Lesson 3: Forest Biodiversity: Tree Case Studies

NUTSHELL

In this classroom lesson, students learn the importance of forest biodiversity. They discuss and define terms important to the study of biodiversity. They study maps that illustrate how climate and glacial history influence the range of different tree species in Wisconsin. Students discuss how levels of biodiversity differ from forest to forest by studying different forest biomes and different forest characteristics. Students then attempt to answer important questions about forest biodiversity by analyzing case studies of five trees found in Wisconsin. Students work in groups to create a poster about their tree case study and give a short presentation.

ENDURING UNDERSTANDINGS

- Forests differ in composition and structure. These are both affected by biotic (e.g., animals, plants, humans) and abiotic (e.g., soil moisture, sunlight, climate) factors.
- Different forest biomes exist around the world. Examples of forests that grow in some of the biomes include tropical forests, temperate forests, and boreal forests. Wisconsin is in the temperate forest biome.
- Different types of forests exist within a biome. Some of the types of forests in Wisconsin include coniferous, deciduous, and mixed forests.
- Biodiversity (or biological diversity) encompasses the variety and variability of all life on earth. It includes three levels: ecosystem diversity, species diversity, and genetic diversity.
- There is biodiversity within a forest. Different forests have different levels of biodiversity.
- Regions in Wisconsin differ in climate (e.g., precipitation, temperature) and the results of glaciation (e.g., soil, topography). These variations lead to different forest communities with differing species, thereby contributing to biodiversity.

ESSENTIAL QUESTIONS

- What is considered "healthy" in terms of forest biodiversity?
- Which types of biodiversity are most likely to fluctuate?

OBJECTIVES

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

- Define the terms "individual," "species," "population," "community," "ecosystem," "adaptation," "genetic diversity," "species diversity," and "ecosystem diversity."
- Explain how regional climatic and geologic differences contribute to biodiversity in Wisconsin.
- Describe four characteristics generally used to distinguish forests.
- Distinguish factors (biotic and abiotic) that cause changes in forest biodiversity.
- Use specific information about Wisconsin tree species to describe healthy levels of forest biodiversity.

SUBJECT AREAS

Language Arts, Science

PROCESS SKILLS

Case study analysis, Map interpretation, Oral presentation, Poster development

(Continued on page 79.)

LESSON/ACTIVITY TIME

Total Lesson Time: 210 minutes

- Introduction............................40 minutes
- Activity 1 ....40 minutes
- Activity 2 ....30 minutes
- Activity 3 ....30 minutes
- Activity 4 ....20 minutes
- Conclusion.............................50 minutes

STANDARDS CONNECTIONS

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

BACKGROUND INFORMATION

Forest Biomes

Biomes are large areas with similar climates and biologic **communities**. Terrestrial biomes are grouped into six major types — tundra, taiga/boreal forests, temperate forests, tropical forests, grasslands (including prairies and savannas), and deserts. There are also freshwater and marine aquatic biomes. Climatic conditions determine where biomes are located because temperature and precipitation largely determine the type of plants that live in an area. The vegetation, in turn, influences what other types of organisms can live there.

"A seed hidden in the heart of an apple is an orchard invisible."

Welsh Proverb

MATERIALS LIST

For Each Student

- Copy of Student Page ***1, Biodiversity Scenarios***
- Copy of Student Pages ***2A-C, American Chestnut***

For Each Group (4 Total)

- Copy of Student Pages ***3A-D, American Elm***
- Copy of Student Pages ***4A-D, Eastern Hemlock***
- Copy of Student Pages ***5A-D, Red Maple***
- Copy of Student Pages ***6A-D, White Oak***

For the Class

- Marker board

For the Teacher

- Copy of Teacher Page ***1, Wisconsin Glacial History Lecture Notes***
- Teacher Page ***2, Glacial Extent Map*** to project
- Teacher Page ***3, Wisconsin Landscape Map*** to project
- Copy of Teacher Page ***4, Wisconsin Climate Lecture Notes***
- Teacher Page ***5, Wisconsin Climate Map*** to project
- Teacher Page ***6, Natural Divisions Map*** to project
- Copy of Teacher Page ***7, Forest Biomes Lecture Notes***
- Teacher Page ***8, Forest Biomes Map*** to project
- Teacher Page ***9, Forest Characteristics*** to project
- Copy of Teacher Key ***10A-D, Case Studies Key***

Temperate forests grow in the midlatitudes of North America, Europe, eastern Asia, and Australia. These include both temperate dry forests and temperate rainforests. Wisconsin is dominated by temperate dry forests, both **coniferous** and **deciduous**. These forests have moderate average temperatures and precipitation (75-250 cm annually) and four distinct seasons. While broadleaf, deciduous trees (e.g., oak, hickory, beech, maple, aspen) dominate, some conifers can also be found (e.g., pine, spruce, hemlock). Losing leaves in the fall is one way that deciduous trees are adapted for the temperate climate because they become relatively inactive after doing so. The lack of leaves on the trees in early spring also allows sunlight to penetrate to the forest floor so many smaller herbaceous plants have a chance to grow. This contributes to **species diversity**.

Temperate forests have many structural layers, each with its own characteristic organisms. Many insects, spiders, and microorganisms live in the soil or just at the forest floor. The forb layer (nonwoody plants) is fed on by many animals (e.g., mice, rabbits) and the shrub layer provides another source of food and shelter for both birds and mammals like the white-tailed deer. The understory and overstory trees add additional habitat. A few common animals in temperate forests include the gray squirrel, woodpecker, neotropical birds, eastern timber wolf, pine marten, and black bear.

Taiga/boreal forest is found in subarctic northern latitudes across North America, Asia, and Europe. Winters are severe and summers are relatively short but feature long days. Precipitation is generally in the 45-125 cm range annually. Soils tend to be acidic, and lowland areas are often waterlogged during the summer. Coniferous trees (e.g., fir, spruce, hemlock, cedar, pine) are better adapted to these conditions than deciduous trees because their needles have a waxy coating that prevents water loss. This is an important **adaptation** since water is frozen much of the year. Many of the smaller boreal animals, such as squirrels, insects, and birds, rely on seeds from the cones of these trees for food. Larger herbivores such as deer, moose, and caribou, eat bark and young shoots.

In Wisconsin, there are small amounts of boreal-type forest in the northwest along Lake Superior and on the Lake Michigan side of the Door County Peninsula. These forests are not necessarily in the boreal biome, but have similar characteristics to such forests. High lake-effect snowfall and low temperatures, due to winds from the north along Lake Superior, create conditions for the existence of boreal forest that may not otherwise be found in northern Wisconsin. Cool, moist air moving across Lake Michigan in the summer and moist soils create conditions in Door County for boreal forest to grow in certain pockets. Due to local conditions, the boreal forests in Wisconsin are not typical of boreal forests in more northern regions of the world (there are higher precipitation levels in Wisconsin). These forests account for less than two percent of the forest cover in the state.

Grasslands are dominated by grasses rather than shrubs or trees. The formation of the Rocky Mountains in western North America created a climate favorable to grasslands in the central and eastern regions of the North American continent. After the last ice age, grasslands expanded in range as hotter and drier climates prevailed worldwide. Temperate grasslands have hot summers and cold winters with moderate rainfall. The amount of annual rainfall determines the height of grassland vegetation, with taller grasses in wetter regions. Seasonal drought and occasional fires are needed to maintain the grassland **ecosystem**. Because of the cyclical fires and the decay of deep-rooted grasses, the soil of the temperate grasslands is deep and fertile. Due to these characteristics, few natural prairies remain since most have been turned into agricultural land.

VOCABULARY TERMS

Abiotic: Nonliving things.

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

Biodiversity: The variety and complexity of life on Earth.

Biotic: Living things.

Community: A group of plants and animals interacting with one another in a given area.

Coniferous: A tree that bears cones and has needles.

Deciduous: A tree that sheds its leaves for part of each year.

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 Diversity: The variety of biologic communities or ecosystems in a given area over time.

Environmental Conditions: The climatic, soil, and landscape characteristics of a forested area.

Extirpation: The extinction of a species from a specific area.

Forest Composition: The tree species within a forest.

Forest Structure: The vertical and horizontal spacing of trees in a forest. Vertical layers are the overstory and the understory. Horizontal spacing is the density of tree cover across the landscape.

Genetic Diversity: Genetic variation within a population or species.

Genotype: An organism's hereditary (genetic) makeup.

Hemlock Woolly Adelgid (Adelges tsugae): An introduced species of insect similar to an aphid that is native to Asia. Adult and nymph adelgids damage eastern hemlock trees by sucking sap from twigs, causing the tree to lose its needles.

Individual: A single organism.

Location: The latitude, longitude, and altitude of a forested landscape.

Northern Hardwood Forest: A type of forest found across much of the north-central and northeastern U.S.; consists of mostly broadleaf, deciduous trees including aspen, birch, basswood, beech, and sugar maple.

Population: A group of individuals of the same species that share the same reproductive gene pool.

Refugia: Areas untouched by glaciers that held the plants, animals, and other organisms native to the region before glaciation.

Species: A group of similar individuals that can produce fertile offspring.

Species Diversity: The variety of different species in a given area.

Savanna is grassland with scattered trees. Savannas usually border other grasslands. Various types of savanna cover almost half the surface of Africa, large areas of Australia, South America, and India, and smaller areas of the North American continent. Savanna is found in warm or hot climates with moderate annual rainfall. For a savanna to form, the rainfall must be concentrated in six or eight months of the year, followed by a long period of drought when fires can occur. Much of central and southern Wisconsin was dominated by savanna at the turn of the century. Savanna has been reduced to less than 1% of its presettlement range in Wisconsin due to agricultural conversion and fire suppression.

Forest Characteristics

Four characteristics are generally used to distinguish types of forests: **forest composition** (dominant tree species), **location**, **forest structure**, and **environmental conditions**.

FOREST COMPOSITION

Forests are often identified by the tree species that dominate the overstory or will dominate the overstory as the forest matures. Maple-basswood, oak-hickory, and pine forests are types of forests that are named for the dominant tree or trees present. Though these forests are named for their dominant tree species, this does not mean that it is the only tree present. Each of these forests has varied composition and can even contain gaps dominated by pioneer species such as birch and aspen that grow after disturbances. Forests that are dominated by deciduous trees are often called hardwood forests.

LOCATION

Forests are also identified by their location. Eastern forests, northeastern forests, eastern hardwoods, and northern hardwoods are all common names for different forested regions. To an experienced forester, the region in which a forest is found can say a lot about the forest's characteristics. This is due to an understanding of the general climate and natural history of the area, as well as the range of different tree species. For example, northeastern forests refer to the forests of New England and the states bordering the eastern Great Lakes. Eastern forest is a general term that describes all the forests east of the Great Plains. Northern forest refers to the temperate forests (like northern hardwoods) that are found north of the Great Lakes, as well as in the Upper Peninsula of Michigan and northern Wisconsin.

FOREST STRUCTURE

The structure of a forest can also be used as a defining characteristic. Oak savannas and oak forests are differentiated by their structure. A savanna has a distinct forest structure characterized by widely spaced trees, giving the overstory an open appearance. An oak forest, on the other hand, refers to a structure that we more typically identify with forests: that of a closed canopy with closely spaced trees.

ENVIRONMENTAL CONDITIONS

Environmental conditions can be used to describe forests as well. Wetland forests, dry oak forests, and upland hardwood forests are all common descriptions of types of forests. The amount of seasonal moisture available to trees has a large influence over the type of trees that will grow in an area and can determine the characteristics of the ecosystem. For this reason, it is often useful to describe the forest in this way.

Distribution of Biologic Communities

Wisconsin is fortunate to have a great deal of **biodiversity**. There are approximately 1,800 species of native vascular plants (those with specialized tissues for moving food and water throughout the plant) and more than 650 species of native vertebrates in Wisconsin. Thousands of species of nonvascular plants and invertebrates can be found in Wisconsin as well. Due to its geographic location and a variety of physical factors, Wisconsin has prairies, temperate forests, and small areas of boreal-type forest in the north. It also has wetlands and a number of other aquatic communities, such as springs, ponds, lakes, streams, and rivers.

Some of the factors that affect where these communities will be found include climate (e.g., temperature, precipitation) and soils. For example, prairies and many of the forest communities dominated by oak or jack pine will be found where conditions are warmer and drier. Boreal forest can only exist where temperatures are quite cool most of the year. Many pine species do well on sandy soils, but most maples need richer, moister soil. Other natural factors also play a role. Glaciation has had a major impact on landforms, soils, and the location of bodies of water that, in turn, influence vegetation growth. Short-term disturbances (e.g., fire, drought, wind, rainstorms) can affect the species present on a smaller scale and over a shorter time frame. All these factors contribute to biodiversity.

"Trees give peace to the souls of men."

Nora Waln

Effects of Biotic and Abiotic Factors on Forests

The location and extent of different types of forests in Wisconsin depend on climate and the state's glacial history. Glacial effects include historic **refugia** for tree species and current soil features and topography. Climatic factors include moisture and temperature.

Glaciation has played a major role in Wisconsin over the last two million years. In the most recent glacial period (the Wisconsin Glaciation from 26,000 to 10,000 years ago), glaciers covered much of the eastern and northern parts of Wisconsin. As glaciers moved across these parts of the state, they smoothed the landscape and left deposits of sand and gravel that changed the soil in some places. Glaciers also created "kettles" and left many lakes in their wake. The southwestern part of the state was not glaciated and has a more rugged topography featuring steep hillsides and river valleys. This part of Wisconsin is called the "driftless" area. Along the edges of glaciers and at the farthest point they reached, moraines formed from the sand, gravel, and rock material deposited as the ice melted. The same moraines formed ridges that act as a continental divide, determining if water will end up in the Great Lakes Basin or the Mississippi River Basin.

The areas untouched by historic glaciers are known as refugia to ecologists. These unglaciated areas held the plants, animals, and other organisms native to the region before glaciation. The refugias were essential to the recolonization of the landscape after the glaciers receded. Historic migration routes of many plants can be traced back to these areas.

Wisconsin is divided into two main climatic zones — northern and southern — with the tension zone dividing them (see page 99). This plays a role in where forests are located. The northern zone receives cool, dry arctic air from Canada. Winters here are longer, with more snow and colder temperatures than in the southern zone. Climate in the southern zone is influenced by air from the Pacific Ocean and Gulf of Mexico. Here winters are warmer with less snow, and summers are longer with more rainfall than in the northern zone. The tension zone is a band that runs somewhat diagonally from west-central Wisconsin to southeastern Wisconsin. Here the climate is intermediate between that of the northern and southern zones. Other climatic influences are latitude and geographic position (e.g., steepness, direction in which a slope faces, placement with regard to water and land formations).

Lake influence also plays a role in the location of different types of forests in Wisconsin. In general, the Great Lakes' influence leads to cooler summer temperatures, warmer winter temperatures, and higher precipitation in coastal areas than surrounding inland areas. There is a relatively small area in northwestern Wisconsin where the climate is influenced by Lake Superior. Arctic winds blow southeast across the lake and carry moisture and precipitation inland. This lake effect leads to lower temperatures and increased snowfall, allowing boreal species to be successful. In eastern Wisconsin, the climate is influenced by Lake Michigan and Green Bay.

Disturbances such as fire, wind, logging, drought, insect infestation, and flooding affect the location of forests. Disturbances have influenced forests throughout history. Plant, tree, and animal species have adapted to them and, in many cases, depend on certain disturbances for their survival. The predominance of a type of disturbance will create conditions suitable for some tree species and unsuitable for others. In this way, disturbances can determine the type of forest present.

Humans can influence natural disturbances and their effect on forests. For example, humans can cut forests or plant forests, start or suppress fires, and introduce insects or control insect infestations. These things can affect the type of forest that will grow. Human resource needs have also affected the location of forests in Wisconsin. Clearing for agriculture and development have altered and continue to alter the distribution of forests in Wisconsin.

Climate change has affected forest distribution and growth throughout history. The climate change the planet is currently undergoing can be understood with scientific studies and paleo-ecological records. Studying historic changes in forest vegetation can help us understand the changes that are occurring now and might occur in the future.

The combination of these factors has led to the current distribution of forests in Wisconsin. Ecologists, foresters, and other scientists have studied this distribution and created maps showing ecological landscapes or natural divisions in the state. Each of these divisions is characterized by unique soil, topographical, temperature, and moisture conditions. Distinct vegetation and forest cover also characterize the divisions.

NOTES

Biodiversity

Biodiversity is short for biological diversity and refers to the variety of life on earth. It encompasses not only the organisms themselves, but also their habitats and the many ecological processes that support them. Biodiversity is often measured on three levels — species diversity, **genetic diversity**, and **ecosystem diversity**.

- Genetic diversity is the variety of different **genotypes** within a **population** or **species**. It can be assessed on three levels – within breeding populations, between breeding populations, and within the species as a whole.
- Species diversity is the variety of different species in a given area. It is assessed by total numbers, relative abundance, and distribution of species.
- Ecosystem diversity is the variety of biological communities in a specified region. This measurement also takes into account the changes that take place through time.

To understand biodiversity in its three forms, it can be looked at as a matter of scale. There is biodiversity within a population, within an ecosystem, and in a geographic region. For example, a population of eastern hemlock trees in a Wisconsin forest may contain individual trees with a slightly different genetic makeup, allowing them to better defend against disease, better survive adverse conditions, grow faster, etc. The presence of the eastern hemlock, and the plants and animals associated with it, adds biodiversity to the forest ecosystem. The forest ecosystem, because it has a different species composition than other Wisconsin forests, adds to the biodiversity found across the state.

In addition, it is important to understand that biodiversity changes over time. For any given area, each of the three types of diversity mentioned is constantly changing.

The Importance of Biodiversity

Biodiversity is important for ecological reasons. The great diversity of organisms that capture the sun's energy, drive the cycling of matter, and are components in food webs makes possible forest regeneration and growth. Humans depend on forest ecosystems in Wisconsin and the world for clean air and water. Forest ecosystems are responsible for the protection, retention, or filtration of two-thirds of the water used by human populations in the United States. Forests also sequester carbon (a major greenhouse gas) from the atmosphere.

Biodiversity is important for social reasons. A wide array of useful products has been derived from wild plants and animals. In fact, the existence of modern civilization is due to the exploitation of wild organisms such as cattle, corn, wheat, wood, etc. As our population grows, so does our need for resources, knowledge, and understanding. Society values biodiversity for aesthetic reasons as well. A day does not pass in which we don't see an image of a wild animal, plant, or landscape on television, in a magazine, on the internet, or in architecture. The more rare or beautiful, the more likely we are to seek and record it. It is argued that nature has inspired more works of art, poetry, and literature throughout history than any other concept.

Biodiversity is important for economic reasons. Biodiversity is a natural way to ensure against ecosystem collapse caused by natural or human caused disturbance. A landscape dominated by a single species of tree is more susceptible to widespread devastation. Maintaining a mix of forest types across the landscape helps ensure that tree cover remains and the economic costs of disturbance are manageable. If drought, flood, or other natural disturbances affect an area that is fairly diverse, chances are that a natural source for regeneration exists nearby. This strategy is carried out across the Wisconsin landscape, as tree plantations, used to produce wood resources, are intermixed with many other types of forests.

Threats to Biodiversity

Living things cannot survive without interaction with other organisms. Organisms have feeding relationships, habitat relationships, and symbiotic relationships — each organism produces or provides something essential to the life of the other organism. Losing one organism can have serious effects on the survival of other organisms in an ecosystem. Understanding this relationship helps us better understand the processes that occurred in the mass extinctions of the past and the importance of protecting biodiversity today.

One may argue that on a large time scale, biodiversity is dynamic. Paleontology has shown that mass extinctions have occurred and that new organisms have developed in response to catastrophic events such as volcanic eruptions, asteroids, and major climate change. Human influence is now causing extinctions to occur at an accelerated rate on a global scale.

Issues related to biodiversity need to be looked at from both local and global perspectives. For example, many birds with habitat in Wisconsin migrate across the United States and into other countries to find habitat during winter. Actions taken in either place affect the bird populations and may determine their success or failure. Since there is interdependence among many species, current actions may lead to changes that are not immediately obvious.

The introduction of non-native invasive species is threatening biodiversity. While a new species may at first seem to add to biodiversity, most non-natives have few natural enemies and often outcompete native species. Over time, this reduces biodiversity. For example, exotic bush honeysuckle and buckthorn may initially add to forest cover; but eventually, they shade out native plants, reduce soil moisture and nutrients, and compete with native plants for pollinators. Since we may purposely or inadvertently bring species from one area to another, we need to be aware of the potential effects our actions may have.

The disruption of natural disturbance regimes is also a threat to biodiversity. All forests are adapted to certain range of disturbance types and intensities. As disturbance types are changed (e.g., fire suppression) or disturbance intensities are increased (e.g., intense wild fires), species can be lost. These effects can be seen in Wisconsin. In northern regions, intense wildfires fueled by logging slash in the early 1900s severely altered soil and ecosystem conditions.

Permanent fragmentation is another threat to biodiversity in Wisconsin. Some forest species, such as the cougar, need large tracts of forested land for habitat. Other species, such as some neotropical birds (birds that spend part of their life cycle in northern latitudes and migrate to equatorial areas during winter) and the pine marten, need large areas of mature, undeveloped forest for habitat. As the forestland in Wisconsin is lost to development, these types of forest are more and more scarce. Many forest areas in Wisconsin are currently undergoing a real estate boom as large tracts of industrial forestland are being divided into small parcels and sold to private landowners. This situation has the potential to further fragment Wisconsin's forest landscape.

NOTES

PROCEDURE

Introduction – Defining Biodiversity

1. Tell students that they will be learning about biodiversity in Wisconsin's forests. They will first discuss and define biodiversity, then look at Wisconsin's forest biodiversity, and finally analyze case studies of Wisconsin tree species in attempt to answer some important questions about biodiversity.

2. Tell the class that their first activity will be to define the term "biodiversity." Have the class discuss the term and decide on a definition. Write the definition on the board. *(Biodiversity: The variety and complexity of life on Earth.)*

3. Once the definition for biodiversity is agreed on, tell students that to understand and measure biodiversity, they must first define a variety of terms related to the study of biodiversity. If your class has some experience with biodiversity issues, you may want to introduce the terms by using a group brainstorm.

   If not, you may wish to write each term and each definition on a separate card and pass the cards out to the class. Have each student find another student in the class who has the corresponding term or definition to their card. Once they have found their match, have them write the term and the definition on the board.

   The terms and definitions are as follows:
   - **Individual:** A single organism.
   - **Species:** A group of similar individuals that can breed and produce fertile offspring.
   - **Population:** A group of individuals of the same species that generally share the same reproductive gene pool.
   - **Community:** A group of plants and animals interacting with one another in a given area.
   - **Ecosystem:** An area that contains organisms (e.g., plants, animals, bacteria) interacting with one another and their nonliving environment.
   - **Adaptation:** Evolutionary adjustments in structure, form, or function that help individuals, populations, or species fit in their environment.

   Tell the class that a good understanding of the terms will help them understand how biodiversity is measured, how organisms are connected to each other and their environment, and how organisms change. Leave the terms and definitions on the board.

4. Explain to students that due to the interdependence of organisms on one another, the disappearance (**extirpation** or extinction) of one species may affect the health and survival of other species. This may have negative effects on the health of an ecosystem. Because of the complexity of the relationships between organisms, it is important that we understand how best to measure it.

   Tell students that there are three components that must be taken into consideration when measuring biodiversity — genetic diversity, species diversity, and ecosystem diversity. Hand a copy of Student Page ✎ ***1, Biodiversity Scenarios***, to each student. Read the definitions at the top of the page and have students fill in the blanks.

5. After students complete the worksheet, provide the following answers and have them discuss how each of the terms fits into the correct scenario:
   - The Whooping Crane = **Genetic Diversity**
   - Buckthorn Invasion = **Species Diversity**
   - The Northern Hardwoods = **Ecosystem Diversity**

Activity 1 – Forest Biodiversity in Wisconsin

1. Ask students if they know the three main factors that influence where different trees (and ultimately different types of forests) grow in Wisconsin. Help the class come up with these three answers — *soil type and topography (glacial history), climate,* and *human activity.* Tell students that though these are the major factors influencing the distribution of forests, there are also other influences, including disturbances like fire, flooding, deer browsing, and insect infestation, that can encourage or discourage the growth of certain trees.

2. Use Teacher Page ***1, Wisconsin Glacial History Lecture Notes***, and project Teacher Page ***2, Glacial Extent Map***, and Teacher Page ***3, Wisconsin Landscape Map***, to explain the glacial history of Wisconsin and describe the distinct regions that the glaciers left behind.

   NOTE: You may wish to skip the glacial history lecture if you have completed *Lesson 2: A History of Succession*.

3. Use Teacher Page ***4, Wisconsin Climate Lecture Notes***, and project Teacher Page ***5, Wisconsin Climate Map***, to explain to students how climate patterns divide the state into two distinct regions.

4. Project Teacher Page ***6, Natural Divisions Map***. Tell the class that by combining climatic factors and glacial history, five natural divisions with distinct growing conditions become evident. Have the class describe each of the natural divisions using the information they have learned about glacial history and climate. *(For example, the northern highland region was glaciated. There are glacial features and rocky and sandy soils. The region is north of the tension zone and the climate is dominated by cool arctic air.)* Tell the class that the natural divisions can be used as a guide to determine where different forests might grow, and point out the types of forests that dominate each area.

5. Ask the class if they think the natural divisions are a perfect guide to determining where trees might grow. *(No.)* Help them understand that tree ranges can extend across natural divisions for a variety of reasons. Guide the discussion to the following reasons:
   - Some trees can tolerate a wide range of climate and soil conditions, thus crossing the natural divisions.
   - The natural divisions do not take into account other influences such as disturbances and human activity.
   - Though a tree might be suited to a region, there may be no seed source or other way for it to become established.

> "It is difficult to realize
> how great a part of all
> that is cheerful and delightful
> in the recollections
> of our own life
> is associated with trees."
>
> *Wilson Flagg*

6. Divide the students into small groups (two to four students) and have them discuss and answer the following question: How do the climate and glacial history of Wisconsin affect the state's biodiversity?

   Once groups are finished, have them present their answers to the class. The students' reasoning should be similar to the following:
   - The tension zone and lake effects create distinct weather conditions in different regions of the state. For example, the colder regions of the north are suitable for plants and animals common to boreal forests, while the southern regions are more suitable for the plants and animals of the temperate biome. By creating a variety of climate conditions, the weather patterns create different habitat conditions — increasing the state's biodiversity.
   - The different types of soil and topography caused by the glaciers create soil conditions suitable for different organisms. For example, the central region has flat, sandy landscapes, while the southwest region is rugged with older, siltier soils. By creating a variety of landscape and soil conditions, glaciers have helped to increase habitat suitable for different plants and animals — increasing the state's biodiversity.

Activity 2 - Case Study Preparation

1. Tell students that during the next activity they will be preparing to answer some important questions about biodiversity in Wisconsin's forests. Tell students that because of the complexity of Wisconsin's forest landscape, it is important that they first understand how forests are differentiated and classified.

   Tell students that to truly understand how forests are classified, it is necessary to start on a global scale by looking at forest biomes. Use Teacher Page ***7, Forest Biomes Lecture Notes***, and project Teacher Page ***8, Forest Biomes Map***, to describe each biome.

2. Ask students to identify in which biomes Wisconsin and the majority of the eastern U.S. are located. *(Temperate forest and grassland.)* Tell students that the two biomes Wisconsin is in contain many different types of forests, each of which consists of deciduous trees, coniferous trees, or a mix of both.

   Be sure the class knows the difference between a broadleaf, deciduous tree and a coniferous tree. *(Broadleaf, deciduous: A tree that sheds its leaves for part of each year [angiosperms]. Coniferous: A tree that bears cones and has needles [gymnosperms]. Most keep their needles for the entire year [one exception in Wisconsin is the tamarack].)*

NOTES

3. Tell the class that four characteristics are generally used by forestry professionals to define types of forests. Project Teacher Page 9, ***Forest Characteristics***, and have students take notes on each of the characteristics. The four characteristics are as follows:
   - **Forest Composition:** Tree species within a forest.
   - **Forest Structure:** Vertical and horizontal spacing of trees in a forest. Vertical layers are the overstory and the understory. Horizontal spacing is the density of tree cover across the landscape.
   - **Location:** Latitude, longitude, and altitude of a forested landscape; often described in general terms as northern forest, southern forest, upland forest, etc.
   - **Environmental Conditions:** Climatic, soil, and landscape characteristics of a forested area; examples include forest wetland and coastal forest.

   If your students are not familiar with forest structure, you may wish to define each layer and use pictures of forests in magazines or textbooks for illustration. The definitions are as follows:
   - **Overstory:** Uppermost trees in a forest; dominant trees in a forest.
   - **Understory:** Forest vegetation present beneath the overstory, which can include regeneration trees, shrub layer, and forb layer.
     - **Regeneration Trees:** Understory tree seedlings and saplings that have the potential to replace existing overstory trees.
     - **Shrub Layer:** Layer of the understory containing woody plants with multiple stems.
     - **Forb Layer:** Layer of the understory containing nonwoody plants.
   - **Litter Layer:** Surface layer of the forest floor composed of leaves, twigs, needles, etc.

4. Explain to students that each of these four characteristics can say a lot about the type of forest in an area. Illustrate this point by writing the following types of forests on the board — forested wetland, savanna, maple-basswood forest, northern hardwoods, eastern forest, even-aged forest, coastal forest, and oak-hickory forest. Have students identify the one defining characteristic used to name each of the forests. *(**Composition [dominant trees]:** maple-basswood forest, oak-hickory forest. **Forest Structure:** savanna, even-aged forest. **Location:** eastern forest, northern hardwoods. **Environment:** forested wetland, coastal forest.)*

5. Ask students if they think that each forest has the same level of biodiversity. *(No.)* Ask them to think about some of the forest biomes they learned about. *(Boreal forest, temperate forest, tropical forest.)* Ask them, in general, if they think a boreal forest has as much biodiversity as a tropical forest. *(No, tropical forests, in general, have higher biodiversity because of year-round warm temperatures and generally humid climates.)*

   Pose the following questions to the class: How do we know how much biodiversity a forest should have? *(You may get a variety of answers to this question, including "the biodiversity that they have in nature," "the biodiversity that they need to be healthy," or "the biodiversity that they had before humans arrived.")*

   Facilitate the discussion with these questions:
   - How do we know what natural levels of biodiversity are?
   - Would natural levels be the levels before European settlement? Before Native American settlement? Before the glaciers arrived?
   - How do we know what a healthy level of biodiversity is?

   Tell students that to find the answers to these questions and truly understand biodiversity, they are going to conduct case studies on a variety of Wisconsin tree species.

Activity 3 – Example Case Study: American Chestnut

1. Tell students that they are going to study a variety of trees to see if they can get any insight into some of the questions they have about biodiversity. To do this, each student will develop a case study for a specific tree species.

   Facilitate the discussion with these questions:
   - What is a case study? *(A case study is a description of the history and current status of a person or object [e.g., an individual, a community, a family, a tree species].)*
   - For what reason would a case study be developed? *(Case studies are developed to help people understand an issue that is important to society. For example, if you were researching how people cope with cancer treatment, you might do a case study on a specific family that has a member suffering from cancer.)*
   - Who develops case studies? *(Scientists and other researchers who are working to understand current and past social, economic, and environmental issues.)*

2. Once students are comfortable with the definition of a case study, tell them they will be looking for insights into three questions:
   - How does forest biodiversity change?
   - How can humans affect forest biodiversity?
   - What is a healthy level of forest biodiversity?

   Have students write down the questions. Be sure to let students know that no single case study can answer all the questions, but by studying the history and current status of a single tree species, they can gain some valuable insights. These insights contribute to the overall understanding of forest biodiversity.

3. Hand a copy of Student Pages ***2A-C, American Chestnut***, to each student and tell them that before beginning their case study, they will all work on a sample case study of the American chestnut.

   Overview the following sections of the handout:
   - **Tree Profile:** Describes the tree characteristics, history, range, and distribution in Wisconsin.
   - **Chestnut's Last Stand:** Article summary that describes the efforts of scientists to protect the last stand of American chestnut.
   - **Assignment Description:** Students should answer the questions using information from the article summary and the tree profile.

4. Discuss the article and assignment questions with the class. Use Teacher Key ***10A-D, Case Studies Key***, to guide the discussion.

   Once the details of American chestnut have been discussed, remind the class that the purpose of a case study is to shed insight on important questions. Ask the class what questions they are trying to address. *(How does forest biodiversity change? How can humans affect forest biodiversity? What is a healthy level of forest biodiversity?)*

> "I think that if you shake the tree, you ought to be around when the fruit falls to pick it up."
>
> *Mary Cassatt*

Ask the class what biodiversity insights can be gained by studying the American chestnut. Help students make the following connections between the American chestnut and forest biodiversity in general:

- The American chestnut was a dominant tree in eastern forests, and many human and wildlife populations depended on it for different reasons — **The loss of one species can influence many other species.**
- Humans purposefully introduced the American chestnut to Wisconsin, and humans accidentally introduced the chestnut blight that decimated the American chestnut throughout its native range — **Choices humans make can have large impacts on forest biodiversity.**
- The American chestnut trees that survived the longest (the stand in La Crosse, WI) were outside of the native range — **Ecosystem diversity can help isolate and protect areas from the effects of disease and other disturbances.**
- Scientists have the opportunity to use genetic resources (diversity) to help the tree survive the continued threat of chestnut blight — **Humans have the opportunity to protect species from extinction and maintain forest biodiversity.**

Activity 4 – Tree Case Studies

1. Tell students that they will develop and discuss case studies for four trees found in Wisconsin. Write the names of the four trees on the board — American elm, eastern hemlock, red maple, and white oak. Explain to the class that they will work in groups to create one case study and present it to the rest of the class.

   Divide the class into four groups, and assign each group a tree species to study. Hand each student in each group their corresponding tree profile – Student Pages ✎***3A-D, American Elm***, OR Student Pages ✎***4A-D, Eastern Hemlock***, OR Student Pages ✎***5A-D, Red Maple***, OR Student Pages ✎***6A-D, White Oak***.

2. Once each student in each group has the corresponding student pages, review the assignment page and be sure that all the groups understand their responsibilities. Explain that the tree profiles will give them a general history and status of the tree species they are studying and that the article will help them understand the major influences on its distribution across the landscape.

   Emphasize that each student should complete the assignment questions first (students can work with members in their group to do so). The answers to the questions will give them information they need to create their poster.

   The visual presentation must have the following five sections: 1) tree importance; 2) range in North America (map); 3) distribution in Wisconsin (map); 4) History and current status; and 5) Biodiversity insights.

3. Once the groups understand the assignment, have them designate the following individual responsibilities:
   - **Group Leader:** Oversight of the entire project and keeping all group members involved and on task so the project is completed on time.
   - **Researchers:** Responsible for organizing the information for the different sections of the visual presentation and acquiring any additional information or pictures.
   - **Developers:** Responsible for creating the visual presentation using the information gathered by the researchers.
   - **Presenters:** Prepare and give a five- to 10-minute presentation on their tree case study, using the visual medium.

   Once the responsibilities are delegated, select a group presentation date and order of presentation. Remind students that in the presentation, they must use the poster and include all the information in the assignment description (more than just the answers to the questions).

Conclusion: Group Presentations

1. Have each of the groups give their presentation. You may need to facilitate the audience discussion at the end of each presentation.

2. After the presentations are complete, have a member from each group write his or her biodiversity insights on the board. Help the groups to consolidate their ideas. Many ideas should be included, but be sure that the ideas are similar to those listed below:
   - Forests are always changing.
   - Forests need a certain level of biodiversity to recover from disturbances.
   - The genetic diversity within a tree species or population can help the species survive disturbances.
   - Each type of forest has a different level of biodiversity and different tolerance to disturbance.
   - Each type of forest has adapted over time to disturbances that are common in their particular region.
   - Disturbances that are too intense, last too long, or are different from any the forest has encountered, may have negative consequences for forest health.
   - Humans have a large influence, positive or negative, on forest biodiversity.

NOTES

SUMMATIVE ASSESSMENT

1. Form small groups of four students composed of one member from each of the large groups. Have the groups use the insights and the specific information they have gained from their research to answer the following questions:
   - How does forest biodiversity change?
   - How can humans affect forest biodiversity?
   - What is a healthy level of biodiversity?

2. Once groups have discussed and answered the questions, lead a class discussion on their answers. Use the groups' answers and insights to guide the discussion to a conclusion similar to the following:
   - *There is no simple answer to the question "What is a healthy level of biodiversity?" because a healthy level of biodiversity varies from forest to forest. We have learned in our case studies that a healthy level of biodiversity for a specific forest can be estimated by looking at the history of the forest in question, understanding the current influences (biotic and abiotic) on the forest, and estimating the types of disturbances that the forest may undergo in the future.*
   - *As humans spread out on the landscape and our growing population depends more and more on our forests, it is extremely important that they are managed (through protection, tree removal, prescribed fire, planting, etc.) to the best of our knowledge and ability so that they can best resist and recover from future disturbances.*

> "He who plants a tree, plants a hope."
>
> *Lucy Larcom*

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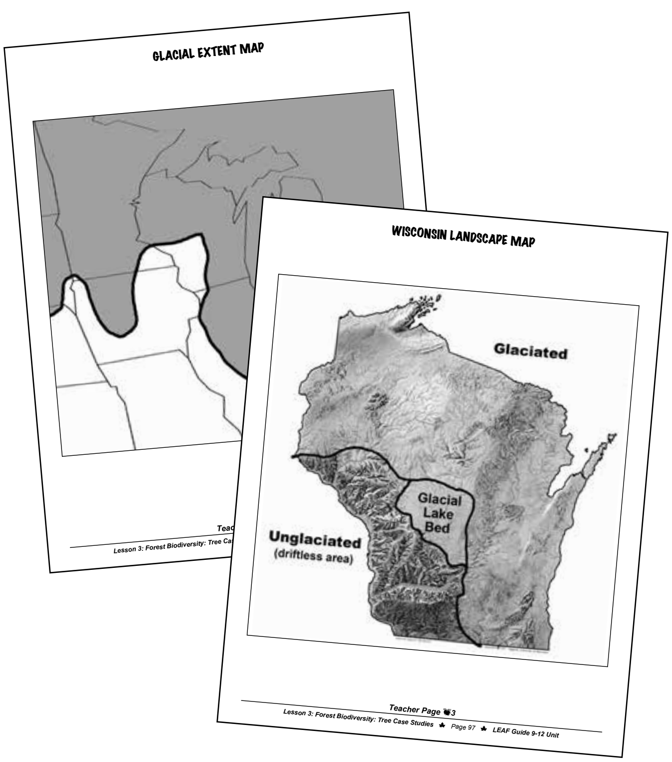
NOTES

WISCONSIN GLACIAL HISTORY LECTURE NOTES

Project Teacher Page 2, Glacial Extent Map

The last glacial period lasted more than a million years and was characterized by a global decrease in temperature and the migration of continental ice sheets (glaciers) from the North Pole. During the glacial period, **glaciers advanced and retreated numerous times, covering the entire area shown in gray on this map**. The most recent age, the Wisconsin Glaciation, ended approximately 10,000 to 14,000 years ago as glaciers receded northward, leaving the current Wisconsin landscape behind.

As you look at the glacial landscape of that time, you will notice a few key features. The first and most obvious is that the **glaciers did not reach over the entire landscape**, leaving the central and southwestern one third of Wisconsin without glacial features. Much of this unglaciated area is called the driftless area because boulders, stones, and gravel (known as glacial drift) deposited by glaciers are not found there.



Project Teacher Page 3, Wisconsin Landscape Map

If we take a look at the resulting topography, you will also notice **two distinct regions in the driftless area**.

- The rugged terrain of the southwest region has no glacial features and is the oldest landscape in Wisconsin.
- The central area was also unglaciated but has a flat to somewhat rolling landscape. The central area, or central sands, is characterized by very sandy soils. The sand was deposited by lakes, rivers, and streams as the glaciers melted. The sand filled in the unglaciated topographic features, creating the subtle, sandy landscape we have today.

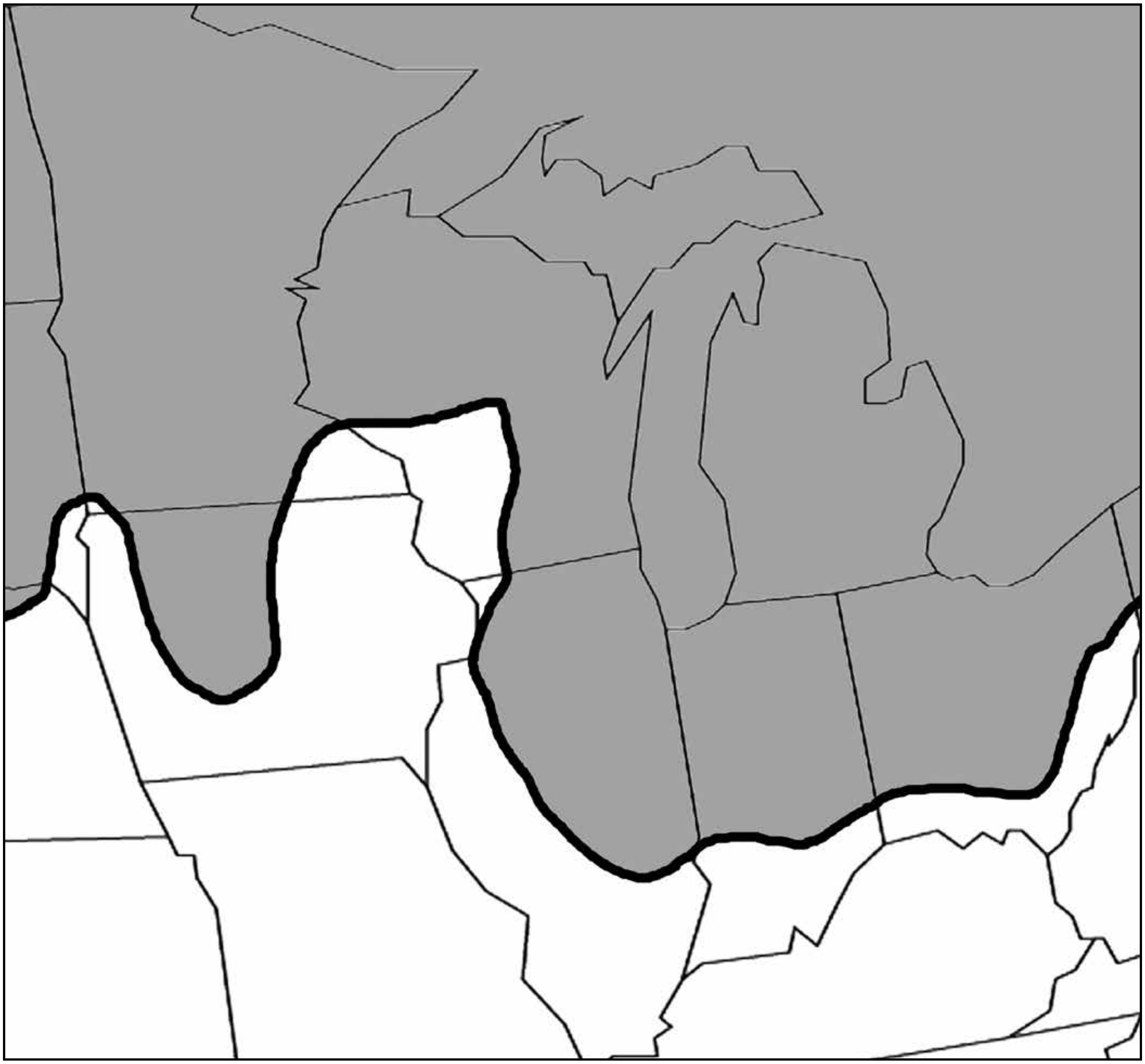
You'll also notice many **moraine features** in Wisconsin. Moraines are glacial deposits that occur between and at the end of glacial lobes. If we had a closer look at the glacial landscape, we could see the lake chains and glacial deposits that are formed as glaciers grow, move, and melt. These features diversify the topography and soil composition across the landscape, creating areas of rocky, sandy, and silty soils.

The last major formation that you'll see is the **well-defined ridge that outlines the tip of Lake Superior**. To the north of the ridge, the landscape dips rather steeply toward the lake. This steep decline is due to both the bedrock geology of the Superior basin (the basin is a graben, a fault in which regional forces cause a large portion of the landscape to sink) and the strong erosive forces of the Superior lobe of the glaciers.

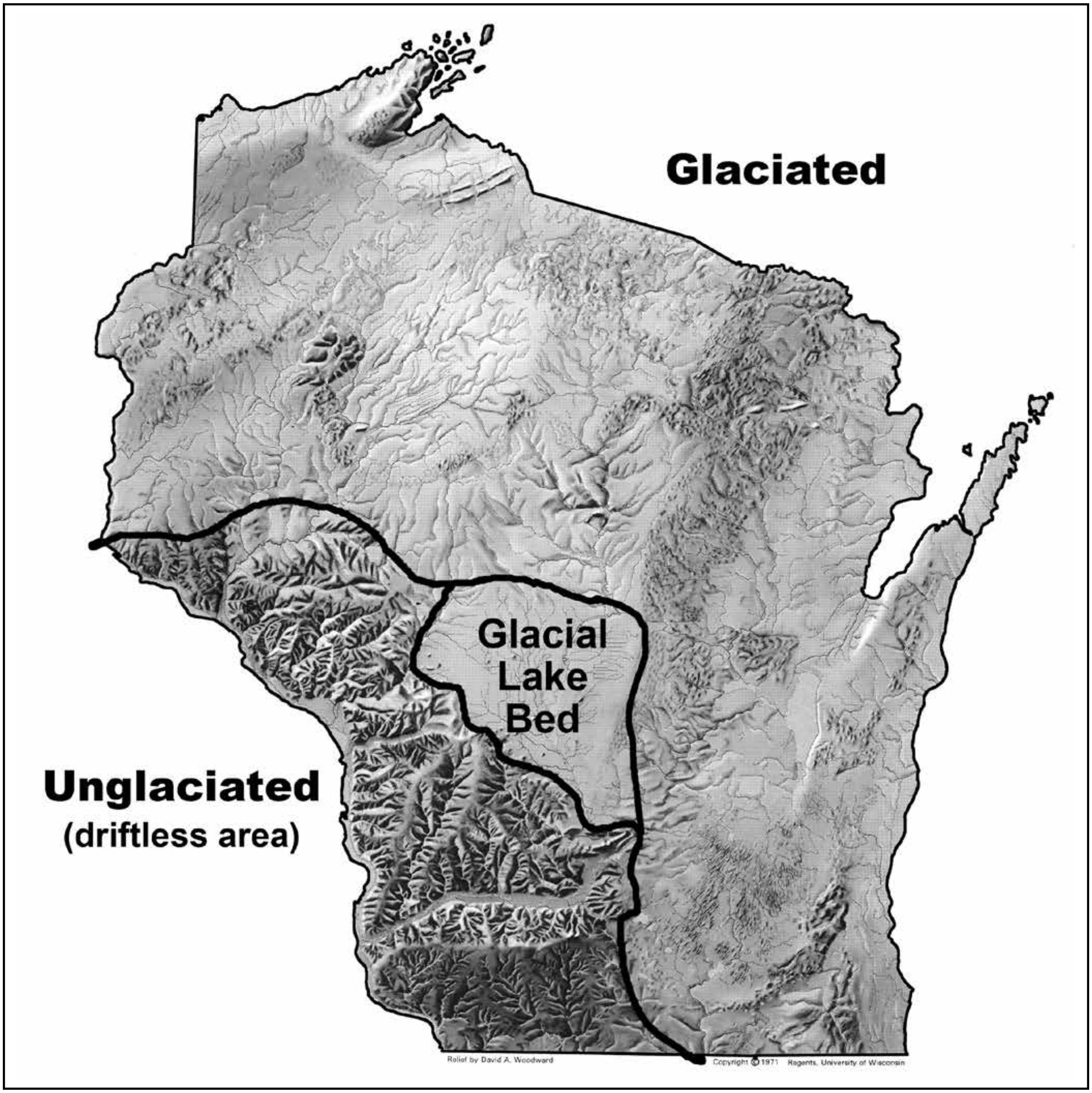
Because of all the glacial influences, different regions of the state have different soils and topography.

Teacher Page 1

GLACIAL EXTENT MAP



WISCONSIN LANDSCAPE MAP



WISCONSIN CLIMATE LECTURE NOTES

Project Teacher Page 5, Wisconsin Climate Map

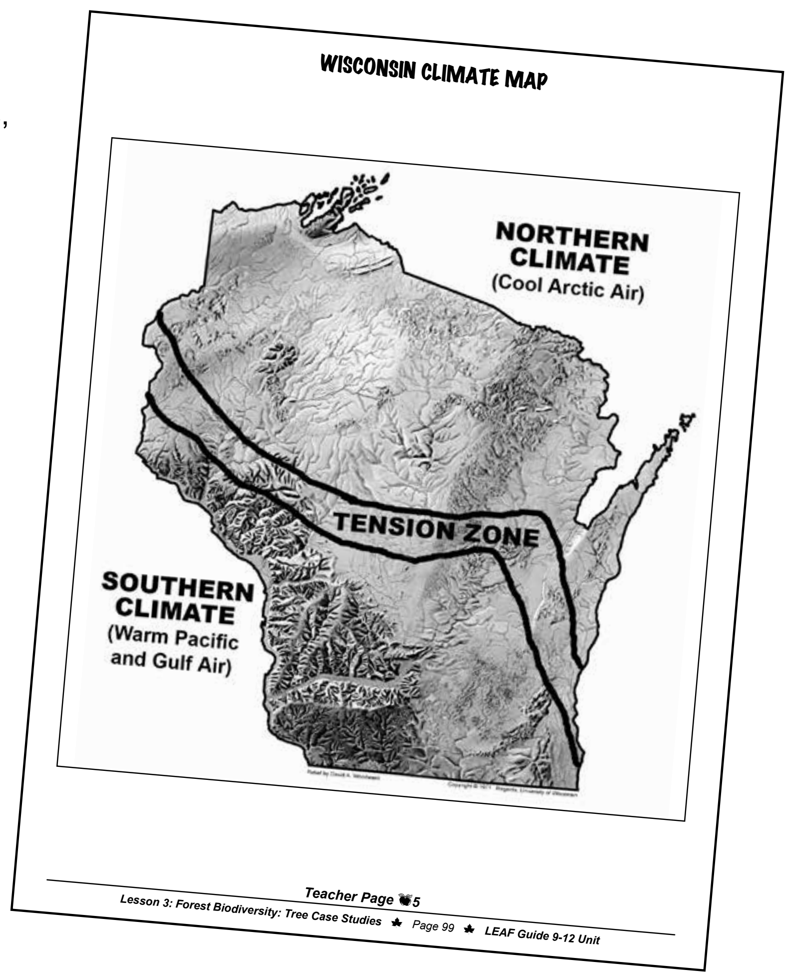
Looking at this map, you'll notice that Wisconsin is divided into **two main climatic zones**, **northern and southern**, with the **tension zone** dividing them. The **northern zone** receives cool, dry arctic air from Canada. Winters here are longer, with more snow and colder temperatures than in the southern zone.

Climate in the **southern zone** is influenced by air from the Pacific Ocean and Gulf of Mexico. Here winters are warmer with less snow, and summers are longer with more rainfall than in the northern zone.

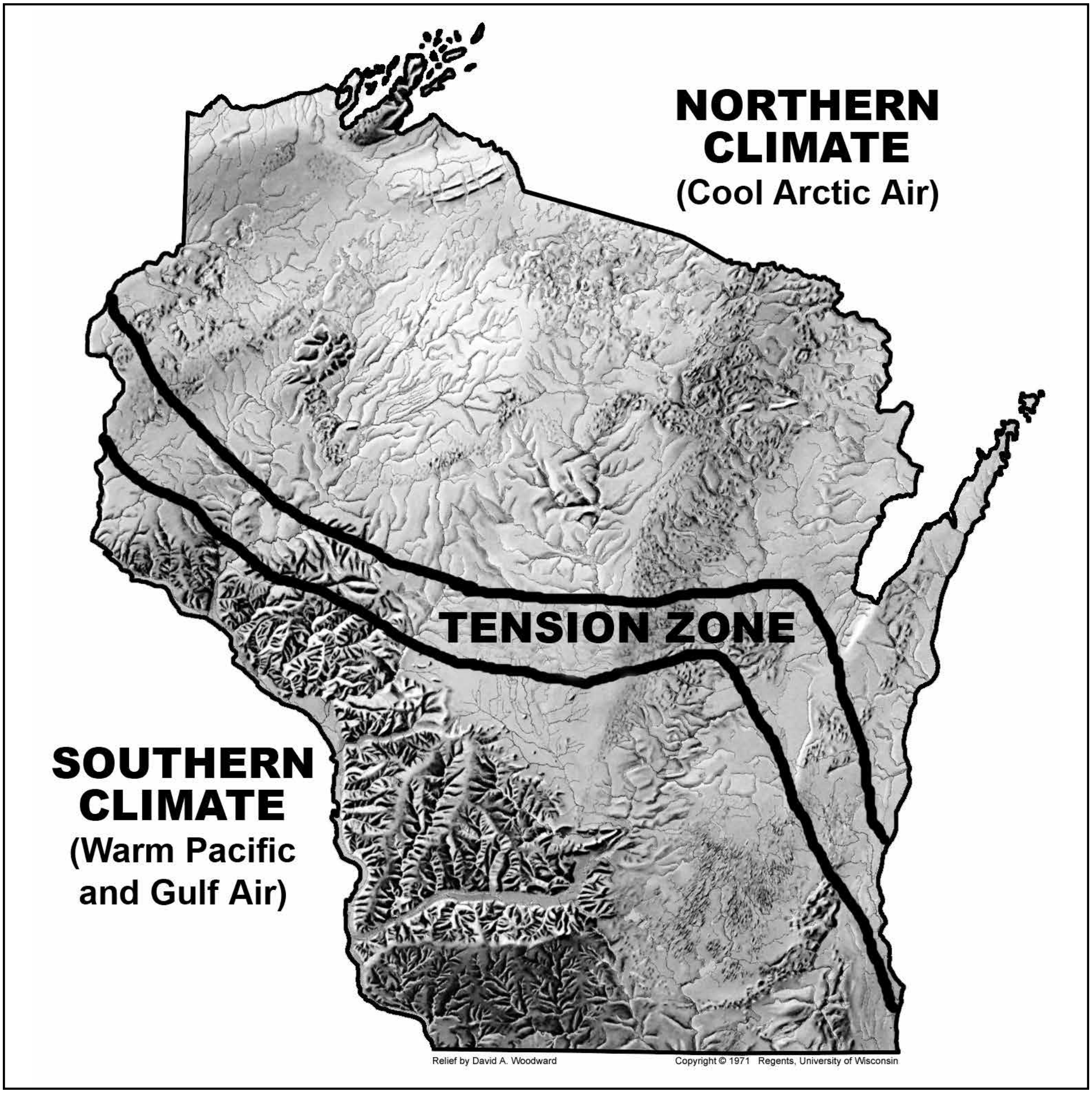
The **tension zone** (outlined in black) is a band that runs somewhat diagonally from north central Wisconsin to southeastern Wisconsin. Here the climate is intermediate between that of the northern and southern zones.

Lake influence plays a role in the regional climate. In general, the Great Lakes' influence leads to cooler summer temperatures, warmer winter temperatures, and higher precipitation in coastal areas than surrounding inland areas. There is a relatively small area in northwestern Wisconsin where the climate is influenced by **Lake Superior**. Arctic winds blow southeast across the lake and carry moisture and precipitation inland. This lake effect leads to lower temperatures and increased snowfall, allowing boreal species to be successful.

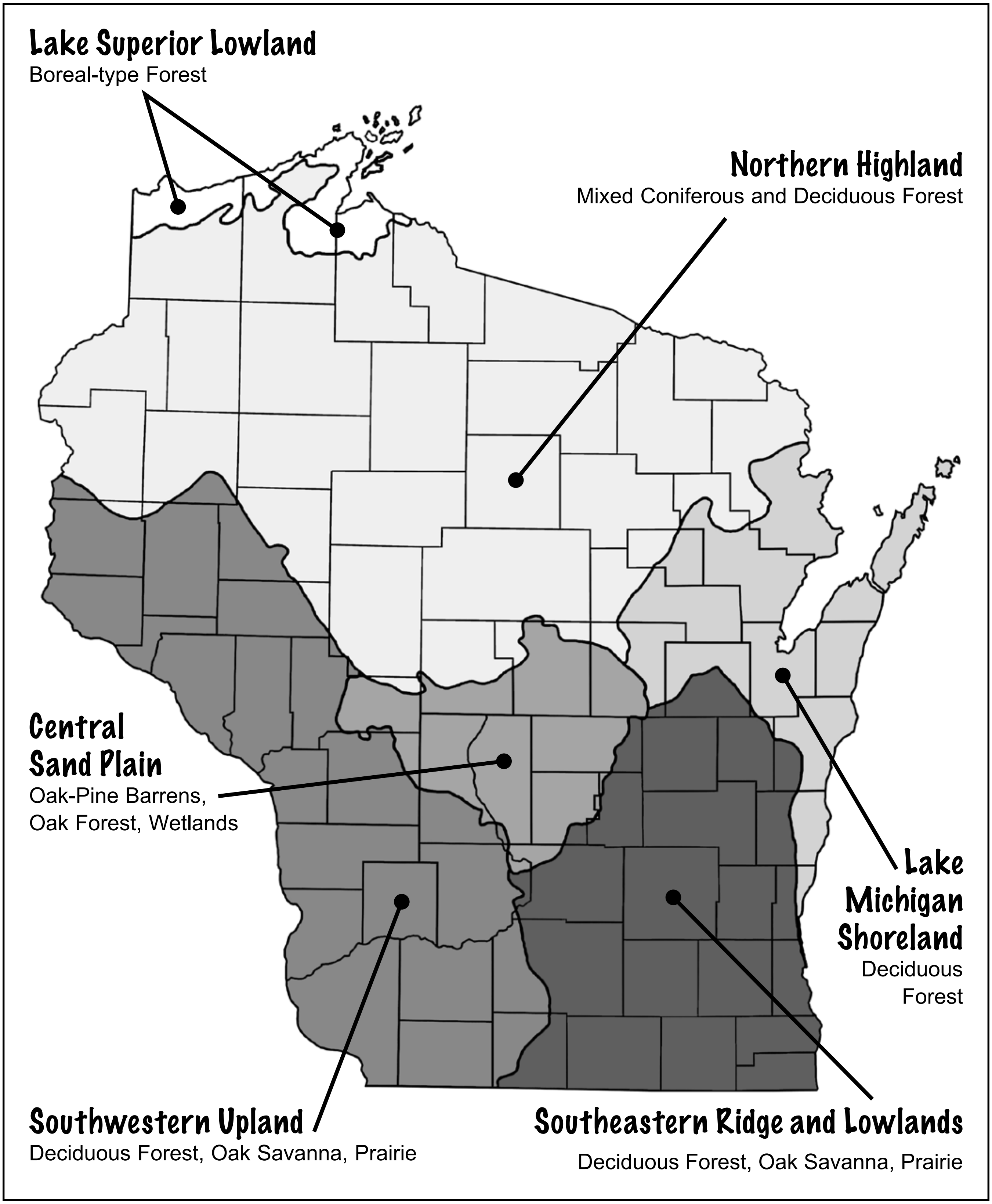
In eastern Wisconsin, the climate is influenced by **Lake Michigan and Green Bay**. The climate is generally more mild and wet than northern and central Wisconsin, helping the region to develop fertile soils and maintain a long growing season.



WISCONSIN CLIMATE MAP



NATURAL DIVISIONS MAP



Teacher Page 6

FOREST BIOMES LECTURE NOTES

Project Teacher Page 8, Forest Biomes Map

Biomes are large areas with similar climates and ecological communities. Terrestrial biomes are grouped into six major types — tundra, boreal forest/taiga, temperate forests, tropical forests, grasslands (including prairies and savannas), and deserts.

Climatic conditions play a major role in where biomes are located. Temperature and precipitation determine the kind of plants that can live in an area. The vegetation, in turn, influences the other types of organisms present.

TEMPERATE FORESTS

- Grow in the midlatitudes of North America, Europe, Eastern Asia, and Australia
- Include both temperate dry forests and temperate rainforests
- Dominate Wisconsin and have moderate average temperatures, moderate precipitation, and four distinct seasons
- Contain deciduous trees (oak, hickory, beech, maple, poplar, etc.) and coniferous trees (pine, fir, spruce, cedar, etc.)

GRASSLANDS

- Are dominated by sun-loving grasses and plants rather than shrubs or trees
- Became established in the Great Plains and Midwest as the formation of the Rocky Mountains in western North America disrupted weather patterns, creating a more arid climate
- Are maintained by the hot, dry summers and cold, wet winters that create conditions suitable for fires
- Have deep, fertile soil because of the cyclical fires and the decay of deep-rooted grasses; due to these characteristics, few prairies remain since most have been turned into farms or grazing land

SAVANNAS

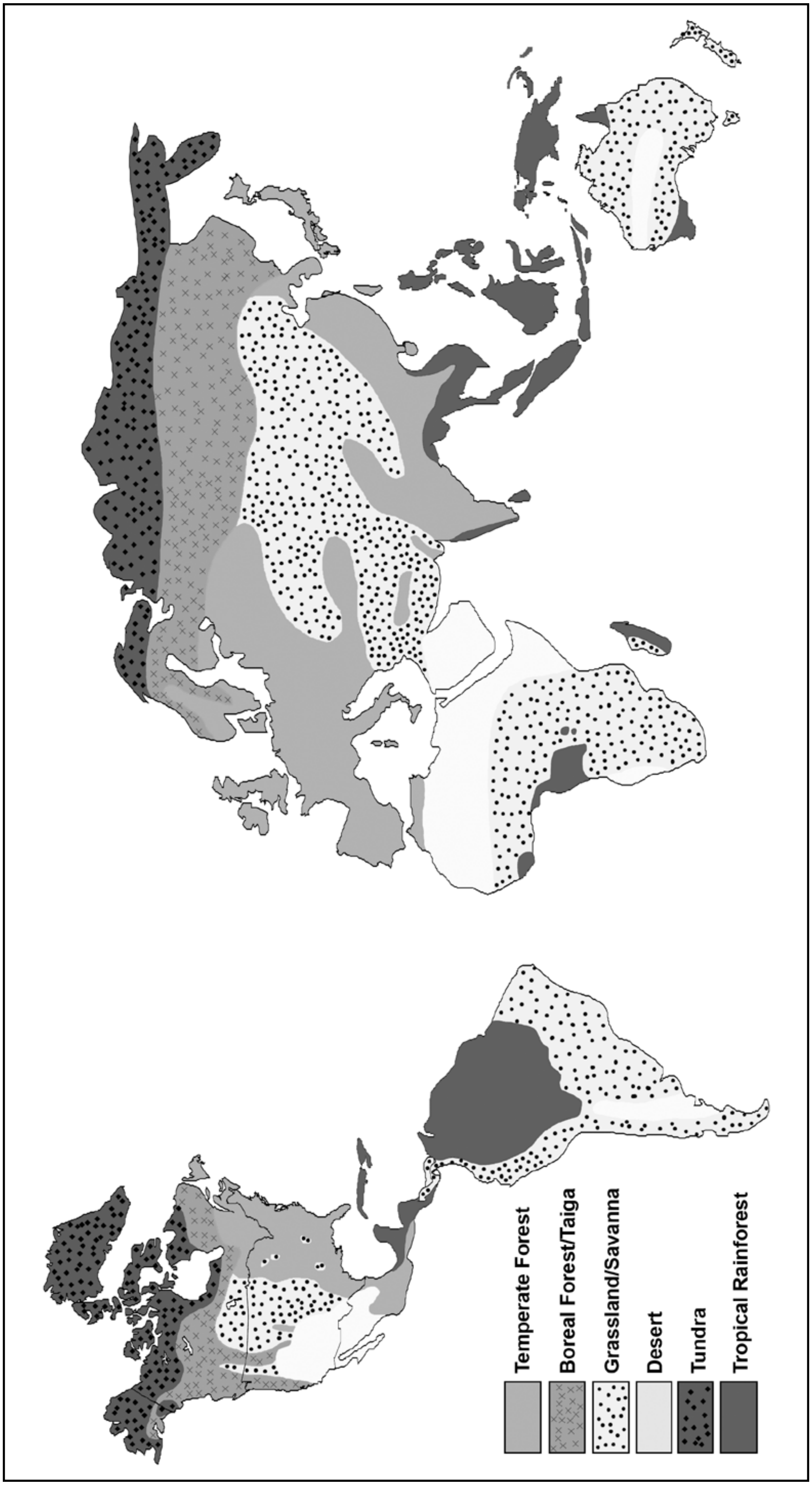
- Are grasslands with scattered trees and usually border other grasslands
- Cover almost half the surface of Africa, large areas of Australia, South America, and smaller areas of the North American continent
- Are found in warm or hot climates with moderate annual rainfall
- Form under specific climate conditions, when rainfall is concentrated in six months of the year and followed by a long period of drought in which fires can occur
- Dominated much of central and southern Wisconsin at the turn of the 20th century
- Have been reduced to less than 1% of their presettlement range in North America due to agricultural conversion and fire suppression

BOREAL FOREST/TAIGA

- Is found in subarctic northern latitudes across North America, Asia, and Europe
- Form when winters are severe and summers are relatively short with long days
- Have acidic soils; low areas are often waterlogged during the summer; coniferous trees (fir, spruce, hemlock, and cedar) are adapted to these conditions

In Wisconsin, there are small amounts of boreal-type forest in the northwest along Lake Superior and in the northern portion of the Door County Peninsula. These forests are not in the boreal biome, but have similar characteristics caused by the cooling effect created by the Great Lakes.

FOREST BIOMES MAP

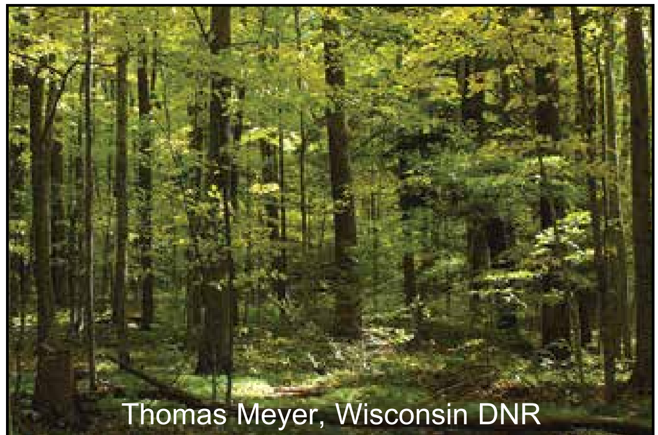


FOREST CHARACTERISTICS

Forest Composition

Tree Species Within a Forest

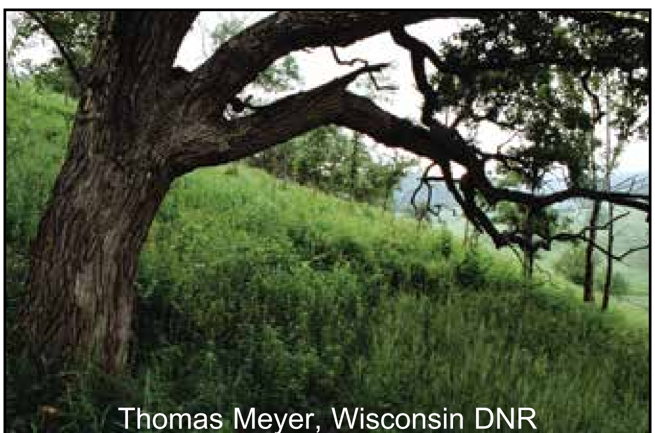
Dominant trees are often used to characterize a forest; for example, **maple-basswood forest** and **oak-hickory forest**.



Forest Structure

Vertical and Horizontal Spacing of Trees In a Forest

Even-aged forests and **savannas** are good examples of how structure is used to define a forest.



Location

Latitude, Longitude, and Altitude of a Forest Region

Location is often used to describe large areas of forest; for example, **northern forest**, **eastern forest**, and **highland forest**.

Environmental Conditions

Climatic, Soil, and Landscape Characteristics of a Forest

The prevailing environmental conditions often best define a forest; for example, **wetland forest**, **arid forest**, and **coastal forest**.

CASE STUDIES KEY

American Chestnut

1. **In the early 1900s, what values did people place on the American chestnut?** The American chestnut was the largest, most impressive tree in the forest. People used the nuts for food, the leaves for medicine, and the wood for construction.

2. **In the early 1900s, where was the American chestnut found?** A 200-million-acre forested area that stretched across the Midwest to Michigan, south to Alabama and Mississippi, and eastward into the Appalachians.

3. **Over the last century, what has happened to the American chestnut?** The fungus, *Cryphonectria parasitica*, commonly known as the chestnut blight, was introduced to the U.S. accidentally with exotic garden plants. From 1904 to 1950, the fungus spread throughout the entire range of the American chestnut and destroyed nearly all the trees.

4. **Why didn't Asian varieties of chestnut show signs of chestnut blight?** The fungus has been in Asia for thousands of years and the chestnut trees have adapted to it. The trees that had the ability (the genetic makeup) to survive the blight did. The trees brought to the U.S. were their descendants.

5. **What effect does the disappearance of the American chestnut have on the tree species diversity of eastern forests?** The species diversity throughout the eastern forests has decreased because of the disappearance of the American chestnut caused by the chestnut blight.

6. **The largest remaining stand of American chestnut is in La Crosse County, Wisconsin, well outside the original range of the tree. How did the trees get there and how did they survive the blight for so long?** They were planted there in the late 1800s by a local resident and have reproduced and spread to cover 60 acres of forest. 2,500 chestnut trees now live in the forest. Because they were outside the natural range of the American chestnut, the fungus didn't reach them.

7. **Why has the stand of American chestnut in La Crosse County become a focal point for forest research?** Because they were planted outside of the original range of the tree, they escaped the chestnut blight for a long time. It is now the largest stand of American chestnut left.

8. **What kind of research is being done in the American chestnut stand and what is at stake?** Forest researchers from all over the country are studying the trees and fungus to find ways to combat the fungus and re-establish the American chestnut in the eastern forest. Currently, they are using a naturally occurring "hypovirus" to attack the fungus itself, which has shown some promise.

9. **How does the concept of genetic diversity become a concern in this story?** The genetic diversity of the chestnut in Asia allowed it to adapt, over long periods of time, to the chestnut blight. The genetic diversity of the fungus is of concern to researchers. The hypovirus that is used to attack the chestnut blight is only effective against certain strains of the fungus. The genetic diversity of the fungus throughout the eastern U.S. may help it survive the hypovirus.

10. **What perspectives does the author give on the American chestnut?** At the end of the article, the author states, "A century without chestnut may sound like a lot in human years, but it is only a moment in ecological time."

CASE STUDIES KEY

American Elm

1. **Where was American elm found in the U.S. at the beginning of the 1900s?** American elm was found from Canada to the Gulf of Mexico and from the Great Plains to the East Coast.

2. **What happened to the American elm in the 1930s?** The Asian fungal disease, *Ophiostoma ulmi*, commonly known as Dutch elm disease (DED), was accidentally introduced to the U.S. It spread throughout the range of the American elm and killed most of the trees.

3. **What observations does the author make about the current level of resistance to DED and the genetic diversity of American elm trees in the United States?** The author states, "Little native resistance was found in the American elm gene pool when DED was first introduced, but small pockets of American elm survived DED due to their isolation and others resisted the disease due to a combination of environmental and genetic factors. By selecting and breeding American elms that showed resistance, researchers found that up to 60% of some remaining American elm populations had levels of resistance to DED."

4. **How is the genetic diversity of *Ophiostoma ulmi* changing? What does that mean for the resistance of the American elm tree?** DED is changing and adapting. Three different strains of the disease are known to exist, and each has slightly different methods of attacking trees. This makes it extremely difficult to breed a tree that is resistant to all three of the deadly strains.

5. **What other sources (other elm species, other countries) have been used to breed DED-resistant elm trees? What are the drawbacks to these more resistant trees?** Researchers have used Siberian elm, Chinese elm, and lacebark elm, but some of the trees cannot tolerate cold weather and others breed rapidly and invade farms and forested areas.

6. **What is genetic engineering?** Genetic engineering is the genetic modification of an individual organism to create a new trait by splicing a gene from another organism into the individual's DNA sequence.

7. **How might genetic engineering help scientists produce an American elm resistant to DED?** Scientists can insert genes that create resistance in some elm trees into trees that do not have a natural resistance.

8. **What perspectives does the author give for the future of genetic engineering and American elm?** Genetic engineering is very costly and often reserved for species that are economically valuable. Resistance in American elm will most likely come from hybrid trees.

Eastern Hemlock

1. **In what type of forest is eastern hemlock usually dominant?** Mature and old-growth forests in the eastern U.S.

2. **What do paleo-ecological studies suggest about the history of eastern hemlock forests?** The history is characterized by cycles of large-scale disturbance that kill eastern hemlock trees in large numbers across its range.

CASE STUDIES KEY

Eastern Hemlock (continued)

3. **What is currently happening to eastern hemlock throughout its range?** The introduced insect, the hemlock wooly adelgid, is killing eastern hemlock trees.

4. **What recent factors have contributed to the decline of eastern hemlock?** Widespread logging during and after European settlement, large deer populations, and the hemlock wooly adelgid.

5. **What impact does the decrease in eastern hemlock have on the ecosystem diversity of the forests of the eastern U.S.?** It is causing a decrease in the complexity and diversity of forest composition and structure throughout eastern forests.

6. **What impact could the decrease in eastern hemlock have on the species diversity of the northeastern forests?** Many species of plants, animals, fungus, insects, and microorganisms that require the habitat conditions provided by old, hemlock dominated forests may decrease in numbers.

7. **How might genetic diversity help the eastern hemlock survive the hemlock woolly adelgid?** If some populations of eastern hemlock have developed a natural resistance to the wooly adelgid, the tree could be crossbred with other hemlock trees to develop a resistant hybrid. The hybrid could then be reintroduced in eastern forests.

8. **What perspective does the author give on the future of the eastern hemlock forest?** At the end of the article the author states, "Although the decline of hemlock could be permanent in our human time frame, in hundreds or thousands of years, history suggests that the hemlock will probably recover."

Red Maple

1. **What is the red maple paradox?** The red maple paradox refers to the fact that red maple is greatly expanding its dominance in eastern forests and replacing other tree species in spite of the fact that the tree itself does not seem to have any biological advantages.

2. **What land use changes are helping the expansion of red maple?** Fire suppression, large white-tailed deer populations, the spread of the gypsy moth, and increased atmospheric carbon.

3. **What characteristics have helped red maple become so widespread in Wisconsin and other northeastern forests during the last century?** Its unique seed life cycle (seeds are disseminated and germinate in early spring), tolerance of a variety of soil conditions, moderate shade tolerance, early maturity, and large seed production.

4. **How have human actions helped the red maple expansion?** Widespread fire suppression and the elimination of large predators (contributing to the increase in deer populations) allow red maple to enter and remain in the understory of many forests.

5. **Which types of forest are being affected as red maple expands?** Many oak forest communities are losing ground to red maple.

6. **What effect do you think the expansion of red maple is having on the ecosystem diversity of forests in Wisconsin and the northeast?** As red maple replaces oaks in forests across the U.S., forest composition and forest structure becomes more homogenous. This represents a decrease in ecosystem diversity.

Red Maple (continued)

7. **What possible effect could a decrease in ecosystem diversity have on the species diversity of northeastern forests?** Animals, plants, insects, fungus, and microorganisms that depend on the habitat conditions provided by oak forests, may decrease in number and disappear from portions of the landscape. This would be a decrease in species diversity.

8. **How does red maple's genetic diversity influence its expansion in the forests of the eastern U.S.?** As a species, red maple is genetically diverse. This allows it to adapt to a variety of environmental conditions across the landscape.

White Oak

1. **Why did white oak dominate eastern forests before European settlement?** White oak dominated many forest communities because of the warmer, drier climate after glaciers receded and because of the widespread influence of cyclical fire.

2. **For the past 100 years, what has happened to the distribution of white oak in the U.S.?** It has declined by at least 10% in most sites across its range.

3. **What are the causes of the white oak decline?** Widespread logging and agricultural conversion at the turn of the century began the white oak decline. More recently, the suppression of fire has allowed other species to invade and outcompete white oak in many forested areas.

4. **What tree species are replacing white oaks as the dominant trees?** Chestnut oak, red oak, and red maple.

5. **What effect has the white oak decline had on the ecosystem diversity of eastern forests?** The large white oaks created unique habitat for a variety of plants and animals. Their acorns are a valuable source of wildlife food (more than 180 different kinds of birds and mammals use oak acorns as food, including squirrels, blue jays, red-headed woodpeckers, deer, turkey, quail, and ducks). As white oak habitat decreases, and animal habitat becomes more homogenous, the ecosystem diversity declines.

6. **What economic effects result from the white oak decline?** White oak is known as an outstanding tree among all trees in the eastern North America. It is a very important lumber tree. Its high-grade wood is useful for many things and it is also planted as an ornamental tree because of its broad round crown, dense foliage, and purplish-red to violet purple fall coloration.

7. **What effect might the dramatic decrease in white oak populations have on the genetic diversity of the species?** As white oak populations decline, the genetic resources of the species decline. A high genetic diversity is important to protect the trees from diseases (as is the case with both American chestnut and American elm).

8. **According to the author, what prospects does the white oak have to regain its dominance in forests of the eastern U.S.?** In paragraph four, the author states, "In light of these facts, it seems that the dominance of the white oak in the forest of eastern North America is over and its numbers continue to decline."

BIODIVERSITY SCENARIOS

Fill in the blank for each of the three biodiversity scenarios with one of the terms defined below.

Ecosystem Diversity: The variety of communities or ecosystems in a given area through time.

Genetic Diversity: The genetic variation within a population or species.

Species Diversity: The variety of different species in a given area.

1. THE WHOOPING CRANE

In 1941, there were only 22 whooping cranes left in the world. This low number was a drastic decrease from the 1,200 to 1,400 birds that biologists estimate existed in the mid-1800s. In 1967, when park rangers in Canada's Northwest Territories found the breeding grounds for these nearly extinct birds, they began to send eggs to the Patuxent Wildlife Research Center in Maryland. The wildlife biologists were very concerned that the low ______________________________ found in the small population of remaining birds would make it nearly impossible to breed a healthy population. Yet with their efforts, and the efforts of other organizations, such as the International Crane Foundation, there are more than 220 birds alive today. Whooping cranes are one of conservation's biggest success stories.

2. BUCKTHORN INVASION

Glossy and common buckthorn are similar shrubs that were introduced from Eurasia for ornamental purposes in the 1800s. The shrubs have been aggressively invading forests in Wisconsin. They are dispersed in forests as birds eat and transport their seeds. The shrubs displace native understory vegetation by forming a thick shrub layer that blocks sunlight and competes heavily for space and water. The shrubs outcompete native plants and trees and inevitably decrease the ______________________________ found in the forest. Unfortunately, the shrub is still available for sale in garden shops and nurseries.

3. THE NORTHERN HARDWOODS

The northern hardwood forest stretches across northern Wisconsin and is home to abundant wildlife and thousands of lakes. A variety of trees make up the forest, with older forest stands dominated by eastern hemlock and sugar maple and younger stands dominated by aspen and birch. One of the defining characteristics of the northern hardwoods is the great variety of ages in the different stands of trees. The variation is caused by small-scale disturbances such as fire, wind, insect outbreaks, drought, and flooding. These localized disturbances kill older, overstory trees and allow sunlight to reach the forest floor. Young sun-loving trees grow in their place causing a patchwork of different forest compositions and structures across the landscape. The variety of biological communities across the forest landscape and through time results in a high ______________________________, providing habitat for a range of different plants and animals.

AMERICAN CHESTNUT

Case Study Assignment

Read the tree profile and article summary. Answer the following questions.

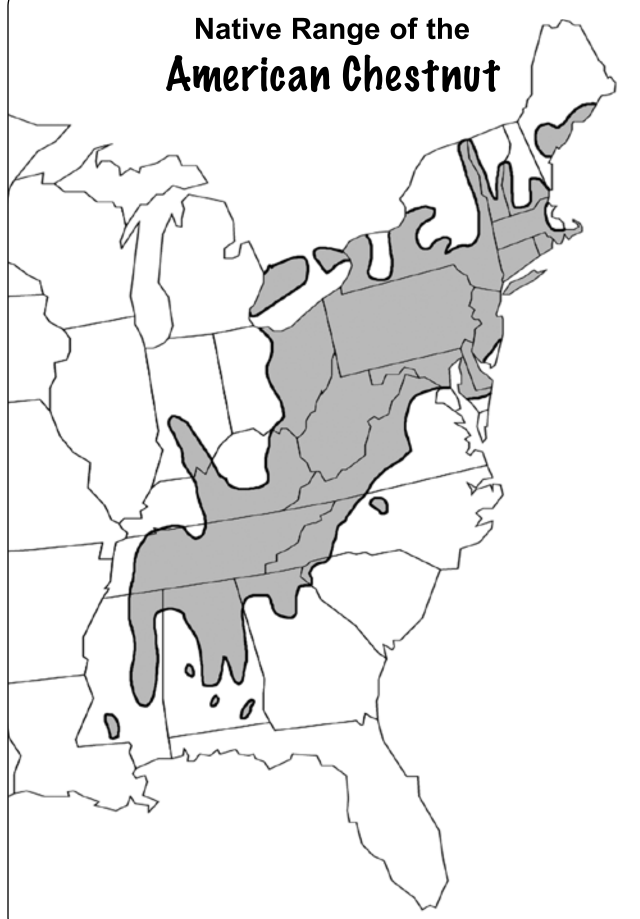
1. In the early 1900s, what values did people place on the American chestnut?
2. In the early 1900s, where was the American chestnut found?
3. Over the last century, what has happened to the American chestnut?
4. Why didn't Asian varieties of chestnut show signs of chestnut blight?
5. What effect does the disappearance of the American chestnut have on the species diversity of eastern forests?
6. The largest remaining stand of American chestnut is in La Crosse County, Wisconsin, well outside the original range of the tree. How did the trees get there and how did they survive the blight for so long?
7. Why has the stand of American chestnut in La Crosse County, Wisconsin, become a focal point for forest research?
8. What kind of research is being done in the American chestnut stand in La Crosse and what is at stake?
9. How does the concept of genetic diversity become a concern in this story?
10. What perspectives does the author give on the future of the American chestnut?

TREE PROFILE

Native Range

American chestnut once grew from southern Maine across the Midwest to Michigan, south to Alabama and Mississippi, and eastward into the Appalachians. It was cultivated in 1800 and was once considered to be the queen of the eastern American forest. With massive, widespreading branches and a broad, round crown, the American chestnut was known to reach a height of 100 feet.

Chestnuts grew along with several species of oak, hickory, maple, and birch. It was commonly found on mountains, hills, and slopes in gravelly or rocky, well-drained glacial soils. With the introduction of the chestnut blight (a fungus from Asia) in the early 1900s, the tree was devastated. Chestnut trees still exist in some eastern forests, but the fungus causes them to grow short and shrub-like, much unlike the great size they are known for historically. Some isolated stands of American chestnut still exist, the largest being 60 acres of private forestland in La Crosse County, Wisconsin.



AMERICAN CHESTNUT

Importance

Before its decimation by the chestnut blight, the American chestnut was economically important. The wood is lightweight, soft, easy to split, very resistant to decay, and does not warp or shrink. Because of its resistance to decay, industries used its wood for posts, poles, piling, railroad ties, and split-rail fences. Its straight-grained wood was ideal for building log cabins, furniture, and caskets. Split-rail fences made from the American chestnut can still be found along country roads throughout the northeast United States and the southern Appalachians. The fruit was an important cash crop. Families raked up chestnuts by the bushels to cook for their own use or sell in nearby towns. The bark and wood were rich in tannic acid, which provided tannins for use in the tanning of leather. The American chestnut was a graceful shade tree found in city squares and on the rural homestead.

ARTICLE SUMMARY – CHESTNUT'S LAST STAND

Summarized from an article published in August 2002, Wisconsin Natural Resources, Vol. 26, No. 4, by Gina Childs of the USDA – Forest Service

Each spring doctors come from all over the country to visit Wisconsin. These are not medical doctors, but doctors who study tree diseases and plant genetics. Their patients are not wriggling babies lined up in the halls of the local public health department; they are 2,500 large American chestnut trees standing on 60 acres of private forestland in La Crosse County. It is the largest remaining stand of American chestnut in the world. The scientists are determined that these large trees will not be the last.

The American chestnut once dominated the Eastern forest. One out of every four trees within the 200 million-acre forest was a chestnut. The tree was majestic, and would cover the east in white flowers during the summer. Parks and towns often featured chestnuts eight to nine feet in diameter (as wide as a car is long!) and as tall as a seven-story building. It was a staple of eastern life, used as a food, a medicine (the leaves were used to cure whooping cough), and a building material.

The widespread death of the American chestnut has been described as the single greatest catastrophe known in North American forest history. The devastation began at the beginning of the 20th century when the fungus Cryphonectria parasitica *was accidentally brought to the U.S. from Asia. The fungus arrived unnoticed with Asian chestnut varieties meant for ornamental gardens and is responsible for chestnut blight.*

The chestnut blight causes cankers on the trunk and branches of American chestnut trees. As the disease progresses, the canker encircles the tree or limb, completely cutting off the tree's ability to transport nutrients. Eventually everything above the canker wilts and dies. The tree survives and can re-sprout below the affected area, but the new growth inevitably becomes infected as well.

The Asian varieties of chestnut evolved with the fungus over thousands of years. The trees introduced to the U.S. were descendants of trees that had the correct genetic makeup, and thus the ability to survive the debilitating effects of the fungus. Showing no signs of disease, the fungus went unnoticed. Unfortunately, the American chestnut, having never experienced the blight, had no resistance to the fungus.

The chestnut blight was first spotted in New York City in 1904. Within 50 years, it spread throughout the entire range of American chestnut and destroyed almost all of the large trees. The spores of the fungus spread readily by wind, birds, and mammals. Not surprisingly, the last stand of big American chestnut trees can be found outside of the natural range of the tree, where the fungal spores were less likely to arrive.

(continued on next page.)

AMERICAN CHESTNUT

ARTICLE SUMMARY: CHESTNUT'S LAST STAND (CONTINUED)

Summarized from an article published in August 2002, Wisconsin Natural Resources, Vol. 26, No. 4, by Gina Childs of the USDA – Forest Service

The stand in La Crosse County is composed of trees descended from American chestnut trees planted by a farmer, Martin Hicks, in the late 1800s. The trees escaped the initial spread of chestnut blight, but the fungus eventually arrived and scientists found the first signs of blight in 1987. Early attempts to save the tree involved the removal and destruction of any tree suspected to have the blight. This strategy did not work and scientists are employing a new tactic — introduce a disease that attacks and weakens the fungus.

The disease is a naturally occurring virus that grows within the fungus and is termed a "hypovirus." Dr. Dennis Fullbright from Michigan State University isolated the virus from a fungus in Michigan and came up with the following theory — by introducing the Michigan virus to the stand of American chestnut trees in La Crosse County, the virus would attack the fungus and the trees would overcome the blight.

In order for the theory to work, the scientists first needed to be sure that only one strain of the chestnut blight existed in the stand. If they found a large amount of genetic diversity in the fungus, then the virus might not be able to weaken all of the strains, and the fungus would persist. A plant geneticist from Cornell University, Dr. Michael Milgroom, tested samples of the fungus taken from La Crosse County and concluded that this indeed was the case – only one strain of the fungus existed. The genetic diversity was potentially small enough to be susceptible to the hypovirus.

In a procedure that appears to be half science fiction and half outpatient surgery, the scientists set out to introduce the hypovirus into the chestnut blight. They collected the hypovirus from trees in Michigan, mixed the virus with the fungus in a laboratory, and injected the mixture into the infected trees in La Crosse County. The trees responded immediately and began to heal over their cankers and recover from the devastating effect of the blight. Unfortunately, the hypovirus proved to be too effective, and the virus-carrying fungus was not moving to other trees. Only the treated trees were recovering. The fungus without the hypovirus was still spreading, and the blight continued to spread through the stand.

Will the stand survive? Will the American chestnut once again dominate the Eastern forests? It seems the answer depends on whether you are a pessimist or an optimist. The most likely scenario is that 50 years from now, American chestnut will still be growing in La Crosse County, but all of the trees may not survive. The widespread inoculation of infected trees with the hypovirus may be too costly, and some strains of the chestnut blight in other parts of the country may have the ability to overcome its weakening effects.

Many institutions are continuing their work to re-establish the American chestnut tree, most notable among them is the American Chestnut Foundation. Hope does exist, and for the optimist, it may be best to look at the problems of the American chestnut in the following way – a century without the chestnut may sound like a lot in human years, but it is only a moment in ecological time.

The fruit of a chestnut tree belongs to the group of nuts. It is protected with a hard, brown husk which is covered with spines.

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Student Page ✐ 2C

AMERICAN ELM

Case Study Assignment

PART A

Read the tree profile and article summary. Answer the following questions about your tree species (you may work with other members of your group if you wish).

1. Where was American elm found in the U.S. at the beginning of the 1900s?
2. What happened to the American elm in the 1930s?
3. What observations does the author make about the current level of resistance to Dutch elm disease (DED) and the genetic diversity of American elm trees in the U.S.?
4. How is the genetic diversity of *Ophiostoma ulmi* changing? What does that mean for the resistance of the American elm tree?
5. What other sources (other elm species, other countries) have been used to breed DED-resistant elm trees? What are the drawbacks to these more resistant trees?
6. What is genetic engineering?
7. How might genetic engineering help scientists produce an American elm resistant to DED?
8. What perspectives does the author give for the future of genetic engineering and American elm?

PART B

As a group, create a poster about your tree case study. The poster will need to include the following elements:

- Brief description of the importance of the tree
- Map of the tree's range in North America
- Map of the tree's distribution in Wisconsin
- A description of the history and current status of the tree
- A list of "biodiversity insights" found in the case study of your tree

PART C

Give a five- to 10-minute presentation about your tree case study using the poster as a visual aid. The presentation will need to include the following elements:

- A description of the important information in all five sections of the poster with special emphasis on the "biodiversity insights"
- A discussion with the class about the case study (this may involve helping the audience form and ask questions, as well as answering questions asked)

Wood of elm was used for the construction of longbows during the Middle Ages.

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TREE PROFILE

Native Range

American elm, also known as white elm, water elm, soft elm, or Florida elm, is most notable for its susceptibility to the wilt fungus, commonly called Dutch elm disease (DED). Scores of dead American elm trees in the forests, rural, and urban areas are testimony to the seriousness of the disease. American elms now comprise a much smaller percentage of the large diameter trees in mixed forest stands than they once did.

American elm is found throughout eastern North America. Its range is from Nova Scotia, west to central Ontario; south to extreme eastern Montana and into central Texas; east to central Florida; and north along the entire east coast.

AMERICAN ELM

Importance

Before the arrival of Dutch elm disease, American elm was prized for its use as a street tree. It was fast-growing, hardy, tolerant to stress, and appreciated for its characteristic vase-like crown. The wood of American elm is moderately heavy, hard, and stiff. It has interlocked grain and is difficult to split, which is an advantage for its use as hockey sticks and where bending is needed. It is used principally for furniture, dimension lumber, flooring, construction timbers, and sheet metal work. Some elm wood goes into veneer for making boxes, crates, and baskets, and a small quantity is used for pulp and paper manufacturing.

Genetic Engineering: The modification of an individual organism to create a new trait by splicing a gene from another organism into the individual's DNA.

ARTICLE SUMMARY – ELMS: PAST, PRESENT, AND FUTURE

Summarized from Shade Tree Wilt Diseases (2001) by Raymond P. Guries of the University of Wisconsin-Madison

In this article, the author discusses the history of the American elm and the prospects of breeding or genetically engineering an American elm that is resistant to the fungal disease Ophiostoma ulmi, more widely known as Dutch elm disease. The article explains the history of the scientific effort to combat the spread of the disease and provides an assessment of the future.

Elm is a common name for streets, parks and other community locations in eastern North America. American elms were everywhere up until the 1930s. In the 1930s, Dutch elm disease (DED) was accidentally introduced to North America from Asia. This disease has decimated the American elm across its range in North America. Its impacts were seen most by the vanishing of cathedral-like trees that lined streets and shaded houses in urban and rural areas.

Within a decade of the introduction of DED scientists began researching ways to control DED and find disease-resistant elms. Studies that involved the control of DED with fungicides and/or widespread tree removal proved to be too costly and impractical. Most research has been in the genetic improvement of elms. This involved first breeding native and ***hybrid*** *elms, and then more recently* ***genetic engineering*** *of elm hybrids.*

Hybrid: The offspring of two plants with different genetic makeup.

AMERICAN ELM

ARTICLE SUMMARY – ELMS: PAST, PRESENT, AND FUTURE (CONTINUED)

Summarized from Shade Tree Wilt Diseases (2001) by Raymond P. Guries of the University of Wisconsin-Madison

All genetic improvement studies started with the search for disease-resistant American elms. Over many decades, researchers looked for the perfect disease-resistant American elm. Little native resistance was found in the American elm gene pool when DED was first introduced, but small pockets of American elm survived DED due to their isolation and others resisted the disease due to a combination of environmental and genetic factors. By selecting and breeding American elms that showed resistance, researchers found that up to 60% of some remaining American elm populations had levels of resistance to DED.

During the years that research was taking place to develop American elms resistant to the disease, DED was also changing and adapting. Eventually, three different strains of the disease existed, each of which had slightly different methods of attacking trees. This made testing for all of the strains of DED equally important and made it extremely difficult to breed a tree that was resistant to all three of the deadly strains.

Because of this difficulty, researchers started looking to Asian elm species to breed hybrids, in addition to looking at native American elm populations. Asian elms were known to be resistant to DED because of their exposure to the disease throughout history. Siberian elm was the first Asian elm species to be used as a source for disease-resistant genes. Siberian elms have great disease resistance, hybridize with most other elms and grow rapidly, but they have limitations. Siberian elm's poor architecture, production of large amounts of seeds, and susceptibility to black leaf spot and elm leaf beetle limit its desirability in many locations.

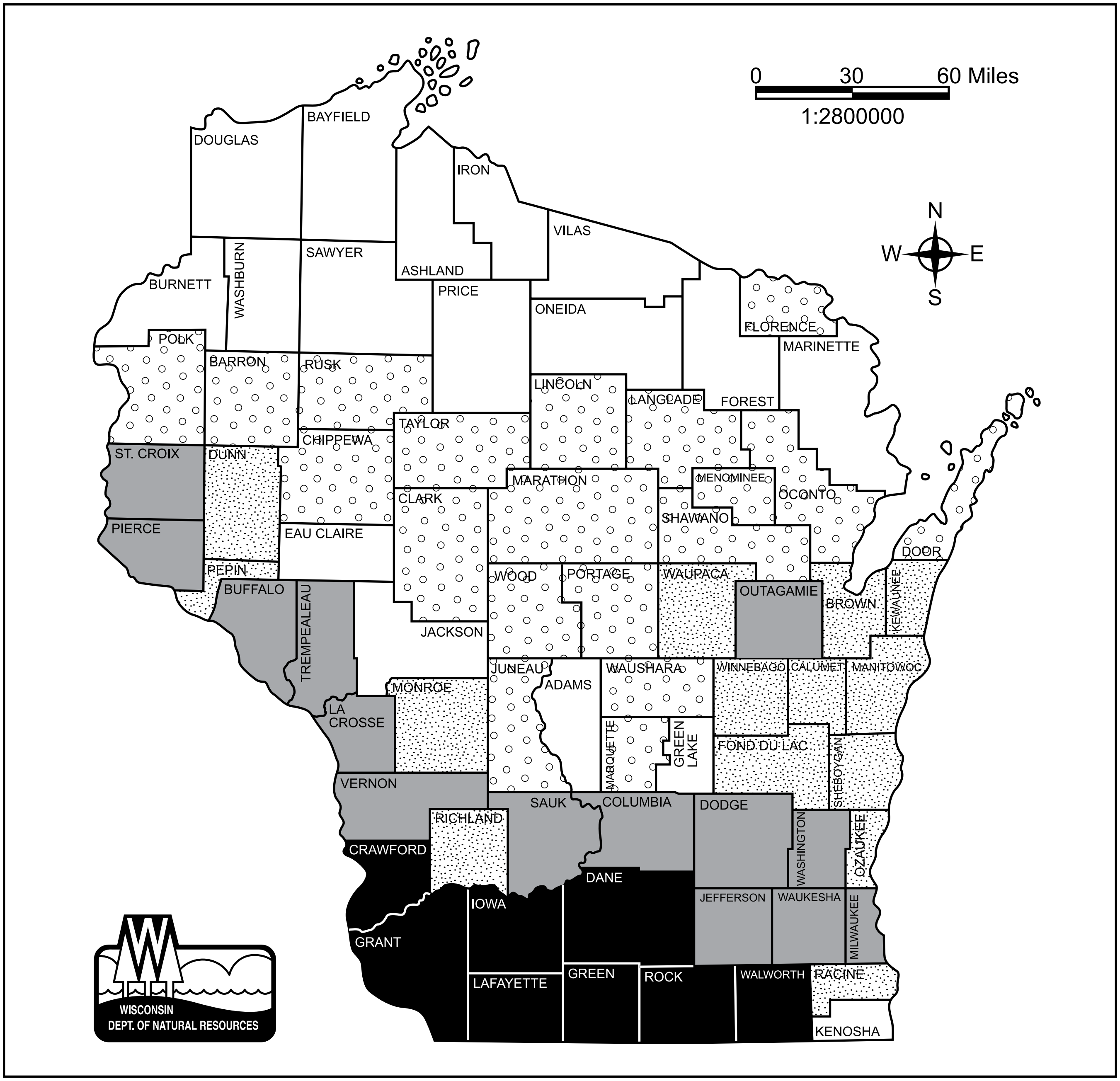
Chinese elm and lacebark elm are two other species that are also hybridized with American elm. Although limited to warmer climates, they are showing some promise in bringing back elms to the eastern North American landscape. This gain comes at a cost. Siberian elms have been hybridizing with native slippery elm across the landscape without aid of the researchers. The hybrid trees reproduce quickly and tend to invade fields and forested areas. In some areas these trees are considered pests due to their prolific seeding.

The future of genetic improvements in elm species seems to lie not only with breeding, but also in genetic engineering. Studying each gene of various elm species will hopefully unlock the answers to DED resistance among various elm species and hybrids. Progress has been slowed by high costs and the fact that funding for genetic research is given on the basis of economic importance. Most of the funding goes to research tree species used for paper or lumber production. The marketing and sale of genetically altered tree products may meet resistance as well. Bioengineered food crops are meeting public resistance already.

Genetic engineering alone will not save the American elm. Researchers will continue to use Asian elms and their hybrids to bring in more genetic diversity to American elm populations in search of DED-resistant elms for our landscape. However, caution needs to be exercised before researchers release these new ***cultivars****. Invasive species like the Siberian and slippery hybrids may otherwise be the result. Saving the American elm is not the main lesson to be learned however. When looking back at the huge social, economic, and environmental costs of DED, we must understand the need to prevent the introduction of exotic plants, animals, insects, and pathogens. And in looking toward the future, we must learn to make better use of the genetic resources available to us.*

AMERICAN ELM

Percent of American Elm Trees by County



Percent of American elm trees within a county.

- 0.0 - 1.0
- 1.1 - 4.0
- 4.1 - 9.0
- 9.1 - 16.0
- 16.1 - 35.0

Map Creator: Division of Forestry, 2004. Data is based on the 1996 Forest Inventory and Analysis Database for Wisconsin.

Student Page ✎ 3D

EASTERN HEMLOCK

Case Study Assignment

PART A

Read the tree profile and article summary. Answer the following questions about your tree species (you may work with other members of your group if you wish).

1. In what type of forest is eastern hemlock usually dominant?
2. What do paleo-ecological studies suggest about the history of eastern hemlock forests?
3. What is currently happening to eastern hemlock throughout its range?
4. What recent factors have contributed to the decline of eastern hemlock?
5. What impact does the decrease in eastern hemlock have on the ecosytem diversity of the forests of the eastern U.S.?
6. What impact could the decrease in eastern hemlock have on the species diversity of the northeastern forests?
7. How might genetic diversity help the eastern hemlock survive the hemlock woolly adelgid?
8. What perspective does the author give on the future of the eastern hemlock forest?

PART B

As a group, create a poster about your tree case study. The poster will need to include the following elements:

- Brief description of the importance of the tree
- Map of the tree's range in North America
- Map of the tree's distribution in Wisconsin
- A description of the history and current status of the tree
- A list of "biodiversity insights" found in the case study of your tree

PART C

Give a five- to 10-minute presentation about your tree case study using the poster as a visual aid. The presentation will need to include the following elements:

- A description of the important information in all five sections of the poster with special emphasis on the "biodiversity insights"
- A discussion with the class about the case study (this may involve helping the audience form and ask questions, as well as answering questions asked)

TREE PROFILE

Native Range

Eastern hemlock, also called Canada hemlock or hemlock spruce, is a slow-growing, long-lived tree which, unlike many trees, grows well in shade. It may take 250 to 300 years to reach maturity and may live for 800 years or more.

The northern limit of eastern hemlock extends from northeastern Minnesota and the northeastern one-third of Wisconsin eastward to Nova Scotia. Within the United States, the species is found throughout northeastern and the Mid-Atlantic states, extending westward from central New Jersey to the Appalachian Mountains, then southward into Alabama.

Oil extracted from the needles of hemlock tree has application in the industry of perfumes.

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EASTERN HEMLOCK

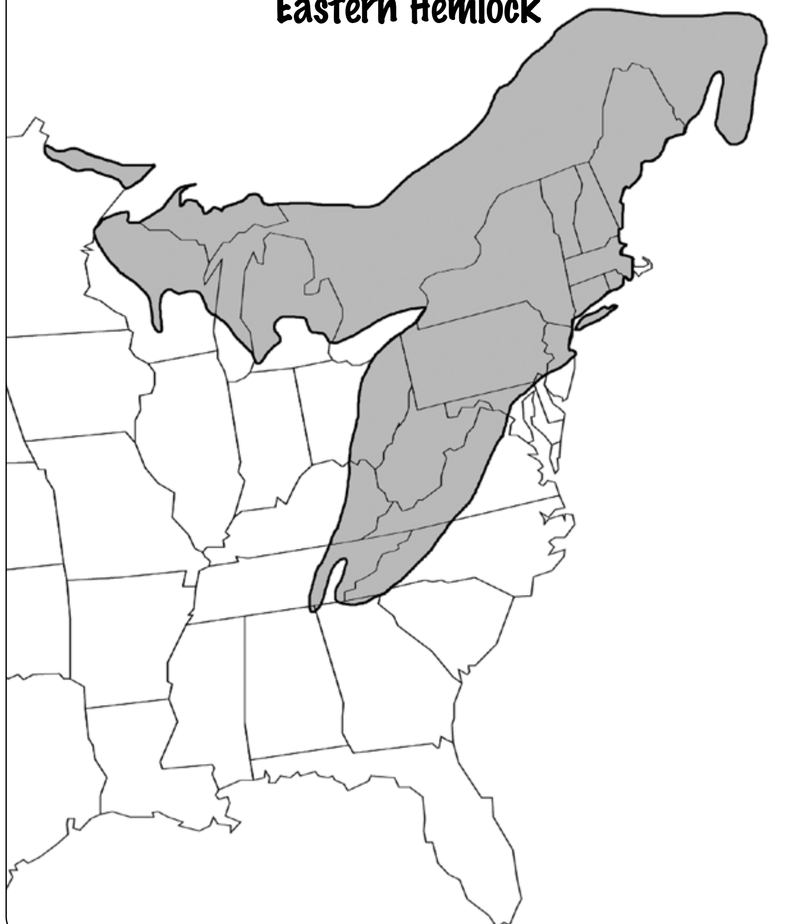
Importance

Lumber production from eastern hemlock reached its peak between 1890 and 1910. Primary uses were in light framing, sheathing, roofing, subflooring, boxes, crates, and general millwork. Much of the present production is used in pulping or newsprint and wrapping papers, but the demand for hemlock lumber appears to be increasing again.

Commercial volumes of eastern hemlock have been greatly reduced by early overharvesting. Both the area and volume are continuing to decline because of the failure to regenerate, particularly in the western portion of the range. The remaining sawtimber is concentrated in the northeast and the Lake States.

Currently, eastern hemlock stands are considered essential for shelter and bedding of white-tailed deer during the winter. They are also considered important as cover for ruffed grouse, turkeys, and many other animals.

Native Range of the
Eastern Hemlock



ARTICLE SUMMARY – HEMLOCK'S FUTURE IN THE CONTEXT OF ITS HISTORY

Summarized from the June 1999, Proceedings: Symposium on Sustainable Management of Hemlock Ecosystems in Eastern North America by David R. Foster of Harvard University

In this article, the author uses observations and ***paleo-ecological*** *records to describe how eastern hemlock forests have responded to environmental conditions throughout history. The article attempts to explain why eastern hemlock is in decline throughout its entire range in eastern North America, including northern Wisconsin. The author also discusses the insect that is devastating hemlock forests, the hemlock wooly adelgid. This insect has not yet been found in Wisconsin but poses a grave threat to hemlock trees in this state and all of the eastern U.S.*

Eastern hemlock is a tree species that has been present on this continent for 8,000 years. It is a long-lived, coniferous tree that is dominant in many of the oldest eastern forests and is widely recognized as one of the primary components of old-growth forest ecosystems.

Paleo-ecology: The study of relationships of past organisms and their environment.

Student Page ✐ 4B

EASTERN HEMLOCK

ARTICLE SUMMARY – HEMLOCK'S FUTURE IN THE CONTEXT OF ITS HISTORY (CONTINUED)

Summarized from the June 1999, Proceedings: Symposium on Sustainable Management of Hemlock Ecosystems in Eastern North America by David R. Foster of Harvard University

The hemlock woolly adelgid is starting to change this historic tree species. The adelgid is a small insect native to Asia and was introduced from England in the early 1950s. Adult and nymph adelgids severely damage eastern hemlock trees by sucking sap from twigs, causing the tree to lose its needles. In areas where adelgids are present, hemlock ecosystems are undergoing major changes in structure, composition, and ecosystem function. The long-term consequences of this disturbance lead to questions of how we should manage stands of hemlock, now and in the future.

Studying many paleo-ecological sites across eastern North America, scientists have been able to establish a historic range and distribution for hemlock. Approximately every 1,000 years, a major disturbance occurred, including fire, forest pest infestation, and European settlement. With each disturbance, hemlock declined abruptly and gradually recovered over the 500+ year period following.

*About 5,000 years ago, hemlock encountered one such disturbance called the **mid-Holocene** decline. It is suspected that this decline was caused by a pathogen, instead of climate or impacts from early Native Americans.*

This disturbance had an effect of an initial decline, small recovery and then a major decline. The hemlock survived in small pockets throughout their range. Although hemlock demonstrated recovery as a species, the process required 1,000 years or more.

Another period of great change for hemlock was the European settlement of the northeastern forests. Much of the land was cleared for agricultural uses. Today, a largely forested condition prevails as much of the marginal agricultural land is reforested. Even still, hemlock and beech continue to decline compared with the numbers of red maple, oak, and birch.

The latest disturbance affecting the hemlock forests is the hemlock woolly adelgid. Currently, the adelgid is widespread in Connecticut and Massachusetts, spreading at a rate of 20-30 km per year. Unfortunately, no trees that have been infested with the adelgid have shown signs of resistance or recovery, and no environmental factors seem to be slowing down the spread. Once eastern hemlock trees start dying off, increased light encourages hardwood species like birch to establish and grow rapidly. Hemlock regeneration is further limited because of the large deer populations that browse on hemlock seedlings.

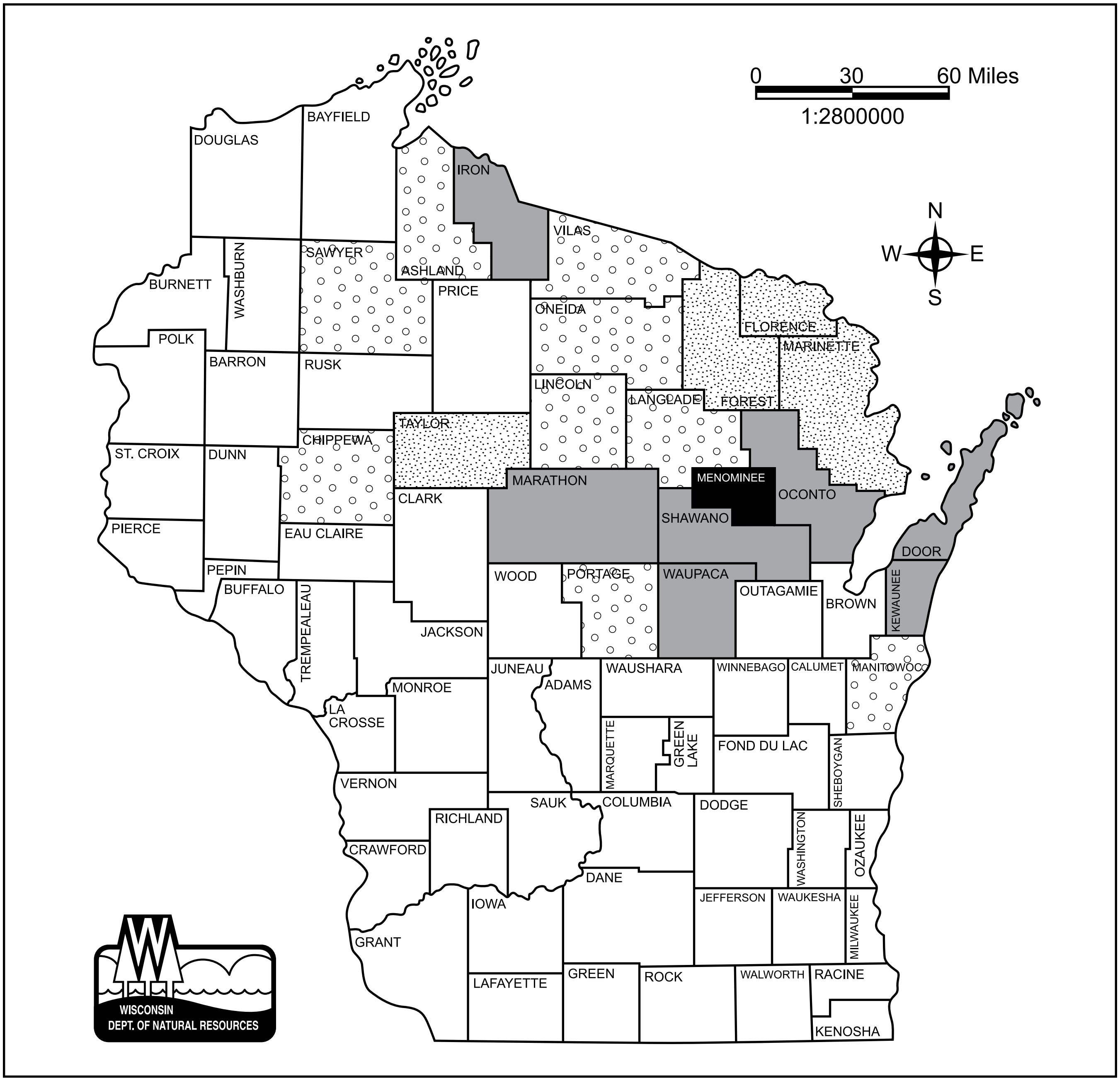
Eastern hemlock is on the brink of major population decline throughout the eastern North American landscape. As hemlock is lost in greater numbers, once shady, old-growth, conifer-dominated forests will become stands of young, rapidly growing hardwoods. The overall effect throughout the forest landscape is a decrease in complexity and diversity in forest structure and composition.

The decline of hemlock will have effects on terrestrial and aquatic ecosystems. The history of hemlock with its decline and recovery cycles sheds new light on the changes that might occur. Although the decline of hemlock could be permanent in our human time frame, in hundreds or thousands of years, history suggests that the hemlock will probably recover.

Mid-Holocene: The Holocene epoch extends from the end of the last Ice Age (11,000 years ago until present. The term mid-Holocene refers to approximately 5,000 years ago.

EASTERN HEMLOCK

Percent of Eastern Hemlock Trees by County



Percent of eastern hemlock trees within a county.

- 0.0 - 0.5
- 0.6 - 1.0
- 1.1 - 1.5
- 1.6 - 4.0
- 4.1 - 8.0

Map Creator: Division of Forestry, 2004. Data is based on the 1996 Forest Inventory and Analysis Database for Wisconsin.

RED MAPLE

Case Study Assignment

PART A

Read the tree profile and article summary. Answer the following questions about your tree species (you may work with other members of your group if you wish).

1. What is the red maple paradox?
2. What land use changes are helping the expansion of red maple?
3. What characteristics have helped red maple become so widespread in Wisconsin and other northeastern forests during the last century?
4. How have human actions helped the red maple expansion?
5. Which types of forest are being affected as red maple expands?
6. What effect do you think the expansion of red maple is having on the ecosystem diversity of forests in Wisconsin and the northeast?
7. What possible effect could a decrease in ecosystem diversity have on the species diversity of northeastern forests?
8. How does red maple's genetic diversity influence its expansion in the forests of the eastern U.S.?

PART B

As a group, create a poster about your tree case study. The poster will need to include the following elements:

- Brief description of the importance of the tree
- Map of the tree's range in North America
- Map of the tree's distribution in Wisconsin
- A description of the history and current status of the tree
- A list of "biodiversity insights" found in the case study of your tree

PART C

Give a five- to 10-minute presentation about your tree case study using the poster as a visual aid. The presentation will need to include the following elements:

- A description of the important information in all five sections of the poster with special emphasis on the "biodiversity insights"
- A discussion with the class about the case study (this may involve helping the audience form and ask questions, as well as answering questions asked)

TREE PROFILE

Native Range

Red maple is also known as scarlet maple, swamp maple, soft maple, and water maple. Red maple can occupy overstory space but is usually replaced by other species. It is shade-tolerant, can grow from root sprouts, and grows in a wide range of habitats. It is one of the most abundant and widespread trees in eastern North America. The species is native to nearly all regions of the eastern United States, with three exceptions — the Prairie Peninsula, coastal prairie of Louisiana and Texas, and swamp prairie of the Florida Everglades.

In the maple genus, red maple is a common lumber species second only to sugar maple.

www.fs.fed.us, Wisconsin Timber Industry, 2013

RED MAPLE

Importance

Many foresters consider the tree undesirable because it is often poorly formed and defective, especially on poor sites. On good sites, however, it may grow fast with good form and quality for saw logs. Red maple is known in the lumber industry as soft maple. The wood resembles sugar maple but is softer in texture, not as heavy, and has somewhat poorer machining qualities.

Brilliant fall coloring is one of the outstanding features of red maple. In the northern forest, its bright red foliage is a striking contrast against the dark green conifers and the white bark and yellow foliage of the paper birches. Red maple is widely used as a landscape tree. Although sugar maple is principally used for syrup production, red maple is also suitable. Red maple is also highly desirable wildlife browse food. Elk and white-tailed deer especially use the current season's growth of red maple and aspen as an important source of winter food.

ARTICLE SUMMARY – THE RED MAPLE PARADOX

Summarized from an article published in May 1998, BioScience Vol. 48, No. 5, by Mark D. Abrams of Pennsylvania State University

A paradox is a statement or truth that is contrary to popular belief. In the *Red Maple Paradox*, the author attempts to explain why red maple is greatly expanding its dominance in eastern forests and replacing other tree species, in spite of the fact that the tree itself does not seem to have any biological advantages over other trees.

Although red maple was a small part of forests of eastern North America before Europeans came to settle here, it is an increasingly dominant species in today's forests. This is does not have a single outstanding trait that makes it more competitive. However, it has lots of good traits and survival techniques that make it a species that is present in ever-increasing numbers in our forests.

RED MAPLE

ARTICLE SUMMARY – THE RED MAPLE PARADOX

Summarized from an article published in May 1998, BioScience Vol. 48, No. 5, by Mark D. Abrams of Pennsylvania State University

Before North America was settled by Europeans, early records indicate that less than five percent of the trees in Wisconsin and Michigan were red maple. Today, red maple makes up a large portion of our forested landscape and is the most abundant and widespread tree species in eastern North America. Red maple is present on a wide range of soil types from sand to clay, acidic to basic, and in wet to dry areas. Red maple is often found on poorer sites because sugar maple tends to outcompete red maple on nutrient-rich sites.

Although red maple does not seem to have tremendous biological advantages over other tree species, changes in the environment and land uses are favoring the characteristics that red maple has.

- *Red maple does not survive well when fire sweeps through an area. Since we now suppress wildfire in most areas, many more red maple seedlings are surviving to maturity. In an ecosystem where fire is allowed to disturb the site, pine and oaks tend to dominate.*
- *Large white-tailed deer populations also tend to increase the red maple population. Even though deer like to browse on red maple, deer like oaks and acorns more. This gives the regeneration advantage to red maple. Deer also tend to browse red maple in the winter and oaks in the summer. Winter browsing is easier to overcome than browsing in the summer.*
- *As the gypsy moth population continues to spread, oaks throughout eastern North America are more frequently damaged. Since gypsy moths don't tend to affect maples nearly as much, it gives the advantage to red maple.*
- *Increased carbon dioxide levels in the environment during the last century have also lead to increased photosynthetic performance for many tree species including red maple. However, no conclusive advantage has been determined for any tree species in particular.*

*Red maple **physiology** and **phenology** can also influence its increase in population. Leaf physiology shows that red maple can adapt to shade; however, it can be outcompeted by other shade-tolerant species in the right environment. Red maple produces and disseminates its seeds in the spring or early summer. The seeds often germinate shortly after they are disseminated, or they can overwinter and germinate the following year. Most other hardwoods produce seeds in the fall that must overwinter. Taken in combination, the characteristics of red maple (unique seed life cycle, sexual maturity at a relatively young age, large seed production each year, and shade tolerance) give it the reproductive edge on other species.*

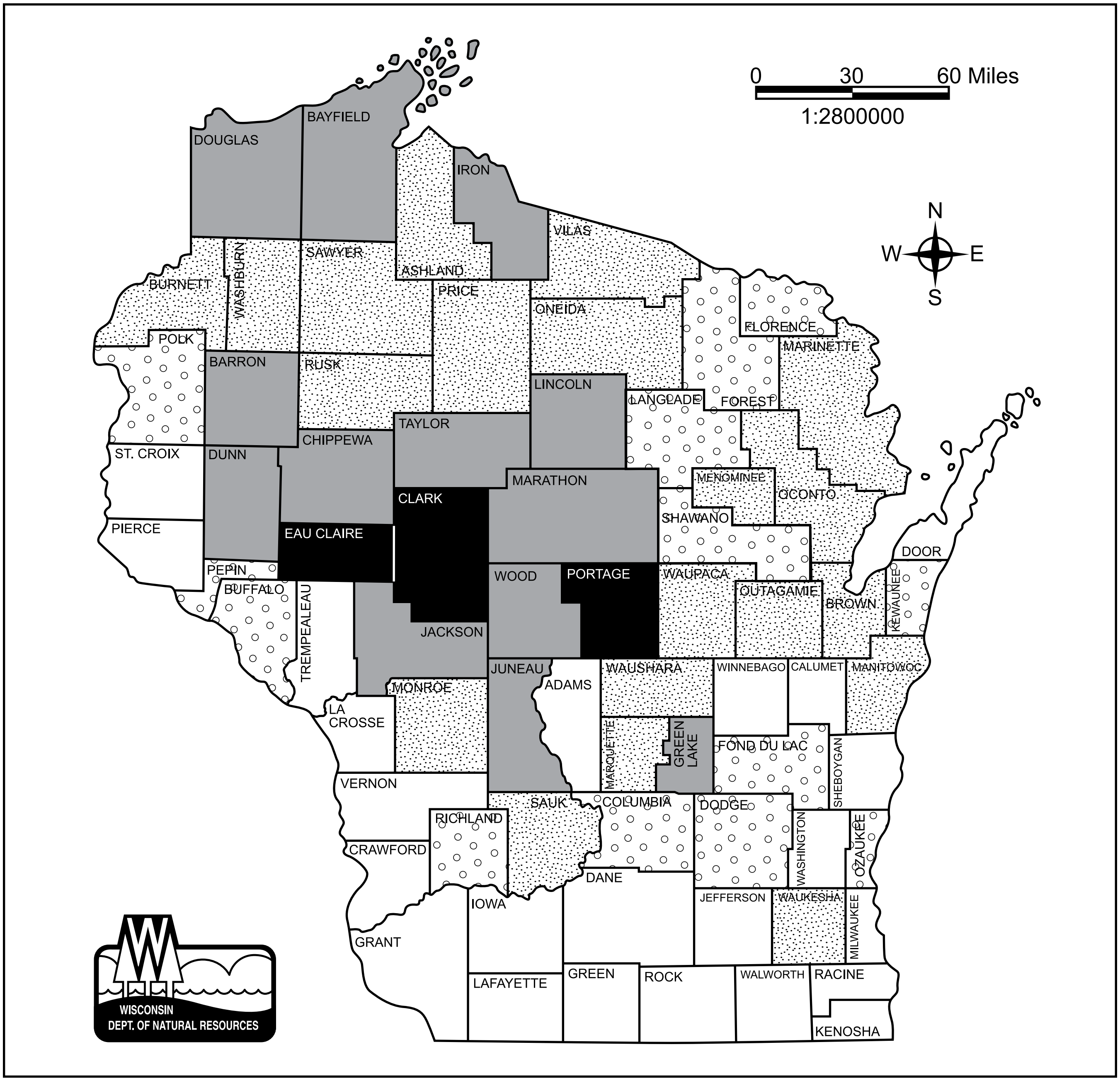
With many characteristics that seem to fit well with the current land uses and environmental factors, red maple will continue to be dominant in the forests of eastern North America. Red maple is widely distributed in young and old forest communities, replacing many oak forest communities. As a species, it is very genetically diverse, allowing it to adapt to many conditions over the landscape. Red maple survives on a wide variety of sites and reproduces prolifically. About the only thing that might impede the progress of red maple continuing its dominance is reintroducing fire or widespread management by forest landowners.

Physiology: Life processes and functions of organisms, their cells, tissues, and organs.

Phenology: Time of appearance of certain stages of the life cycle of an organism.

RED MAPLE

Percent of Red Maple Trees by County



Percent of red maple trees within a county.

- 0.0 - 4.0
- 4.1 - 8.0
- 8.1 - 13.0
- 13.1 - 19.0
- 19.1 - 32.0

Map Creator: Division of Forestry, 2004. Data is based on the 1996 Forest Inventory and Analysis Database for Wisconsin.

WHITE OAK

Case Study Assignment

PART A

Read the tree profile and article summary. Answer the following questions about your tree species (you may work with other members of your group if you wish).

1. Why did white oak dominate eastern forests before European settlement?
2. For the past 100 years, what has happened to the distribution of white oak in the U.S.?
3. What are the causes of the white oak decline?
4. What tree species are replacing white oaks as the dominant trees?
5. What effect has the white oak decline had on the ecosystem diversity of eastern forests?
6. What economic effects result from the white oak decline?
7. What effect might the dramatic decrease in white oak populations have on the genetic diversity of the species?
8. According to the author, what prospects does the white oak have to regain its dominance in forests of the eastern U.S.?

PART B

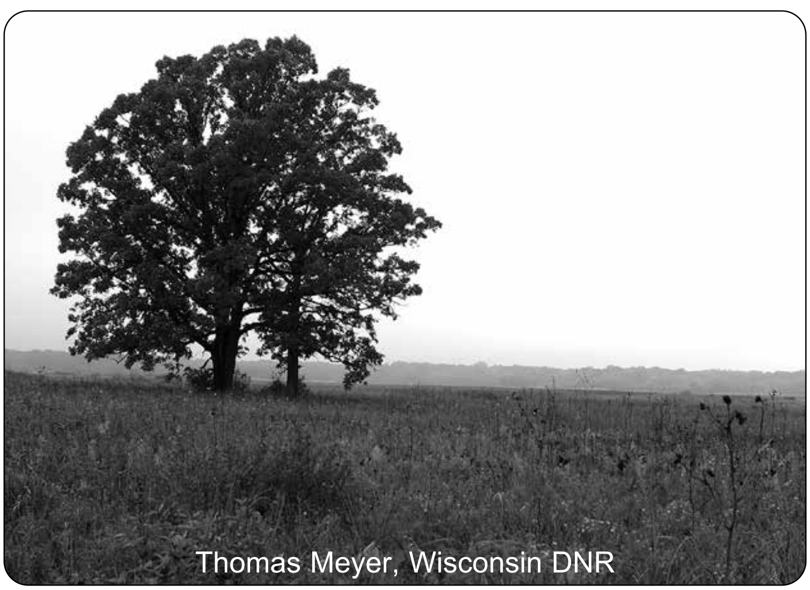
As a group, create a poster about your tree case study. The poster will need to include the following elements:

- Brief description of the importance of the tree
- Map of the tree's range in North America
- Map of the tree's distribution in Wisconsin
- A description of the history and current status of the tree
- A list of "biodiversity insights" found in the case study of your tree

PART C

Give a five- to 10-minute presentation about your tree case study using the poster as a visual aid. The presentation will need to include the following elements:

- A description of the important information in all five sections of the poster with special emphasis on the "biodiversity insights"
- A discussion with the class about the case study (this may involve helping the audience form and ask questions, as well as answering questions asked)



Thomas Meyer, Wisconsin DNR

Oak trees produce 2,200 acorns in a season, but each acorn only has a 1 in 10,000 chance of becoming an oak tree.

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WHITE OAK

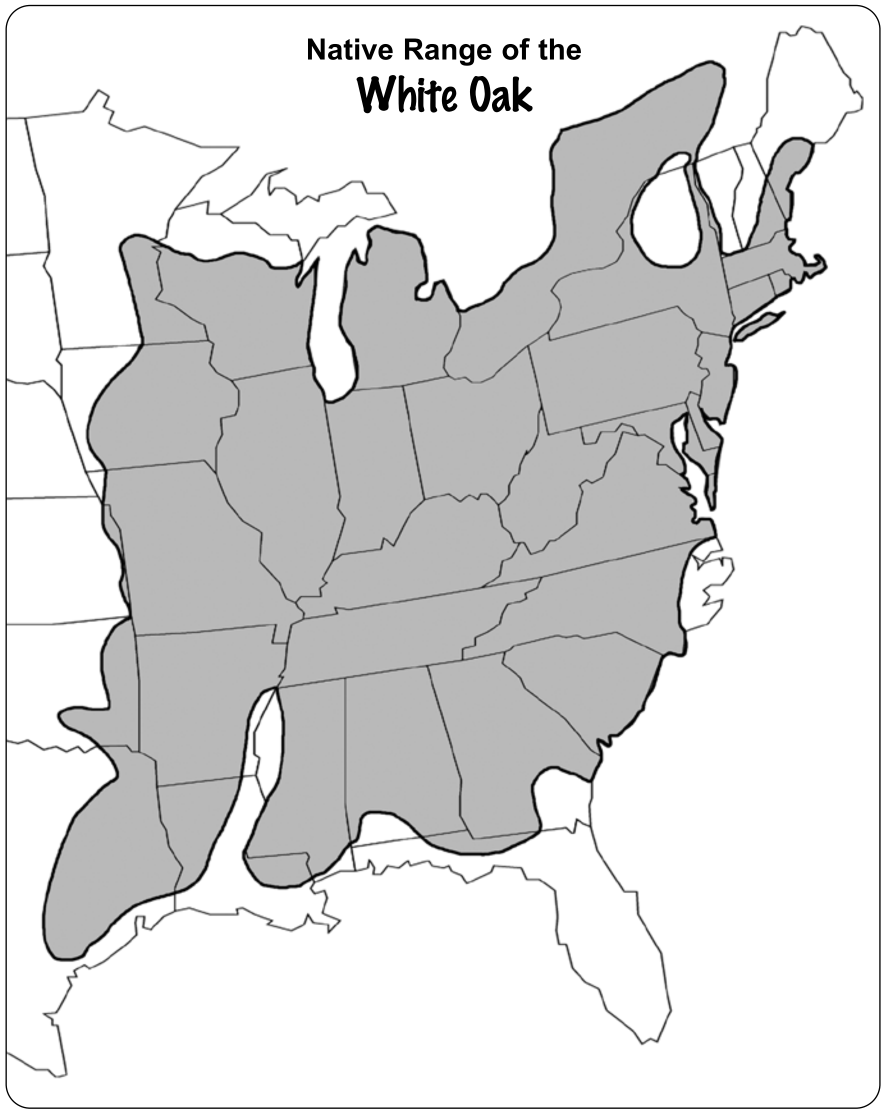
TREE PROFILE

Native Range

White oak grows throughout most of the eastern U.S. It is found from southwestern Maine and extreme southern Quebec, west to southeastern Minnesota; south to Texas; east to northern Florida and Georgia. The west slopes of the Appalachian Mountains and the Ohio and central Mississippi River valleys have optimum conditions for white oak, but the largest trees have been found in Delaware and Maryland on the eastern shore.

Importance

White oak is known as an outstanding tree among all trees and is widespread across eastern North America. A very important lumber tree, growth is good on all but the driest shallow soils. Its high-grade wood is useful for many things, an important one being staves for barrels. It is also planted as an ornamental tree because of its broad round crown, dense foliage, and purplish-red to violet-purple fall coloration. The acorns are an important food source for many kinds of wildlife. More than 180 different kinds of birds and mammals use oak acorns as food including squirrels, blue jays, crows, red-headed woodpeckers, deer, turkey, quail, mice, chipmunks, ducks, and raccoons. White oak twigs and foliage are browsed by deer, especially in harvested areas less than six years old.



WHITE OAK

ARTICLE SUMMARY – WHERE HAS ALL THE WHITE OAK GONE?

Summarized from an article published in October 2003, BioScience Vol. 53, No. 10, by Marc D. Abrams of Pennsylvania State University

In this article, the author looks at many factors that have influenced the decline of white oak in the last two centuries. The article overviews human and environmental factors that have affected the white oak and describes how these factors have helped the expansion of other species.

Paleo-ecological *studies of eastern North America have shown that oak species dominated many forest communities over the last 10,000 years. Oak dominated due to the warmer, drier climate and frequency of fire after glacial retreat.*

White oak trees like all but the wettest and very driest sites. Although it doesn't survive well on perpetually dry sites, white oak has adapted to survive on drought-prone and fire-swept sites. Fire scars are healed quickly by white oak. Together with their deep roots, vigorous sprouting ability, and increased germination after fire, white oak is well-adapted to periodic fires. Oak leaves are also well-adapted to drought conditions compared with other upland hardwood species. Their leaves are thicker, have greater mass per unit area, and greater stomata density.

Since European settlement, white oak has been declining across its range. In the majority of sites studied across its range, it has declined by at least 10 percent. American Indian populations interacted with forests across the white oak range by clearing land, farming, and using fire as a land and wildlife management tool, but the use by European settlers had the most influence on the distribution of white oak trees.

European settlement of North America caused large-scale changes in forest cover. First, extensive logging and land clearing took place, removing much of the white oak overstory. Then catastrophic fires, followed by fire suppression, took their toll. The introduction of exotic insects and diseases (such as oak wilt and the gypsy moth) and heavy browse by a large deer population completes the list of causes for the decline of white oak and other oak species. White oak's slow growth further hinders its recovery after disturbance. In light of these facts, it seems that the dominance of the white oak in the forests of eastern North America is over and its numbers continue to decline.

After initial impacts of European logging and land clearing took their toll, the chestnut blight of the early 20th century also affected the forest landscape. Faster growing red and chestnut oaks filled in the gaps as American chestnut trees fell. As they took a firmer hold in the forest landscape, fire suppression started. This made it even harder for the white oak to compete. White oak relies on fire to reduce competition from its faster growing competitors, like red maple. Red maple is now a dominant species in many of the forests of eastern North America where white oak once stood.

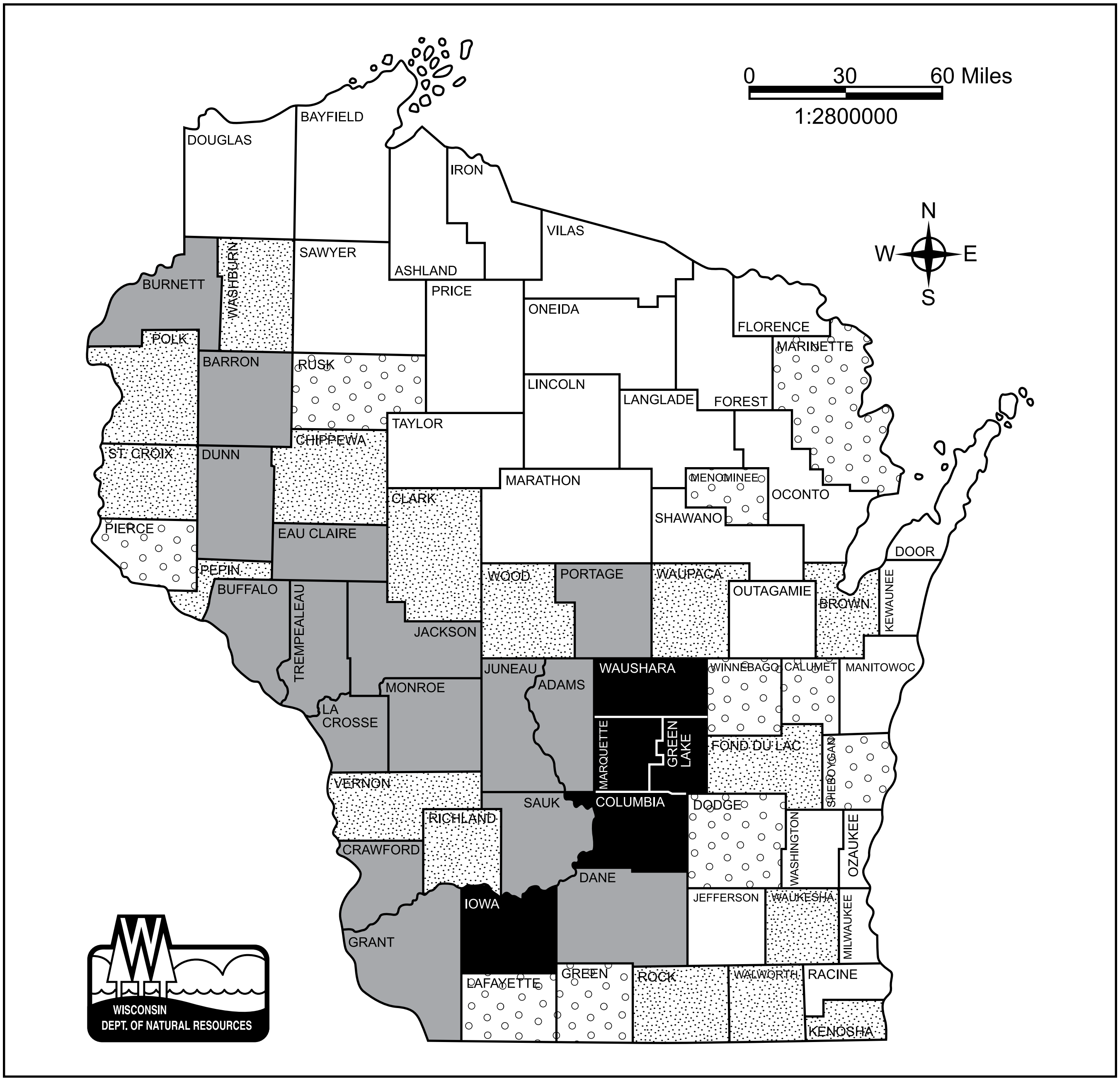
The one exception to the widespread decrease in white oaks is in areas that were once bur oak savannas. These forest stands in the Midwest and Great Lakes states were characterized by large, sparse bur oaks, under which frequent ground fires occurred. Now that the short fire cycle has been suppressed and replaced by a human-controlled fire management program, white oaks are beginning to re-establish themselves.

The impact of white oak decline is great. Oak lumber, white oak lumber in particular, is prized for its quality. It is used extensively for making furniture, flooring, cabinetry, and barrel making. The acorns and browse white oak provides for wildlife is also invaluable. The loss of this food source will affect wildlife across the eastern landscape. With the decline of the white oak, economic and ecological benefits decline as well.

Paleo-ecology: The study of relationships of past organisms and their environment.

WHITE OAK

Percent of White Oak Trees by County



Percent of white oak trees within a county.

- 0.0 - 0.5
- 0.6 - 1.0
- 1.1 - 3.0
- 3.1 - 6.0
- 6.1 - 13.0

Map Creator: Division of Forestry, 2004. Data is based on the 1996 Forest Inventory and Analysis Database for Wisconsin.

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