Lesson 1: The Forest Odyssey

NUTSHELL

In this classroom lesson, students learn about ecosystem functions and the natural processes that occur in forests. They read the essay "Odyssey" from* Aldo Leopold's A Sand County Almanac *and discuss the concepts of change, interconnectivity, and sustainability. In small groups, students research a forest ecosystem in Wisconsin and then work in a large group to create ecosystem food webs. Together, students use the knowledge they have gained to create a story that describes the journey of an atom through different forest ecosystems.

ENDURING UNDERSTANDINGS

- An ecosystem is characterized by its composition, structure, and function.
- Ecosystem functions include the fixation of energy through the process of photosynthesis, the flow of energy through food chains and food webs, and the cycling of matter.
- Forest ecosystems are connected with other terrestrial (e.g., prairies) and aquatic (e.g., wetlands) ecosystems.

ESSENTIAL QUESTIONS

- What connections, large and small, exist between ecosystems?
- How are processes like photosynthesis, food webs, and cycling of matter related?

OBJECTIVES

Upon completion of this lesson, students will be able to:

- Identify and describe ecosystem functions and natural processes in forests.
- Compare and contrast the ecology, natural history, and human aspects of three different forest ecosystems in Wisconsin.
- List specific examples of how ecosystems are interrelated, how ecosystems change, and how ecosystems are sustained.

SUBJECT AREAS

Language Arts, Science (Earth and Space Science, Life and Environmental Science)

PROCESS SKILLS

Large group analysis and consensus building, Research, Science-based creative writing.

LESSON/ACTIVITY TIME

Total Lesson Time: 250 minutes

- Introduction............................5 minutes
- Activity 1..............................45 minutes
- Activity 2..............................30 minutes
- Activity 3..............................70 minutes
- Activity 4..............................50 minutes
- Conclusion............................50 minutes

STANDARDS CONNECTIONS

Standards for this lesson can be viewed online at the LEAF website ***(www.leafprogram.org)***.

BACKGROUND INFORMATION

Forests As Ecosystems

A biologic community is a group of plants and animals that live and interact with one another in a given area. The term **ecosystem** is used to describe a biologic community together with the abiotic (nonliving) components in it. An ecosystem's abiotic components can include physical characteristics (e.g., soils, topography), climatic factors (e.g., sunlight, temperature, moisture), and **nutrients**, elements and other chemical compounds (e.g., nitrogen, phosphorous, carbon dioxide, water, mercury, pesticides). Ecosystems can vary in size from a large forest to a rotting log.

The living things in an ecosystem may be classified as producers and consumers. Producers, or autotrophs, are plants that make their own food. Consumers, or heterotrophs, are animals that need to consume other organisms to obtain energy and nutrients. Decomposers (including **detritivores**, bacteria, and fungi) are a type of consumer that break down organic matter, making nutrients available for plants.

Forest ecosystems are not isolated from other ecosystems. They are interconnected with other terrestrial ecosystems (such as prairies) and with aquatic ecosystems (such as wetlands). For many of us, the biotic connections are most obvious. For example, many animal and bird species, such as the eagle, osprey, and black bear, find shelter in the forest but get much of their food from adjoining areas. Forest edges receive added sunlight, increasing the habitat for sun-loving plants, and providing important habitat for many birds and animals, including deer, turkey, and grouse. Some organisms (notably amphibians) need a wetland for part of their life cycle but live other parts of their life in terrestrial areas, such as forests.

Forests are also connected to other ecosystems by abiotic factors. Forests retain water and protect surface and groundwater resources. Surface water and groundwater connect forests with lakes, rivers, wetlands, farms, and cities. Fires spread from fields to forests. Erosion from upland areas can cause siltation of waterways and create soil deposits in lowland areas. Forested areas can act as windbreaks and temperature buffers. All of these are examples of the abiotic connections between forests and surrounding ecosystems.

"Trees indeed have hearts."

Henry David Thoreau

MATERIALS LIST

For Each Student

- Copy of Student Pages ***1A-B, Aldo Leopold's "Odyssey"***
- One copy of either Student Pages ***2A-B, Forest Ecosystem Profile: Oak Savanna***, OR ***3A-B, Forest Ecosystem Profile: Forested Wetland***, OR ***4A-B, Forest Ecosystem Profile: Northern Hardwood Forest***
- Copy of Teacher Page ***2, Habitat and Wildlife*** (optional)
- Copy of Student Page ***5, Food Webs***

For Every 2 Students

- Cards made from Teacher Page ***1, Natural Process Cards***

For the Teacher

- Marker board
- Copy of Teacher Page ***2, Habitat and Wildlife***

Ecosystem Functions

Ecosystems maintain functions that support life. These include the **fixation of energy** through **photosynthesis**, the **cycling of matter**, and the **flow of energy** through food webs.

Ecosystem functions are driven by a host of **natural processes**. These processes can be biological, chemical, or physical. The processes connect biotic and abiotic components of an ecosystem. Important natural processes in forest ecosystems include: **respiration**, **assimilation**, **photosynthesis**, **decomposition**, **mineralization**, **weathering**, **erosion**, **nitrogen fixation**, **herbivory**, **competition**, **reproduction**, **succession**, **migration**, **carbon sequestration**, and **adaptation.**

VOCABULARY TERMS

Adaptation: Evolutionary adjustments in structure, form, or function that help individuals, populations, or species fit in their environment.

Assimilation: The incorporation of energy and nutrients into the bodies of plants or animals.

Carbon Sequestration: The capture and storage of carbon dioxide from the atmosphere into biotic (e.g., trees) or abiotic (e.g., coal) pools of carbon.

Competition: The struggle that exists among organisms to acquire finite resources (e.g., light, space, nutrients, water).

Cycling of Matter: An ecosystem function in which elements are deposited, used by organisms, and stored or exported.

Decomposition: The breakdown of organic matter (through a number of interrelated processes) into simple compounds available for use by plants.

Detritivores: Scavengers (e.g., millipedes, wood lice, slugs, snails, springtails, beetles) that feed on dead plants and animals or their waste; essential for the cycling of nutrients.

Ecosystem: An area that contains organisms (e.g., plants, animals, bacteria) interacting with one another and their nonliving environment (e.g., climate, soil, topography).

Ecosystem Functions: Functions that support life including the fixation of energy, the cycling of matter, and the flow of energy through food webs.

Erosion: The wearing away of the land surface by water, wind, ice, gravity, or other natural or human forces.

Fixation of Energy: An ecosystem function in which solar energy is changed into chemical energy (photosynthesis) and assimilated in plants.

One of the most important natural processes in an ecosystem is photosynthesis. Photosynthesis is the process by which plants harness the electromagnetic energy of the sun and convert it into chemical energy (i.e., sugar). The chemical energy found in plant material can then be digested, assimilated (as carbohydrates, protein, and/or fat) and used to perform processes that the body needs to survive. The process of photosynthesis is essential to life on Earth. The appearance of green algae preceded the first explosion of life on this planet, and autotrophs continue to be a fundamental component of ecosystems.

Photosynthesizing organisms are called producers since, in all but a few ecosystems (e.g., hydrothermal vents on ocean floors), they provide all of the energy to the ecosystem.

Organisms that do not photosynthesize are called consumers because they must consume other organisms for their energy.

A complex web of feeding relationships is maintained in an ecosystem. An organism's feeding position in an ecosystem is its trophic level. There are four main trophic levels: 1) producers (photosynthetic plants, algae, bacteria); 2) primary consumers (herbivores); 3) secondary consumers (carnivores and omnivores); and 4) tertiary consumers (top carnivores). Ecosystems have a large number of producers supporting a smaller number of primary consumers that support an even smaller number of secondary consumers, which in turn support only a few top carnivores. The relationship is often illustrated as a trophic pyramid to show the amount of energy stored and ultimately transferred to different levels in the ecosystem.

VOCABULARY TERMS

Flow of Energy: An ecosystem function in which chemical energy (found in carbohydrates, proteins, and fats) is moved through the food webs of an ecosystem.

Forest Ecosystem: An ecosystem characterized by a dominance of tree cover.

Herbivory: The consumption of living plant material by plant-eating animals (herbivores and omnivores).

Interconnectivity: The relationships that exist between ecosystems.

Migration: The repeated movement of a population of organisms from one ecosystem to another.

Mineralization: The conversion of an element from an organic to an inorganic form; combustion, the act of burning, is a very rapid form of mineralization.

Natural Process: A specific biological, chemical, or physical interaction that occurs between the components of an ecosystem (e.g., erosion, decomposition, photosynthesis, predation).

Nitrogen Fixation: The process by which atmospheric nitrogen is made available for use by plants in an ecosystem.

Nutrient: The chemical elements that contribute to the growth and development of an organism.

Odyssey: An extended wandering or journey.

Photosynthesis: The process by which plants convert the electromagnetic energy of the sun into chemical energy usable by other organisms.

Reproduction: The process by which organisms produce offspring.

Respiration (plant): A process involving the assimilation of carbon from the atmosphere.

Succession: The change from one biologic community to another over time.

Sustainability: The ability of natural resources to provide ecologic, economic, and social benefits for present and future generations.

Weathering: The process by which rocks are broken down into minerals usable by plants.

Food chains explain simple feeding relationships between organisms (e.g., willow saplings are eaten by snowshoe hares, which are eaten by eastern timber wolves). Since most organisms feed on a variety of different things, food chains are often too simple to represent the variety of relationships that exist. As different feeding relationships are added, food chains turn into food webs that illustrate the variety of food sources that organisms depend on (e.g., snowshoe hares eat grasses, willows, berries, conifer buds, aspen bark, etc.).

The feeding relationships between organisms are a component of the cycling of matter in ecosystems. Matter is cycled through the biotic and abiotic components of ecosystems. Matter consists of elements and makes up all the substances in an ecosystem. Elements such as calcium can be moved from rocks to plants, to animals, to soil, and to water. The movement or cycling of matter is dependent on a variety of natural processes, including deposition, assimilation, erosion, mineralization, decomposition, carbon sequestration, and competition for nutrients by organisms.

The elements and elemental compounds essential to plant and animal life are called nutrients. Nutrients known to be essential to plants include hydrogen, oxygen, carbon, nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, boron, copper, iron, manganese, molybdenum, and zinc. Nutrients essential to animals include proteins, carbohydrates, fats and oils, and a variety of minerals and vitamins found in plant matter.

Aldo Leopold

Aldo Leopold was born in Burlington, Iowa, in 1887. He received a Master of Forestry from Yale University in 1909, and after earning his degree, went on to serve for 19 years in the U.S. Forest Service. Leopold worked in the Southwest until he was transferred in 1924 to the Forest Products Lab in Madison, Wisconsin. In 1933, he was appointed Professor of Game Management in the Agricultural Economics Department at the University of Wisconsin-Madison. Leopold taught at the University of Wisconsin until his death in 1948.

Aldo Leopold is best known as the author of *A Sand County Almanac* (1949), a volume of sketches and essays that helped define an ecological attitude toward people and the land. The notion of a land ethic was rooted in Leopold's perception of the environment. He was an internationally respected scientist and conservationist instrumental in formulating policy, promoting wilderness, and building ecological foundations for forestry and wildlife ecology.

Aldo Leopold died in 1948 but left an amazing legacy. In 1930, he served as chair of the Game Policy Institute, which developed the American Game Policy. He assisted in the foundation of both the Wilderness Society and the Wildlife Society. Aldo Leopold also left us with one of the most eloquent and definitive collections of environmental writing in American history.

Odyssey Concepts

In Leopold's essay "**Odyssey**," three main concepts emerge: change, **interconnectivity**, and **sustainability**. When *A Sand County Almanac* was first published, the importance of these concepts was not widely recognized. Today, these concepts are widely studied and their significance understood. This occurred, in part, because writers like Leopold helped people develop these concepts for themselves by providing real life examples in interesting, meaningful, and personal stories.

Throughout the essay "Odyssey," the reader repeatedly encounters the concept of change in nature. Describing change in geologic terms, Leopold writes, "In the flash of a century, the rock decayed." He demonstrates the resilience of natural systems to disturbance as he explains, "But the prairie had two strings to its bow. Fires thinned its grasses, but they thickened its stand of leguminous herbs…" He emphasizes natural change and death when he states, "The beaver starved when his pond dried up during a bitter frost." He explains the cycles of prairie life when he says, "The only certain truth is that its creatures must suck hard, live fast, and die often, lest its losses exceed its gains." He introduces the human element of change as he concludes the short story, "… a new animal had arrived and begun redding up the prairie to fit his own notions of law and order."

Leopold strings the concept of interconnectivity throughout "Odyssey." Describing the life of an atom, he writes, "He helped build a flower, which became an acorn, which fattened a deer, which fed an Indian, all in a single year." He describes the web of life as "the bloodstream of the land." And he illustrates the connection that organisms have even after death when he writes, "The dying fox sensed the end of his chapter in foxdom, but not the new beginning in the odyssey of an atom."

Though Leopold does not use the term "sustainability" in his essay, he provides us with examples of the fundamental principles used to define the term. He refers to the resilience of natural systems and their ability to adapt to disturbance when he writes, "Thus the prairie savings bank took in more nitrogen from its legumes than it paid out to its fires. That the prairie is rich is known to the humblest deer mouse; why the prairie is rich is a question seldom asked in all the still lapse of ages." He gives an example of ecosystem self-regulation (nature's balance sheet) when he writes, "For every atom lost to the sea, the prairie pulls another out of the decaying rocks." He stresses the importance of biodiversity in long-term ecosystem stability as he states, "The old prairie lived by the diversity of its plants and animals, all of which were useful because the sum total of their co-operations and competitions achieved continuity."

Throughout the essay, Leopold discusses the human tendency to simplify and take a short-term perspective when he writes, "He failed to see the downward wash of over-wheated loam, laid bare in spring against the pelting rains." Finally, he refers to growth and expansion and the problems that they present to sustainability when he writes, "But he used his alfalfa, and every other new weapon against wash, not only to hold his old plowing, but also to exploit new ones which, in turn, needed holding."

> "Ethical behavior is doing the right thing when no one else is watching — even when doing the wrong thing is legal."
>
> *Aldo Leopold*

PROCEDURE

Introduction – Aldo Leopold

1. Have students raise their hand if they have heard of Aldo Leopold. Ask them to keep their hand raised if they have read anything he has written. If there are any students who have read Leopold, have them explain what he writes about. Guide the conversation to include nature, conservation, and society.

2. Tell the class that Aldo Leopold is one of the most famous North American nature writers, and his most acclaimed book, *A Sand County Almanac*, is written about his life on a rural homestead in Wisconsin. Today, they will read a short essay found in *A Sand County Almanac* and develop a similar science-based creative writing about forest ecosystems.

Activity 1 – Ecosystem Function Brainstorm

1. Tell students that they will be reading Aldo Leopold's "Odyssey." Before they read "Odyssey," they should have a good understanding of what forest ecosystems are, the functions they maintain, and the natural processes that occur in them. Begin a brainstorming session to define the word "ecosystem." Further refine the definition to describe a forest ecosystem. Use the students' ideas to form a clear definition and write it on the board. *(Ecosystem: An area that contains organisms [e.g., plants, animals, bacteria] interacting with one another and their nonliving environment [e.g., climate, soil, topography]. Forest: An ecosystem characterized by a dominance of tree cover.)*

2. Once forest ecosystem is defined, explain to the class that different ecosystems can have very different communities of plants and animals in them. Have students think of two very different terrestrial ecosystems (e.g., one in the tropical rainforest biome and one in the desert biome) and list the different characteristics of each (e.g., moisture, temperature, type of vegetation, etc.) and the types of animals and plants that might be found in each (cactus vs. tree, armadillo vs. orangutan, etc.).

   Once students have differentiated the two ecosystems, explain that even though ecosystems have different species composition and different species relationships, every ecosystem maintains specific functions that keep organisms alive.

   Ask students to list things that organisms need to stay alive. *(Plants need sunlight, nutrients, air, space, and water. Animals need food, shelter, air, space, and water.)*

3. Lead a discussion that helps students distinguish between ecosystem functions and natural processes, and form a list of each. To best organize the discussion, divide the board into three vertical sections.

   Tell students that an ecosystem function is defined as a system (a collection of interrelated natural processes) that supports all of the life in an ecosystem (allows organisms access to food, water, space, nutrients, sunlight, shelter). Write one of the following three ecosystem functions in the top of each the three sections of the board:
   - The fixation of energy through photosynthesis
   - The flow of energy through food webs
   - The cycling of matter

4. Once the functions are listed on the board, ask students to define each one and to explain why the three functions are essential to living organisms.

   Facilitate the discussion by asking students why organisms (e.g., animals, plants, people) need energy. *(Organisms need energy to power all of the body's processes. In humans, these processes include blood circulation, respiration, and body movement.)* Ask students where the energy comes from. *(From food. More specifically from the carbohydrates [e.g., sugar], proteins, and fats found in plants and animals.)* Ask students where the energy in food comes from. *(All of the energy comes from the process of photosynthesis. Plants perform this process and change the electromagnetic energy of the sun into chemical energy that is embodied in sugars. The sugars produced during photosynthesis are modified by plants and animals for different uses — creating more complex forms called proteins and fats.)* Ask students what would happen without plants, or more specifically, without photosynthesis. *(Energy would not be available for all of the other organisms in ecosystem, including humans!)*

   Help students define the flow of energy by asking if the producers (plants and algae) have all the energy, how does the energy get to other organisms. *(Herbivores and omnivores eat green plants, and carnivores eat the herbivores, etc.)* Ask students what the feeding relationships are called. *(Food webs.)* Tell students that ecosystems maintain complex feeding relationships that distribute food energy to organisms through food webs.

"I am glad I will not be young in a future without wilderness."

Aldo Leopold

> "We all strive for safety, prosperity, comfort, long life, and dullness."
>
> *Aldo Leopold, A Sand County Almanac*

Finally, help students discuss the cycling of matter by asking if producers (plants) get everything that they need from the sun. *(No, plants need nutrients.)* Ask students how plants get nutrients. *(Nutrients are found in the atmosphere and soil. Trees absorb many nutrients, such as phosphorous, potassium, and calcium, through their roots as minerals are weathered from rocks and organic matter is decomposed. They get other elements, such as carbon, from the carbon dioxide in the atmosphere.)* Ask students how animals get nutrients. *(They eat plants, animals, and other organisms. They assimilate the nutrients during digestion.)* Tell students that all of the processes that make nutrients available to plants and animals are part of the cycling of matter.

5. Once the students are comfortable with the three ecosystem functions, ask them if they know the difference between an ecosystem function and a natural process. Explain that natural processes are the biological, chemical, and physical interactions that occur between the components of an ecosystem. Ecosystem functions involve many different processes. For example, the cycling of matter is an ecosystem function that involves the decomposition of organic matter and the weathering of minerals, both of which are natural processes. Other natural processes include respiration, assimilation, growth, mineralization, erosion, nitrogen fixation, predation, herbivory, competition, reproduction, succession, migration, carbon sequestration, and adaptation.

6. Divide students into pairs and hand each pair two of the process cards found on Teacher Page ***1, Natural Process Cards***.

   Refer to the three ecosystem functions on the board (the fixation of energy, the flow of energy, the cycling of matter). Tell the student pairs that they will need to read the definition of their term to the class, match their natural process to one of the three ecosystems functions, and explain how it is related. Groups with the same card should approach the board together and work out any differences in front of the class.

7. Guide the class through following example:

   Who has the card "carbon sequestration?" What is the definition of carbon sequestration? *(The capture and storage of carbon dioxide from the atmosphere into biotic [e.g., trees] or abiotic [e.g., coal] pools of carbon.)* What is carbon used for in a tree? *(It is the main component of cellulose [wood].)* Which function depends on the natural process of carbon sequestration? *(The cycling of matter.)* Does carbon provide energy? *(No. Carbon is matter, an element that trees need to survive.)* How is the process of carbon sequestration related to the cycling of matter in an ecosystem? *(As trees convert solar energy into chemical energy [photosynthesis], they also absorb carbon from the atmosphere [they grow]. A tree's biomass is primarily carbon in the form of cellulose [wood]. As organisms eat the plant matter or wood from a tree, they take and use the carbon. As trees and animals die, the carbon in their bodies is added to the soil. Insects, fungi, and microorganisms decompose the plant and animal material, releasing the carbon back to the atmosphere.)*

   Tell students that some processes are part of more than one ecosystem function.

"We grieve only for what we know."

Aldo Leopold

8. After you have helped the students write the process in the correct place(s) on the board and explain why it is an important part of the ecosystem function, have the rest of the class attempt to do the same with their cards. Once students are ready, have them raise their hands and proceed one at a time.

   The relationships between natural processes and ecosystem functions should be similar to the following:
   - **The Fixation of Energy:** Photosynthesis, assimilation
   - **The Flow of Energy Through Food Webs:** Assimilation, competition, decomposition, predation/herbivory, migration, reproduction
   - **The Cycling of Matter:** Carbon sequestration, mineralization, decomposition, erosion, nitrogen fixation, weathering

9. Once the list is complete, tell students to copy it down because they can use it when writing their short stories.

10. Hand out Student Pages ***1A-B, Aldo Leopold's "Odyssey,"*** to each student in the class, and tell them they are going to be reading the essay as a homework assignment. Have students define the word "odyssey" *(an extended wandering or journey)* and explain that the story describes the extended journey of an atom through an ecosystem.

    NOTE: Since the story is short, you may also wish to give students 10 minutes to read the essay individually or out loud at the end of this activity.

Activity 2 - Odyssey

1. After students have read "Odyssey," have them work in small groups to map the odyssey of atom X and atom Y (you may wish to have some groups do X and others do Y). Have the groups identify, in paragraph or diagram form, in which living and nonliving things X resided and describe how the atom got there (identify the natural process). Once the groups are finished, have them explain parts of their interpretation to the rest of the class.

2. After students have described the odyssey of atom X, lead a discussion on what the students thought about the way Aldo Leopold presented it. You may wish to ask the following questions:
   - What was different about your brief description of the atom's journey and Leopold's?
   - Did you think the essay was interesting?
   - What did the essay make you think about?
   - Did you understand everything?
   - Did it leave any questions unanswered?
   - Do you think the essay is scientifically and historically accurate?
   - Was it too technical to understand?

   Further the discussion by asking about the content of the essay.
   - What ecosystem(s) did Leopold write about?
   - What processes did Leopold write about?
   - What concepts or themes are emphasized in the writing?

   As students try to find concepts and themes in the writing, put all of their ideas on the board. Guide them to the following concepts: change, interconnectivity, and sustainability. Use a few examples from the writing that illustrate the concepts.

   Examples for each concept are found in the section "Odyssey Concepts" of the Background Information.

Activity 3 – Forest Ecosystem Research

1. Ask students if it is apparent that Aldo Leopold had an in-depth understanding of ecosystems he was writing about. *(Yes.)* Tell students that during the next few class periods, they will be preparing to write an essay similar to Aldo Leopold's "Odyssey." They will write about the odyssey of an atom through a forest ecosystem.

   Ask students what kind of preparation they will need before writing the essay. *(They will need to study the natural history, ecology, and human aspects of forest ecosystems.)* Tell students that they will do research about three distinct forest ecosystems.

2. Write the following forested ecosystem names on the board: **Oak Savanna**, **Forested Wetland**, and **Northern Hardwood Forest**.

   Help students discuss what they know about each of the ecosystems. Have them make inferences into what type of animals live there and where the ecosystems are located in Wisconsin. Have students attempt to compare and contrast the environmental conditions of each forest.

3. Once all three ecosystems are discussed, divide the class into three large groups. Tell the groups that each of them will research one of the ecosystems listed. Assign groups to work on a specific ecosystem and hand all of the students in each group a copy of the corresponding student pages – either Student Pages ✐***2A-B, Forest Ecosystem Profile: Oak Savanna***, OR ✐***3A-B, Forest Ecosystem Profile: Forested Wetland***, OR ✐***4A-B, Forest Ecosystem Profile: Northern Hardwood Forest***.

   Give students 10 minutes to read their profile and to highlight information that they feel will be important when developing an essay similar to Leopold's "Odyssey." Remind them that the story uses the concepts of interconnectivity, change, and sustainability.

4. Ask the class if the profiles are missing any information that they might need. *(They have a section on change and sustainability, but are missing any mention of interconnectivity.)* Ask students to list ways that they think that forest ecosystems are connected to other ecosystems. Help them come up with the following ideas:
   - Many animals move from ecosystem to ecosystem and depend on forest ecosystems for different parts of their life cycle.
   - Many ecosystems depend on water resources that come from forest ecosystems.
   - Fire can start in a forest ecosystem and move to other ecosystems.
   - Forest ecosystems can influence the climate patterns and moisture levels of neighboring ecosystems.
   - Soil erosion from an ecosystem can affect the water quality and landscape characteristics of neighboring ecosystems.

5. Tell the large groups that to finish their profile, they will need to do some research outside of class. Have each student find a partner within their large group to do research with. Explain that each student pair will do research on one specific aspect of ecosystem interconnectivity – food webs. During their research, each student pair should look for the following information:
   - Animals and plants common to their ecosystem
   - Feeding relationships between the animals and plants in their ecosystem
   - Migration patterns, feeding habits, and other life cycle characteristics that connect animals in their ecosystem to other ecosystems

   Tell students that they can use the internet, classroom resources, school library, and public library to find information. Students should bring copies of the resources to class. Discuss the importance of citing resources when doing research. Explain to students the way you expect resources to be cited for this project.

6. To better facilitate student research, you may wish to give each student pair a copy of Teacher Page ***2, Habitat and Wildlife***. They can use the general habitat and wildlife description about their ecosystem to get started with their research.

   You may also wish to have them brainstorm some good internet search terms. The list should include the following: "Wisconsin wildlife," "animal habitat," "wildlife and habitat and Wisconsin," "forest ecosystems in Wisconsin," "forested wetlands and Wisconsin," "oak savannas and Wisconsin," "northern hardwoods and Wisconsin."

7. Once the student pairs understand their research assignment, have the large groups discuss and decide their research strategy. Tell the large groups that they will work together and use all of the research from each student pair to form food webs that describe the wildlife relations in their ecosystem.

   Tell them that it might be wise to divide the work so that students do not bring the same information to class. You may wish to give the large groups the following suggestions:
   - **Divide Research by Animal Group:** Predatory birds, migratory birds, predatory mammals, large mammals, small mammals, reptiles, amphibians, detritivores, introduced species, etc.
   - **Divide Research by Location:** Internet, classroom resources, school library (books, magazines, digital), public library (books, magazines, digital)

   Once the large groups have their research plan, answer any questions they have about research methods. Tell students that they will most likely come across a lot of "generic" wildlife information that is not specific to their ecosystem. Explain that a good strategy would be to find an organism that uses their ecosystem as habitat, and further research the habitat needs and feeding relationships of that organism.

NOTES

Activity 4 – Forest Ecosystem Profiles

1. Once the groups have done their research, have them reconvene to review their findings and to form food webs for their ecosystem. Tell the class that their large groups are going to work together to review the resources, identify important information, and develop the food webs that explain the wildlife and habitat relationships in their ecosystem.

   Hand each student pair a copy of Student Page ✐ ***5, Food Webs***. Review the food web shown on the page, emphasizing how the relationships are identified and explained. Tell the class that each large group should produce two to three food webs similar to the example.

2. Direct students to the second part of the student page, “Group Assignment.” Tell the students that to complete the assignment, each large group will need to assign the following roles to its members:
   - **Group Leader (1 Student):** Lead large group discussions and help the group agree on important information to include in the food webs.
   - **Organizer (1-2 Students):** Highlight and take notes about the information that will be included in the food webs, create resource citation page.
   - **Web Designer (2-3 Students):** Draw the food web diagrams using the information gathered by the organizer.
   - **Web Profiler (2-3 Students):** Write a short paragraph describing each food web.
   - **Presenter (1-2 Students):** Use the food web diagrams and description to do a five-minute presentation to the rest of the class.

   Tell the class that each of the small groups should present their resources to the other members of their large group. The group leader should help the large group review and discuss each of the materials and identify the important information in each.

   Once the information is identified, web designers and web profilers should depict the food webs in a drawing and describe them in writing. When all the work is complete, presenters from each group should use their diagrams to explain the food webs in their ecosystem to the rest of the class.

3. Before beginning the presentations, highlight some main points in each of the ecosystem profiles. As each group presents their food webs, correlate the wildlife and habitat to different aspects of the ecosystem. Emphasize the points by asking questions and continuing discussion.

   Once the presentations are finished, help students compare and contrast some of the environmental conditions, major natural processes, wildlife, and human elements of each of the ecosystems. You can use Teacher Page ***2, Habitat and Wildlife*** to verify the students’ information.

> “It is part of wisdom never to revisit a wilderness,
> for the more golden the lily,
> the more certain that someone has gilded it.”
>
> ✦ *Aldo Leopold, A Sand County Almanac and Sketches Here and There* ✦

Conclusion – Group Odyssey

1. After the discussion is complete, arrange the room so that the class can sit in a large circle. Be sure that students are segregated by group.

2. Explain to the class that just like in Leopold's "Odyssey," they are going to describe the journey of an atom. Each student will contribute a part to the story. The story will move from student to student until it completes the full circle.

   Tell students that the first person will describe where the atom is (e.g., as part of a beaver's front teeth), what happens to it (e.g., the teeth erode as the beaver uses them to fell trees), and where it ends up (a mushroom grows on the wood chips and assimilates the atom). As the student identifies the beginning location, the natural process, and the destination of the atom, be sure he or she can explain how it happens and how it is characteristic of the ecosystem. The atom's journey must be realistic.

   The student next in line will need to invent what happens to the atom and where it ends up. This continues around the circle.

   When the story is passed to a student with a different ecosystem profile, an interconnection needs to be identified and used. This is very important since the character of the story should change as the atom moves to a different ecosystem. Play the role of the facilitator by clarifying points, describing natural processes, and distinguishing the ecosystems from one another.

3. Start the circle as described above and have each student write down where the atom starts, what happens to it, and where it ends up during his or her turn. This first round will form the structure of the story.

4. After the first round is completed, tell students that they have created the structure of a story that is plausible, based in science and ecology. Ask students what they will have to do to make it into an essay like Leopold's "Odyssey." *(They need to make it readable, interesting, and creative. They need to give the reader a reason to continue reading by relating it to their life.)*

   Give students a few minutes to write a paragraph about their piece of the story. Tell them that they need to use the same structure as they did in the first round but should expand on their idea. Ask them to use creative writing element that make the journey of the atom come to life for the reader. They can further explain the situation; smells, colors, time span, hidden meanings, etc.

   You may wish to give students this example:

   > *X rested in the wood chips at the base of a fallen aspen tree. The beaver had been industrious. It had worn away a good bit of its teeth during the last week, allowing atom X a brief taste of freedom after the months trapped in the tooth's prison-like structure. In a matter of weeks, a soft breeze and gentle rain brought a mushroom spore to the surface of the newly exposed wood. It grew quickly, incorporating atom X into its cap and preparing to continue the cycle of life and death with which X was so familiar.*

5. Once the students have their paragraphs ready, start the second round of the circle by having the students read their paragraphs one after the other. Once the story is read, allow students to discuss what they liked and didn't like, if it was realistic, and what they learned.

SUMMATIVE ASSESSMENT

Tell students to use the information they learned about forest ecosystems and the development of science-based creative writings to create their own essay (one to two pages) similar to Aldo Leopold's "Odyssey." Have them, like Leopold, tell the story from the atom's perspective and emphasize the concepts of change, interconnectivity, and sustainability.

You may want to allow the students to be creative when choosing the location and time they choose to write about. Ideas might include forests of the past, urban environments, the moon, and ecosystems of the future.

Explain to students that the key to writing a good science-based, creative essay is to be scientifically accurate, while at the same time, use common sense, broadly understood relationships, and well-known examples that people can relate to. The essay should be easy to understand, interesting, and help the reader better understand the concepts of change, interconnectivity, and sustainability.

A sample of a student essay can be found on the following page (page 30). You may wish to share this with students to help generate ideas.

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SAMPLE STUDENT ESSAY

The Adventures of Lewis

From an atom's point of view, the world is a big place. There are many things and places to see.

Lewis found himself in a leaf, resting atop a majestic black oak. He had been there since spring, but he could feel it getting colder and he knew he would be on the move again. A couple of months later, he broke free and was swept away in a gust.

After the snow had come and gone, he was part of the soil and became a patch of ladder lichen. Lewis went straight to the top of one of the lobes as he did in the black oak, but this time he was eaten by a deer mouse.

After finishing some more of the lichen, the deer mouse returned to her hole only to find it overrun with a snake that had eaten her three offspring. She turned and ran, but was no match for the quickness of the snake. Soon, Lewis found himself part of the snake's skin.

Three weeks later, Lewis was shed along with the skin. The skin then decomposed and turned to rich soil that then became the bed of a small creek. Lewis rode the current for many miles until the rich soil was washed ashore, and covered some seeds that sprouted into water reeds.

When the reeds were full-grown, they stood about four feet tall. One day, Lewis could feel something tickling him but couldn't figure out what it was. He then found himself in the stomach of a caterpillar. After the reed meal, the caterpillar hung itself upside down, and turned into a chrysalis. Weeks later, it had transformed into a monarch butterfly. As summer was ending, the monarch, with thousands of its friends, traveled south to Mexico. Lewis and the monarch never made it. During a strong windstorm in northern Texas, the monarch lost control and was thrown into the side of a cliff.

The monarch decomposed and Lewis sank deeper into the ground until he found some graphite. He became friends with the other atoms so he bonded with them.

Many years later, he was dug up with all of his friends, and put on a truck. Together, they went to a factory where they were ground up and put into a mold. Then they were pressed together and wrapped in a wooden blanket. Lewis and the rest of the graphite-filled wooden rods were packaged and sent to the store. I picked up Lewis and his friends and brought them to school. So, Lewis, who began as a leaf on an oak tree, ended up in the last period on this page.

NATURAL PROCESS CARDS

Photosynthesis The process by which plants convert the electromagnetic energy of the sun into chemical energy usable by other organisms.	**Reproduction** The process by which organisms produce offspring.	**Herbivory** The consumption of living plant material.
Weathering The process by which rocks are broken down into minerals usable by plants.	**Mineralization** The conversion of an element from an organic to an inorganic form; combustion, the act of burning, is a very rapid form of mineralization.	**Decomposition** The breakdown of organic matter into simple compounds available for use by plants.
Carbon Sequestration The capture and storage of carbon dioxide from the atmosphere into biotic (e.g., trees) or abiotic (e.g., coal) pools of carbon.	**Assimilation** The incorporation of energy and nutrients into the bodies of plants or animals.	**Nitrogen Fixation** The process by which atmospheric nitrogen is made available for use by plants in an ecosystem.
Competition The struggle that exists among organisms to acquire finite resources (e.g., light, space, nutrients, water).	**Erosion** The wearing away of the land surface by rain, running water, wind, ice, gravity, or other natural or human forces.	**Migration** The repeated movement of a population of organisms from one ecosystem to another.

HABITAT AND WILDLIFE

OAK SAVANNA

Probably the most well-known wildlife species associated with savanna is the American bison. Bison in Wisconsin were killed off by hunters in the 1800s. In the Midwest, they are currently classified as extirpated, meaning that there are no wild populations. In Wisconsin, all of the large mammals that once lived in the savannas (namely the elk, lynx, and bobcat) have shared similar histories; yet, in recent years, the bobcat shows signs of recovery.

The areas of savanna that remain provide habitat for the coyote, fox squirrel, red fox, woodchuck, and striped ground squirrel. They provide crucial habitat for the sharp-tailed grouse, swallow-tailed kite, Karner blue butterfly, and the greater prairie chicken. Many important wildlife plants are found in savannas, such as huckleberry and blueberry. Savannas are also home to some endangered plants, including wild blue lupine, sand flameflower, and goat's rue.

FORESTED WETLAND

In lowland broadleaf forests, the overstory is partially open so that direct sunlight often reaches shrubs and plants. The open layers are used by birds such as flycatchers to catch insects. Standing and fallen dead trees supply abundant crevices and cavities for raccoons and wood ducks. They also provide perfect perches for the barred owl that waits patiently to swoop down and feed on an unsuspecting mouse, frog, bird, or snake. Dense clumps of shrubs, such as dogwood, willow, and alder, provide cover for small birds, like the veery, and mammals, such as the woodland jumping mouse. A rich assortment of ferns, sedges, and grasses grow in the cool moist ground layer and provide habitat for heat- and moisture-sensitive species, such as the four-toed salamander and the wood frog. The grass is first to green-up in spring and is heavily used by black bears.

There are two distinct varieties of lowland conifer forest: black spruce bogs and white cedar swamps. Few animals make their homes in spruce bogs, and those that do, capitalize on the limited food available. The spruce grouse feeds on conifer needles and the leaves of healthy plants. Songbirds (like warblers, kinglets, and chickadees) and squirrels pry seeds out of the tiny spruce cones and the three-toed woodpecker chisels in dead trees for insect larvae. The great grey owl scans the sphagnum moss for rodents and can plunge in up to 18 inches below the bog surface to feed.

White cedar swamps are known to be mild environments in the winter because the dense cedar canopy provides protection from wind and shelter from snow. Wildlife finds not only shelter, but plenty to eat. White-tailed deer strip white cedar branches clean, and porcupines often eat bark from the trunks. Snowshoe hares are prized prey for the great horned owl and eastern timber wolf. Many insect-eating songbirds, like the northern parula, can be found in large numbers when insects are present.

NORTHERN HARDWOOD FOREST

Some of the most well-known wildlife species in northern hardwood forests are the northern goshawk, ruffed grouse, neotropical birds (such as the blue-headed vireo), the fisher, black bear, redneck salamander, and the ringneck snake. Wildlife species have both deciduous and coniferous trees at their disposal. The southern flying squirrel will often find habitat in birch trees next to the ruby-crowned kinglet that depends on coniferous trees, like spruce, for its needs.

Neotropical birds migrate each spring from tropical areas in Central America, South America, and the Caribbean. They reproduce in the northern forests and return to the tropics as winter approaches. The birds depend on habitat in both regions to survive. The fisher, a type of weasel, is one of the top carnivores in northern hardwood forests. Since the fisher needs about one and a half pounds of food a day, it has become a very efficient predator of snowshoe hares, squirrels, mice, shrews, game birds, and even porcupines. Not long ago, it was almost impossible to see a fisher in the wild, but thanks to conservation and reintroduction efforts, the mammals have made a comeback in many areas.

ALDO LEOPOLD'S "ODYSSEY"

X had marked time in the limestone ledge since the Paleozoic seas covered the land. Time, to an atom locked in a rock, does not pass.

The break came when a bur oak root nosed down a crack and began prying and sucking. In the flash of a century the rock decayed, and X was pulled out and up into the world of living things. He helped build a flower, which became an acorn, which fattened a deer, which fed an Indian, all in a single year.

From his birth in the Indian's bones, X joined again in chase and flight, feast and famine, hope and fear. He felt these things as changes in the little chemical pushes and pulls that tug timelessly at every atom. When the Indian took his leave of the prairie, X moldered briefly underground, only to embark on a second trip through the bloodstream of the land.

This time it was a rootlet of bluestem that sucked him up and lodged him in a leaf that rode the green billows of the prairie June, sharing the common task of hoarding sunlight. To this leaf also fell an uncommon task: flicking shadows across a plover's eggs. The ecstatic plover, hovering overhead, poured praises on something perfect: perhaps the eggs, perhaps the shadows, or perhaps the haze of pink phlox that lay on the prairie.

When the departing plovers set wing for the Argentine, all the bluestems waved farewell with tall new tassels. When the first geese came out of the north and all the bluestems glowed wine-red, a forehanded deer mouse cut the leaf in which X lay, and buried it in an underground nest, as if to hide a bit of Indian summer from the thieving frosts. But a fox detained the mouse, molds and fungi took the nest apart, and X lay in the soil again, foot-loose and fancy-free.

Next, he entered a tuft of side-oats grama, a buffalo, a buffalo chip, and again the soil. Next, a spiderwort, a rabbit, and an owl. Thence a tuft of sporobolus.

All routines come to an end. This one ended with a prairie fire, which reduced the prairie plants to smoke, gas, and ashes. Phosphorus and potash atoms stayed in the ash, but the nitrogen atoms were gone with the wind. A spectator might, at this point, have predicted an early end of the biotic drama, for with fires exhausting the nitrogen, the soil might well have lost its plants and blown away.

But the prairie had two strings to its bow. Fires thinned its grasses, but they thickened its stand of leguminous herbs: prairie clover, bush clover, wild bean, vetch, lead-plant, trefoil, and Baptisia, each carrying its own bacteria housed in nodules on its rootlets. Each nodule pumped nitrogen out of the air into the plant, and then ultimately into the soil. Thus the prairie savings bank took in more nitrogen from its legumes than it paid out to its fires. That the prairie is rich is known to the humblest deer mouse; why the prairie is rich is a question seldom asked in all the still lapse of ages.

Between each of his excursions through the biota, X lay in the soil and was carried by the rains, inch by inch, downhill. Living plants retarded the wash by impounding atoms; dead plants by locking them to their decayed tissues. Animals ate the plants and carried them briefly uphill or downhill, depending on whether they died or defecated higher or lower than they fed. No animal was aware that the altitude of his death was more important than his manner of dying. Thus a fox caught a gopher in a meadow, carrying X uphill to his bed on the brow of a ledge, where an eagle laid him low. The dying fox sensed the end of his chapter in foxdom, but not the new beginning in the odyssey of an atom.

ALDO LEOPOLD'S "ODYSSEY"

An Indian eventually inherited the eagle's plumes, and with them propitiated the Fates, whom he assumed had a special interest in Indians. It did not occur to him that they might be busy casting dice against gravity; that mice and men, soils and songs, might be merely ways to retard the march of atoms to the sea.

One year, while X lay in a cottonwood by the river, he was eaten by a beaver, an animal that always feeds higher than he dies. The beaver starved when his pond dried up during a bitter frost. X rode the carcass down the spring freshet, losing more altitude each hour than heretofore in a century. He ended up in the silt of a backwater bayou, where he fed a crayfish, a coon, and then an Indian, who laid him down to his last sleep in a mound on the river bank. One spring an oxbow caved the bank, and after one short week of freshet X lay again in his ancient prison, the sea.

An atom at large in the biota is too free to know freedom; an atom back in the sea has forgotten it. For every atom lost to the sea, the prairie pulls another out of the decaying rocks. The only certain truth is that its creatures must suck hard, live fast, and die often, lest its losses exceed its gains.

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It is the nature of roots to nose into cracks. When Y was thus released from the parent ledge, a new animal had arrived and begun redding up the prairie to fit his own notions of law and order. An ox team turned the prairie sod, and Y began a succession of dizzy annual trips through a new grass called wheat.

The old prairie lived by the diversity of its plants and animals, all of which were useful because the sum total of their co-operations and competitions achieved continuity. But the wheat farmer was a builder of categories; to him only wheat and oxen were useful. He saw the useless pigeons settle in cloud upon his wheat, and shortly cleared the skies of them. He saw the chinch bugs take over the stealing job, and fumed because here was a useless thing too small to kill. He failed to see the downward wash of over-wheated loam, laid bare in spring against the pelting rains. When soil-wash and chinch bugs finally put an end to wheat farming, Y and his like had already traveled far down the watershed.

When the empire of wheat collapsed, the settler took a leaf from the old prairie book; he impounded his fertility in livestock, he augmented it with nitrogen-pumping alfalfa, and he tapped the lower layers of the loam with deep-rooted corn.

But he used his alfalfa, and every other new weapon against wash, not only to hold his old plowing, but also to exploit new ones which, in turn, needed holding.

So, despite alfalfa, the black loam grew gradually thinner. Erosion engineers built dams and terraces to hold it. Army engineers built levees and wing-dams to flush it from the rivers. The rivers would not flush, but raised their beds instead, thus choking navigation. So the engineers built pools like gigantic beaver ponds, and Y landed in one of these, his trip from rock to river completed in one short century.

On first reaching the pool, Y made several trips through water plants, fish, and waterfowl. But engineers built sewers as well as dams, and down them comes the loot of all the far hills and the sea. The atoms that once grew pasque-flowers to greet the returning plovers now lie inert, confused, imprisoned in oily sludge.

Roots still nose among the rocks. Rains still pelt the fields. Deer mice still hide their souvenirs of Indian summer. Old men who helped destroy the pigeons still recount the glory of the fluttering hosts. Black and white buffalo pass in and out of red barns, offering free rides to itinerant atoms.

FOREST ECOSYSTEM PROFILE: OAK SAVANNA

GENERAL ECOSYSTEM DESCRIPTION

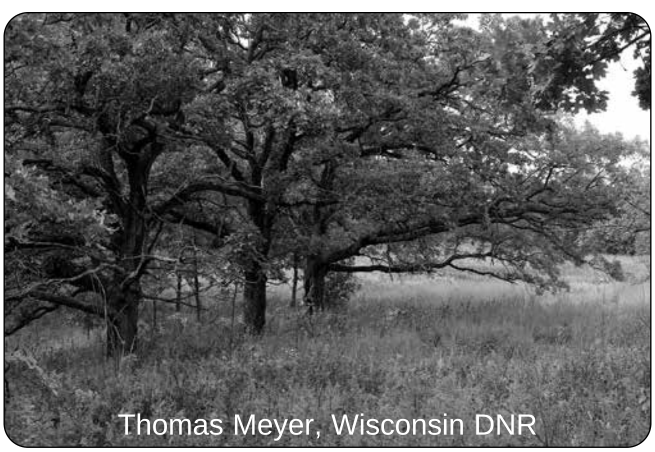
Oak savannas in the Great Lakes region occur in Minnesota, Wisconsin, Michigan, Iowa, Illinois, Indiana, and Ohio. This ecosystem is characterized by dry soils, limited moisture, and periodic wildfire. Oak savannas generally contain an understory of prairie grasses and plants but can have a variety of different tree compositions and **structures**.

The common forest structure and tree composition for savannas is as follows:

- Oak Savanna: Widely spaced oak trees
- Oak Barren: An even-aged stand of small oak trees
- Jack Pine Barren: An even-aged stand of small jack pine trees
- Brush Prairie: Small scattered oak trees and other shrubs

In this profile, the term “savanna” is used to describe all of the above.

Savannas in Wisconsin are found on glacial landscapes (**moraines**, outwash plains, and historic lake beds) and on the more nutrient-rich soils of southwest Wisconsin. In northern Wisconsin, northern pin oak, northern red oak, and jack pine are the common trees present in savannas. In southern Wisconsin, bur oak, white oak, black oak, and Hill’s oak are common.



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CHANGE

The formation of the Rocky Mountains, beginning 60 million years ago, created climate conditions suitable for grasslands across what is now the Great Plains and into the tall grass prairies of Wisconsin. Savannas were predominantly found on the fringe of the large grassland region, but could also be found scattered throughout the area.

Savannas developed from other forest ecosystems through time due to the dry climate patterns and a variety of environmental factors. The most influential factor was periodic ground fires. Naturally occurring ground fires killed the undergrowth and small trees, leaving only widely spaced, mature fire-resistant trees. Prairie plants and grasses that were adapted to fire, like little and big bluestem, became an established component of the ecosystem.

When the first government land surveys were done in Wisconsin in the late 1800s, it was estimated that 4.2 million acres of the landscape (12.1%) could be characterized as savanna. Today only 50,000 acres remain (0.15%). Though this is a small percentage, it is considerably more than the 0.02% of the presettlement savanna that is left in the Midwest as a whole.

Most of the original savannas were logged and abandoned in the early 1900s. Loggers left behind many branches and dead trees that allowed fires to move to the crowns of remaining trees and spread to other forested areas. Many trees died due to intense wildfires. The abandoned lands were then converted to farmland, used as grazing areas for cattle, or overtopped by urban areas. In some small, scattered undeveloped areas, plant communities regenerated, but the periodic ground fires that shaped the structure and composition of the savanna were absent. Human populations suppressed wildfires to protect homes and property. The absence of fire left many of the areas to form into oak woodlands and mixed hardwood forests.

FOREST ECOSYSTEM PROFILE: OAK SAVANNA

NATURAL PROCESSES

Largely due to the influence of ground fires, savanna ecosystems cycle matter rapidly. As fires pass through the ecosystem, the chemical energy bound in the organic matter is transformed into heat energy and lost as the matter is broken down. Some minerals and nutrients are lost, but many remain in the soil and are used by the next generation of plants and trees.

Fires speed up the process of mineralization that is needed to make minerals and nutrients available to plants and trees. During normal decomposition, this process can take years, decades, and even centuries, but fire can complete this process in hours or days. Some nutrients are available to plants after fires, but much of the nitrogen is lost to the atmosphere.

Some nitrogen is replaced in the ecosystem by lightning and certain species of soil fungi, but most nitrogen is replaced by plants that have a symbiotic relationship with soil bacteria. Working with the bacteria, plants add nitrogen to the soil through the process of nitrogen fixation. The majority of plants and trees do not have the ability to fix nitrogen and can only use the nitrogen made available by nitrogen-fixing plants. The rate of plant growth is most often limited by the rate that nitrogen is fixed in the soil.

VOCABULARY

Even-aged: A group of trees that are all nearly the same age.

Moraine: A ridge or mound of boulders, gravel, sand, and clay left behind by a glacier.

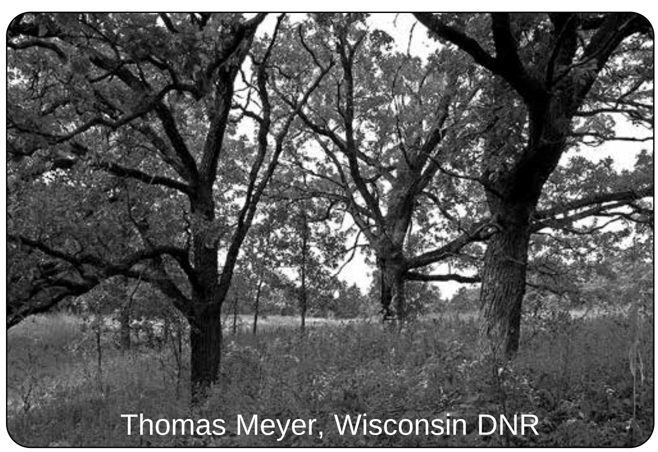
Structure: The horizontal and vertical distribution of layers in a forest, including height, diameter, and species present.

SUSTAINABILITY

Temperate savanna is one of the most endangered ecosystems in the world. It is widely understood that the restoration of oak savannas and prairie ecosystems to its presettlement areas is not feasible. The savanna, once characteristic of the midwestern U.S., is today only 0.02% of its original size.

The savannas that existed before settlement were vast expanses of open land that hosted herds of buffalo, elk, and deer in a fashion similar to the herds of zebra, gazelle, and wildebeest of the African savanna. This is not likely to be restored in today's agricultural and human landscape, yet efforts to conserve the remnant savannas, barrens, and grasslands will protect the wildlife that depend on them.

Major threats to the remnant savannas include fire suppression, development, and introduced species. Like many forested ecosystems faced with the conditions of today's populated landscape, the savannas require active forest management to maintain healthy biological communities characteristic of the ecosystem. Savannas will require controlled burns to maintain the forest structure and composition, the control of introduced species to protect native flora and fauna, and wildlife management to ensure that native wildlife populations continue to thrive.



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FOREST ECOSYSTEM PROFILE: FORESTED WETLAND

GENERAL ECOSYSTEM DESCRIPTION

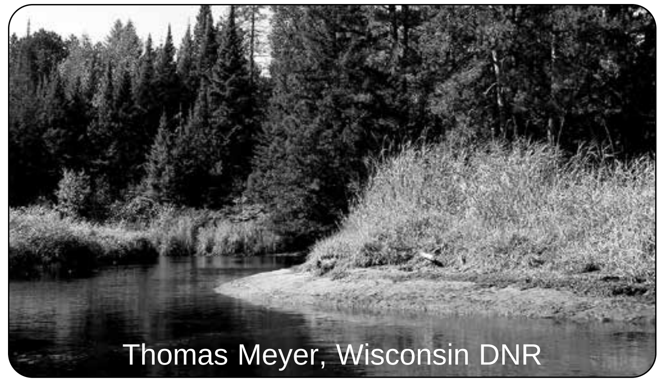
Forested wetlands are defined as forested areas that are transitional between terrestrial and aquatic systems. The water table is usually at or near the soil surface. Wetlands are referred to by many names, including mire, bog, fen, swamp, and marsh. Two distinct types of wetland forest exist in Wisconsin: the lowland conifer forest and the lowland broadleaf forest. In the lowland conifer forest, white cedar, tamarack, balsam fir, and black spruce are common. In the lowland broadleaf forest, black ash, red maple, yellow birch, and basswood trees are common.

In Wisconsin, forested wetlands are found in the low-lying areas of glaciated landscapes and alongside rivers. They are often associated with ponds, kettle lakes, and streams. They support unique plant and animal communities, help regulate water levels, and keep waterways free of sediment and other pollutants.

CHANGE

Although forested wetlands covered much of the Wisconsin landscape after the glaciers receded 10,000 years ago, the majority of them supported only scattered, stunted trees. In most places in Wisconsin, the water table was too high to allow tree growth. A large proportion of the total original wetland area has remained without trees, but in many areas the water table has gradually lowered, allowing for the expansion of forested wetlands across the state.

During the period from 1830 to 1890, logging and settlement activities began to drastically alter the northern forested regions of Wisconsin. Prior to 1900, white and red pines were the prized tree species for many commercial loggers. Since these species were found in upland forests, forested wetlands were not severely affected until sometime after 1900. By the early 1900s, as the supply of white and red pine were diminished,



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demand for white cedar fence posts, railroad ties, and utility poles increased. Black spruce was cut as a substitute for white pine, and tamarack was cut for fence posts and log cabin construction.

Today, forested wetlands are used for timber and fiber products, hunting, fishing, trapping, recreation, and sanctuaries for plants and wildlife. Over the last half century, the majority of forested wetlands in Wisconsin have been logged and some have been converted to agricultural or urban land use.

NATURAL PROCESSES

Wetlands are among the most important and biologically diverse parts of forest ecosystems. They support a diversity of plants and wildlife, and they link aquatic and terrestrial ecosystems. Forested wetlands maintain shoreline stability, stream temperature, and water quality. They store water, provide nutrient and food input into aquatic systems, and provide habitat for many species of fish, mammals, birds, reptiles, amphibians, and insects.

Trees grow slowly in wetlands compared to other forest ecosystems in Wisconsin. Most wetland soils are submerged under water for most or part of the year. The anoxic (without oxygen) soil conditions limit the number of microorganisms that are available to decompose organic matter. This slows decomposition, resulting in an accumulation of organic matter and a slow cycling of nutrients through the ecosystem.

FOREST ECOSYSTEM PROFILE: FORESTED WETLAND

SUSTAINABILITY

Since the widespread logging of Wisconsin's forest in the early 1900s and the elimination of large predators from forest ecosystems (i.e., eastern timber wolf, bobcat), the population of white-tailed deer has increased dramatically. Deer eat tree saplings. Large populations of deer can severely affect the regeneration of forests. White cedar swamps are currently feeling these effects, and the regeneration of white cedar trees has been difficult.

Clean water is essential to the quality of life. Forested wetlands play a very important role in the provision of clean water. Though many forested wetlands have been logged and converted to other land use, others have been managed for forestry or protected for environmental and/or social benefits. Management practices are used by many foresters and private landowners across the state to protect water resources. These practices (such as logging when the water is frozen in winter, leaving many standing trees, and removing brush and other debris) reduce the environmental impacts of forestry by protecting shorelines, soils, and biologic communities.

Wetlands can be managed to provide both ecological and environmental benefits, but because of the wet soils, trees grow slowly, reducing the productivity of the site. Commonly, wetlands are drained before managing for economic benefits. This increases tree growth rates and allows greater access to the site, but severely alters the wetland ecosystem, ruining the habitat and environmental services that wetlands provide. As logging pressure increases on forested wetlands, their sustainability will depend on our dedication to forestry practices that protect the physical characteristics of the ecosystem.

VOCABULARY

Regeneration: Regrowth of trees naturally or by human means.

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Student Page ✎3B

FOREST ECOSYSTEM PROFILE: NORTHERN HARDWOOD FOREST

GENERAL ECOSYSTEM DESCRIPTION

The term "hardwood" is often used to describe broadleaf, deciduous trees. This is because their wood is typically harder than the wood of coniferous trees, which are often called "softwood" trees. Many northern hardwood forests are composed of stands of deciduous trees, including maple, aspen, birch, ash, basswood, and beech, but they also have mixed stands, which contain coniferous trees such as hemlock, fir, white pine, and red pine.

Forests cover nearly 7,700,000 acres (12,000 square miles) in the northern part of Wisconsin. Due to disturbances such as logging, fire, wind, and disease, a variety of tree ages are found in northern hardwood forests. The vertical and horizontal contrasts that result tend to give the forest a patchwork appearance when viewed from the sky. This variety provides a mixture of habitat for wildlife, making northern hardwood forests one of the most ecologically diverse on the continent.

Old growth forest areas are noticeably absent and make up less than 1% of northern hardwood forests in Wisconsin. Characteristics of old growth forests in Wisconsin include large trees, gaps in the canopy, multilayered vegetation, large standing dead trees, and large fallen logs and limbs. Since the cutover period in the early 1900s, forests have not yet had time to redevelop many of these characteristics, yet more and more forests are approaching this stage.


Thomas Meyer, Wisconsin DNR

CHANGE

The geologic history of the Great Lakes region has been dramatic. A billion years ago, a mountain range similar to the Rocky Mountains dominated the landscape. Hundreds of millions of years of erosion, including glacial activity, dulled the mountain peaks and reduced their height. When the last glaciers receded from northern Wisconsin 12,000 years ago, they left a rolling landscape that is dotted with small to medium-sized lakes. This glacial landscape supports northern hardwood forests that we know today.

Climate patterns have played major roles in forming the northern hardwoods ecosystem. The convergence of warm gulf air and cold arctic air creates a zone that divides the state of Wisconsin into a northern and southern region. The "tension zone," as it is called, is a climate gradient that defines the northernmost range of some trees (e.g., white oak, hickory) and southernmost range of others (e.g., northern hemlock, beech). Northern hardwood forests are found entirely north of the tension zone.

Wind, fire, flooding, animals, human use, and disease have also shaped northern hardwood forests over time. Trees, plants, and animals adapt to the conditions created following the death of single trees and large areas of trees. Trees are in constant competition with each other to make use of these areas.

By the early 1900s, nearly the entire expanse of northern hardwood forests was cut by loggers. Settlers attempted to turn much of what had been forest into farmland, but the majority went bankrupt due to the short growing season and poor soil. High intensity wildfires burned through the **slash** left behind by the loggers, leaving many bare, charred landscapes. As farms went bankrupt, wood supplies ran dry, and the environmental damage became evident, the state began to reforest the cutover areas and provide incentives for landowners to replant and care for forests.

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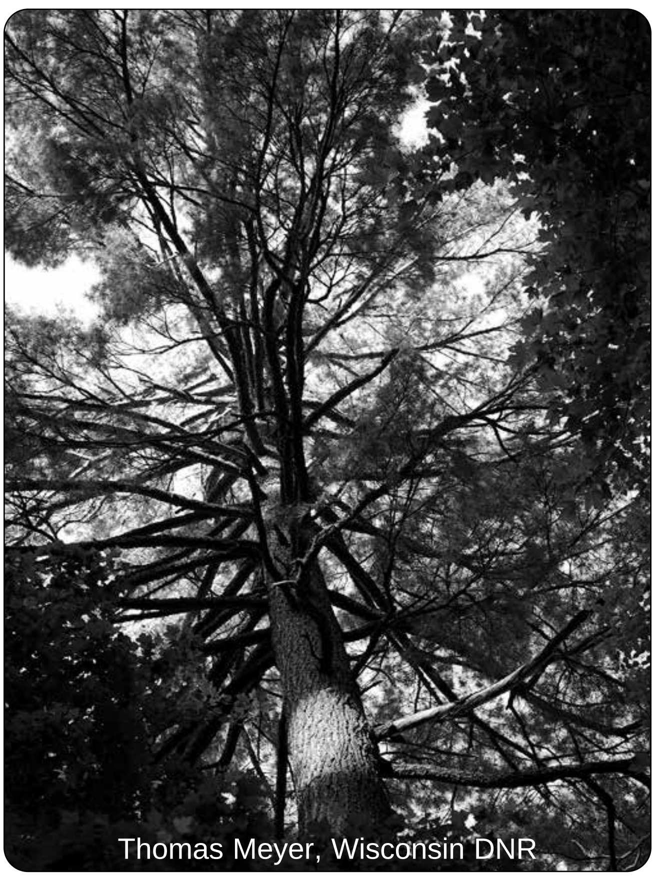
FOREST ECOSYSTEM PROFILE: NORTHERN HARDWOOD FOREST

NATURAL PROCESSES

Northern hardwood forests are productive compared to other forest ecosystems in Wisconsin due, in part, to the rich soil formed by the input of tree leaves, needles, and other plant matter. There is a diversity of micro-organisms in the soil due to a variety of nutrient and pH conditions. Many northern hardwood forests contain a layer of rich, organic matter called humus just under the leaf layer. The rich topsoil layer supports plant communities that are not found in other systems.

The most notable aspect of northern hardwood forests is the great diversity of habitat that exists and the complex food webs that result. Due to seasonal variations, localized disturbances, variety of tree ages, and differences in soil composition, habitat can vary from place to place, season to season, and year to year.



Thomas Meyer, Wisconsin DNR

SUSTAINABILITY

Due to the long disturbance history of northern hardwood forests (glaciers, fires, animal migrations, disease outbreaks, windstorms, etc.), the plant and animal life was well prepared for the near complete logging of forests starting in the late 1800s. It can be said today that northern hardwood forests, with the help of many natural resource professionals, have recovered much of their original biodiversity. Forests have proven resilient, but many challenges still exist.

Many of the presettlement northern hardwood forests are still designated as forestland, but old growth forest is scarce and the landscape is fragmented by human development. The shift from a landscape dominated by old growth upland forests to one that has only scattered patches of old growth forested wetlands may have unrecognized consequences for the region's plant and animal diversity. Introduced species and high population densities of white-tailed deer are also displacing plant and animal populations and placing pressure on some threatened and endangered species.

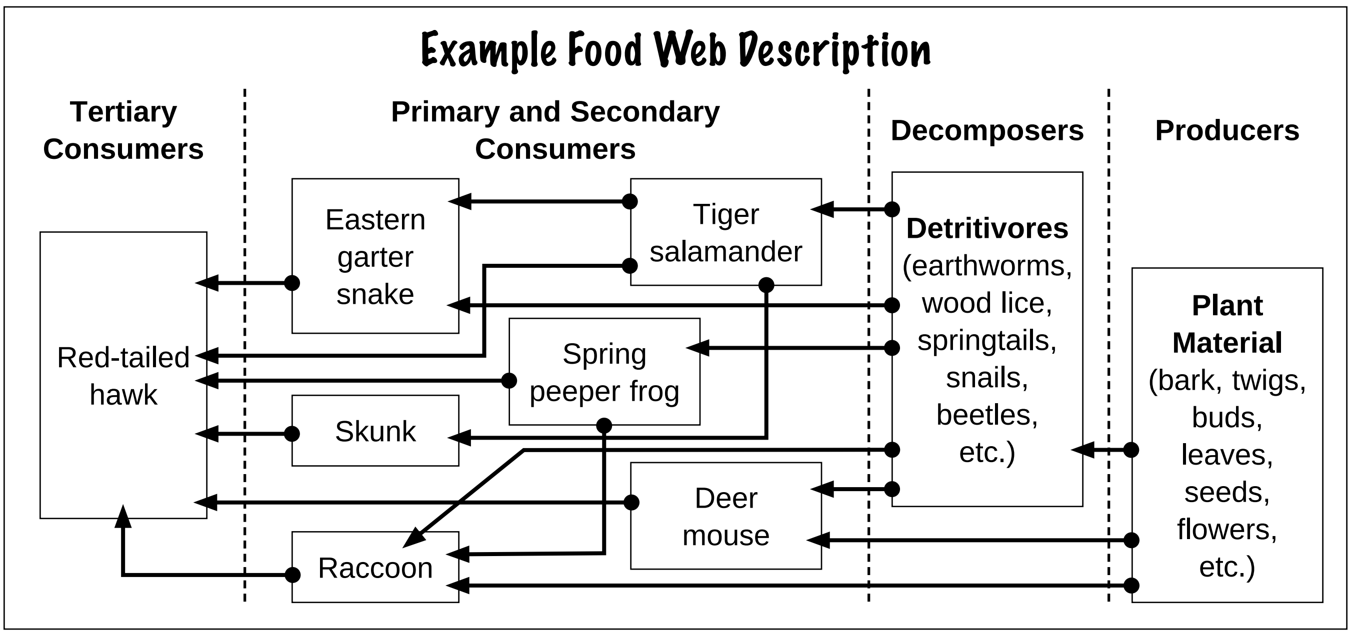
VOCABULARY

Slash: Branches, leaves, and twigs left after cutting down a tree.

FOOD WEBS

Example Food Web Description

The following food web represents the feeding relationship between some of the organisms that are widespread throughout different ecosystems in Wisconsin. Many mammals, such as the skunk and raccoon, eat a variety of small mammals, reptiles, and plant materials. They can feed and reproduce in a variety of habitats and are known to migrate over large areas. Predators like the red-tailed hawk are widely distributed because of their ability to hunt small animals and their ability to move over large areas in short periods of time. They are the top predator in many ecosystems and feed on a variety of small mammals, reptiles, and amphibians. The eastern garter snake can survive in nearly every habitat, including urban areas, wetlands, and dry upland areas. It feeds on frogs, salamanders, and mice, but has a primary diet of earthworms and other detritivores. Earthworms, which are not native to Wisconsin forests, are spreading rapidly through forest soils due to transport by anglers and the movement of soil to and from gardens and construction sites. They digest plant material deposited on the forest floor by plants and trees. The nuts and seeds of both broadleaf and coniferous trees serve as a source of food for large mammals such as the raccoon, small mammals such as the deer mouse, and many species of detritivores.



Group Assignment

To create food web descriptions and food web diagrams for your forest ecosystem, you will need to assume one of the following roles in your large group:

- **Group Leader (1 Student):** Lead large group discussions and help the group agree on important information to include in the food webs.
- **Organizer (1-2 Students):** Highlight and take notes about the information that will be included in the food webs, create resource citation page.
- **Web Designer (2-3 Students):** Draw the food web diagrams using the information gathered by the organizer.
- **Web Profiler (2-3 Students):** Write a short paragraph describing each food web.
- **Presenter (1-2 Students):** Use the food web diagrams and description to do a five-minute presentation to the rest of the class.