Master Naturalist
EAST CENTRAL ILLINOIS

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CHAPTER 11

Forest Ecology and Management

Chapter Goals

Goals of the chapter are to describe

- ❒ The major forested regions and types of forests in Illinois
- ❒ The major factors influencing forest composition and structure in Illinois
- ❒ Patterns of succession in Illinois forested ecosystems
- ❒ Forest cycles: nutrients, water, carbon, oxygen
- ❒ Benefits of forests
- ❒ The differences and meanings of preservation and conservation in forest ecology and management
- ❒ Major threats to the health of Illinois forests
- ❒ Ecological goals of forest management
- ❒ The benefits of urban forests and their management

Introduction

Forest ecology is the study of the components and functions of forest ecosystems: communities of organisms interacting with each other and with their physical environment. Forest ecosystems consist of many components including bacteria, fungi, insects and other arthropods, plants, birds, mammals, reptiles, amphibians, climate, soil, water and air. Forest ecosystems differ from others in that they are dominated by trees. Each biological and physical component plays a role in the function and health of a forest.

Forest ecology is not rocket science. In fact, it is much more complicated. Consider the fact that a volume of forest soil about the size of a sugar cube may contain from 6,000 to 10,000 different types of bacteria. Most of these bacteria are virtually unknown to science, detected only by the structure of their DNA extracted from soil and analyzed using techniques of molecular biology. This large number of bacterial types does not include other soil microbes such as fungi, protozoa, algae, and viruses. On top of this, organisms found in the soil component of the forest ecosystem alone include nematodes, earthworms, millipedes, mites, moles, salamanders, and many others. We certainly do not understand all of the interactions among forest organisms and their environments for even a single forest stand, let alone a forest type. But many ecological patterns of forests have been established by science. It is part of human nature to seek patterns, after all, and those patterns of forest structure, function and change that have been determined serve as the basis for protecting and managing forests.

Forest Classification and Regions

The broadest regional classification recognized by plant geographers and other scientists is a **biome**. A forest biome is a zone where predictable tree, plant and animal communities exist resulting from the effects of climate, soil, the presence or lack of moisture and other physical variables.

In North America, biomes include tundra, boreal forest, **broad-leaved temperate deciduous forest**, desert, prairie, mixed evergreen and deciduous forest, tropical, montane, temperate and tropical rain forest and Mediterranean scrub. The temperate deciduous forest biome of North America occupies most of the eastern part of the United States and a small strip of southern Ontario and Quebec. Temperate deciduous forests comprise 14% of the world's forests and are dominated by broad-leaved deciduous trees.

The retreat of the last major glacial front from central and northern Illinois began 20,000 years before present. The ancestors of our current Illinois broad-leaved deciduous tree species migrated northward from **refugia**, or refuges, in which they sheltered from the harsh, ice age climate. Fossil records suggest that these refuges were in the southern and southeastern part of North America in the lower reaches of river valleys flowing into the Atlantic Ocean and Gulf of Mexico, as well as in coves of the bluffs of the southern reaches of the Mississippi River. Fossils of an extinct species of spruce have been found in the lower Mississippi valley from this time, probably because the river cooled its floodplain area with torrents of glacial melt water in the summers. This likely created a cool, misty environment for the spruces, relegating broadleaved deciduous species of the lower Mississippi River drainage to warmer, sheltered upland areas.

The broad-leaved temperate deciduous trees migrated northward and expanded beyond their refuges as the climate warmed, joining with and separating from a variety of tree associates during their continental migrations. To the north a narrow zone of tundra occurred near the retreating glaciers, and pine and spruce forests covering large areas retreated northward with the warming climate. The migrations were spurred by the warming of the current interglacial period and have culminated today in the widespread, eastern, temperate deciduous forest biome. Precipitation in the temperate deciduous forest biome ranges from 28 inches per year in the northwestern section of the biome to 60 inches in the southeastern part. In most areas the precipitation is evenly distributed throughout the year. Frost occurs throughout this biome and summer and winter are distinct seasons.

Illinois is within both prairie and temperate deciduous forest biomes. At the time of European settlement temperate deciduous forest covered 40% of what is now Illinois, mainly in the south, in areas of rough terrain that glaciers did not impact, and along river systems (Figure 1). Tall grass prairie ecosystems of the prairie biome dominated the rest of the area.

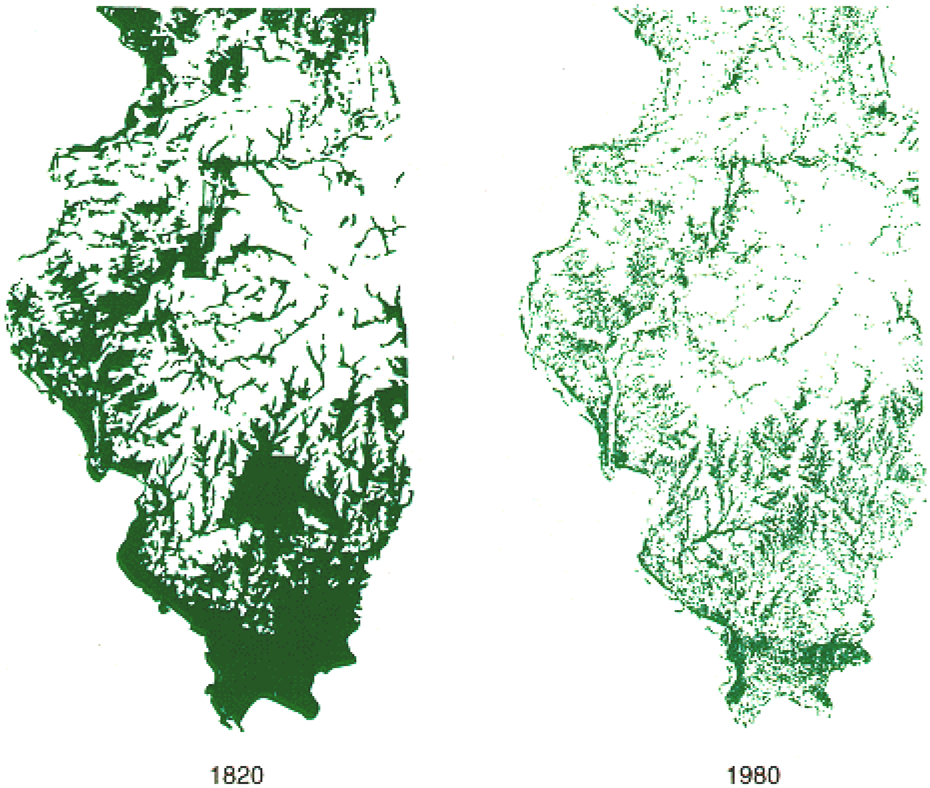

Figure 1. Forests in Illinois, 1820 and 1980

Source: *The Changing Illinois Environment: Critical Trends. Volume 3: Ecological Resources.* Illinois Natural History Survey, 1994.

Because the temperate deciduous forest biome covers such a large geographic area, differences in climate, soils, topography and other factors have led to the recognition of eight major forest regions within the biome. This diversity is often reflected in more detailed classifications at smaller scales called **ecoregions**. Ecoregions are defined by similarities in plant and animal species, climate, soils, and the general topography of the landscape. Ecoregions exist at three levels of definition: domains, divisions, and provinces, from largest to smallest, respectively. A method for naming these forest ecoregions is to list the dominant tree species that characterize these distinct elements of the temperate deciduous forest biome. In Illinois the most widespread major region within the eastern temperate deciduous forest biome is the oak-hickory forest region. Illinois also contains elements of the maple-basswood forest region and the beech-maple forest region.

These regions are not totally uniform in forest composition. Within these regions are smaller areas with unique types of forests, sometimes with affinities to neighboring regions, such as oak-pine forest stands in the Illinois Ozarks, cypress-tupelo swamps of the Cache River bottoms, larch bogs in northeastern Illinois, and white pine-northern hardwood stands of northern and northwestern Illinois. Other important types of forest in Illinois include those of extensive floodplains and wetlands that vary in composition from north to south and with topographic features within the floodplains and wetlands themselves. **Forest associations**, even at the smallest scale, are often named for their dominant tree species.

Another ecological classification system is the **Natural Divisions of Illinois** (Schwegman 1973) which includes 14 bioregions plus Lake Michigan (Figure 2). These fifteen natural divisions of Illinois are defined by both biological and geological characteristics. This classification scheme is based upon geographic regions having similar topography, soils, bedrock, plants, and animals. Natural Divisions are an important classification system for recognizing biological variation across Illinois. Illinois Department of Natural Resources (IDNR) staff members and other professionals have organized regional needs, objectives and strategies in the IDNR Comprehensive Wildlife Conservation Plan, organized around the Natural Divisions of Illinois http://dnr.state.il.us/orc/Wildliferesources/theplan/final/.

Summarized in the next section are distinctive features of Illinois Natural Divisions (Schwegman 1973), including their forest types derived from the IDNR Comprehensive Wildlife Conservation Plan. The physical part of the forest descriptions often includes topographic terms such as upland, floodplain, beach, dune, terrace, flat or slope, often mixed with water regime descriptors, such as **xeric** (dry) upland forest, **mesic** (moist) slope forest, or **hydric** (wet) swamp forest. The forest descriptions also refer to soil features such as acidity (pH below 7.0), texture (i.e. gravel, sand, clay, loam) or temperature (i.e. algific soils that are cold during the summer because they are underlain by ice in rock formations such as fissures). Biotic components of the forest descriptions can include compositional information such as dominant tree species (i.e. cypress-tupelo) and forest structure (i.e. barrens, savanna, open woodland). The same topographic term for a forest might be used in different locales, but in each locale different dominant tree species with different ranges, soil requirements, and climatic tolerances could occur. For example, minor upland forest associations in northern Illinois might include uniquely northern species such as paper birch and eastern white pine, while minor associations occurring in similar topographic and soil situations in southern Illinois upland forests might include black oak and shortleaf pine. Note how different combinations of topographic, moisture, soil, forest structure and dominant tree information are used to describe the forests of each Natural Division.

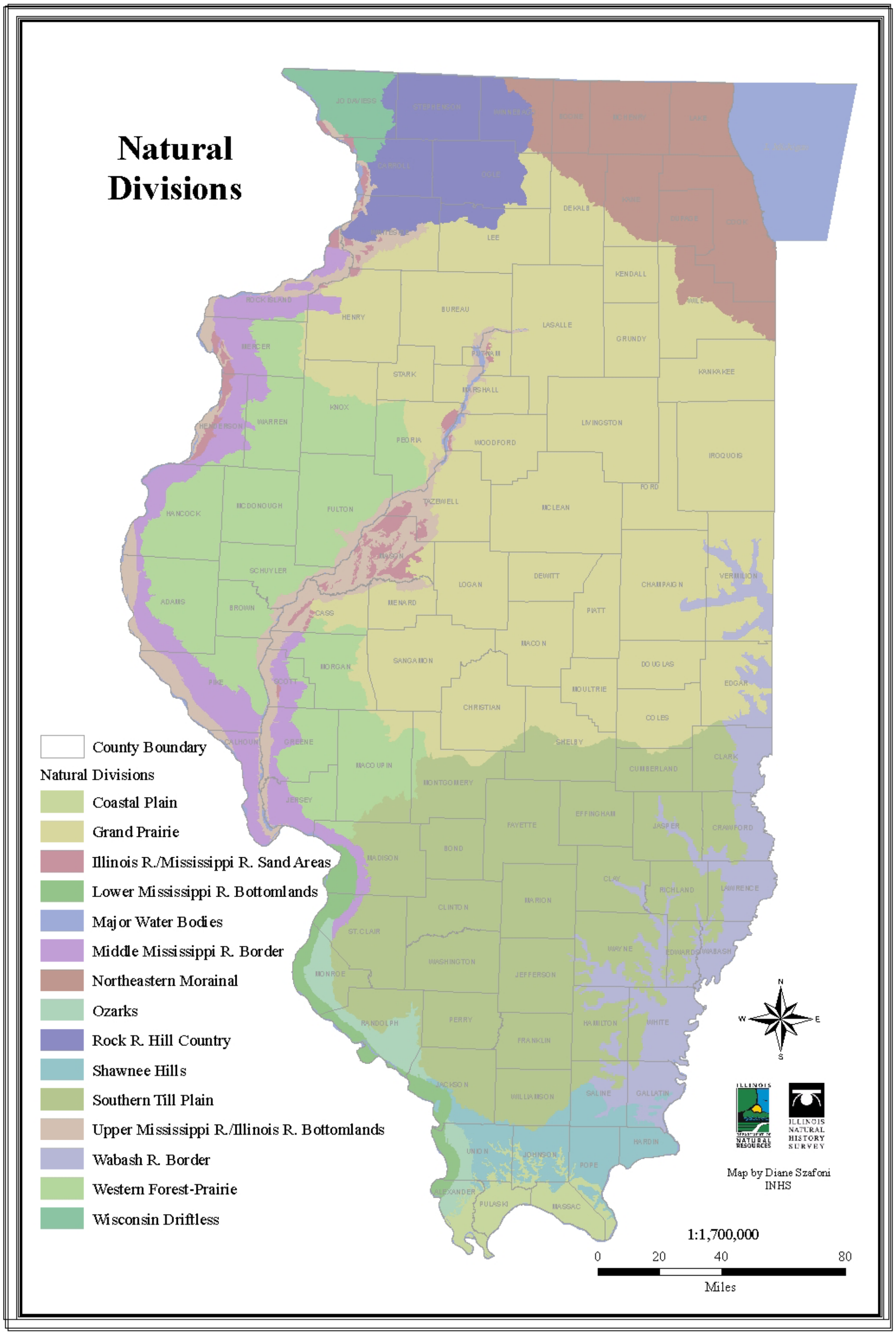
Natural Divisions
County Boundary
Natural Divisions
Coastal Plain
Grand Prairie
Illinois R./Mississippi R. Sand Areas
Lower Mississippi R. Bottomlands
Major Water Bodies
Middle Mississippi R. Border
Northeastern Morainal
Ozarks
Rock R. Hill Country
Shawnee Hills
Southern Till Plain
Upper Mississippi R./Illinois R. Bottomlands
Wabash R. Border
Western Forest-Prairie
Wisconsin Driftless
N
W
E
S
Map by Diane Szafoni INHS
1:1,700,000
0 20 40 80
Miles

Figure 2

Natural Divisions of Illinois

Coastal Plain

The Coastal Plain Natural Division of extreme southern Illinois is a region of swampy forested bottomlands and low clay and gravel hills that is the northernmost extension of the Gulf of Mexico Plain Province of North America. Bald cypress-tupelo swamps are a unique feature of the natural division, as are many southern animals such as bird-voiced tree frog and the poisonous wetland snake called the cottonmouth. The floodplains at the confluence of the Mississippi and Ohio rivers and Cache and Ohio rivers host rich southern bottomland forests, while the "Cretaceous Hills" section is a steep to rolling area of unconsolidated sand, gravel and clay hosting Cretaceous period fossil beds.

Forest types

Dry-Mesic Acid Oak Upland Forest
Interior Highlands Oak Barrens
Backswamp/Slough Floodplain Forests
Midwestern Wet Flatwoods
Mesophytic Slope Forest

The Grand Prairie

The Grand Prairie Natural Division of central and east-central Illinois is a vast plain formerly occupied primarily by tall grass prairie, now converted extensively to agriculture. Natural drainage of the fertile soils was poor, resulting in many marshes and potholes. Bison, Blanding's turtles, and Franklin's ground-squirrels are distinctive animals of the Grand Prairie, but are now extirpated or imperiled–as is the native prairie itself.

Forest types

Upland Forest
Open Woodland/Savanna
Bottomland Forest
Sand Savannas

The Illinois River and Mississippi River Sand Areas

The Illinois River and Mississippi River Sand Areas Natural Division are several discrete patches of sand areas. The Illinois River Section is characterized by flat to gently rolling sand plains and sand dunes along the eastern side of the Illinois River. Oak-hickory forest, sand prairie, and marshes were the predominant vegetation groups prior to European settlement. The Mississippi Section encompasses sand areas and dunes in the bottomlands of the Mississippi River and the "perched dunes" atop the bluffs near Hanover. Scrub oak forest and dry sand prairie are the natural vegetation of this division. Several relict western amphibians and reptiles, such as western hognose snake, Illinois mud turtle, and Illinois chorus frog, are known only from these sand areas. Many plant species, including yucca and prickly pear cactus found in these sandy areas are more typical of the short grass prairies to the west of Illinois.

Forest types

Sand Forest
Sand Savanna

Lake Michigan

About 6% or 1 million acres of Lake Michigan occurs in Illinois It is one of the Great Lakes and part of the largest freshwater ecosystem in the world. While water quality in Lake Michigan has improved in recent decades, declining water levels and invasive animals now pose the greater threats to the ecosystem. Characteristic fishes of the Lake Michigan Natural Division include yellow perch and lake trout.

The Lower Mississippi River Bottomlands

The Lower Mississippi River Bottomlands Natural Division, including the Mississippi River and its floodplain from Alton to the Thebes Gorge in southwestern Illinois, is glaciated bottomland country that used to be mostly forested with numerous marshes, wet prairies, and oxbow sloughs scattered throughout it. It historically was the wide Mississippi River bed before channelization, and is divided into a northern and southern section. The northern part of the division is also known as the American Bottoms, and it was here that the wet prairies and marshes occurred. The southern part of the division was more heavily forested. Glacial flood waters created this vast floodplain ecosystem. The soils in this natural division are finely textured, with both sandy (well-drained) and clay (poorly drained) areas, all developed from river deposits. The Mississippi River, silt-laden below the confluence with the Missouri River, contains a distinctive fish assemblage of silt-tolerant plains species (plains minnow, sturgeon chub, flathead chub, sicklefin chub).

Presettlement condition of this division was mostly forested, with historic wet prairies and marshes in the Northern Section. Many of the wet prairies were drained and converted into agricultural fields. Wet prairies were replaced by more forest and bottomland swamp tree species typical of the coastal plain in the Southern Section. Aquatic habitats of this division are represented by oxbow lakes and sloughs, marshes, and springfed swamps. Some unique fish species are found only in the springfed swamps, and Gulf Coastal Plain reptiles and amphibians reach the northernmost edge of their range.

Forest types

Floodplain Forest
Cypress-Tupelo Swamp Forests

The Middle Mississippi Border

The Middle Mississippi Border Natural Division of west-central Illinois consists of a relatively narrow band of river bluffs and rugged terrain bordering the Mississippi River floodplain from Rock Island County to St. Clair County and the lower Illinois floodplain. Forest is the predominant vegetation with interspersed hill prairies common on west-facing bluffs. Limestone cliffs are common features, and the dark-sided salamander and western worm snake are restricted to this division. Forests of this division, close to river foraging areas, are important winter roosting sites for significant concentrations of bald eagles.

Forest types

Open Woodland/Savanna/Barrens
Upland Forests

The Northeastern Morainal Division

The Northeastern Morainal Natural Division contains a landscape of the most recently glaciated portion of Illinois within the counties of Boone, DeKalb, DuPage, Kane, Lake, McHenry, Will, and Winnebago. Four distinct Sections within the Division are recognized due to variations in topography, soil, glacial activity, flora and fauna. Drainage is poorly developed in some areas; thus abundant marshes, natural lakes, and bogs are distinctive features. Other areas have well-drained glacial outwash soils with seeps, fens, and springs. The Chicago lake plain and ancient beach ridge, bluff and panne communities provide unique critical habitat found only in the Northeastern Morainal Natural Division in Illinois. Higher gradient streams flow over gravel, cobble, and bedrock, providing good substrate for habitat and more stable stream bed characteristics compared to the many "older" regions of Illinois with loess (wind-deposited soil parent material)-dominated soils. Stable, rocky substrate, combined with significant ground water flow in some areas provides unique coolwater conditions for excellent gamefish populations and diverse nongame communities. With such diverse wetlands, prairie, forest, savanna, lakes, and streams, the Northeastern Morainal Natural Division hosts the greatest biodiversity in Illinois. Along with the largest human population, northeastern Illinois also has the most extensive acreage of protected natural areas, which offer excellent active and passive recreational opportunities. Like most areas of the state, natural land cover has been extensively altered, although urbanization is considerably more extensive than elsewhere and expansion of development continues to be a major stressor.

Forest types

Beach, Dune, Swale, Panne, Sand and other Savannas
Forested Fen,
Northern and Sand Flatwoods,
Upland Forests
Larch Bogs

The Ozark Division

The Ozark Natural Division, the part of the Ozark uplift that extends into extreme southwestern Illinois, is partially unglaciated and partially glaciated hill country that is mostly forested, although it is interspersed with many hill prairies. It is divided into three sections: Northern, Central, and Southern. The northern part of the division has an underlay of pure limestone, which is replaced in the southern part with cherty limestone that is more resistant to erosion. Underlying the central part of the division is sandstone. There are bedrock outcrops in all three sections of the division, and cave/sinkhole features are more numerous in the limestone portion of the north and less in the south. Glaciation occurred in the Central and part of the Northern sections, but none in the Southern. Topography of this division comprises a mature dissected plateau with steep bluffs along the Mississippi River, with ravines and stream canyons throughout. Deep loess soils in the Northern and Central sections make up much of the hill prairie and rock outcrop areas along the river bluffs and interior ravines. Much of the soils in the Southern Section are acidic. Pre-settlement condition of this division was mostly forested, with loess hill prairie openings in the Northern Section along the river bluffs. The Ozark Division contains several Ozarkian, southern, and southwestern plant and animal species that are rare or absent elsewhere in the state, such as plains scorpion, spring cavefish, eastern narrow-mouthed toad, coachwhip, and northern flat-headed snake. Aquatic habitats of this division are few, but are represented by sinkhole ponds, springs, and creeks.

Forest types

Dry Upland Forest
Mesic Upland Forest
Floodplain Forest
Shortleaf Pine-Oak Forest

The Rock River Hill Country

The Rock River Hill Country Natural Division of north-central and northwestern Illinois is a region of rolling topography drained by the Rock River. Prairie formerly occupied the larger expanses of level uplands, with forest equally abundant along water courses and in the dissected uplands. Areas of sandy outwash support black oak savanna, and relict white pine stands occur on eroding sandstone and talus slopes.

Forest types

Open Woodland/Savanna
Floodplain Forest
Upland Forest
Eastern White Pine-Oak Forest

Shawnee Hills

The Shawnee Hills Natural Division in the southern tip of Illinois is unglaciated hill country characterized by ridged uplands with many cliffs and deeply dissected valleys. Cuesta Ridge of the northern Shawnee Hills extends from the Mississippi River to the Ohio. The steep south-facing escarpment is nearly in the middle of the division and separates the land to the north known as the Greater Shawnee Hills and the hills to the south which average 200 feet lower, known as the Lesser Shawnee Hills. Cave and sinkholes are locally common in the division. Presettlement vegetation was mostly forest with some prairie vegetation contained in glades and barrens. At present this natural division is the most heavily forested in the state and hosts some of the state's greatest biodiversity.

Forest types

Xeric Upland Forest
Mesic Slope and Cove Forests
Riparian Forests
Upland Oak-Hickory Forest
Open Woodland/Savanna/Barren

The Southern Till Plain

The Southern Till Plain Natural Division of south-central Illinois is a dissected Illinoisan till plain south of the terminal Wisconsin glacial moraine. Forest was found along streams and prairie occupied the level uplands. Although about 40% of the natural division was prairie at the time of European settlement, upland soils are largely alfisols formed under forests. These soils are relatively poor because of high clay content and frequent "claypan" subsoil. Because these soils have a comparatively light color, upland prairies here have been referred to as the "gray prairie." Southern flatwoods are a characteristic natural community found on level uplands and river terraces and are dominated by unique mixtures of pin oak, post oak, shingle oak and blackjack oak. Crayfish frog, ornate box turtle and remnant populations of greater prairie chickens are characteristic animals of the Southern Till Plain Natural Division. The division encompasses large portions of the Kaskaskia River and Big Muddy River watersheds, and tributaries to the Wabash River. Extensive areas of river floodplain and ancient glacial lakebeds were occupied by forested wetlands and some wet prairies. Upland prairies were highly interspersed in the Southern Till Plan, and many were likely quite open due to the influence of fire.

Forest types

Southern Flatwoods
Dry Barrens,
Dry-Mesic Forest
Dry-Mesic Savanna
Floodplain Forest

The Upper Mississippi River and Illinois River Bottomlands

The Upper Mississippi River and Illinois River Bottomlands Natural Division of western and west-central Illinois encompasses the river and floodplains of the Mississippi River above the confluence with the Missouri River, and also the bottomlands and backwater lakes of the Illinois River and its major tributaries south of LaSalle. Much of the division was originally forested but prairie and marsh occurred. Agriculture is the primary land use in the floodplains today. The big rivers, their fish and mussel communities, and the backwater lakes of the Illinois River are distinctive.

Forest types

Floodplain Forests
Pin Oak/Pecan Floodplain Forest

The Wabash Border

The Wabash Border Natural Division includes the bottomlands and the loess-covered uplands bordering the Wabash River and its major tributaries in southeastern Illinois. Lowland oak forests with beech, tuliptree and other species characteristic of the eastern deciduous forest are found here. The ravines and uplands were primarily forested throughout the Natural Division. Barrens were common in the southern part of the division. Grassland primarily existed as large scattered tracts in Wabash River bottoms and terraces. Cliffs are primarily sandstone exposures that are widely scattered, mostly in the southern half of the division along ravines of the larger Wabash tributaries. The Wabash River drainage contains several distinctive fishes and mussels, and once supported a large and diverse bottomland landscape which included large forest tracts, wet prairies, sand barrens, wetlands, canebreaks, and oxbow lakes and meander scars. Cypress swamps occurred in the far southern end of the natural division.

Forest types

Beech-Maple-Tuliptree Forests
Wabash Floodplain Forests including Shumard Oak
Cypress Swamp Forest (extirpated)
Upland Forests
Open Woodlands/Barrens/Savannas
Sand barrens

The Western Forest-Prairie Division

The Western Forest-Prairie Natural Division of west-central Illinois is a strongly dissected glacial till plain of Illinoisan and Kansan age. Open woodland was the predominant vegetation, with considerable prairie on the level uplands. This character is reflected today with forests in riparian zones and on steep hillsides, and agriculture and rural grasslands in upland areas. This division has a well-developed natural drainage system with major streams having significant flood plains. Land use patterns of this division and the Southern Till Plain are similar, and five-lined skink, ground skink and ornate box turtle are animals characteristic of these two divisions.

Forest types

Dry-Mesic Savannas
Open Woodland/Savannas/Barrens
Dry-Mesic Forests
Riparian Forests
Oak-Hickory Forests

Wisconsin Driftless Area

The Wisconsin Driftless Natural Division is part of an area extending from the northwestern corner of Illinois into Iowa, Wisconsin and Minnesota that apparently escaped Pleistocene glaciation. Bordered by the Mississippi River Bottomlands on the west and characterized by rugged terrain that was originally mostly forested with some prairie, the division contains northern and pre-Ice Age relict species (e.g., Iowa Pleistocene snail), dolomite outcrops, hill prairies, extensive savannas, coolwater streams and caves. The Driftless area is so named because it has little or no “drift” - the sediments deposited across the remainder of northern and central Illinois by glaciers that bypassed this corner of the state. The rough, unglaciated terrain features wooded uplands, rolling hills, narrow valleys, numerous streams, springs, and cliffs and bluffs.

Forest types

Upland Forest
Savanna
Sand Savanna
Algific (cold soil type where ice persists in rock pockets into the summer) Slope Forest
Eastern White Pine Forest

Major Factors Influencing Forest Composition and Structure in Illinois

Climate, soils and topography are the major factors that interact to determine the structure and species composition of Illinois forests.

Climate

Illinois is 390 miles long and 210 miles wide with a widely varying climate. Five different plant hardiness zones occur in Illinois (Figure 3). Average annual temperatures range from 48°F (north) to 58°F (south), with highs ranging from 57°F (north) to 67°F (south). Average winter highs range from the 30s (north) to the mid-40s (south), while average lows range from the teens (north) to the upper 20s (south). Average summer highs are in the 80s, while lows are in the 60s across the state. Both spring and fall have more moderate temperatures. Illinois averages 10 days at or above 90°F (north) compared to just over 40 days (south). Illinois averages 140 days at or below 32°F (north) but only 80 such days (south). The average length of the frost-free growing season in Illinois ranges from 160 days (north) to more than 190 days (south).

Average precipitation exceeds 48 inches a year (south), compared to less than 32 inches (north). Snowfall distribution is just the opposite, with averages of 36 inches a year (north) and less than 10 inches (extreme southern Illinois). Winter snowfall is heaviest in the Chicago area, enhanced by lake-effect snows from Lake Michigan. Variability in precipitation also extends over time. There have been major multi-year droughts in the 1930s and 1950s and major prolonged wet periods during the 1970s and 1980s. May and June are typically the wettest months, and January and February are the driest. Each year, Illinois has rainstorms producing 40 or more flash-floods each with 4 to 8 inches of rainfall in a few hours in localized areas.

Tree occurrence varies by species, and also by geographic populations of a species. The geographic range of a tree species might be determined by its adaptation to cold extremes, rainfall requirements, soil temperature limits, or length of the growing season. In southern Illinois, forest tree species at the northern extent of their natural range include willow oak, swamp hickory, cherry bark oak, southern red oak, swamp cypress, water tupelo, sweetgum, Nuttalls oak, overcup oak, cucumber magnolia, Carolina silverbell, and shortleaf pine. In the north, tamarack, paper birch, trembling aspen, yellow birch, northern pin oak, mountain ash, white pine, and northern white cedar are among those at the southern edge of their range for this longitude. From east to west there is less apparent variability in climatic limits to tree species distribution.

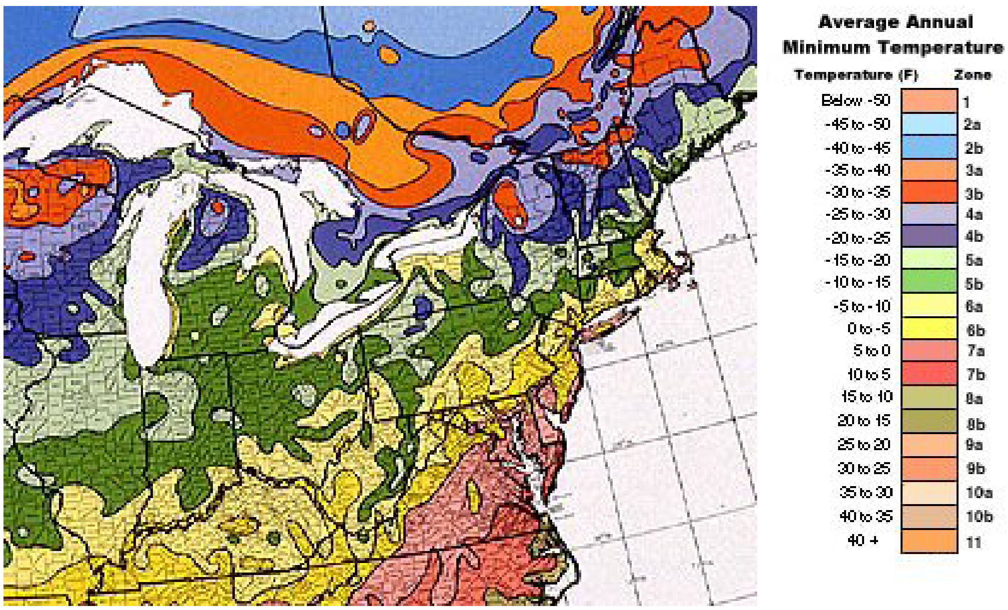

Figure 3. USDA Miscellaneous Publication No. 1475. Issued January 1990. Authored by Henry M. Cathey while Director, U.S. National Arboretum Edited, formatted and prepared for the US National Arboretum web site by Ramon Jordan, March 1998 & Revised March 2001 U.S. National Arboretum, Agricultural Research Service, U.S. Department of Agriculture, Washington, DC 20002 Note: This publication is not copyrighted, and permission to reproduce all or any part of it is not required.

Geographic populations within a species are known as **ecotypes** when they differ **genecologically**. Ecotypic adaptations are genetically controlled and determine the conditions under which a tree can grow. For example, native cottonwood trees from southern Illinois require fewer cold days during the winter in order to break dormancy in the spring than do northern ecotypes of the same species. Hence they can show frost damage from late winter injury when moved north a distance of 200 miles or more. **Leaf senescence** and **bud set** will occur later in the fall for southern ecotypes of cottonwood trees than northern ecotypes of the same species. The combination of lower temperatures and daylength necessary to trigger the onset of dormancy in the fall for southern Illinois cottonwood ecotypes is different than corresponding requirements for cottonwood trees in the north. Southern ecotypes will senesce, drop leaves, set buds, and become winter hardy when the daylength is shorter later in the growing season than in the north. In common garden studies of cottonwood ectotypes from southern and northern Illinois in Urbana, the offspring of trees from extreme southern Illinois broke dormancy too early in the season in response to warm spells and succumbed to freezing injury on the southwest lower trunk of the trees. In contrast, northern ecotypes set bud so early in the fall and broke bud so late in the spring that they did not fully take advantage of the growing season. Moving ecotypes genetically adapted through ongoing natural selection to their specific climate, latitudinally or altitudinally, actually puts them at a disadvantage to compete with local ecotypes.

For this reason Illinois is divided into three seed zones, each about 130 miles from north to south. The purpose of seed zones is to insure that seed sources for planting stock originate in the same zones in which tree seedlings will be planted so that they will be **hardy** (adapted to climatic conditions, especially cold temperatures). The genetic programming of a tree-species ecotype is conservative with respect to avoiding the latest spring and earliest fall season frosts, so it is generally safe to move ecotypes about 100 miles to the north. In fact, trees moved a safe distance north may exhibit slight growth advantages because, in spite of some risk of frost damage, they will have a slightly longer growing season. Northern tree species can be moved further south with less risk, and this is often the case for ornamental trees, but their potential for competing in the wild with southerly cousins is not good because of reduced growth due to their attenuated growing season.

Moisture regime

Soil moisture, determined by climate, soils and topography combined, is a major determinant of forest types in Illinois. At the xeric extreme in Illinois are sands and gravels with water tables far beneath the soil surface in dunes exposed to sunlight. Water in these soils quickly percolates below the root zone or is evaporated from the soil surface rapidly. Other dry soils are found along the edges of valleys in southern Illinois where eroded **loess** (wind- deposited, silty soil parent material) is thin over rock, with little depth to store water from rainfall. Here cedar glades dominated by drought-tolerant eastern red cedar, also called eastern juniper, occur with blackjack oak, Texas hickory, lichens and prickly pear cactus.

Trees adapted to survive on dry sites have **stomates**, or small openings in the leaves, that close quickly and efficiently in order to slow the process of transpiration. In transpiration water evaporates, most quickly under hot, dry, windy conditions, from the surfaces of cells inside the leaves as it evaporates and diffuses through the open pores of the stomates. In so doing, water displaced from cells inside the leaves is "wicked up" from the soil through the small pipe-like tubes of the sapwood. This process is similar to the replacement of kerosene burned from the top of a lamp wick. In a burning kerosene lamp the liquid fuel is drawn up through the small pores of the wick. **Xylem** tissue and lamp wicks allow liquids to be lifted up intact, due to internal cohesion of small "columns" of the liquids constrained by small pores. Water moves from soil through the continuous system of small-diameter xylem vessels found in roots, sapwood and leaf veins. When stomates close, the tree reduces water uptake drastically and conserves it, preventing leaf wilting and desiccation damage to living tissue. A trade-off for water conservation is that closed stomates also prevent diffusion into the leaves of carbon dioxide from the air. Unless carbon dioxide is able to diffuse into the leaves through open stomates, it is unavailable to be fixed photosynthetically into substances used for tree metabolism and growth. For this, and other reasons, drought tolerant trees on dry sites do not grow as rapidly as trees of moist sites.

Many drought-tolerant plants have waxy leaf surfaces to reduce water loss from leaves. This is illustrated by one of the ways of distinguishing drought-tolerant black oaks from mesic red oaks in the field, which is to look for the shiny, waxy leaves of **drought-tolerant** black oak. Illinois trees genetically adapted to survive dry conditions might also have small, thick leaves with less exposed leaf surface area and fewer stomates, as in the case of eastern juniper. Other drought adaptations of plants include leaves that have sunken stomates to slow **diffusion** of water from leaves, drought-induced leaf shedding, thick bark, deep rooting pattern, and **tap roots**, or **sinker roots** from lateral roots. These roots are possessed by bur oak, other white oaks, walnuts and hickories. Tap and sinker roots grow straight down from lateral roots to access water in deep soil strata. While these roots allow the trees to take up water, nutrients are taken up only by roots in the top 18 inches or so of soil where there is sufficient oxygen to fuel the metabolism associated with actively pumping mineral nutrient ions into root cells, loading them against a concentration gradient from soil solution to the cells of root tissue. This fact is demonstrated, much to the unhappiness of people building homes in centuries-old stands of majestic bur oak, when trees suddenly die from mineral nutrient starvation several years after construction. When this occurs, the cause is often determined to be **soil compaction** from the parking of trucks, heavy equipment, and the placement of heavy bundles of lumber, roofing materials and dry wall in the shade of the trees. In compacted soil, particles are packed together so tightly that soil pore space is greatly reduced and oxygen is unable to diffuse into the soil. Surficial roots are robbed of oxygen needed to allow sufficient respiration to fuel the metabolic process of nutrient loading, even though the sinker roots in deeper, moist, but low-oxygen soil strata allow the water needs of the tree to be met. Some drought-tolerant trees of Illinois include post oak, black oak, shagbark hickory, shortleaf pine, blackjack oak, Texas hickory, white oak, mockernut hickory, black walnut, Kentucky coffee tree, black locust, bur oak, sumac, and sassafras.

At the other extreme are trees tolerant of various degrees of flooding or soil water saturation in swamps, wetlands and floodplains. Swamp species, or very tolerant species (Table 1), such as bald cypress, water tupelo, pumpkin ash, swamp cottonwood, black willow, water hickory, Nuttall oak, overcup oak, and buttonbush inhabit wetlands and are able to survive deep, prolonged flooding for more than a year. Tolerant species that can tolerate a deep, flooding event for one growing season include silver maple, red maple, boxelder, green ash, sycamore, pin oak, sweet gum, pecan, shingle oak, cottonwood, deciduous holly, sugar berry, shellbark hickory, and hackberry. Trees that are somewhat tolerant, able to survive seasonal flooding of up to a month, include river birch, honeylocust, American elm, red elm, swamp white oak, bur oak, and cherrybark oak. These somewhat flood-tolerant species often occupy elevated portions of flood plains and flood plain margins. Some of these species are also able to tolerate drought, such as pin oak, shingle oak, hackberry, boxelder, and bur oak.

Flood-tolerant tree species can produce energy sufficient to keep their roots alive initially after flooding through a greater capacity than upland trees to support **anaerobic root respiration**. Flood-tolerant species exposed to flooding eventually produce special roots and root structures, including thick, white "**water roots**" or **cypress knees**. Both such root structures are filled with spaces between cells that aid in the diffusion of oxygen from lenticels (porous wart-like growths) and bark tissue above the saturated zone down to the roots. Without sufficient oxygen, root cells cannot support metabolic processes to actively take up nutrients from soil solution. Over time, flooded tree roots will die in accord with their flood tolerance capacities, killing the tree. **Flood-tolerant trees** can grow in upland areas, but flood -intolerant species cannot grow in wet soils. Another strategy to avoid flood stress is exemplified by tag alder, a small, wetland tree of northern Illinois. Though a wetland, bog and streamside species, tag alder does not actually tolerate long periods of root flooding. It produces roots near the soil surface to access oxygen on wet soils that do not flood such as those along ponds and small streams.

The most demanding trees are mesic species, upland species that require ideal moisture and nutrient conditions most of the time. Examples include beech, black maple, red oak, tuliptree and sugar maple. These are found in Illinois primarily in sheltered coves, valleys, lower slopes, and north-facing slopes. Deep, **loamy soils** rich in nutrients and with a balance between sand, silt, clay and organic matter to maximize retention of water, nutrient availability and soil oxygen diffusion rates are often characteristic of sites that support mesic forest species. Such favorable conditions also support a greater number of plant species, hence these mesic forests tend to be more diverse and are more difficult to manage to favor a limited set of "preferred" tree species. Tree species that characterize mesic forests, such as tuliptree, are competitive and become dominant because they are able to become established readily and grow faster than other tree species under favorable "mesic" conditions.

Clearly soil moisture regimes dictate what types of trees will group together in distinct associations across the landscape and are a major determinant of forest types in Illinois. Flood and drought tolerance rankings for Illinois trees are given in Table 1.

Table 1
Relative tolerance of trees and shrubs to flooding during the growing season, Lower Mississippi Valley and Missouri River Divisions. (Source: Whitlow and Harris 1979)

Very Tolerant	Tolerant	Somewhat Tolerant	Intolerant
Water hickory	Boxelder	Tag alder	Bitternut hickory
Buttonbush	Red maple	River birch	Shagbark hickory
Waterlocust	Silver maple	Downey hawthorn	Mockernut hickory
Deciduous holly	Pecan	Honeylocust	Redbud
Water Tupelo	Shellbark hickory	Blackgum	Flowering dogwood
Water elm	Hackberry	Black walnut	White ash
Overcup oak	Persimmon	Swamp white oak	Kentucky coffeetree
Nuttall oak	Sugarberry	Southern red oak	Shortleaf pine
Black willow	Green ash	Bur oak	White pine
Bald cypress	Sweetgum	Willow oak	Paper birch
Swamp cottonwood	Sycamore	American elm	Trembling aspen
Pumpkin ash	Eastern cottonwood	Red elm	Wild plum
Tamarack	Shingle oak	Winged elm	Black cherry
Black ash	Pin oak		White oak
	Shumard oak		Black oak
	Cherrybark oak		Post oak
			Blackjack oak
			Texas hickory
			Northern red oak
			Post oak
			Sassafras

Fire and disturbance

Fires, which were observed by early European explorers to be set by native peoples for purposes such as driving game to pre-stationed hunters, played a major role in maintaining tall grass prairies and also influenced the type of temperate deciduous forest that dominated the landscape. The **oak-hickory forest type** resulted from periodic fire and other disturbances, such as windstorms, ice storms and logging. These disturbances opened the forest canopy to allow in enough light to support establishment and growth of tree species such as oaks, walnut and hickories, that are intermediate in their tolerance of shade and forest understory conditions. With enough light, oak and hickory species can sprout repeatedly after fire and browsing, and can in time produce a large root with sufficient carbon reserves to develop a sprout six feet in height in a single year. Left undisturbed long enough, these oaks and hickories gave rise to oak-hickory forests. Between the prairie and the forest, **savannas** with large, scattered oaks that resisted fire because of thick, insulative bark (bur oak) or prolific sprouting (black oak) were found with a mix of both prairie plants and forest understory plants. Oaks, hickories, and walnuts have large seeds that are distributed and cached in soil by squirrels and blue jays. Because their large seeds contain sufficient carbohydrates and fats to generate long roots and tall shoots before the seedling has to rely solely on its own photosynthesis to grow, these species can invade and establish themselves competitively in prairie grasses that would prevent establishment of tree species with smaller seeds. Today the intermediate savanna zone that once resulted from the widespread interplay of fires, forests and prairies at the landscape level, is the rarest type of ecosystem in Illinois, and the oak-hickory forest is not regenerating, giving rise to increasing dominance of Illinois forests by sugar maple.

Before settlement, maple-beech and maple-basswood forests were found in coves and river valleys where moist soils, stream barriers and the fact that fires traveled upslope much better than downslope protected them. Beech, maple and basswood have thin, dense bark that does not protect the **meritematic** cells just beneath the bark (**vascular cambium**) that give rise to water and nutrient-conducting vessels. On the other hand, bur oak trees and other upland tree species have thick, low density bark that acts as an insulator to prevent heat from a fire from damaging the vascular cambium. Other tree species respond to fire mortality by sprouting prolifically from stumps (black and red oaks) or roots (aspens), thus surviving intense fires.

Other factors influencing forest tree species composition in Illinois and elsewhere include pollutants, deer browse, soil pH, clay pans, wind, diseases, insects, urban conditions, competition from exotic plants, and diverse human activities.

Patterns of Succession in Illinois Forested Ecosystems

Succession is the natural replacement of plant or animal species, or species associations, in an area over time. Forest succession is the replacement of tree species or tree **associations.** Each stage of succession creates the conditions for the next stage. Temporary plant communities are replaced by more stable communities until a stable forest community develops in which there is an equilibrium between the trees and the environment. The following general sequence is typical over time in forests when no disturbance occurs:

Forest Succession

Early: Forbs, grasses and shrubs dominate the site. Oak, hickory and walnut seedlings may be present in old pastures or tallgrass prairies. These trees share and then begin to dominate the site. The shade- (and understory-) **intolerant** tree species typically grow most rapidly. Aspens, upland oaks, hickories and walnuts are intolerant to mid-tolerant (can tolerate partial shade). Competitiveness of grasses with thick thatch and dense root systems prevents most smaller-seeded tree species from becoming established.

Middle: Intolerant and **mid-tolerant** oaks and hickories eventually overtop the grasses, forbs and shrubs. The intolerant, pioneer tree species continue rapid height growth. Tree-to-tree competition may become severe, eliminating overtopped and shade-intolerant trees. Their growing space may be subsequently occupied by tolerant trees.

Late: Mortality of less-competitive, individual, intolerant trees continues as they are overtopped and shaded out. Both intolerant and **tolerant** trees may now share the main canopy. Ancient bur and white oaks may persist as dominants for a long time as tolerant sugar maple, Ohio buckeye, basswood, and beech establish in the understory and quickly fill in gaps created by mortality of the mid-successional oak dominants.

Climax: A relatively stable plant community develops. It has dominant tree populations of tolerant tree species such as maple, basswood or beech-suited to their environmental niche in the climax forest stand. Tolerant species dominate the site and seedlings of the tolerant climax species will become successfully established under their own shade. Intolerant trees cannot reproduce. At this point disturbances and gaps created by mortality of dominant trees allow the pre-existing tolerant trees in the understory to fill in the gaps, insuring continuity of the stand. Some intolerant trees such as tuliptree have seed banks that persist up to seven years in soil and can germinate and grow quickly on rich soils when large gaps occur in climax forests. Thus some intolerant species can exist in climax forests.

Tolerance

Most tolerant trees are shade tolerant, but the term tolerance can also refer to **understory** tolerance. The soils under a mature forest contain the root systems of dominant trees that compete for soil nutrients and water with seedlings and saplings. Another tolerance mechanism is found in Ohio buckeye trees that leaf out early in the season at the same time as spring wildflowers, taking advantage of needed higher light intensities prior to full leaf expansion of the trees in the main canopy. Ohio buckeye trees also shed their leaves as early as July and August to avoid the maintenance cost of leaves not able to supply the necessary **photosynthates** to maintain leaves at low light intensities. Some trees such as Eastern hophornbeam and hornbeam are tolerant of shade but are small trees that never reach the upper canopy of forests. Their **niche** is in the understory.

A list of understory tolerance of Illinois tree species is included below.

Table 2

Tolerance of native Illinois forest tree species

Very Tolerant	Tolerant	Intermediate	Intolerant	Very Intolerant
Eastern hemlock	N. white cedar	E. white pine	E. red cedar	Tamarack
E. hophornbeam	Red maple	Bald cypress	Shortleaf pine	Jack pine
Hornbeam	Silver maple	White oak	Red pine	Willows
American beech	Boxelder	Red oak	Black walnut	Aspens
Sugar maple	Basswood	Black oak	Butternut	Cottonwoods
Fl. dogwood	Persimmon	American elm	Pecan	Grey birch
	Buckeyes	Hackberry	Hickories	Black locust
		Sugarberry	Paper birch	Osage orange
		Yellow birch	Tuliptree	
		Cuc. magnolia	Sassafras	
		White ash	Water tupelo	
		Green ash	Black gum	
		Black ash	Sweetgum	
		Oaks	Sycamore	
			Black cherry	
			Honey locust	
			Kentucky coffee tree	
			Northern catalpa	

In floodplain forests of Illinois, the ravages of frequent flooding tend to open up forest stands, create new sand and silt deposits for the establishment of water- and wind-borne seeds, and maintain a mixture of intolerant and midtolerant tree species as subclimax dominants. Ironically, an examination of drawings and paintings of early explorers in Indiana and Illinois suggests that the floodplain forests of today are more similar to their presettlement condition than are most upland forests.

Forest Nutrient Cycles

Temperate deciduous forests tend to be very efficient at recycling nitrogen, phosphorus, potassium and other nutrients that are limiting to plant growth in most soils. In forested watersheds in which nutrient levels in the stream are monitored, the loss of nutrients in stream water and soil erosion are minimal until disturbance eliminates the vegetative cover. Even then, the increased nutrient loss may be erased as soon as three years after disturbance as vegetation and associated nutrient recycling become re-established.

Integrated with nutrient cycling are carbon and water cycles. During the growing season, trees take up water through their roots and transpire water through stomates in the leaves. A single mature oak tree well supplied with soil water might take up and give off through transpiration as much as 150 gallons of water on a hot, dry day. If there are 100 such oaks on an acre of land, the movement to the atmosphere of ground water could be 15,000 gallons per acre. The evaporation of water from leaves results in cooling and lowers temperatures under forest canopies while preventing heat loading of leaves. In southern Illinois on warm mornings you can see water vapor actually escaping from forests. In Central America the visible, transpired water rising as mist from lowland forests is necessary to provide water to the atmosphere to create the condensation at cooler, higher elevations that sustains cloud forests. When lowland forests are eliminated, cloud forests are adversely affected as well. Thus trees play an important role in the water cycle from atmosphere to soil and back to the atmosphere in terrestrial ecosystems. In fact, watershed forests managed for city water supplies can be managed to reduce the number of trees transpiring or to shift from evergreen to deciduous species, which transpire only during the part of the year when they bear leaves, to decrease water movement to the atmosphere rather than through soil to the watershed for human consumption. Also, in montane and boreal regions, forests shade snow in the spring, slowing seasonal melting, and providing root channels and organic material to soils that absorb and allow infiltration of this water into soil. Shading by forests and forest soil features moderates the flow of streams for human use so that water flows all summer rather than exiting via surface runoff and massive spring flooding followed by stream drying.

Traveling in the water from the soil to the leaves are mineral nutrients actively loaded from the soil solution, respired carbon dioxide from living cells in the roots and trunk of the tree, and hormones produced in roots and other tissues. Mineral nutrients from the xylem supplied to leaf and other living tissues can be biochemically transformed into many substances and move in all directions through the **phloem** tissue located in leaf veins and also throughout the tree, just outside the vascular cambium, in the inner bark of twigs and stems. Some of the carbon from tissue respiration can be internally recycled through the photosynthetic process in leaves and, in some tree species with green bark signifying photosynthetic cells, bark tissue. Some of the mineral nutrients are recycled through decomposition and transformation processes performed by soil microorganisms on fallen leaves, twigs and sloughed roots. Microbial decomposition releases photosynthetically fixed carbon from plant tissue back into the atmosphere as respired carbon dioxide from microbial respiration, completing carbon cycling. However, during the autumn process of leaf senescence, carbohydrates, nitrogen, phosphorus, sulfur, and potassium are **resorbed** in quantity from leaves and stored in twig, stem and root tissues to fuel the explosion of growth the following spring. It is some of this carbohydrate stored as starch in living cells among the vascular tissue in sapwood that is transformed to sugars in the late winter and tapped for syrup in sugar maple trees. Ammonium, nitrates, potassium, sulfates, phosphates, calcium and other nutrients released from decomposed tissue are taken up again by root systems of trees. Some of these nutrients, particularly **anions** such as nitrates, are not held as readily as are **cations** by the surfaces of soil particles and can leach from soil.

Nitrates are anions that leach through surficial soil and reach anaerobic zones where they are denitrified and returned to the atmosphere as gaseous nitrogen. The inert nitrogen in the atmosphere is returned to soil via nitrogen fixation by free-living and symbiotic bacteria that transform the inert, gaseous dinitrogen, that makes up 80% of air, into ammonia that can be used by plants and other organisms in soil. This makes up the **nitrogen cycle**. Other mineral nutrient cycles involve similar, but less-complex soil transformation, leaching and uptake processes.

Most trees have root symbiotic fungi called **mycorrhizae**, that inhabit both roots and surrounding soil and aid in nutrient and water uptake by effectively increasing the root surface area and improving nutrient uptake efficiency in other ways as well. A restricted number of tree species have a specialized, highly efficient form of mycorrhizae termed **ectomycorrhizae** which can even accelerate nutrient release from rock particles and alleviate drought stress. In Illinois ectomycorrhizae are found on pines and oaks. This may help to explain how white pine regenerates on rock slides and sandy soils where most broadleaved trees cannot survive. This symbiosis undoubtedly assists in the survival of black oaks, blackjack oaks and other oak species on sand dunes and leached flatwood soils.

The carbon cycle, and the role of forest in carbon cycling, has been much discussed lately. Considerable amounts of carbon are sequestered in forest biomass and forest soils as organic matter. Forest trees and other plants tap the 370 parts per million of carbon dioxide in the atmosphere through photosynthesis employing **chlorophyll** in their green tissues. *Growing* forests remove carbon dioxide from the atmosphere and are an important sink for carbon. However, trees also give off carbon as they respire, and in a mature state, forests give off almost as much carbon from living tissue in massive stems and roots that do not photosynthesize as they take up in photosynthesis. Carbon fixed by trees is also given off as carbon dioxide released from microbial metabolism of wood-decomposing fungi and bacteria as well as other soil organisms in their food webs in soil. Recent discoveries, initiated by satellite sensing of the atmosphere over forest areas, suggests that trees give off methane, a greenhouse gas that would counteract, in part, the benefits that young forests provide by taking up the greenhouse gas carbon dioxide through photosynthesis. Forest trees also can release as much as 3% of the carbon that they fix as low molecular weight volatile organic substances such as **isoprene**. These chemicals are part of what makes up the blue haze over the forested Blue Ridge Mountains and Great Smoky Mountains of the eastern U.S. The relative importance of forest biomass in the carbon cycle and as a mitigant of global warming is not totally resolved. Nonetheless, forests provide many other benefits that are essential to maintaining the quality of human life.

Forest benefits

Many benefits are received from the forest resources of Illinois, ranging from lumber to natural areas for public enjoyment and relaxation. In addition, the forest resources of Illinois contribute financially to the state through jobs and income generated by forestry-related businesses and industries. The following information is based in part on the publication "Illinois Forest Resources" published by the Department of Natural Resources and Environmental Sciences at The University of Illinois and by the Illinois Forestry Development Council ifdc.nres.uiuc.edu/publications/**forest**rc02.htm.

Noncommodity benefits

By slowing rainwater so that it can be absorbed into the ground, forests help filter pollutants and sediment from our waters while replenishing aquifers and keeping annual stream flows steady. Surface waters in Illinois are polluted with nitrates, sediments and pesticides. Forests and buffer strips around streams and in wetlands can assist in cleaning water before it reaches streams, resulting in positive benefits locally and as far away as the Gulf of Mexico.

Temperate deciduous forests are among the most species-rich areas outside of the tropics-meaning we have more types of mammals, birds, reptiles, amphibians, snails, butterflies and native vascular plants than residents of colder or drier regions of the U.S. About 70% of the biotic diversity in Illinois is associated with forest ecosystems. This biotic diversity is our natural heritage and merits careful stewardship by any people who would claim to be civilized.

Recreation-based tourism in the region is important. Passive outdoor recreational activities such as hiking, canoeing and bird watching nationwide bring in $18 billion in revenues. Hunting in Illinois forests alone generates millions of dollars in retail sales each year and supports wildlife management activities through the sale of licenses and special stamps.

Illinois is a populous state with millions of people within a day's drive of its forested regions, including the Shawnee National Forest. Illinois forests are rich in cultural wealth, having a long human history, with many locales acquiring cultural significance and meaning. Kaskaskia mounds and the use its builders made of wood for canoes, shelters, and even its "woodhenge" celestial observatory is just one example of the importance of forests for many human societies in Illinois dating back as far as 20,000 years ago.

There are 244.2 thousand acres of publicly-owned reserved forest land available to users as state parks, conservation areas, wildlife management areas, nature preserves, and recreational areas. This reserved forest land is well distributed throughout the state. Many recreational benefits exist within Illinois forests, where participants are involved in activities such as hiking, horseback riding, camping, fishing, and picnicking. The Illinois Department of Natural Resources estimates that more than 3.4 million Illinoisans spend in excess of $670 million participating in activities such as observing, feeding, and photographing wildlife.

An estimated 350 thousand hunters and trappers spend more than 7.4 million days in Illinois each year. Their activities contribute as much as $627 million to the state's economy (Illinois Department of Natural Resources Office of Resource Conservation).

The forested areas on the Illinois Natural Areas Inventory (INAI) are valuable resources that serve as an example of the native forest vegetation in Illinois before European settlement. Community types are based on topographic position and soil moisture classes rather than the dominant species within the forest that the USDA Forest Service uses. Wet-mesic floodplain forest has the highest acreage, followed by dry-mesic upland forest. Forest community types with small acreages include dry-mesic sand forest, xeric upland forest, and wet-mesic upland forest. These areas represent very small remnants of original forest community types deserving protection. The total acreage of forested communities listed in the INAI is slightly less than 25 thousand acres. This is only 0.18 percent of the estimated 13.8 million acres of forest land in Illinois at the time of settlement.

Illinois forests are a source for both self-discovery, public education and a place of spiritual renewal. They foster a reverence for nature and can lead us to the integrity necessary to sustain all of their attributes for future generations.

Commodity benefits

Most, but not all, of the commodity benefits received from the forest resources of Illinois are in the form of wood products. Many private landowners provide resources for hunting and fishing through sportsman club rents and leases. Some Illinois forests provide alternative products, such as medicinal plants, notably ginseng, nuts, berries, fruits, and other edible plants and fungi.

Looking at available statistics, it is possible to get an idea of how much and what kind of trees were harvested for products in Illinois. In recent years about 75,000 cubic feet of wood has been harvested annually. This amount is less than the total annual growth in wood volume, so that Illinois is harvesting less timber than could be sustainably produced on current forested land in the state. Of this total, about 43,000 cubic feet were used for products. The remaining volume removed was in logging residue and other removals. The highest volume removed for a product was saw logs, or boards used for such things as furniture, flooring and cabinetry. Red oaks and quality white oaks were the two groups most used to produce saw logs. Select white oaks had the highest volume used for veneer logs, followed by black walnut. The remaining oak species also represented a significant portion of the volume used for veneer logs but not nearly as much as the white oaks and black walnut groups. The pines, cottonwoods and aspens had the highest volumes of wood used for making pulp. Soft maples (silver and red) and elms were also important for pulpwood production. For fuelwood, white oaks, hickories and red oaks were the most used. The volume of logging residue by species was similar to that of total removals. Logging residue is a by-product of removals and usage. The private individual was responsible for the greatest average annual volume of timber removed. Private owners control the majority of Illinois timberland.

The wood harvested from Illinois timberland is used for a variety of goods and products. Forty-six percent of recent annual removals was used for saw logs. Veneer logs, pulpwood, fuelwood, and miscellaneous products combined represent only 12 percent of the removals, while logging residue accounts for 13 percent. Many industries make use of logging residue as fuel and convert it into usable products. Logging residue in the form of branches and other woody material left at the logging site eventually decomposes and returns valuable nutrients to the soil. Other removals include wood removed in **timber-stand improvement** cuttings (where undesirable trees are removed), trees removed during land clearing, and growing-stock trees on land removed from timberland classification, as in suburban development.

A total of 2,032 businesses in Illinois deal with forest resources. The three general business types are forestry, lumber and wood products, and paper products. Forestry includes those businesses that deal directly with the forest resource itself, whereas lumber and wood products and paper products include businesses that convert the raw wood material into products used by consumers. The paper products type has both the highest sales volume and the greatest number of employees: twelve thousand jobs, $8 billion in revenues, and 253 establishments. Companies that make miscellaneous paper products have the highest sales volume, followed by paperboard mills and paper mills. Manufacturers of corrugated and solid-fiber boxes employ the greatest number of people and have the highest number of establishments. Bag manufacturing and coated and laminated paper manufacturing businesses are also large employers. Many businesses manufacture paperboard products, and these businesses also employ large numbers of people. Most businesses that manufacture paper products are found in and around Chicago.

There are few businesses in Illinois that deal directly with the forest resource. The majority of these are tree farms and timber tracts, where trees are grown for commercial harvest, and forest services. Many of the tree farms are Christmas tree farms. Businesses providing forestry services are those that can assist timberland owners with the various aspects of managing timber. As the importance of private ownership of Illinois timberland becomes recognized, a new opportunity for businesses in this field may exist.

In the lumber and wood products industry, millwork has the most businesses, the highest annual sales volume, and the most employees. Businesses that make wood kitchen cabinets and wood pallets and skids also have high numbers of employees. Structural wood members and reconstituted wood products also have large annual sales volumes. The forest resources of Illinois provide the majority of the total volume of saw logs used for products within the state. Only 72 percent of the total saw-log volume harvested in Illinois stays within the state for manufacturing. Indiana and Missouri combined receive 21 percent of the Illinois saw-log volume. Iowa and Kentucky are also significant importers of Illinois' saw logs. There is an opportunity for more wood-using industries in Illinois.

Forest Health and Management

Two broad forest management objectives are **conservation** and **preservation**. Conservation means wise use, and applies to management of state forests and U.S. National Forests where policies call for sustainable forest use for timber production, wildlife benefits, water resources protection, mushroom collection, plant collection, limited mineral extraction, and recreation. Preservation refers to management to maintain the natural qualities of an area. This is the policy that governs the National Park Service and the state parks. Usually commodity production and hunting are restricted in state and national parks. However, there is increasing recognition that ecosystem preservation requires active management, such as the use of prescribed burns to mimic pre-settlement fire cycles, and the reintroduction of keystone species such as wolves to naturally balance populations of large herbivores such as elk and moose that can damage forest resources when they overpopulate areas. In Illinois, white-tailed deer populations become so large, especially in urban areas where population control by hunting is not possible, that they consume herbaceous plants and tree seedlings producing a visible browse line in forests. Lacking natural predators and hunting pressure, deer can prevent forest seedlings from becoming established, interfering with forest regeneration, and consume such threatened and endangered forest plants as the yellow lady's slipper orchid. Other organisms that can disrupt forests include insect and disease pests.

Among the greatest threats to the health and integrity of Illinois forests are exotic and invasive insects, diseases, plants, and animals. In the past, the introduction of Eurasian diseases for which North American species had no natural resistance or checks resulted in major changes in forest composition. Chestnut blight all but eliminated American chestnut from North America, including some native stands in southern Illinois. All that remains are a few isolated stands or plantings and sprouts that are prevented from growing into a full-sized tree by the persistent disease.

Dutch elm disease and its insect vector decimated the large red and American elms in forests and cities, pointing out the dangers of monoculture in street-tree plantings. Today numerous American and red elms occur in our forests, but they are mostly small and are eliminated by Dutch elm disease before they can reach their full stature.

New threats include the Asian longhorned beetle that made its way to Chicago in green wood containers for imported machines. (Such wood is supposed to be **kiln** dried before use in importation in order to kill insects and diseases, but, obviously, not all containers have been, or can be, inspected for this requirement.) The Asian longhorned beetle prefers maple trees, but will infest many other species. Its larvae tunnel under the bark of the tree, cutting off the phloem that supplies nutrients throughout the tree, and eventually killing it. Prompt action by federal, state and city officials in the Chicago area employing inspections and sanitation removals of infected trees on both public and private property, seems to have held this pest in check. Similarly, the Asian Emerald Ash Borer, introduced into the Detroit area, has made its way into Illinois. It was probably transported into Detroit in shipping materials and into Illinois from Michigan as larvae under the bark of killed ash trees used for firewood. In spite of a quarantine and large signs alerting travelers not to bring ash wood across state boundaries, this insect is spreading. This beetle is smaller and able to travel farther than the Asian Longhorned Beetle. It threatens to destroy a majority of ashes in Illinois.

Another exotic pest, the Gypsy Moth, has also recently spread into northeastern Illinois. This insect defoliates large areas of forest, preferring oak species. In Pennsylvania and other eastern states, large areas have been defoliated, and the **frass** from infected trees around homes can coat outdoor chairs and tables while eliminating the shade benefits of infested trees. It has been treated with aerial applications of the bacterial agent, ***Bacillus thuringensis,*** or BT, that attacks the larvae of the moth. However, BT can also kill the larvae of desirable moths and butterflies, and so must be used judiciously.

Sudden oak death syndrome has spread in California to oak and redwood trees and has been found in some of the eastern states, apparently moving in with imported ornamental shrubs. It may be exotic in origin and is certainly being monitored as a possible threat to oak trees in Illinois.

Oak wilt also occurs in native forests. This is an indigenous disease that occurs in pockets, affecting the **red oak group** of trees more than the **white oak group**. Apparently there are natural checks to this disease because it does not spread in an epidemic fashion from infected patches, but eventually subsides after killing local groups of trees.

Two of the most notable exotic plant invaders in Illinois are European buckthorn in northern Illinois and garlic mustard throughout the state. Introduced as an ornamental and a food plant, these two species proliferate in forest understories apparently displacing native seedlings, shrubs and spring wildflowers. Methods to eliminate them using fire, herbicides and pulling are employed. A reasonable goal for managing these species is probably to control rather than totally eliminate them.

With globalization, we can expect more and more movements of exotic pests into Illinois. With the movements of exotic pests, we need more and more educated volunteers to help protect and restore forest ecosystems.

Ecological Considerations for Forest Management

Forest stand dynamics in the predominant oak-hickory forests of Illinois have been altered since European settlement. Periodic, presettlement fires spreading from prairie to forest on a wide scale across the landscape killed dominant trees of forests, opening the canopy by 50 to 60% and favoring oak and hickory seedlings and sapling sprouts. These fires have been eliminated to a large extent. Massive harvesting of oak-hickory forests in the late 19^{th} century, when sugar maple trees had yet to invade many upland forests, resulted in the regeneration of midtolerant oak and hickory trees that today comprise some of the best examples of old-growth oak-hickory forests. Transition towards maple-basswood and maple-beech dominated forests is today occurring across Illinois' topographically-diverse landscape, although more slowly or not at all on the drier, less productive sites, aspects and slope positions. A sizeable component of the presently dominant overstory species will require remedial management strategies that take into account the regeneration requirements of desired oaks, hickories and associated species if we are to maintain oak-dominated forests. With the widespread presence today of sugar maple as an emerging dominant in Illinois forests, maintenance of the oak-hickory type will require such methods as **shelterwood regeneration**, opening the canopy substantially and leaving desirable oak and hickory species as seed sources in the opened canopy. At the same time it will be necessary to remove maple and other tolerant tree species from the understory using combinations of mechanical removal, herbicides and repeated, low intensity fires to establish the desirable composition of advance regeneration. Once this advance regeneration is established, remaining trees can be left, or be removed to release the young saplings. Saplings mowed down as part of the final shelterwood removal often produce tall, straight sprouts from residual roots that quickly close canopy on the site, insuring their own succession to forest dominance.

Individual tree removals in a climax forest of tolerant trees such as maple will maintain climax forest cover, as will making the management decision to do nothing. So-called selective cutting in forests with both mid-tolerant and tolerant species will accelerate succession to dominance of the tolerants such as sugar maple.

Tree planting is another option to reforest or create new forests. Two methods are available. Direct seeding with rather large numbers of seeds using agricultural equipment for site preparation and specialized seeders for planting is one method. The other, more common method is to plant seedlings obtained from a tree nursery specializing in smaller seedlings for reforestation. Tree species should be carefully matched according to their habitat and soil type requirements. For example, you would only plant flood-tolerant species in a floodplain and drought-tolerant species on a sand dune. The major problem in establishing and growing planted trees on most, fertile, upland sites in Illinois is weed control, especially the control of the highly competitive perennial grasses. Herbicides, mulches, and mechanical means can be used to control weed competition. Once trees close canopy, which happens sooner at higher planting densities, they shade out the weeds and weed control is no longer necessary.

Good sources of detailed information on tree planting can be obtained from IDNR district foresters, the state and local offices of the Natural Resources Conservation Service, and the University of Illinois Extension.

Urban Forests

Trees are indicators of a community's ecological health. While urban ecology is more complex than just tree cover, trees are good indicators of the health of an urban ecosystem. When trees are large and healthy, the ecological systems—soil, air and water—that support them are also healthy. In turn, healthy trees provide valuable environmental benefits. The greater the tree cover and the less the impervious surface, the more ecosystem services are produced in terms of reducing stormwater runoff, increasing air and water quality, storing and sequestering atmospheric carbon and reducing energy consumption due to direct shading of, and wind reduction around, residential buildings. Trees increase property values and make communities more attractive for new residents and businesses. There is even evidence that the presence of trees reduces tensions and crime rates in urban areas.

In order to maintain these benefits, cities need to invest in the planting and management of trees. City forestry programs typically are governed by a board or commission and headed by a professional arborist, city forester or landscape architect. Effective management entails many elements. The selection of trees appropriate for planting on city property and rights of way is necessary. Trees that grow into sewer lines, produce noxious fruit or nuts, require high levels of maintenance, are not adapted to urban soil conditions, that are too large for planting under power lines, or that break up in ice storms or with exposure to high winds are usually listed and banned from planting by the city. A maximum percentage (i.e. 5 or 7%) of trees of any species is stipulated, insuring that a diversity of suitable trees are planted to avoid disasters that occur when a disease or insect eliminates an entire species, as happened with Dutch elm disease. Tree trimming cycles are set and trees hazardous to people or property are identified and removed promptly. Insects and diseases of trees are treated as effectively and safely as necessary. Educational programs and public news releases inform citizens of current forest health issues, assistance programs, historical and unusual tree resources, and other facts and issues concerning city trees. Provisions are made through zoning requirements to incorporate trees and green spaces in parking lots, new subdivisions, apartments and office buildings.

Ecological knowledge is applicable to urban forestry. For example, many trees commonly and successfully planted along streets and in restricted spaces in cities are floodplain trees: green ash, bald cypress, red maple, swamp white oak, pin oak, hackberry and sugarberry. It is not coincidental that the same properties that allow a floodplain tree to tolerate the low oxygen conditions of saturated soils also allow the same species to handle barriers to oxygen diffusion resulting from urban soil compaction, pavement and heavy clay soils deposited at the surface by construction activities. Some of these same floodplain trees, such as sycamores and cottonwoods, are able to tolerate soil moisture and low oxygen of deeper soils around sewer pipes and infiltrate gaps between sewer tiles, blocking the pipes with a proliferation of roots. Root expansion can even break the sewer tiles and, in other situations, uplift sidewalks. Female cottonwood trees produce abundant cottony seeds in the spring that can clog air filters. Hence only male clones, if any, of cottonwood are allowed to be planted according to some city tree ordinances.

Understanding trees both in forests and outside of forests, and using this knowledge to effectively manage forests, is critical to sustaining our quality of life. This introduction to some of the basics of forest ecology must serve as a foundation for lifelong learning and development as a naturalist. Other useful skills related to trees and forests include tree identification, arboricultural practices, map reading, orienteering, street tree inventory methods and forest measurement techniques.

References

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