ILLINOIS ENVIROTHON
WILDLIFE MANUAL 2017

ILLINOIS
ENVIROTHON

The Illinois Envirothon Modules assist students and teachers in preparing for the Illinois Envirothon program.
Every year, more than 500,000 students, teachers and families across North America take part in the unique learning experience of Envirothon. The program engages high-school students in learning more about four main areas of the environment—soils, aquatics, wildlife and forests. Students learn in the classroom and through interactive workshops aimed at strengthening scientific knowledge of our natural ecosystems and helping develop foundational skills needed to pursue studies and careers in the environmental sciences.

The program supports students in developing:

- A scientific understanding of natural ecosystems (soils, wildlife, forests, aquatics).
- Each year, a fifth subject area is chosen that is timely and relevant.
- Practical experience in resource management practices and technologies.
- The ability to apply scientific knowledge and creativity in developing innovative and sustainable solutions to major environmental challenges.
- Stronger communication, collaboration and problem solving skills.

North American Envirothon (NAE), a program of the National Conservation Foundation, partners with 56 provinces and states that coordinate events in which students receive training in essential resource management technologies and practices such as invasive species monitoring, habitat restoration, water and soil analysis, and forest management. Students are then tested on their ability to apply these practices.

This study guide has been prepared in partnership with Forests Ontario and the Natural Environment Technician and Fish and Wildlife Conservation Technician Programs at Sault College, Sault Ste Marie, ON.

Special thank you goes to the authors of the guide, Sault College students Miranda Aelick, Erin Budgell, Corey Burt, Laura Dougherty, Ashley Odorizzi, Justin Pittman, and Meaghan Sutherland and Sault College Instructor Cynthia Marcinkowski.

Illinois Envirothon reviewed material and reconfigured for Illinois purpose.
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Updated: December 2016

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Learning Objectives

Overall Objectives

Students must be able to:

A. Understand and use identification tools to identify common Illinois mammal, bird, fish and amphibian and reptiles species
B. Understand and describe the characteristics and processes of wildlife ecology, including habitat and community dynamics
C. Understand and describe the impact of humans and human development on wildlife and wildlife ecology, and vice versa
D. Understand and describe practices involved in the conservation and management of wildlife and wildlife resources

Specific Objectives

Students must be able to:

A. Understand and use identification tools to identify common Illinois mammal, bird, fish, amphibian and reptile species

1. Understand and use a field guide, dichotomous key, or index to identify a variety of wildlife, including, but not limited to: insects and larvae (aquatic and terrestrial), reptiles, mammals (terrestrial and aquatic; large and small), birds, amphibians, and fish
2. Identify the presence of wildlife based on a variety of indicators, including, but not limited to: scat, eggs, tracks, patterns on trees, sounds and calls, pest evidence, feathers, and nests

B. Understand and describe the characteristics and processes of wildlife ecology, including habitat and community dynamics

1. Identify specific biotic and abiotic habitat components for common Illinois wildlife species
2. Identify the requirements for survival for common Illinois wildlife species
3. Know and explain why a certain species' habitat requirements might change and describe the changes
4. Understand and describe the concept of carrying capacity with reference to a variety of common Illinois wildlife species
5. Understand and describe succession in terrestrial (bare ground) and aquatic (pond) environments
6. Define predator, prey, herbivore, carnivore and omnivore, and explain how each of them interact with each other
7. Understand and explain how predator-prey relationships and carrying capacity are related and give examples
8. Compare and contrast the difference between adaptable (generalized) and non-adaptable (specialized) wildlife

C. ***Understand and describe the impact of humans and human development on wildlife and wildlife ecology, and vice versa***

1. Identify and explain reasons for wildlife habitat loss in Illinois
2. Explain how a change in weather/climate, topography or land use might modify the process of succession
3. Examine the factors (natural and external) that affect the survival and equilibrium of populations in an ecosystem
4. Understand and describe the effects that climate change has on wildlife ecology
5. Identify Illinois's rare, threatened and endangered wildlife species, as identified by United States Fish and Wildlife Service (USFWS), and explain how selected species were reduced to those levels
6. List examples of wildlife species that are non-native to Illinois
7. Identify and explain how non-native species arrived in Illinois
8. Describe how various non-native species have naturalized to Illinois and if and how they have been harmful

D. ***Understand and describe practices involved in the conservation and management of wildlife and wildlife resources***

1. Understand and describe how the impacts of climate change on wildlife populations are being mitigated
2. Describe how sustainable agriculture practices and techniques, such as windbreaks, filter strips and buffers, benefit wildlife.
3. Explain how Illinois' rare, threatened and endangered wildlife species, as identified by USFWS, are being managed to return populations to healthy levels
4. Recommend measures to remove/reduce impact of non-native species on Illinois Ecosystems
5. Interpret a variety of laws, agreements, treaties, etc. that govern Illinois' wildlife resources
6. Identify a variety of major stakeholders and agencies, including Federal, State and Municipal government bodies, that provide oversight of wildlife resources in Illinois

Application/Analysis

Students must be able to…

1. Identify wildlife species common to Illinois using a field guide, dichotomous key, or index
2. Classify wildlife as rare, threatened or endangered species based on USFWS status categories
3. Identify wildlife signs and describe their significance
4. Identify animals as predator, prey, herbivore, carnivore and omnivore
5. Identify explain food chains and food webs

Evaluation/Synthesis

Students must be able to…

1. Evaluate and assess a site as suitable habitat for common Illinois wildlife species
2. Describe and evaluate factors contributing to environmental resistance and the carrying capacity of ecosystems
3. Investigate sites for evidence of common Illinois wildlife species
4. Analyze how the change in one species' population can affect the entire ecosystem's food web

1.1 Identification Tools

The following tools are recommended resources that can help you better prepare for the Envirothon program.

Envirothon Guides

A copy of the Illinois Envirothon Mammal and Bird Identification Guide can be found below:

- Mammal Identification Guide
- Illinois Bird Identification Guide

Identification Apps and Websites

Audubon Guides
https://audubonguides.com/field-guides/mobile-apps.html

- Insects and Spiders
- Birds
- Mushrooms
- Wildflowers
- Butterflies
- Mammals
- Trees
- Fish

Nature Tracking – iTrack Wildlife
http://www.naturetracking.com/itrack-wildlife/

Illinois Raptor Bird Guide
http://www.illinoisraptorcenter.org/birdguide.html

Alpha list of Bird Calls
http://naturebits.org/alphabetic.php

2.0 Wildlife Ecology

2.1 Introduction

Wildlife are the animals that live wild in a country. Animals include amphibians, reptiles, fish, mammals, birds, and invertebrates. Invertebrates are generally not included as wildlife, with the exception of crustaceans that are used by humans for food or bait. Only animals native to the country are usually considered wildlife and **domesticated** animals that have become **wild**, or feral, are usually not included.

The term wildlife is arbitrary depending upon who is using it. Today most government wildlife management agencies in U.S. have an interest in reptiles, amphibians and small animals that are not used by humans nor are seen as pests, as well as being interested in traditional game species. In the past, wildlife management agencies were only concerned with **game** and **vermin**. However, game and vermin species are still the major focus of wildlife management agencies. Partially this is a result of the history of interest and greater quantities of research into these species. Since we know much more about these animals, it is much easier to make management decisions regarding them. Non-government agencies that are interested in the conservation of wildlife may use a very broad definition of wildlife, focus specifically on the non-game species or take a non-utilitarian stance on game species. As our societies have begun to express the wider interest utilitarian and non-utilitarian values of animals, the term wildlife has become more inclusive.

Regardless of your definition of wildlife, all living organisms have needs for the continual survival of their species. These needs are grouped together and called **habitat**, which includes food, water, shelter and space. Animals are **adapted** to their environment and therefore may have specific habitat requirements that may be different or overlap with others. Animals with overlapping requirements can sometimes find themselves in **competition** for limited resources. The **carrying**

capacity of the habitat as well as predator and disease influence the population of wildlife. Populations normally fluctuate and some **populations** follow cyclical patterns of high population followed by decreases to a low population at which time the populations start to grow again until they hit a high number and start to decrease again. A constant population size is not in a natural equilibrium.

The term "habitat" describes the environmental conditions where wildlife species live. Food, water, cover, and space all contribute to the basic habitat needs for all organisms. These factors are responsible for determining species numbers and distribution and, when in short supply, can be the limiting factor (Environment Canada, 2013).

- **Food** – a requirement to meet an animal's energy demands: growth, reproduction, predatory avoidance, surviving long winters and migrations. Certain species are more specific to what food item they invest time into locating and consuming (i.e. specialist vs. generalist).
- **Cover** – shelter is required to either protect the animal from the elements, avoid predation, or raise young. Dense vegetation is the most common, but downed woody debris, cavities, pits, mounds, and rock piles can also serve similar purposes.
- **Water** – an essential requirement for all living organisms. Certain species obtain water from their diet/food and some are required to ingest it directly. Like humans, without water many species are unable to survive as it forms the basis of their biological functions.
- **Space** – animals need space to survive. Overcrowding increases competition for food, cover, and water but can also lead to the rapid spread of disease or parasites. For example, whitetail deer (*Odocoileus virginianus*) require a mix of open and forest cover to protect their fawns and bald eagles (*Haliaeetus leucocephalus*) require large trees in proximity to shorelines to raise their young. All species are, to a certain extent, territorial to ensure proper spacing and prevent overcrowding.
- **Abiotic –** non-living chemical and physical parts of the environment that affect living organisms and the functioning of ecosystems
- **Biotic** – the living things that shape an ecosystem

2.1.1 Wetland Habitat

Wetlands are important habitats for many terrestrial and aquatic organisms. In Illinois, approximately 42 percent of all the native plant species are wetland species (Illinois Department of Natural Resources 1994). There are also are a number of plant species usually associated with upland areas that can survive in wetlands. The US Fish and Wildlife Service has identified a total of 6,728 species of plants that occur in wetlands throughout the United

States (Reed 1988). Because wetlands are highly productive and support a diversity of plant life, they are an important source of food and habitat for wildlife. This productivity helps support commercial and recreational fish and waterfowl harvests throughout the Illinois and the rest of the world (Illinois Department of Natural Resources 1997).

There are several species of animals dependent upon wetlands for their day to day survival. Most people readily identify some of these animals, such as frogs and ducks, as wetland species. There are, however, many other species of wildlife usually associated with upland or deep water areas that depend on or use wetlands for feeding, spawning, and/or resting grounds at some point in their life cycles. Most people do not readily identify these various species of shiners, sunfish, bats, and terns with wetlands. They also do not realize many well-known species, such as bald eagles and bobcats, are also commonly found in and around wetlands.

Photo by: Illinois Natural History Survey, Forbes Biological Station staff

In rivers, streams, and most lakes the constant flow of water washes away many of these nutrients. But in marshes, and other wetlands, nutrients tend to remain and accumulate. In northern regions, where water levels are relatively stable, nutrients often become trapped in the bottom sediments; but in southern regions they are released each year during spring flooding. This is one of the reasons why wetlands in southern regions are so productive and why they attract so many forms of wildlife. Wetlands also provide necessary and valuable services to humans.

2.1.2 Forest Habitat

An ecosystem's ability to support wildlife depends on the amount of forest cover, size of individual forest patches, forest type, and linkages to other patches in a landscape. Mammals and forest interior birds require extensive forests. More is known about the habitat requirements and distribution of forest birds than any other group of wildlife, and for this reason they are most often used as an indicator of the quality of the forest.

Wood Thrush on nest, Source: All About Birds website

2.1.3 Riparian Habitat

Riparian areas are the zones along water bodies that serve as interfaces between terrestrial and aquatic ecosystems. Riparian ecosystems generally compose a minor proportion of the landscape. Typically, however, they are more structurally diverse and more productive in plant and animal biomass than adjacent upland areas. Riparian areas supply food, cover, and water for a large diversity of animals, and serve as migration routes and connectors between habitats for a variety of wildlife (Manci 1989).

Aerial photograph of an environmental corridor. (Reprinted from Conservation Corridor Planning at the Landscape Level Handbook, USDA NRCS.)

Riparian areas are important in mitigating or controlling nonpoint source pollution. Riparian vegetation can be effective in removing excess nutrients and sediment from surface runoff and shallow ground water and in shading streams to optimize light and temperature conditions for aquatic plants and animals. Riparian vegetation, especially trees, is also effective in stabilizing streambanks and slowing flood flows, resulting in reduced downstream flood peaks.

Riparian areas are often important for their recreation and scenic values, such as hunting, fishing, boating, swimming, hiking, camping, picnicking and bird watching. However, because riparian areas often are relatively small areas and occur in conjunction with watercourses, they are vulnerable to severe alteration.

Riparian ecosystems throughout the United States have been heavily impacted by human activities, such as highway, bridge, and pipeline construction; water development; channel modifications for flood control; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; logging; and mining. Offsite disturbances in the watershed that change watershed hydrology can also have adverse effects on the composition and productivity of riparian plants and corresponding animal associations (Manci 1989).

2.2 Food Chains & Species Interactions

Within an ecosystem there are **food chains** and **food webs**. Both of these systems organize organisms based on a trophic level system (Figure 3). The basis of a food chain is a primary producer which is an organism that produces organic compounds from inorganic compounds. Plants undergoing photosynthesis by utilizing carbon dioxide and energy from the sun to produce oxygen and complex sugars are a good example of this. **Primary consumers**, also known as **herbivores**, are organisms which feed solely on these primary producers. An excellent example of an herbivore is the white-tailed deer (*Odocoileus virginianus*). Moving up the food-chain we have our secondary and tertiary consumers. Some of these consumers are **carnivores**, organisms which feed solely on other animals (e.g. wolves). Some carnivores are **predators**, as they hunt other animals as **prey**, while other carnivores are **scavengers**, feeding on the carcasses of dead animals. Lastly, **omnivores** are animals which feed on both plant and animal matter, for example, black bears (*Ursus americanus*) (Schraer & Stoltze, 1993). Omnivores can be secondary or tertiary consumers.

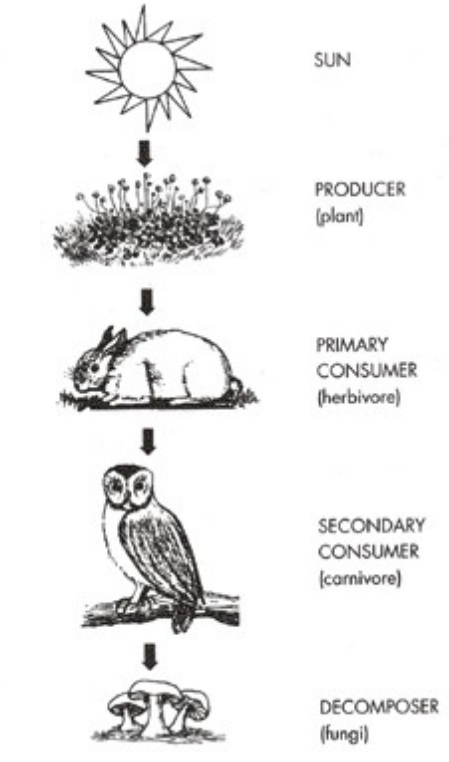


Figure 3. Simple Food Chain (Study Everywhere, 2015)

The soil food web (Figure 4) is the community of organisms living all or part of their lives in the soil. A food web diagram shows a series of conversions (represented by arrows) of energy and nutrients as one organism eats another.

All food webs are fueled by the primary producers: the plants, lichens, moss, photosynthetic bacteria, and algae that use the sun's energy to fix carbon dioxide from the atmosphere. Most other soil organisms get energy and carbon by consuming the organic compounds found in plants, other organisms, and waste by-products.

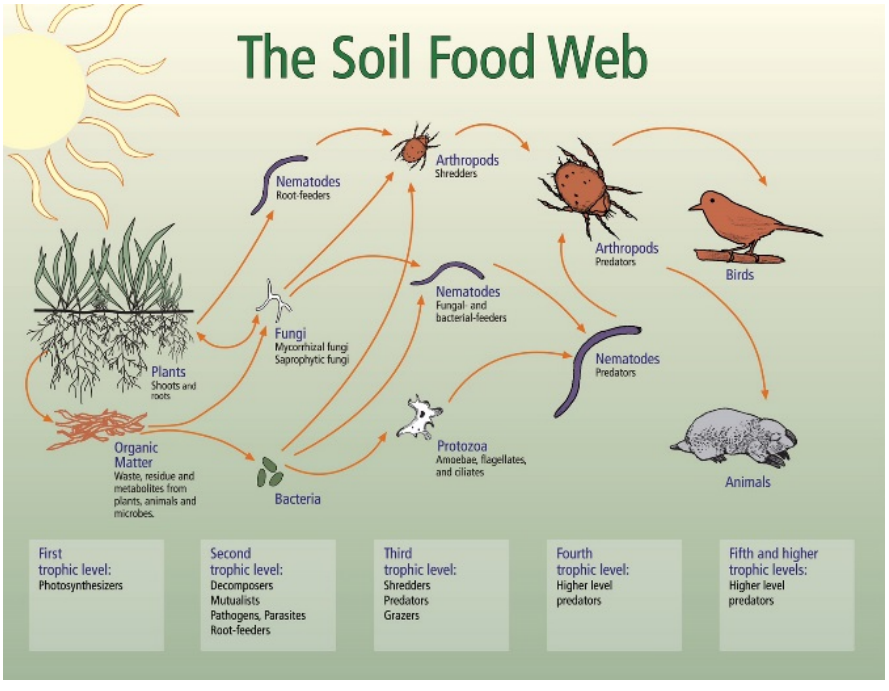


Figure 4. NRCS Soil Biology Primer

As organisms decompose complex materials, or consume other organisms, nutrients are converted from one form to another, and are made available to plants and to other soil organisms. All plants - grass, trees, shrubs, agricultural crops - depend on the food web for their nutrition.

2.2.1 Species Interactions

Symbiosis is the close and long-term interaction between two different biological species. Mutualism, parasitism and commensalism are different examples of symbiotic relationships.

Mutualism is the way two organisms of different species exist in a relationship in which each individual benefits from the activity of the other. These species work together which each benefiting from the overall relationship. A great example of a mutualistic relationship is the bee and flower. Bees fly from flower to flower gathering the nectar which they make into food. During this process they also pick up pollen from one flower and transfer it to the next one, helping to pollinate the plant.

Parasitism is a non-mutual relationship where one organisms gains while the other suffers. The parasite (gain) attacks the host (sufferer), and may cause sickness but unlikely death. One such example is the deer tick, which feeds on deer blood and may cause sickness to the deer.

Commensalism is where one species benefits while the other is neither helped nor harmed. The benefits for the one organism can be food, shelter, transportation or seed dispersal. One example would be beavers making dams to create a new water body that fish, waterfowl and many other animals can use for food, water, shelter and raise their next generations.

2.3 What Makes Habitat Suitable?

Scientists have been studying particular species for many years to understand their habitat requirements and how to manage them. *Habitat Suitability Index Models (HSI)* provide habitat information for evaluating impacts on fish and wildlife habitat resulting from water or land use changes. These models are used to serve as a basis for improved decision-making and increased understanding of habitat relationships because they specify hypotheses of habitat relationships that can be tested and improved (Source: USGS National Wetlands Research Center, n.d.).

2.4 Carrying Capacity

Carrying capacity is the maximum quantity of a species an area will support without deteriorating (Merriam- Webster, 2015). As mentioned previously, populations which become too large typically decline drastically or "crash" when their habitat is no longer able to support them. Fortunately, predator-prey relationships often regulate population numbers to decrease the chances of exceeding the carrying capacity. Similarly, the predator population is also kept in check by the size of the prey population and fluctuates accordingly. It is evident that predator-prey relationships are essential in regulating populations and therefore preventing the carrying capacity from being exceeded (Source: McGraw-Hill Companies, n.d.).

Illinois is home to some 58 mammal species, 383 different resident and migrant birds, 104 types of reptiles and amphibians, 174 species of fish, and some 27,000 types of insects, mussels, and other invertebrates. There are more than 2500 species of plants and more than 1,000 species of fungi and algae, and hundreds of lichens and mosses. (Sources: Illinois Environmental Council, Illinois Department of Natural Resources, and the Illinois Ornithological Society)

Case Study – Raccoons and Songbirds in Illinois

Biodiversity is crucial to maintain healthy, resilient ecosystems. A variety of stable wildlife populations is a common indicator of ecosystem health and is important for all species in a food web.

Case Study Paper (See Illinois Envirothon Wildlife Manual Toolbox):
Nest Predation and Population Declines in Illinois Songbirds: a Case for Mesopredator Effects
Researcher: Kenneth A. Schmidt

This case study illustrates the potential impacts on songbirds when the top predator is removed or declines in numbers allowing for the potential increase in mesopredator numbers. A mesopredator is defined as a medium-sized predator which often increases in abundance when larger predators are eliminated. When wolves were present in Illinois, they were considered a top predator, and coyotes were a mesopredator and were prey of wolves. However, with the expatriation of wolves from Illinois, coyotes are now a top predator throughout Illinois.
In regions of Illinois where coyote populations have been severely reduced by means such as hunting, disease, or malnutrition, other mesopredators such as raccoons, skunks, foxes, and opossums can increase in numbers. As these mesopredator numbers increase, there is an increased pressure on prey species that these mesopredators can more easily access that the primary predator may have passed up as prey, or had indirectly helped the prey numbers by keeping the mesopredators in check. This, in turn, can have a detrimental effect on the prey species that the mesopredators prey on, such as songbirds.

As seen in this case study many factors – including, but not limited to genetics, food sources, disease, and the presence of other wildlife species, such as predators – are highly influential in population dynamics in a habitat. One species can have a tremendous impact on another which reiterates the importance and value of increased biodiversity (McGraw-Hill Companies, n.d.).

2.5 Indicator Species

An **indicator species** is an organism whose presence, absence and/or abundance reflect specific environmental conditions. Indicator species can show a change in a specific ecosystem through biological conditions. By studying indicator species you can assess the health of an ecosystem (Jaffe et. al., 2012).

Examples of indicator species include:

- **Insects:** Honeybees and butterflies are pollinators that indicate and strongly influence the health of plant populations. They are highly sensitivity to a plethora of factors, including temperature and weather, parasites, and air, water and soil quality. All of these factors can help assess the overall health of an ecosystem (Libal and Media, 2015).
- **Frogs**: Their shell-less eggs, absorbent skin, moisture dependence, predatory feeding, and their amphibious life cycles make them vulnerable to changes on land and in water. They are often used to monitor and track changes in water quality, and overall environmental health (Libal & Media, 2015).
- **Lichens:** They are indicator species for air quality due to different types of lichens being susceptible to different pollutants. Certain compounds can affect certain species differently when in an ecosystem. Some compounds can cause a certain species population to grow at exponential rates whereas that same compound could cause other species to die (Libal & Media, 2015).

2.6 Seasons and Wildlife

The change in seasons has a huge impact on behaviors of wildlife. From migration to hibernation, animals have to adapt to changes in the ecosystem in order to survive.

2.6.1 Migration

Migration is the seasonal movement of animals from one area to another area. Migration may be a means of avoiding harsh environmental conditions, to find food, or to travel to breeding grounds (Parry, 2010). Many animals throughout North America and the world practice migration, from large mammals to small insects. The act of migration may be carried out by flight, through water or on land.

Bird Migration

Over 1000 bird species in the US are considered to be 'migratory' (US FWS, 2010). Nearly all of these birds migrate north to the US to breed and raise their offspring, and migrate south to favorable environmental conditions, food and habitat for the winter months. Some birds have relatively short flights, migrating across North American borders into the southern United States and Mexico for winter, while others travel much farther such as the arctic tern, whose journey spans nearly from pole to pole (The Arctic Tern Migration Project, n.d.).

Examples of Illinois migratory birds

- Sandhill Crane (*Grus canadensis*)
- American Golden Plover (*Pluvialis dominica*)
- American White Pelican (*Pelecanus erythrorhynchos*)
- Canvasback Duck (*Aythya valisineria*)
- Ruby-throated Hummingbird (*Archilochus colubris*)
- Turkey Vulture (*Cathartes aura*)

American Golden Plover

During late April, nearly all of the American golden-plovers on the planet congregate in Illinois' open fields. There are only about 150,000 of these rare birds on Earth today due to market hunting in the 19th and early 20th centuries. Each spring, they migrate from South America up through North America to their summer breeding grounds in the Arctic. Along the way, they stop in Illinois to feed in fields and prairies, such as the Conservancy's Kankakee Sands. In fact, the American golden-plover makes one of the longest migratory journeys of any shorebird. (Top Five Must-See Migrations in Illinois, The Nature Conservancy)

Figure 5. American Golden Plover (*Pluvialis dominica*) (Audubon Guide to North American Birds)

2.6.2 Mammal Migration

Birds are not the only wildlife that migrate, some mammals migrate as well. These include marine mammals such as seals and whales, flying mammals such as bats, and terrestrial mammals such as caribou and polar bears. Bat species in Illinois are triggered into a migration caused by cool temperatures in the fall, forcing them to travel to either caves, or warm tree cavities much farther south in order to hibernate for the winter months (Hinterland, 2005).

Bats are the only mammals that actually migrate in Illinois, and only two species of the 12 species found in Illinois do an annual migration- the Evening Bat (Nycticeius humeralis) and the Hoary Bat (Lasiurus cinereus).

Figure 6. Evening Bat (*Nycticeius humeralis*) (Heather Kaarakka/Wisconsin Department of Natural Resources

Evening bats roost in buildings (in attics or walls) and trees (under loose bark or in cavities). Maternity colonies in buildings can include hundreds of females, which typically give birth to two young in June. Evening bats are early evening fliers, and eat beetles, flies, leafhoppers, and moths. Evenings bats are a rare bat in Illinois, and may migrate long distances to warmer regions in the autumn. (Source: Joyce E. Hoffman, Illinois Natural History Survey)

2.6.3 Invertebrate Migration

Many different species of insects including beetles, dragonflies, butterflies and moths migrate. Most invertebrate species found in Illinois have developed strategies to withstand the cold such as entering into dormant states, using a type of 'antifreeze' or simply having adults die off leaving larval stages of the invertebrate to lie dormant and overwinter (McDonough, 2011). For some species, however, avoiding the winter entirely has been the strategy to survive the cold, harsh winters Illinois provides. These invertebrates often travel by flight from Illinois to the southern states of the U.S., however some make a much further journey, such as the monarch butterfly travelling into Mexico (The Nature Conservancy, 2015b).

Examples of Illinois Migratory Invertebrates:

- Monarch Butterfly (*Danaus plexippus*)
- Green Darner (*Anax junius*)
- Giant Swallowtail Butterfly (*Papilio cresphontes*)
- Black Saddlebag (*Tramea lacerata*)

Monarch Butterflies

One of the most well-known species of migratory insects is the monarch butterfly (*Danaus plexippus*) (Figure 7). Though there are different populations, eastern populations of monarch butterflies migrate annually from their winter home in Mexico to the United States and Canada once the weather begins to change. Female monarchs lay their eggs in their northern residence between March and April, giving life to the first new generation of monarchs (The Nature Conservancy, 2015b). However, only monarchs that are born late in the summer have a prolonged life span and make the 2796 miles journey to Mexico in autumn (WWF, n.d.). Western populations behave in a similar manner; however they migrate west of the Rocky Mountains and overwinter in California (WWF, n.d.).

Figure 7. Monarch Butterflies - *Danaus plexippus* (Smith, 2015)

2.7 North American Flyways

No two bird species travel the exact same migration route or distance and many migration routes have varying levels of complexity. Despite these differences, bird migrations all tend to follow general land masses such as coast lines, mountain ranges, and large river systems. These North and South migration routes have been given the name 'flyways' and have been divided into four distinct routes based on geographic structure (e.g. mountain ranges or water sheds), habitat requirements (e.g. tall grass prairie, wetlands), and/or food requirements (Figure 8).

Pacific Flyway

The Pacific Flyway stretches from the Arctic Archipelago, through Alaska, British Columbia, the Yukon, and throughout the western states of the U.S. (with some species travelling to Mexico and beyond) (Ducks Unlimited, n.d.). This flyway covers diverse terrain from the arctic tundra, through the Rocky Mountains, as well as desert regions further south. Species like the varied thrush (*Ixoreus naevius*), snowy plover (*Charadrius nivosus*) and least tern (*Sternula antillarum*) migrate along this flyway (Audubon, 2015).

Figure 8. North American Flyways (Ducks Unlimited, n.d.)

Central Flyway

The Central Flyway covers many arctic islands south to Central and South America, travelling through the Prairie Provinces in Canada, as well as the mid-western Great Plains states. Many grassland species such as the lesser prairie-chicken (Tympanuchus pallidicinctus) and whooping crane (*Grus americana*) migrate along this flyway (Audubon, 2015). Modern agriculture has resulted in the disappearance of many grasslands, which is threatening the existence of these migrating birds found along this flyway (Audubon, 2015).

Mississippi Flyway

The Mississippi Flyway is quite geographically flat, with no significant ridges, mountains or hills large enough to interfere with bird migration (The Nutty Birdwatcher, 2001). The flyway encompasses Illinois, Saskatchewan, Manitoba, and the central-eastern states (Ducks Unlimited, n.d.). This flyway also encompasses the Great Lakes as well as the large Mississippi river system and the Gulf Coast. Nearly half of North America's bird species spend at least some time on the Mississippi flyway (Audubon, 2015). Species such as the mottled duck (*Anas fulvigula*), little blue heron (*Egretta caerulea*), and brown pelican (*Pelecanus occidentalis*) use this flyway during migration (Audubon, 2015).

Atlantic Flyway

The Atlantic Flyway encompasses Newfoundland, Labrador, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and some of the eastern US. This flyway is used by small land birds such as wood thrushes (*Hylocichla mustelina)*, prothonatary warblers (*Protonotaria citrea*), and American woodcocks (*Scolopax minor*), as well as sea and shore birds such as the Arctic tern and the piping plover (*Charadrius melodus*) (Audubon, 2015). This flyway is the most densely populated by humans, and therefore most susceptible to human interference (Ducks Unlimited, n.d.).

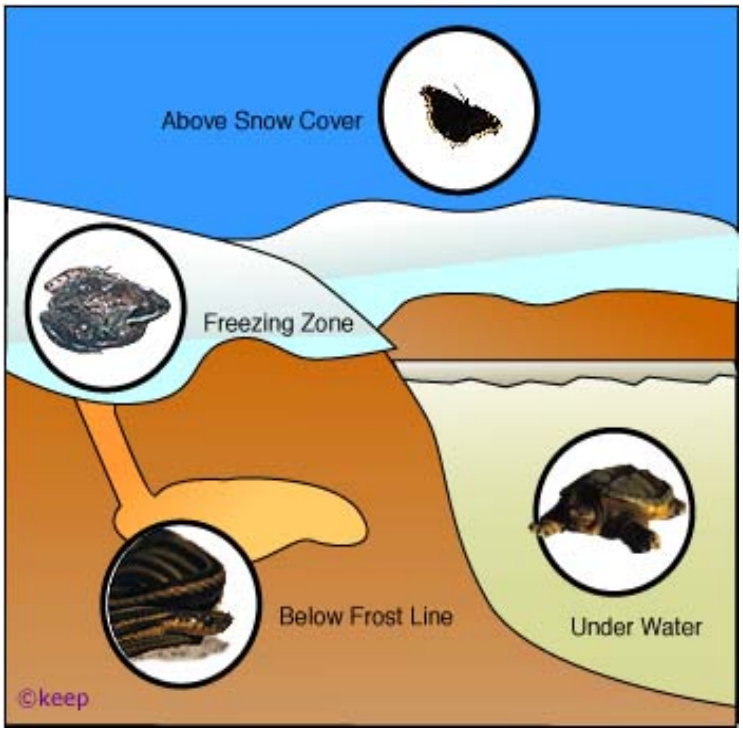
Geese in formation in December, DeWitt County, IL, E. Burns

2.8 Hibernation

Hibernation is a response to colder temperatures, in which an animal finds or makes a living space that protects it from winter weather and predators, and so that the animal can slow its metabolism using only its stored energy sources to survive the winter (Scientific American, 1997). Animals hibernate in a living space called a **hibernacula**.

Animals that hibernate in Illinois:

- Amphibians
  - Frogs – hibernate within mud, under leaf litter, or in cracks and crevices of logs or rocks and emerge in spring
- Reptiles
  - Turtles – hibernate underwater in ponds, rivers, wetlands and other freshwater sources and emerge in spring
- Mammals
  - Meadow Jumping Mouse- hibernates in 20 inch deep small earthen chambers plugged with earth and curled up in a nest of dry plant fibers. Many do not survive hibernation because of insufficient fat reserves.
  - Little Brown Bat – hibernates and over winter in caves or abandoned mines that are above freezing



Surviving Winter with different strategies:

Mourning Cloak *(Nymphalis antiopa) Winters as an adult in cracks in tree bark or under roof shingles.*

Wood Frog *(Rana sylvatica) Can freeze beneath forest litter.*

Garter Snakes *spend winter below the frost line in holes or rock caves.*

Snapping Turtle *(Chelydra serpentina) Can breathe underwater during winter!*

(Source: Nature North website)

3.0 Humans and Wildlife

3.4 Global Change

Five main changes are expected to occur across the globe that will have impacts on the diversity of species found within Illinois. These changes and impacts are outlined in Table 1. Global change will not only have local impacts on biodiversity, but will impact the levels of biodiversity worldwide leading to a massive decline in the number of plant and wildlife species.

Table 1. Impacts of Global Change on Biodiversity (Sage 2008)

Expected Changes	Impacts of Changes
1. Atmospheric Carbon Dioxide Enrichment	• increased photosynthesis
	• faster plant growth
	• reduced transpiration
	• increased occurrence and intensity of
	• change in competitive patterns
	• altered quality of forage
	• ocean acidification and calcification
2. Climate Change -warming of 1.5-2 degrees F in Illinois in the long-term	• drier soils
	• warmer winters
	• disruptions in natural cycles
	• increased frequency of storms
	• altered photosynthesis
3. Land Use Change	• increased agricultural production
	• reduced diversity of crops
	• increased occurrence and intensity of
4. Terrestrial Eutrophication -increase in the amount of terrestrial nitrogen through use of fertilizers	• increased growth of weeds
	• reduced biodiversity due to the lack of ability to compete with weeds
5. Invaders	• infected and consume natives
	• altered hydrology of an area
	• altered soil properties
	• altered regional climate
	• loss of species
	• altered disturbance regimes
	• out-compete native species

The above impacts of global change can ultimately have devastating impacts on local **biodiversity**. Reduced resiliency of an area can result in increased **vulnerability**. With fewer species contributing to the overall functioning of an ecosystem there is a reduced ability to respond to large disturbances.

3.2 Threats to Wildlife

The threats facing Illinois's plant and animal species are constantly increasing. There are five main threats that are impacting all species across Illinois: habitat loss, pollutants, invasive species, unsustainable use, and climate change.

3.2.1 Habitat loss

Habitat loss and degradation are perhaps the most important pressures facing wildlife today. Certain types of habitat are disappearing at a tremendous rate in almost all parts of Illinois. Wetlands are being filled in, forests are being fragmented and clear cut of forested areas and grasslands have been plowed under. Unfortunately, these mechanical means aren't the only harm humans are causing.

One of the greatest contributors to habitat loss is **population expansion,** or urbanization. Urbanization has converted many species' habitats into neighborhoods, industrial plants, airports, and shopping malls (Champagne, 2005). Although urbanization has destroyed many species' habitats, it has not removed species altogether. Many species, such as coyotes and raccoons, have adapted to these human interferences, which unfortunately, has resulted in more negative human-wildlife interactions.

3.2.2 Pollutants

There are few places left on the planet where there is an absence of human impact. In addition to the effects that urbanization has on wildlife habitat loss, the by-products of our daily lives (sewage, exhaust, trash, agricultural and lawn chemicals, industrial emissions and more) make their way into the natural environment through the air and water (NWF, 2015). As pollutants enter these systems, they make their way through the ecosystem and into wildlife species living in that area.

Illinois residents have depended on and continue to depend to a great extent on chemical products as part of their modern lifestyle. These products may be used in industry, around the house, and/or in agriculture both historically and currently (e.g. PCBs, DDTs, dioxins, fertilizers, and pesticides). Unfortunately, these some of these products in the past posed, and in some cases continue to pose, a serious risk to the health of wildlife species directly and indirectly (Champagne, 2005).

Some of the banned pollutants that have affected aquatic and terrestrial wildlife are:

- Mercury
- Polychlorinated biphenyls (PCBs)
- Dioxins
- Mirex/photomirex
- DDT – pesticides
- Toxaphene

The issue with some pollutants and their metabolites entering the water systems is that they are hydrophobic (water-hating) and lipophilic (fat-loving), meaning they are not easily diluted with water and they like to attach to the fatty tissue of organisms.

These characteristics lead to bioaccumulation. **Bioaccumulation** (Figure 6) is the build-up of persistent contaminants in an organism from poisons in water, sediment and/or food sources. Bioaccumulation occurs within an organism, where a concentration of a substance builds up in the tissues and is absorbed faster than it is metabolized or removed.

Biomagnification refers to an increase in the concentration of a substance as it moves up the food chain. This often occurs because the pollutant is persistent, meaning that it cannot be, or is *very* slowly, broken down by natural processes. These persistent pollutants are transferred up the food chain faster than they are broken down or excreted (Van Der Hoop, 2013). For example, a Polar Bear, as the top predator (tertiary consumer) in a food chain, will consume the greatest accumulated amount of chemical (see Figure 9).

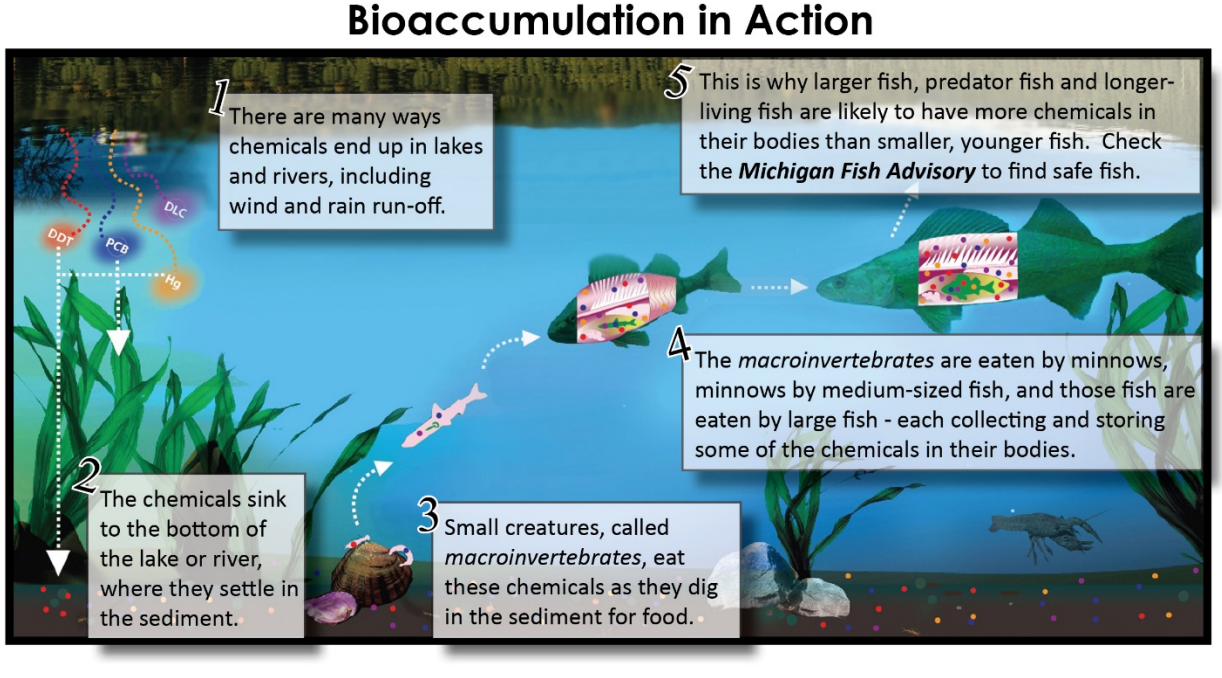


Figure 9. Bioaccumulation and Biomagnification (Michigan State Department of Health)

3.2.3 Invasive Species

Non-native species or "**alien** species" are species or subspecies which are introduced, often by human activity, to an environment which is outside of that species' natural past or present distribution. Non-native species can be non-invasive or **invasive**. Invasive non-native species refer to those that spread and cause damage to the introduced ecosystem and can also damage the economy and human health. Invasive species pose a huge threat to biodiversity by outcompeting native species and altering ecosystems (OFAH & OMNR, n.d.). Some examples of non-native invasive species are the Asian carp, European green crab, purple loosestrife, zebra mussel, sea lamprey, emerald ash borer, didymo, gypsy moth, Asian long-horned beetle, and round goby.

Invasive species are becoming more and more of an issue in Illinois. The spread of invasive species can have negative effects on the environment, the economy and society. These species often compete with native Illinois species over resources and habitat, resulting in a reduction of native flora and fauna. One example of such a species is the zebra mussel (Figure 10). This fresh water mussel as introduced into Illinois's lakes and has disrupted ecosystem composition and structure, clogged water intake pipes and effected public beaches.

Figure 10. Zebra Mussel (World Customes Organization, 2007)

Many non-native species such as the European starling have become very common (Figure 11). It was first introduced to North America in 1890 when 60 of them were released in Central Park in New York. While native to Europe and Asia they thrived in North America and spread across the continent. These aggressive birds compete with native species, claiming native birds' nesting sites and displacing the birds and their eggs. They also compete with native birds for food and are responsible for spreading disease, ticks, and mites which are detrimental to native bird populations. They're especially well adapted to urban areas and farmland, and have decimated crops (Royal BC Museum, 2011).

Figure 11. European Starling (Royal BC Museum, 2011)

3.2.4 Unsustainable Use

Unsustainable use is the harvest of individuals at a rate higher than can be sustained by the natural reproductive capacity of the species. Reduction in population levels due to harvesting can have dramatic impacts on the population, such as reduced genetic variability. Wildlife managers attempt to control harvesting rates by using permits and licenses for certain game species. (Refer to the Illinois Envirothon Wildlife Manual Toolbox – Illinois Hunting and Trapping Guide).

3.2.5 Climate Change

Current concerns regarding climate change and the impacts on the environment have focused a great deal on impacts on biodiversity. Increasing global temperatures will result in altered conditions and changing landscapes. These changes will result in changes in habitat for many plant and animal species. Climate change is expected to impact biodiversity in the following ways:

- insect and/or disease breakout patterns may change or become more severe (European Gypsy Moth spread);
- plant species will change their distribution, resulting in new types of forest (Kudzu spread northward in Illinois) ;
- animal species distributions will continue to change (movement north in Illinois of the Nine-Banded Armadillo) ; and,
- an increase in the frequency of extreme events may affect habitats (droughts and floods) .

Impacts of Climate Change on the Midwest

"The Midwest's agricultural lands, forests, Great Lakes, industrial activities, and cities are all vulnerable to climate variability and climate change. Climate change will tend to amplify existing risks climate poses to people, ecosystems, and infrastructure. Direct effects will include increased heat stress, flooding, drought, and late spring freezes. Climate change also alters pests and disease prevalence, competition from non-native or opportunistic native species, ecosystem disturbances, land-use change, landscape fragmentation, atmospheric and watershed pollutants, and economic shocks such as crop failures, reduced yields, or toxic blooms of algae due to extreme weather events. These added stresses, together with the direct effects of climate change, are projected to alter ecosystem and socioeconomic patterns and processes in ways that most people in the region would consider detrimental.

Most of the Midwest's population lives in urban environments. Climate change may intensify other stresses on urban dwellers and vegetation, including increased atmospheric pollution, heat island effects, a highly variable water cycle, and frequent exposure to new pests and diseases. Further, many of the cities have aging infrastructure and are particularly vulnerable to climate change related flooding and life-threatening heat waves. The increase in heavy downpours has contributed to the discharge of untreated sewage due to excess water in combined sewage-overflow systems in a number of cities in the Midwest."
(NCA Highlights, p.74)

3.3 Species at Risk

A species at risk is the classification of any wildlife species that is at-risk of extinction or extirpation (USFWS, 2005). In Illinois, the **Endangered Species Protection Board (ESPB)** is responsible for determining which species should be listed at-risk (IDNR). The Board may list, as endangered or threatened, species of animals or plants which have reproduced in or otherwise significantly use, as in migration or overwintering, the area which is now the State of Illinois, if there is scientific evidence that the species qualify as endangered or threatened as defined by the Act. Federally designated endangered and threatened species are automatically placed on the Illinois List. The first Illinois List was published in 1981. Since then, there have been six 5-year reviews and revisions of the entire List, as well as some administrative and editorial revisions, resulting in the current (2015) Illinois List of 480 endangered and threatened species. (Source: Illinois Department of Natural Resources ESPB)

The **United States Fish and Wildlife Service (USFWS)**

The U.S. Fish and Wildlife Service's mission is, working with others, to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. This is the only agency of the U.S. Government with that primary mission. The Service's origins date back to 1871, when Congress established the U.S. Fish Commission to study the decrease of the nation's food fishes and recommend ways to reverse the decline. The Service helps protect a healthy environment for people, fish and wildlife, and helps Americans conserve and enjoy the outdoors and our living treasures. The Service's major responsibilities are for migratory birds, endangered species, certain marine mammals, and freshwater and anadromous fish. (Source: USFWS)

A series of codes has been developed to identify the current status of each listed species in the USFWS endangered species database. See below for descriptions of some of the more commonly used codes.

E = endangered. A species "in danger of extinction throughout all or a significant portion of its range."

T = threatened. A species "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

C = candidate. A species under consideration for official listing for which there is sufficient information to support listing.

Emergency Endangered - A temporary (240 days) listing for emergency purposes when species is at significant, immediate risk.

Delisted - Species that has been removed from the list due to recovery, original data in error, or extinction.

Species of Concern (SC) - Species that have not been petitioned or been given E, T, or C status but have been identified as important to monitor.

Species at Risk in Illinois

CRITERIA FOR STATE LISTING 1) Species or subspecies designated as federally endangered or threatened , 2) Species proposed for Federal Endangered or Threatened status that occur in Illinois, 3) Species that formerly were widespread in Illinois but have been nearly extirpated from the State due to habitat destruction, collecting, or other pressures resulting from the development of Illinois, 4) Species that exhibit very restricted geographic ranges of which Illinois is a part, 5) Species that exhibit restricted habitats or low populations in Illinois, or 6) Species that are significant disjuncts in Illinois i.e., the Illinois population is far removed from the rest of the species' range.

- 19 endangered and 16 threatened fish species
- 3 endangered and 6 threatened amphibian species
- 10 endangered and 8 threatened reptile species
- 24 endangered and 7 threatened bird species
- 5 endangered and 4 threatened mammal species
- 44 endangered and 10 threatened invertebrate species
- 251 endangered and 73 threatened plant species

(IDNR Final Checklist, 2015) For an official and up to date lists of species at risk in Illinois refer to the Illinois Envirothon Wildlife Toolbox Resources.

3.3.1 Why are they at Risk?

The number of Illinois wild plant and animal species that are at-risk of disappearing is growing. Species face a number of ongoing threats that vary in complexity, although the destruction of their habitat and contamination of their environment through human involvement is most prevalent (Environment Canada, 2014). Other factors involved with the decline of species population include the spread of diseases, invasive species infringement on natural habitats, and overexploitation of exhausted species for food, clothing and trophies (Hogan, 2014).

The international trade of millions of plants and animals is estimated to be worth billions of dollars annually. This wildlife trade is diverse and is comprised of live plants and animals, along with a vast array of wildlife products derived from them. Some species have become heavily exploited. As a result, those species and their products gain higher trading values, which, combined with other factors (e.g. habitat loss), is enough to severely deplete at-risk populations, bringing these species close to extinction.

Questions for Discussion

1. Are there any species at risk in your area? What is the main reason for the decline of this species? How can your school try to help recovery efforts?
2. How have humans impacted local plant and wildlife populations in your region? List both the positive and negative impacts.
3. Can you think of any major or minor disturbances/natural disasters that have occurred in Illinois in your lifetime? What were its impacts on biodiversity in your area?

4.0 Conservation and Management

4.1 Managing Wildlife Populations

Techniques for managing wildlife populations varies by species, however, the reasons we manage remain the same. We manage and monitor wildlife to ensure there is adequate habitat and resources available to sustain them and to understand their life cycles.

4.1.1 Mammals

The Illinois Department of Natural Resources oversees a variety of monitoring programs, such as radio telemetry and furbearer management, to keep a close watch on populations of mammals and make changes where necessary to keep a population healthy. When monitoring wildlife populations biologists look at different factors like habitat loss, human intervention, or invasive species that may contribute to the loss or increase of the species populations.

Figure 19. Radiolocations of an alpha female coyote associated with the Poplar Creek Forest Preserve during 2000. More than 99 percent of the radio-locations are located within the forest preserve, and the animal (and pack) rarely left the park for three years. Source: Bulletin 929- Urban Coyote Ecology and Management project

Monitoring Raccoons in Illinois

All of the species that are hunted or trapped in Illinois are abundant. But how do biologists know this, and how do they use this information? Methods for monitoring wildlife populations are different for different species. A spring spotlight survey is the main tool used to track Illinois' raccoon population. Each spring, biologists and conservation police officers take to the road about an hour after dark. Driving slowly, they use 100,000-candlepower spotlights to identify and count wildlife along 25-mile routes. About half of the counties in Illinois are sampled during March and April.

This method does not provide a complete count of raccoons. It does provide an index estimate that can be used to track changes in the population over time. For example, the number of raccoons observed per mile in the early to mid-1990s was two to three times as high as the number observed when the survey started in 1981. This tells biologists that the raccoon population increased by a wide margin during the past two decades and that the largest changes occurred in 1990 (+38.6%) and 1991 (+24.4%). The same trend showed up in other methods used to track the raccoon population.

How do biologists use this information? Most types of wildlife are not hunted or trapped, and for these species, surveys and population estimates are used mostly as an early warning system signaling biologists of potential problems. For species that are hunted and trapped, the information guides decisions about harvest regulations. For instance, laws can be made stricter to reduce harvest levels if populations decline. If need be, hunting and trapping can be prohibited altogether.

Raccoons are a different story. Not only did populations increase in the 1900s, but they reached unhealthy levels. The signs were pretty convincing: Reports of die-offs caused by diseases. Problems with crop damage and raccoons moving into peoples' homes. Low survival of songbirds caused in part by raccoons eating their eggs and young. In this case, more liberal hunting and trapping regulations were put in place to help reduce raccoon populations and some of the problems they caused.

In the 1800s and early 1900s, unregulated hunting and trapping caused many types of wildlife to decline. Today, hunting and trapping are important tools used in wildlife conservation, and there are plenty of safeguards to prevent a repeat performance. Since the time that seasons, bag limits and other restrictions were established to regulate hunting and trapping, not a single species of game animal has become endangered or extinct.

Source: Illinois Department of Natural Resources

Radio Telemetry

Radio signals bounce off a transmitter in the collar of an animal and connect back to a central antenna to create a certain signal that can be tracked through varying terrain (Figure 12). (See Attachment A for an article on bobcat studies in Illinois)

Figure 12. Illinois biologists safely trap and tranquilize a bobcat for radio-collaring and extended study. License fees and special taxes from trappers and hunters further Illinois conservation efforts. IDNR *Photo by Alan Woolf*

Furbearer management

Populations vary from year to year and are manipulated by factors such as predator/prey relationships, food supply and disease. Some wildlife divisions monitor furbearer populations through data collected from trappers including trends such as trapper effort, trapper success, cumulative indices, anecdotal information from conservation personnel, and relative abundance obtained from trapping license returns (Department of Environment and Conservation, 2014)

4.2.1 Amphibians

Amphibians provide a valuable indication to the health of our ecosystems. Because most amphibians breathe through their skin, they are very susceptible to small changes in the environment, especially increases in concentrations of pollutants. Monitoring frogs and toads throughout Illinois includes visual observation and recording their calls. Depending on species presence/absence, location, and timing, we can determine an ecosystems quality, species distribution, and effects of climate change when monitoring a south to north progression (phenology) of calls. In Illinois, FrogWatch USA is the Association of Zoos and Aquariums' citizen science program and provides individuals, groups, and families' opportunities to learn about wetlands in their communities by reporting on the calls of local frogs and toads. (Source: FrogWatch USA)

4.2.2 Birds

Birds have an important ecological role via the plants they pollinate, the seeds they disperse, the vast quantities of insects and rodents they consume and the part they play as prey. Because of these important relationships between birds and various ecosystems, changes in bird populations can tell a story about the health of the environment. Birds are valuable as indicator species because they are relatively easy to observe and there are many different species with diverse habitat requirements for breeding, migrating and over-wintering (Tommy Thompson Park, n.d.). Some of the many ways we can look at bird populations and monitor them are:

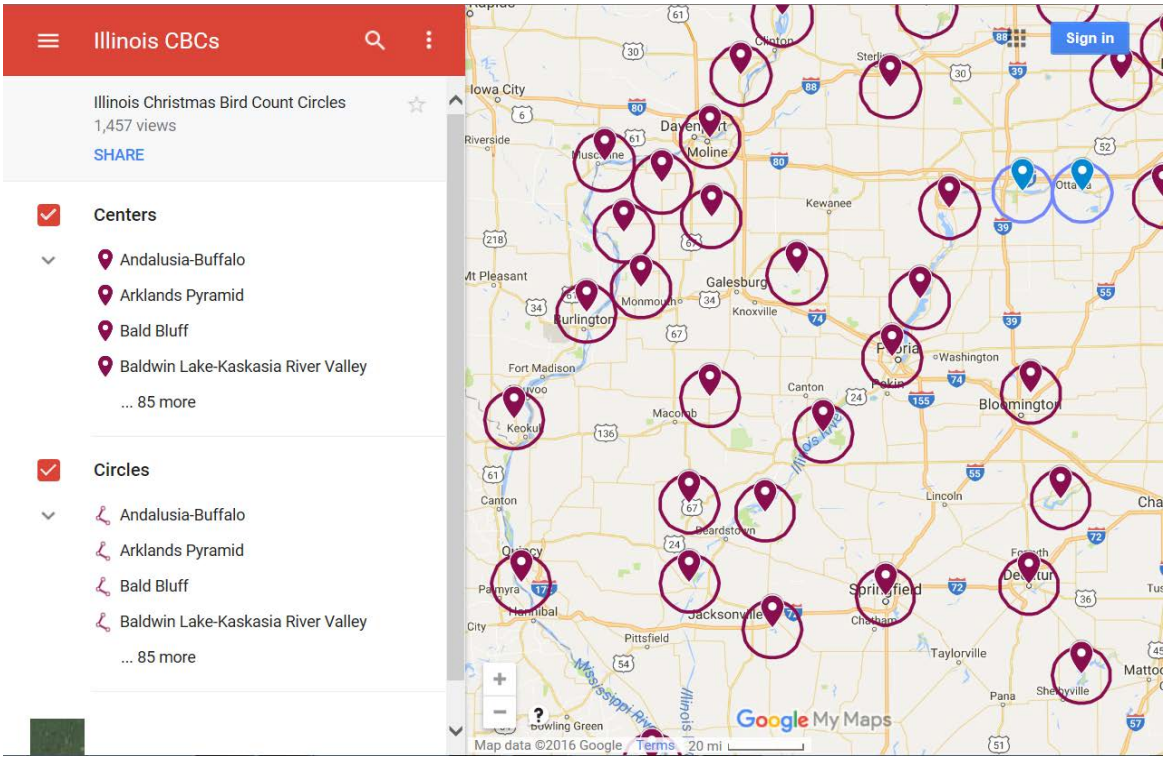
Spring Bird Count

The first Spring Bird Count, SBC, was organized by Chandler Robbins, organizer of the North American Breeding Bird Survey, in 1959. A decade later the Illinois Department of Natural Resources asked Vernon Kleen to organize the first Illinois statewide SBC in the early 1970's. Vern had been mentored by Chandler Robbins and also helped with the first SBC in Maryland making him a great candidate for taking on such a large task. With the help of Illinois Audubon Society the first count was conducted on Saturday, 6 May 1972 and included 650 observers in 62 counties. Vern continued organizing the count for over 30 years, before transitioning the

count to the Illinois Natural History Survey. Today the survey has electronic SBC data dating back to 1975. Each year SBC reports are published in the Meadowlark a journal of the Illinois Ornithological Society, where along with Illinois Audubon many of the counts volunteers come from.

The Spring Bird Count is a yearly bird count that consists of volunteers conducting bird censuses on the Saturday that falls between May 4th and May 10th. The censuses are conducted in all 102 counties in Illinois, however in any given year a few counties are not included in the census. Each county has a compiler responsible for recruiting volunteers and assigning them areas to count within their county. This is especially important to avoid double coverage of an area. Compilers also tabulate all data collected within their county and send it to the state compiler. Volunteers record all birds seen or heard, along with the number of hours they spend "owling" (pre-dawn hours), the number of hours spent looking for birds during the day, the number of miles driven in a car, and the number of miles walked. (Source: Illinois Natural History Survey)

Christmas Bird Counts are also held statewide by various organizations.



Bird Banding

Bird banding data is useful in both research and management projects. Individual identification of birds makes possible studies of dispersal and migration, behavior and social structure, life span and survival rate, reproductive success and population growth. Banding and marking birds can also be used to estimate the numbers of birds in a population using a mark-recapture technique (Figure 13). Birds are marked in one time period, and then recaptured or re-sighted in a later period. The number of birds marked in the first period and the ratio of marked to unmarked birds in the population in the second period allow the total population of birds to be estimated (Environment Canada, 2013).

Figure 13. Banding a goldfinch at the Cache River Nature Fest (Source: Enjoy Illinois Blog)

Breeding Bird Survey (BBS)

This is a continent wide volunteer based roadside survey designed to measure long term changes in breeding bird populations (Konze, K. and McLearen, M., 1997). There are approximately 3700 active BBS routes across the continental U.S. and Canada, of which nearly 2900 are surveyed annually.- The volunteers are encouraged to survey their routes during the peak of the breeding season, usually the first two weeks of June. The starting point and starting direction of routes are selected randomly in order to sample a range of habitats. Each of the participants surveys his or her individual route for as many consecutive years as possible. Each route is 24.5 miles long, with a total of fifty stops located at 0.5 mile intervals along the route. The participants record the total number of individual bird species heard or seen within each stop during a three-minute observation. Data on starting and finishing times, as well as weather conditions, are also recorded (Environment Canada, n.d. and United States Geologic Survey).

4.2.3 Insects

Human activities such as agriculture, forestry, and pastoralism have resulted in the simplification of many terrestrial ecosystems. Attempts to quantify the effects of such practices for the purposes of conservation assessment, classification of land types and monitoring of impacts tend to be characteristics of plants communities emphasizing the use of vegetation mapping data. Data on vertebrate distributions and communities have been incorporated into surveys for conservation purposes. (Gullan, P.J. and Cranston P.S., 2007)

Monarch Butterfly Monitoring

Monarch Butterflies (*Danaus plexipps*) are currently monitored in many different locations, using a variety of techniques (Figure 14). Some of the monitoring programs assess local densities of breeding monarchs throughout their breeding range, numbers of individual butterflies passing through migratory stop over sites, and areas occupied on the winter range. Another program assesses the timing and location of fall and spring migratory cycles, which makes their population dynamics difficult to assess. Monarch Mania is an online resource by the Illinois Department of Natural Resources that has a wealth of information about Monarchs (See References).

Figure 14- Tagged Monarch butterfly from IDNR Monarch Mania

4.2.4 Fish

Fisheries depend on strong, healthy ecosystems which are assessed by monitoring fish populations for signs of stress, maintaining and repairing fish habitats and protecting native species from disease and invasive species (Ministry of Natural Resources and Forestry, 2006). Of Illinois' 57,914 total square miles, 4.1% of that total is water- creeks, ponds, rivers, and lakes (Source: USGS).

Electro-fishing

This is the technique and science of utilizing an electrical current to momentarily stun fish or force them to involuntarily swim towards an electrical field for collection (EPA, 2014). Electrofishing is a common technique used by fisheries biologists to sample fish populations in bodies of freshwater (Figure 15). Fisheries managers use this method to learn details about fish populations such as species composition, age distribution and presence of invasive species (Smith-Root International, 2015).

Figure 15. Workers with the U.S. Fish and Wildlife Service electrofish for asian carp (Credit: U.S. Fish and Wildlife Service via Wikimedia Commons)

Tagging and Marking

Scientists use various methods to study fish populations, including tagging and mark-recapture. This information can aid researchers and managers in evaluating abundance, migration patterns, birth rates, mortality rates, and harvest levels of different marine populations. The mark-recapture method is the most commonly used technique where a random group of fish is captured, marked with a tag or band, and released. Upon sampling another random group any previously marked species are recorded (National Geographic, 2015).

4.2.5 Indicator Species

An **indicator species** is an organism whose presence, absence and/or abundance reflect specific environmental conditions. Indicator species can show a change in a specific ecosystem through biological conditions. By studying indicator species you can assess the health of an ecosystem (Jaffe et. al., 2012).

Examples of indicator species include:

- **Insects:** Honeybees and butterflies are pollinators that indicate and strongly influence the health of plant populations. They are highly sensitivity to a plethora of factors, including temperature and weather, parasites, and air, water and soil quality. All of these factors can help assess the overall health of an ecosystem (Libal and Media, 2015).
- **Frogs**: Their shell-less eggs, absorbent skin, moisture dependence, predatory feeding, and their amphibious life cycles make them vulnerable to changes on land and in water. They are often used to monitor and track changes in water quality, and overall environmental health (Libal & Media, 2015).
- **Lichens:** They are indicator species for air quality due to different types of lichens being susceptible to different pollutants. Certain compounds can affect certain species differently when in an ecosystem. Some compounds can cause a certain species population to grow at exponential rates whereas that same compound could cause other species to die (Libal & Media, 2015).

4.3 Mitigation Measures

4.3.1 Solutions for Increasing Biodiversity

Changes in the global environment are constantly occurring. These changes are going to become more severe as our world faces climate change. There are several ways in which our society can reduce the impacts of global climate change on biodiversity due to global change. Since habitat loss is one of the major threats facing species throughout Illinois and across the US decreasing habitat loss is one of the most effective ways of preserving the biodiversity in an area. Increased development and road construction has led to decreased habitat and increased fragmentation between habitats. Regional planners can be proactive when developing plans for a new community ensuring habitat assessment is completed prior to construction allowing the best quality habitat to be preserved in an area.

FUN FACT

"The Cache River and Cypress Creek Wetland was designated a "Wetland of International Importance" (Ramsar site) for its rich diversity of plant and animal communities. The refuge contains some of the oldest living trees east of the Mississippi River and harbors 91% of Illinois' high-quality swamp habitat." Source: USFWS

Increasing public awareness of biodiversity loss is also an important step to saving the biodiversity that remains in our communities.

The decision to protect biodiversity (or not to protect it) is the result of choices people make as families, community members, voters, consumers, employees, politicians and neighbors. These choices can reflect values and beliefs, knowledge of the issues and the consequence of a choice, a need to satisfy basic human needs or other factors. An understanding of biodiversity issues can help us predict future trends and determine the positive and negative effects of our choices and the values they reflect. (page 152, Illinois Biodiversity Basics)

The Canadian Biodiversity Information Network (2006) provides some tips on how to increase biodiversity in your community:

- develop a community-based monitoring program in your community;
- transform an empty lot into wildlife habitat;
- create natural spaces around buildings;

- join a conservation group;
- fish sustainably;
- assist in completing a wildlife survey or bird count; and,
- take part in an endangered species recovery project.

Implementing legislation to protect species that are currently or will become at risk in the near future is the most powerful way to help to preserve biological diversity within Illinois. Legislation such as the Federal Endangered Species Act help to protect species by developing recovery plans to increase their population numbers and providing legislation ensuring the protection of their habitat and food sources. Recovery plans identify ways to manage and improve the status of species that are designated threatened, endangered or extirpated and provide advice on how to recover the species. These plans consist of two parts: a recovery strategy and one or more action plans.

4.3.2 Habitat Protection

Governments and other stakeholders (non-governmental organizations (NGO), the public, and private sector groups) share joint responsibility in the protection and wise use of Illinois' wildlife habitats. Some of these habitats are protected by the Illinois Nature Preserve Commission. The INPC permanently protects by state law, nature preserves that are on both private and public lands that have rare plants, animals, or other unique natural features. Ranging in size from one acre to more than 2,000 acres, nature preserves protect tall grass prairies, oak groves, sandstone bluffs, wetlands, bogs and other threatened natural areas. These lands are the last remnants of the Illinois wilderness, which provides homes for endangered species like the prairie white-fringed orchid, the Prairie Chicken and Illinois Chorus Frog. (Source: Illinois Department of Natural Resources)

Without this protection, many of these exceptional areas would be lost forever. Currently, nature preserves protect over 900 occurrences of endangered and threatened plants and animals. In fact, more than 20% of all Illinois endangered species are in state dedicated nature preserves.

Other partnerships, such as Emiquon on the Illinois River near Havana, IL, are a partnership between an NGO, The Nature Conservancy, and public agencies including the Illinois Natural History Survey and the University of Illinois. The Conservancy also works closely with these and other partners to collect monitoring data about the current state of Emiquon's species and natural communities. These activities will continue throughout the restoration and give scientists a means to measure progress and provide for adaptive management of the project.

The restoration at Emiquon also benefits the economic development and prosperity of local communities. With a wide-spread reputation for great fishing, hunting and birding, Emiquon attracts sportsmen and women from throughout the state, bringing more business to local sporting goods shops and the restaurants where these visitors eat. (Source: The Illinois Nature Conservancy)

The Illinois Wildlife Action Plan benefits the health of wildlife and people; enhances our quality of life; fulfills our responsibilities to conserve wildlife and the places they live for our children; and, provides a cost effective investment by protecting species before they become critically rare, which strengthens our state economy. Important services of the plan include:

* Conservation of wildlife and habitat, thereby protecting clean water and air-making both wildlife and people healthier;
* Identification and prevention of problems before they threaten wildlife and affect humans, as wildlife often are early indicators of disease and pollution;
* Conservation of wildlife and natural places that bring peace and relaxation to our busy lives, and are important to many of our family traditions;
* An outline of actions developed by scientists, sportsmen, conservationists and members of the community working together;
* Documentation of the importance of non-consumptive wildlife recreation activities, which are enjoyed by more than 2.6 million Illinoisans, have an annual economic impact of about $1.3 billion and support more than 13,000 jobs. (Source: Illinois Department of Natural Resources)

4.4 Wildlife Management, Protection and Recovery

Endangered and Threatened Species in Illinois:

The Illinois Endangered Species Protection Act was passed in 1972, predating the federal Endangered Species Act of 1973. The original version of the Act protected animals but not plants, and only established the category of “Endangered.” Subsequent amendments added a “Threatened” category, included plants, and gave much clearer protections for endangered species and their habitats — indeed, Illinois was among the first states to attempt to protect endangered species’ habitats through legislation. Later amendments provided equal protections for both threatened and endangered animal species, and added provisions for the incidental taking of endangered and threatened species. The Act establishes the Endangered Species Protection Board and the Endangered and Threatened Species program administered by the Department of Natural Resources.

In addition, all Illinois agencies and local governments are required to consult with DNR

whether actions carried out by them are likely to jeopardize the continued existence of Illinois listed endangered and threatened species or are likely to result in the destruction or adverse modification of the designated essential habitat of such species. (Source: Illinois Environmental Council)

Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora

CITES in an international agreement between governments, with the objective to ensure that the international trade of wild plant and animal specimens does not threaten their survival. There are currently more than 175 parties involved, with Canada being the 10th country to ratify the Convention which came into effect in 1975. Although many wildlife species traded are not endangered, the presence of this agreement helps to protect these resources for the future by providing a level of protection (CITES, n.d.). While countries of the Convention participate voluntarily, it provides them with a framework to help implement laws within their own countries.

International Union for the Conservation of Nature (IUCN) Global Species Programme

The IUCN Global Species Programme together with the IUCN Species Survival Commission (SSC) are responsible for assessing the conservation status of species on a global scale (IUCN, 2014). Their responsibility is providing scientifically-based and objective information regarding the current status of globally threatened flora and fauna. Conservation status information is essential in informing decisions regarding the conservation of biodiversity at both local and global levels (IUCN, 2014). The IUCN Red List of Threatened Species was created to globally identify individual species at risk of extinction. It is universally recognized as the most in-depth global approach for the evaluation of the conservation status of plants and animals (IUCN, 2014).

Appendix 1: Disease

Disease is a normal occurrence within the natural world and plays an essential role in moderating populations. Most ecosystems include organisms such as bacteria, fungi, viruses, and parasites that cause disease. A healthy ecosystem with greater genetic and species diversity is more resilient to the impacts of disease because there are greater possibilities that some species have evolved resistance, or an array of species exist to fulfill several important roles. The loss of one species to disease may be less impactful when there are numerous other species that are able to withstand that disease. Unhealthy ecosystems or those with less biodiversity can be more vulnerable to the impacts of disease, because disease can cause immediate impacts to which the ecosystem cannot quickly adapt.

Diseases

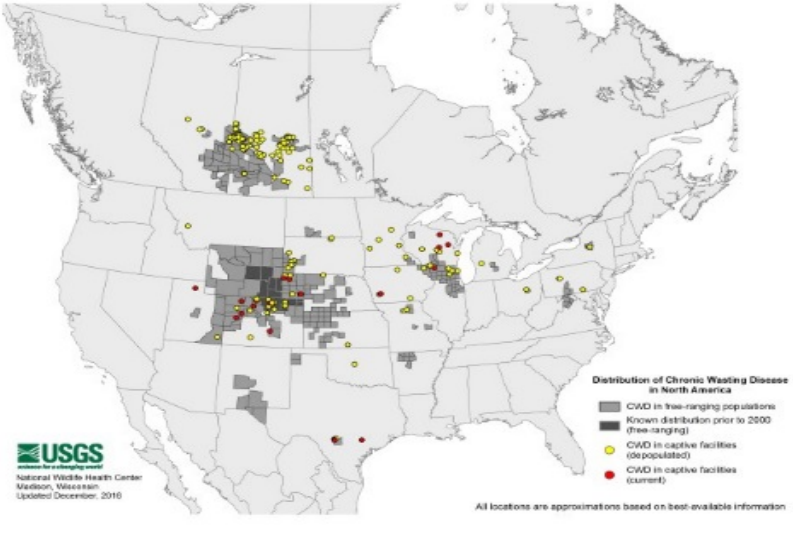
Chytrid Fungus (*Batrachochytrium* dendrobatidis)

This is a fungus that targets amphibian species, and grows on their skin (Figure 16). The fungus will interfere with the amphibian's ability to breathe and/or take up water through their skin. This fungus has been decreasing frog populations significantly globally (National Wildlife Federation, 2015).

Figure 16. Swabbing for *Batrachochytrium dendrobatidis* (Vredenburg, 2013)

Chronic wasting disease *(Spongiform encephalopathy)*

This is a highly contagious disease that primarily infects cervids such as white-tailed deer and elk. Prions, which are modified proteins, are believed to be the cause of the disease (National Wildlife Federation, 2015). Chronic wasting disease leads to significant weight loss and behavioral changes that inevitably cause malnutrition in the animal and death.



Whirling disease

Trout, salmon and whitefish are infected by the parasite, Myxobolus *cerebralis*, which causes whirling disease. The disease damages nerves and cartilage causing young fish to die, and older fish to swim in a repetitive whirling motion. This behavior makes it difficult for older fish to find food, and it increases their vulnerability to predation (National Wildlife Federation, 2015).

Sylvatic plague

This is a bacterial disease that is transmitted by fleas that affects rodents and prairie dogs, and even the black- footed ferret, an endangered species. It can cause high mortality among populations of these species, impacting the ecosystem food webs (National Wildlife Federation, 2015).

White-nose Syndrome

Hundreds of thousands of bats have been infected or have died from the white-nose fungus (Figure 17). The fungus affects hibernating bats by infecting the skin of their muzzles, ears and wings (National Wildlife Federation, 2015). Along with infection, bats can display erratic behavior such as daytime flying and movement towards to mouths of the cave during cold, winter months. This additional activity consumes the fat stores within bats leading to starvation.

Figure 17. Illinois bat showing fungus associated with White Nose Syndrome (MNRF, 2010)

Roundworm Brain Parasite (*Baylisascaris*)

This infection is caused by an intestinal roundworm found primarily in raccoons. The roundworm can infect people as well as other animals. If humans are infected it can be severe especially if the parasites invade the eyes, organs or brain (CDC, 2012).

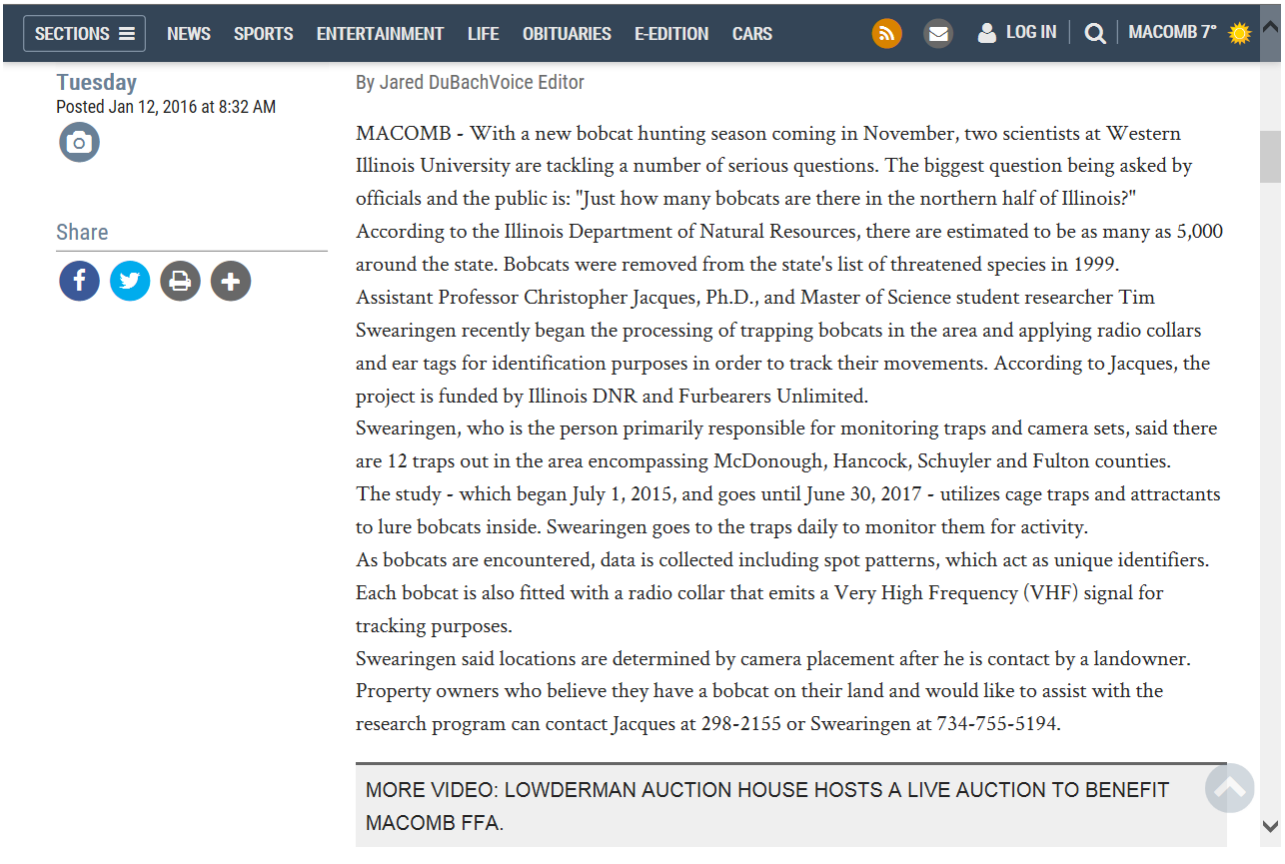
Avian Botulism

This is a disease that causes immobilization in birds. This is caused by ingestion of a toxin produced by the bacteria, Clostridium *botulinum*. This bacterium requires warm temperatures and is widespread in soil. The combination of decomposing vegetation, invertebrates, and warm temperatures can provide the perfect conditions for the botulism bacteria to produce toxins (USGS, 2013).

Rabies

Rabies is an infectious and contagious disease of the central nervous system – spread by warm-blooded animals. If left untreated, rabies may result in death. The rabies virus is concentrated in the saliva, mucus membranes and central nervous tissue of an infected animal. Humans and other mammals can become infected through a cut or scratch from an animal with rabies, or if the rabies virus comes in contact with the moist tissues of the mouth, nose or eyes (OMNR, 2009).

ATTACHMENT A



SECTIONS NEWS SPORTS ENTERTAINMENT LIFE OBITUARIES E-EDITION CARS LOG IN MACOMB 7°

Tuesday
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By Jared DuBachVoice Editor

MACOMB - With a new bobcat hunting season coming in November, two scientists at Western Illinois University are tackling a number of serious questions. The biggest question being asked by officials and the public is: "Just how many bobcats are there in the northern half of Illinois?"

According to the Illinois Department of Natural Resources, there are estimated to be as many as 5,000 around the state. Bobcats were removed from the state's list of threatened species in 1999.

Assistant Professor Christopher Jacques, Ph.D., and Master of Science student researcher Tim Swearingen recently began the processing of trapping bobcats in the area and applying radio collars and ear tags for identification purposes in order to track their movements. According to Jacques, the project is funded by Illinois DNR and Furbearers Unlimited.

Swearingen, who is the person primarily responsible for monitoring traps and camera sets, said there are 12 traps out in the area encompassing McDonough, Hancock, Schuyler and Fulton counties.

The study - which began July 1, 2015, and goes until June 30, 2017 - utilizes cage traps and attractants to lure bobcats inside. Swearingen goes to the traps daily to monitor them for activity.

As bobcats are encountered, data is collected including spot patterns, which act as unique identifiers. Each bobcat is also fitted with a radio collar that emits a Very High Frequency (VHF) signal for tracking purposes.

Swearingen said locations are determined by camera placement after he is contact by a landowner. Property owners who believe they have a bobcat on their land and would like to assist with the research program can contact Jacques at 298-2155 or Swearingen at 734-755-5194.

MORE VIDEO: LOWDERMAN AUCTION HOUSE HOSTS A LIVE AUCTION TO BENEFIT MACOMB FFA.

http://www.mcdonoughvoice.com/news/20160112/rise-of-bobcats-wiu-research-duo-studies-predators-population-in-area

Glossary

Adapt (ed/ation) - the process of making adjustments to suit the environment

Alien - foreign, something introduced into a new area

Bioaccumulation - the storing and building up of contaminants in the tissues of organisms

Biodiversity – the variety of life

Biomagnification - the increased amount of contaminants in a top predator due to eating prey who have themselves consumed contaminants, but at a low level

Carnivore - a meat eater

Carrying Capacity - the equilibrium or balance between any life form and its environment; how many organisms an environment can support

Commensalism - a relationship in which one species derives food or shelter from another without either harming or helping that other species in return

Competition - when two or more organisms have the potential for using the same habitat

Domesticated - animals bred in captivity for specific human uses

Endangered - any organism whose existence is threatened with immediate extinction through all or significant portion of its range

Eutrophication - over-enrichment of a lake or other water body with nutrients, resulting in excessive growth of organisms and the depletion of oxygen

Exotic (see alien)

Extinction - the condition of having been removed from existence, does not live anywhere in the world anymore

Extirpation - the local extinction of a species, i.e., does not exist in the wild in Canada anymore, but can be found in the U.S.

Food chain - the transfer of food energy from plants through a series of animals, with repeated eating and being eaten

Food web - an interlocking pattern of food chains

Forage - vegetation naturally used by herbivorous animals

Game - legal designation for animals that may be managed and hunted only under regulation

Habitat - the food, water, shelter and space necessary for the survival of a species

Herbivore - a plant eater

Hibernacula – a place where a species seeks refuge during hibernat

Hibernation - the act of passing the winter in a state of torpor, which may include sleep, lowered metabolism and lowered body temperature

Home range - the area in which an animal travels during their normal activities

Indicator species – a species that defines a trait or characteristic of the environment

Indigenous - a naturally occurring species

Insectivorous - insect eater

Invasive - a species that encroaches upon and pushes out the native species

Limiting factors - influences in the life history of an animal, population or species

Mesopredator - is a medium-sized predator, which preys on and is also preyed upon. Examples include raccoons, skunks, snakes, opossums, and foxes.

Migration - the periodic movement of animals from one area to another and back again as a natural part of their life

Mutualism - the association between two different species whereby each benefits from the relationship

Native (see indigenous)

Natural selection - a process in nature resulting in the survival and perpetuation of only those forms of life having certain favorable characteristics that enable them to adapt best to their environment

Nocturnal - active at night

Non-native (see alien)

Omnivore - eats both plants & animals

Organism - a living thing

Parasite - an organism that lives by deriving benefit from another, which causes harm, but not immediate death to the other

Pest (see also vermin) - an organism whose presence and behavior causes harm to humans or their property

Population - the number of a particular species in a defined area

Predator - an animal that kills and eats other animals

Prey - animals that are killed and eater by other animals

Primary Producer – any plant or microorganism that can convert light energy or chemical energy into organic matter

Rare - an organism that exists in low numbers in a defined area or in a very restricted area, as a result of its biological characteristics or because it is at the edge of its range, but these numbers are not threatened

Riparian – the area that is the interface between land and a river or stream

Scavenger - an organism that feeds on dead animals or refuse

Special Concern – a wildlife species that may become threatened or endangered

Species - a population of individuals that are alike, are able to breed and produce fertile offspring under natural conditions

Symbiosis - a close living relationship between organisms

Territory - "ownership" or dominance over an area defended against others of the same species, used for breeding, feeding or both

Threatened - a species that is likely to become endangered if the factors affecting its vulnerability do not become reversed

Trophic level – the position an organism occupies in a food chain

Vermin (see pest)

Vulnerable - a species that is particularly at risk because of low or declining numbers or other reasons, but is not considered threatened

Wild - not tamed or domesticated

Wildlife – wild animals collectively

References

Audubon Conservation. (2015). ***Where We Work.*** **Retrieved from** http://www.audubon.org/conservation

Bird Studies Canada. (n.d.) Retrieved from http://bsc-eoc.org/

Champagne J. (2005). Hinterlands Who's Who: Species at Risk in Canada. Retrieved from http://www.hww.ca/en/issues-and-topics/species-at-risk-in-canada.html

CITES. (n.d.). ***What is CITES?*** **Retrieved from** http://www.cites.org/eng/disc/what.php

Department of Environment and Conservation. (2014, October 30). ***Furbearer Management in Newfoundland and Labrador.*** **Retrieved from** http://www.env.gov.nl.ca/env/wildlife/wildlife_research/furbearers.html

Ducks Unlimited. (n.d.) ***Waterfowl migration flyways.*** **Retrieved from** http://www.ducks.org/conservation/flyways

Environment Canada. (n.d.). ***Breeding Bird Survey.*** **Retrieved from** https://ec.gc.ca/reom-mbs/default.asp?lang=En&n=416B57CA-1

Environment Canada. (2013). ***Bird Banding Office.*** **Retrieved from** http://www.ec.gc.ca/bbo/Default.asp?lang=En&n=85700A22-1

Environment Canada. (2013). ***Convention on international trade in endangered species of wild fauna and flora*****. Retrieved from** http://www.ec.gc.ca/cites/default.asp?lang=En&n=93ECD241-1

Environment Canada. (2014). ***Migratory Birds*****. Retrieved from** http://www.ec.gc.ca/nature/default.asp?lang=En&n=fdf836ef-1

Environment Canada. (2014). Species at risk. Retrieved from https://www.ec.gc.ca/nature/default.asp?lang=En&n=FB5A4CA8-1

Environment Canada. (2014). ***Wild animal and plant protection and regulation of international and interprovincial trade act*****. Retrieved from** http://www.ec.gc.ca/cites/default.asp?lang=En&n=18F4A0BC-1

Environment Canada. (2013). ***Wildlife Habitat*****. Retrieved from** https://www.ec.gc.ca/nature/

Environmental Protection Agency. (2014) ***Electro-fishing.*** **Retrieved from** https://www.epa.gov/regionallabs/epa-region-1-laboratory-electrofishing

Government of Canada (2015a). Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Retrieved from http://www.cosewic.gc.ca/default.asp?lang=En&n=A9DD45B7-1

Government of Canada (2015b). First Nations in Canada. Retrieved from https://www.aadnc- aandc.gc.ca/eng/1307460755710/1307460872523

Gullan, P. J., Cranston, P.S. (2007). *The Insects an outline of Entomology .* Hoboken, New Jersey, USA: Blackwell Publishing, John Wiley & Sons. ISBN: 978-1-4051-1113-3

Hinterland who's who. (2005). ***Bats*****. Retrieved from** http://www.hww.ca/en/wildlife/mammals/bats.html?referrer=https://www.google.ca/

Hogan, C. (2014). ***Causes of extinction*****. Retrieved from** http://editors.eol.org/eoearth/wiki/Extinct

Jaffe, D., McDonough, C., Watzin M., McGinley, M. (2012). ***Indicator species.*** **Retrieved from** http://editors.eol.org/eoearth/wiki/Indicator_species

Konze, K., McLaren, M. (1997). *Wildlife Monitoring Programs and Inventory Techniques for Ontario: NEST Technical Manual TM-009*

Libal, A., Media, D. (n.d.) ***Examples of Indicator Species.*** **Retrieved from** http://classroom.synonym.com/examples-indicator-species-16895.html

McDonough, M. (2011). *How insects survive the long, cold winter.* Retrieved from http://www.udel.edu/udaily/2011/feb/insects-winter-020311.html

Ministry of the Environment. (1998). *Wildlife Radio-telemetry* Retrieved from Ministry of Natural Resources and Forestry. (n.d.). Wetlands are Important. ISBN 978-1-4249-7654-6. Print.

Ministry of Natural Resources and Forestry. (2006). ***Fisheries in Ontario.*** **Retrieved from** http://www.Ontario.ca/environment-and-energy/fisheries-Ontario

Ministry of Natural Resources and Forestry. (2009). ***Protecting the far north*****. Retrieved from** http://news.Ontario.ca/mnr/en/2009/06/protecting-the-far-north.html

Ministry of Natural Resources and Forestry. (2010). ***Ontario bat showing fungus associated with White Nose Syndrome [image].*** **Retrieved from** https://news.ontario.ca/mnr/en/2010/3/white-nose-syndrome-detected-in-ontario-bats.html

Ministry of Natural Resources and Forestry. (2014a). How species at risk are listed. Retrieved from https://www.Ontario.ca/environment-and-energy/classifying-species-risk

Minister of Public Works and Government Services Canada. (2004). How Much Habitat is Enough? 2nd Ed. Retrieved from https://www.ec.gc.ca/nature/default.asp?lang=En&n=E33B007C-1

National Geographic. (2015). ***Fish Tagging and Monitoring.*** **Retrieved from** http://www.nationalgeographic.org/activity/fish-tagging-and-monitoring/

National Wildlife Federation. (2015). ***Disease*****. Retrieved from** https://www.nwf.org/Wildlife/Threats-to-Wildlife/Disease.aspx

Oberhauser, K., Batalden, R., Howard, E. (2009). ***Monarch Butterfly Monitoring in North America: Overview of Initiatives and Protocols.*** **Retrieved from** https://www.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/documents/Monarch-Monitoring_en.pdf

OFAH/OMNR Invading Species Awareness Program. (n.d.). ***Invaders*****. Retrieved from** http://www.invadingspecies.com/invaders/

OFAH/OMNR Invading Species Awareness Program. (2012f). ***Zebra Mussel.*** **Retrieved from** http://www.invadingspecies.com

Ontario Biodiversity Council (2011). ***Ontario's Biodiversity Strategy.*** **Retrieved from** http://ontariobiodiversitycouncil.ca/

Ontario Nature. (2013). ***Ontario Reptile and Amphibian Atlas Program*****. Retrieved from** http://www.Ontarionature.org/protect/species/herpetofaunal_atlas.php

Parry, W. (2010). ***Why do animals migrate?*** **Retrieved from** http://www.livescience.com/10235-animals-migrate.html

Rouge River Bird Observatory. (1992). ***Exploring the importance of urban natural areas to birds since 1992.*** **Retrieved from** www.rrbo.org

Royal BC Museum. (2011). *European starling*. Retrieved from http://www.cbc.ca/news/canada/british-columbia/invasive-starlings-captured-and-killed-in-okanagan-1.1895410

Schraer, Stoltze. (1993). *Biology: The study of life* (5th ed.). Retrieved from http://www.smithlifescience.com/ProducersConsumersDecomposers.htm

Scott, W.B., Crossman, E.J. (1998). *Freshwater Fishes of Canada.* Oakville, Ontario, Canada: Galt House Publications Ltd.

Smith, K. (2015). Monarch butterfly migration. Retrieved January 16, 2015, from https://goodmorninggloucester.wordpress.com/tag/monarch-butterfly-migration/

Smith-Root International. (2015). *Introduction to Electro-fishing and Safety Principles*. Retrieved from http://www.smith-root.com/services/training/

The Nature Conservancy (2015b). *Monarch butterfly migration.* Retrieved from http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/indiana/journeywithnature/monarch-butterfly-migration.xml

The Nutty Bird Watcher (2001). *North American migration flyways*. Retrieved from http://www.birdnature.com/flyways.html

Tommy Thompson Park (n.d.). *Toronto's Urban Wilderness.* Retrieved from www.tommythompsonpark.ca

USGS National Wetlands Research Centre. (n.d.). *Habitat Suitability Index Models*. Retrieved from http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiintro.htm

World Wildlife Fund (n.d.). *Monarch butterfly*. Retrieved from http://wwf.panda.org/about_our_earth/species/profiles/insects/monarch_butterfly/

Van der hoop, J. (2013). *Bioamplification, Bioaccumulation and Bioconcentration.* Retrieved from http://mercurypolicy.scripts.mit.edu/blog/?p=499

Vredenburg, V. (2013). *Frog being swabbed for Chytrid Fungus [image].* Retrieved from http://cisr.ucr.edu/chytrid_fungus.html

Additional References for the Illinois Edition

USGS National Wetlands Research Center Digital Library Habitat Suitability Index Models
http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiintro.htm

Frozen Alive- overwintering strategies for animals
http://www.naturenorth.com/winter/frozen/Ffrozen.html

Indiana State Department of Health, Contaminants in Fish http://www.in.gov/isdh/26877.htm

Illinois DNR, Endangered Species Protection Board, The Illinois List Review and Revision
https://www.dnr.illinois.gov/ESPB/Pages/ETListandListreviewandrevision.aspx

USFWS, Who We Are https://www.fws.gov/who/

USFWS Environmental Conservation Online System, Listed species believed to or known to occur in Illinois http://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=IL

Illinois DNR, Checklist of Illinois Endangered and Threatened Animals and Plants, Illinois Endangered Species Protection Board
https://www.dnr.illinois.gov/ESPB/Documents/2015_ChecklistFINAL_for_webpage_051915.pdf

Urban Coyote Project http://fermilabnaturalareas.org/assets/urban-coyote-project.pdf

FrogWatch https://www.aza.org/frogwatch

Illinois Natural History Survey, Spring Bird Count
http://wwx.inhs.illinois.edu/collections/birds/sbc/

Illinois Ornithological Society, Christmas Bird Count http://www.illinoisbirds.org/new-christmas-bird-count-cbc-map/

North American Breeding Bird Survey Distribution Maps https://www.mbr-pwrc.usgs.gov/bbs/ra2013/ra2013_red_v1.html

Illinois DNR, Monarch Mania https://www.dnr.illinois.gov/education/Pages/monarchgen.aspx

The USGS Water Science School http://water.usgs.gov/edu/wetstates.html

USFWS Midwest Region Report
https://www.fws.gov/midwest/documents/statebooks/illinois.pdf

Illinois DNR, Illinois Nature Preserves Commission
https://www.dnr.illinois.gov/INPC/Pages/default.aspx

The Nature Conservancy, Emiquon Site
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/illinois/placesweprotect/emiquon.xml

Illinois DNR, Illinois Wildlife Action Plan
https://www.dnr.illinois.gov/conservation/IWAP/Pages/default.aspx

Illinois Environmental Council, Wildlife and Habitat Conservationhttp://ilenviro.org/wildlife-and-habitat-conservation/

Illinois DNR Division of Fisheries http://www.ifishillinois.org/

Illinois DNR 2016 Illinois Fishing Information
https://www.dnr.illinois.gov/fishing/Documents/IllinoisFishingInformation.pdf

Illinois Natural History Survey, Fisheries Management & Conservation
http://wwx.inhs.illinois.edu/programs/aquatic/5748/

Sport Fish Research in Illinois http://www.ifishillinois.org/science/F69R_Booklet.pdf

Illinois DNR, BioBasics manual
https://www.dnr.illinois.gov/education/Documents/BioBasics_pubication.pdf

Illinois Natural History Survey, **Amphibians and Reptiles of Illinois Lists**
http://wwx.inhs.illinois.edu/collections/herps/data/ilspecies/

Illinois DNR, Division of Education A to Z
https://www.dnr.illinois.gov/education/Pages/AtoZ.aspx

USFWS Newsroom, Official Number of Protected Migratory Bird Species Climbs to More than 1,000 March 2010 https://www.fws.gov/midwest/news/184.html

Enjoy Illinois Blog http://www.enjoyillinoisblog.org/2011/04/18/birds-and-birders-of-various-feathers-flock-to-southern-illinois/

USFWS, Migratory Bird Data Center https://www.fws.gov/birds/surveys-and-data/migratory-bird-data-center.php

The Nature Conservancy, Illinois, Top Five Must-See Migrations in Illinois
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/illinois/explore/the-nature-conservancy-in-illinois-top-five-must-see-migrations-in-illi.xml

Audubon Bird Field Guide, American Golden Plover http://www.audubon.org/field-guide/bird/american-golden-plover

Peoria Audubon Society, Natural History of Illinois Bats by Joyce Hoffman
http://www.peoriaaudubon.org/docs/Bats_Illinois_Joyce-Hoffman_2009-12-xx.pdf

USGS Bat Population Data Project https://my.usgs.gov/bpd/

Adirondack Ecological Center, From: Saunders, D. A. 1988. Adirondack Mammals. State University of New York, College of Environmental Science and Forestry. 216pp. http://www.esf.edu/aec/adks/mammals/meadow_jumping.htm

All About Birds, Wood Thrush https://www.allaboutbirds.org/guide/Wood_Thrush/id

USGS, National Wildlife Health Center, Chronic Wasting Disease https://www.nwhc.usgs.gov/disease_information/chronic_wasting_disease/44