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More than just a puddle:

Understanding the pond ecosystem for better management

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Photo by Ryan Hagerty, USFWS

Introduction

Ponds and small lakes are diverse environments found across the Midwest. From suburban ponds to farm ponds and natural lakes, many people have fond memories associated with ponds, such as fishing with relatives, teaching a child to swim, and viewing wildlife in their natural environment. Ponds are dynamic natural systems with many living (biotic) and non-living (abiotic) factors. These living and non-living factors, and their interactions with each other, create an ecosystem. This means no two ponds or lakes are the same. You might be thinking: "Why do I need to know this?" The truth is, understanding the pond ecosystem can help you better understand how your management actions affect each element of the ecosystem. With an understanding of the ecosystem, you can have better outcomes from your pond management.

Ponds are dynamic natural systems with many living (biotic) and non-living (abiotic) factors.

Each individual pond has a certain level of potential productivity, which is the number of organisms it can produce. The overall productivity of a pond is driven by non-living factors such as sunlight, nutrients, dissolved oxygen, temperature, pH, and turbidity. Biotic factors, such as plants and animals, also interact with each other and affect productivity. For example, largemouth bass eat bluegill, but bluegill will also eat largemouth bass eggs. Both interactions can affect bluegill and largemouth bass populations. For effective pond management, it is important to take each living and non-living factor into consideration when making decisions. This publication addresses important living and non-living factors in ponds, their interactions, and how to use this information when managing a pond.

Non-living Factors

Non-living factors, also called abiotic factors, include sunlight, nutrients, dissolved oxygen, temperature, pH, color, and turbidity (i.e., water clarity). These factors, when taken together, not only distinguish one pond from another, but also directly impact the productivity of a pond.

SUNLIGHT

Sunlight is essential for most ecosystems on Earth, and ponds are no different. As sunlight enters a pond, it enables primary producers like algae and plants to create energy through photosynthesis. As animals eat these primary producers, and larger animals eat smaller animals, the energy initially created by plants moves through the food web. Sunlight entering a pond provides the initial energy that sustains almost all plants and animals living in a pond.

Sunlight influences the amount of photosynthesis that takes place, as well as the temperature of the water. Sunlight is variable throughout the year, with more light available during the summer than the winter. Variability also exists from day to day, since sunny days have more sunlight than cloudy days. More clouds or less daylight (e.g., in winter) result in less photosynthesis and tends to result in cooler water than days with more sunlight. As a rule, cooler water temperatures slow the rate of growth of plants and algae and reduce the metabolism of animals.

NUTRIENTS

Various nutrients are required to maintain a healthy pond ecosystem. Important nutrients for ponds include potassium, iron, magnesium and manganese; however, the two most important nutrients in pond management are nitrogen and phosphorus. Too little nitrogen or phosphorus can limit the growth of plants. Conversely, too much nitrogen or phosphorus can cause excessive growth of algae and plants. When plants and algae overrun a pond, fish communities can be negatively impacted. For example, excessive plant growth reduces the ability of bass to catch prey, resulting in overcrowded and stunted bluegill populations. Most Midwestern ponds have problems with excessive nutrients and plant and algae growth.

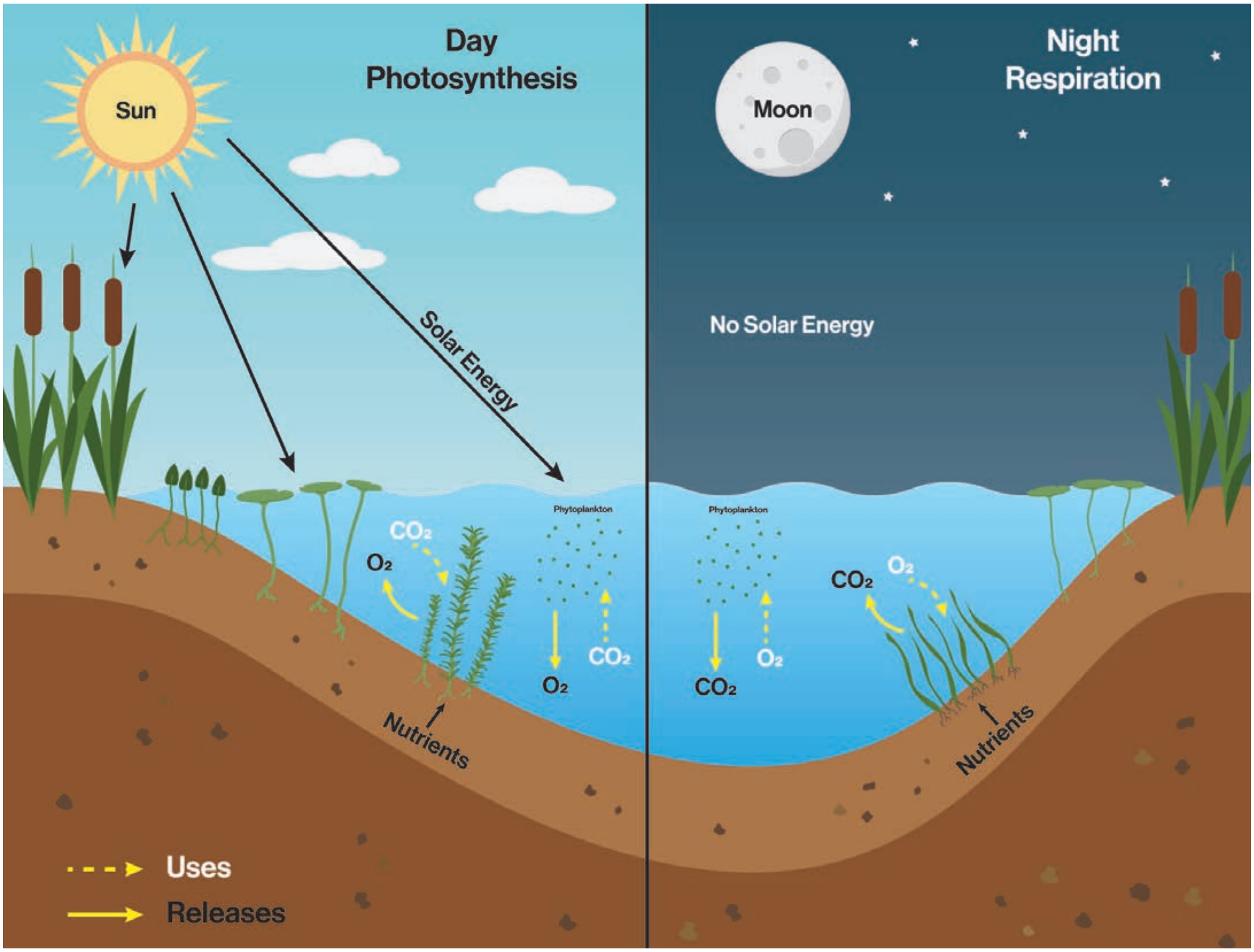
Nutrients can enter a pond in a number of ways, including leaching from sediments, decomposition of dead plant and animals, fecal matter from livestock and waterfowl, and through direct fertilizer application to a pond. However, most nutrients enter a pond through runoff from surrounding land. Runoff occurs when rainwater or excessive irrigation passes over the surrounding land - called the watershed - collecting nutrients along the way. Some of the nutrients are dissolved in the water; others are attached to soil as it moves into a pond. Once these nutrients enter a pond, they will contribute to plant and algae growth. Land use practices around a pond can dramatically influence nutrient levels in a pond. Maintaining a shoreline that is as natural as possible will go a long way to reducing the amount of nutrients that enter a pond. For example, providing a buffer strip of grass or woody vegetation around the perimeter of a pond helps to slow down runoff so that it soaks into the soil or is used by plants, reducing the sediment and nutrients that enter the water.

> ***Nutrients enter a pond through runoff, leaching, decomposition, fecal matter, and direct fertilizer application.***

Occasionally in the Midwest, ponds contain too few nutrients to sustain productive aquatic communities. These can include strip pits, old quarries, and ponds with sandy/rock bottoms or small watersheds. Visual evidence that a pond doesn't have an adequate amount of nutrients can be seen by a lack of vegetation, water that is so clear you can see many feet into a pond, or stunted fish. In these cases, a pond can be fertilized to stimulate phytoplankton growth. It should be noted that it is seldom necessary to fertilize a typical pond. Fertilizing a pond when it is not necessary usually results in explosive algal and plant growth, which could ultimately cause a fish kill. It is always best to consult a professional before fertilizing a pond.

DISSOLVED OXYGEN

While humans and other terrestrial animals get oxygen from the air we breathe, aquatic organisms like plants and fish use oxygen that is dissolved in the water. This dissolved oxygen enters a pond in two ways: (1) through surface agitation and (2) from photosynthesis. When the surface of a pond is agitated by wind, oxygen from the air is dissolved in the water. Artificial agitation through an aerator or fountain will help increase dissolved oxygen in a similar manner as wind movement. The second way that dissolved oxygen is added to water is through photosynthesis. During photosynthesis, plants and algae use sunlight and nutrients to make energy. As part of the process, plants release oxygen into a pond as a byproduct.



Algae and plants release oxygen as they photosynthesize during the day, and consume oxygen at night. Diagram by Jade Layman.

Oxygen is also removed from pond water. While plants and algae produce oxygen during the day when there is ample sunlight, they will actually consume oxygen at night when there is no sunlight. Because of this, ponds with high amounts of vegetation can see big swings in dissolved oxygen each day, with much higher levels in the evening and lower levels in the morning. Animals living in the water, like insects and fish, constantly consume dissolved oxygen to survive, with the rate of consumption dependent on the activity level of each animal. For example, a bass swimming quickly to catch bluegill consumes more oxygen than the same bass resting under a log. Even bacteria, which are important for breaking down dead animals and plants, constantly consume dissolved oxygen. A healthy pond ecosystem has a balance between oxygen production and consumption, enabling all organisms in a pond to thrive.

TEMPERATURE

The water temperature of ponds can vary widely depending on the season and factors unique to each pond. In the summer, a pond may be 70-90°F, whereas in the winter, ponds can be covered in ice for long periods of time. In the spring and fall, water temperatures change rapidly with the changing weather.

Temperature is connected to other non-living factors such as sunlight, dissolved oxygen and turbidity. Warm water does not hold as much dissolved oxygen as cold water; therefore, dissolved oxygen levels drop as a pond heats up in the summer. Turbid ponds with suspended sediments heat up faster and reach more extreme temperatures than clear ponds because the suspended particles absorb more solar energy and heat than clear water.

Temperature is connected to other non-living factors such as sunlight, dissolved oxygen and turbidity

Other non-living factors that affect the temperature of a pond include water source, pond depth and rainfall. Ponds fed by groundwater contain cooler water (e.g., 55°F) in summer and warmer water in winter than ponds that receive water from rainfall, runoff or streams. The overall depth of a pond also influences temperature. Shallow ponds heat up and cool down more quickly and may reach more extreme temperatures than deeper ponds. The temperature of rainfall droplets can influence water temperature. For example, an early spring rain can dramatically increase water temperature in a short time. In a similar way, a cool summer thunderstorm can decrease pond water temperatures.

Temperature also influences living factors like fish reproduction and metabolism, as well as vegetation growth. The timing of fish reproduction is often regulated by water temperature. For example, largemouth bass tend to spawn in the spring when water temperature reaches 60°, while bluegill start spawning closer to 70°F. Fish metabolism and activity levels are linked to temperature. Fish are ectotherms, meaning that their internal body temperature is dictated by the temperature of the water. Fish are less active and consume less food in cold water, compared to fish in warm water. As a general rule, the cooler the water temperature, the less productive a pond will be. The type of vegetation around and in a pond can also influence water temperature. Floating plants like lilies or large overhanging trees can shade a pond and prevent sunlight from heating the water.

TURBIDITY AND COLOR

Both water color and turbidity affect the penetration of light into lakes and ponds. Turbidity refers to water cloudiness and represents the concentration of suspended particles in the water. The most common types of suspended particles in ponds are sediments and phytoplankton.

Suspended sediments in the water column are the most common causes of high pond turbidity. Suspended clay particles are typically the culprit when a pond is described as "muddy." Pond additives like gypsum and aluminum sulfate can be used to help settle out clay particles, but you should work with a pond consultant before trying these products in your pond. Silt particles are typically larger than clay and settle out of the water column more readily. Although silt eventually settles to the bottom of a pond, the feeding strategies of some fish species, such as

Suspended sediments such as clay and silt are the most common causes of muddy ponds. Photo by Robin Webster.

common carp and bullheads, or the trampling activity of livestock, can resuspend silt particles and create muddy ponds. Soil erosion on pond banks or within the watershed can also lead to more sediments finding their way into the water, further increasing turbidity.

Dissolved organic substances such as tannins may also affect the color of the water. Tannins are compounds found in decaying leaves that turn the water tea-colored. While tannins are not usually a cause for concern, they do lower light penetration. In addition, excessive amounts of leaves can reduce oxygen content in a pond through bacterial composition of leaves and other organic matter.

Phytoplankton are microscopic plants that drive pond productivity. Phytoplankton are invisible to the naked eye, and ponds with low phytoplankton densities appear relatively clear. However, phytoplankton can go through seasonal blooms, and high densities can cause pond water to look like green soup. Phytoplankton form the base of the food web and are important for pond productivity. However, phytoplankton blooms can lower the dissolved oxygen in ponds as phytoplankton consume high levels of oxygen at night, and when they die, oxygen is also consumed by decomposing bacteria. The most effective way to reduce the frequency and intensity of phytoplankton blooms is to limit nutrients entering a pond.

PH

pH is a measurement that quantifies if pond water is acidic or alkaline. A measurement of 7 is considered neutral, while less than 7 is acidic and more than 7 is alkaline. In general, fish can live in water with a wide range of pH, anywhere from 4 to 10. The pH value of water is influenced by soil characteristics in pond sediment and in the watershed. Pond pH fluctuates throughout the day, with the highest pH reading during the day and the lowest at night. Testing pH multiple times throughout a 24-hour period can provide a good idea of what the average pH is in a pond. In general, basic ponds with high pH values tend to be more productive than acidic ponds with low pH values. Pond pH is an important consideration when selecting chemicals to use for pond management.

Non-Living Processes

SEDIMENTATION

Ponds accumulate sediments over time. Sediments enter a pond through runoff, and eventually settle on the bottom. Ponds fed by streams or with large watersheds are especially prone to filling in with sediment. Over time, sedimentation gradually decreases the depth of a pond. Ponds with increased sedimentation are prone to unfavorable conditions such as water with increased turbidity, higher temperatures, excessive vegetation growth, and lower dissolved oxygen.

The amount of sedimentation that occurs in a pond depends on its design, size and the surrounding landscape. Land-use practices in the watershed will greatly influence the amount of sediment that flows into a pond. Over time, a pond may need to be dredged to maintain its depth and overall health. Maintaining vegetation around the perimeter of a pond, such as buffer strips, can help to slow the rate of sedimentation.

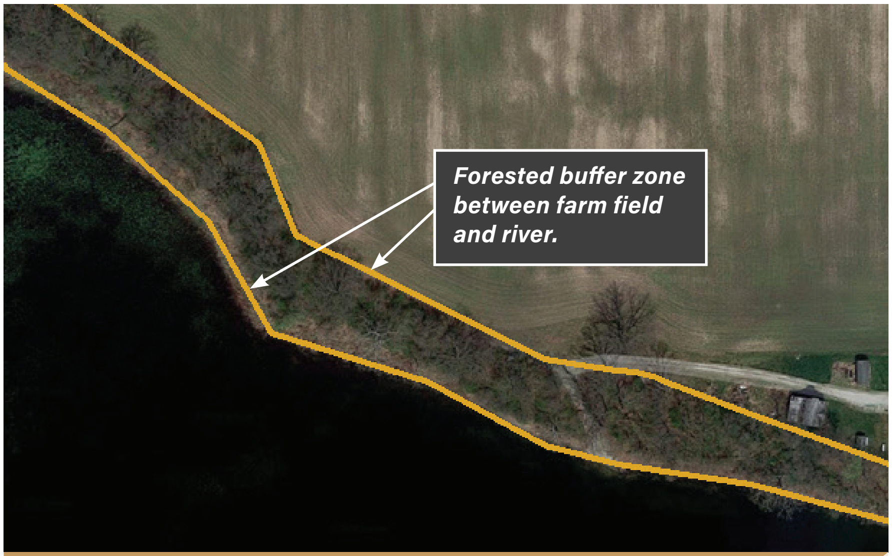
STRATIFICATION AND TURNOVER

If you've ever dived into into a pond in the summer, you've probably felt a rapid temperature drop just a few feet below the surface. What you've felt is called pond stratification. Stratification occurs when a pond is divided into two broad layers: a top layer of warm water and a bottom layer of cold water. Where these two layers are separated is called the thermocline. Stratification tends to occur during the summer and winter due to different densities of surface water and bottom water.

Stratification is when a pond develops two distinct water layers: a warm top layer and a cool bottom layer.

At different times of the year, the two pond layers will mix together, which is called pond turnover. During winter, surface water tends to be slightly colder than water at the bottom of a pond. This is because water is most dense at about 39°F. Water that is less than 39°F moves closer to the surface above the water that is 39°F. When spring temperatures warm the surface water to the same temperature as water on the bottom, the water mixes. This process is called spring turnover. During the summer, the sun heats up the surface of a pond. This creates warm water which remains at the top of the water column, since it is less dense than cold water. When fall arrives, the air cools the surface water which results in both layers mixing together. This process is called fall turnover.

Pond turnover can also occur from weather events, such as strong summer thunderstorms; high winds and runoff agitate the water and cause the pond to mix. Visual signs that suggest pond turnover is occurring include cloudy water, algal blooms (as nutrients in the sediment are resuspended), a sulphur-like odor, and fish kills.

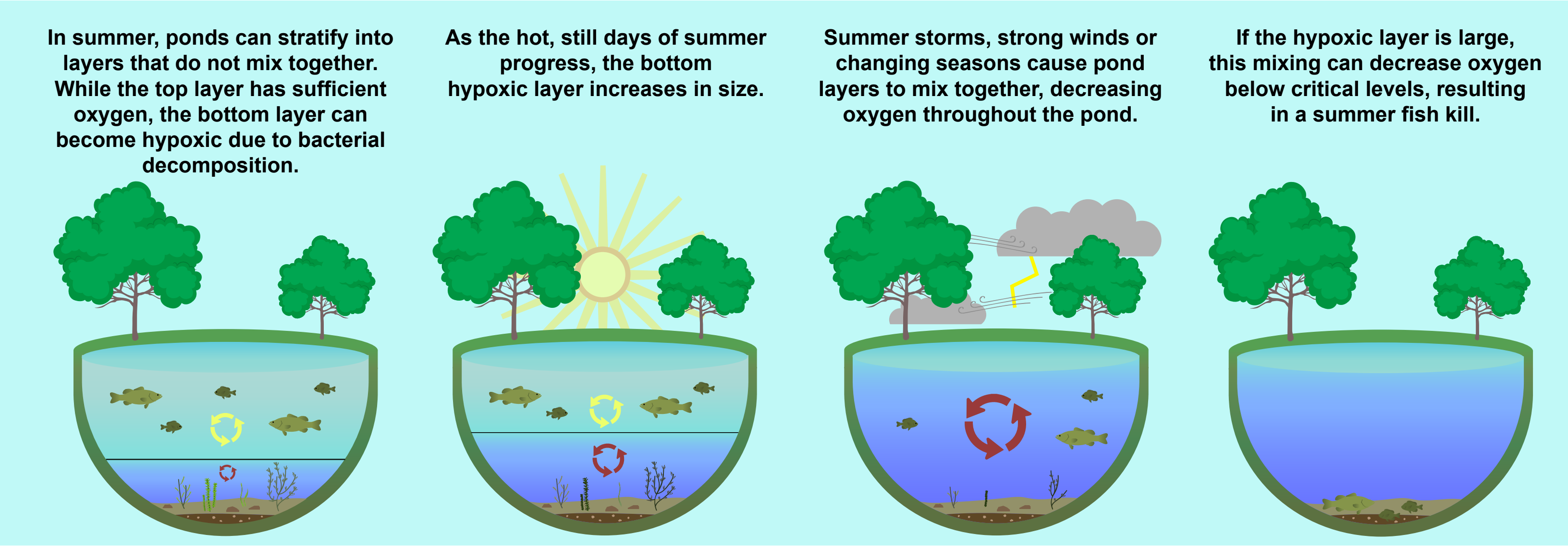


Buffer strips can help prevent excessive sediments and nutrients running into ponds, lakes and rivers. Photo courtesy of the Purdue Pesticide Program

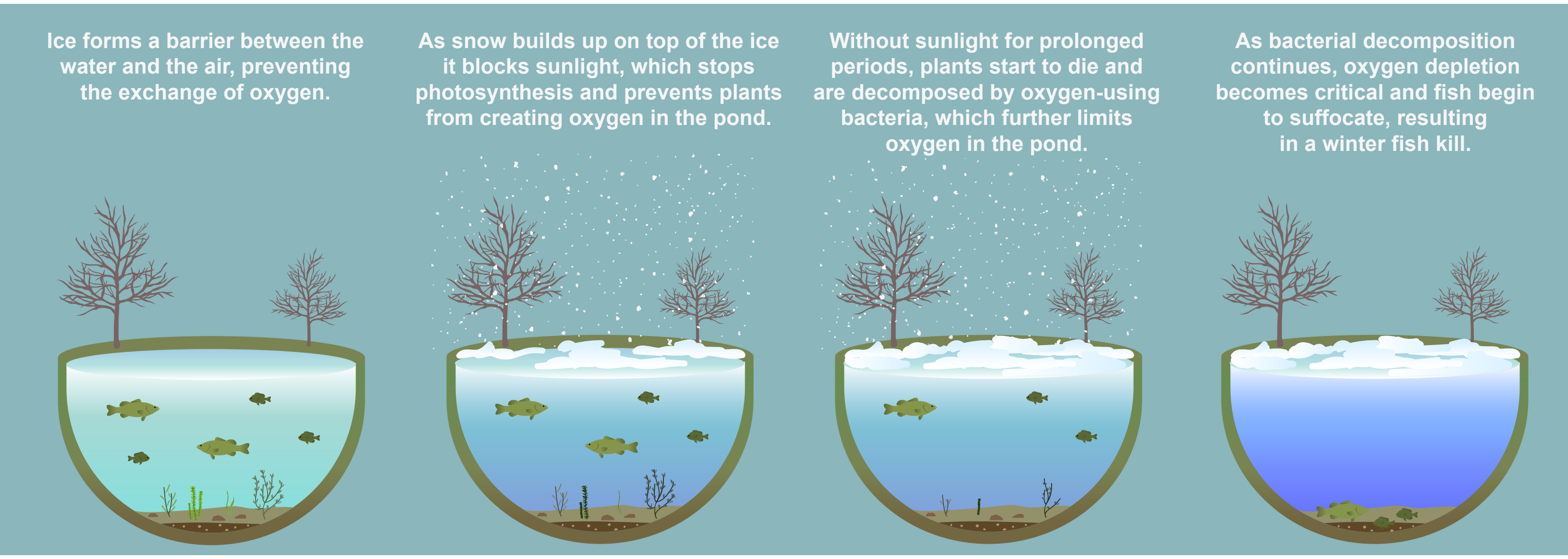
FISH KILLS

Though stratification and turnover are natural events, rapid mixing of pond layers can result in fish kills. This occurs because the colder water at the bottom of a pond tends to have low oxygen levels. If the mixing happens quickly, the rapid introduction of water with low oxygen into the upper layers can result in fish kills. This can occur during seasonal turnover events or extreme weather events like thunderstorms. Fish that require more oxygen, such as large fish, typically die first during a low oxygen event. This is in contrast to a pollution event, when small, less-hardy fish typically die first.

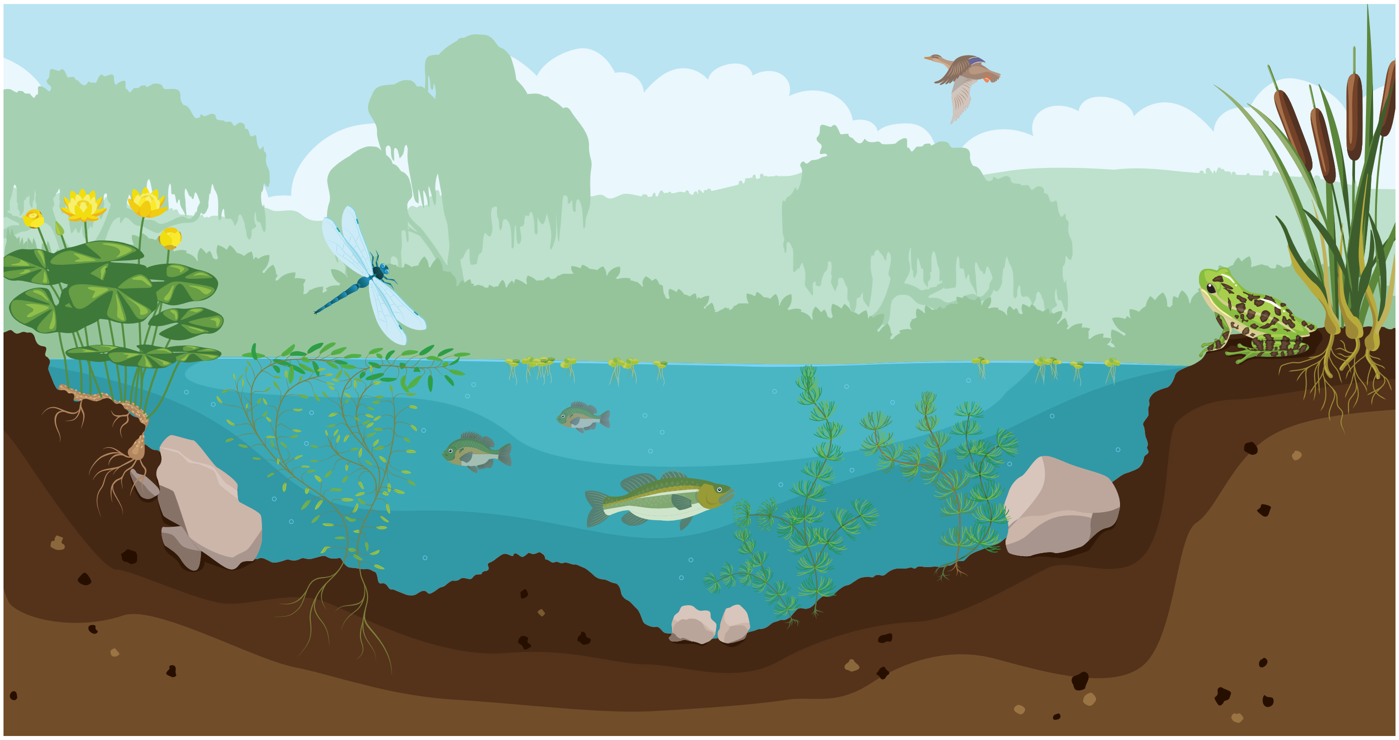
Fish kills can also result from winter ice cover. Ice cover prevents wind action from aerating a pond, and snow accumulation diminishes light penetration. With less light, plants and algae under the ice cannot photosynthesize and produce oxygen. Dead plant matter and other organic materials continue to decompose, which uses oxygen already in short supply. This combination of conditions can result in winter fish kills that can be seen once the ice thaws.



Typical process for a summer fish kill. Diagram by Jade Layman.



Typical process for a winter fish kill. Diagram by Jade Layman.



An example of a pond ecosystem. Diagram courtesy of Purdue Pesticide Programs.

Living Organisms

Biotic factors include all living organisms in a pond ecosystem, such as viruses, bacteria, plants and animals. An ecosystem can be organized into a food web, with organisms divided into trophic levels. Trophic levels separate organisms based on their diet and place in the food web. The first trophic level includes primary producers like phytoplankton and algae. Subsequent trophic levels include primary consumers–those that feed on primary producers–and secondary consumers–those that feed on other consumers.

POND MICROBES

While not visible to the naked eye, microbes like viruses, fungi and bacteria play an important role in the pond ecosystem. Some microbes process nutrients like carbon and nitrogen so they can be used by plants. Some bacteria change nitrogen into forms that are less toxic to fish and other organisms. Many microbes decompose dead plants and animals to create an efficient ecosystem that minimizes waste, recycles nutrients and promotes healthy ponds.

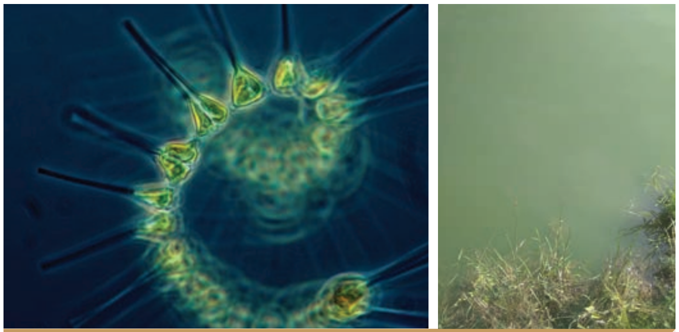
Although many microbes are important to pond health, pathogenic viruses, bacteria and parasites can infect fish and result in poor health, or even death. Disease outbreaks in ponds can often be due to overcrowding. When managing a pond, it is important to keep fish densities at proper levels to help prevent disease issues. Transporting fish between ponds and lakes can introduce diseases and other pathogens. Other stressors such as spawning periods, rapid temperature changes, and poor water quality can also lead to disease outbreaks. If a disease issue is suspected in your pond, you should contact a professional to diagnose the issue as quickly as possible. For a fee, the Indiana Animal Disease Diagnostic Laboratory at Purdue University can help identify fish diseases.

Some bacteria are actually primary producers in ponds. One such bacteria often found in Midwestern ponds is cyanobacteria, commonly known as blue-green algae. Some blue-green algae contain toxins that can be harmful to humans, dogs, and animals who ingest the water while swimming. While not all species of blue-green algae are harmful, care needs to be taken when blooms are observed in your pond. If a bloom of blue-green algae is suspected in your pond, you should restrict pets and humans from having contact with the water until the bloom disappears. You should also have your pond water tested once every 2-4 weeks to monitor for blue-green algae and associated toxins. It may be tempting to use an herbicide like copper sulfate to kill blue-green algae, but doing so may kill other phytoplankton that compete with blue-green algae, causing more issues in the long run.

A blue-green algae bloom in a pond.
Photo courtesy of Purdue Pesticide Programs.

PRIMARY PRODUCERS
Primary producers use photosynthesis to combine nutrients and sunlight to generate their own energy for growth and survival. Primary producers "fuel" the rest of the ecosystem and are essential for balanced ponds. Common primary producers in Midwestern ponds include phytoplankton, algae, floating plants, submersed plants and emergent plants. Floating, submersed, and emergent plants are referred to as macrophytes.

ALGAE
The three most common types of algae in ponds are phytoplankton, filamentous algae and macroalgae. Phytoplankton are microscopic algae that suspend or float in the water column. Most of the food web is supported by phytoplankton rather than other algae or plants. Zooplankton (microscopic animals) consume phytoplankton, and in turn are consumed by fish such as bluegill and fathead minnows. Healthy phytoplankton levels can increase the overall productivity of the pond, and result in faster fish growth.



A microscopic image of a single phytoplankton (left) and pond water with a bloom of phytoplankton (right).
Photos by Purdue Pesticide Program and Logan Halderman, respectively.

Filamentous algae are what most people visualize when they think of algae. These algae, which actually represent hundreds of different species, form mats below or on the water surface, or can cover the bottom of a pond and other plants. Filamentous algae are a natural part of a pond ecosystem and are consumed by organisms like crayfish, fathead minnows and tilapia. However, excessive growth of filamentous algae can crowd a pond and choke out other plants.

Filamentous algae can form mats on the top of a pond that become a problem when they cover a large area.
Photo by Rod Williams.

Macroalgae are sometimes misidentified as rooted aquatic plants; however, they are actually algae and not plants. The most common macroalgae are *Chara* species found commonly in shallow water. *Nitella* is another common type of macroalgae, but these are usually found in deeper water where other plants and algae struggle to grow. Both *Chara* and *Nitella* are important food sources for waterfowl. Starry stonewort is an invasive macroalgae that is rapidly spreading from infested lakes and ponds to establish in other ponds. It grows in immensely thick patches that crowd out native plants. Unfortunately, starry stonewort provides poor habitat for fish and other organisms living in a pond. Starry stonewort can resemble *Chara*, but one easy way to tell them apart is to squeeze the algae. If it pops, then it is not *Chara*. If starry stonewort is found in your pond, you should contact your local Department of Natural Resources office.

While Chara resembles a plant, it is actually a type of algae.
Photos courtesy of John Boldt (left) and Cassi Saari (right).

Starry stonewort is an invasive macroalgae that "pops" when squeezed. Photo courtesy of Blake Cahill.

Some algae issues can be controlled through proper nutrient management and making sure that boats are cleaned of algae and other plant before being put into a pond. However, chemical treatments may be needed to deal with large outbreaks of algae.

FLOATING PLANTS

Floating plants are divided into two groups: those that are completely free-floating and those that are rooted to the bottom. The two most common free-floating plants in ponds are duckweed and watermeal. Duckweed are often confused with algae, but are actually small green plants with small roots that float in the water where they absorb dissolved nutrients. Watermeal are extremely small, about the size of a grain of sand, and do not have roots. Watermeal is actually the world's smallest flowering plant. Both duckweed and watermeal are beneficial plants that provide shade for fish and other animals in a pond as well as serve as food for waterfowl. However, excessive growth can shade out other plants in a pond. Both mechanical and chemical control can be effective in limiting their growth. Adding an aerator can confine them to the edges of a pond, where they are more easily removed with a scoop or net. Contact herbicides can be used for short term or spot treatments, and pond-wide treatments can be used to limit their growth for the entire season.

A close-up photo of duckweed (larger green circles) and watermeal (tiny green dot) on a person's finger.
Photo courtesy of iNaturalist.

Common rooted floating plants include watershield and water lilies. Both watershield and water lilies have roots in the bottom of a pond and stems that connect the roots to the leaves floating on the surface. Similar to free-floating plants, rooted floating plants provide fish with shade and cover and are used as food by some wildlife species. However, when they are left to grow over many years they can become dominant and invasive. If they are growing beyond the intended area, mechanical removal (e.g., rake or cutter) or a contact herbicide might be required to reduce the spread of these plants.

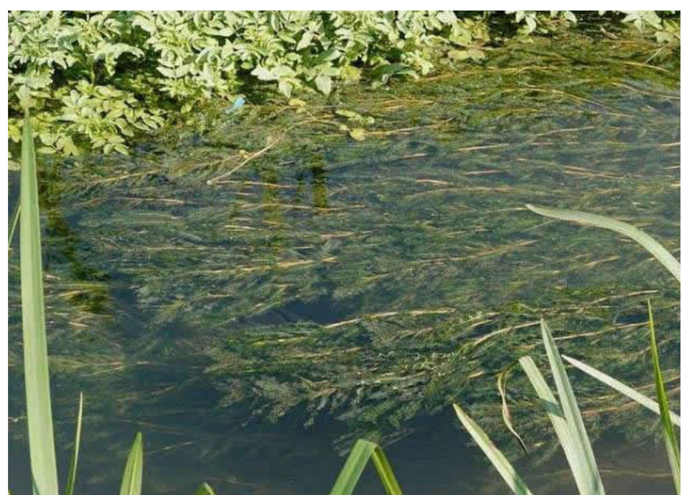
A pond covered in water lilies (dark green leafy plants) and duckweed (small light-green plants).

Photo courtesy of Purdue Pesticide Program.

SUBMERSED PLANTS

Submersed plants grow completely underwater, but occasionally find their way to the surface. They create essential nursery habitat where young fish feed and hide from predators. At the same time, some predators use areas of submersed vegetation to ambush prey. Waterfowl consume some types of submersed vegetation, such as pondweed and naiad species. Native submersed plants include coontail, naiads, sago pondweed, variable pond-weed, eelgrass and bladderwort. Ponds can also contain non-native species of submersed plants such as Eurasian watermilfoil and curly-leaf pondweed. Submersed plants are important to wildlife, but many species, especially non-natives, will grow to nuisance levels and require active management.

All pond plants require sunlight to survive and grow. While floating and emergent/shoreline plants have no shortage of sunlight, sunlight can become a limiting factor for submersed plants. Submersed plants require sufficient sunlight to penetrate through the water column to grow. However, sunlight diminishes quickly in water, particularly if the water is turbid. As such, submersed plants grow in the shallowest areas of ponds and lakes where there is sufficient sunlight. Water clarity is a significant factor in determining how much sunlight penetrates the water. A clear pond may allow submersed plants to grow in water that is 15-20 feet deep, but a pond with low water clarity may not allow vegetation to grow at all. To promote healthy fish populations, 15-20% of a pond should contain submersed vegetation. However, this can be difficult to achieve in a small pond. If a pond has issues with excessive submersed vegetation, one possible solution is to use dyes to prevent sunlight from penetrating deeply into the water. Dyes prevent some sunlight from penetrating through the water and basically starve submersed plants of light. In addition to light, submersed plants also require soft sediments to sink their roots into. Removing or restricting access to soft sediments, such as adding rip-rap, can be used to reduce submersed vegetation growth. In addition to preventative measures, mechanical removal and chemical treatment are both options for reducing excessive growth. Invasive species like Eurasian watermilfoil are primarily spread through contaminated equipment, such as boats, trailers, and bait buckets. It is important to clean any equipment thoroughly before putting it in a pond.



Curly-leaf pondweed (invasive species) growing in clear water.

Photo by Patrizia Ferrari.

SHORELINE AND EMERGENT PLANTS

Shoreline and emergent plants grow in shallow water along the banks of a pond. Examples of common shoreline plants include bulrushes, cattails, arrowhead, and black willow. They help stabilize the area around the bank, prevent erosion, and utilize nutrients coming into a pond from runoff. They also provide shade for ponds during summer, and woody debris from dead shoreline trees and shrubs provides structural habitat for fishes, basking structure for turtles and food for insects. However, some emergent plants can be problematic. Without some form of management, emergent plants like cattails and Phragmites can reduce access to a pond for recreation (e.g., fishing and boating), and displace other vegetation.

Cattails are an emergent shoreline plant that can grow over 6 feet tall and completely cover up the shallow areas in a pond. Photo courtesy of Alex McClellan.

SEASONALITY OF PRIMARY PRODUCERS

Primary producers have the fastest growth rates during the summer when energy from the sun is at its peak. Their growth slows in the fall and winter as much of the algae and vegetation dies. However, phytoplankton blooms can occur in the winter. Rooted plants can also continue to live in winter. When spring and summer arrive, phytoplankton blooms occur frequently due to increased water temperatures, nutrient levels and sunlight. Algae are typically the first primary producers to begin growing in the spring because they grow faster and can respond quickly to the changing conditions. Macrophytes as a rule tend to grow more slowly than algae.

Primary producers have the fastest growth rates during late spring and summer when energy from the sun is at its peak.

Many macrophytes experience an annual cycle similar to that of algae. Just like with terrestrial plants, some macrophytes are annual while others are perennial. Annual plants grow from seed, produce new seed and then completely die over the course of a year. Examples of annual macrophytes are eelgrass and coontail. Other macrophytes are perennial plants that grow during the warm months and die back in the fall, but maintain the same root system which allows them to regrow when favorable conditions occur. Examples of perennial pond plants are water lilies and cattails. Perennial plants are more consistent on a year-to-year basis, while annual plants can have more variable growth depending on annual nutrient levels or other conditions. More information on specific plant species can be found at our website: https://extension.purdue.edu/pondwildlife/.

CONSUMERS

Unlike plants, consumers must consume other organisms to obtain the energy needed for life. This process causes energy to transfer from producers to many different consumers before the energy eventually reaches the top of the food web. As organisms consume one another, energy is transferred from one trophic level to the next. In the real world, most of that energy is lost due to inefficiencies and metabolic use. It's been estimated that only 1% of the energy from phytoplankton gets transferred to the zooplankton that eat them. From this point onwards, about 10% of the energy gets transferred from consumer to consumer. This means that to produce a 1-pound bass, 10 pounds of bluegill, 100 pounds of zooplankton and 10,000 pounds of phytoplankton would be required.

Consumers must eat other organisms to survive, thereby transferring energy from primary producers to many different organisms in the food web.

ZOOPLANKTON

Zooplankton are microscopic, free floating animals that live in a pond. Most types of zooplankton cannot be seen with the naked eye, but they are numerous and essential to a pond ecosystem. Zooplankton are important consumers of phytoplankton, and also form an important food source for smaller fish like minnows and bluegill. Many types of zooplankton occur in ponds, including daphnia, rotifers and even larval fishes. Daphnia and rotifers are small animals that consume phyto-plankton, which makes them primary consumers. Larger zooplankton like larval fish and copepods often consume smaller zooplankton, making them secondary consumers.

Daphnia are an example of zooplankton in ponds.
Photo courtesy of Oregon State University.

AQUATIC INSECTS

Aquatic insects, although individually small, are an important component of a pond ecosystem. They play a major role in the conversion of dead and decaying plant and animal material into food that sustains other aquatic animals. They also may consume algae, zooplankton, other insects, and even small fish. In both numbers and total weight, the most important pond insects usually are the immature stages of small flies, especially non-biting midges. Depending on pond depth, oxygen content of the water, aquatic vegetation, and especially the presence of fish, other insects may be present, including species of mayflies, dragonflies and damselflies, and aquatic bugs and beetles. Aquatic insects hatch from eggs and most initially live in the water where they grow through several stages. Many forms emerge from water as winged adults, while others remain in the water as adults. Insects are a preferred food item for larger consumers such bluegill and fathead minnows.

A mayfly nymph is a common aquatic insect in pond ecosystems.
Photo by Martin J. Calabrese.

CRAYFISH, SNAILS, AND MUSSELS

Crayfish, snails, and freshwater mussels can also live in ponds. Crayfish and snails are detritivores, meaning they feed on decomposing plant and animal remains that fall to the bottom of a pond. Crayfish are especially common, and provide forage for predators such as largemouth bass. Snails also provide forage for fish as well, especially redear sunfish. However, snails can act as hosts for parasites that can harm fish, so large snail populations can cause disease outbreaks in fish populations. A few species of freshwater mussels can occur in ponds, but they are not as common in ponds as they are in streams and rivers. To feed, mussels filter algae, bacteria and other small particles from the water. Mussels have a unique life-cycle that requires fish to transport their juveniles, so ponds connected to streams where fish can enter and exit commonly contain mussels. One invasive species of freshwater mussel, known as zebra mussels, can enter ponds via streams or from boats and trailers just like invasive plants. When launching a boat into your pond, always be sure to inspect and clean all associated equipment to prevent the introduction of zebra mussels and other potential pests.

Zebra mussels can be an invasive species in ponds.
Photo courtesy of the NOAA Great Lakes Environmental Research Laboratory

FISH

To most pond owners, fish and fishing are one of the more enjoyable aspects of owning a pond. Depending on the species, fish can be first order, second order, or third order consumers. First order consumers include species like grass carp and tilapia that eat plants and algae directly. Second order consumers include fish that eat zooplankton, such as larval fish, bluegill and fathead minnows. Examples of third order fishes are largemouth bass and channel catfish. For assistance identifying fish in your pond, refer to Purdue Extension publication FNR-584 *Indiana Pond Fish Species Identification.*

REPTILES AND AMPHIBIANS

Ponds are also home to reptiles and amphibians. Reptiles found in ponds include snakes and turtles. Northern watersnakes, painted turtles and snapping turtles are just a few examples of species commonly found in ponds. All turtles commonly found in ponds are omnivores and are important scavengers in ponds.

Frogs are common amphibians found in ponds. Tadpoles are herbivores that consume algae. Adults tend to be carnivorous, relying on insects and small fish for nutrition. Frogs and tadpoles are a common prey item for pond predators like large fish, birds and raccoons. A few frog species common in ponds include bull frogs, green frogs, and leopard frogs.

Tadpoles are herbivores and consume algae.
Photo courtesy of Renee Grayson.

BIRDS

Ponds can attract many different species of birds, including waterfowl and predatory birds. Waterfowl, such as ducks and geese, are commonly found in and around ponds. Most waterfowl are omnivorous and consume aquatic plants and algae, as well as fish and other organisms. One species of concern is the Canada goose, which can become a serious nuisance when large numbers congregate on a pond or lake. Canada geese feed on vegetation along the shoreline and can remove so much that it causes erosion problems. Fecal matter from geese can be a nuisance along the shoreline and a source of excessive nutrients entering a pond. Electric fences, decoys and bangers are among several ways to deter geese. Always research state regulations regarding nuisance goose control before taking action. Great blue herons, green herons, kingfishers and cormorants are predatory birds that occasionally visit pond habitats. Predatory birds are high on the food web, consuming mostly fish and amphibians. These birds can serve as hosts to parasites that also can infect fish, but for the most part, birds do not cause long-term issues in ponds.

MAMMALS

Although mammals are often overlooked when it comes to pond ecosystems, many mammals occasionally visit ponds and a few are reliant on pond habitats. Wildlife such as raccoons, white-tailed deer, opossums, and coyotes visit ponds to feed and drink. Common muskrats also frequently use ponds, and are the mammal species that will most likely cause issues to pond owners. Muskrats will burrow into dams, which may cause them to fail. Constructing dams with gentle slopes can limit the attractiveness of the dammed area to muskrats. Other habitat modifications, like removing aquatic vegetation, can help deter muskrats, but some issues may require trapping and removal. In cases where muskrats are a nuisance, contact a wildlife biologist or nuisance control operator for direction.

Muskrats are common mammals found in and around ponds. Muskrat burrowing can cause pond dams to leak.

Photo courtesy of Su Snyder.

Interactions Between Living Organisms

Living organisms interact with each other in many different ways. These interactions have an impact on the abundance of each species and the overall health of a pond. The most important interactions in ponds are predation and competition.

PREDATION

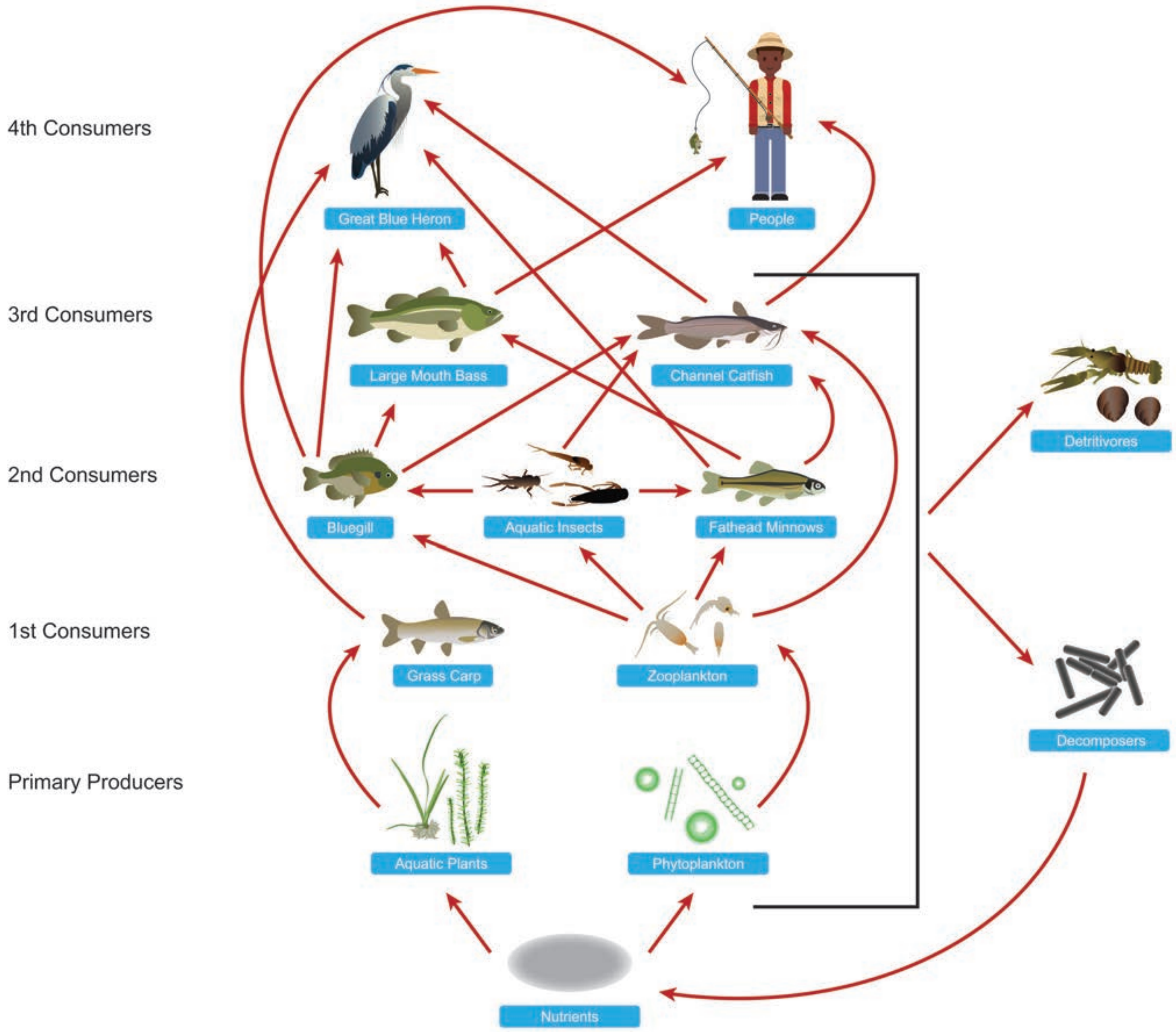
Predation is one of the key processes that drives the abundance of fish communities in ponds. The abundance of predators depends on the amount of prey available, and the abundance of prey is determined by the number of predators in a pond. Some organisms may eat many different prey species, while others specialize on certain food types and sizes. One of the best ways to illustrate predation in an ecosystem is through a food web. A food web shows how organisms are related to each other, which organisms eat which prey, and how energy flows through the ecosystem. As seen in the food web below, energy flow can also skip trophic levels depending on the organisms. For example, great blue herons may consume fathead minnows, as well as largemouth bass.

Predation not only sustains predators, but also has positive benefits to prey populations. For example, an appropriate density of largemouth bass predation keeps the bluegill population low enough that they maintain excellent condition and growth rates. However, in many cases bluegill become so numerous that they run out of food and their growth is stunted. In this situation, humans can influence the predator-prey relationship by stocking more bass or removing numerous stunted bluegill.

COMPETITION

Competition is an important process in ponds. Each organism in a pond is specifically suited for its role, and does its best to succeed. Since organisms sometimes use similar resources, there is competition for those resources. There are two types of competition in ponds, intraspecific competition and interspecific competition. Intraspecific competition is between animals and plants of the same species. An example of this is when different sizes of large-mouth bass compete for food or spawning locations. Similarly, plants of the same species will also compete for nutrients and sunlight. Interspecific competition is between animals and plants of different species. For example, bluegill and redear sunfish compete with each other to eat zooplankton and aquatic insects. Healthy competition often results in stronger individuals and a well-balanced pond ecosystem.

However, too much competition can result in unwanted consequences. For example, if there are too many bass in a pond, interspecific competition can cause fish growth to slow and bass populations to become stunted. Also, while bluegill and redear can coexist successfully in a pond, the



A pond food web showing nutrients and primary producers at the bottom and various levels of consumers. Arrows indicate plants and animals that are eaten by others. Detritivores like crayfish consume algae and dead animals, and are eaten by larger fish. Decomposing bacteria break down decaying plant and animals and recycle nutrients that can be used again by primary producers. Diagram by Jade Layman.

presence of other sunfish species such as green sunfish can cause high interspecific competition that impacts the growth of desirable species. Conducting regular fish assessments in a pond can help monitor healthy levels of competition and predation that promote strong fish communities. More information on fish management can be found in the Purdue Extension publication *FNR-598-W Managing Fish Populations in Indiana Ponds*.

A Note on Habitat

Habitat can be defined as the factors that an organism requires to survive and grow. Habitat can include non-living factors such as temperature and oxygen, as well as substrate and structure like sand, gravel and woody debris. Habitat also includes living factors that provide structure, such as aquatic vegetation and invertebrates like mussels. Habitat is essential to all life in ponds and many species, including fish, will not thrive without appropriate habitat. Aquatic vegetation is the most important type of habitat in ponds. It is usually quite abundant and provides important places for insects and fish to feed and hide. Other natural habitat, like woody debris and rocky structures, can also provide hiding places for invertebrates and fish, as well as areas for insects to burrow. Some fish also require specific habitat during certain parts of the year. For example, shallow (<4ft), relatively flat areas with gravelly substrate are needed for fish spawning habitat. Similarly, deep water (10+ ft) is important fish habitat in the winter to provide refuge from cold temperatures. Typically, a healthy pond will have a good variety and quantity of habitat for fish and other organisms.

Conclusion

Ponds are complex, ever-changing environments that consist of many living and non-living factors. A balance between nutrients, plant growth, fish populations, water chemistry, sedimentation and other factors must be maintained to maximize the health and utility of a pond. Land use practices, vegetation control and fish harvest all impact the ecosystems. While it takes some effort to manage a pond, it can be a rewarding experience that has positive benefits to both wildlife and humans.
For more information about pond and wildlife management, please visit the Purdue Extension website https://extension.purdue.edu/pondwildlife.

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Photo by Mitch Zischke

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