

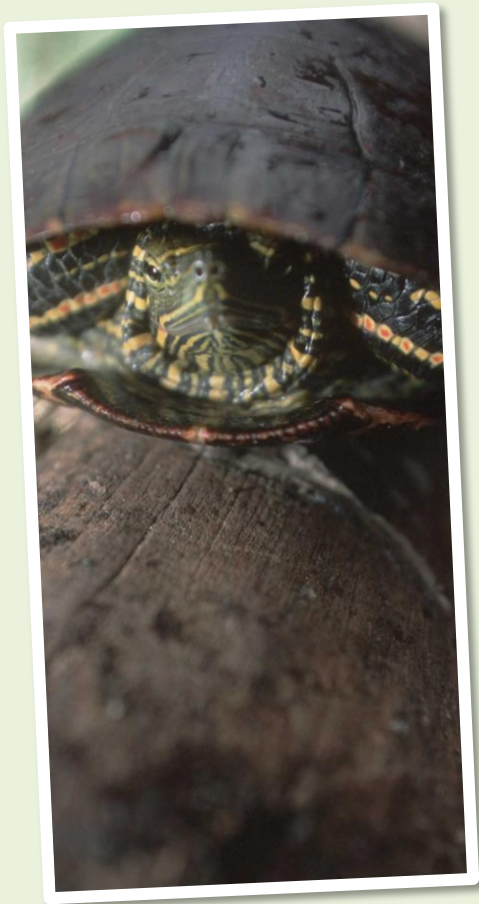
Living Around an Urban Pond



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Living around an urban pond

Many urban developments contain a body of water of one type or another. It may be a seasonal stream or pond, or a pond that maintains a constant water level. In addition to improving the landscape, these water features are often part of the water management plan for the development. Most new sub-divisions today must include a water management plan that addresses surface water flow on the property and takes into account water moving from surrounding properties onto the newly-developed site.

Urban ponds can be a valuable asset to a new sub-division. However, if they are not designed and managed properly, they can turn into a liability. This publication is designed as a reference for homeowners who live near urban ponds. It describes: different types of urban ponds; how location, access, and use impact the pond; issues that affect water quality and fish populations; and best management strategies for ponds.

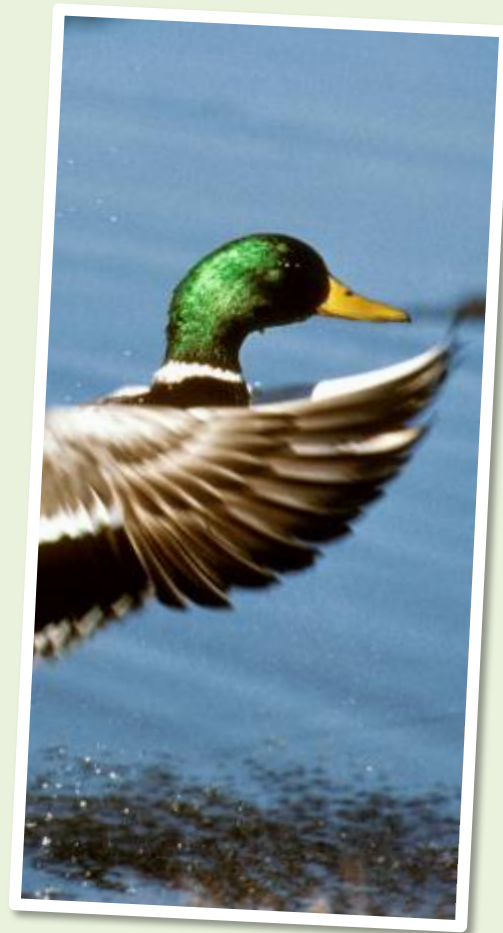
Why are ponds needed?

Ponds provide many valuable opportunities for people in the community. Ponds add beauty throughout the year because of the plants and animals found in and around them. Wildlife attracted to ponds present endless opportunities for wildlife observation and photography. Maintained walking trails around urban ponds afford access to community members to enjoy the pond in various ways.

Some ponds serve environmental purposes by mitigating urban water issues (flood control), while others are even used for irrigation. Ponds are also aesthetic and add to property values.

Ponds are often a meeting place for people in the neighborhood who share an interest in bird watching, wildlife watching, fishing, and other outdoor activities, such as swimming and toy boat races. If the pond is large enough, it can be explored by canoe or kayak or even a small boat.

Ponds are a venue in which human relationships and a sense of community can be deepened through continuation of a fishing tradition, teachable moments that present themselves through careful observation and experience, and stewardship and maintenance activities in and around the pond.



What are the types of ponds?

Ponds built in urban areas generally fall into one of two categories: retention ponds or recreational ponds. Occasionally a pond doesn't fit into either of those categories, such as an irrigation pond or a decorative pond. Each pond type performs a specific function in the landscape.

Retention Ponds

A retention pond is designed to hold a specific amount of water indefinitely. These ponds have a drain structure that releases water downstream during a large inflow event such as a rainfall, ensuring a constant water level in the pond. Some of these ponds may also be set up as "dry basins". These are constructed to release all or nearly all of their water some time after a rain event and often have concrete bottoms to allow equipment access for cleaning.



Recreational Ponds

Recreational ponds are both beautiful and functional. Pond owners typically crave the ability to use their ponds for fishing, swimming, or other recreational activities. Often recreational ponds have features installed to aid these activities. These additions might include canoe or boat ramps, walking trails, fishing docks and piers, and features such as flower gardens or fountains. Though the pond may also serve a purpose in the storm water system, their primary goal is to provide people a place to go to enjoy nature and have fun outdoors.

Where should ponds be located?

There are several important points to consider when deciding where to locate a pond. Before pond building begins, water source, water quality and quantity, watershed size, soil type and access points should all be taken into account.

Water Source

Water source is an important consideration before building a pond. Water can come from a combination of streams, runoffs, springs, or wells. There is no one perfect water source because each has benefits and drawbacks. For example, groundwater may be relatively free of organic wastes, but it is low in dissolved oxygen essential to aquatic organisms. A low level of dissolved oxygen may also be a significant problem when the water flows directly into ponds from springs or other underground sources. Surface runoff has high dissolved oxygen, but it also may have a high sediment and nutrient load. Dammed streams may have the liability of including established stream organisms into a newly developed pond. A pond's "watershed" is a combination of all of its water sources added together.

Water Quality

Clean water is needed not only for aesthetics, but also for the health of wildlife. The term "clean water" as used in this publication means water that has low levels of both suspended solids and dissolved nutrients, principally nitrogen and phosphorus compounds. With a reasonably clean watershed and a sediment basin, ponds can meet these needs. Remember that with water quality, looks are not always everything. Clear water does not necessarily mean clean water. A quality pond stores clean

water, or the cleanest water possible, for a given location.

Dissolved nutrients are as important as sediments in terms of the overall health of a pond. Dissolved nutrients are introduced into the water from the surrounding watershed. These nutrients combine with the influx of sediments to often allow for an ideal habitat for aquatic weed growth (due to shallow pond depth and enriched nutrients). Ponds that have too many weeds can make it difficult to harvest fish or to swim, and often become eyesores.

Watershed Features

A no-mow buffer adjacent to the water will eliminate the need to mow right up to the water's edge. Grass clippings that end up in the pond can add significantly to nutrient pollution. In addition to reducing runoff that reaches a pond, rain gardens and buffer strips allow pollutants suspended in the runoff to be released into the soil before reaching the pond. Because the speed of water movement is reduced, the suspended particles are able to settle out and fall onto the ground surface in the rain gardens and buffer strips. This is particularly important because sediments and solids make up a significant percentage of pollutants that enter urban ponds.



Access Points

For recreational ponds, proper pond access is vital. Piers, jetties, and docks all provide great pond access to users. Having areas of cleared and fairly level shoreline are also useful. While a completely mowed pond edge may be the best access, it can affect things like nutrients and sediment reaching the pond as well as wildlife use. Coupled with fish attracting structures such as felled trees, rocks, and aquatic vegetation - access points can make a good fishery a great one. An overabundance of aquatic vegetation can hinder access however, and often an inside bank slope of 3:1 (one foot of depth is gained over each three feet of distance from shore) is recommended to maximize fishable areas around shorelines. A pond slope that is too steep may endanger those that use the shoreline (if they were to fall in).

What elements can harm urban ponds?

Urban areas can be surprisingly challenging locations to create ponds with good, sustainable water quality and fisheries. Despite efforts at mitigation, cities and towns often have elevated levels of nutrients and sediment in their runoff. The US Environmental Protection Agency (EPA) lists urban and municipal water sources as second only to agriculture in pollutant input to water bodies. These inputs increase fertility of the water body. The high fertility is often exemplified by rampant vegetation growth and the all too common “green and smelly” condition.

Matters are made worse in urban areas by frequent construction and broken ground. These “disturbed areas” are often direct inputs of high sediment and nutrient loads into the watersheds of one or more streams or ponds.

Soil Type

The soil used for the pond dam and bottom type should have high clay content. A pond built on a sandy or gravel substrate will leak. Such a pond will require either bentonite (a type of clay) or plastic to seal it, both of which are expensive. Soil types may be determined from county soil survey maps. Soil maps can be found for many areas through the Natural Resources Conservation Service: www.nrcs.usda.gov



Other urban inputs routinely encountered include chloride from de-icing road salts, the same pesticides often encountered in agricultural runoff, and a variety of metals and other chemicals. Chlorides at high concentrations may affect the health of aquatic plant and invertebrate populations which further affect the other wildlife in the pond. Care must be taken in construction and management to control or eliminate as much of these inputs as possible to ensure pond health and usability.

How can homeowners prevent these elements from entering ponds?

Implementing sustainable landscape management strategies is an effective way to reduce the number of potential pollutants found on a landscape site. Storm water is an obvious source of pond water input in urban areas. Whether from a street, roof, parking lot,



or open area, all storm water inputs eventually lead into a city's various streams and ponds. A wide variety of pollutants are carried with this water from the usual sediment and nutrients to ice melting salt and fuel and oils from cars and asphalt. Each of these can have an effect on neighborhood ponds or streams. Sustainable practices include limiting the amount of fertilizer (in particular those that include high amounts of nitrogen and phosphorous) and pesticide applications, and ensuring that these products are applied correctly if they are used. Removing animal waste from yards is also an effective way to reduce potential pollutants that might reach the pond. Controlling these inputs at the source will help to clean up neighborhood waterways. Soil testing for intelligent fertilizer use, using phosphorus-free detergents, and cleaning up after pets will keep nearby ponds healthy.

What is siltation and how can it be prevented?

Nutrients are not the only issue impacting ponds and waterways, however. Siltation due to waterborne sediment (dirt particles) can shorten the life of a pond dramatically. Not only do these sediments dirty the water and carry phosphorous – the keystone of aquatic vegetation growth and eventual overabundance – but they also build up and cause the pond to lose depth. Reduced pond depth compounds the aquatic vegetation problem as more of the bottom of the pond is within the reach of sunlight – essential to all vegetation growth. The reduced depth also affects fish dramatically, as they are unable to find refuge from lowered dissolved oxygen zones or hazardous water temperatures. Eventually with unchecked sedimentation, a pond will become

nearly devoid of game fish as it transitions from pond to wetland.

If the pond has already gotten too shallow for proper management, the excess sediment will need to be removed. This is often quite expensive and destructive to both the land around the pond and the things that live in it. Sediment removal without sediment input reduction will also be a fruitless effort, as over time the process will need to be repeated. The use of sediment basins and best management practices in the watershed will provide the best chance at providing the pond a long, healthy life. These best management practices include installation of raingardens and buffer strips in the watershed. Focusing on key locations such as collapsing stream banks or large areas of pavement will be most effective.



How can homeowners reduce runoff?

Reducing surface runoff and pollutants that end up in that surface water are key to maintaining water quality since nutrients that enter a pond from surrounding landscapes can have a significant impact on water quality and aquatic life. In addition to large-scale watershed management approaches, there are a number of things homeowners can do to reduce runoff and pollutants from reaching an urban pond. One example is diverting water from downspouts onto a portion of the property that allows the water to move slowly across the area and filter into the soil. Lawns alone will not prevent runoff. Runoff will only be reduced effectively if the turf grass is relatively tall (2 to 3 inches) and dense. Strategically planted buffer strips or rain gardens are an effective way to do

this, as is a large area of turf managed for maximum silt retention. Another option is to use permeable surfaces (pervious concrete, permeable pavers) instead of non-permeable materials like concrete for patios, driveways and walkways.



Rain gardens reduce runoff and prevent pollutants from reaching an urban pond.



What causes ponds to get “green scum” or an oily sheen?

Water quality is of vital importance to fisheries health and a water body’s appeal. Unattractive looks and smells can often be attributed to an overabundance of aquatic vegetation such as algae and duckweed. This “green scum” grows because of elevated nutrient levels – most commonly high phosphorus. A look described often as an “oily sheen” can commonly be attributed to blue-green algae, or other similar organisms like diatoms (another type of algae).

Aesthetics are not the only thing affected by these high nutrients. Often wildlife can suffer as well. Dissolved oxygen is essential to all water-breathing organisms like fish. It is primarily produced in ponds by vegetation, phytoplankton, and algae. Problems occur when that vegetation gets overabundant and then dies with a seasonal change or from another cause. This dead organic material decays on the bottom of the pond as it sinks, depleting the oxygen in the water. Sustained low levels of dissolved oxygen will cause the death of many or all of the fish in the system. Other causes of low oxygen include thick ice and snow cover in winter or large burst inputs of organic pollution such as a manure spill.



Green algae and duckweed



Blue-green algae

Photo courtesy of Michael Masser, Texas A&M



How can aeration make ponds healthier?

To combat this deadly loss of dissolved oxygen, pond owners often turn to aeration. Aerators work by mixing the water column of a pond and injecting oxygen from the air into the water. The mixing of the water also breaks stratification – layers of water of different temperatures – which creates a more uniform dissolved oxygen profile. This can help prevent the buildup of deoxygenated water at the bottom of ponds, which can cause fish kills when the pond suddenly mixes (breaks stratification) from wind or rain. It is important to note that only true aeration systems, not just a fountain, will provide these benefits and that these systems are often prohibitively expensive for pond owners.

Another potential benefit of aeration is limiting the release of phosphorous from bottom

sediments. Phosphorous is a key nutrient to aquatic vegetation and algal growth and often leads to their overabundance. Aeration breaks up the deoxygenated (anaerobic) layer found at the bottom of a lake or pond. This anaerobic condition is thought to promote the release of phosphorus from bottom sediments. Keeping the water circulated through aeration will limit the formation of this anaerobic layer, and therefore reduce internal pond phosphorus release and lower total pond nutrient levels.

Pond aeration and circulation – as well as natural wind circulation – will also help limit the pervasiveness of duckweed and floating algae mats. Wind and water movement keeps these often nuisance-causing plants from establishing a strong pond-wide foothold. Having a pond that is 100% covered with algae or duckweed is often a result of a lack of wind. Consider removing trees and other windbreaks on the shoreline that receives the prevailing summer winds. Wind and mechanical pond circulation may shift the types of nutrient-using aquatic vegetation that are present, but will not necessarily affect nutrient levels – so addressing the source of those over-abundant nutrients is often a better approach if possible.



Some specialized fountains can act as aerators, mixing the water column and injecting oxygen into the pond. However, not all fountains serve this function.

How does vegetation affect pond health?

Vegetation abundance and diversity in an aquatic system – both on shore and in the water – provide vast benefits to fish and other wildlife. Moderate plant growth is essential to water bodies because plants produce oxygen, food, and cover for fish and other aquatic organisms. Nutrients introduced into the water (often from the surrounding watershed) can create an ideal habitat for aquatic weed growth. Fish production, especially, is positively affected by a good balance of aquatic plants.

Many different aquatic plants can be found in ponds. These plants range from microscopic organisms, known as phytoplankton that drift suspended in the water, to larger plants rooted in the pond bottom.



Aquatic vegetation is vital to the health of a pond, but often times these “weeds” can become unsightly and over populous. It is very much a “Goldilocks effect”: not too much, not too little, but just right. Diversity is also key, as it is in terrestrial environments such as prairies and forests. In ponds that have too many weeds, it may be difficult to harvest fish using nets and/or fishing tackle. Aquatic plants that interfere with sport fishing and commercial fish production may be considered weeds.

Common Types

Algae

Primitive plants without true leaves or flowers. Many are free, in strings, or clumped together. Pea green soup coloration will often result from these plants.

Free floating plants

Vegetation not attached to the bottom, such as duckweed.

Submerged plants

Attached to the bottom and grow to the surface, these plants are often called seaweed, moss, or water grass.

Emergent plants

Rooted to the bottom and extending beyond surface. Common emergent plants are cattails, bulrushes, water lilies, smartweed, and willows.

Problematic Types

Algae, duckweed, and watermeal.

Beneficial Types

Arrowhead, fragrant water lilies, and sweetflag.

What are blue-green algae and how are they harmful?

Plants for Rain Gardens and Buffer Strips which are beneficial to ponds

6"-12" tall

Wood's aster series
wild petunia
path rush

12"-24"

common yarrow
purple prairie clover
prairie phlox
meadow sage
spiderwort
side oats grama
blue grama
rushes and sedges

24"-48"

shining bluestar
coneflower
daylily
iris
little bluestem
prairie dropseed

More plants can be found in the resources listed at the end of the publication.

Blue-green algae are a type of bacteria/algae that act like plants by harvesting energy from the sun through photosynthesis. Nutrient levels in the water determine if it occurs abundantly. This alga is often the most problematic type of vegetation that occurs in Midwestern water bodies – urban and rural alike. The primary issue is pervasiveness – it can often become an overwhelming presence as a thick and smelly mat floating on or near the pond surface, known as a bloom.



These blooms are unsightly and can sometimes cause health problems for animals and humans alike. Blue-green algae sometimes produce a toxin that can cause a variety of health problems in pets – even leading to death – when ingested. The risk to humans is less severe, as ingestion is unlikely. However some people are sensitive to skin contact with the toxin, developing an itch or rash. A noticeable overabundance of blue-green algae in a pond can often limit recreational activities.

The solution to a blue-green algae problem is often neither a simple nor a short-term process through pesticide treatment. The true answer lies in the watershed. Proper nutrient management at the pond site and in the watershed will keep nutrient conditions (primarily phosphorous) from becoming favorable for an algal bloom.

What fish are typically recommended for ponds?

A mix of largemouth bass, bluegill, and channel catfish is the combination that is typically stocked into small Midwestern ponds for sport fishing. These three species have proven to provide the best angling opportunities and the lowest risk of management problems (such as stunted growth). An adequate number of largemouth bass is vital to a “sustainable fishery” (defined as adequate numbers of desirable fish for fishers) which, in turn, means that their harvest by fishers be limited to a few larger fish, typically greater than 15 inches in length. In contrast, bluegill harvest is strongly encouraged to maintain desirable adult sizes – too many small bluegills (3 inches or less) will limit food resources and depress the growth of all fish. Channel catfish in a pond with a healthy bass population will not be effective at replenishing their numbers through reproduction. Maintenance stockings are recommended every few years or as dictated by level of harvest.



What other fish are sometimes stocked in ponds?

Pond owners may want to stock other fish species in their ponds. For instance, walleye, northern pike, and hybrid striped bass are highly sought after by anglers, but they will not reproduce in ponds and must be restocked periodically. Northern pike and hybrid striped bass often will grow large, while walleye will not. Care must be taken in mixing these fish with others, however, as these larger predators may actually prey upon largemouth bass. Crappie stocked into small ponds (not recommended by Iowa Department of Natural Resources personnel) result in a large population of small stunted fish. Their small size, large numbers, and

similar food habits enable crappie to compete directly with largemouth bass. Bullheads, though popular with Iowa anglers, should not be stocked into ponds. Bullheads will overpopulate and grow slowly in ponds with a limited bass population. Common carp, grass carp, and bullheads are also known to cause water quality issues as their feeding habits disturb sediments that are on the bottom of the pond. Other ornamental fish, such as Koi and goldfish, are colorful additions to ponds but may cause water quality problems similar to common carp when they are allowed to have uncontrolled reproduction.



Are the fish safe to eat?

As of July 2011, there has been a limited number of health advisories warning against fish consumption in small ponds. Most fish consumption related health advisories address toxicant issues, e.g., polychlorinated biphenyls (PCBs) in Great Lakes and mercury contaminants in rivers and lakes associated with industrial manufacturing. Instead, most concerns related

to fish consumptions in small ponds are related to the presence of fish parasites that are not harmful to humans. These parasites are specific to fish and not humans and fully cooking fish will destroy the parasites. For more information and up to date fish consumption advisories check: www.iowadnr.gov, www.fda.gov, and www.epa.gov

What type of fishing experience can ponds provide?

Urban ponds can provide fishing opportunities for local residents. In many cases, the kinds of fishing experiences available at urban ponds are most suitable for family fishing rather than avid recreational anglers. For families, particularly parents who want to get their young children interested in the outdoors and associated activities, the numbers of fish that can be caught may be of more importance than the size or species of fish caught. In many instances, fishing for bluegills can provide peak experiences for beginning anglers. When asked, residents from many urban areas in Iowa have indicated that they are most interested in having a fishery at an urban pond so they may take a youngster fishing, and for the fun of catching fish, rather than emphasizing trophy fish.



Snakes! Does a pond really need snakes?

One group of animals which can easily startle people who are enjoying time at a pond is snakes. There are more than two dozen kinds of snakes that live in Iowa, and only four potentially pose a safety risk to people. Copperheads, prairie rattlesnakes, timber rattlesnakes, and eastern massasaugas are found in Iowa, but it should be noted that all of these snakes are rare. The most commonly encountered snakes at ponds are garter snakes and water snakes because of their dietary preferences. Water snakes are known for their lack of fear of people, and boldness when it comes to stealing bait in an unguarded minnow bucket or fish from a stringer. Though it may seem appealing to get rid of snakes around ponds, keep in mind that snakes feed on other animals that are also often considered pests, such as insects, crayfish and worms. Snakes will also eat fish, amphibians and other reptiles.

Endangered & Dangerous

The State of Iowa lists copperheads, prairie rattlesnakes and eastern massasauga rattlesnakes as “endangered,” meaning that these species are at imminent risk of becoming extinct in Iowa. The timber rattlesnake is declining in abundance in Iowa and is listed as a Species of Greatest Conservation Need by the Iowa Department of Natural Resources.



Other wildlife questions

Will birds eat too many of the fish?



Snakes aren't the only animals that depend on ponds for habitat and food. Wading birds, such as herons and egrets are attracted to ponds due to the prey available, including fish, snakes, frogs, and insects. Although wading birds are fish consumers, they will not reduce angling opportunities in ponds. Most of the fish taken by these birds are those that are somehow less fit than others of their species, or have been injured, are nearing the natural end of their life cycles, or are diseased.

Are turtles a threat to pond fish or visitors?

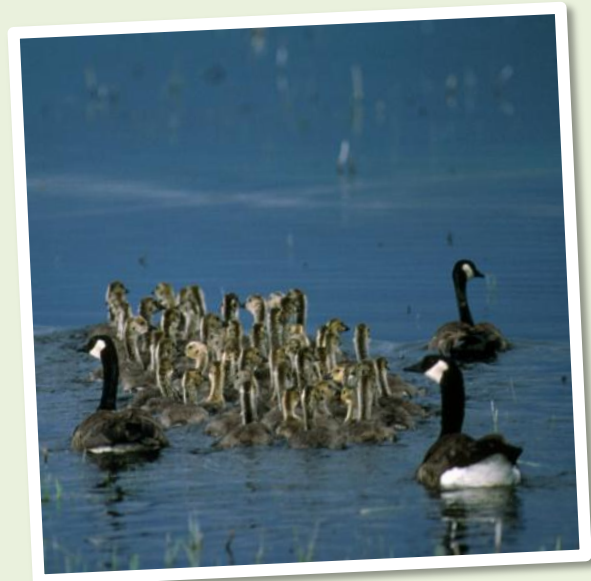
Turtles are also attracted to ponds for food and thermoregulatory opportunities. Aquatic turtles will bask on logs to raise their body temperatures in the early morning and late afternoon hours. Most turtles eat both plant and animal matter, and some species, such as snapping turtles, provide a valuable ecosystem service by eating dead animal matter found in ponds. Although anglers sometimes believe otherwise, turtles do not pose a threat to fisheries. They take a minimal amount of fish and help to cull animals that are less fit from remaining fish populations. Turtles will not harm swimmers. Even snapping turtles, which can be rather defensive when on dry land, are quite calm in the water and will not attack swimmers.



How should geese at a pond be managed?

Canada geese serve as but one example of successful wildlife management in the 20th century. While these birds were quite rare 50 years ago, they are now abundant in urban and rural ponds. In areas where urban ponds are located in a matrix of lawn such as in a city park, a golf course, or a suburban housing development, abundant numbers of geese can be problematic due to their grazing of lawns and associated damage to plants, as well as the volume of waste they produce and deposit in and around ponds.

During the spring breeding season, geese may become highly territorial and drive off intruders, including people who come to fish at a pond. Ways to prevent or minimize problems with geese include: 1) banning the feeding of wildlife in and around the pond, 2) having walkways or trails adjacent to the pond to increase human traffic and discourage geese from nesting on the pond, and 3) leaving a buffer of taller vegetation around the pond to make geese feel less safe from potential



predators such as coyotes or dogs. (This tall buffer also has the added benefit of preventing silt from reaching the pond.) Most people appreciate the sight of a pair of geese with their goslings, but would prefer to limit the numbers of these birds using urban ponds. Taking the simple precautions listed above can help to keep geese numbers in check around ponds.

Should pesticides be used to control insects?

Ponds are important breeding and nursery sites for many invertebrates such as insects. Like wildlife, people have groups of invertebrates that they generally consider as “welcome” on their properties such as butterflies, and groups that are unwelcome, such as spiders. Each of these animals has an important role to play in the pond’s web of life, whether it’s as food for another animal, or as a consumer of plants, or a pollinator, or predator on other animals.

One way to cut down on the numbers of nuisance invertebrates around a pond is to provide bat houses and purple martin houses in

the near vicinity. Purple martins will consume vast numbers of flying insects during the day, and bats will perform that same service during the night. Panfish, like bluegill and other sunfish, will also feed on insects and larvae in the water. Birds, bats, and fish provide a “natural” form of pest control, precluding the need for pesticides, which can potentially poison other pond-dwelling animals, such as fish. Another way to cut down on pest insects is to keep inflow and outflow structures free-flowing by removing sediment and clogging vegetation.

Resources

American Public Works Association. 2008. Manual for Best Management Practices for Stormwater Quality. Kansas City Chapter and Mid American Regional Council, Kansas City, Missouri.

Clayton, R. 2008a. Managing Iowa Fisheries: Water Quality. Iowa State University Extension Publication Pm1352a. Available: <http://www.extension.iastate.edu/fisheries/publications/PM1352A.pdf> (July 7, 2011).

Clayton, R. 2008b. Managing Iowa Fisheries: Farm Ponds. Iowa State University Extension Publication PM1352b. Available: <http://www.extension.iastate.edu/fisheries/publications/PM1352B.pdf> (July 7, 2011).

Clayton, R. 2009. Managing Iowa Fisheries: Aquatic Plant Management. Iowa State University Extension Publication Pm1352-J. Available: <http://www.extension.iastate.edu/fisheries/publications/PM1352J.pdf> (July 7, 2011).

Hartsig, T. and S. Rodie. 2010. Bioretention Gardens. Available: http://water.unl.edu/c/document_library/get_file?uuid=574d311b-cd96-480a-9920-b505b723b03c&groupId=468067&.pdf (July 7, 2011).

Hill, K., J. Schwartz, and D. Anderson. 1980. Iowa's Farm Ponds. Iowa Department of Natural Resources. Available: <http://www.iowadnr.gov/Fishing/AboutFishinginIowa/IowaFarmPonds.aspx> (July 7, 2011).

Rain Gardens: Iowa Rain Garden Design and Installation Manual. 2008. Iowa Stormwater Partnership. Available: <http://www.ia.nrcs.usda.gov/features/raingardens.html> (July 7, 2011).

Rodie, S. and T. Hartsig. 2010. Sustainable Landscapes Rain Gardens, Bioswales and Xeric Gardens. Available: http://water.unl.edu/c/document_library/get_file?uuid=ba1e2f50-cb43-4457-b86f-20a90a819a12&groupId=468067&.pdf (July 7, 2011).

