Current and Historical Forest Conditions and Disturbance Regimes in the Hoosier-Shawnee Ecological Assessment Area

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ABSTRACT

We review the historical and current status of forests in the Hoosier-Shawnee Ecological Assessment Area. Native American people influenced the vegetation through fire and agricultural clearing across the region until the early 1800s when European settlers arrived.

Clearing of the land for agriculture peaked in the early 1900s after which badly eroded land was abandoned and either planted or naturally regenerated to forest. Many of these abandoned farms were purchased for public parks and forests and managed as timberlands throughout the 20th century.

Today, about 43 percent of the landscape is covered by forest and 49 percent in agriculture. Land use varies across the region depending on its suitability for nonforest use. For instance, much of the uplands across the assessment area, including the Ozark Highlands, Interior Low Plateau, Shawnee Hills (hereafter "Shawnee Hills"), and Interior Low Plateau, Highland Rim (hereafter "Highland Rim") Sections are dominated by forest land. In contrast, much of the best lands are privately held and support agricultural activities.

Forests are mostly temperate deciduous hardwoods with coniferous forests covering only 8 percent of the forest area. Forests are currently dominated by oak and hickory species that cover about 40 percent of the forest area. However, species composition is changing from species established as the result of frequent past disturbances (<1950) to more shade tolerant species as the result of the decreased disturbance regimes of the late 20th century (>1950). There is concern about the loss of landscape diversity and maintenance of oak species as these shifts occur, and current management activities are being implemented to reduce this transition.

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We review the historical and current status and management of forest within the region surrounding the Hoosier National Forest in southern Indiana and the Shawnee National Forest in southern Illinois. The assessment area, encompassing over 12 million acres, has a long history of human activity beginning with Native American peoples 12,000 years before present. Human-caused disturbances including the use of fire, grazing by livestock, and extensive clearing have been important factors in determining the condition of the vegetation in the region today.

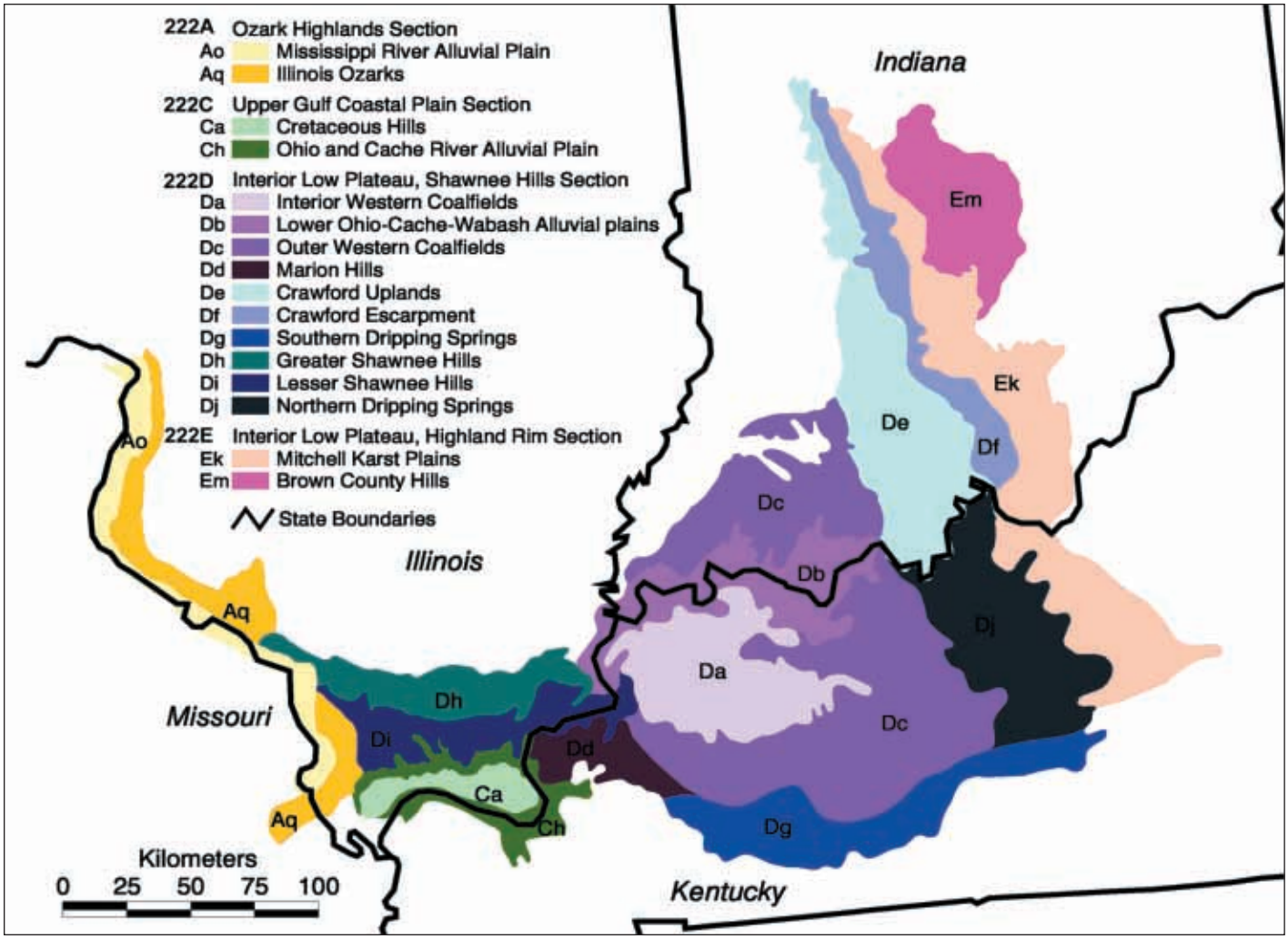
We document the rich historical ecology of the Hoosier-Shawnee Ecological Assessment Area by coupling the historical disturbance regimes with the changing vegetation patterns across ecological units. Vegetation is examined within the context of the National Hierarchical Framework of Ecological Units, a classification system that divides landscapes into ecologically significant regions at multiple scales (Keys et al. 1995). Section and subsection names and numbers follow Keys et al. (1995) and are also listed in Ponder (2004). The diversity of history and management is discussed for 4 ecological sections and 16 subsections (fig. 1). As history of resource use, major forest types, and current management activities are examined for each unit, descriptions are limited due to the large spatial area each unit encompasses.

MAJOR CHANGES IN VEGETATION AND THE INFLUENCE OF HUMANS FOLLOWING GLACIAL RETREAT

Prehistoric period (before 1650)

During the height of the Wisconsin glaciation (28,000 years BP), ice sheets were located in central Illinois and Indiana, but landscapes were ice free in southern Indiana, southern Illinois, and western Kentucky. The preglacial landscape of this region, however, was greatly influenced by the ice sheets to the north. During the Wisconsin glaciation, a mixture of boreal-northern hardwood/pine forests dominated portions of western Kentucky and southern Illinois alternating with southern pine-prairie species during warm episodes (Franklin 1994, Whitehead 1997). Following the disappearance of the ice sheets by 17,000 years BP, deciduous species migrated into the region and forests were comprised of oak, hickory, elm, and beech species by 11,500 years BP. In the Middle Holocene, a warming trend known as the Hypsithermal period (8,700-5,000 years BP) resulted in prairie expansion into the region; mesophytic tree species retreated to mesic bottomland and cove sites while oak and hickory dominated upland sites (Franklin 1994). Following the Hypsithermal, a cooler, moister climate fostered woody invasion into prairie and open savannas. Through time, these open woodlands were heavily influenced and probably maintained by recurring fire, both natural and human caused (Fralish et al. 1999). By 2,000 years BP, forests of the region were comprised of oak-hickory and mixed mesophytic forests with inclusions of glades, prairies, and savannas. Braun (1950) classified regional forests as oak-hickory in the Ozark Hills of southwestern Illinois and mixed mesophytic across the Shawnee Hills of southeastern Illinois and western Kentucky. Küchler (1964) mapped the potential vegetation of this region as oak-hickory.

Coupled with the natural interactions of vegetation and climate were the interactions of humans and vegetation. By the Middle Holocene, Archaic peoples had settled into the lower Ohio and middle Mississippi River areas. Archaic people (8,000-2,500 years BP) were seminomadic hunter-gatherers who were adept at manipulating their environments (Caldwell 1958; Delcourt 1987; Munson 1986, 1988). Cultural ecologists believe Archaic peoples used fire widely for altering forest composition and



structure as well as for clearing forest patches, driving game, and other activities (Caldwell 1958, Delcourt et al. 1998, Mellars 1976). Although the overall impact of these activities is equivocal based on uncertain population sizes and shifting demographics, most paleoecologists accept that Archaic peoples altered their local environments to augment their subsistence economy (Gardner 1997, Munson 1986). Later, Woodland period (2,500-1,000 years BP) cultures had an intensified hunting-gathering economy with growing dependence on swidden horticulture. These cultures were dependent on the seasonal availability of collected resources, and thus their occupation sites rotated between bottomland and upland forests. Woodland cultures also used fire to clear forest patches and aid in collecting and processing mast resources of upland forests (Clark and Royall 1995, Ruffner 1999). Paleoecologists recently reported the influence of Woodland cultural activities in the form of "forest gardens" in central hardwood forests (Delcourt et al. 1998). Mississippian period (1,000-500 years BP) natives moved into the region, establishing the earliest agriculture at their large agricultural village sites along river bottoms (Cole 1951, Muller 1985). These villages supported populations as large as 500 persons and were characterized by stockaded enclosures surrounded by cultivated fields where corn, beans, and squash were grown (Cole 1951, Muller 1985). Mississippian communities disintegrated into tribes after 500 years BP and dispersed widely across the landscape with few permanent settlements. Pre-European Native groups of the southern Illinois region consisted of the Kaskaskia, Michigamea, and Shawnee (Brown 1985). As a result of growing hostilities between Native and European groups in the 1700s,

Figure 1. Ecological sections and subsections within the Shawnee-Hoosier Ecological Assessment Area.

numerous migrations moved tribal groups up and down major river drainages. By the mid-1700s, the lower Ohio River Valley was a major thoroughfare for westward movement of displaced tribes from the Mid-Atlantic including the Delaware and Shawnee (McConnell 1992). Population numbers varied during this period, and the effect of humans on the environment is poorly understood.

Historical accounts of the region depict the area as heavily influenced by Native activities (Allen 1945, Brown 1985, Kimmerer and Lake 2001, Temple 1966). Indeed, the anthropogenic landscape encountered by early European settlers in the 18th century reflected a long-term interaction between Native activities and vegetation associations. Native American use of fire and clearing land for agriculture was probably much greater in the 1400s than it was in the 1700s when Europeans started settling in the region (Denevan 1992, Williams 2000). European diseases had greatly reduced Native American populations by the late 1,500s—early 1,600s, reducing their overall impact on vegetation across the landscape, allowing some recovery of forested conditions by the 1700s when Europeans became more active in the region (Olson 1996). However, fire and agriculture continued to be used across the landscape by a smaller number of Native Americans. Research on the barrens of southern Indiana indicates that some areas were burned about every 23 years from 1650 to 1820 (Guyette and Dey 2000). However, fire history across the assessment area needs to be studied more intensively to further elucidate these relationships.

Based on General Land Office survey records, pre-European settlement forests of southern Illinois were loosely characterized into four ecotones: 1) mesic oak-hickory forests dominated by white oak (*Quercus alba*), black oak (*Q. velutina*), and hickory (*Carya* spp.) occurring on thin loess upland soils across the Shawnee Hills, 2) mixed hardwood forests with tulip-poplar (*Liriodendron tulipifera*), American beech *(Fagus grandifolia)*, white oak, black oak, hickory, and sweetgum *(Liquidambar styraciflua)* on thick loess deposits of the Ozark Hills, 3) lowland-depression forests with elm (*Ulmus* spp.), ash (*Fraxinus* spp.), sweetgum, oaks, hickories, bald cypress *(Taxodium distichum)*, and red/silver maple *(Acer rubrum/saccharinum)* on low-lying terraces and bottomlands of the Ohio, Wabash, Cache, Saline, and Mississippi Rivers, and 4) floodplain forest (elms, ashes, hackberry *(Celtis occidentalis)*, eastern cottonwood *(Populus deltoides)*, and American sycamore *(Platanus occidentalus))* in narrow bands along riverbed margins (Leitner and Jackson 1981, Schulte and Mladenoff 2001).

Isolated fragments of savanna and prairie were present across upland north-central portions of the region (Williamson and Johnson Counties, Illinois), the Cretaceous Hills of southeastern Illinois, and the hill prairies along bluffs of the Mississippi River (Anderson and Anderson 1975, Evers 1955, Fralish et al. 1999). Small native populations of shortleaf pine *(Pinus echinata)* occur on extreme, xeric uplands of the Ozark Hills at LaRue-Pine Hills in Union County and the Piney Creek Reserve of Jackson County, Illinois (Ashby and Kelting 1963, Davis and Ruffner 2001, Suchecki 1997, Turner 1936).

The presettlement landscape of southern Indiana was predominantly forested (Lindsey et al. 1965, Potzger et al. 1956) with significant areas of prairie and disturbed and open forest (Eagelman 1981, McCord 1970, Olson 2001). Oak and hickory species were dominant on the Brown County Hills, Crawford Uplands, and Interior Western Coal Fields Subsections, and mixed forests of American beech, sugar maple (*Acer saccharum*), oaks, and hickories were dominant on the limestone soils of the Mitchell Karst Plain and Crawford Escarpment Subsections. The Lower Ohio-Cache-Wabash Alluvial Plains Subsection was dominated by floodplain forests of elm, hackberry, sycamore, and beech (Gordon 1936). Many other species

were also present in these areas and will be discussed in more detail later.

Current overstories of old-growth forests are indicative of species present during the presettlement period (Lindsey and Schmelz 1965, 1970; Lindsey et al. 1969, Lindsey 1962; Parker 1989; Ruffner et al. 2002; van de Gevel and Ruffner 2002). Many of these old forests have seral oak species in their overstories due to the disturbance regimes spanning the Native American-European settlement periods (DenUyl 1954). Old-growth studies have attempted to identify key characteristics of forest structure and composition, but few generalizations can be made because of the scarcity of data (<1% of original forest remains) (Parker 1989). Most old-growth forests of this region are small, highly fragmented parcels with older canopies (>150 years) of oak and hickory that developed during periods of frequent fire, and midstories of later seral species such as sugar maple or American beech that developed as a result of fire suppression (Fralish et al. 1991, McCune and Menges 1986, Parker 1989, Ruffner et al. 2002, Schlesinger 1976, van de Gevel 2002, Weaver and Ashby 1971).

Historic Period (>1650-Present)

Exploration of the lower Ohio and middle Mississippi Valleys was begun by French traders and missionaries in the mid-1600s (Brown 1985). A tannery was established at Grand Chain, Illinois, along the lower Ohio River in 1703, but the enterprise failed by 1704 because of Native American hostilities and disease. Between 1720 and 1750, the first permanent European settlements were founded at Cahokia, Kaskaskia, Prairie du Rocher, and Fort de Chartres (Meyer 1996). Obviously, these settlements were located at key Native American village sites to foster trade networks.

Competition between France and Great Britain for supremacy of the Native American trade culminated in the French and Indian War (1754-1763). Fort Massac, a new French fort on the Ohio River, was completed in 1757, but all French holdings in southern Illinois were in British hands by 1765. Between 1765 and 1778, the British garrison co-existed with the local Kaskaskia and Michigamea Indians. When the American Revolution began, the British garrison departed for Detroit and the region was eventually "conquered" and claimed by George Rogers Clark for the Virginia Colony (Clark [1790] 1920). During his tenure as commander of the Illinois garrison, Clark's strong leadership guaranteed the growth and stability of the region with ever increasing numbers of emigrating settlers moving through the Cumberland Gap, across Kentucky, and into the Illinois Country. When the conflict ceased and trade routes opened westward, the lower Ohio and middle Mississippi Valleys experienced great population fluxes.

By 1830, the population density of southern Illinois had grown to an average of 6 to 18 persons per square mile (Meyer 1996, Meyers 2000). Settlement patterns in 1830 included incipient agriculture along the Mississippi and Ohio corridors with frontier subsistence across the central portion of the Shawnee Hills. Early European land uses reflected farmstead development such as clearing forest for agricultural patches, grazing livestock in forested areas, and consuming basic fuelwood/fiber for building. Throughout the 19th century, settlers continued to harvest forest lands for timber production, eventually cutting most of the old-growth forests (Fralish 1988).

Active European settlement began in southern Indiana during the early 1800s as Native American tribes ceded their lands to the United States government. Settlers began clearing land for crops and allowed livestock to roam freely through the forest (Latta 1932, Parker 1997). Trees were felled for building materials or simply piled and burned. Fire was a common disturbance in forests and became more frequent

following European settlement. For example, the fire return interval in the southern Indiana barrens decreased from 23 years to 5 years after European settlement (Guyette and Dey 2000). While fire became more frequent on certain sites during settlement, it also was more controlled and fragmented as firebreaks were established through roadbuilding and agricultural clearing. Drainage of wetlands and farming of prairies became common practices by the late 1800s.

Logs were floated down streams during spring flows to sawmills by the 1830s. Wooden products were floated on flatboats to New Orleans and shipped to other areas. With the advent of railroads in the mid-1800s, forests could be logged and shipped to markets throughout the Eastern United States. Railroads also used large quantities of wood for ties and fuel to produce steam (Brundage 1934). Steam-powered engines were also responsible for numerous fires. Increased logging allowed more rapid settlement of sites less suited to agriculture, resulting in resource degradation.

By 1900, most of the forest had been cut and all forests had been subjected to fire and grazing by domestic livestock during the 100 years of European settlement (DenUyl 1947, DenUyl and Day 1939). Some of the cut-over forest land was allowed to regrow, but most was permanently cleared for rowcrop agriculture. More land was permanently cleared in the relatively level areas of the landscape than in the areas of more hilly topography. Clearing steeply sloping lands led to severe erosion and eventual abandonment (Freeman 1908, Sieber and Munson 1994). Settlers farmed "ten year" land, so called because erosion quickly rendered it unsuitable for agriculture (Sieber and Munson 1994). Selective harvesting of forests for specialty products in the 1920s and 1930s led to degraded forest structure (Brundage 1936, 1937).

Burning of woodland understories continued to be a common practice for maintaining open woodlands for pasture, controlling insects, and improving appearance into the early 1900s (Skinner 1939). However, with modern agriculture and reduced woodland grazing, intentional burning of woodlands has declined since the 1950s. Reduced grazing and burning resulted in regrowth of forest understories (Den Uyl 1961). Aerial photography in 1939 shows many open forest canopies without woody subcanopies due to fire and grazing.

After 1900, there was increasing concern about soil erosion and resource abuse (Freeman 1908). Forest abuse began to decline in the 1930s as severely eroded lands were transferred from private to public ownership and better management practices were established. Programs to control soil erosion and fire were begun in the 1930s with the formation of the Civilian Conservation Corps. During the middle to late 20th century, forests across the assessment area were primarily managed first by selection cutting (up to late 1960s-early 1970s) and then by clearcutting (on national forests into 1980s). Single tree and group selection was used primarily on State and private lands into the 1990s. However, on many Federal and State forest lands, the importance of timber management has been reduced while the scope and importance of other forest uses including recreation, education, and interpretation have increased.

HISTORIC CHANGES BY ECOLOGICAL SECTION

The following discussion describes the general site conditions, past disturbance regimes, and forest types occurring within each section (see fig. 1). The disturbance history is similar across all sections: fire, grazing, and agricultural clearing occurring as common human activities, and wind and ice storms representing frequent natural disturbances. Species composition is driven by climate changes from north to south and east to west interacting with the local disturbance regimes across the assessment area.

Ozark Highlands Section—

Mississippi River Alluvial Plain Subsection (222Ao) and Illinois Ozarks Subsection (222Aq)

The Ozark Hills region in southwestern Illinois is characterized by mature dissected topography capped with loess deposits underlain with cherty limestone (Fralish 1997). Ridgetop sites are relatively narrow spur ridges capped with loess above steep sideslopes of colluvial materials that descend to narrow riparian zones comprised of alluvial soils. Pre-European settlement forests were dominated by oak-hickory species with increased numbers of American beech, sugar maple, and tulip-poplar across more mesic sites (McArdle 1991). McArdle argued that these forests developed under a moderate to infrequent disturbance regime based on the increase in oak-hickory importance after European settlement in response to the more intense disturbance regime of logging and clearing for conversion to agriculture lands, and increased grazing and burning. Indeed, much of the region's forests were extensively logged between 1880 and 1920 and frequent fire was identified as a major problem for forest development in the 1920s (Fralish 1997, Miller 1920, Miller and Fuller 1922). Although much of the Ozark Hills were purchased by the USDA Forest Service in the late 1930s and effective fire control measures were implemented, fires continued through the 1940s.

Despite this disturbance regime, forests of the Ozarks today appear wholly transitional towards sugar maple-beech domination (Fralish 1997, Helmig 1997, Ozier 2001). During the more infrequent disturbances of the 20th century, an understory of maple-beech developed that is slowly coming to dominate forests as the overmature oak-hickory overstory begins to break up (Groninger et al. 2002, Oliver and Larson 1990, Ozier 2001, van de Gevel 2002). Recent management efforts in State forests of this region include prescribed burning of sugar maple understories to top-kill maples and increase advanced regeneration of oak-hickory individuals (Ruffner and Davis 2002, Ruffner et al. 2002).

One important forest type not found elsewhere in the region is the shortleaf pine *(Pinus echinata)*-blackjack oak *(Q. marilandica)* found on the bluffs overlooking the Mississippi floodplain. Turner (1936) described the status of shortleaf pine as "waning" in southern Illinois due to competition from deciduous species and the absence of fire. Suchecki (1997) reported the shortleaf pine overstories at LaRue-Pine Hills were changing to more mesic black oak, white oak, pignut hickory *(Carya glabra)*, and sugar maple. Forest Service attempts to use prescribed burning to increase pine recruitment have unfortunately resulted in a proliferation of oak sprouts across the sites with a near failure of pine recruitment (Suchecki 1997). Davis and Ruffner (2001) reported that pine recruitment appears tied to large overstory gaps at LaRue-Pine Hills.

Infrequent vegetation communities include the numerous hill prairie and barrens on xeric, southwestern ridge sites, notably the Ozark Hill Prairie Research Natural Area, Shawnee National Forest (Perkins 2002), and the Browns Barrens, Union County, managed by the Illinois Department of Natural Resources Natural Heritage Program (McCall and Gibson 1999).

Upper Gulf Coastal Plain Section—

Cretaceous Hills Subsection (222Ca) and Ohio and Cache River Alluvial Plain Subsection (222Ch)

Across the southern tip of southern Illinois lies the northernmost extension of the Gulf Coastal Plain Province (Fenneman 1938). Topography varies from gently rolling uplands to flat, poorly drained bottomlands (Fralish 1997). Presettlement upland forests were largely similar to those of surrounding provinces with oak-hickory dominating dry exposed

sites (Schildt 1995). However, due to the predominance of moist sites and lower elevations across the coastal plain, more mesophytic species were reported (Fralish 1997, Schildt 1995). Alluvial sites and northern exposures were nearly dominated by such mesophytes as sugar maple, red maple, American beech, elms, and various ash species. In addition, numerous cypress swamps are located within this region and have been dendrochronologically dated to the mid-1400s.

Small local inclusions of barrens communities occur in the extreme southeastern portion of this subsection and are managed by State and Federal agencies with prescribed fire to maintain the open character of these unique communities (Anderson et al. 2000). Over 25 years, the authors documented vegetation change in relation to altered burning regimes. Many prairie species increased following initial burning of these sites between 1968 and 1973. However, fire cessation has reduced the occurrence of most prairie species while increasing the density and basal area of encroaching tree species. Unfortunately, despite the recent reintroduction of prescribed fire, many prairie species have been lost on these sites and species composition has shifted toward more closed canopy woodland (Anderson et al. 2000).

Major ecological changes across this province include the widespread cutting of forest land in the late 1800s for agricultural lands due to the fine soils and level topography (Fralish 1997). Selective logging of certain species for cooperage and transportation boxes reduced the amount of oak and cypress across the area. With the reduction of oak and the removal of fire from the landscape in the middle of the 20th century, mesophytic species increased in importance even on the driest sites (Fralish 1997).

Shawnee Hills Section—

Southern Indiana and western Kentucky

Crawford Escarpment Subsection (222Df), Crawford Upland Subsection (222De), Outer Western Coalfields Subsection (222Dc), and Lower Ohio-Cache-Wabash Alluvial Plains Subsection (222Db)

The Crawford Upland and Crawford Escarpment Subsections are areas of great diversity with steep slopes and narrow valleys (Homoya 1997, Schneider 1966). Oaks and hickory species dominate the uplands, and other species occur on more mesic sites of north slopes and stream valleys. Massive sandstone cliffs occur in the upland and are unique sites for many specialized plant species. The Hemlock Cliffs area on the Hoosier National Forest is an outstanding example of these unique sites where disjunct species such as eastern hemlock *(Tsuga canadensis)* and mountain-laurel *(Kalmia latifolia)* occur. American chestnut *(Castanea dentata)* was also found in this area before being eliminated by the introduced chestnut blight *(Endothia parasitica)*. The Crawford Escarpment Subsection is an area of limestone cliffs that provide unique habitat for specialized species of plants and animals. Other unique communities found in these subsections include limestone and sandstone glades and springs including acid seeps (Bacone and Casebere 1983, Olson 2001).

The Crawford Upland and Escarpment Subsections have a history of clearing for agriculture, grazing by domestic livestock, and human-caused fires. Forests are recovering from these disturbances and are changing in species composition due to recent protection from disturbance. Many specialized communities such as barrens and glades were maintained by past disturbance regimes, but are quickly transitioning to closed canopy forests with protection from fire (Bacone and Casebere 1983, Olson 2001). Prescribed burning has been used since the 1980s to arrest these changes.

The Outer Western Coal Fields Subsection is relatively flat undulating topography with wide valleys (Hedge 1997). This landscape was originally covered with a variety of forest communities with many species of more southern affinity. Southern red oak *(Q. falcata),* post oak *(Q. stellata),* and blackjack oak *(Q. marilandica)* were common on upland drier sites. Poorly drained, acid soils supported a southern flatwoods community dominated by post oak and a mixture of southern bottomland species such as sweetgum and cherrybark oak *(Q. pagodaefolia)*. Fire was probably a factor in maintaining barrens in some of these flatwoods (Olson 2001). Several large tributaries of the Ohio River extend into this subsection with bottomland forest species such as pecan *(Carya illionensis)*, sugarberry *(Celtis laevigata)*, green ash *(Fraxinus pennsylvania),* and American sycamore.

The relatively level topography of the Outer Western Coalfields Subsection has largely remained in private ownership with 47 percent of the landscape in forest cover today. This subsection had vast deposits of coal, which resulted in historic changes different from other parts of the region. Coal extraction began in 1915 and underground mining dominated until the 1930s. Surface mining of coal began in the 1920s, and Indiana led the Nation in surface-mined coal in 1926 and 1927 (Unpublished data, Indiana Department of Natural Resources, Division of Reclamation). Approximately 100,000 acres of land (4%) were disturbed by mining within this subsection from 1941 to 1982. Most of this land (89,934 acres) was in Pike and Warrick Counties. The land mined before 1968 (47,738 acres) was primarily planted to forest species with no soil replacement, grading, or drainage control. From 1968 to 1977, grading of strip-mined lands to approximate original contours was required and much of the acreage was returned to rangeland. After 1977, the Federal Surface Mining and Reclamation Control Act was passed requiring replacement of topsoil and more diversification of restored conditions including criteria for wildlife habitat and wetland uses. Since 1982, 55,834 acres have been strip mined in southwestern Indiana including counties outside the subsections being considered in this report. Some of the restored land has been transferred to public ownership for State parks, forests, and fish and wildlife areas.

Shawnee Hills Section—

Southern Illinois (Greater Shawnee Hills Subsection (222Dh) and Lesser Shawnee Hills Subsection (222Di))

The Shawnee Hills make up 950,495 acres of unglaciated east-west escarpment bisecting southern Illinois (Fralish 1997). Topography of this section is characterized by broad ridgetops bearing deep loess deposits dissected by moderately steep sideslopes opening onto broad flat valleys (Fenneman 1938). Pre-European settlement forests of this region were dominated by xerophytic species such as post oak, black oak, white oak, and northern red oak *(Q. rubra)*; mesophytic species such as tulip-poplar, American beech, and sugar maple had low importance values across most sites (Fralish 1997).

Of particular interest were the open savanna woodlands on exposed south-southwestern facing ridges maintained by recurring fire and intermittent droughts (Fralish et al. 1999). At presettlement, a matrix of small isolated patches of post oak, chestnut oak, and eastern redcedar *(Juniperus virginiana)* woodlands was found on uniquely xeric, edaphic sites within the surrounding oak-hickory forest (Fralish et al. 1999). The open canopy structure of these xeric woodlands was probably maintained by recurring fire across this region resulting from Native American burning and lightning fires (Abrams 1992, Fralish 1997, Ruffner and Abrams 1998a).

Following European settlement, the number of fires increased in the forests as did selective cutting and clearcutting of forested areas.

Recurring cutting of oak and hickory species encouraged these species due to their resprouting abilities (Abrams 1992, Fralish 1997, Ruffner et al. 2002). By the early 1910s, long-term harvesting and poor farming practices on highly erodible lands caused many farmers to abandon their farms; much of the land was then sold through the Weeks Act of 1911 and the Clark-McNary Act of 1924 (Conrad 1978, USDA 2000). Original reports of forest conditions in the 1930s suggest that the area had been farmed for over 100 years and that most forest stands had been logged from 1 to 10 times with nearly all the original timber removed and replaced by second-growth forest (USDA 2000). Forest products for the region were listed as "few saw logs, much mining material such as props, ties, lagging, and considerable fruit basket veneer" that supported the numerous orchards (USDA 2000). Clearly, by the mid-1920s, timber quality had been reduced to the point that low value outputs were the only viable products.

Stands disturbed during the early 20th century by harvesting, fire, or grazing are 58 to 84 percent similar to presettlement oak hickory forests, suggesting compositionally stable forests (Fralish 1997, Harty 1978). However, the reduction of harvesting and the eventual near removal of fire from the landscape during the 20th century have caused a shift in importance particularly across northern aspects and low slope positions (Fralish 1997, Hall and Ingall 1910, Miller 1920). Reduced disturbances have resulted in a distinct increase in sugar maple and American beech recruitment into the midstory and understory (Fralish 1997, Ruffner et al. 2002, Schlesinger 1976). The current management objectives of Illinois Department of Natural Resource agencies across this section focus on increasing oak-hickory advanced regeneration while reducing mesophytic stem density with experimental prescribed burns coupled with timber stand improvement cuttings (Allen 2001, Ruffner and Davis 2002). Justification for this rests on the assertion that anthropogenic disturbances (either Native American or Euro-American) have been the driving force influencing forest structure and function across this region for at least the last 400 years (Fralish 1997, Ruffner et al. 2002).

Highland Rim Section—

Brown County Hills Subsection (222Em) and Mitchell Karst Plain Subsection (222Ek)

The Brown County Hills Subsection is predominantly a forested landscape with different mixtures of deciduous species occurring on sites due to variation in physiography and soil parent material (Homoya and Huffman 1997, Van Kley et al. 1995). Mixed species forests of sugar maple, American beech, tulip-poplar, northern red oak, and hickory occupy north facing slopes and minor stream valleys. White, black, and scarlet oak *(Quercus cocinea)* and shagbark hickory *(Carya ovata)* species along with red maple are dominant on ridges and south facing slopes. Chestnut oak *(Q. prinus)* occupies the highest and driest ridges. Black maple *(Acer nigrum),* chinkapin oak *(Q. muehlenbergii),* and Ohio buckeye *(Aesculus glabra)* are common on sites where limestone soils occur.

The Brown County Hills Subsection is a landscape of steep topography with narrow ridges and valleys (Homoya and Huffman 1997). Although Native Americans were present in the area, they are not believed to have been a major influence on vegetation, so the landscape was likely in forest cover at the time of European settlement in the early 1800s. Early settlers were subsistence farmers, clearing forests on ridges to grow corn, running hogs in the forest, and using native plants and animals for food and shelter. These people also used fire to help them clear forests. Most of the large trees were burned in the early 1800s due to a lack of technology to produce lumber. Tanneries were important in this subsection due to the need for bark from the chestnut oak (Eagleman 1981).

Increased logging due to railroads allowed more land to be settled and farmed in the late 1800s. With most of the flat, alluvial land occupied, settlers either cultivated or grazed livestock on steeply sloping lands. These practices continued into the 1930s when economic conditions and degraded resources forced many farmers from the area. An examination of land use in the Charles C. Deam Wilderness of the Hoosier National Forest using 1939 aerial photography found 33 percent of the 13,000 acres in agriculture or old fields, 26 percent in open canopy forest (indicating livestock grazing), and the remaining 41 percent in closed canopy forest. Upland flats and stream bottoms were most heavily cleared for agriculture, although nearly 20 percent of the slopes were also cleared (Jenkins and Parker 2000). Declining productivity due to widespread topsoil erosion and changing agricultural technology better suited to more level topography placed these farms in a less economically competitive position.

Much of the Brown County Hills area was transferred from private to public ownership as farmlands were abandoned or willingly sold beginning in the early 1900s. Land first purchased for the Brown County Game Preserve in 1924 later became Brown County State Park (Eagleman 1981). The Hoosier National Forest was established in 1935. With farm abandonment and conversion to public ownership, much of the area has returned to forest cover. Many of the badly degraded areas were planted to pine species by the Civilian Conservation Corps during the depression years in the 1930s and 1940s. Today, approximately 67 percent of the Brown County Hills landscape is covered by forest.

The Mitchell Karst Plain Subsection was the largest area of western mesophytic forest found in Indiana (Lindsey et al. 1969). A rich mixture of deciduous tree species on more productive soils characterized the area. Donaldson Woods in Spring Mill State Park is a good example of presettlement forest (Lindsey and Schmelz 1965). Much of this forest is dominated by seral tree species, such as white oak, probably the result of Native American activities. Native Americans are believed to have used fire in this area on an annual basis. The shallow, droughty soils and limited surface streams in this karst topography allowed fires to spread widely across the landscape and were an important factor affecting the native vegetation (Homoya and Huffman 1997). For example, eastern redcedar, a common species throughout the landscape today, was probably much less common during this period of annual burning. Barrens were common in the southern part of this subsection on dry, infertile soils. This community, maintained by fire, was a mixture of scattered post oak and blackjack oak with understories of prairie grasses and forbs (Homoya 1994, Olson 2001).

The history of the Mitchell Karst Plain Subsection is similar to that of the Brown County Hills except settlement occurred more rapidly in the former due to the less rugged topography. Although the soils are shallow in the Mitchell Karst Plain Subsection, the topography was more suitable to permanent clearing for agriculture and livestock grazing. As a result, more of this area has remained in private ownership and nonforest cover. Approximately 29 percent of this subsection is in forest cover. This area has also been the source of limestone rock for buildings, and numerous open pit quarry mines are scattered across the landscape.

EFFECTS OF NATURAL AND HUMAN DISTURBANCE ON FOREST DEVELOPMENT

Disturbance is widely considered to be important in maintaining diversity of species and community structure and function within landscapes (Attiwil 1994, Loucks 1970). Species composition is constantly changing across the region due to an array of disturbance factors

including type, frequency, and intensity. This section focuses on the principal exogenous disturbances including fire (largely human caused) and other natural disturbances such as wind, ice, drought, and biotic factors. These disturbances are discussed in context of their frequency and intensity in relation to influencing species composition across the landscape.

Disturbance From Fire

There is little doubt that fire was an important historical factor throughout the region based on numerous accounts of early travelers (McCord 1970). However, little information exists on the size, frequency, and intensity of fire on specific sites or sections (Robertson and Heikens 1994). Nonetheless, a growing body of evidence for the region supports the widespread role fire played in forest systems across the assessment area.

Native American-caused fires

Most of the fires before 1800 were due to Native American activities. Fire was used regularly to clear land for agriculture, aid in hunting, and stimulate plant growth. Early travelers and surveyors reported areas of grassland and barrens in the early 1800s. These communities, with fire-tolerant plant species, were maintained via Native American burning and some natural lightning-caused fire. Although Native Americans may have set fires whenever conditions were suitable, most fire probably occurred in late summer and fall when grasses were dry and forest leaf litter was abundant. Fires were allowed to burn until natural breaks, such as streams, were encountered. During drought years, these fires would have spread over large areas of the landscape. These widespread fires were important in maintaining more open forest understories and in promoting tree species tolerant of periodic fire such as oak, hickory, and shortleaf pine.

Although presettlement fire history data are currently unavailable for the region, fire as a natural component of the ecosystem is widely accepted (Abrams 1992, Fralish 1997, Heikens and Robertson 1995, Robertson and Heikens 1994, Ruffner et al. 2002). Fire histories for the Missouri Ozarks have been widely studied by Guyette and associates. General trends across southern Missouri indicate that during periods of Native American settlement (1701-1820), fire return intervals were longer (11.96 years + 2.4, Mean + SE) than those during European settlement (3.64 years + 0.35) (adapted from Guyette and Cutter 1991). The authors attribute this disparity to the scattered, ephemeral distribution of Native settlements compared to the extensive clearing and agricultural development of European settlers. It must be understood that these data represent the fire history of only the southern Missouri Ozarks. However, we suggest that most forest ecologists would agree with the assumption that similar relationships existed across the region. Because Native settlements were distributed across the Ozarks and Shawnee Hills, forests of this province were probably impacted by burning by Native and European settler. While Woodland Indian cultures of the region probably depended largely on “Three Sisters” agriculture (maize-beans-squash), they continued to practice hunting and gathering of wild faunal and floral resources into the Historic period (Black and Abrams 2001, Delcourt et al. 1998, Gardner 1997, Ruffner 1999, Ruffner and Abrams 2002).

Archaeologists believe these agrarian groups practiced a form of swidden agriculture in which forests were cleared and burned to create open areas. Cultigens included sunflowers, maize, squash, and beans. Crops were cultivated in cleared fields extending out from the central settlement. Fields were cultivated until crop harvests decreased enough (8-12 years) to warrant moving the village to another site (Ritchie and Funk 1973, Sykes 1980). Although it is widely accepted that Native populations had sharply decreased before contact, Indian groups still inhabited and farmed settlements along

major riverways. Thus, by the time of European contact (AD 1650), the anthropogenic landscape resembled a mosaic pattern of 1) croplands near settlements, 2) abandoned clearings with early successional taxa, and 3) open forest stands dominated by fire-adapted species such as oak, hickory, and walnut (*Juglans nigra*) (Black and Abrams 2001, Chapman et al. 1982, Delcourt 1987, Delcourt et al. 1998, Ruffner 1999, Ruffner and Abrams 2002).

Historic period fires

Although some fires probably started from lightning on dry sites during dry years, fire in this region has mostly been the result of human activities (Skinner 1939). While there is little documented evidence of lightning-caused fire (cf. Ruffner and Abrams 1998b), Martin (1991) speculated these fires most likely occurred in late summer on the top of dry ridges as smoldering embers in hollow trees, and then spread to dry leaf litter.

In this region, lightning-caused fires most likely occur during dry years and, therefore, could spread over large areas of the landscape. Of the 311 fires reported for the Hoosier National Forest from 1973 to 2000 for which a cause was listed, lightning was given as the cause in two fires (USDA 2001). One occurred in July 1976 and the other occurred in April 1996. Both fires were 0.1 acre in size. All other causes were attributed to human activities.

Regional studies reporting Historic period fire histories indicate that fire ignitions were high during this period due to farmers clearing underbrush from the forest (Miller 1920, Robertson and Heikens 1994). Reports during the early 1900s noted that farmers annually burned forests to increase regeneration of grasses and forbs as well as to reduce the understory to ease hunting and travel (Hall and Ingall 1910, Miller 1920). Clearly, forests could not be burned annually for lack of adequate fuels from year to year. However, these early accounts probably describe some portions of the forests being affected by fires each year but not complete burning of the woods (Robertson and Heikens 1994).

Following the frequent burning of the settlement period, fire disturbances were largely controlled or removed after the turn of the 20th century. Numerous local bans on fires and regional laws forbidding this activity led to the overwhelming decrease in ignitions after 1900 (Miller 1920). Major efforts to detect and control wildfires from 1920 to 1940 are reflected in the numerous fire towers erected, the assignment of fire wardens, and to a large extent the efforts of the Civilian Conservation Corps throughout the New Deal years. At the time, foresters suggested that fire control was essential for maintaining forest health and integrity (Miller 1920, Pyne 1982). Thus, the effects of periodic fire in maintaining a healthy oak-hickory forest were removed, and many recent authors cite a significant shift in species composition across much of the region after this (Fralish et al. 1991, Parker 1989, van de Gevel 2002, Weaver and Ashby 1971).

Another way to explore this change in species composition is through investigating the long record (>200 years) of continuous recruitment by oak and hickory species on many sites including the mesic oak woodlands of the Shawnee Hills (Ruffner et al. 2002) and xeric uplands of the Ozark Highlands (van de Gevel 2002) (fig. 2A, B). These age/diameter graphs reflect the date of establishment for each tree cored on a site and can provide insight into the changes in species composition during the history of the stand. From these and many other studies, a clear pattern emerges. Oak and hickory recruitment tended to dominate such sites up until the early 20th century. However, composition changed quickly when between 1920 and 1940 a large cohort of later successional “fire intolerants” established themselves, representing the period when

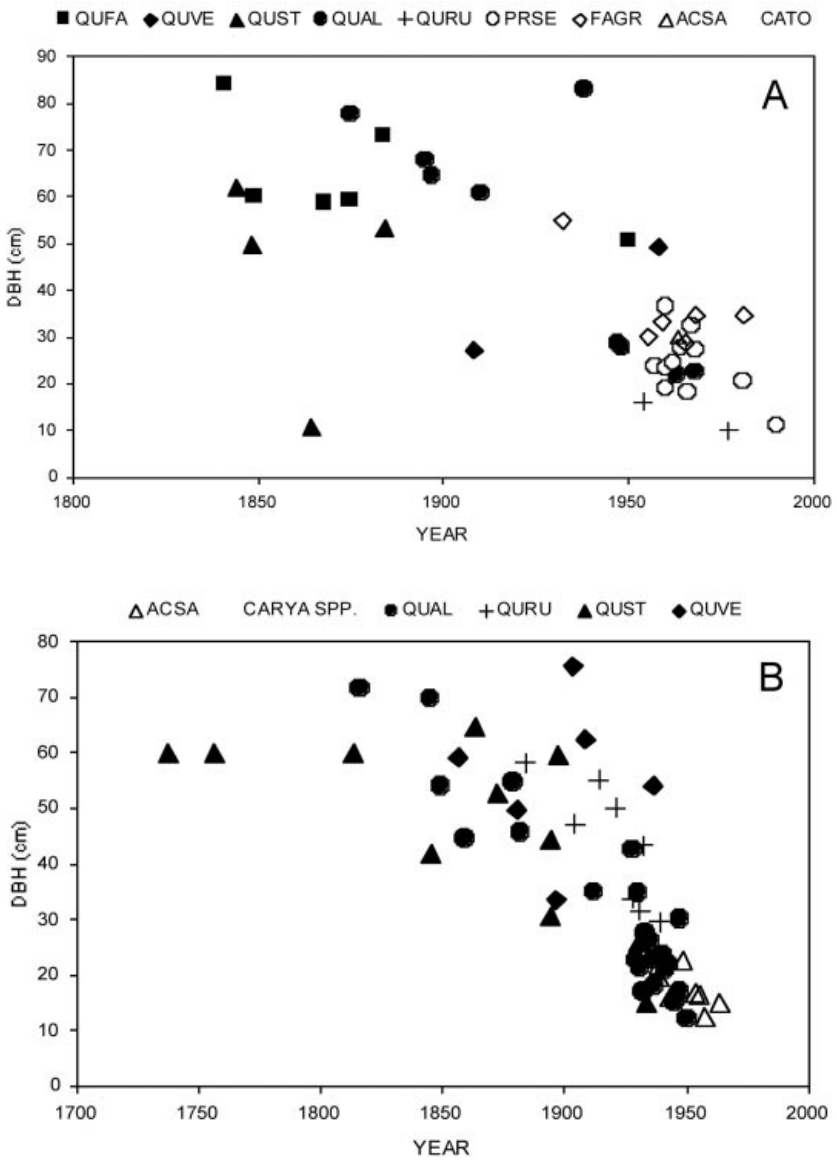


Figure 2. Age-diameter relationships for cored trees at selected forest sites in southern Illinois.

A) Thompson Woods, Southern Illinois University Campus, Carbondale.

B) Trail of Tears State Forest, Union County.

QUFA = *Quercus falcata,*
QUVE = *Q. velutina,*
QUST = *Q. stellata,*
QUAL = *Q. alba,*
QURU = *Q. rubra,*
PRSE = *Prunus serotina,*
FAGR = *Fagus grandifolia,*
ACSA = *Acer saccharum,*
CATO = *Carya tomentosa*

effective fire control measures were enacted across the region. It appears that the cessation of fire encouraged recruitment of fire-intolerant species such as sugar maple and American beech at the expense of fire-adapted oak and hickory species (Abrams 1992, Lorimer 1985, Schlesinger 1976).

Wind

Wind is an important factor in opening forest canopies for more rapid growth of understory trees. Increasing sunlight to the forest floor also allows species intolerant of shade to grow and reproduce. Wind's influence on species composition depends on site condition, species present, and extent of canopy removal. Small openings due to wind may favor shade-tolerant tree species present before canopy removal, whereas large openings may favor a mix of tolerant and intolerant species. Intolerant species are more likely to be favored on drier sites.

Severe windstorms or tornadoes occur frequently, but irregularly throughout the assessment area (NCDC 2001). Severe wind-caused disturbances, in the form of windsheer or tornadoes, can have an intense impact on vegetation, normally felling the overstory and creating large, open areas that typify early successional habitat (Peterson and Pickett 1990). Tornadoes reported across the assessment area from 1950 to 1995 varied largely in intensity and area affected (NCDC 2002).

In Indiana, one of the largest tornadoes occurred in Jackson County in 1963 and had a track 85 miles long and 1,400 yards wide. The data indicate tornadoes are less common in the Highland Rim Section than in the Shawnee Hills Section. Two tornadoes occurred on the Hoosier National Forest from 1990 to present. The first damaged approximately 1,000 acres of the northern part of the Crawford Upland Subsection in 1990. The second occurred on the Brown County Hills Subsection in 1996 and damaged approximately 1,500 acres.

Many notable tornadoes have impacted the southern Illinois region during the past several decades, in particular, the Tri-state Tornado of 1925. This killer tornado devastated a wide swath between the Ozark Hills in southeastern Missouri across the Ozark and Shawnee Hills of southern Illinois and into the Wabash basin of southern Indiana. It appears that tornadoes have always been an important disturbance across the assessment area (NCDC 2002). Indeed, historical accounts taken from Native Americans at Fort Kaskaskia indicate numerous large tornadoes impacting the southern Illinois landscape (Meyer 1996).

Similar in effect, but less intense are windsheer events, or downbursts. Downbursts are generally

explained as extreme, localized cells of high intensity winds that are forced downward from storm clouds. Downbursts can also have devastating effects on forest structure, opening large gaps in mature overstory canopies. It appears that these are quite common in southern Illinois and have been responsible for destroying several noted old-growth stands, namely the Weaver tract near Jonesboro and the Thompson Woods tract in Carbondale (Roth, unpublished data; Ruffner et al. 2002). Downburst gaps are characterized by a large hole in the canopy in which many dominant overstory trees have been blown down, resulting in an even-aged patch of species spanning the successional continuum. Advanced regeneration or shade-tolerant species would tend to capture the open gap, but early successional species do seed in portions of the area with the highest amount of light and, with their fast growth rates, can maintain a presence in the canopy (Ruffner et al. 2002). Thus, high-intensity wind disturbances tend to benefit early successional species such as oaks, hickories, black cherry *(Prunus serotina)*, and birches (*Betula* spp.).

Lighter wind disturbances generally cause single-tree mortality or simply blow down an already stressed or dead stem, creating a small canopy gap. These gaps tend to be captured quite quickly by residual trees by way of lateral encroachment of foliage into the open space (Canham 1985). The smaller open area, coupled with the short period of increased light, favors later successional species that may already be present in the understory. Because of the lack of understory fire during the 20th century, species such as sugar maple and beech typically dominate the seedling and sapling layers of many forest stands and generally benefit from these small canopy gaps. It appears certain that small overstory canopy gaps are too small to regenerate oak species (Abrams et al. 1995, Jenkins and Parker 1998, Ozier 2001, Ruffner and Abrams 1998b). Current research is underway to better understand gap dynamics within mature oak-hickory forests of southern Illinois (Ruffner and Groninger, unpublished data). In the Ozark Hills, early data suggest that sugar maple and sweetgum seedlings come to dominate small, single-tree canopy gaps formed by overmature red and white oaks.

Ice and Snow

Occasional ice (glaze) and snowstorms cause damage to trees such as top breakage and uprooting of species such as eastern redcedar, tulip-poplar, and sweetgum. The National Climatic Data Center reported 14 winter storms from 1993 to 2000 in Brown County, Indiana (Highland Rim Section). Two were reported as heavy snow and one as a sleet/ice storm. The remainder were extreme cold or winter storms. In contrast, Perry County, Indiana, in the southern part of the Crawford Upland (Shawnee Hills Section) had five storms reported from 1970 to 2000. Three of these were heavy snow. In Warrick County, Indiana (Outer Western Coal Field of the Shawnee Hills Section), 15 storms were reported; 1 of these was heavy snow and 6 were freezing rain or ice storms. USDA Forest Service records from 1990 to the present reported snow damage to approximately 300 acres in the southern part of the Crawford Upland Subsection in 1996.

Most glaze ice damage involves large branch breakage without the loss of the whole tree, thus creating scattered canopy openings of varying size. Several glaze storms have been detected in tree rings from forests of the Ozark Hills region of southern Illinois (Davis and Ruffner 2001, van de Gevel 2002, van de Gevel and Ruffner 2002). At the Trail of Tears State Forest, Union County, Illinois, glaze storms damaged fast growing tulip-poplar and sweetgum crowns on bottom sites, which fostered a recruitment pulse of tulip-poplar, hickory, white oak, and sweetgum in the understory (van de Gevel 2002). On exposed cliffs and ridges of the

LaRue Pine Hills Research Natural Area, Union County, Illinois, recruitment of native shortleaf pine appears tied to canopy gaps formed by ice storms that damaged tree crowns (Davis and Ruffner 2001).

Generally, in the Midwest, white oak and shagbark hickory are some of the species considered least susceptible to ice storm damage (Rebertus et al. 1997). Damage severity is highly variable across the Midwest, but trees on lower slopes and mesic aspects tend to have more damage (Rebertus et al. 1997).

Drought

Although severe drought can kill plants that expanded their range to drier sites during moist years, the combined effect of fire with drought is probably more important than that of drought alone. Visher (1944) reported that drought occurred approximately every 10 years in southern Indiana from 1900 to 1939. Drought has several implications for forests of the region including stress and vulnerability to pest infestation, reduced growth rates, and interactions with fire.

Dendroecological studies have reported the synergistic effects of drought and fire in forests of southern Illinois (Ruffner et al. 2002, van de Gevel 2002, van de Gevel and Ruffner 2002). Analysis of a 275-year-old post oak stand revealed significant relationships between drought severity and radial growth dynamics from 1895 to the present (van de Gevel 2002). Van de Gevel also reported that severe droughts (PDSI >2.5) drastically reduce radial growth for up to 2 years and may increase a tree's susceptibility to insects or pathogens.

Floods

The influence of flooding on forests depends on the length of time water remains and the time of year that the flood occurs. Winter floods are less damaging than are summer floods. Generally, control of species composition by flooding is more common along the floodplains of larger streams. Flooding along small headwater streams is generally brief enough that species are not killed. Flooding also moves substrate within stream channels and causes erosion of streambanks. In Brown County, Indiana, six floods were reported from 1993 to 2000: two during winter and the other four in April or May. In Perry County, 22 floods were reported from 1970 to 2000: 5 during the winter, 16 during spring (March to May), and 1 in July. In Warrick County, 31 floods occurred from 1970 to 2000: 10 during the winter, 14 in spring (March through June), and 7 during summer (July and August).

Biotic Disturbance

Although insects and disease occasionally defoliate and kill trees, widespread soil erosion due to clearing for agriculture and free-roaming livestock has been the most important biotic disturbance to occur in the region. Forest Service records on date of initiation of forest stands indicate that 69 percent of the Hoosier National Forest was established between 1800 and 1940. Although stand-replacing events such as tornadoes were occurring during this period, most stands were initiated due to the widespread disturbance by human activities. About 31 percent of the stands on the national forest were begun after 1940 or during the period of transfer from private to public ownership.

Overhunting and habitat destruction had greatly reduced white-tailed deer populations by 1900. Reintroduction programs and management since the 1930s and 1940s have allowed deer populations to recover and even exceed their historic levels. Understories of forests in areas protected from hunting since the 1960s have been negatively impacted by this species (Webster and Parker 1997).

Pathogens such as chestnut blight and Dutch elm disease have changed the structure of forests throughout the assessment area (Parker

and Leopold 1982). The American chestnut, a minor component of forest in southern Indiana, has been largely eliminated due to blight introduced in the early 1900s. Elm species, particularly American *(Ulmus americana)* and slippery *(U. rubra)*, have been greatly reduced as canopy trees due to the introduced Dutch elm disease and phloem necrosis.

CURRENT ECOLOGICAL CONDITIONS

Forest Types by Ecological Section

For this assessment, area by major forest type is based on Forest Inventory and Analysis data of the USDA Forest Service (FIA Web site). Although the most current data were used (1998), the date of collection varies by State. Forest types have been combined into seven general cover types due to limitations in the number of sample points for any given type within a subsection (table 1). These general types are quite variable across the assessment area due to north-south and east-west changes in species composition. Forest types are named after the dominant species currently present on the landscape. Many of these types are the result of past disturbance and are gradually changing in species composition. For example, the oak-hickory forest type currently covers more of the region than any other forest type but is gradually transitioning to beech-maple or upland mixed hardwoods types on nearly all site types.

Pine-cedar forest type

Highland Rim Section—This forest type is currently dominated by eastern white pine (*Pinus strobus*), shortleaf pine and loblolly pine (*Pinus taeda*), or eastern redcedar. Some stands of red pine (*Pinus resinosa*) are also present. These forests are primarily the result of the planting of pines on lands that were in agriculture or the natural invasion of eastern redcedar into pasture or croplands. Eastern redcedar is a more common species on limestone soils of the Mitchell Karst Plain Subsection. Hardwoods species such as red oaks, tulip-poplar, black cherry, and other miscellaneous species will gradually replace the current overstory species as they age. Management activities such as logging and prescribed fire will hasten the conversion of this type to native hardwoods.

Shawnee Hills Section—The change in this forest type is similar to that described for the Highland Rim Section (primarily within Indiana) except that Virginia pine (*Pinus virginiana*) becomes the dominant species in the extreme southern portion of the Crawford Upland and Escarpment Subsections (table 1). This native pine invades old fields or poor sites after fire and is transitional to hardwood species (Fowells 1965). The western portion of the section in Illinois and Kentucky has native shortleaf pine as well as planted species. Few pure pine stands exist in southern Illinois except where planted for erosion control or reforestation by the Civilian Conservation Corps (CCC) and State forests. Of these, many loblolly pine stands are in an advanced stage of succession with hardwood encroachment. Eastern redcedar has increased across the assessment area in abandoned fields and is generally transitional to hardwoods except in limited redcedar glades on exposed sandstone or limestone outcrops. Illinois Department of Natural Resource heritage biologists also use prescribed fire to maintain cedar glade habitats by reducing hardwood encroachment on sites spanning the Shawnee Hills and Ozark Hills of southern Illinois.

Pine-hardwood forest type

Highland Rim Section—This forest type is a mixture of planted pine species (primarily white, shortleaf, and loblolly) and various species of native hardwoods. This type is transitional from pine to hardwood species because the pine species were planted and are not regenerating.

Table 1. Area of forest land by forest type for each subsection within the Hoosier-Shawnee Ecological Assessment Area based on FIA data (1998).

FOREST TYPE									
Subsection	**P/C**	**P/H**	**PO/SSO**	**O/H**	**B/M**	**MUH**	**BH**	**NS**	**Total**
Acres									
Ozark Highland Section									
222Ao				31,742	1,680	529	47,795	1,680	83,424
222Aq	746	5,454	6,592	128,598	44,223	9,458	17,440	289	212,800
Total	746	5,454	6,592	160,340	45,902	9,986	65,235	1,969	296,224
Upper Coastal Plain Section									
222Ca		3,883	2,368	27,820	9,718		24,861		68,650
222Ch		2,336	7,360	16,094	10,157	45,302	16,858		98,106
Total		6,219	9,728	43,914	19,874	45,302	41,719		166,756
Shawnee Hills Section									
222Da				37,374		102,180	51,650		191,204
222Db				23,058	7,271	22,966	61,191		114,486
222Dc	60,806	43,428	57,115	270,035	81,659	378,916	125,336	10,233	1,027,527
222Dd	8,705	6,812	17,367	39,052	6,625	42,292			120,854
222De	13,762	18,559	29,745	333,246	235,641	30,323	36,780	7,066	705,121
222Df	10,439	14,746	3,241	102,656	79,826	16,720	6,612		234,238
222Dg	21,098	12,013	25,604	90,570		168,472	12,104		329,860
222Dh	11,360	12,943	13,291	165,003	30,991	7,139	26,801		267,529
222Di	9,214	7,106	7,718	122,162	32,797	12,894	22,175		214,066
222Dj	19,457	31,697	28,871	93,405	45,548	278,064	17,520		514,563
Total	154,841	147,303	182,952	1,276,559	520,357	1,047,072	360,170	17,299	3,719,447
Highland Rim Section									
222Ek	29,817	26,022	9,889	129,358	113,458	92,154	17,079	171	417,947
222Em	13,148	5,676	1,172	233,904	95,565	18,906	23,366	278	392,015
Total	42,965	31,698	11,061	363,262	209,023	111,060	40,444	449	809,962
Total	198,552	190,674	210,333	1,844,075	795,156	1,213,420	507,568	19,717	4,992,389

P/C= Pine/Cedar, P/H= Pine/Hardwoods, PO/SSO= Post Oak/Southern Scrub Oak, O/H= Oak/Hickory
B/M= Beech/Maple, MUH= Mixed Upland Hardwoods, BH= Bottomland Hardwoods, NS= Non-stocked.
For subsection identification and location, see figure 1.

Shawnee Hills Section—This forest type in the eastern portion of this section (primarily within Indiana) is similar to that described in the Highland Rim Section except that Virginia pine is an important species in the extreme southern portion of the Crawford Upland and Escarpment Subsections.

Ozark Highlands Section—The only stands of native shortleaf pine within this section occur at the Piney Creek reserve in northwestern Jackson County, Illinois, and the LaRue-Pine Hills Research Natural Area of Union County, Illinois. Both these areas appear to be edaphic climax forests on extreme southwest facing bluffs and ridges (Davis and Ruffner 2001, Suchecki 1997). Frankly, these two areas can more accurately be labeled as pine-hardwood forest type due to the high percentage of blackjack and black oak in these stands. At first glance, it appears that these stands may be transitional

toward oak domination, but recent research into stand structure suggests that oak has been a component of these forests for several hundred years (Davis and Ruffner 2001, Suchecki 1997). Forest Service prescribed burning in the late 1980s resulted in prolific sprouting of oak and hickory species and little pine regeneration (Suchecki 1997). Most researchers agree that successive, hot fires are required for pine recruitment on these sites. At present, successful shortleaf pine regeneration appears tied to large gap-phase dynamics across bluffs on these sites, but much more research needs to be completed to understand the successional status of these forests.

Post Oak-Scrub Oak forest type

Highland Rim Section—This type is included with the oak-hickory type in this section.

Shawnee Hills Section—Post oak barrens of Illinois and Indiana generally occur in one of two unique ecological conditions. The first of these conditions is the post oak flatwoods of the Till Plains and Outer Western Coal Fields Subsections where a soil fragipan prohibits drainage during the wet spring and is exceedingly dry during the late summer. Post oak is the only species that can tolerate these soil extremes and appears successionally stable on these rare sites (Fralish 1997). The other unique post oak sites are the extreme southwest facing, rock strewn hilltops of the Ozarks and Shawnee Hills of southern Illinois (Fralish 1997, van de Gevel 2002). These successionally stable sites are dominated by post oak with small numbers of white and black oak as associates (Fralish 1997).

Chestnut oak barrens in southern Illinois contain nearly pure chestnut oak overstories with shrub and herbaceous species in the understory (Spivey 2000). These barrens sites are considered edaphic climaxes where no potential replacement species are as drought tolerant as the chestnut oak and appear to be compositionally stable (Fralish 1997). In Indiana, this type is found on narrow ridges and south to southwestern slopes on soils, with thin A horizons, that are droughty in summer and fall (Bacone and Casebere 1983, Van Kley 1993). Post oak and white oak, along with black, chinkapin, and chestnut oak, and pignut hickory, dominate the better sites. Understory species include white ash along with sugar maple and black and white oak. Post oak along with blackjack oak, eastern redcedar, and white ash dominates on poorer sites. White ash, eastern redcedar, post and blackjack oak, and persimmon (*Diospyros virginiana*) are common understory species on these poorer sites. Prescribed fire is being used on public lands to maintain the prairie component in these communities.

Oak-hickory forest type

Highland Rim Section—This forest type is a highly variable mixture of species depending on site condition and disturbance history. The type tends to be transitional to more shade tolerant hardwoods species on most sites (Jenkins and Parker 1998, Lindsey and Schmelz 1965, McCune and Menges 1986). Van Kley et al. (1995) sampled forests within this section to develop a habitat classification system for the Hoosier National Forest. They found forest composition was strongly associated with physiographic location, soil pH, and depth of the A soil horizon. This forest type was primarily found on dry-mesic ridges and south to southwest slopes. Chestnut oaks mixed with white oak stands were restricted to dry narrow ridges or middle to upper convex, southwestern slopes. Red maple, sugar maple, and American beech were the most common understory species in these stands. White oak, mixed with black oak and pignut hickory, was common on dry-mesic ridges and steep south slopes. The current understory species composition of this forest type indicates a gradual shift in species composition to more shade tolerant hardwoods if left undisturbed.

Shawnee Hills Section—Across the assessment area, oak-hickory is the dominant forest type with most subsections ranging from 45 to 55

percent oak-hickory (table 1). Although the dominant canopy individuals represent this forest type, the sapling and midstory classes are commonly dominated by more mesophytic species such as sugar maple, American beech, and tulip-poplar. This transitional forest is most apparent on north and east facing slopes where evapotranspiration rates are lower, but it is becoming more common on other slopes as well due to the fire exclusion policies and reduced harvesting levels of the 20th century. Thus, according to Fralish (1997), few compositionally stable oak-hickory stands exist across this region and occur only under the most extreme topographic conditions. In Indiana, the oak-hickory forest type is primarily found on convex knobs, dry ridges, and south to southwestern slopes (Van Kley et al. 1995). Species composition shifts with physiographic position and depth of the soil A horizon. Upper elevation convex knobs and nose slopes are dominated by chestnut oak with white, black, and scarlet oaks and pignut hickory as common associates. Chestnut oak and sassafras, along with black, scarlet, and northern red oak and pignut hickory, are major understory species. Upper southwestern slopes are dominated by chestnut and white oak with pignut hickory, and black and scarlet oak as associates. Chestnut oak and sassafras, along with American beech, red maple, blackgum (*Nyssa sylvatica*), sugar maple, black oak, and pignut hickory, are common in the understory. White, black, and chestnut oaks and pignut hickory dominate narrow, convex ridges with occasional fragipans. Sugar maple, a common overstory associate, dominates the understory. White oak, along with black oak and sugar maple as common associates, dominates south slopes. Sugar maple, American beech, and red maple are common understory species. Poorer sites seem to be fairly stable in species composition, while better sites appear to be shifting toward more shade tolerant species.

Beech-maple forest type

Highland Rim Section—Separation of this forest type from the mixed upland hardwoods type is based primarily on how dominant sugar maple and American beech are within the stand (Jenkins and Parker 1998, Van Kley 1993 and 1994). Currently one or both of these two species strongly dominate sites found on steep, convex east and west slopes with limestone soils, headwaters of intermittent streams, and elevated portions of larger streams. East and west slopes are dominated by sugar maple with American beech, northern red oak, and shagbark hickory as common associates. Sugar maple, American elm, and blue ash (*Fraxinus quadrangulata*) are the most common understory species, and American beech, white ash, black maple, and Ohio buckeye are common associates. Headwaters of intermittent streams are dominated by sugar maple and American beech with black and northern red oak and shagbark and pignut hickory as associates. Sugar maple, red maple, and white ash are the most common understory species. Elevated portions of larger streams are dominated by sugar maple, red maple, and American beech. American beech with sugar maple, red maple, and shagbark hickory as associates are common understory species. This type appears to be stable in species composition.

Shawnee Hills Section—This forest type is considered late successional due to the high understory tolerance of the principal species and thus is considered the climax forest type for the region (table 1) (Braun 1950, Küchler 1964, Petty and Lindsey 1961). Historically, the highest proportion of this forest type has been found in the northeastern portions of the assessment area in central Indiana where soil nutrient status is higher due to the limestone parent material. In other areas, this forest type dominates mesic footslope and lowland positions where few soil limitations exist and oak-hickory species are outcompeted. In Indiana,

this type is primarily found on sheltered northeast slopes of narrow valleys, on benches and lower slopes, or on level footslopes along streams in narrow valleys. This type is dominated by sugar maple and American beech with sugar maple occurring as the most common understory species. As disturbance is reduced across much of the region, this forest type appears to be expanding onto sites previously dominated by disturbance-oriented species.

Mixed Upland forest type

Highland Rim Section—This type occurs on steep, linear to concave north slopes or along narrow bottoms of intermittent to perennial streams (Jenkins and Parker 2001, Van Kley et al. 1995). It currently includes a mixture of hardwood species such as tulip-poplar, oak and hickory species, sugar maple, and American beech. The understory is usually dominated by sugar maple and American beech indicating that it will transition to the beech-maple type without disturbance.

Shawnee Hills Section—This type appears to be transitional to the beech-maple type and currently has a mixture of species due to past disturbances. It occurs on broad flat ridges with fragipans and on backslopes of varying aspect with limestone soils or concave shapes. A mixture of upland hardwood species occurs in the overstory with sugar maple and American beech the most common understory species.

Bottomland hardwoods forest type

Highland Rim Section—This type is primarily found along floodplains of major streams. Major species include silver maple, boxelder (*Acer negundo*), green ash, and American sycamore. Boxelder and silver maple are the most common understory species.

Shawnee Hills Section—This type varies in species composition depending on geographic location within the section. Major species include eastern cottonwood, American elm, green ash, silver maple, and sweetgum in the northern areas. Swamp chestnut, cherrybark and overcup (*Quercus lyrata*) oaks, pecan, and water tupelo (*Nyssa aquatica*) occur further south in the section.

Land Cover Classes and Forest Type Distribution Within Ecological Subsections

The following land cover data are based on an assessment of 1992 Landsat Thematic Mapper Data and ancillary data sources (Vogelmann et al. 1998). Current land use reflects the past history of human activity in relation to topographic variation across the region (table 2, fig. 3). Subsections with the greatest topographic relief have regenerated to forest cover in greater proportion than subsections with more moderate terrain. Land use in the 12.2-million acre assessment area is predominantly forest (43%) or agriculture (49%) (table 2). The remaining 8 percent is in urban (1.8%), wetlands (3.0%), water (2.5%), and barren or transitional land (0.6%). Patterns of land ownership within both national forests are quite dissimilar (fig. 4). Private landowners clearly dominate the landscape in each purchase area. However, the Shawnee National Forest actually holds 27 percent of the purchase unit whereas the Hoosier National Forest holds only 4 percent of its purchase unit. Other landowners, including some corporate and various State and Federal agencies, hold much of the remaining land.

Fragmentation of the forested area within each subsection is based on an analysis of Advanced Very High Resolution Radiometer (AVHRR) data using FRAGSTATS (table 3). FRAGSTATS is a computer program used to analyze spatial patterns of large land areas (McGarigal and Marks 1994). Thus, subsections with smaller forest patches and thus higher patch density (per 100 acres) are more fragmented by other land uses (note values in each subsection description). The estimated area of forest for each subsection using either AVHRR data or FIA data is compared in table 4 (Zhu and Evans 1994).

Table 2. Land use within the Hoosier-Shawnee Ecological Assessment Area based on 1992 National Land Cover Data Analysis.

Subsection	Total Area	Forest		Agriculture		Urban		Wetlands		Water		Other land	
	Acres	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
Ozark Highland Section													
222Ao	469,537	53,367	11.4	261,237	55.6	39,594	8.4	58,099	12.4	55,948	11.9	1,292	0.3
222Aq	546,060	199,371	36.6	310,351	56.8	12,767	2.3	15,223	2.8	7,366	1.3	983	0.2
Total	1,015,597	252,738	24.9	571,588	56.3	52,362	5.2	73,322	7.2	63,314	6.2	2,275	0.2
Upper Coastal Plain Section													
222Ca	192,877	60,448	31.3	123,525	64	751	0.4	7,212	3.7	939	0.5	0	
222Ch	354,200	70,205	19.8	183,568	51.8	12,817	3.6	48,686	13.7	37,749	0.7	1,176	0.3
Total	547,078	130,653	23.9	307,093	56.1	13,568	2.5	55,899	10.2	38,688	7.1	1,176	0.3
Shawnee Hills Section													
222Da	830,540	163,030	19.6	605,120	72.9	16,369	2	32,088	3.9	10,535	1.3	3,404	0.4
222Db	736,171	76,266	10.4	500,751	68	35,249	4.8	66,865	9.1	54,903	7.5	2,137	0.3
222Dc	2,413,998	1,125,322	46.6	1,093,558	45.3	31,789	1.3	82,325	3.4	38,245	1.6	42,783	1.8
222Dd	244,135	113,289	46.4	126,444	51.8	1,551	0.6	1,702	0.7	1,000	0.4	151	0.1
222De	1,193,640	681,903	57.1	455,424	38.2	8,220	0.7	5,755	0.5	34,116	2.9	8,220	0.7
222Df	454,216	252,950	55.7	194,527	42.8	4,493	1	321	0.1	1,284	0.3	642	0.1
222Dg	736,663	412,754	56	307,448	41.7	5,567	0.8	6,536	0.9	3,631	0.5	726	0.1
222Dh	466,741	286,819	61.5	154,405	33.1	3,411	0.7	12,113	2.6	9,878	2.1	119	<0.5
222Di	483,754	216,011	44.7	232,017	48	3,201	0.7	19,592	4	12,419	2.6	511	0.1
222Dj	931,938	552,700	59.3	352,607	37.8	5,236	2.6	5,236	0.6	15,025	1.6	1,139	0.1
Total	8,491,796	3,881,044	45.7	4,022,301	47.4	115,087	1.4	232,533	2.7	181,036	2.1	59,831	0.7
Highland Rim Section													
222Ek	1,523,412	554,140	36.4	908,224	59.6	38,507	2.5	6,575	0.4	10,332	0.7	5,637	0.4
222Em	647,278	435,342	67.3	166,634	25.7	4,703	0.7	2,117	0.3	14,111	2.2	235	<0.5
Total	2,170,690	989,482	45.6	1,074,858	49.5	43,210	2	8,692	0.4	24,443	1.1	5,871	0.3
Total land area	12,225,161	5,253,917	43	5,975,839	48.9	224,227	1.8	370,446	3	307,480	2.5	69,153	0.6

Other land= barren or transitional lands
For subsection identification and location, see figure 1.

Ozark Highland Section

222Ao—The Mississippi River Alluvial Plain Subsection consists of 469,537 acres of land area with 11.4 percent forested, 55.6 percent agricultural, 8.4 percent urban, and 24 percent in either wetland or water bodies. The high percentage of agricultural land reflects the rich fertile bottoms in proximity to the Mississippi floodplain. Within southern Illinois, 12.5 percent of this subsection occurs within the Shawnee National Forest Purchase Area. Bottomland hardwoods (57%) and oak-hickory (37%) are the dominant forest types. Beech-maple and upland mixed hardwood forest types are of minor importance at 2 percent each. The forests are fragmented due to clearing for agriculture. Forest patches average about 7.5 acres in size and occur at 13 patches per 100 acres.

222Ag—The Illinois Ozarks Subsection covers 546,060 acres of land area with 37 percent forested, 57 percent agricultural, and less than 3 percent each of urban, wetlands, and water. The large proportion of forest land reflects the steep

upland topography. Still, agricultural land use dominates on the wide valley bottoms of the Ozarks. Within southern Illinois, nearly 18 percent of this subsection occurs within the Shawnee National Forest Purchase Area. Oak-hickory (60%) and beech-maple (21%) forest types are the dominant forest types in this subsection. Historically, oak-hickory forests dominated uplands, particularly south and southwest facing slopes as well as ridges. In contrast, beech-maple forests dominated lower slopes and riparian zones. This pattern is apparently changing with beech-maple forests coming to dominate all sites due to the rich loess deposits. The bottomland hardwood forest type covers about 8 percent of the subsection. The remaining forest types cover less than 4 percent each. Forests are fragmented with an average forest patch area of 14.6 acres and a patch density of 6.8 forest patches per 100 acres.

Upper Gulf Coastal Plain Section

222Ca—The Cretaceous Hills Subsection covers 192,877 acres of land area with 31 percent forested, 64 percent agricultural, and a small percentage of wetland area with virtually no urban lands or water bodies. The high agricultural component represents the rich alluvial soils of the Cache River drainage. In contrast, the other substantial component, forest land, dominates the low upland ridges that span this subsection. Within southern Illinois, nearly 21 percent of this subsection occurs within the Shawnee National Forest Purchase Area. Oak-hickory (41%) and bottomland hardwoods (36%) are the two dominant forest types. The beech-maple forest type covers about 14 percent of the subsection with small areas of pine/hardwood (5%) and post/scrub oak (4%) forest types. Forest patches average about 12.8 acres in area and patch density averages 8 per 100 acres.

222Ch—The Ohio and Cache River Alluvial Plain Subsection consists of 354,200 acres of land area with 20 percent forested, 52 percent agricultural, 13 percent wetland and small proportions of urban and water. Again, the high agricultural component represents the rich alluvial deposits of both the Cache and Ohio Rivers with the next most abundant land use being forest. Within southern Illinois, 12 percent of this subsection occurs within the Shawnee National Forest Purchase Area. Mixed upland hardwoods forest type makes up 46 percent of the forest in this subsection. Bottomland hardwoods and oak/hickory forest types are next most important at 17 percent and 16 percent,

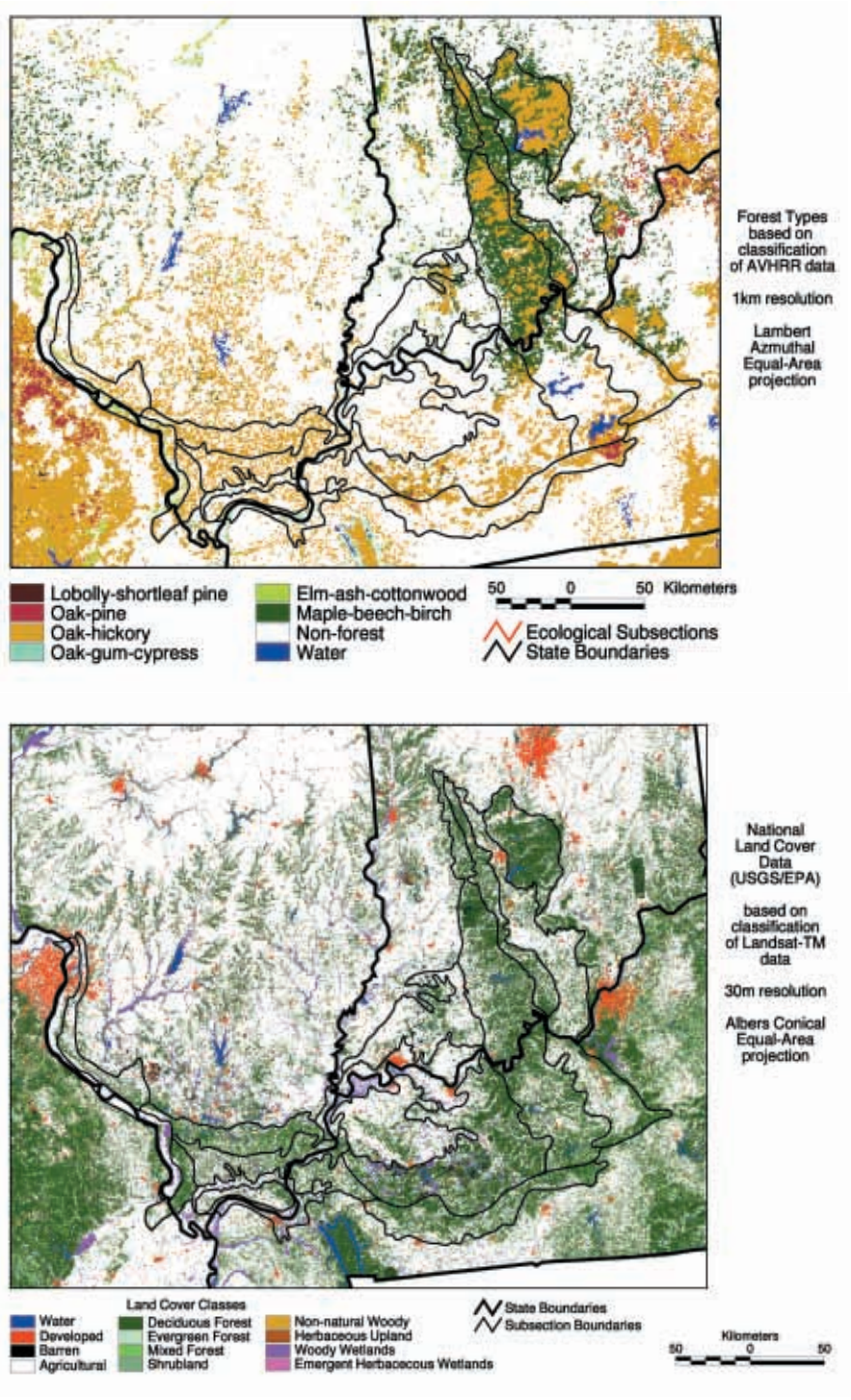


Figure 3. Forest types and land cover classes across ecoregion subsections within the Shawnee-Hoosier Ecological Assessment Area.

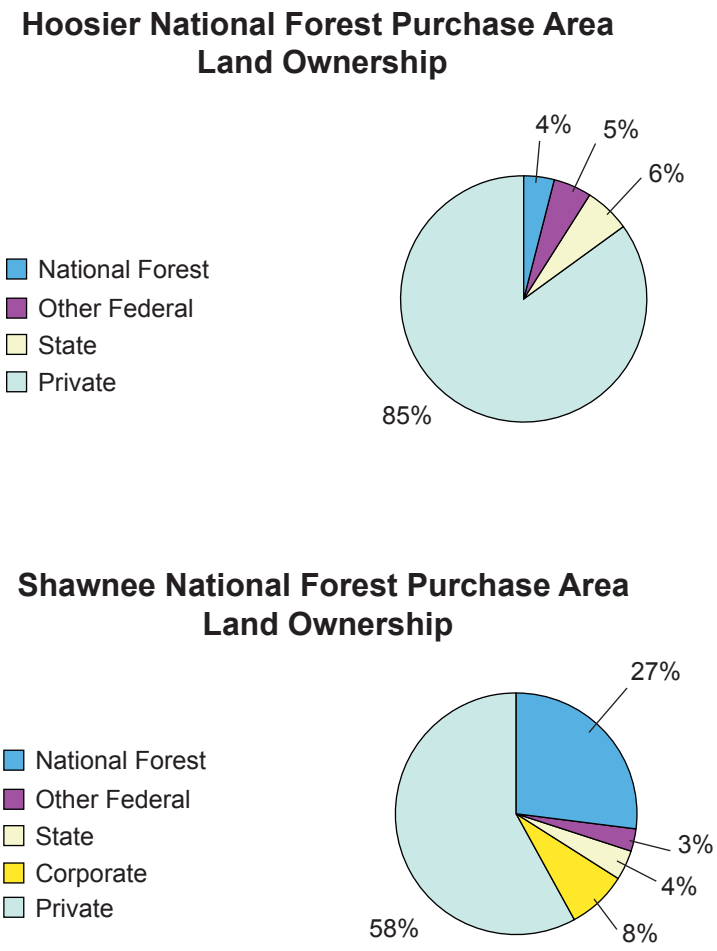


Figure 4. Land ownership relationships for lands within the Hoosier and Shawnee National Forest Purchase Units.

respectively. Forest patch area averages about 10 acres and patch density averages about 10 per 100 acres.

Shawnee Hills Section

222Da—The Interior Western Coalfields Subsection of western Kentucky covers 830,540 acres of land area with 20 percent forested, 73 percent agricultural with less than 3 percent each of urban, wetland, and water. Much of the agricultural lands reflect grazing areas with some rowcropping. None of this subsection occurs within either the Shawnee or Hoosier National Forest Purchase Areas. Mixed upland hardwoods (53%) and bottomland hardwoods (27%) are the two dominant forest types. Oak-hickory covers the remaining 20 percent of the subsection. Forest patches average 7.3 acres in area and patch density averages 13.5 per 100 acres.

222Db—The Lower Ohio-Cache-Wabash Alluvial Plains Subsection covers 736,171 acres of land area with 10 percent forested, 68 percent agricultural, 9 percent wetland, 7.5 percent water, and small quantities of urban and other. Again, agriculture dominates these areas due to the rich alluvial deposits of these river systems. None of this subsection occurs within the Shawnee or Hoosier National Forest Purchase Areas. Bottomland hardwoods (53%) dominate this subsection with the oak-hickory and upland mixed hardwoods forest types each covering about 20 percent of the subsection. Forest patches average about 8.5 acres and patch density averages 11.6 forest patches per 100 acres.

222Dc—The Outer Western Coalfields Subsection covers 2,413,998 acres of land area with nearly equal proportions of forest (47%) and agricultural (45%) land cover. Ninety-two percent of the wetland area is forested. The Outer Western Coalfields Subsection does not include the purchase area of the Hoosier National Forest. Oak/hickory (26%) and mixed upland hardwoods (37%) are the dominant forest types. The other forest types occur in about equal proportions ranging from 4 to 12 percent of the subsection area. Mean forest patch size is 22.4 acres and patch density is 14.5 forest patches per 100 acres.

222Dd—The Marion Hills Subsection covers 244,135 acres of land area, with 46 percent forested, 52 percent agricultural and <1 percent each of urban, wetland, water, and barrens. None of this subsection is within the Shawnee or Hoosier National Forest Purchase Areas. Mixed upland hardwoods (35%) and oak/hickory (32%) are the dominant forest types. The post oak-scrub oak forest type covers 14 percent of the subsection. Other forest types cover less than 7 percent of the subsection each. Mean forest patch area is 17 acres and patch density averages 5.8 forest patches per 100 acres for this subsection.

222De—The Crawford Uplands Subsection covers 1,193,640 acres of land area, with 57 percent in forest cover, 38 percent in agriculture, 3

percent in urban and 3 percent water or wetlands. Ninety-three percent of the wetland area is forested. Thirty-nine percent of the Crawford Uplands Subsection is within the purchase area of the Hoosier National Forest. Of the purchase area, 68 percent is forested, 28 percent is agriculture, 1 percent is urban, 2 percent is water or wetland, and 1 percent is barren or transitional. Oak-hickory (47%) and beech-maple (33%) are the dominant forest types. The five other forest types occurring in this subsection cover less than 5 percent each. Mean forest patch area is 34.9 acres and patch density averages 2.9 forest patches per 100 acres for this subsection.

222Df—The Crawford Escarpment Subsection covers 454,216 acres of land area, with 56 percent in forest cover, 43 percent in agriculture, and 1 percent in urban. Less than 1percent is water or wetlands. Twelve percent of the subsection is within the purchase area of the Hoosier National Forest. Of the purchase area, 71 percent is in forest cover, 26 percent is agriculture, and 2 percent is urban. Oak-hickory (44%) and beech/maple (34%) are the dominant forest types. The other five forest types average less than 7 percent each. Mean forest patch area is 37.5 acres and patch density averages 2.6 forest patches per 100 acres.

Table 3. Forest area, mean forest patch area, patch area coefficient of variation, largest patch index, total edge, and total core area for each subsection based on FRAGSTATS analysis using AVHRR data.

Subsection	Total area	Forest area	Mean forest patch area	Patch area coefficient of variation	Largest patch index	Total edge	Total core area
	Acres	*Acres*	*Acres*	*Percent*	*Percent*	*Miles*	*Acres*
Ozark Highlands Section							
222Ao	469,537	53,367	7	2,602	17.8	6,794	70,036
222Aq	546,060	199,371	15	5,273	41.3	9,206	147,652
Upper Gulf Coastal Plain Section							
222Ca	192,877	60,448	13	3,556	49.3	2,943	45,156
222Ch	354,200	70,205	10	1,490	6.8	6,645	65,143
Shawnee Hills Section							
222Da	830,540	163,030	7	3,126	16.6	12,812	116,830
222Db	736,171	76,266	9	1,587	8.0	9,411	84,809
222Dc	2,413,998	1,125,322	22	11,661	40.1	42,334	899,073
222Dd	244,135	113,289	17	3,933	43.2	5,411	74,885
222De	1,193,640	681,903	35	5,208	23.3	21,941	513,775
222Df	454,216	252,950	38	2,390	16.9	8,505	196,560
222Dg	736,663	412,754	24	6,948	42.5	13,815	323,676
222Dh	466,741	286,819	45	5,661	63.3	7,247	244,111
222Di	483,754	216,011	20	4,813	43.2	9,472	157,351
222Dj	931,938	552,700	26	12,691	87.2	17,876	426,189
Highland Rim Section							
222Ek	1,523,412	554,140	13	5,035	22.9	26,949	358,152
222Em	647,278	435,342	66	6,494	79.5	9,804	359,560

FRAGSTATS is a software program for determining spatial parameters of land areas.
AVHRR= Advanced Very High Resolution Radiometer.
Largest patch index is the percent of the forest area in the largest patch.
Core area is based on a 30-meter edge.
For subsection identification and location, see figure 1.

222Dg—The Southern Dripping Springs Subsection covers 736,663 acres of land area with 56 percent forested, 42 percent agricultural and <1 percent each of urban, wetland, and water. None of this subsection occurs within national forest purchase area boundaries. Mixed upland hardwoods (51%) and oak-hickory (27%) are the most widespread forest types. Post oak-southern scrub oak forest covers about 20 percent of the subsection. The pine-cedar, pine-hardwoods, and bottomland hardwoods forest types each cover 6 percent or less of this subsection. Mean forest patch area is 23.6 acres and patch density averages 4 per 100 acres.

222Dh—The Greater Shawnee Hills Subsection covers 466,741 acres of land area with 62 percent forest, 33 percent agricultural, and less than 3 percent urban, wetland, and water each. The high percentage of forest land reflects the steep uplands of the region, which support less agricultural land than the adjacent Lesser Shawnee Hills Subsection. Eighty-six percent of this subsection lies within the Shawnee National Forest Purchase Area. Oak-hickory (62%) is the dominant forest type with beech-maple (12%) and bottomland hardwoods (10%) the next most widespread forest types. The other four forest types present in the subsection

Table 4. Comparison of AVHRR and FIA land area data by subsection for the Hoosier-Shawnee Ecological Assessment Area.

	Total area			Forest area			Percent forest		
Subsection	**AVHRR**	**FIA**	**Difference**	**AVHRR**	**FIA**	**Difference**	**AVHRR**	**FIA**	**Difference**
	Acres		*Percent*	*Acres*		*Percent*	*Percent*		
Ozark Highland Section									
222Ao	469,537	422,723	10	53,367	83,427	36.0	11.4	19.7	8.3
222Aq	546,060	554,369	1.5	199,371	212,795	6.0	36.5	39.5	3.1
Upper Coastal Plain Section									
222Ca	192,877	173,866	9.9	60,448	68,651	12.1	31.3	39.5	8.3
222Ch	354,200	363,542	2.6	70,205	98,106	28.4	19.8	27.0	7.2
Shawnee Hills Section									
222Da	830,540	815,270	1.8	163,030	191,203	14.7	19.6	23.5	3.9
222Db	736,171	735,665	0.1	76,266	114,485	33.4	10.4	15.6	5.2
222Dc	2,413,998	2,409,332	0.2	1,125,322	1,027,527	8.7	46.6	42.6	4
222Dd	244,135	229,372	6	113,289	120,855	6.3	46.4	52.7	6.3
222De	1,193,640	1,184,125	0.8	681,903	705,121	3.3	57.1	59.5	2.4
222Df	454,216	399,305	12.1	252,950	234,238	7.4	55.7	58.7	3.3
222Dg	736,663	781,399	5.7	412,754	329,859	20.1	56.0	42.2	3.8
222Dh	466,741	480,148	2.8	286,819	267,528	6.7	61.5	55.7	5.7
222Di	483,754	478,827	1	216,011	214,067	0.9	44.7	44.7	0.2
222Dj	931,938	916,921	1.6	552,700	514,563	6.9	59.3	56.1	3.2
Highland Rim Section									
222Ek	1,523,412	1,437,039	5.7	554,140	417,949	24.6	36.4	29.1	7.3
222Em	647,278	594,270	8.2	435,342	392,016	10.0	67.3	66.0	1.3
Total land area	12,225,161	11,976,173	9.8	5,253,917	4,992,389	9.5	43.0	41.7	1.3

AVHRR= Advanced Very High Resolution Radiometer, FIA= Forest Inventory and Analysis.
For subsection identification and location, see figure 1.

cover less than 5 percent each. Mean forest patch area is 45.5 acres and patch density averages 2.2 patches per 100 acres.

222Di—The Lesser Shawnee Hills Subsection covers 483,754 acres of land area with 45 percent forested, 48 percent agricultural, and small proportions of wetland and urban areas. Forty-seven percent of this subsection lies within the Shawnee National Forest Purchase Area. Oak-hickory (57%) is the dominant forest type with beech-maple (15%) and bottomland hardwoods (10%) the next most widespread forest types. The other four forest types found in this subsection average less than 6 percent each. Mean forest patch area is 19.6 acres and patch density averages 5 forest patches per 100 acres.

222Dj—The Northern Dripping Springs Subsection covers 931,938 acres of land area with 59 percent forest, 38 percent agricultural, and 3 percent urban. None of this subsection occurs within either of the national forest purchase areas. Mixed upland hardwoods (54%) dominate with oak-hickory (18%) and beech-maple (9%) the next most widespread forest types. The other four forest types present average 6 percent or less each. Mean forest patch area is 26.2 acres and patch density averages 3.7 forest patches per 100 acres.

Highland Rim Section

222Em—The Brown County Hills Subsection covers 647,278 acres of land area. Land use in this subsection is 67 percent forest cover, 26 percent agriculture, 2 percent urban, and 2 percent water. Ninety-nine percent of the forest cover is deciduous, and the remainder is in coniferous or mixed deciduous/conifer forest. Twenty-two percent of the Brown County Hills Subsection is within the purchase area of the Hoosier National Forest. Land use within the purchase area is 80 percent forest cover, 13 percent agriculture, less than 1 percent urban, and 6 percent water. Oak-hickory (31%), beech-maple (27%), and mixed upland hardwoods (22%) are the dominant forest types. The other four forest types cover 7 percent or less of the subsection each. Mean forest patch area is 12.8 acres and patch density averages 8.1 forest patches per 100 acres.

222Ek—The Mitchell Karst Plain Subsection covers 1,523,412 acres of land area with 36 percent in forest cover, 60 percent in agriculture, and 2.5 percent urban. Less than 1 percent is water or wetland. Seventy-two percent of the forest cover is deciduous, and the remainder is in coniferous or mixed deciduous/conifer forest. Less than 1 percent (3,676 acres) of the Mitchell Karst Plain Subsection is within the purchase area of the Hoosier National Forest. Land use within the purchase area is 78 percent forested, 22 percent agriculture, and 3 percent urban. Oak-hickory (60%) and beech-maple (24%) are the dominant forest types. The other five forest types average less than 6 percent of the subsection each. Mean forest patch area is 66 acres and patch density averages 1.5 forest patches per 100 acres.

Forest Age Across the Region

This section examines the current age structure of forests across the region. Although most of the forests in the region are relatively young due to the widespread clearing of the late 1800s and early 1900s, old-growth forests (>150 years in age) are expected to dramatically increase in spatial area under current management practices. Forest patches (>5 acres in size) less than 10 years of age are declining in area across the assessment area.

Most of the timberland within the assessment area is less than 100 years of age, reflecting the major logging activities at the turn of the 20th century (Clark 1987, Schmidt et al. 2000, Tormoehlen et al. 2000). In Indiana, 81 percent of the timberland in the Knobs Unit is between 31 and 100 years of age and 80 percent of the

Lower Wabash Unit falls within this age range. Only 6 percent of the timberland within the Knobs Unit and 2.8 percent of the Lower Wabash Unit exceed 100 years of age. Forests less than 10 years of age account for 2 percent of the Knobs Unit and 1.2 percent of the Lower Wabash Unit. Timberland exceeding 100 years of age is 1.2 percent of the land within the Hoosier National Forest and timberland less than 10 years of age is 1 percent.

The acreage of forests in older age classes within the assessment area is expected to dramatically increase due to current management systems and areas protected from harvest. Old-growth forests on public lands within Indiana are expected to increase from 895 to 136,450 acres over the next 50 years (Parker 1989, Spetich et al. 1997). Most of this additional old forest (99,090 acres) will be within the Hoosier National Forest. Forests less than 10 years of age are expected to decrease under current management systems.

Age structure across the ecological sections of southern Illinois was investigated by stratifying FIA forest type data into 20-year age classes and assigning a midrange age to these stands, i.e., for the 21- to 40-year age class, the median age of establishment would be 30 years ago, approximately 1970. These data revealed that across sections less than 10 percent of the current forest land was established before 1900 indicating very little of the landscape is in old-growth condition (fig. 5). A rough estimate of old growth is 3 to 5 percent of the current forest land (Ruffner, personal observation). Across the region, many stands originated between the 1930s and 1950s with a slight decrease in cutting around 1970 (fig. 5). The Ozark Highlands and the Upper Gulf Coastal Plain Sections have experienced more recent cutting, whereas the Shawnee Hills and Highland Rim Sections have seen a drop in recently established forest stands.

RECENT TRENDS IN FOREST MANAGEMENT

This section is a review of the literature on the ecological implications of current forest management trends. The general trend in management across the region has been to minimize disturbance through complete protection or drastic reduction in harvest opening size. There has also been an increase in the use of prescribed burning in some fire-dependent communities. Protection from disturbance is likely to hasten the transition of species and will likely result in a loss of biological diversity across the region (Loucks 1970, Thompson and Dessecker 1997).

Major management initiatives of the 20th century are primarily responsible for the forest development pathways that created the current forest cover of the assessment area. At the end of the 19th century, much of the area was recovering from widespread cutting for numerous products (Fralish 1997, Ruffner et al. 2002), rampant grazing and forest burning (Miller 1920), and poor agricultural practices (Fralish 1997). The first major initiative saw the reforestation of many abandoned old fields and pastures, and much of the burned and grazed over lands, with the introduction of nonnative pine species. Reforestation of abandoned lands and reduced grazing of forests have reduced landscape fragmentation, particularly in areas with large public ownership (Spetich et al. 1997) and have generally improved the condition of forests across the region.

Coupled with reforestation and reduced grazing was the control and suppression of fires on the landscape. With the organization of State forestry divisions in the 1920s, the Civilian Conservation Corps (1930-1941), and eventually the full resources of the USDA Forest Service in 1933, an aggressive fire suppression campaign was begun. At the time, managers were acting under accepted concepts and procedures that suggested a healthy vibrant forest

must be protected from the damaging scourge of wildfire. Even though numerous people (living at the time) must have experienced and appreciated the long-term effects of introduced fire in the early part of the 20th century, an active fire monitoring system was developed. Fire towers were constructioned, old logging roads were maintained and improved for fire access, and a general public relations campaign was begun to alert the populace to the need for these activities.

At the time of these efforts, the important role of recurring disturbances in the maintenance of oak-hickory forests was poorly understood (Abrams 1992, Lorimer 1985, Schlesinger 1976). These authors, and many others, have contributed greatly to our knowledge of the historical development of these ecosystems. It is generally accepted that the numerous disturbances of the post-European settlement period fostered the expansion of oak-hickory in the eastern deciduous biome (Abrams 1992, Lorimer 1992). Indeed, the frequent cutting regime, coupled with fire and grazing, of southern Illinois, southern Indiana, and western Kentucky that fed stave mills, charcoal iron furnaces, railroad expansions, and the cottage industries that produced fences, fruit containers, clapboards, and building timbers for the rapidly growing region is largely responsible for the mixed oak-dominated forests across the study region.

However, the fire cessation of the early 20th century fostered the expansion of mixed mesophytic species across the region (Fralish et al. 1991). Numerous authors have studied these central hardwood old-growth stands typified by the cessation of cutting, burning, and most forms of management (Barton and Schmelz 1987, Fralish et al. 1991, Fralish 1997, Groninger et al. 2002, Martin 1992, Nelson et al. 1973, Robertson and Heikens 1994, Ruffner et al. 2002, Schlesinger 1976, Spetich 1995, Weaver and Ashby 1971, Zaczek et al. 2002).

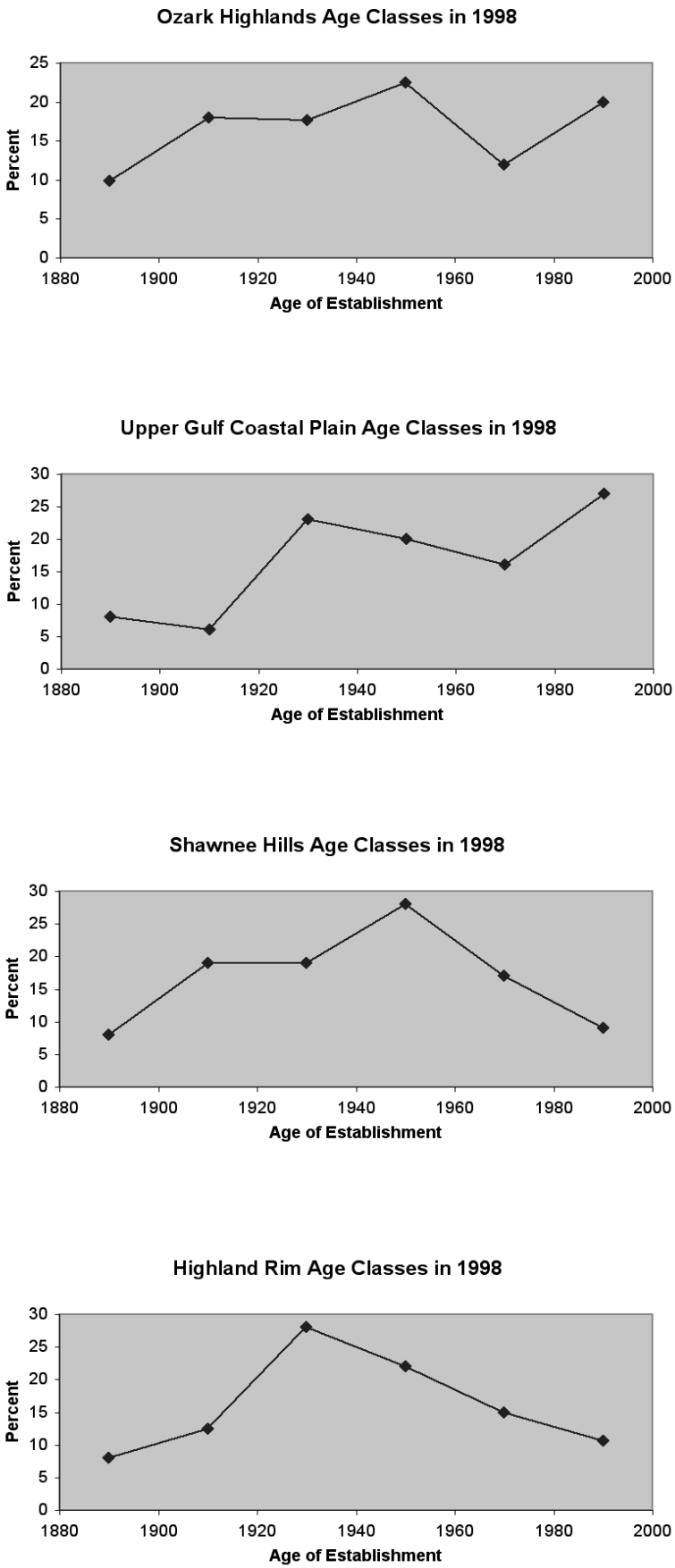


Figure 5. Stand age classes across ecoregions within the Shawnee-Hoosier Ecological Assessment Area.

Across the spectrum of sites in the assessment area, these studies report significant shifts in species composition and forest structure. Overwhelmingly, sugar maple and American beech are found to be increasing in stand density and basal area at the expense of the oak-hickory overstory. Age-diameter figures suggest that a large cohort of mixed maple, beech, ash, and gum was recruited only a few years after the control of understory fire and the elimination of harvesting across forests of the Ozark Hills, Shawnee Hills, and Highland Rim (Parker 1989, van de Gevel and Ruffner 2002, Zaczek et al. 2002).

Although a complete database of harvest removals for the assessment area does not exist at this time, it is possible to chronicle the major forest management activities of the middle to late 20th century. By the middle to late 1960s, most forest management agencies had adopted clearcutting as the preferred regeneration method for forests of the region (Illinois Technical Forestry Association 1965, Mills et al. 1987). Success of these clearcuts is equivocal based on the variability of site characteristics such as land use history, soils, and species composition (Fralish et al. 1991, Gleason 1926). Depending on the date of fire cessation, many of these clearcuts did not result in regeneration of oak as planned but merely released the advanced regeneration pool in the transitional maple-beech understory (Abrams and Scott 1989, Fralish 1997, Groninger et al. 2002, Heiligmann et al. 1985). In general, clearcutting on upland sites has failed to regenerate oak when adequate advanced regeneration of oak was not in place at the time of harvest (Sanders and Graney 1992). However, oak seedlings and sprouts are usually present in young stands following clearcutting but are overtopped by other faster growing species within a few years (George and Fischer 1991, Jenkins and Parker 1998), indicating the need for additional cultural treatments such as applying herbicide, thinning, or prescribed burning to reduce the competition of these faster growing stems.

The successful regeneration of oak was further reduced by the adoption of group selection cutting in the mid- to late-1980s, despite the reported failure of previous attempts to maintain oak through uneven-aged management options. Under this management scheme, small multistem groups were harvested in an attempt to reduce the visual impact of clearcuts on the landscape. While these altered harvest methods may have reduced the visual impact and quieted clearcutting opponents, many ultimately hastened the replacement of oak-hickory forests by later successional species in the small patches (≤0.5 acre) that were created (Fralish 1997, Groninger et al. 2002, Nelson et al. 1973, Ruffner et al. 2002, Weigel and Parker 1997, Zaczek et al. 2002). Group selection openings may vary from 0.5 to 5 acres in size. The larger openings are capable of providing a light regime more favorable to midtolerant species such as oaks (Jenkins and Parker 1997). Group selection (ranging in size between 1 and 5 acres) is the predominant silvicultural system used in Indiana State Forests (Indiana Department of Natural Resources 2001), but no timber cutting is occurring in the State forests of Illinois.

Because of these preliminary experiments, managers now understand that regeneration methods must be based on an evaluation of the oak regeneration potential (Sanders and Graney 1992). Where oak reproduction is low, stand treatments to enhance oak establishment and growth are needed. Where oak reproduction is adequate, clearcutting is the best method to use (Sanders and Graney 1992). In stands with little or no oak reproduction, the shelterwood method is probably the only one that will succeed in regenerating oaks (Sanders and Graney 1992, Van Lear and Watt 1992). However, success depends on quality of the

site and application of additional treatments to reduce competition (Brose et al. 2001).

Perhaps the most successful experiments to date include those in forests of the Piedmont region of Virginia (Brose and Van Lear 1998, Brose et al. 2001, Keyser et al. 1996). Following shelterwood harvests with a 50 percent basal area reduction, these authors conducted repeated prescribed burns to significantly reduce tulip-poplar regeneration and increase advanced oak regeneration. They suggested that this harvest/fire disturbance regime closely mimics the conditions that fostered the development of these oak-dominated systems (Brose et al. 2001). In addition, they reported a critical need for several years between the initial cut and burning. This waiting period allows for several key components including the establishment and growth of vigorous oak seedlings and the regeneration of the buried tulip-poplar seed pool. Although burns were conducted in the winter and summer, spring appeared to be the best time for burning because it presented the most favorable weather conditions such as warm temperatures, lower humidities, and sunny days (Brose et al. 2001).

Within forests of southern Illinois, land managers have been using prescribed fire since the mid-1980s. Although the USDA Forest Service fire management program has largely been forced into a "suppression" mode due to extensive analysis requirements, several Illinois Department of Natural Resources divisions actively manage vegetation with prescribed fire (Ruffner 2001). The Divisions of Forestry and Natural Heritage both use fire to maintain unique vegetation and habitat types in glade and oak savannas, improve wildlife habitat, and foster oak regeneration while reducing competing mesophytic species in forest lands (Ruffner 2001). New research initiatives have been developed to provide empirical data that monitor long-term vegetation dynamics within burned forests of southern Illinois (Allen 2001, Ruffner and Davis 2002). State forestry officials in cooperation with ecologists and silviculturists at Southern Illinois University have begun a landscape-scale study to test the effects of timber stand improvement with fire in upland oak stands of the Shawnee and Cretaceous Hills (Allen 2001; Ruffner, personal observation). These researchers hope that substantial removals of understory and midstory mesophytes, coupled with the application of prescribed fire for 3 to 5 years following removals, will increase advanced oak regeneration at the expense of later successional species.

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