request a copy of "What's Bugging That Fish? An Angler's Guide to Fish Diseases and Parasites," or go online to Commissions website — see page 88.

Shoreline Erosion

Most ponds will be protected from erosion by establishing well-vegetated shorelines. Where grass or aquatic vegetation isn't sufficient to protect a shoreline, rock rip-rap should be used. Football-size rocks or pieces of broken concrete can be placed along the dam, or other eroding shorelines, several feet above and below the water line. A steep, eroded bank may first have to be graded and engineering cloth laid to create a stable base for the rip-rap; otherwise, erosion could persist and possibly cause rip-rap to collapse into the pond.

Logs, rocks, or trees, placed several feet out in the water and parallel to shore, will absorb the energy of waves and prevent shoreline erosion, or facilitate healing of eroded areas. Emmergent plants and willows should be used to expedite healing. During early spring, rootstock from emergent plants can be dug up, cut or pulled apart into sections (two nodes/new shoots per section) and planted in combination with 18-inch long willow sections between the shoreline and wave-absorbing materials.



Willow Plantings for Shoreline Stability

Leaking Ponds

Some water loss can be expected in new ponds until the basin and immediate shoreline become saturated. In older ponds, a 6-inch to 1-foot loss due to evaporation during a dry month is normal. If your pond loses more than a foot of water in a month and there is no withdrawal of water from the pond or nearby well, you should look for a leak. Ponds usually leak through a porous layer of sand, gravel, or broken rock extending under the dam. The water may come to the surface some distance below the dam. If you find places below the dam that are often soggy, even in dry weather, investigate further. The seepage could be due to a spring, unrelated to your pond. Leaks are difficult to locate. If the water level stops dropping, you can assume that the leak originates at or above that water level and efforts to seal the leak can be concentrated there.

Pond dams with a well compacted clay core tied into an existing clay substrate rarely leak. One cause of leakage is a failure to place anti-seep collars along drainpipes through the dam. These collars prevent water from seeping through the dam alongside the drainpipes.

Repair of a leaky dam or pond bottom often is difficult, expensive, and usually requires draining the pond. Adding a blanket of clay or bentonite to the bottom normally seals leaks. A bulldozer can be used to remove material in a problem area and then add and compact 1 to 2 feet of soil that has a high clay content. Bentonite

can expand up to 20 times its original size when moistened. For best results, bentonite should be spread evenly over the dry pond bottom at 1 to 3 pounds per square foot of pond bottom (the higher amount in deep water areas and sandy soils), mixed into the top 4 to 6 inches of existing soil with a disc, moistened, and then compacted with a roller. If feasible, a layer of clay can then be placed over the bentonite/soil mixture. Keep in mind a bentonite sealed bottom will crack and likely leak if the water level drops and it is exposed to air.

The best way to avoid pond leaks is to choose a good site and use proper dam construction techniques.

Ponds may also be sealed by installing a liner of flexible plastic or rubber sheeting made of polyethylene, vinyl, or butyl at least 2 mm thick. To protect against punctures or tears, the pond liner should be covered by at least six inches of fine clay soil. Livestock can also be used to seal a pond. When fenced into the dry basin for several months, their activity will compact a mixture of soil, manure, and waste feed into the bottom, sometimes producing a seal. Once a repaired pond fills, livestock need to be excluded or their hooves may break the seal or puncture liners.

An emulsion of oil-soluble resinous polymers can be used to seal a pond without draining. The effectiveness of this material varies with condition and character of the soil, water, and climate, as well as the manner of application. It is expensive and toxic to fish, but a pond can be restocked a few days after the water has cleared. Spreading a bentonite slurry or granular bentonite uniformly across the pond surface can also form a seal. This is often less successful than an application to a dry pond because of uneven settling onto the bottom.

It is often easier to build a new pond if a good site is available, rather than restoring an old one.

The NRCS can help determine the best way to stop leaks based on the soil types found at your pond. You can also contact the Private Waters Specialist or area Commission district office for a list of companies and products available for pond sealing.

Filled-In Ponds

As they age, ponds accumulate sediment, debris, and decaying vegetation, eventually becoming marshes, and finally dry land. Ponds that have filled with sediment through the years can be rehabilitated, but the process is expensive. If you wish to deepen the existing pond, you can remove sediment with a drag line. A cheaper method is to drain the pond by breaching the dam with a backhoe or to pump it dry. Once the pond has dried for several months, the bottom should be firm enough that a bulldozer or backhoe can be used to remove sediment from the basin. Compacted layers of clay should be used to patch a breached dam. Soil should also be pushed up against the pond side of the dam to ensure the dam is resealed. Contact your local NRCS office to discuss the feasibility of breaching your dam.

Non-Fishing Ponds

Perhaps your old pond is no longer suitable for producing viable bluegill, largemouth bass, and channel catfish populations and you do not want to spend the time or money to correct environmental problems. The pond can still be managed in ways to provide enjoyment or possibly profit. Some of these uses are:

- raising crayfish, salamanders, or minnows for bait
- providing habitat for frogs, turtles, snakes, and assorted bugs and birds
- creating a marsh or waterfowl area.

Raising koi is another option for small ponds, particularly backyard ornamental ponds. Koi are a fancy version of the common carp. Through

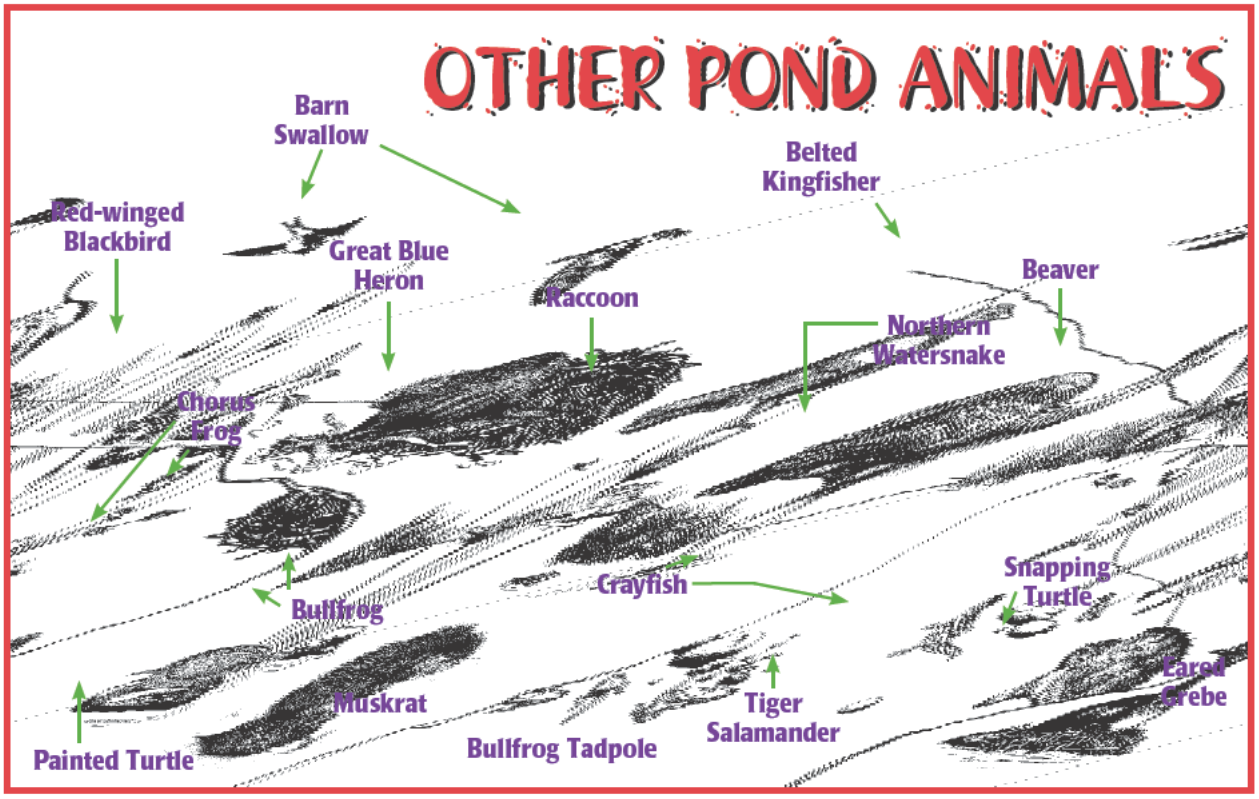
years of breeding, hobbyists have produced an amazing array of color variations and patterns on these fish and no two look exactly alike. Raising them can be a fascinating and relaxing hobby or they can even be entered into contests. Koi will reach 18 inches in 3 to 4 years and a maximum length of about 3 feet. The average life span of koi is 25 to 35 years, but some live much longer. Koi ponds should be aerated and filtered constantly, cleaned regularly, and heated in the winter (a stock tank heater works well). They should be fed pelleted feed once or twice a day. In many ways, having a koi pond is a lot like having an outdoor aquarium. They are popular among suburban residents with no land for a fishing pond. Pond kits and supplies are now sold in many large pet, garden, and home improvement stores. Koi can be costly. Goldfish are less expensive and just as hardy.

Mosquito control in backyard ornamental ponds or small waters can be accomplished by stocking fathead minnows, small bluegills, or green sunfish to consume the larvae. Keep in mind that fathead minnows can reproduce in these smaller ponds, and possibly attain a high enough population to interfere with water quality and any other fish species present.

Other Pond Animals

A pond will attract various kinds of animals throughout the year. If the pond is properly designed and maintained, most wildlife will cause little harm. Those that do become a nuisance may have to be controlled. The following information can be used to determine if control is necessary.

Turtles are common in ponds, not harmful to fish populations, and should not be killed without good reason. Common pond residents are the snapping, painted, and occasionally, softshell turtles. Turtles are scavengers that feed primarily on aquatic plants, along with insects, frogs, crayfish, and dying or dead fish. Fish on a stringer are an easy meal. Snapping turtles may also capture small ducklings. When turtles are in the water, they are shy by nature and will avoid larger animals, including anglers and swimmers. Snapping turtles are good to eat and can be



caught with a baited bank line or by rod and reel, or even harvested with archery equipment. For the adventurous, they can also be caught by hand, even in early winter. Snapping turtles can often be spotted in shallow water under the ice. Because of the cold temperatures, they are very lethargic so you can chop or drill a hole in the ice and grab them by the tail. If turtles should become a nuisance and authorization is obtained from the Commission, they can be captured with homemade traps that allow entrance only from above the water surface. Traps should be set in shallow weedy areas and baited with fish heads, watermelon rind, or fresh meat.

Snakes do eat fish, but do not pose a threat to fish populations. Water snakes are harmless to humans and should not be killed. Clearing debris and mowing the pond edges in areas used frequently by the pond owner and invited guests reduces hiding places for snakes and will reduce their numbers.

Crayfish are not harmful to fish populations. Some crayfish species build burrows that may cause leaks in a small dam that has limited free-board. Crayfish overwinter in their burrows in the bottom mud or pond banks and become active when water temperatures are above 40 degrees. Crayfish are good to eat and they can be used for bait. They are most active at night and traps can be set in late afternoon and left out overnight. Regulations require crayfish traps be made with one-fourth inch square mesh material with a length of 24 inches or less, a diameter of 16 inches or less, and a throat opening of one inch or less in diameter. Traps can be baited with fish heads, meat scraps, dog food, or soybean cakes. Crayfish are readily eaten by trout, bass, and catfish. Maintaining a balanced fish population is the best way to control crayfish numbers.

Beavers are rodents that build lodges in open water or on land near water. The lodge is usually dome-shaped and is built of sticks and mud. Lodges usually have one or two underwater entrances. The den inside the lodge is above water and is used to raise young, for sleeping and some food storage. If the water level rises and remains high, these rodents will burrow upward and construct a new dry den close to the soil surface. It may even break the surface or be close enough that the den caves in easily. This damage to the den encourages them to dig further. If a beaver den is located in the dam, burrowing can then weaken it and cause dam failure during major storm runoff events. Placing rock rip-rap 2 feet above and 3 feet below the water surface on the dam will discourage beaver burrowing.

Most damage caused by beavers is a result of dam building and tree cutting. They often plug drainpipes in ponds, resulting in loss of water level control and damage to the emergency spillway. Hog-panel or electric fencing can be used to keep beavers away from outlet tubes. Although beavers prefer trees such as poplar, green ash, willow, and pine, they will eat the bark, twigs, and leaves of most woody plants growing near water. The best way to prevent beaver damage to trees is to wrap chicken wire around the base of the tree. Beaver also eat corn, soybeans, and other crops.

If beaver activity is jeopardizing the stability of the dam, outlet tube, or emergency spillway, they should be controlled. The use of traps is the most effective, practical, and environmentally safe method of controlling them. Contact the Commission for information regarding trapping regulations, depredation permits, and a list of depredation trappers in your area.

Muskrats construct lodges in open water or dig tunnels to their dens in the bank or dam. The tunnels are dug both above and below the water surface and can threaten the integrity of a dam. Rising and falling water levels could eventually cause a dam containing muskrat tunnels and dens to leak or fail. Placing rock rip-rap on the face of the dam will also discourage muskrats from digging. One-inch mesh wire screening

is also effective in deterring burrowing along the dam.

Cattails, arrowhead, and other vegetation form much of this rodent's food. Removing the food source will discourage muskrats. Keeping the pond banks mowed also limits their activities.

Muskrats can be driven from the dam by placing a half cup of mothballs in holes drilled at 3 foot intervals along the face of the dam near the water's edge. The holes should be sealed shut with soil after the mothballs have been added. Nuisance muskrats can also be controlled by trapping, either during the trapping season or after obtaining a depredation permit.

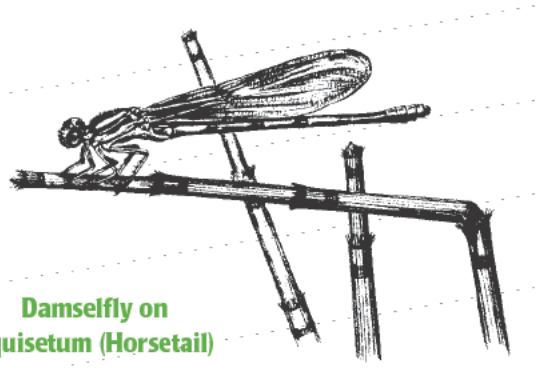
Frogs need water to reproduce and thus are common in ponds. Gelatinous masses of frog eggs can be found attached to vegetation along shallow shoreline areas during the spawning season from spring through early summer. Maintaining good shoreline vegetation cover is important for all life stages of frogs. It also provides them protection from terrestrial and aquatic predators.

Frogs do not have a negative or positive affect on a fish community. Some frog species are quite mobile and adults may not stay at a pond, but bullfrogs usually make a pond their permanent home. The bullfrog is the only species that has a tadpole stage lasting longer than a year. Bass and other predators will feed on frogs and keep their numbers in check. Consult fishing regulations regarding possession or harvest of bullfrogs.

Salamanders also need water to reproduce. They normally are not common in ponds containing fish, especially if predators, such as largemouth bass and catfish, are present. High numbers of salamanders in a pond normally indicates the pond is too shallow to sustain a viable fishery or that no fish have been introduced yet. If a pond contains a high number of salamanders and has adequate depth to support sport fish, they should be eliminated before fingerling fish are stocked; otherwise, the salamanders will eat them. Adult fish should be stocked if removal of salamanders isn't feasible.

Waterbirds, such as terns, gulls, herons, kingfishers, cormorants, pelicans, and grebes, are attracted to ponds. While many will eat fish, they rarely consume enough to affect fish populations; however, a high concentration of pelicans and cormorants on a small pond can greatly reduce fish populations. Some of these birds are intermediate hosts for the black and yellow grubs. While they are often thought to carry fish or fish eggs from one pond to another, it has never been documented. These birds, like snakes and turtles, are normally beneficial predators that remove weak or diseased fish from a pond. Some of these birds can also help control nuisance pests such as leeches and snails.

Other birds that frequent ponds, such as swallows, purple martins, and kingbirds, are effective in controlling pesky insects, such as mosquitos and biting flies. Nearly all birds are protected by state and federal laws and should not be killed or discouraged from feeding or nesting around ponds. Although a pond will also attract migrating waterfowl, pond owners near metropolitan areas across the state and all pond owners east of Highway 14 should not feed or encourage them to nest. This is especially true for Canada geese. They can become over-abundant and cause health and water quality problems. See page 46 regarding additional information on waterfowl.



Damselfly on Equisetum (Horsetail)

APPENDIX A

TECHNICAL ASSISTANCE CONTACTS

Nebraska Game and Parks Commission (Commission)
2200 N 33rd Street PO Box 30370
Lincoln, NE 68503
Private Waters Specialist 402-471-5435
Natural Heritage Program 402-471-5419

Northwest - Alliance
Game and Parks Commission
299 Husker Road PO Box 725
Alliance, NE 69301
308-763-2940
Fisheries Division or
Wildlife Habitat Partners Section

Northeast - Norfolk
Game and Parks Commission
2201 N 13th Street
Norfolk, NE 68701
402-370-3374
Fisheries Division or
Wildlife Habitat Partners Section

Southwest - Kearney
Game and Parks Commission
1617 First Avenue
Kearney, NE 68847
308-865-5310
Fisheries Division or
Wildlife Habitat Partners Section

Field Office - Valentine
Valentine State Fish Hatchery
90164 Hatchery Road
Valentine, NE 69201
402-376-8080 or 402-376-2244
Fisheries Division

Field Office - Bassett
Game and Parks Commission
524 Panzer Street PO Box 508
Bassett, NE 68714
402-684-2921
Fisheries Division or
Wildlife Habitat Partners Section

Field Office - North Platte
Game and Parks Commission
301 East State Farm Road
North Platte, NE 69101
308-535-8025
Fisheries Division or
Wildlife Habitat Partners Section

Southeast - Lincoln
Game and Parks Commission
2200 N 33rd Street PO Box 30370
Lincoln, NE 68503
402-471-7651or 402-471-5561
Fisheries Division or
Wildlife Habitat Partners Section

United States Department of Agriculture - Natural Resources Conservation Service (NRCS)
Federal Building, Room 152
100 Centennial Mall North
Lincoln, NE 68508
Statewide Wildlife Biologist (402-437-4100)
or contact Local County Office

University of Nebraska - Lincoln, Cooperative Extension

211 Agriculture Hall - UNL East Campus
Lincoln, NE 68583
402-472-2966, main office
or contact local county extension office

402-643-2981, ext. 115 for water quality questions

Nebraska Department of Natural Resources (DNR)

301 Centennial Mall South, PO Box 94676
Lincoln, NE 68509

402-471-2363 for water storage permits or
402-471-1222 for dam safety guidelines

U.S. Army Corps of Engineers (ACOE)

8901 S. 154th Street, Suite 1
Omaha, NE 68138 402-896-0723

or contact the Kearney office at:
1430 Central Avenue
Kearney, NE 68847 308-234-1403

Nebraska Department of Environmental Quality (NDEQ)

1200 N Street, PO Box 98922
The Atrium, Suite 400
Lincoln, NE 68509
402-471-0096

Nebraska Association of Resources Districts (NARD)

601 S. 12th Street, Suite 201
Lincoln, NE 68508
402-471-7670
or contact your local Natural Resources District (NRD)
listed in White Pages of the phone book

APPENDIX B

LIST OF AQUATIC CONSULTANTS AND SERVICES PROVIDED

The Nebraska Game and Parks Commission does not promote or endorse personnel, agencies or companies that are not part of Nebraska state government, but provides a listing as a service. If you would like to request a copy of the listing or would like to be considered for any of the services listed, contact the Private Waters Specialist at the Commission's headquarters (402-471-5435). The listing contains individuals and/or companies that provide the following services:

Complete Ecological Consulting Services (includes design and construction guidelines)

Construction Contractors

Fisheries/Lake Management
(lake, fisheries and water quality assessment and/or management along with vegetation control)

Aeration Systems

Water Testing

Vegetation Sources

Lake Dredging/Deepening (lakes should be drained and excavated when feasible)

Shoreline Stabilization/Fish Habitat Structures

Pond/Lake Sealing

Flowing Water Filter System

Aquatic Vegetation Control (chemical dealers)

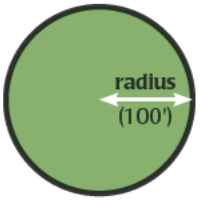
Clarity Improvement for Turbid Water

Lake Mapping

APPENDIX C

CALCULATING THE SURFACE AREA AND VOLUME OF A POND

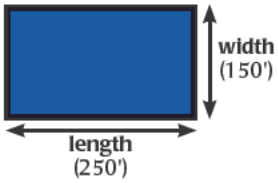
Presented below are formulas for calculating the **surface area** of a pond. Pick a shape that most closely resembles the pond and measure the necessary distances in feet. Put these measurements into the appropriate equation and multiply to find the surface area in square feet. Surface area in acres is simply obtained by dividing the surface area by the number of square feet in an acre (43,560). If a pond is irregular in shape, the best thing to do is divide it into workable shapes and then add the areas of the smaller units together to get the area of the whole.



CIRCLE = 3.14 x radius^2

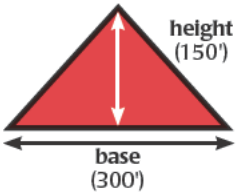
EXAMPLE: pond radius 100 feet x 100 feet x 3.14 = 31,400 square feet total surface area ÷ 43,560 = .72 surface acre

RECTANGLE = length x width



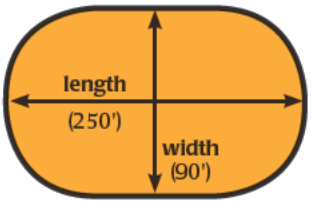
EXAMPLE: pond length 250 feet x width 150 feet = 37,500 square feet total surface area ÷ 43,560 = .86 surface acre

TRIANGLE = $\frac{\text{base x height}}{2}$



EXAMPLE: pond base 300 feet x height 150 feet = 45,000 square feet ÷ 2 = 22,500 total surface area ÷ 43,560 = .52 surface acre

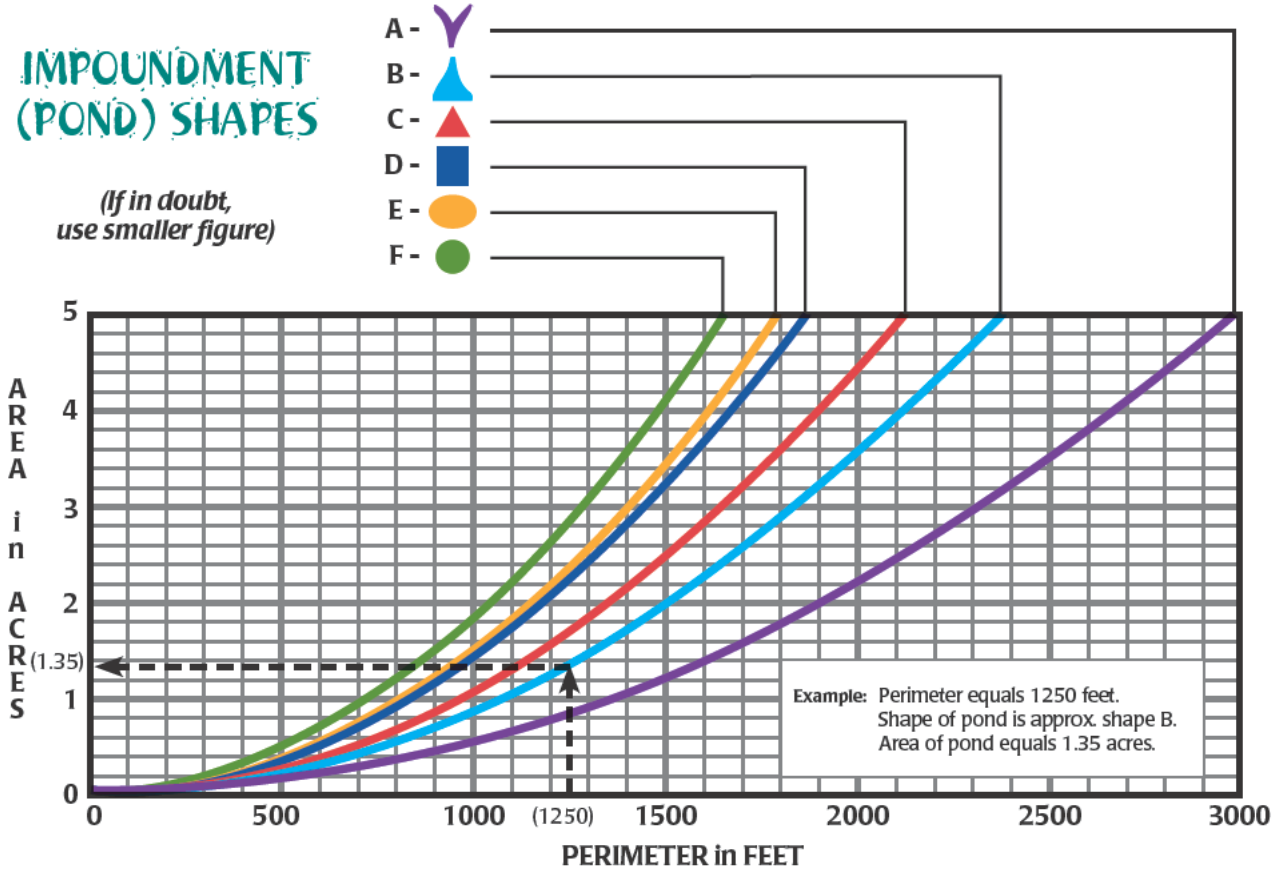
ELLIPSE = length x width x 0.8



EXAMPLE: pond length 250 feet x pond width
90 x 0.8 = 18,000 square feet total surface area
÷ 43,560 = .41 surface acre

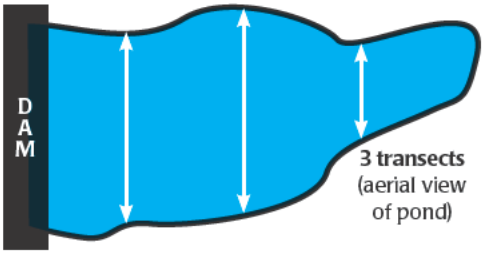
If the distance around the entire pond can be measured, the pond estimator can be used.

POND AREA ESTIMATOR



The formula for calculating a pond's **volume** is surface area (acres) x average depth (feet). Average pond depth can be estimated by measuring the depth of the water in a number of places throughout the pond, adding these measures together to get a total, and then dividing the total by the number of measurements. Several transects should be established across the pond (from one side straight across to the other side). Depth measurements should be taken/recorded every 40 feet with an electronic depth finder or a weight attached to a string marked in feet.

VOLUME (acre-feet) = surface area (acres) x average depth (feet)



EXAMPLE: forty measurements were taken while conducting three transects across the surface of a .75 acre pond; average depth calculated to be 4 feet; therefore, .75 x 4 = 3 acre-feet

APPENDIX D

ADDITIONAL AERATION INFORMATION

AERATION SYSTEM

The first step is to determine if aeration is needed. A deepening project should be considered instead of aeration for most shallow-water situations. However, aeration can be used during drought conditions to maintain a fishery until the pond or lake refills. Aeration systems are usually installed for several reasons: expanding available fish habitat (providing oxygen to water depths normally devoid of oxygen, a common problem in most sandpits, very deep and/or wind protected ponds, and some dugouts); improving water quality (keeping the bottom oxygenated results in bottom sediment retaining phosphorous, which usually reduces algae blooms); and preventing winterkills and summerkills.

Decomposition of organic material, primarily dying or dead aquatic vegetation, uses up available oxygen in the water and can lead to low dissolved oxygen levels during both winter and summer months, particularly in shallow ponds. Aquatic vegetation die-offs usually occur when excessive amounts of vegetation are present and available sunlight is cut off for an extended period of time. Sunlight can be blocked by excessive snow cover and thick ice or when silt-laden runoff following thunderstorms muddies the pond or lake water upon entering. Extended periods of cloudy days during summer months can also cause aquatic vegetation die-offs.

Aeration systems can be powered by electricity or by wind or solar energy. The following information will deal primarily with an electrical system utilizing these basic components:

- power source
- air compressor
- delivery hose/tubing
- diffuser

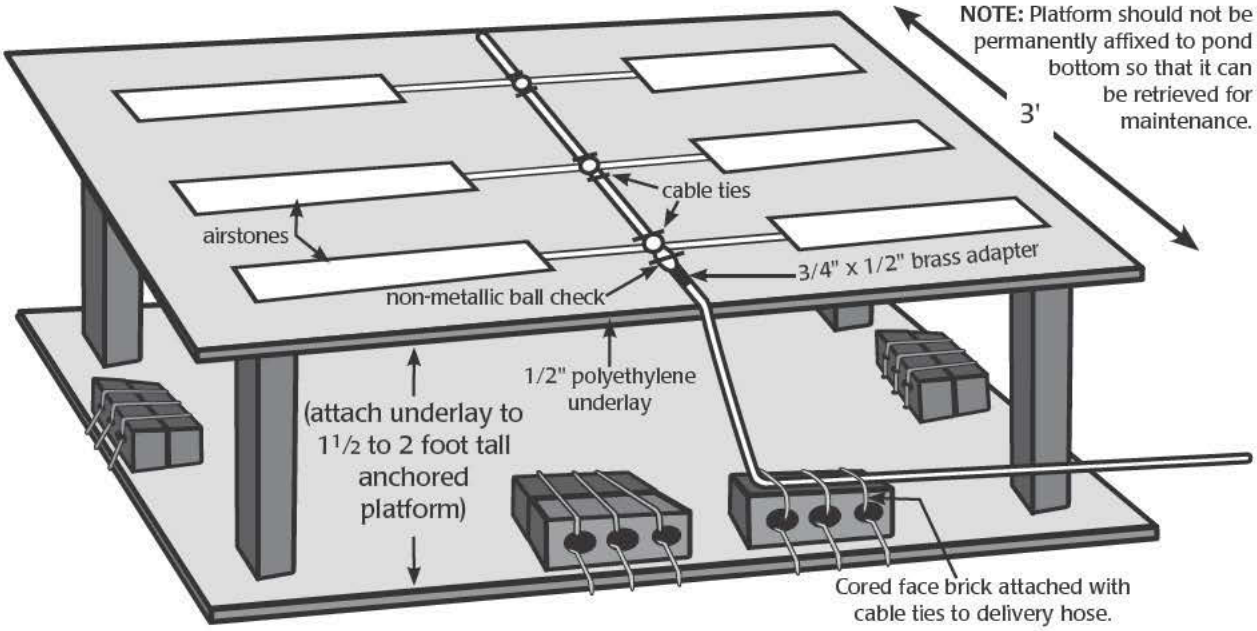
The air compressor is designed to draw in air and force it through a delivery system to the diffuser near the pond bottom. Although most air compressors can be adjusted in the field for either 120 or 240 volts, the 240v is preferred, especially if the delivery line runs more than 300 feet from the main power line. The best situation is when power is readily available at the site. Then it's just a matter of running a short power line to a fuse box. Portable generators can be used if power isn't readily available. Purchase a generator that has a large fuel capacity for extended operation. The kilowatt rating should be at least twice the motor horsepower (3 kilowatts or 3000 watts for 1½ horsepower). Check with the generator manufacturer to be sure. The air compressor should have a case/box surrounding it to protect it from the elements with a lock to lessen the likelihood of vandalism. This structure should be ventilated to prevent the compressor from over-heating. The case/box should be constructed to allow easy access to the compressor for periodic maintenance.

The delivery system is usually ½-inch factory weighted hose or polyethylene tubing. It should be buried below the frost-line to the water's edge and kept underground a short distance into the water. Non-factory weighted 1-inch hose/tubing can also be used as long as it is occasionally weighted by attaching one brick every 5 feet with plastic zip ties. Or, the delivery system can be buried in exposed pond/lake bottom prior to filling. The delivery system needs to be anchored to prevent it from floating and becoming snagged by anglers or frozen into the ice during the winter.

The diffuser is used to break up delivered air into very small bubbles. The diffuser can be a ceramic airstone (preferred), porous hose or perforated PVC pipe. The delivery system should have an automatic check valve installed just before the diffuser. This will keep water from entering the delivery system and prevents freeze up during the winter if the aeration system gets turned off. The diffuser should be attached to an anchored platform that will hold the diffuser about 2 feet off the bottom. This prevents circulation of bottom sediment/nutrients throughout the water column.

Larger bodies of water may require several compressors and diffusers. A general rule for air output is 1.3 cubic feet per minute per surface acre of water. For example, a ¾-horsepower, two piston compressor can supply sufficient air to operate either one 6-stone diffuser or two 4-stone diffusers. A 1½-horsepower, four piston compressor can have either two 6-stone or four 4-stone diffusers.

3/4 VIEW OF CERAMIC AIRSTONE DIFFUSER



REFERENCE MATERIAL

OTHER SOURCES OF INFORMATION

Producing Fish and Wildlife from Kansas Ponds, Kansas Department of Wildlife and Parks, 512 SE 25th Avenue, Pratt, Kansas 67124

Missouri Pond Handbook, Missouri Department of Conservation, PO Box 180, Jefferson City, Missouri 65101

Ohio Pond Management Handbook - a guide to managing ponds for fishing and attracting wildlife, Ohio Division of Wildlife, 1840 Belcher Drive, Columbus, Ohio 43224

Management of Virginia Ponds for Fishing, Virginia Department of Game and Inland Fisheries, 4010 West Broad Street, PO Box 11104, Richmond, Virginia 23230

Iowa's Farm Ponds, Iowa Department of Natural Resources, Wallace State Office Building, Des Moines, Iowa 50319

Ponds - Planning, Design, Construction, Agriculture Handbook Number 590, United States Department of Agriculture, Natural Resources Conservation Service offices

What's Bugging That Fish? - an angler's guide to fish diseases and parasites, Nebraska Game and Parks Commission and University of Nebraska State Museum

Nebraska Pond Management Guide Series, Nebraska Game and Parks Commission
Homepage: *www.OutdoorNebraska.org/Fishing/Programs*
Click on the following: Private Waters, Pond Management Guide Series.

This is a 13 Part Series on Pond Construction, Habitat Modifications, Stocking, Management, Potential Maintenance Problems and Other Pond Animals.

LakeLine and/or Lake & Reservoir Management (multiple publications on managing lakes and reservoirs), North American Lake Management Society, 4513 Vernon Blvd., Suite 100, Madison, WI 53705 or *www.nalms.org*

LakeSmarts - The First Lake Maintenance Handbook - A Do-It-Yourself Guide to Solving Lake Problems, Terrene Institute, 1717 K Street, NW, Suite 801, Washington, DC 20006

CATCH RECORD

All fishing trips should be recorded — one angler per line. If no fish were caught, place a zero under species fished for. Keep records for an entire season (the more trips the better). Use this as the original, make additional copies for the actual recordings. If bass < 8 inches or bluegill < 3 inches are caught, use the **Other** column to record them. **K** = Kept (harvested), **R** = Released (catch-and-release).

Date	Total Hours Fished	Largemouth Bass								Bluegill								Channel Catfish								Other (Species, Number, Length)
		8-11.9″		12-14.9		15-19.9		≥20		3-5.9″		6-7.9		8-9.9		≥10		<11″		11-15.9		16-23.9		≥24		
		K	R	K	R	K	R	K	R	K	R	K	R	K	R	K	R	K	R	K	R	K	R	K	R	

Notes: Body condition of fish caught, etc. _____

CATCH & RELEASE FISHING

Knowing how to grasp and unhook fish properly means anglers can release them unharmed. They can survive to grow, spawn, and be caught again. Even when only measuring a fish, you must handle it gently and release it quickly. Handling fish correctly also eliminates injuries to the angler caused by teeth and spines.

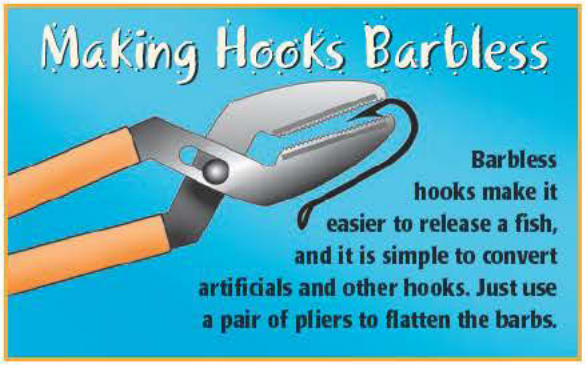
How to Catch & Release

Landing the Fish

Avoid playing the fish to total exhaustion. The longer you play it, the more stress it experiences and the less chance it has to survive.

Rubber Nets

If you use a net, choose one with rubber mesh. Soft rubber is less harmful to a fish than cord. Using a net properly can make handling a large fish quicker and easier than doing it by hand.



Barbless Hooks

Keep the fish in the water as much as possible. Barbless hooks reduce the time needed to handle a fish and make it simpler to remove the hook, often by merely backing it from the fish's mouth without lifting the fish from the water.

Wet Hands

If you must handle the fish, wet your hands before touching it. Dry hands will remove a fish's protective surface mucus, which guards it against bacterial and fungal infections. Using a wet glove can help control lively, slippery fish.

Careful Touch

Handle the fish carefully. Don't squeeze the gills or body cavity, and don't put your fingers into its gill flaps or eye sockets. Try to keep it horizontal. A firm grip behind the head and around the tail is the least harmful. Don't let it flop around on the bank or bottom of the boat.

Helpful Tools

Remove the hook carefully with a hemostat or other hook removal device. If the fish is deeply hooked, cut the line as close to the hook as possible and release the fish. The fish's digestive juices will dissolve the hook in time. Pulling or jerking on a hook will damage a fish's esophagus, stomach, or gills.

Act Quickly

Once the hook is removed, quickly and gently return the fish to the water. Don't just toss it back into the pond. If the fish hasn't regained its equilibrium, cradle it upright in your hand in the water until it can swim away. Don't move it back and forth in the water "to revive it" because gills are fragile and can be damaged by water being forced through them the wrong way.

Definite NO

Never place fish that will later be released in a live-well, in a fish basket, or on a stringer. It is better to release them immediately.

NEBRASKA GAME AND PARKS COMMISSION

APPLICATION FOR FISH AND MANAGEMENT REPORT FORM

Waterbody Owner/Operator: _____ Phone: _____ (Home)
Address: _____ _____(Work)
City: _____ ZIP: _____
Does the waterbody have multiple landowners? _____ If yes, how many: _____
All landowners or lake association boards have to be in concurrence with stocking request, otherwise the application will be denied.
Waterbody Location (miles from nearest town): _____
County: _____ Quarter _____ Section _____ Township _____ Range _____
(Illustrate location on reverse side)
Surface Acres: _____ Depth: _____ Date constructed: _____
Use by livestock: _____
Watershed: % pasture _____ % crop _____ % other (describe) _____
Is waterbody open to fishing by permission without charge? _____
Fish present in waterbody: _____

Instructions: The kind and number of fish provided will be determined after review of the application and an on-site inspection. The deadline for receiving applications in this office is **August 1** for stocking during that calendar year. Please complete this form accurately and completely for each waterbody you want stocked. Failure to do so may mean disqualification.

Mail to: Nebraska Game and Parks Commission, P. O. Box 30370, Lincoln, NE 68503.

I herein make application for fish. It is understood and agreed that all fish secured are to be used for initial stocking in the waterbody described above and open to fishing by permission without charge; and that a valid Nebraska fishing permit is required of every angler 16 years of age and older.

Signed: _____ Date: _____

FOR STATE USE ONLY

Private Waterbody Activity Report Form

Type of Contact: Walk-in _____ Letter _____ Phone _____ Field investigation _____
Date: _____
Time Spent: _____
Activity and/or Summary of Recommendation: _____
_____
_____
_____
Approved for stocking _____ Disapproved for stocking _____ Biologist: _____

STOCKING DATE		NUMBER	RECEIVED BY	SOURCE OF FISH/DELIVERED BY
	BLG			
	LMB			

N

PLEASE DRAW IN LOCATION OF THE POND, IN RELATION TO QUARTER SECTION

R ____

NW ¼ | NE ¼

SECTION _____

T ____

SW ¼ | SE ¼

HOUSED BY SCOTTISH MANAGEMENT