# FORESTS

## SUMMARY

A review of some of the trends apparent in Illinois forests over the past several decades reveals the following conclusions:

1. Total forest area is now increasing statewide due to several incentive and educational programs. The only exception may be in the south-central portion of the state, where fragmentation is apparently continuing.

2. Timber volume increased by 40% between 1962 and 1985. Volumes for most forest types have increased substantially, with the exception of elm-ash-cottonwood, which has decreased because of Dutch elm disease. Net annual growth, by contrast, was 30% higher in 1962 than in 1985, showing the aging nature (with concomitant slowing of growth rates) of our secondary forests.

3. The composition of the forests is changing dramatically. Maple species are replacing much of the oak-hickory forests as well as dominating new forestland succeeding from abandoned pastures. The oak-hickory forests are not being regenerated and will thus continue to decrease in area and importance.

4. Because of the dramatic increases in volume, the Illinois forests served as a large carbon sink from 1962 to 1985. The annual sequestration of carbon into Illinois forests is estimated to be 1.37 million metric tons, enough to counteract about 2.65% of the total carbon emissions being put into the atmosphere by the people of Illinois.

5. Most of the forests are associated with the state's stream network. In the south-central portion of the state, 78% of the forestland lies within 300 m of the streams.

6. The biological diversity of the state is being carried, in large part, by the forests. Over half of the native flora and over half of the threatened or endangered flora are found in the state's forests. According to one index, over 75% of the wildlife habitat in the state is found within the forests.

7. The invasion of exotic species is one of the most serious problems facing Illinois forests, and this problem continues to increase both in severity and scope. Exotic plants reduce within-site plant diversity, as well as reducing habitat quality for native fauna. Exotic insect pests and pathogens threaten Illinois populations of several key species of trees.

8. Forest habitat loss and fragmentation have reduced the ability of Illinois forests to maintain biological diversity in numerous ways. The effects of habitat loss and fragmentation include (a) loss of appropriate habitat for species requiring large tracts of forest (e.g., many large mammals and birds); (b) invasion by exotic species, particularly weedy plants, of the forest interior and habitat edges; (c) increases in potentially damaging native species (e.g., deer) that use habitat edges and threaten biological diversity within sites; (d) increased probability of chance extinction of small, isolated populations; and (e) decreased gene flow between isolated populations, increasing the likelihood of inbreeding depression for both flora and fauna.

9. Effects of pollution ($NO_2$, $SO_2$, ozone depletion) and global warming on forest health in Illinois appear minor relative to changes in forest health in the northeastern United States and Europe, where forest decline is severe. Habitat fragmentation, exotic species, and plant diseases, however, are having a negative impact on forest biodiversity in Illinois. Past timber harvest practices may also have had a long-lasting negative impact on forest quality. Although Illinois currently does not have forest decline problems, all of these factors may contribute to decreased forest health in the future.

## FOREST AREA

### Historical Changes: 1820–1985

Illinois forests have undergone drastic changes in the decades since European settlement. In 1820, 13.8 million acres of forest existed in the state (Figure 1). Only 31% (4.26 million acres) of the forest area present in 1820 remained in 1980 (Figure 1), and essentially all (except for about 11,600 acres) of the present forests are considered to be secondary forest. Illinois ranks 49th (Iowa is 50th) in the percentage of land remaining in its original vegetation type (11%) (Klopatek et al. 1979). The pattern and rate of deforestation in the latter part of the last century rivals, and even surpasses, that of tropical deforestation occurring today.

Nonetheless, forest area has recently been increasing in the state. The lowest estimate of forest area in the state was made by Telford (1926), which estimated forest area to be only 3.02 million acres, compared to estimates of 4.0 million acres in 1948 (U.S. Forest Service, 1949), 4.04 million acres in 1962 (Essex and Gansner, 1965, updated by Hahn 1987), and 4.26 million in 1985 (Hahn 1987). Forest area increased by 10% from 1962 through 1985, due primarily to reduced cattle production in the state during that period with subsequent conversion of hayland and pastures to secondary forest. Recent farm programs, such as the Conservation Reserve Program and the Illinois Forestry Development Act, have provided incentive to convert additional, marginal acres to forestland.

When the state is evaluated according to five ecologically based regions (Figure 2), the changes in forest area since 1820 show similar patterns: major declines in forest area occurred between 1820 and 1924, with slow increases in area since 1924 (Figure 3). The only region to lose forest area between 1962 and 1985 was the South-Central Region, a group of 31 counties south of the Shelbyville moraine and north of the Shawnee Hills. In this region, Bond, Clark, Clinton, Fayette, Franklin, Gallatin, Hamilton, Jasper, Lawrence, Marion, Montgomery, Perry, Richland, Shelby, St. Clair, Wabash, and Wayne counties each lost more than 5,000 acres of forestland. Counties in other regions losing more than 5,000 acres were Alexander and Massac from the Southern Unglaciated Region, Greene from the Western Region, and Lake from the Northern Region. By contrast, 38 counties gained more than 5,000 acres of forestland during this interim,

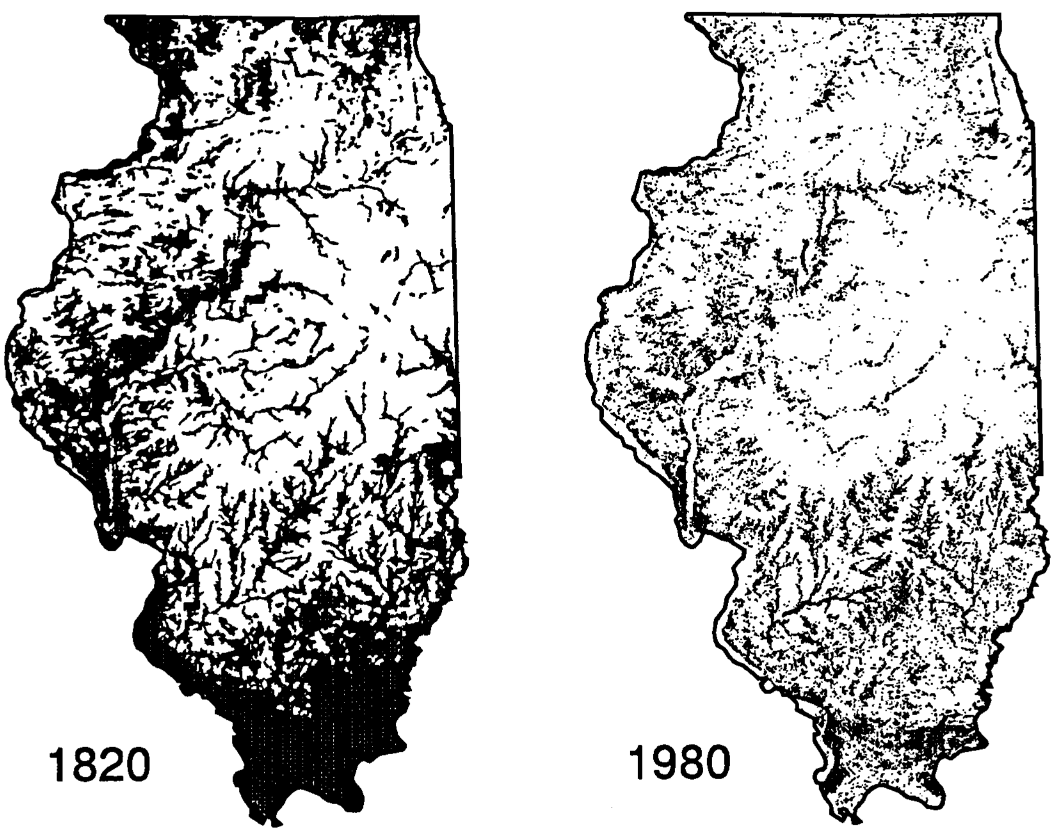



*Figure 1. Forests in Illinois in 1820 (left) and 1980 (right). Sources: Anderson 1970 and U.S. Geological Survey land-use data, 1973–1981.*

mostly from the northern two-thirds of the state (9 of 12 counties from the Northern Region, 11 of 31 counties from the Grand Prairie Region, 14 of 21 counties from the Western Region, 1 of 31 counties in the South-Central Region, and 3 of 7 counties in the Southern Unglaciated Region). County-by-county trends in forest area between 1962 and 1985 are shown in Figure 4. Clearly, forest area generally increased in northern counties (especially those along the major river systems), while significant forest losses occurred in the southern portion of the state (with the exception of Shawnee National Forest counties).

## Forest Pattern and Trends in the South-Central Region

To better understand the temporal and spatial patterns of forest patches in the South-Central Region, one 1990 Landsat TM scene, which covered all of 13 counties, was analyzed in detail (Figure 5). This region was selected for intensive study because it was the only region where forest loss occurred from 1962 to 1985. The satellite data were at a resolution of 98 x 98 ft (30 m x 30 m), so that forest patches as small as approximately 0.25 acre (0.1 ha) could be identified . The

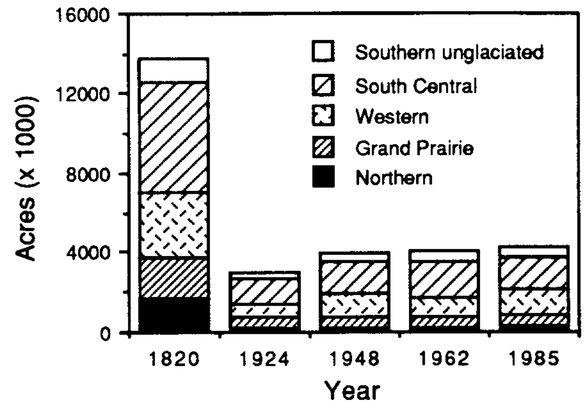



*Figure 3. Changes in forest area by region, 1820–1985.*

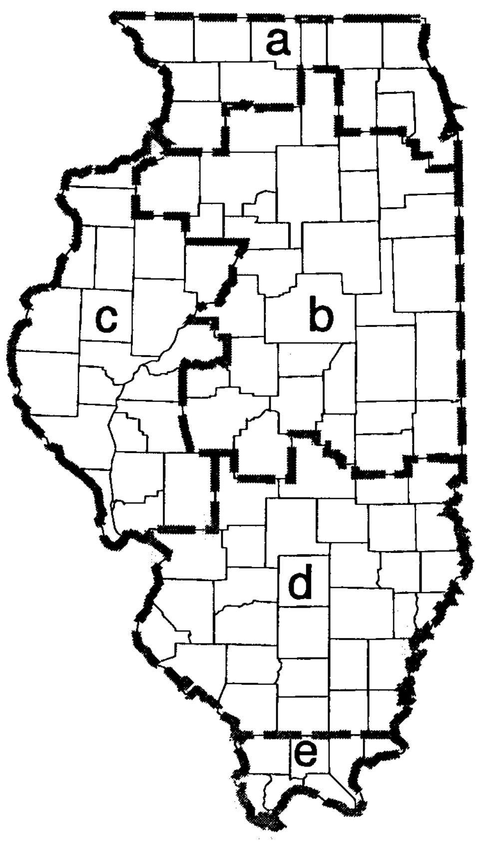



*Figure 2. Illinois regions: (a) Northern, (b) Grand Prairie, (c) Western, (d) South Central, and (e) Southern Unglaciated.*

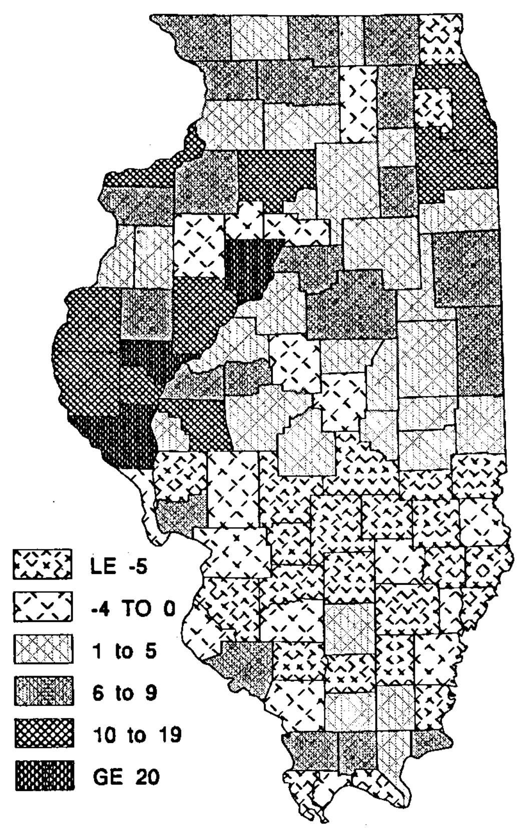



*Figure 4. Changes in forest area by county (acres x 1000), 1962–1985.*

distribution of the forest is highly fragmented, and the forest is primarily located adjacent to streams.

Direct comparisons of the 1990 satellite image assessment and a 1985 estimate by the U.S. Forest Service (a sampling procedure) are not reliable because the two studies used completely different methodologies. Still, it is useful to estimate forest area and fragmentation amount in this portion of the state. U.S. Forest Service data are summarized as "commercial" forestland, where commercial forestland is defined as all forested habitat that is not publicly held or explicitly withheld from potential timber harvest (state parks and nature preserves); this covers 95% of all forestland in Illinois.

The forest area for the 13 counties as determined from the 1990 satellite data was substantially lower than the 1985 or 1962 estimates of the U.S. Forest Service (Figure 6). It is likely, however, that many of the changes can be attributed to variation in the methodology; the classification of the satellite data did not include some areas that were interpreted by the U.S.

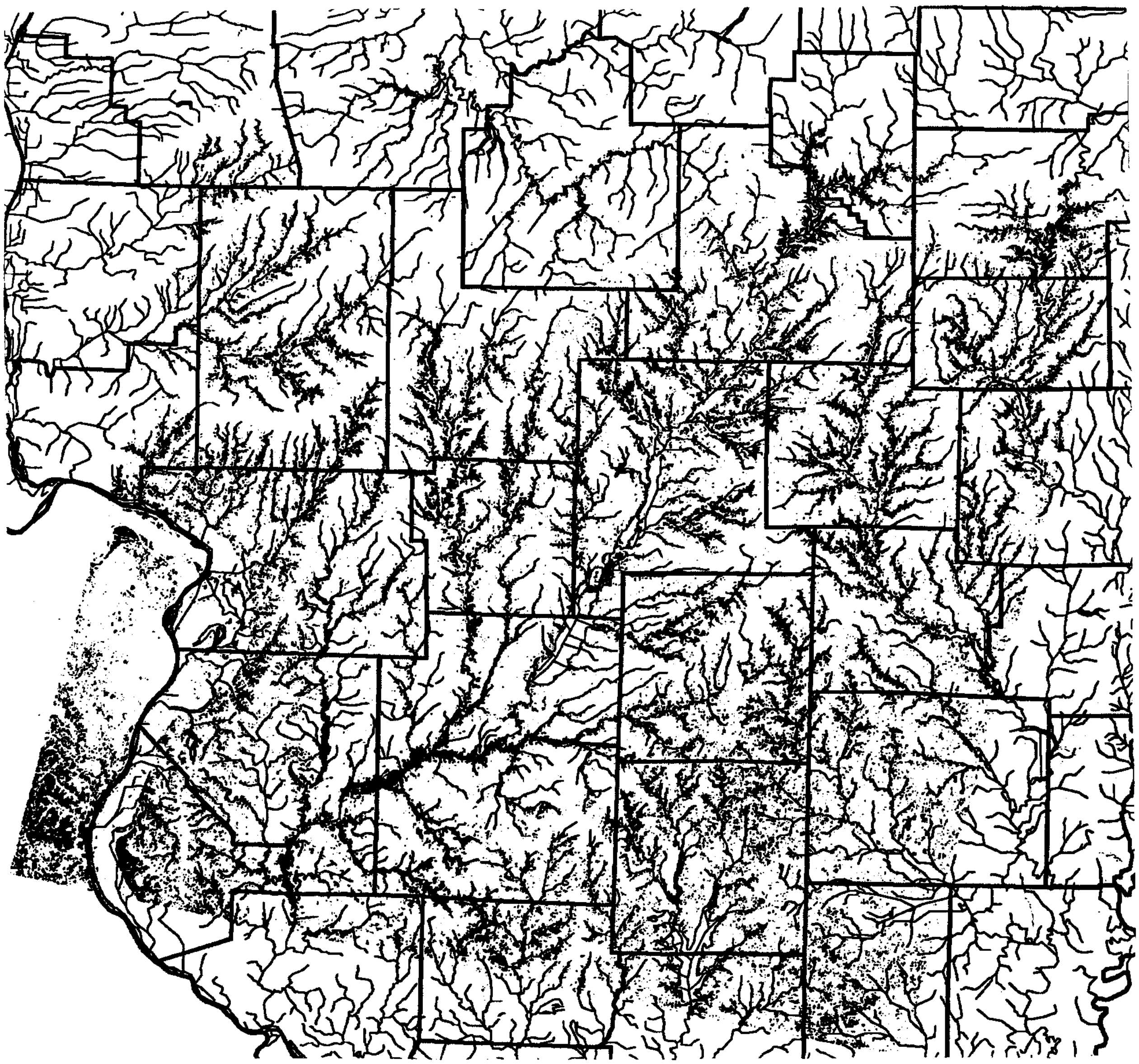


*Figure 5. Satellite image classification (from 1990) of forests for 13-county region in south-central Illinois, showing that most remaining forest stands are along streams and rivers.*

Forest Service as forest in 1985. Still, the region of satellite analysis was the one portion of the state that showed a decline in forest area between 1962 and 1985 (Figures 3 and 4), and the decreasing trend might have continued from 1985 to 1990.

The satellite data also show the fragmented nature of the forests. Fragmentation of forest habitat generally has negative implications for wildlife, especially for neotropical migrant birds that need large blocks of uninterrupted forest for successful nesting. As large tracts of forest are broken into small, isolated woodlots, more forest edge is created and more opportunities exist for edge-adapted species, most commonly the cowbird, to invade the area and prevent adequate nesting for many forest songbirds. The vast majority of forest parcels in this region are less than 1 acre (0.4 ha) (Figure 7). These small forest patches would be areas (ranging to as small as about 65 x 65 ft, or 20 x 20 m) where trees dominate, even in backyards, so that the 98 x 98 ft (30 x 30 m) pixel would classify as forest in the satellite imagery. Parcels greater than 40 acres (16 ha) are much less common, with the number of parcels of this size in each county ranging from 95 in St. Clair County to 269 in Fayette County. When one considers the larger forest patch sizes that may be needed to support forest interior birds (e.g., 600 acres or 243 ha), the numbers drop to a range of 3 in Montgomery County to 17 in Fayette County.

When evaluated on a per-unit area basis (the density of forest patches per township-sized area of 36 square miles, or 93.2 $km^2$), one can better understand the "population dynamics" of the forest patches. The number of forest patches under 1 acre (0.4 ha) per township-sized area ranged from 211 to 770 in St. Clair and Jefferson counties, respectively. The data also show the paucity of large forest patches in the region. A summation of all patches greater than 40 acres (16 ha) reveals that only 5.2 patches of this size can be found, on average, in each township of St. Clair County, ranging up to 14.1 patches per township in Jefferson County. Jefferson County originally (ca. 1820) was 73% forest, at least 20% higher than any of the other counties in the study area (Iverson et al. 1989); it therefore would be expected to have the highest density of forest patches remaining. For the entire 13-county area, there were an average of 10.1 forest patches per township, only about one patch for each 4 square miles (10 $km^2$).

A cautious comparison of these data can be made to data from a different study. Using U.S. Geological Survey land-use data dating from 1974 to 1979, Iverson et al. (1989) found that the density of forest patches greater than 40 acres ranged from 7.1 to 9.7 per township in this region. Although the data are not completely comparable, they suggest a slight increase in patch density from the 1970s to 1990. This trend could have occurred in at least two ways: (1) some additional patches of at least 40 acres could have been added to the pool due to regrowth or aggregation of smaller patches, or (2) some quite large patches could have been split into two or more medium-sized (but

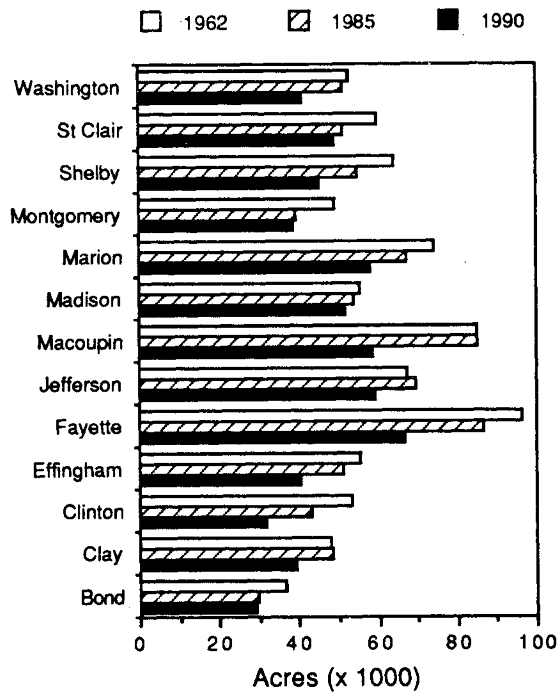



*Figure 6. Number of acres of forest in 13 counties in south-central Illinois, 1962–1990.*

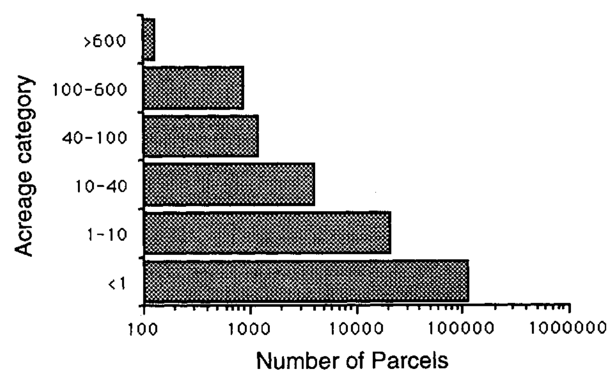



*Figure 7. Number of forested parcels in 13 counties in south-central Illinois, as detected by satellite in 1990.*

still > 40 acres) patches due to continued fragmentation. Based on the data presented here and a reevaluation of the data in Iverson et al. (1989), the latter is most likely the case.

By overlaying the forest classification from satellite data with the streams from the area (1:100,000 digital line graph files), we can estimate the proportions of the Illinois forests that lie within certain distances of the streams. For this area, no less than 78% of the forests exist within 984 ft (300 m) of the streams (Figure 8). A full 22% of the forests are found within 98 ft (30 m) of the streams. An evaluation of the distribution of forests circa 1820 (Figure 1) shows that the close proximity of streams and forest in this region has historically been the case; the streams were efficient fire barriers that reduced the frequency of fires. The data also show the massive elimination of upland forests that were deemed more "suitable" for other uses. These data provide at least circumstantial evidence of the importance of forests in maintaining stream health, and the reverse is also true (see Osborne and Wiley 1988).

This original research on 13 counties in south-central Illinois can be summarized as follows: (1) in the absence of more frequent U.S. Forest Service inventories (which would be very valuable), satellite data can be used to understand the distribution of forestlands across the state (however, calibration and further research is needed in this area); (2) forest area changes in the region are unclear, but forest area is probably not increasing as in the rest of the state; (3) there is extraordinary fragmentation of the forests; and (4) forests occur mainly near streams and rivers.

### Ownership Patterns of Illinois Forests

More than 90% (3.64 million acres) of the commercial forests in Illinois are privately owned, mostly by farmers and other individuals (Figure 9). The remaining 10% is publicly owned, primarily by the federal government in the form of the Shawnee National Forest. The Cooperative Extension Service of the U.S. Department of Agriculture estimated that Illinois had 169,073 private forestland owners, each of whom owned an average of 21.5 acres of forest. The primary reasons for forest ownership given by the holders of small parcels were wildlife habitat and aesthetic value (Young et al. 1984); income was of greater importance for those who owned large forest parcels (McCurdy and Mercker 1986).

## FOREST PLANT DIVERSITY

### Vascular Plant Diversity

The Illinois Plant Information Network (ILPIN) contains habitat and distribution data for the flora of Illinois (Iverson and Ketzner 1988). Using ILPIN, one can assess the distribution of forest vascular plant species within Illinois. Mapping the number of species of forest plants by county reveals that the areas of highest diversity are the Chicago region, western Illinois, and the very southern tip of Illinois (Figure 10). This geographic distribution corresponds to the general regions of maximum forest cover (Figure 1), but climate and geomorphic variations are also responsible for the biogeography of the state. The wide range in latitude from north to south accounts for a considerable range in climate and geomorphic conditions, and subsequently, a remarkable diversity of habitats. The presence of many species with affinities toward the northern temperate flora results in increased diversity

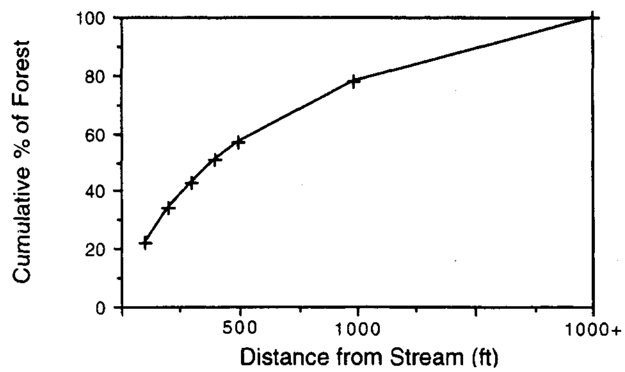



*Figure 8. Cumulative percentage of forest within various distances from streams in 13 counties in south-central Illinois.*

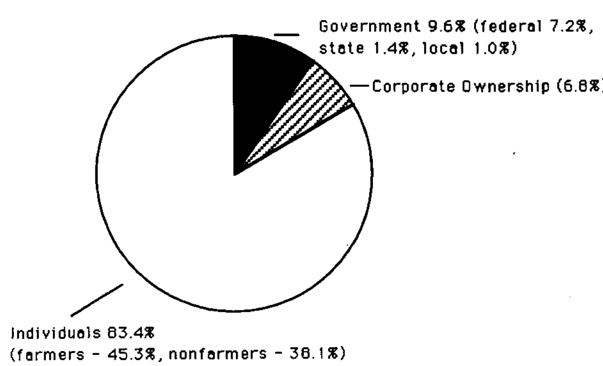



*Figure 9. Ownership of Illinois forests, 1985.*

in the northern counties, while species characteristic of the Appalachian flora increase diversity in the southern counties (Figure 10). Likewise, plants with affinities toward southern floodplains increase the species diversity along the major waterways in the western counties (Figure 10). This general pattern of regions with high biological diversity is reflected in both wetland and prairie species as well (see corresponding chapters in this report). Over 250 species of trees (native and introduced) have been recorded in Illinois. Southern counties have the greatest variety: Jackson has 145 species, Pope 129, and Union 128; several northeastern counties also have high diversity due to varied landscapes and escaped cultivars from the Chicago region (Figure 10). In addition to the trees, there are 284 taxa of shrubs (some of which can also be called trees) and 47 taxa of lianas reported for the state. Overall, 508 taxa of woody plants have been recorded, including 138 introduced species.

Illinois' forests are exceptionally rich in nonwoody taxa as well. Including the woody species, there are 1,581 forest-associated plant taxa in the state, 1,414 (89%) of which are native. Jackson County—a botanically rich southern county that is also the home of Southern Illinois University, from which numerous botanical surveys have been conducted—has 954 forest-associated native taxa on record, whereas Warren County in the northwest (not close to a botanical center) has had only 262 taxa recorded. In general, higher botanical diversity occurs in the southern counties, with species having affinity to the Appalachian flora, and in the northern counties, with species rich in the northern temperate flora. As one might expect, relatively lower diversities of forest-associated species are naturally found in the counties formerly dominated by prairie.

With diversity at its highest in the northern and southern counties, it is not surprising that the highest concentrations of threatened and endangered species, as well as exotic species, occur in the northern and southern counties (Figure 10). One additional pattern is noteworthy among these figures on the distribution of floral diversity in Illinois. There are a great many more non-native species in any given region than there are threatened and endangered species (Figure 10). This observation suggests that the exotic species problem may be bigger than the threatened and endangered species problem with respect to conserving biological diversity within Illinois. Legislative action has assured some level of protection against further losses in native species diversity. The lack of such legislative structure regarding exotics gives very little protection from further introductions of exotic species, whether intentional or accidental (see below).

## Recent Changes in Forest Composition

The composition of Illinois forests has changed dramatically over the past three decades. Today, about one-half of the commercial forest acreage is oak-hickory, one-fourth is maple-beech (almost exclusively sugar maple), and one-sixth is elm-ash-soft maple (Figure 11). Together, the remaining forest types (white-red-jack pine, loblolly-shortleaf pine, oak-pine, and oak-gum-cypress) account for an additional 217,000 acres of commercial forestland. In 1962, however, there was much more acreage of oak-hickory and elm-ash-cottonwood and very little area dominated by the maple-beech type. Since 1962, the maples have increased by a factor of 41, whereas the oaks have been reduced 14% and the elms have been cut in half (Figure 11). The loss of oak-hickory forest is largely explained by the "maple take-over," in which mature oak-hickory forests are unable to regenerate themselves because the tree seedlings are intolerant of excessive shade in the absence of fire. By contrast, maple seedlings thrive in the shady environment and are positioned for rapid growth and dominance once the overstory is removed or dies. The reduction of elm-ash-soft maple is largely due to the effects of Dutch elm disease and the conversion to agriculture of bottomland forests that once supported these trees (especially in the South-Central Region).

These trends are also evident by the age class distribution of the major forest types (Figure 12). The oak-hickory type dominates in the older age classes, whereas the maple-beech type dominates in the younger age classes; as time passes, maples will continue to increase in dominance. The age class distributions within forest types have changed between 1962 and 1985. Both the elm-ash-cottonwood and oak-hickory forests have matured during this 23-year period (Figure 13). In contrast, the oak-gum-cypress has shifted from primarily older stands to primarily younger stands (Figure 13). Maple-beech forests, while increasing dramatically in total acreage (Figure 11), have not shifted in the age distribution of stands (Figure 13). This pattern is likely to change in the future as these stands mature. Finally, pine has not shifted its relative distribution between older and younger stands during the 23-year census interval (Figure 13).

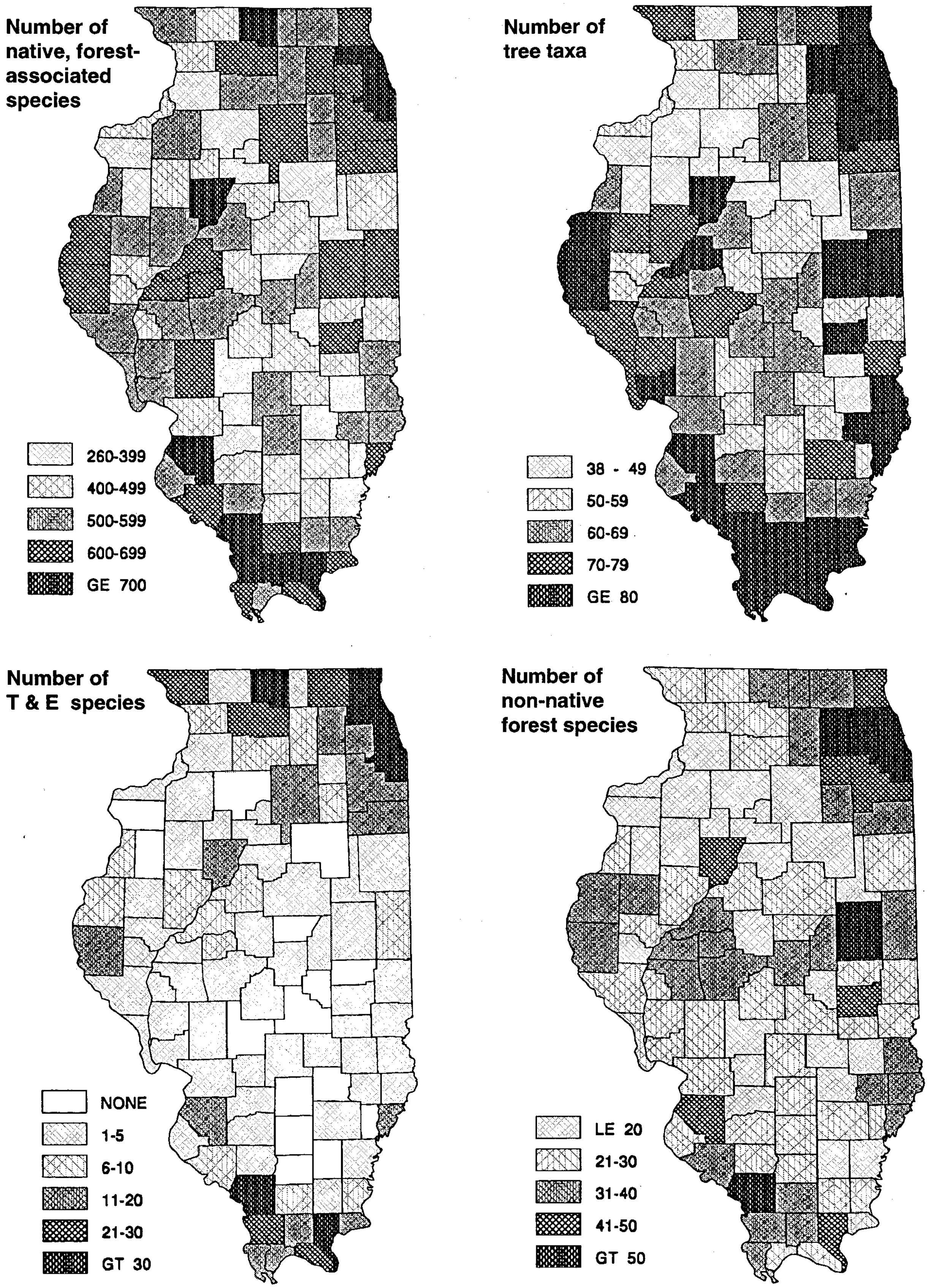



*Figure 10. The total number of forest-associated, native species (top left), number of tree taxa (top right), number of threatened and endangered (T & E) species (bottom left), and number of non-native forest species (bottom right) in each Illinois county as recorded by the Illinois Plant Information Network.*

## Tree Abundance

An estimated 1.93 billion trees stood in Illinois commercial forests in 1985 (Hahn 1987). Surprisingly, the most common tree type was the elm, with 344 million trees (Figure 14). These are not the American elm, however, which was devastated by Dutch elm disease, but the slippery, or red, elm, which rarely attains a large stature but is very common in the understory. Overall, white oaks (99 million), red oaks (136 million), hickories (185 million), hard maples (117 million), and soft maples (91 million) were very abundant. Based on these trends and the dynamics of forest regeneration in the absence of fire, the future will show an increase in maple abundance and concomitant decreases in oak and hickory abundance.

## Timber Volume, Growth, Harvest, and Mortality

The total volume of growing stock in 1985 was 4.8 billion cubic feet, 40% greater than the 3.4 billion cubic feet reported for 1962 (Hahn 1987). Net volume estimates for 1985 showed the prominence of oak and hickory in commercial forests, with considerable amounts of ash, black walnut, cottonwood, elm, maple, and sycamore as well (Figure 15). The 1985 volumes averaged 47.4 million cubic feet per county or 1,200 cubic feet per acre of commercial forestland in the state.

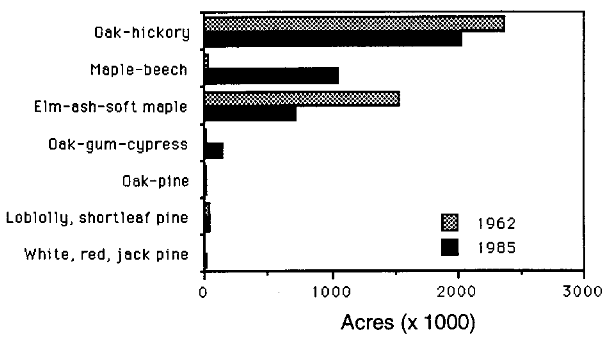



*Figure 11. Composition of Illinois commercial forests, 1962 and 1985.*

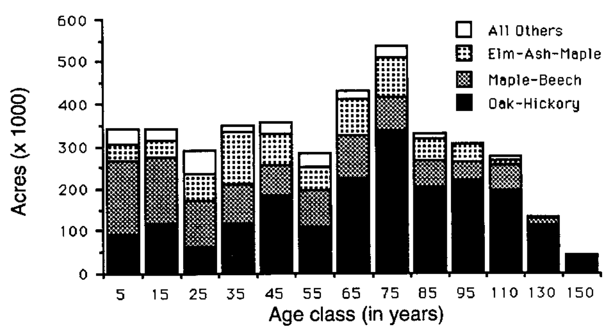



*Figure 12. Acreage by age class of the major forest types in Illinois, 1985.*

The trends in volume since 1948, by species group, are shown in Figure 16. For all groups except elm, there was a dramatic increase in volume since 1962. The elms have declined since 1948 due to bottomland conversion to agriculture and Dutch elm disease. White and red oaks and black walnut had total volume decreases from 1948 to 1962 (due to a drop in forest-land area because volume per acre increased slightly during the period), but showed increases in volume from 1962 to 1985 (due to a large increase in volume per acre in spite of a decrease in oak area during this period). The other types—hickories, maples, and ashes—have increased in volume since 1948.

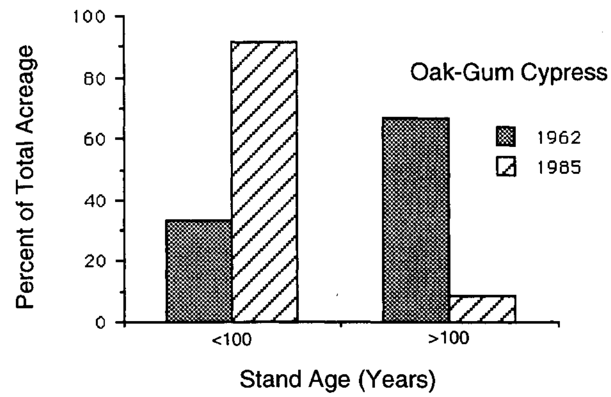
Net annual growth was estimated in 1985 (Hahn 1987) to be 96 million cubic feet of growing stock or 437 million board feet of sawtimber. Over 42% of net annual sawtimber growth was accounted for by oaks, with another 10% from soft maple, 6.3% from ashes, 3.7% from black cherry, 3.3% from hard maple, and 3.2% from black walnut. Only elm and black ash showed negative growth rates between 1962 and 1985, attributable to Dutch elm disease and the clearing of bottomlands.

Compared to the 1985 data, the 1962 inventory showed a 30% higher level of annual growth (125 million cubic feet of growing stock). The lower annual growth and higher volumes in 1985 compared to 1962 indicate that growth has outstripped removals in the past several decades and that growth rates may be declining due to maturing forests (Figure 16). The trends in volume during 1962–1985, when evaluated by county, show large percentage increases for all northern and central counties (except Whiteside) but generally lower or even negative volume changes for south-central counties (Figure 17). This trend can be primarily linked to the area changes for the region as discussed previously (see Figure 4).

Illinois ranks fifth in the nation in demand for wood but 32nd in the production of wood. Although we import much of the wood we need from other states, 14% of the wood harvested in Illinois is processed in neighboring states. This processed wood is often then imported back into Illinois. Currently, the annual growth of timber (96 million cubic feet) exceeds timber removals (68.6 million cubic feet), so that accumulation of volume statewide will continue, barring major harvest changes, into the near future.

An enormous quantity of firewood—nearly 2 million cords a year—is harvested from Illinois forests. About 43% of the trees used (harvested or salvaged) in a given year in Illinois are used for firewood! The demand for firewood does not currently present a major threat to our forests, however, because 75% of the firewood cut is taken from dead trees. The major harvest of fuelwood takes place in the heavily populated northeastern counties (Figure 18). Trees cut for sawlogs, by contrast, are primarily found in the southern half of the state (Figure 19), with the major counties cutting sawlogs in 1983 being Franklin, Fulton, Jackson, and White (with over 6 million board feet per county).

To summarize, biomass and annual harvest have increased statewide during the past 23 years while annual growth has decreased (Figure 20), possibly as a result of maturing stands (Figure 13). Mortality rates during this period have increased dramatically (Figure 20). Although the sources of this mortality cannot be ascertained in many cases, the leading known causes of mortality are insect damage and pathogens, which account for 38% of the mortality (Table 1). The



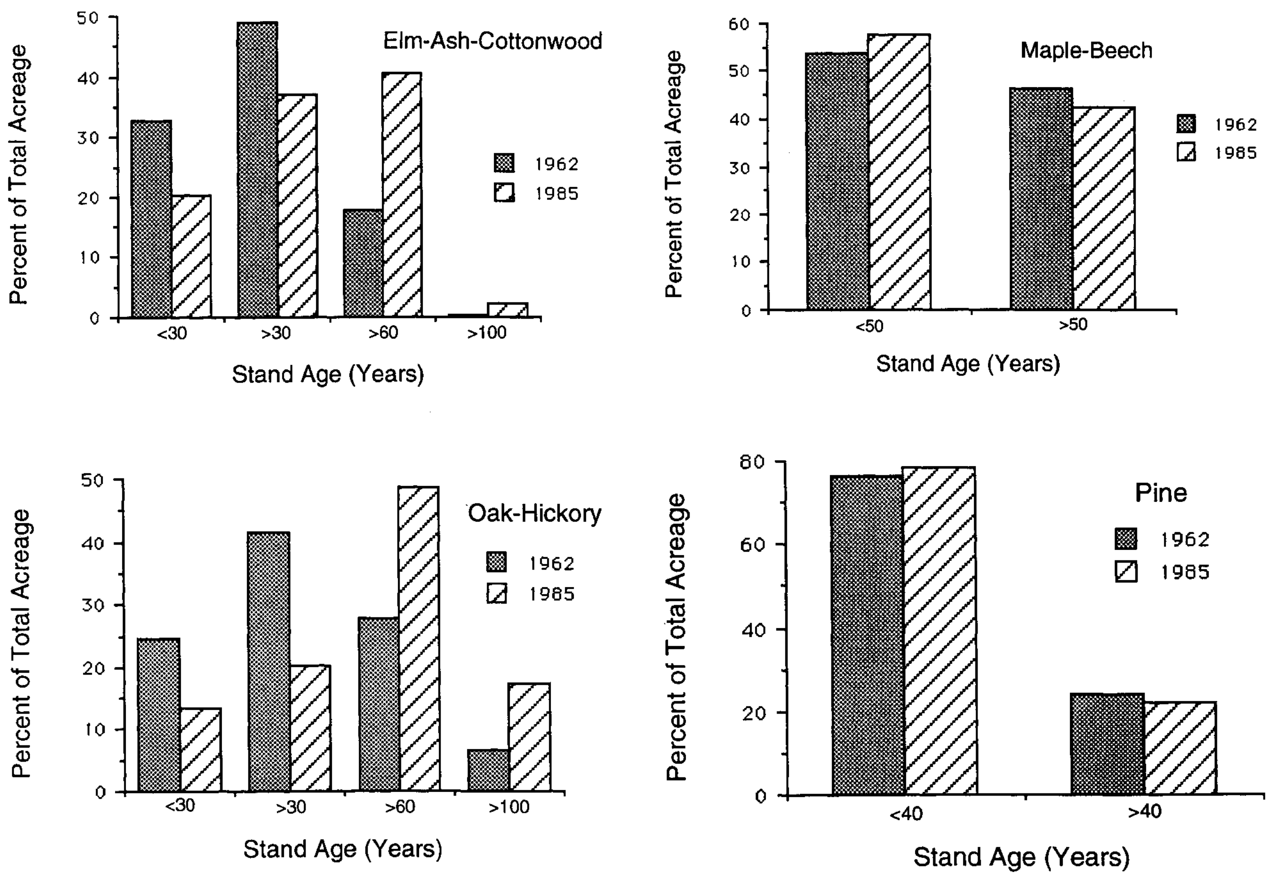




*Figure 13. Age structure of various forest types in 1962 and 1985. Source: Hahn 1987.*

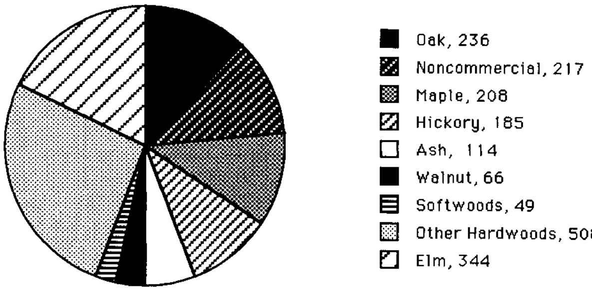



*Figure 14. Number (in millions) of live trees of various types in Illinois commercial forestland, 1985.*

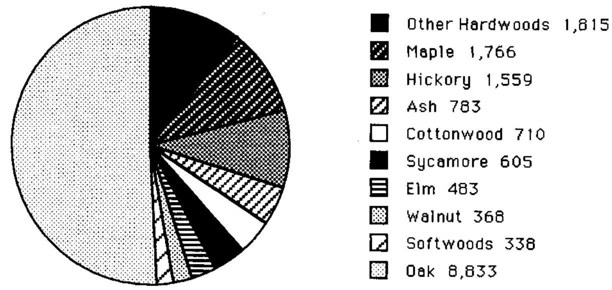



*Figure 15. Volume (in million board feet) of various types of trees in Illinois commercial forestland, 1985. Total volume of sawtimber was 17.5 billion board feet.*

majority of insect and pathogen mortality can be traced to two sources: (1) introduced pests spreading through the region (such as Dutch elm disease) or (2) decreased resistance to disease and herbivores as a result of environmental stress (such as the red spruce decline in the northeastern United States or the general forest decline in northern Europe). Examining mortality patterns by species shows that elm leads all species in mortality rates (Table 1). The majority of this mortality is the result of continued spread of Dutch elm disease in Illinois. Thus, it seems likely that the observed increase in mortality rate from 1962 to 1985 may not be symptomatic of general forest decline (Figure 20) but may indicate a peak in mortality associated with a single disease spreading through the region. There appear to be no major differences in mortality rates of trees by ownership category (Table 2).

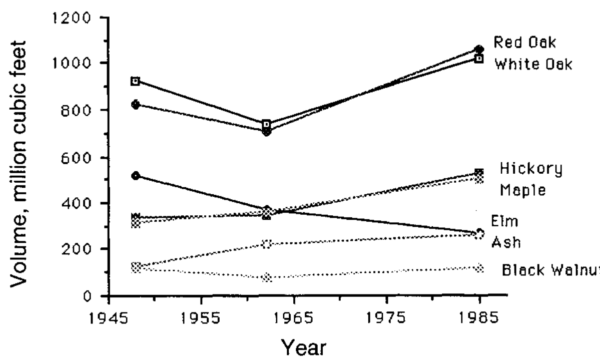



*Figure 16. Trends in volume of various types of tree, 1948–1985.*

## Tree Health

An investigation of tree health in Illinois forests was conducted during the summer of 1992 (Iverson and Schwartz, unpublished data). For this study, the investigators followed the USDA Forest Service Forest Health Monitoring (FHM) protocol (Conkling and Byers 1992). The FHM protocol is designed to establish long-term monitoring stations from which periodic samples are collected in order to assess changes in the health and status of forests throughout the United States. The federal project is in a test phase, with current information available for only three regions (USDA Forest Service 1993, Bechtold et al. 1992). Iverson and Schwartz (unpublished data) implemented the FHM protocol in 31 forest plots across Illinois. The sites were stratified to sample each portion of the state in approximate relation to the abundance of forests within that region (Figure 21). Likewise, sampling attention was divided between upland (24 sites) and bottomland forests (7 sites) with respect to their relative abundances. Finally, although publicly held forestlands were primarily selected, the sample included six privately held woodlots.

For each sampled plot, tree composition and health were assessed. Within tree plots sapling density, seedling recruitment, and herbaceous species cover were also sampled. To assess forest health, the following measurements are collected for trees: species, size, crown diameter, crown density, crown damage, and foliage transparency. The crown health measurements (density, damage, and transparency) can indicate symptoms of disease, herbivore damage, or environmental stress. While these data are most useful in subsequent re-measurements, the initial results among species were compared to determine whether certain species are showing signs of stress. In addition, the Illinois results were compared to forest health in other regions.

The canopy health measurements demonstrate relatively low signs of damage among most species and most categories (Table 3). The exceptions are a relatively high incidence of crown dieback in white oak (*Quercus alba*) and sugar maple (*Acer saccharum*) (Table 3). It is not clear why these species are showing these potential symptoms of stress. Likewise, silver maple (*Acer saccharinum*) and sweetgum (*Liquidambar styraciflua*) showed relatively high frequencies of low crown density (Table 3). Again, we have little information with which to interpret these data, but sweetgum is often susceptible to crown damage as a result of late spring freezes, as was the case over much the state in 1992. There did not appear to be any significant differences in tree health between upland and bottomland forests or between publicly owned versus private upland woodlands. These results also demonstrate uniformly lower levels of damage in Illinois than in comparable studies for all crown damage parameters; Illinois trees appear in good health compred to those in Southern, Mid-Atlantic and New England states (Table 3).

## Herbaceous Species Diversity

The FHM study was used to measure floristic composition and diversity among Illinois forests. Three 1-m$^2$ quadrats were sampled for plant cover in each of four subplots at each site. The results indicated no differences in overstory or understory species richness in forests differing in ownership category (public versus private), or in upland versus lowland forests (Table 4). Despite wide variation in the mean number of understory species sampled (range: 3.0 to 13.8/m$^2$), understory diversity did not correlate well with general characteristics of the forest plot (e.g., overstory composition, tree density). Thus, although different forest types received different levels of management attention, no systematic differences in the ability of forest types to conserve forest health or species diversity were demonstrated. Further, this sampling

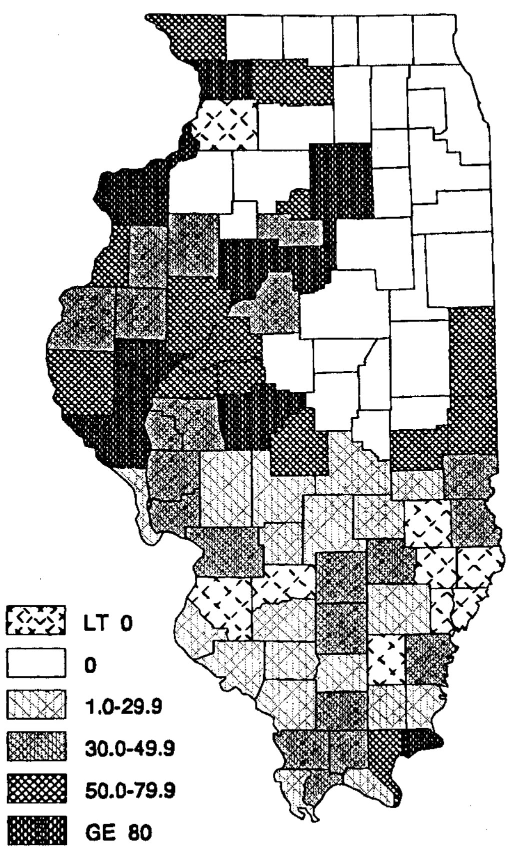



*Figure 17. Changes in forest volume by county from 1962 to 1985, given in millions of cubic feet of sawtimber. [Note: for 28 counties with no coded change, no specific data were available for 1962 volumes; over all these prairie counties, however, there was a 269% increase in volume between 1962 and 1985.]*

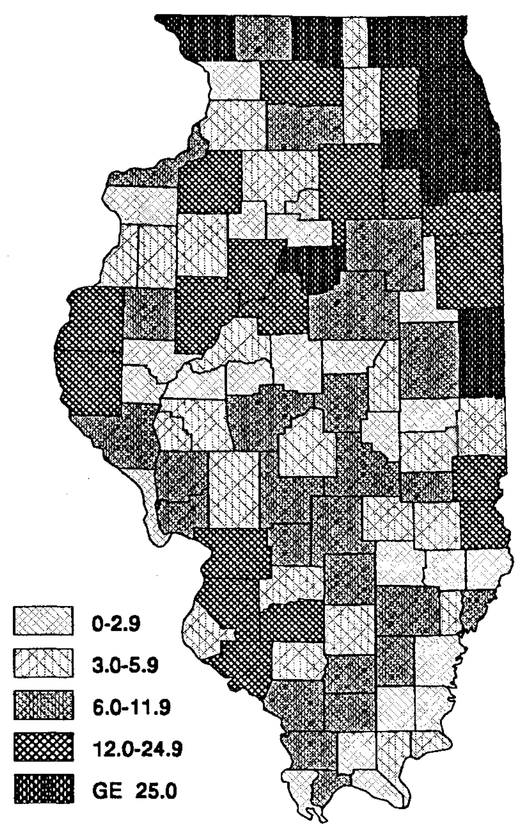



*Figure 18. Number of standard cords of fuelwood (x 1000) produced in each Illinois county, 1983.*

provides no specific indicators to suggest how forest diversity may be increased or maintained.

## Exotic Forest Weeds

Exotic plant species in Illinois may be defined in three contexts—broad, narrow, and legal. In a broad sense, exotic species are those that did not naturally occur in Illinois before European settlement. This includes species that are common in surrounding states but were formerly not found in Illinois. At present, exotic species make up 28% of the Illinois flora. Table 5 shows the increase of exotic species in the flora over the past 146 years. From 1975 to 1992 the number of exotic species does not appear to have increased.

In the narrow sense, exotic species are all plant species not native to North America. Seventy-eight percent of the 28% of exotic species in the Illinois flora are non-North American natives; these species thus constitute about 21% of the Illinois flora.

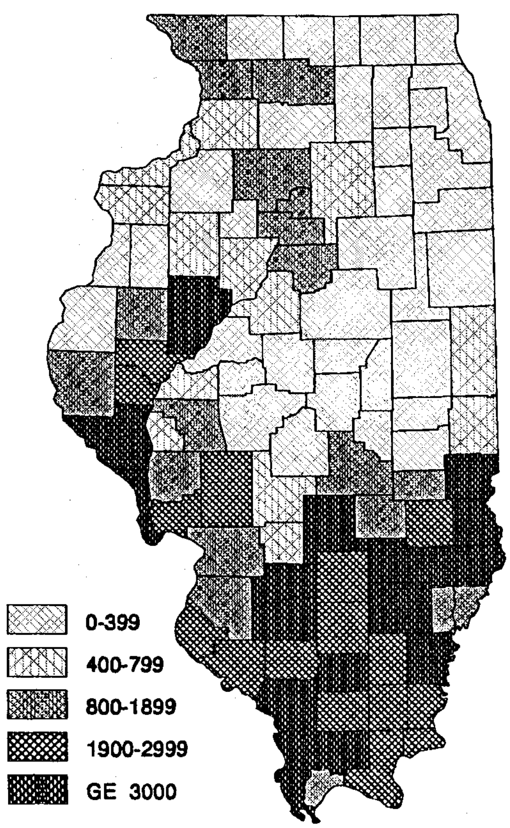



*Figure 19. Sawlog production (in thousands of cubic feet) by county, 1985.*

The legal definition of an exotic species in Illinois is provided by the Illinois Exotic Weed Act (IEWA) of 1988. It defines an exotic plant as "those plants not native to North America which, when planted, either spread vegetatively or naturalize and degrade natural communities, reduce the value of fish and wildlife and wildlife habitat, or threaten an Illinois endangered species." (Gould and Gould 1991). Although many species fit this description, at present only three exotic species are covered by the IEWA —Japanese honeysuckle (*Lonicera japonica* Thunb.), multiflora rose (*Rosa multiflora* Thunb.), and purple loosestrife (*Lythrum salicaria* L.).

The definition of an exotic species in the IEWA highlights some of the reasons exotic species are considered undesirable components of the Illinois flora. Some exotic species are barely able to survive in Illinois and are poorly established, but many more are widespread and aggressive in growth habit. Generally, these more successful and aggressive exotic weeds originate from an area that has a climate similar to Illinois and do well in the state in the absence of their natural pests. These exotic weeds alter the structure, species composition, and diversity of native plant communities. Table 6 lists 25 of the species that pose the most serious threat in native Illinois forest communities.

Exotic weedy shrubs are currently the most serious threat to Illinois forest communities. Often these exotic shrubs were intentionally introduced by landowners and wildlife managers. The shrubs were easy to obtain, were relatively disease- and pest-free, and reproduced rapidly. Many, such as amur honeysuckle (*Lonicera maackii* [Rupr.] Maxim.), autumn olive (*Elaeagnus umbellata* Thunb.), common buckthorn (*Rhamnus cathartica* L.), multiflora rose, glossy buckthorn (*Rhamnus frangula* L.), and tartarian honeysuckle (*Lonicera tatarica* L.) were introduced to provide food and cover for wildlife. Some exotic shrubs, such as multiflora rose, were also used to reduce erosion, provide living fences for livestock (Albaugh et al. 1977), serve as crash barriers along highways, and reduce headlight glare in the median of highways (Schery 1977). Other shrubs, such as amur honeysuckle, Japanese barberry (*Berberis thunbergii* DC.), privet (*Ligustrum obtusifolium* Sieb. & Zucc.), tartarian honeysuckle, and winged euonymus (*Euonymus alata* [Thunb.] Sieb.) were frequently planted as ornamentals in Illinois.

These shrubs vary widely in the severity and range of their invasion in our native forest communities. A few shrubs, such as common buckthorn, are presently of major concern in northern Illinois forests, while multiflora rose is a major problem in forests throughout Illinois. Autumn olive generally does not do well in the deep shade of Illinois forests and is more commonly encountered in disturbed or weedy areas. However, it is spread by birds that regurgitate the seeds and may quickly invade newly timbered or disturbed sites. Although first released in 1963, autumn olive was not considered to spread extensively from cultivation. The Illinois Department of Conservation began producing autumn olive in 1964, and by 1982 their nurseries were distributing more than 1 million autumn olive seedlings per year (Harty 1986). The Illinois Department of Conservation no longer provides autumn olive through its seedling nursery program, and the department is currently growing only native species. Nonetheless, this species is now expected to naturalize throughout the southern two-thirds of Illinois (Ebinger 1983). Another example is winged euonymus, a native to China and Japan, which has been reported as rarely escaping from cultivation in the eastern United States (Gleason 1952). However, winged euonymus was first reported as naturalized in Illinois in 1973; some of the plants were more than 25 years old (Ebinger and Phillippe 1973). It is presently found in 13 counties in Illinois and undoubtedly occurs in many more. Unlike autumn olive, the winged euonymus can grow and reproduce in the dense shade of relatively undisturbed forest communities (Ebinger et al. 1984). Many exotic shrubs are now serious pests, and others have the potential to become major problems in Illinois forests.

Second to the shrubs as a serious threat to Illinois forest communities are woody vines. Table 6 lists four vines causing the most problems. Japanese honey-suckle, the most troublesome exotic weedy vine, was introduced into the United States as an ornamental and

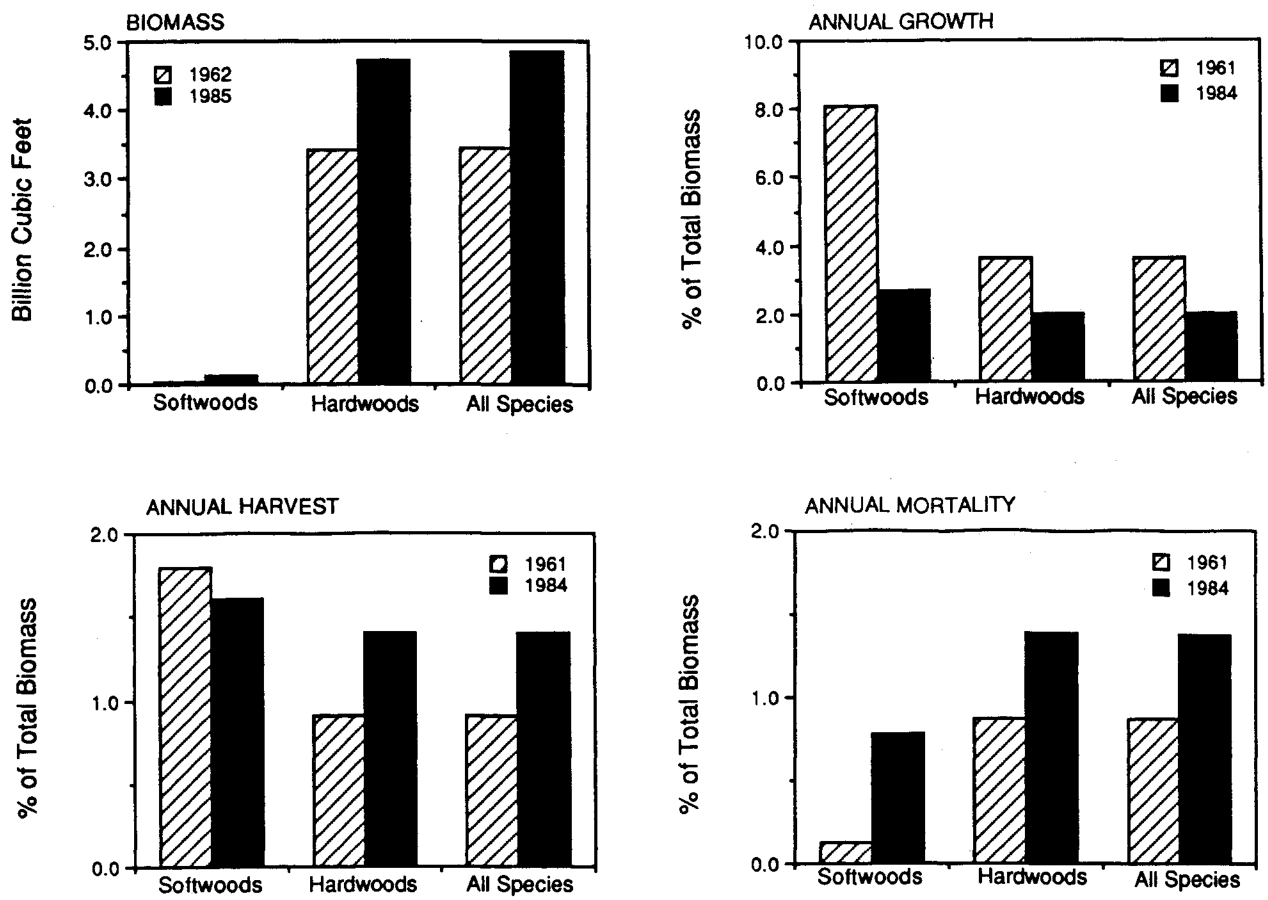



*Figure 20. Biomass (top left), annual growth (top right), annual harvest (bottom left), and annual mortality (bottom right) of forest growing stock, 1961 (or 1962) and 1984. Source: Hahn 1987.*

Table 1. Annual mortality rates for major tree species in Illinois. Data compiled by the U.S. Forest Service (1987).

| Species | Net volume | % annual mortality | Source (%) Insects | Disease | Weather | Other |
|---|---|---|---|---|---|---|
| White Oak | 1,017,620 | 0.535 | - | 45.9 | - | 54.1 |
| Red Oak | 1,062,426 | 1.225 | 2.1 | 40.8 | 3.8 | 46.7 |
| Hickory | 522,473 | 1.010 | 24.3 | 15.8 | 8.8 | 51.1 |
| Basswood | 54,075 | 1.041 | - | - | - | 100. |
| Beech | 12,096 | 0.405 | - | - | - | 100. |
| Hard maple | 163,083 | 0.658 | - | 51.9 | - | 48.1 |
| Soft maple | 341,610 | 1.432 | 34.9 | - | 31.0 | 34.1 |
| Elm | 267,399 | 6.449 | 0.8 | 56.3 | - | 42.9 |
| Ash | 260,998 | 0.983 | - | 29.5 | 13.0 | 57.5 |
| Sycamore | 134,626 | 1.570 | - | - | - | 100. |
| Cottonwood | 157,795 | 1.658 | - | 47.8 | 52.2 | - |
| Willow | 50,267 | 1.653 | - | 28.0 | 51.1 | 20.8 |
| Hackberry | 93,543 | 1.368 | - | - | - | 100. |
| Bigtooth Aspen | 1,945 | 2.108 | - | - | - | 100. |
| River Birch | 36,822 | 1.472 | - | - | 19.9 | 80.1 |
| Sweetgum | 45,077 | 1.477 | - | - | - | 100. |
| Tupelo | 28,043 | 1.590 | - | 51.8 | - | 48.2 |
| Black Cherry | 87,658 | 1.629 | - | 74.0 | - | 26.0 |
| Black Walnut | 119,982 | 1.023 | - | 67.2 | - | 32.8 |
| Butternut | 5,712 | 1.173 | - | - | - | 100. |
| Yellow Poplar | 51,773 | 1.120 | - | - | - | 100. |
| Other | 203,486 | 1.827 | - | - | - | 100. |
| Jack Pine | 702 | 0.285 | - | - | - | 100. |
| Red Pine | 11,986 | 0.801 | - | - | - | 100. |
| White Pine | 16,811 | 0.773 | 100. | - | - | - |
| Loblolly and Shortleaf Pine | 64,736 | 0.695 - | 36.9 | - | 63.1 | |
| Baldcypress | 8,904 | 1.606 - | - | - | 100. | |
| Eastern redcedar | 11,359 | 0.607 - | - | - | 100. | |
| Other softwoods | 2,995 | 0.534 - | - | - | 100. | |

has been widely planted for wildlife enhancement. It provides valuable cover for bobwhite quail (*Colinus virginianus*) and turkey (*Meleargris gallopavo*), the stems and leaves serve as food for white-tail deer (*Odocoilens virginiana*), and the berries are consumed by a number of song birds (Handley 1945). Japanese honeysuckle may be found in shaded and open conditions and, despite its ornamental use and value to wildlife, is a tremendous threat to native plant species.Although it is seldom a major concern in established forests, when the forest is disturbed by natural causes such as windthrow or disease, or by human activities such as lumbering or construction, Japanese honeysuckle grows rapidly (Evers 1984). Rapid growth of this vine is a threat to rare native plant species and may modify natural succession. The vine may physically deform, bend, or eventually kill saplings, and foresters are sometimes reluctant to cut forests that have been invaded by Japanese honeysuckle because they fear the forest will not become reestablished following cutting (Little and Soanes 1967).

Table 2. Growth and mortality rates of growing stock timber by ownership category. Data expressed as a percentage of the total biomass.

| Ownership class | Growth (%) | Mortality (%) |
|---|---|---|
| National forest | 1.90 | 1.16 |
| Misc. federal land | 1.03 | 1.77 |
| State | 0.86 | 1.36 |
| County and municipal | 2.25 | 1.59 |
| Forest industry | 2.61 | 0.95 |
| Farmers | 1.98 | 1.41 |
| Misc. private corp. | 1.86 | 1.47 |
| Misc. private individuals | 2.12 | 1.33 |
| All | 1.99 | 1.38 |

Table 3. Evaluation of health (as indicated by crown density, crown dieback, and foliage transparency) of individual forest tree species in Illinois and a comparison of hardwood health in Illinois with that in other regions. Except for values for sample size, all numbers represent percentages of trees.

**Health of individual species in Illinois**

| Crown density[1] | n | Good | Average | Poor | |
|---|---|---|---|---|---|
| White oak | 77 | 85.7 | 14.3 | 0.0 | |
| American elm | 51 | 68.6 | 31.4 | 0.0 | |
| Sugar maple | 49 | 75.5 | 24.5 | 0.0 | |
| Silver maple | 43 | 65.1 | 32.6 | 2.3 | |
| Sweetgum | 28 | 50.0 | 46.4 | 3.6 | |
| Black oak | 28 | 85.7 | 14.3 | 0.0 | |
| Black walnut | 25 | 88.0 | 12.0 | 0.0 | |
| Box elder | 25 | 84.0 | 16.0 | 0.0 | |
| Red elm | 23 | 60.9 | 39.1 | 0.0 | |
| Red oak | 20 | 85.0 | 15.0 | 0.0 | |
| **Crown dieback[2]** | | **None** | **Light** | **Moderate** | **Severe** |
| White oak | 77 | 93.5 | 3.9 | 0.0 | 2.6 |
| American elm | 51 | 96.1 | 2.0 | 2.0 | 0.0 |
| Sugar maple | 49 | 98.0 | 0.0 | 0.0 | 2.0 |
| Silver maple | 43 | 95.3 | 4.7 | 0.0 | 0.0 |
| Sweetgum | 28 | 100.0 | 0.0 | 0.0 | 0.0 |
| Black oak | 28 | 89.3 | 10.7 | 0.0 | 0.0 |
| Black walnut | 25 | 92.0 | 8.0 | 0.0 | 0.0 |
| Box elder | 25 | 76.0 | 20.0 | 4.0 | 0.0 |
| Red elm | 23 | 91.3 | 8.7 | 0.0 | 0.0 |
| Red oak | 20 | 85.0 | 10.0 | 5.0 | 0.0 |
| **Foliage transparency[3]** | | **Normal** | **Moderate** | **Severe** | |
| White oak | 77 | 98.7 | 1.3 | 0.0 | |
| American elm | 51 | 98.0 | 2.0 | 0.0 | |
| Sugar maple | 49 | 100.0 | 0.0 | 0.0 | |
| Silver maple | 43 | 100.0 | 0.0 | 0.0 | |
| Sweetgum | 28 | 96.6 | 3.4 | 0.0 | |
| Black oak | 28 | 100.0 | 0.0 | 0.0 | |
| Black walnut | 25 | 100.0 | 0.0 | 0.0 | |
| Box elder | 25 | 96.0 | 4.0 | 0.0 | |
| Red elm | 23 | 100.0 | 0.0 | 0.0 | |
| Red oak | 20 | 100.0 | 0.0 | 0.0 | |

**Hardwood health in Illinois compared to that in other regions**

| Crown density | | Good | Average | Poor | |
|---|---|---|---|---|---|
| Illinois[4] | 655 | 75.7 | 23.2 | 1.1 | |
| Southern U.S.[5] | 2746 | 37.9 | 61.3 | 0.8 | |
| New England[6] | 2602 | 54.8 | 41.7 | 3.4 | |
| Mid-Atlantic[6] | 351 | 68.7 | 30.2 | 1.1 | |
| **Crown dieback** | | **None** | **Light** | **Moderate** | **Severe** |
| Illinois | 655 | 91.9 | 5.0 | 1.4 | 1.7 |
| Southern U.S. | 2746 | 85.1 | 13.1 | 1.3 | 0.4 |
| New England | 2602 | 78.4 | 17.3 | 2.9 | 1.4 |
| Mid-Atlantic | 351 | 70.1 | 29.3 | 0.6 | 0.0 |
| **Foliage transparency** | | **Normal** | **Moderate** | **Severe** | |
| Illinois | 655 | 75.7 | 23.2 | 1.1 | |
| Southern U.S. | 2746 | 37.9 | 61.3 | 0.8 | |
| New England | 2602 | 54.8 | 41.7 | 3.4 | |
| Mid-Atlantic | 351 | 68.7 | 30.2 | 1.1 | |

[1] Crown denstiy class: good > 50%; average = 21–50%; poor < 20%.
[2] Crown dieback class: none = 0–5%; light = 6–20%; moderate = 21–50%; severe > 50%.
[3] Foliage transparency class: normal <30%; moderate = 31–50%; severe >50%.
[4] Data from Iverson and Schwartz, unpublished.
[5] Data from Bechtold et al. 1992.
[6] Data from Eagar and Adams 1992.

The herbaceous exotic weeds found in nearly all of the forests in Illinois include annual, biennial, and perennial herbs (Table 6). Common chickweed (*Stellaria media* [L.] Vill.) has been found in all 102 counties of Illinois. However, garlic mustard (*Alliaria petiolata* [Bieb.] Cavara & Grande) appears to be the greatest threat to Illinois forests. Introduced as a food or medicinal herb, it was first found in Cook County, Illinois, north of Chicago, in 1918. Garlic mustard readily spreads into high-quality old-growth forest and

Table 4. Mean herb diversity per square meter in forest plots sampled in 1992.

| | Herb diversity | SE | n |
|---|---|---|---|
| Ownership (Uplands only) | | | |
| Public | 6.53 | 3.1 | 19 |
| Private | 8.50 | 3.5 | 5 |
| Forest type (public only) | | | |
| Upland | 6.53 | 3.1 | 19 |
| Bottomland | 7.59 | 3.6 | 7 |

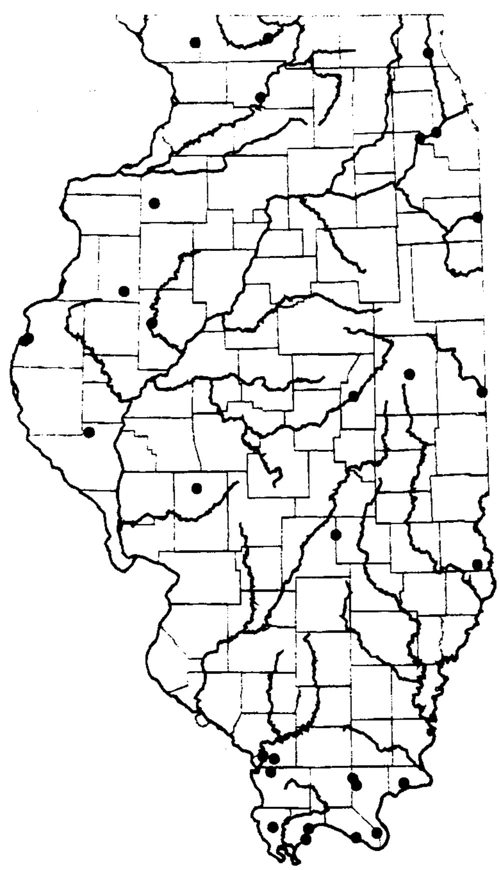


*Figure 21. Locations of 31 study sites sampled to assess forest health in Illinois using the FHM sampling procedure (see text for additional explanation).*

may now be found in at least 41 counties in Illinois (Schwegman 1988, Nuzzo 1991). This biennial plant produces numerous seeds and is a major threat to Illinois' woodland herbaceous flora, and to wildlife that depend on it for food and cover (Schwegman 1988). The threat of garlic mustard is particularly acute since it has only recently spread through the state (Figure 22), and populations are still expanding throughout the state.

Table 5. Percentage of alien species in the Illinois spontaneous vascular plant flora from 1846 to 1992.

| Flora author | Year of publication | % alien species |
|---|---|---|
| S.B. Mead | 1846 | 10.2 |
| I.A. Lapham | 1857 | 6.6 |
| H.N. Patterson | 1876 | 7.5 |
| W.C. Flagg and T.J. Burrill | 1878 | 10.5 |
| G.N. Jones | 1945 | 15.9 |
| G.N. Jones | 1950 | 15.9 |
| G.N. Jones and G.D. Fuller | 1955 | 25.0 |
| G.S. Winterringer and R.A. Evers | 1960 | 26.0 |
| G.N. Jones | 1963 | 24.7 |
| R.M. Myers | 1972 | 25.4 |
| R.H. Mohlenbrock | 1975 | 27.9 |
| R.H. Mohlenbrock and D.M. Ladd | 1978 | 28.7 |
| ILPIN | 1992 | 28.0 |

Source: Henry and Scott 1980.

Four problematic exotic weed trees in Illinois forests are amur maple (*Acer ginnala* Maxim.), golden-rain tree (*Koelreuteria paniculata* Laxm.), tree-of-heaven (*Ailanthus altissima* [Mill.] Swingle), and white mulberry (*Morus alba* L.). Tree-of-heaven and white mulberry are found throughout Illinois. Tree-of-heaven is especially abundant on steep slopes below the bluffs of the Illinois and Mississippi rivers. Golden-rain tree, though uncommon, has also become naturalized on steep slopes below the river bluffs north of Alton, Illinois, in Madison County. Amur maple, a native of central and northern Manchuria, northern China, and Japan is commonly planted as an ornamental throughout Illinois. This species most commonly naturalizes in open fields and prairies but occasionally occurs in open woods and potentially may become a major weed problem in the Midwest (Ebinger and McClain 1991).

Exotic weeds make up more than one-fifth of Illinois' flora, and they affect forest communities. The distur-

Table 6. The 25 exotic weeds that pose the greatest threat to Illinois forests.

| Growth habit | Common name | Scientific name |
|---|---|---|
| Herbs | Garlic mustard | *Alliaria petiolata* Bieb. |
| | Ground ivy | *Glechoma hederacea* L. var. *micrantha* |
| | Sericea lespedeza | *Lespedeza cuneata* Dum.-Cours. |
| | Moneywort | *Lysimachia nummularia* L. |
| | Eulalia | *Microstegium vimineum* Trin. |
| | Beefsteak plant | *Perilla frutescens* L. |
| | Creeping smartweed | *Polygonum cespitosum* var. *longisetum* DeBruyn |
| | Self-heal | *Prunella vulgaris* L. |
| | Common chickweed | *Stellaria media* L. |
| Shrubs | Japanese barberry | *Berberis thunbergii* DC. |
| | Autumn olive | *Elaeagnus umbellata* Thunb. |
| | Winged euonymus | *Euonymus alata* Thunb. |
| | Privet | *Ligustrum obtusifolium* Sieb. & Zucc. |
| | Amur honeysuckle | *Lonicera maackii* Rupr. |
| | Tartarian honeysuckle | *Lonicera tatarica* L. |
| | Common buckthorn | *Rhamnus cathartica* L. |
| | Glossy buckthorn | *Rhamnus frangula* L. |
| | Multiflora rose | *Rosa multiflora* Thunb. |
| Trees | Amur maple | *Acer ginnala* Maxim. |
| | Tree-of-heaven | *Ailanthus altissima* Mill. |
| | Golden-rain tree | *Koelreuteria paniculata* Laxm. |
| | White mulberry | *Morus alba* L. |
| Vines | Round-leaved bittersweet | *Celastrus orbiculatus* Thunb. |
| | Climbing euonymus | *Euonymus fortunei* Turcz. |
| | Japanese honeysuckle | *Lonicera japonica* Thunb. |
| | Kudzu-vine | *Pueraria lobata* Willd. |

Sources: L.R. Iverson, L.R. Phillippe, and J. Schwegman, unpublished data.

bance is quite variable in degree and may affect any stratum. In areas severely invaded by exotic shrubs and vines, succession may be altered so the structure of the forest is drastically changed. Exotic weeds also alter the biodiversity of Illinois forests. Japanese honeysuckle and multiflora rose are two exotic weeds recognized by the IEWA that pose serious threats to the forests of Illinois, and for these species, "It shall be unlawful for any person, corporation, political subdivision, agency or department of the State to buy, sell, offer for sale, distribute or plant seeds, plants, or plant parts, of exotic weeds without a permit issued by the Department of Conservation" (Gould and Gould 1991). Exotic weeds are a serious problem in Illinois forests, and recovery depends on the appropriate actions taken and enforced, such as those stated in the Illinois Exotic Weed Act.

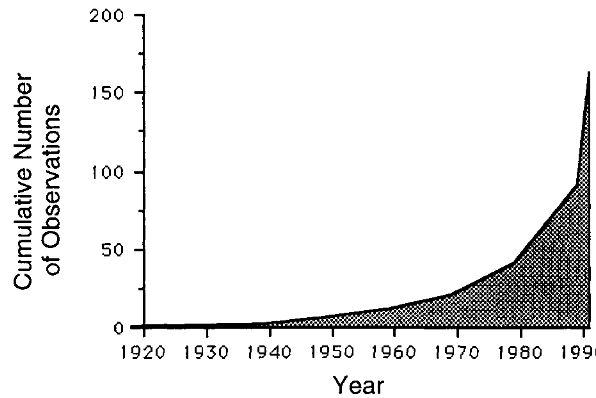



*Figure 22. Spread of garlic mustard (*Alliaria petiolata*), an exotic weedy pest species, through Illinois, as demonstrated by the cumulative number of occurrences by decade. Data are from Nuzzo (1993) and are based on herbarium collections, sight observations, and literature references.*

## Threatened and Endangered Forest Plants

Threatened and endangered plants make up 17% of our native Illinois flora. Threatened plants are those likely to become endangered within the foreseeable future, and endangered plants are those in danger of extirpation from Illinois. Three hundred fifty-six taxa are listed as threatened or endangered under the Illinois Endangered Species Act (Herkert 1991). Forty-nine percent of these taxa have been found in the forests of Illinois. Thirty-three threatened taxa are listed in Table 7, and 142 endangered taxa are listed in Table 8.

Of the 172 vascular plant families in the Illinois flora (Mohlenbrock 1986), 32% are represented by these threatened and endangered forest taxa. The sedge family (Cyperaceae) has the most taxa (22), followed by the grass family (Poaceae) with 14, and the aster (Asteraceae) and orchid (Orchidaceae) families with 10 each.

Fourteen percent of the Illinois genera of vascular plants are represented by these threatened and endangered forest taxa. Sedge (*Carex*) is the most represented taxa (18), followed by panic grasses (*Panicum*) with 5, and grape ferns (*Botrychium*) and bluegrasses (*Poa*) with 4 each.

Most of these threatened and endangered species are at the edge of their natural distribution. Forty-four percent have primarily north or northeastern affinities, 31% have primarily south or southeastern affinities, 20% have primarily eastern affinities, and the remaining 5% have western, southwestern, or midwestern affinities. These species include 17 trees, 20 shrubs, 6 woody vines, 19 ferns and fern allies, 13 annual or biennial herbs, and 99 perennial herbs.

Of the 175 threatened and endangered taxa in the forests of Illinois, 15 listed as state endangered have not been seen in the past 20 years. These species are Price's groundnut (*Apios priceana* Robins), screwstem (*Bartonia paniculata* [Michx.] Muhl.), dwarf grape fern (*Botrychium simplex* E. Hitchc.), lined sedge (*Carex striatula* Michx.), spotted wintergreen (*Chimaphila maculata* [L.] Pursh), finger dog-shade (*Cynosciadium digitatum* DC.), moccasin flower (*Cypripedium acaule* Ait.), northern cranesbill (*Geranium bicknellii* Britt.), cow wheat (*Melampyrum lineare* Desr.), long-leaved panic grass (*Panicum longifolium* Torr.), white mountain mint (*Pycnanthemum albescens* Torr. & Gray), round-leaved shinleaf (*Pyrola americana* Sweet), goldenrod (*Solidago arguta* Ait.), nodding trillium (*Trillium cernuum* L.), and deerberry (*Vaccinium stamineum* L.).

Two Illinois state-endangered species, Price's groundnut and small whorled pogonia (*Iostria medeoloides* [Pursh] Raf.), are also federally listed species. Price's groundnut, a perennial herbaceous vine, is a federally threatened species, which means it is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Price's groundnut is known only from Alabama, Illinois, Kentucky, Mississippi, and Tennessee. In Illinois, Price's groundnut was collected in Union County in 1941. Its collection location has been repeatedly searched, but Price's groundnut has not been relocated in Illinois (Bowles et al. 1991). Small whorled pogonia, a perennial herb, is a federally endangered species, which means it is in danger of extinction or of extirpation from a significant portion of its range. Although small whorled pogonia is known from a number of states, it is often found in only small numbers. In Illinois, for example, small whorled pogonia is known from a single population in Randolph County (Herkert 1991).

About 50 taxa formerly known from Illinois are thought to be extirpated from the state (Page and Jeffords 1991). Twelve are forest species: eight monocots and four dicots. The two flowering plant families with the most extirpated species are the grasses with four and the orchids with three.

The monocots are drooping wood reed (*Cinna latifolia* [Trev.] Griseb.), bluebead lily (*Clintonia borealis* [Ait.] Raf.), brown plume grass (*Erianthus brevibarbis* Michx.), adder's mouth orchid (*Malaxis unifoia* Michx.), rice grasses (*Oryzopsis asperifolia* Michx. and *Oryzopsis pungens* [Torr.] Hitchc.), Hooker's orchid (*Platanthera hookeri* Torr.), and round-leaved orchid (*Platanthera orbiculata* [Pursh] Torr.). The four dicots are trailing arbutus (*Epigaea repens* L. var. *glabrifolia* Fern.), twinflower (*Linnaea borealis* L. ssp. *americana* [Forbes] Hulten), flowering wintergreen (*Polygala paucifolia* Willd.), and false bugbane (*Troutvetteria caroliniansis* [Walt.] Vail).

Six species (bluebead lily , trailing arbutus, twinflower, rice grass, round-leaved orchid, and flowering wintergreen) are northern Illinois taxa, one (Hooker's orchid) is a northern and western Illinois taxon, one (drooping wood reed) is a northern and southern Illinois taxon, three (adder's mouth orchid, rice grass, false bugbane)

Table 7. Threatened vascular plants in Illinois forests. All taxa are perennial unless otherwise stated.

| | Scientific name | Common name | Growth habit |
|---|---|---|---|
| Ferns | *Botrychium multifidum* (Gmel.) Rupr. | Northern grape fern | Evergreen |
| | *Asplenium bradleyi* D.D. Eat. | Bradley's spleenwort | Evergreen |
| | *Asplenium resiliens* Kunze | Black spleenwort | Evergreen |
| | *Dennstaedtia punctilobula* (Michx.) | Hay-scented fern | Deciduous |
| Gymnosperms | *Thuja occidentalis* L. | Arbor vitae | Tree |
| | *Larix laricina* (DuRoi) | Tamarack | Tree |
| Dicots | *Aristolochia serpentaria* L. var. *hastata* (Nutt.) | Virginia snakeroot | Herb |
| | *Matelea obliqua* (Jacq.) | Climbing milkweed | Herb; vine |
| | *Aster furcatus* Burgess | Forked aster | Herb |
| | *Aster schreberi* Nees | Schreber's aster | Herb |
| | *Aster undulatus* L. | Wavy-leaved aster | Herb |
| | *Circium carolinianum* (Walt.) | Carolina thistle | Herb; biennial |
| | *Helianthus angustifolius* L. | Narrow-leaved sunflower | Herb |
| | *Solidago sciaphila* Steele | Cliff goldenrod | Herb |
| | *Lonicera flava* Sims | Yellow honeysuckle | Woody vine |
| | *Sambucus pubens* Michx. | Red-berried elder | Shrub |
| | *Euonymus americanus* L. | Strawberry bush | Shrub |
| | *Lathyrus ochroleucus* Hook. | Pale vetchling | Herb |
| | *Quercus phellos* L. | Willow oak | Tree |
| | *Quercus prinus* L. | Rock chestnut oak | Tree |
| | *Trientalis borealis* Raf. | Star flower | Herb |
| | *Rubus pubescens* Raf. | Dwarf raspberry | Shrub |
| | *Sullivantia renifolia* Rosendahl | Sullivantia | Herb |
| | *Besseya bullii* (Eat.) Rydb. | Kitten tails | Herb |
| | *Styrax americana* Lam. | Storax | Shrub |
| | *Viola conspersa* Reichenb. | Dog violet | Herb |
| Monocots | *Scirpus polyphullus* Vahl | Bulrush | Herb |
| | *Polygonatum pubescens* (Willd.) | Downy Solomon's seal | Herb |
| | *Stenanthium gramineum* (Ker) | Grass-leaved lily | Herb |
| | *Trillium viride* Beck | Green trillium | Herb |
| | *Veratrum woodii* Robbins | False hellebore | Herb |
| | *Corallorhiza maculata* Raf. | Spotted coral-root orchid | Herb |
| | *Oryzopsis racemosa* (J.E. Smith) | Rice grass | Herb |

Table 8. Endangered vascular plants in Illinois forests. All taxa are perennial unless otherwise stated.

| | Scientific name | Common name | Growth habit |
|---|---|---|---|
| Fern allies | *Equisetum pratense* Ehrh. | Meadow horsetail | Deciduous |
| | *Equisetum scirpoides* Michx. | Dwarf scouring rush | Evergreen |
| | *Equisetum sylvaticum* L. | Horsetail | Deciduous |
| | *Lycopodium dendroideum* Michx. | Ground pine | Evergreen |
| | *Lycopodium clavatum* L. | Running pine | Evergreen |
| Ferns | *Botrychium biternatum* (Sav.) | Southern grape fern | Evergreen |
| | *Botrychium matricariaefolium* A. Br. | Daisyleaf grape fern | Deciduous |
| | *Botrychium simplex* E. Hitchc. | Dwarf grape fern | Deciduous |
| | *Cystopteris laurentiana* (Weath.) Blasd. | Laurentian fragile fern | Deciduous |
| | *Dryopteris celsa* (Wm. Palmer) Small | Logfern | Deciduous |
| | *Gymnocarpium dryopteris* (L.) Newm. | Oak fern | Deciduous |
| | *Gymnocarpium robertianum* (Hoffm.) Newn. | Scented oak fern | Deciduous |
| | *Thelypteris noveboracensis* (L.) Nieuwl. | New York fern | Deciduous |
| | *Thelypteris phegopteris* (L.) Slosson | Long beech fern | Deciduous |
| | *Woodsia ilvensis* (L.) R. Br. | Rusty woodsia | Deciduous |
| Gymnosperms | *Pinus echinata* Mill. | Shortleaf pine | Tree |
| | *Pinus resinosa* Ait. | Red pine | Tree |
| Dicots | *Justicia ovata* (Walt.) Lindau | Water willow | Herb |
| | *Adoxa moschatellina* L. | Moschatel | Herb |
| | *Iresine rhizomatosa* Standl. | Bloodleaf | Herb |
| | *Conioselinum chinense* (L.) BSP | Hemlock parsley | Herb |
| | *Cynosciadium digitatum* DC. | Finger dog-shade | Herb |
| | *Ptilimnium costatum* (Ell.) Raf. | Mock Bishop's weed | Herb; annual |
| | *Ptilimnium nuttallii* (DC.) Britt. | Mock Bishop's weed | Herb; annual |
| | *Matelea decipiens* (Alex.) Woods | Climbing milkweed | Herb; vine |
| | *Eupatorium incarnatum* Walt. | Thoroughwort | Herb |
| | *Lactuca hirsuta* Muhl. | Wild lettuce | Herb; biennial |
| | *Melanthera nivea* (L.) Small | White melanthera | Herb |
| | *Solidago arguta* Ait. | Goldenrod | Herb |
| | *Berberis canadensis* P. Mill. | Allegheny barberry | Shrub |
| | *Betula alleghaniensis* Britt. | Yellow birch | Tree |
| | *Betula populifolia* Marsh. | Gray birch | Tree |
| | *Hackelia americana* (Gray) Fern. | Stickseed | Herb |
| | *Lonicera dioica* L. var. *glaucescens* Rydb. | Red honeysuckle | Woody vine |
| | *Viburnum molle* Michx. | Arrowwood | Shrub |
| | *Stellaria pubera* Michx. | Great chickweed | Herb |
| | *Cornus canadensis* L. | Bunchberry | Herb |
| | *Corylus cornuta* Marsh. | Beaked hazelnut | Shrub |
| | *Melothria pendula* L. | Squirting cucumber | Herb; annual vine |
| | *Gaultheria procumbens* L. | Wintergreen | Subshrub |
| | *Vaccinium stamineum* L. | Deerberry | Shrub |
| | *Amorpha nitens* Boyn. | Smooth false indigo | Shrub |
| | *Apios priceana* Robins | Price's groundnut | Herb; vine |
| | *Astragalus crassicarpus* Nutt. var. *trichocalyx* | Large ground plum | Herb |
| | *Cladastris lutea* (Michx. f.) K. Koch | Yellowwood | Tree |
| | *Dioclea multiflora* (Torr. & Gray) | Boykin's dioclea | Herb; vine |
| | *Trifolium reflexum* L. | Buffalo clover | Herb; annual/biennial |
| | *Castanea dentata* (Marsh.) Borkh. | American chestnut | Tree |
| | *Quercus nuttallii* Palmer | Nuttall's oak | Tree |
| | *Bartonia paniculata* (Michx.) Muhl. | Screwstem | Herb |
| | *Geranium bicknellii* Britt. | Northern cranesbill | Herb; annual/biennial |
| | *Carya pallida* (Ashe) Engl. & Graebn. | Pale hickory | Tree |
| | *Pycnanthemum albescens* Torr. & Gray | White mountain mint | Herb |
| | *Pycnanthemum torrei* Benth. | Mountain mint | Herb |
| | *Synandra hispidula* (Michx.) Baill. | Hairy synandra | Herb; annual/biennial |

Table 8 (continued)

| | Scientific name | Common name | Growth habit |
|---|---|---|---|
| | *Circaea alpina* L. | Small enchanter's nightshade | Herb |
| | *Oxalis illinoensis* Schwegman | Illinois wood sorrel | Herb |
| | *Corydalis aurea* Willd. | Golden corydalis | Herb; biennial |
| | *Plantago cordata* Lam. | Heart-leaved plantain | Herb |
| | *Lysimachia fraseri* Duby | Loosestrife | Herb |
| | *Lysimachia radicans* Hook. | Creeping loosestrife | Herb |
| | *Chimaphila maculata* (L.) Pursh | Spotted wintergreen | Herb |
| | *Chimaphila umbellata* (L.) Bart. | Pipsissewa | Herb |
| | *Pyrola americana* Sweet | Round-leaved shinleaf | Herb |
| | *Cimicifuga americana* Michx. | American bugbane | Herb |
| | *Cimicifuga racemosa* (L.) Nutt. | False bugbane | Herb |
| | *Clematis crispa* L. | Blue jasmine | Woody vine |
| | *Clematis occidentalis* (Hornem.) DC. | Mountain clematis | Woody vine |
| | *Clematis viorna* L. | Leatherflower | Woody vine |
| | *Berchemia scandens* (Hill) K. Koch | Supple-jack | Woody vine |
| | *Amelanchier interior* Nielsen | Shadbush | Shrub |
| | *Amelanchier sanguinea* (Pursh) DC. | Shadbush | Shrub |
| | *Malus angustifolia* (Ait.) Michx. | Narrow-leaved crabapple | Tree |
| | *Rosa acicularis* Lindl. | Rose | Shrub |
| | *Rubus enslenii* Tratt. | Arching dewberry | Shrub |
| | *Rubus odoratus* L. | Purple-flowering raspberry | Shrub |
| | *Sorbus americana* Marsh. | American mountain ash | Tree |
| | *Waldsteinia fragarioides* (Micxh.) Tratt. | Barrens strawberry | Herb |
| | *Populus balsamifera* L. | Balsam poplar | Tree |
| | *Bumelia lanuginosa* (Michx.) Pers. | Wooly buckthorn | Shrub |
| | *Ribes hirtellum* Michx. | Northern gooseberry | Shrub |
| | *Saxifraga virginiensis* Michx. | Early saxifrage | Herb |
| | *Collinsia violacea* Nutt. | Violet collinsia | Herb; annual |
| | *Melampyrum lineare* Desr. | Cow wheat | Herb; annual |
| | *Penstemon brevisepalus* Pennell | Short-sepaled beard tongue | Herb |
| | *Halesia carolina* L. | Silverbell tree | Shrub |
| | *Styrax grandifolia* Ait. | Bigleaf snowbell bush | Shrub |
| | *Tilia heterophylla* Vent. | White basswood | Tree |
| | *Planera aquatica* (Walt.) J.F. Gmel. | Water elm | Shrub |
| | *Ulmus thomasii* Sarg. | Rock elm | Tree |
| | *Urtica chamaedryoides* Pursh | Nettle | Herb; annual |
| | *Viola canadensis* L. | Canadian violet | Herb |
| | *Viola incognita* Brainerd | Hairy white violet | Herb |
| Monocots | *Sagittaria longirostra* (Micheli) J.G. Sm. | Arrowhead | Herb |
| | *Carex alata* Torr. & Gray | Winged sedge | Herb |
| | *Carex brunnescens* (Pers.) Poir. | Brownish sedge | Herb |
| | *Carex canescens* L. var. *disjuncta* Fern. | Sedge | Herb |
| | *Carex communis* Bailey | Fibrous-rooted sedge | Herb |
| | *Carex decomposita* Muhl. | Cypress-knee sedge | Herb |
| | *Carex gigantea* Rudge | Large sedge | Herb |
| | *Carex intumescens* Rudge | Swollen sedge | Herb |
| | *Carex laxiculmis* Schwein. | Spreading sedge | Herb |
| | *Carex nigromarginata* Schwein. | Black-edged sedge | Herb |
| | *Carex oxylepis* Torr. & Hook. | Sharp-scaled sedge | Herb |
| | *Carex physorhyncha* Liebm. | Bellow's bead sedge | Herb |
| | *Carex prasina* Wahlenb. | Drooping sedge | Herb |
| | *Carex reniformis* (Bailey) Small | Reniform sedge | Herb |
| | *Carex striatula* Michx. | Lined sedge | Herb |
| | *Carex styloflexa* Buckl. | Bent sedge | Herb |
| | *Carex tuckermanii* Boott | Tuckerman's sedge | Herb |
| | *Carex willdenowii* Schkuhr | Willdenow's sedge | Herb |

Table 8 (continued)

| Scientific name | Common name | Growth habit |
|---|---|---|
| *Carex woodii* Dewey | Pretty sedge | Herb |
| *Cyperus lancastriensis* Porter | Galingale | Herb |
| *Fimbristylis annua* (All.) Roem. & Schult. | Baldwin's fimbristylis | Herb; annual |
| *Scirpus verecundus* Fern. | Bashful bulrush | Herb |
| *Luzula acuminata* Raf. | Hairy woodrush | Herb |
| *Lilium superbum* L. | Turk's cap lily | Herb |
| *Medeola virginiana* L. | Indian cucumber root | Herb |
| *Trillium cernuum* L. | Nodding trillium | Herb |
| *Trillium erectum* L. | Ill-scented trillium | Herb |
| *Cypripedium acaule* Ait. | Moccasin flower | Herb |
| *Cypripedium calceolus* L. var. *parviflorum* (Salisb.) | Small yellow lady's slipper | Herb |
| *Cypripedium reginae* Walt. | Showy lady's slipper | Herb |
| *Hexastylis spicata* (Walt.) Barnh. | Crested coralroot orchid | Herb |
| *Isotria medeoloides* (Pursh) Raf. | Small whorled pogonia | Herb |
| *Isotria verticillata* (Willd.) Raf. | Whorled pogonia | Herb |
| *Platanthera clavellata* (Michx.) Luer | Wood orchid | Herb |
| *Platanthera flava* (L.) Lindl. var flava | Tubercled orchid | Herb |
| *Platanthera psycodes* (L.) Lindl. | Purple-fringed orchid | Herb |
| *Glyceria arkansana* Fern. | Arkansas manna-grass | Herb |
| *Gymnopogon ambiguus* (Michx.) BSP. | Beard grass | Herb |
| *Milum effusum* L. | Millet grass | Herb |
| *Panicum joorii* Vasey | Panic grass | Herb |
| *Panicum longifolium* Torr. | Long-leaved panic grass | Herb |
| *Panicum ravenelii* Scribn. & Merr. | Ravenel's grass | Herb |
| *Panicum stipitatum* Nash | Tall flat panic grass | Herb |
| *Panicum yadkinense* Ashe | Panic grass | Herb |
| *Poa alsodes* Gray | Grove bluegrass | Herb |
| *Poa autumnalis* Muhl. | Autumn bluegrass | Herb |
| *Poa languida* A.S. Hitchc. | Weak bluegrass | Herb |
| *Poa wolfii* Scribn. | Wolf's bluegrass | Herb |
| *Schizachne purpurascens* (Torr.) Swallen | False melic grass | Herb |

are west-central Illinois taxa, and one (brown plume grass) is a southern Illinois taxon. All of these species are more common outside Illinois.

## FOREST ANIMALS

### Trends in Wildlife Habitat

Illinois forests provide the major habitat for more than 420 vertebrate species, and losses in the quality and quantity of that habitat severely affect wildlife populations (Illinois Wildlife Habitat Commission 1985). Of the more than 420 vertebrates listed as occurring in Illinois by the Illinois Fish and Wildlife Information System (IFWIS–Illinois Department of Conservation/ Illinois Natural History Survey), 82.5% of the mammals, 62.8% of birds, and 79.7% of the amphibians and reptiles require forested habitat for a portion of their life cycle. Clearly, forests are an important component of maintaining vertebrate diversity in Illinois. A more fine-tuned method of summarizing the value of Illinois wildlife habitat is based on land use. Complete details are presented in Graber and Graber (1976), and revised calculations based on current data are given in Iverson et al. (1989). The habitat evaluation index devised by Graber and Graber is based on the relative amount of a particular habitat type within a given area, the availability of that habitat type within the state or region, the changing availability of that habitat, and the "cost" of a given habitat measured in years required to replace the ecosystem. A summary of habitat factors (which sum to the habitat evaluation index) for Illinois as a whole, as of 1985, is presented in Table 9. By this calculation, over three-quarters of the wildlife habitat (88 of 115.73 habitat factor points) is derived from forests. Elm-ash-cottonwood rates highest because this forest type has been disappearing so quickly over the past two decades (Figure 11). Oak-hickory values would be higher except that numbers in older age classes are increasing as secondary forests mature, even though numbers in younger age classes are decreasing (Figure 11). A very minor rating was earned by maple-beech because this forest type has increased so dramatically in recent years (Figure 9). Habitat factor scores were generally much more favorable for wildlife habitat in the southern half of the state, which has more forests. In fact, the total habitat factor scores for the south region were twice those of the central region, with the north region being in between (Iverson et al. 1989).

By comparing the habitat factor scores obtained by Iverson et al. (1989) for 1985 data to those of Graber and Graber (1976) for 1973 data, one can evaluate the temporal trends in habitat and the role of forestland in those changes. This evaluation was possible for three regions of the state—north, central, and south (caution is advised in this comparison, however, because the three regions do not exactly match geographically). It was not possible to directly compare the habitat scores between dates because of slight variations in the methodology. However, by calculating the percentage of the habitat factor occupied by each land type for the two dates, one can evaluate relative contributions to habitat by each land type over time (Figure 23). Total contributions of forestland to habitat can also be calculated. For example, in the north, the cumulative percentage from forest was 53.4% in 1973 and 65.3% in 1985—a 22% increase in relative habitat from forests in that region (Figure 23). The increase is mostly due to large increases in relative habitat factors for the elm-ash-cottonwood and pine types and a decrease in the marsh habitat factor. In the central region, relative habitat increased from 71.6% to 76.1% (Figure 23), while in the south region, relative habitat decreased from 88% to 84% (Figure 23). In all regions, there were increases in relative habitat factors for elm-ash-cottonwood because the type decreased in area by nearly 50% during that time period (Figure 13). Oak-gum-cypress, likewise, increased in all regions (Figure 23) as a result of increasing availability in younger age classes (Figure 11). Pine scores increased in the northern region (Figure 23) because its availability increased, especially in the older (> 40 year) age class.

In contrast, all regions showed a decrease in relative habitat value for the oak-hickory type and the maple-

Table 9. Habitat factors for Illinois, 1985, calculated according to Graber and Graber (1976).

| Land type | | Habitat factor | % of wildlife habitat |
|---|---|---|---|
| Forest | Pine | 5.70 | 4.9 |
| | Oak-hickory | 30.07 | 26.0 |
| | Oak-gum-cypress | 11.97 | 10.3 |
| | Elm-ash-cottonwood | 40.19 | 34.7 |
| | Maple-beech | 0.14 | 0.1 |
| Subtotal | | | 76.0 |
| Nonforest | Cropland | 0.29 | 0.3 |
| | Pasture/hayland | 10.01 | 8.7 |
| | Prairie | 1.46 | 1.3 |
| | Marsh | 15.28 | 13.2 |
| | Water | 0.38 | 0.3 |
| | Urban, residential | 0.03 | 0.0 |
| | Fallow | 0.19 | 0.2 |
| Subtotal | | | 24.0 |
| Total | | 115.73 | 100.0 |

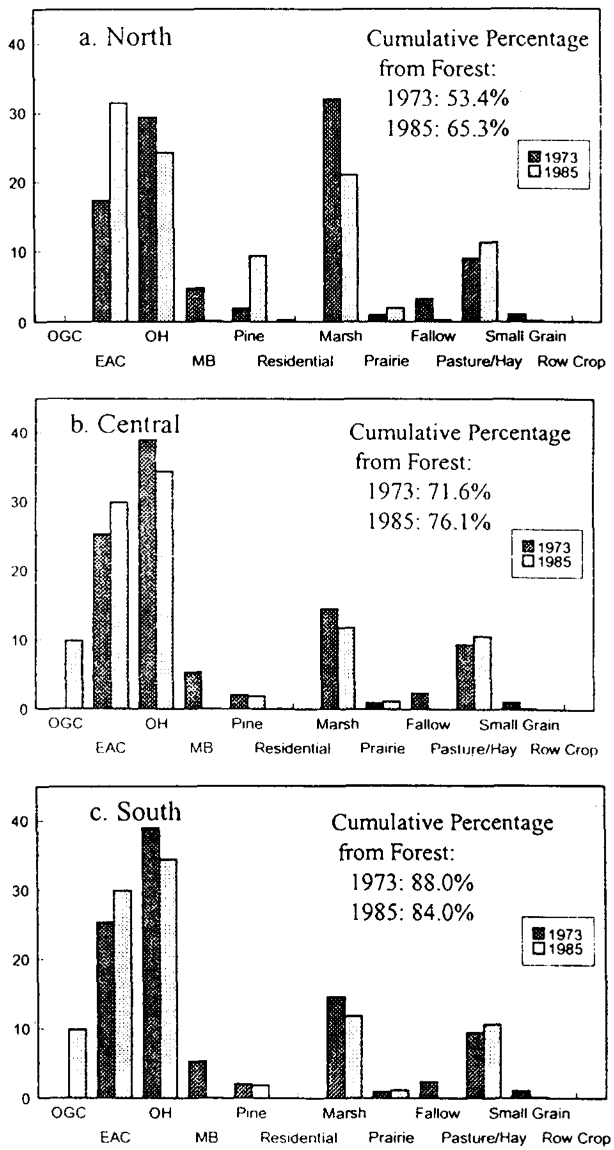



*Figure 23. Relative habitat factors for three regions in Illinois in 1973 and 1985. OGC = oak-gum-cypress, EAC = elm-ash-cottonwood, OH = oak-hickory, MB = maple-beech.*

beech type, but for different reasons. The oak-hickory type decreased because regeneration is not occurring, resulting in a loss of acreage (to maple) (Figure 11); habitat factor scores were especially reduced in the young age classes. The maple-beech type decreased in relative habitat value because of the extremely large increases in area (Figure 11), resulting in very low changing availability scores, which caused the habitat factor scores to be very low as well. Overall, the data show the extremely high value of forests for wildlife habitat across the state and how the value of forests for wildlife is increasing.

## Geographical Patterns in Abundance of Major Vertebrates

Beginning in 1991, Illinois began an ongoing project to systematically inventory incidental wildlife observations of bow-and-arrow hunters in 10 regions of the state (see Figure 24). Although we have only one year of data, several noteworthy features have become apparent. First, on a statewide basis nothing is close to deer and squirrel in abundance (Table 10). This report is supported by estimates of densities of up to 30 deer per square mile of forested habitat (Gladfelter 1984), and a statewide population of up to 500,000 deer (C. Nixon, Illinois Natural History Survey, personal communication). In interpreting these data, however, one should bear in mind that the hunters were in search of deer and that other common forest animals, such as raccoon, are nocturnal.

The data for predators show that coyotes are the most frequently observed species and that they increase in abundance toward the southern end of Illinois (Table 10). In contrast, the number of observations of red fox was highest in the northern portion of the state (Table 10). Likewise, badger observations increased in the southern regions, while grey fox showed no strong geographical trend (Table 10). The data for game birds indicate that turkey, the most frequently observed game bird, reached peak densities along the western rim of the Illinois (Table 10). Not surprisingly, pheasant were observed most frequently in those regions dominated most strongly by agricultural lands (e.g., Grand Prairie and Central Sand Prairie) and in the northern portion of the state (Table 10). Quail showed no strong geographical trends in observation frequency.

Squirrels were observed more frequently in the southern end of the state, whereas deer and rabbit observations peaked in the northern regions (Table 10). Finally, both raccoon and housecat observations outpaced opossum and skunk observations in all regions, with no strong geographical pattern detected in any group (Table 10).

## Trends in Forest Birds

In many regions of North America, forest habitat islands harbor relatively few species of forest birds. Concern is deepest for species that breed in North America and migrate to winter in Central or South America. These species are commonly called long-distance or neotropical migrants and include warblers, vireos, and tanagers.

Do islands of forest habitat in Illinois support viable populations of forest songbirds? Trends in species diversity and abundances of breeding birds within woodlots of various sizes were examined to assess this question. Long-term data are especially useful because abundances of birds and other wildlife fluctuate even under a stable habitat.

Owing to the work of the late Dr. S. Charles Kendeigh, studies of forest songbirds in the heavily farmed landscapes of east-central Illinois extend back to the late 1920s and, in some cases, continued through the mid-1970s. In 1992, birds were censused on two areas used by Kendeigh: Trelease Woods and Allerton Park (J. Brawn, Illinois Natural History Survey, unpublished data). Trelease Woods is a 24-ha woodlot surrounded by agricultural fields. The Allerton Park study plot is a 24-ha area within a 600-ha forest. Two variables are assessed in this report: numbers of species found breeding on the study areas (total and neotropical migrants) and the proportion of neotropical migrants found within the areas (relative abundances).

The number of breeding species neither increased nor decreased overall (Figure 25). Annual fluctuations were common, but for all species and for neotropical migrants, numbers of species did not decrease markedly. In fact, on Trelease Woods, numbers of species increased during the 1950s and have remained comparatively high. These data confirm numerous other studies that report higher numbers of species of neotropical migrants within larger tracts of forests than smaller tracts.

Figure 26 illustrates distinct decreases in relative abundances of neotropical migrants on both plots. Data for many more years are available for Trelease Woods, but on both plots relative abundances decreased markedly in the 1950s and remained low (importantly, abundances of two pest species, starlings [*Sturnus vulgaris*] and brown-headed cowbirds [*Molothorus*

Table 10. Numbers of various species of wildlife observed by bow-and-arrow hunters in 10 regions of Illinois.* Values represent the number of animals observed per 1000 hunter-hours.

| | Region | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | NW Hills | NE Moraine | Missouri Border N | Grand Prairie | W Prairie | Central Sand Prairie | Missouri Border S | S Plain | Wabash Border | Shawnee Hills | Avg. for Illinois |
| Squirrel | 824 | 719 | 864 | 817 | 892 | 969 | 1014 | 1141 | 999 | 1064 | 912 |
| Rabbit | 7 | 14 | 15 | 17 | 8 | 4 | 4 | 6 | 4 | 5 | 11 |
| Deer | 1046 | 992 | 635 | 895 | 711 | 792 | 723 | 791 | 884 | 887 | 850 |
| Coyote | 21 | 20 | 39 | 36 | 50 | 27 | 33 | 51 | 68 | 71 | 40 |
| Red fox | 15 | 12 | 16 | 9 | 8 | 15 | 13 | 12 | 10 | 9 | 11 |
| Grey fox | 1 | 6 | 2 | 2 | 2 | 2 | 4 | 4 | 5 | 4 | 3 |
| Badger | 1 | 0 | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 5 | 1 |
| Pheasant | 23 | 26 | 1 | 22 | 6 | 21 | 0 | 0 | 0 | 0 | 12 |
| Quail | 3 | 2 | 45 | 2 | 50 | 14 | 15 | 29 | 4 | 7 | 15 |
| Turkey | 334 | 6 | 147 | 23 | 95 | 39 | 151 | 43 | 32 | 140 | 83 |
| Raccoon | 31 | 34 | 31 | 30 | 22 | 49 | 23 | 23 | 41 | 18 | 28 |
| Housecat | 21 | 31 | 17 | 16 | 16 | 13 | 12 | 20 | 18 | 14 | 18 |
| Opossum | 3 | 9 | 4 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 3 |
| Skunk | 1 | 3 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 2 | 1 |

* For a depiction of the 10 regions, see Figure 24 (below).

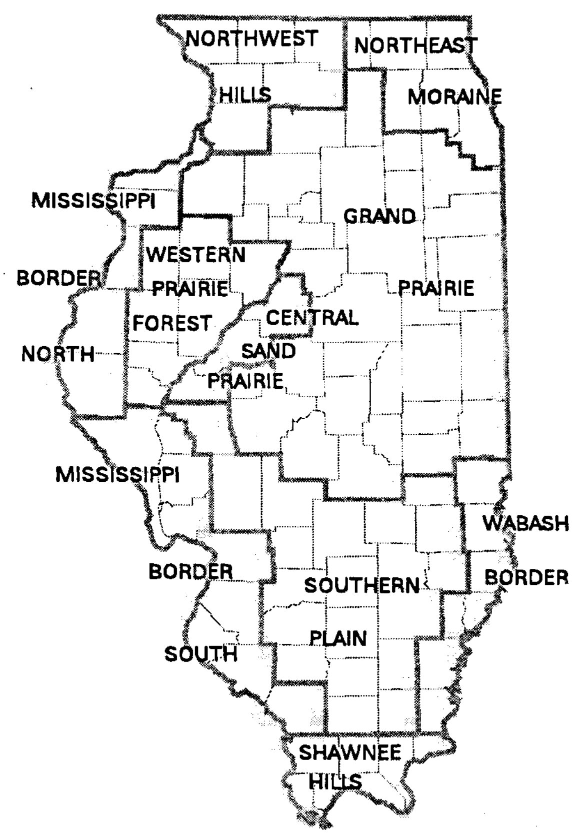



*Figure 24. Illinois regions in which wildlife observations of bow-and-arrow hunters were inventoried. See Table 10 (above).*

*ater*], were factored out of this analysis). These changes have brought about a dramatic change in the nature of breeding bird communities on the study areas and, likely, throughout Illinois. Neotropical migrants formerly accounted for over 70% of the breeding birds. Now they account for less than 50%—even on large woodlots. On small woodlots, like Trelease Woods, the problem appears extreme because the migrants account for only 25% of all resident birds.

In summary the analyses indicate that few, if any, species have been lost during the 20th century, but that a large group of species may be in trouble. If trends persist, one-third to one-half the species typical of Illinois' forests may disappear from many areas.

## Forest Insects

The many species of trees found in the forests of Illinois serve as food for a great diversity of insects. In more northerly regions, by contrast, the limited number of tree species supports a more limited insect fauna. With a high diversity of tree species and of insects, there appear to be more factors, such as predators and parasites, that limit the possibility of severe outbreaks of any given insect species. In contrast, agricultural crops planted as monocultures provide many examples of great buildups of an insect species that can devastate the crop. Likewise, near monocultures of spruce and fir dominate many regions of Canada and the northern states. In these areas, periodic outbreaks of the spruce budworm result in the defoliation and death of thousands of acres of forest. Although forest monocultures of pine are not uncommon in Illinois, most forests

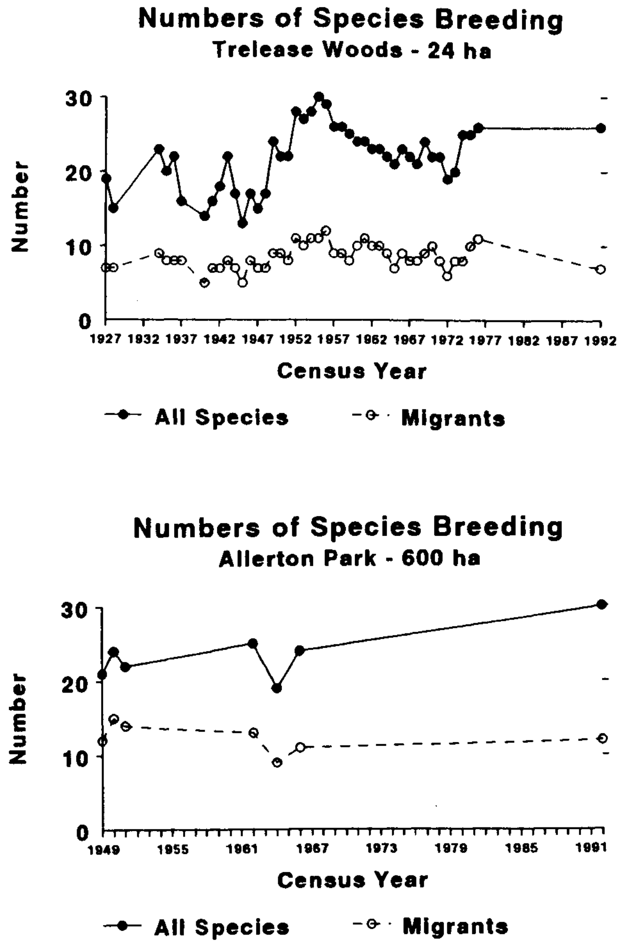



*Figure 25. Number of bird species breeding in two woodland units from 1927 to 1992.*

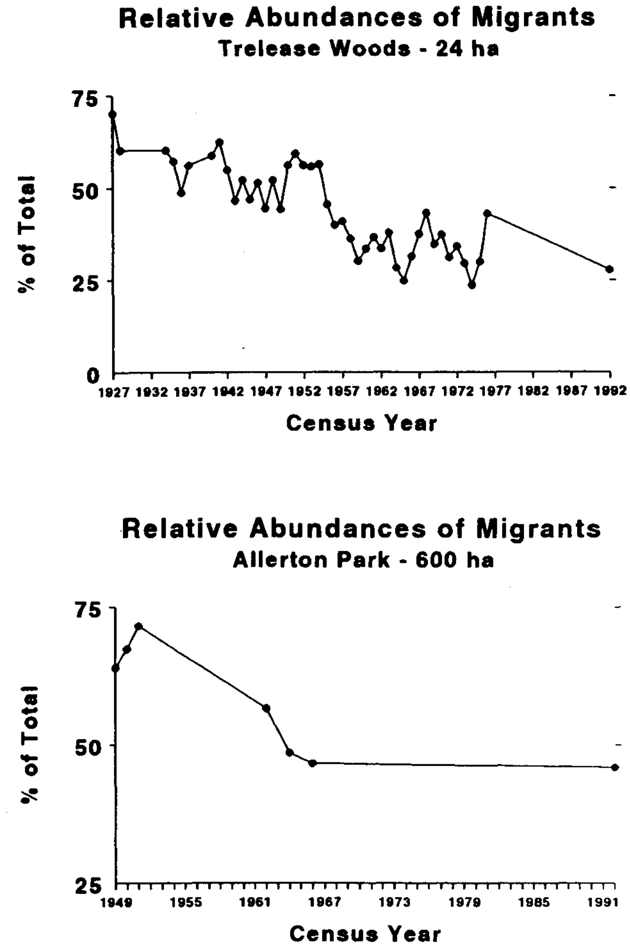



*Figure 26. Relative abundance of migrant birds in two woodland study units from 1927 to 1992.*

consist of mixed stands of many tree species. Thus, even though a given tree species may be seriously affected by an insect or pathogen, as in the case of Dutch elm disease, the forest is buffered from total loss.

As the Illinois landscape changed from a mixture of prairie and forest to agriculture, so too were there probable changes in the insect fauna that flourished in forests. There were no insect surveys prior to or during the earlier periods of European development, so we cannot determine what native insects may have been lost through settlement. We do know from some historical data that the original upland forests were almost exclusively mixed deciduous forest dominated by oaks and hickories. Insect species that flourish in undisturbed forests include cicadas, many species of cerambycid beetles, carpenterworms, and clearwing moths. Populations of such species probably declined as forestlands were cleared. Logged areas that were allowed to regenerate as second-growth forest supported dramatically different insect communities. Populations of native species such as the eastern tent caterpillar, fall webworm, and yellownecked caterpillar probably flourished as they do today in similar areas. The tree species diversity of the regenerated forests was not as great as it was in the former stands, and thus insect populations may have fluctuated more dramatically.

Since the 1930s there has been an increase in the number of acres of pine planted in Illinois. Insect pests native to the United States such as the northern pine weevil, pales weevil, and Nantucket pine tip moth are now quite common throughout Illinois in areas in which they formerly did not exist because their host trees were absent.

In 1979, pine wilt disease, which is caused by a nematode that infects the native Carolina pine sawyer beetle, was discovered in Illinois. Thus, a native insect is acting as a vector for an exotic disease. The disease has devastated red and Scotch pine plantations throughout the state.

### Exotic Insect Pest Introductions

With industrial development in the mid-1800s came the increased possibility of the accidental introduction of insect pests. Several important exotic insect pests of forests that are now established in Illinois include the European elm scale, the smaller European elm bark beetle, European pine shoot moth, European pine sawfly, gypsy moth, and common pine shoot beetle.

Sometime in the late 1800s the European elm scale was found in the United States. The first Illinois record is unknown, but it probably was in the early 1900s. The scale insect injures young elm trees. Heavily infested trees are stunted. In urban areas elm trees often become heavily infested, which kills some tree limbs.

In 1909, the first report of the smaller European elm bark beetle was made in Boston, Massachusetts. The first incidence of Dutch elm disease in Ohio was 1930, and in Illinois the first record was 1950. The smaller European elm bark beetle is the vector of the fungus that causes Dutch elm disease. During the 1950s through the 1970s, Dutch elm disease eliminated nearly all American elm in the forests of Illinois. In Illinois today, American elm trees exist only in limited numbers and only in communities where strict regulations dictate the rapid removal of dead trees.

The European pine shoot moth was found in Illinois in 1914. The borer infests Scotch, red, and Austrian pines. The larva bores into the new growth of pines, thereby causing a reduction in growth and disfiguration of the tree. This insect infests pines in the northern half of Illinois.

The first report of the European pine sawfly in the United States was recorded in New Jersey in 1925. The sawfly is now well established in the pine forests east of the Mississippi River, from the northern half of Illinois eastward, including southern Canada. Severe defoliation of red, Scotch, and Austrian pines occurs during population outbreaks.

The gypsy moth became established in Massachusetts in 1869 and spread westward. To date the gypsy moth has not been permanently established in Illinois; however, since 1981 male moths have been captured in pheromone traps placed in locations throughout the state. The number of male moths caught in Illinois has increased since 1986. This trend will probably continue, due to the increased mobility provided by our modern transportation system which aids in the dispersal of egg masses from infested into noninfested areas. Most of the moths have been captured in the five-county area surrounding Chicago. Once the gypsy moth becomes established in Illinois it could have a devastating effect on oak stands throughout the state. Woodlands that are already under stress are particularly susceptible to diseases after gypsy moth defoliation. For more details on gypsy moth invasion to Illinois see the chapter on agricultural lands.

If it were not for the control programs enacted by the Illinois Department of Agriculture and the USDA APHIS in the early 1980s, the gypsy moth would undoubtedly be well established in Illinois today. The number of sites with gypsy moths, however, continues to increase. Soon it may be impossible to contain the infestations. An outbreak of gypsy moths in Illinois, probably beginning in the Chicago region, seems inevitable. Infestation patterns in other states suggest that the deciduous forests of Illinois, with abundant oaks, would be severely afffected by such an outbreak. Many deciduous trees that are in a weakened condition will be killed. Understory plants that cannot tolerate direct sunlight during the period of defoliation in June will also be severely affected. The experience of eastern states suggests that forest plant communities will dramatically change as a direct result of the gypsy moth.

The most recent exotic insect introduction into Illinois is the common pine shoot beetle. The beetle was found in August of 1992 in a pine planting in Kane County. The beetle is a common forest pest in Europe, where it destroys the current year's growth of pine twigs. Beetle populations can build to large numbers in dead pine trees and pine stumps. The insect could pose a threat to certain Illinois pine plantations where dead trees are not removed and where pine stumps are not treated or removed. Quarantine regulations and control measures will soon be in effect to curtail the spread of the beetle and possibly to eliminate it from the state. Many commercial pine stands will probably be eliminated by the late 1990s because of pine wilt disease.

Under current global trade patterns, with weak restrictions on importation of plant material, exotic insect pest introductions are likely to continue. Some of these pests will become established, causing both ecological and economic effects on the forests of Illinois.

## FOREST CONSERVATION

Numerous types of land are used to preserve biological diversity in Illinois forests (for example, state parks and nature preserves). One major concern for conservation of this biological diversity is undesired changes in community composition among forests through time. Early settler records suggest that most northern and central Illinois upland forests were open mature forests dominated by oaks and hickories (Anderson 1991). The abundance of oak-hickory forest was maintained through occasional fire (Anderson 1991). After European settlement, forests that were not logged began to change as a result of fire suppression. These changes continue today, as witnessed by the rapidly increasing amount of sugar maple and beech forest types within the state (Figure 11). This transition from oak-hickory forests to sugar maple forests has diminished overall forest quality by reducing species diversity (Wilhelm 1991). From an economic perspective, this shift in community composition toward sugar maple is also viewed unfavorably because sugar maple is a lower value timber product than either oaks or hickories.

With respect to other conservation efforts, recent evidence suggests that clear-cutting of forests erodes the habitat's ability to maintain populations of wildflowers (Duffy and Meier 1992). Clear-cutting causes severe damage to the understory herb layer, and it appears that this herbaceous flora does not recover during a typical growth cycle between cutting events. A recent trend that has ameliorated this effect is that the managers of Shawnee National Forest are now moving away from the use of clear-cutting in sites that support native forest species.

Forest size is an important predictor of habitat quality. Of the 214 grade A and B forest sites classified by the Illinois Natural Areas Inventory (White 1978), only 11% are greater than 100 acres (Figure 27). By contrast, among all forest parcels in Illinois, 55.7% are greater than 100 acres (Figure 28), indicating that our large forest patches are less frequently of high quality than we would expect. This is likely to be the result of large tracts being used for intensive logging. At the same time, 19% of sites classified as grade A or B forest are so small (less than 10 acres) that they may experience severe problems maintaining biological diversity (Figure 27). Even the majority of the grade A and B forest sites (20–50 acres, Figure 27) are prone to edge and small patch size effects. To put this in perspective, if a 40-acre site were square, there would be no place in this forest more than 220 yards from an edge. Given that most forest patches are linear strips along waterways, most high quality forest is within 100–200 yards of a habitat border (see subsequent section in this report on forest fragmentation). Finally, the data on grade A and B sites show that there are very few sites supporting flatwood or sand forest vegetation, making them critically threatened habitats (Figure 27).

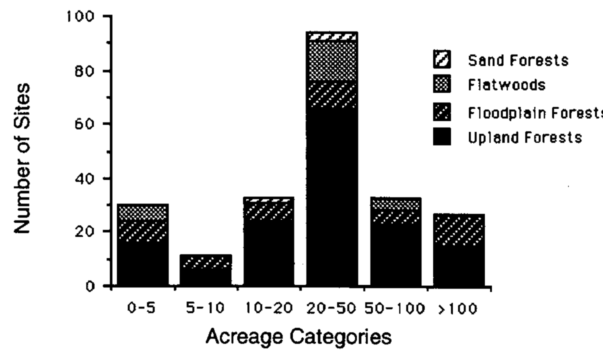



*Figure 27. Size distribution of grade A and B forest parcels identified by the Illinois Natural Areas Inventory (White 1978) for each of four forest types.*

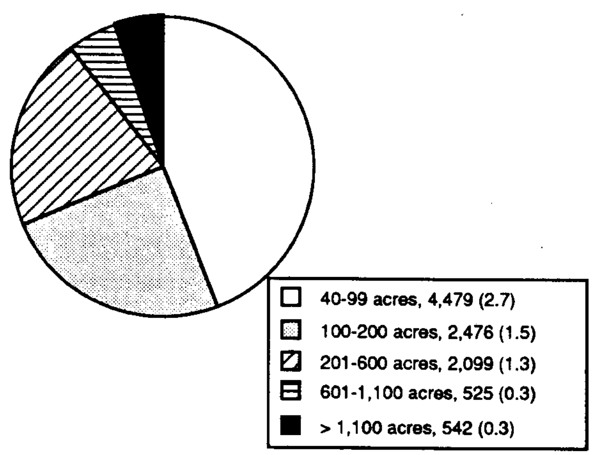



*Figure 28. Number of forested parcels in Illinois by size and average number of parcels per township equivalent (36 square miles). The total number of parcels of a given size is the number immediately following the size; the average number of parcels of a given size per township is given in parentheses. Source: U.S. Geological Survey land-use data, 1973–1981.*

## STRESSORS

### Pollution

Ozone, $NO_2$, and $SO_2$ are among the numerous anthropogenic pollutants that pose well-documented threats to forested habitats (see Schulze et al. 1989, Johnson and Lindberg 1992, Eagar and Adams 1992). Case studies demonstrate the severe effects of pollutants on ecosystem function in forested habitats (e.g., Johnson and Lindberg 1992). Further, widespread pollutants have been implicated in forest declines (e.g., Schulze et al. 1989, Eagar and Adams 1992). In particular, pollutants increase levels of stress in trees (Johnson and Fernandez 1992, McLaughlin and Kohut 1992). Stress increases the susceptibility of trees to other sources of mortality such as plant pathogens (Schoeneweiss 1975, 1978; Manion 1981). Studies of the abiotic environment suggest that Illinois does not, as of yet, suffer from the same levels of acid rain that have been implicated in the decline of forests in the northeastern United States or northern Europe. The pollutant deposition data are supported by recent data indicating lower overall forest damage in Illinois than other regions of the eastern United States (Table 3).

### Deforestation

A recent study comparing plant composition in Appalachian old-growth and second-growth forests showed that herbaceous species diversity does not recover following clear-cutting, not even after 80 years (Duffy and Meier 1992). Similarly, the long-term effect of past clear-cutting in Illinois may have been to reduce the biodiversity of Illinois forests. Illinois forests are going through a process of maturation (Figure 13), and these younger stands may require specific management to recover natural levels of biodiversity. We need additional research to assess the potential damage in Illinois, as well as management programs to restore woodland habitats. Fortunately, most current forestry operations in Illinois employ less destructive selective logging techniques to harvest timber. Nonetheless, we need additional reserach on the long-term impact of selective logging on forest biodiversity.

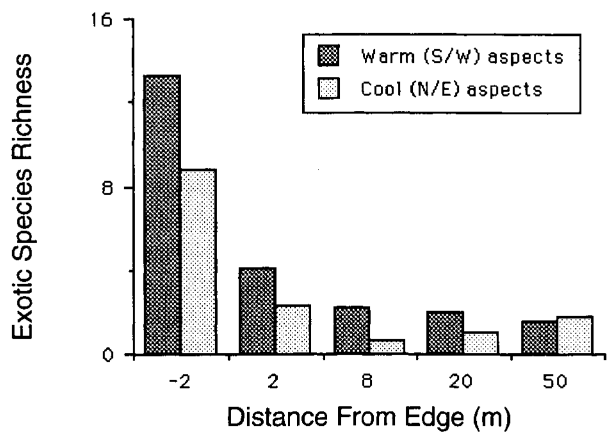
### Fragmentation

The Illinois forested landscape, as discussed above, is extremely fragmented. According to U.S. Geological Survey data, there were 10,121 forested parcels of 40 acres or more in Illinois in 1980. These parcels averaged 358 acres, and about 44% of the parcels were 100 acres or less (Figure 28). There were an average of 6.1 parcels per township (an area of 36 square miles). Of course, the density of forest patches was much higher in the southern counties.

Fragmentation of forest habitat has negative implications for biological diversity at many levels. First, many plants and animals may need large blocks of uninterrupted forest for successful reproduction (e.g., see Robinson 1988, Blake 1991). Several studies have found that small habitat patches tend to be dominated by generalist birds, and as habitat size increases, the diversity of birds requiring specialized habitats also increases (Martin 1981, Whitcomb et al. 1981, Ambuel and Temple 1983, Blake and Karr 1987). In an examination of forest patch use in Illinois by migrant and resident birds in 1979 and 1980, Blake (1991) found that there is a high level of predictability of habitat patch use based on the size of the patch. In studying habitat use on 12 forest remnants that varied from 1.8 to 600 hectares, Blake found that small patches (< 20 hectares) were dominated by generalist birds.

Second, as large tracts of forest area are broken into small, isolated woodlots, more forest edge is created and more opportunities exist for edge-adapted species to usurp habitat from forest-interior species. In a study of old-growth forest fragments in Indiana, Brothers and Spingarn (1992) found that 21 species of alien plants had invaded the forests. While the number of species (species richness) of the alien flora invading the forest fragments dropped dramatically just 2 m inside the forest edge (compared to 2 m outside the forest edge—Figure 29), the frequency of alien species (compared to native species) remained above 20% over 20 m into the forest in many instances (Figure 29). Further, the frequency of alien species was higher on south-facing edges than on north-facing edges. These results suggest that an important aspect to consider in forest fragments is the edge-to-center ratio (or perimeter-to-area ratio) of individual fragments. Increasing edges of fragments increases the probability of invasion by species from other habitats. In Illinois, much of our remaining forests occurs as one of two types: (1) very small, isolated patches where the edge-to-center ratio is very high and (2) riparian zone forests where there is practically no center and lots of edge. Both of these forest fragment types are very susceptible to the negative effect of habitat edges.

The conclusion that habitat edges should be minimized runs counter to traditional wildlife management goals to establish habitat edges to enhance populations of deer, pheasant, and other species valued primarily by hunters. Although it is difficult to estimate presettlement deer populations, we know that populations increased in the 1800s in association with land clearing (Torgerson and Porath 1984). During the early 20th century, deer populations were very low but have rebounded substantially during the past 30 years (Gladfelter 1984, Torgerson and Porath 1984). This increase is, in part, a result of managing forestlands for habitat openings and food plots (Gladfelter 1984). Although the current abundant deer populations are viewed favorably by hunters, they appear to pose serious threats to biological diversity in forests (Anderson and Loucks 1979, Alverson et al. 1988, Strole and Anderson 1992, Anderson and Katz 1993). This conflict between the conservation of plant diversity and deer points out an inherent problem with managing biological resources: species-based management goals often conflict with those developed to maintain the full array of native biodiversity.



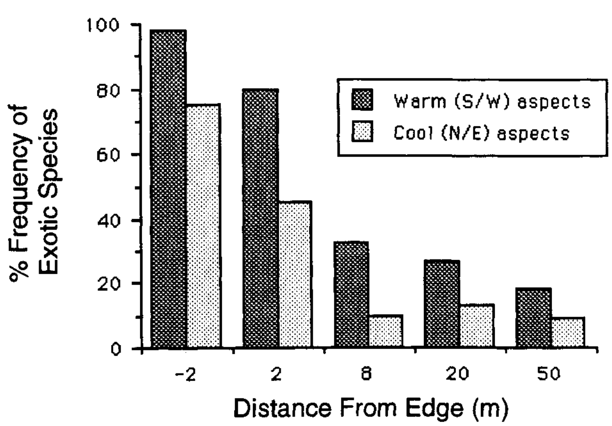




*Figure 29. Mean alien species richness (top) and mean frequency of sample transect segments containing alien species (bottom), summarized by transect position and aspect. Sample size = 7 for each combination of transect and aspect. Redrawn from Brothers and Spingarn (1992).*

Third, fragmentation of forests into small habitat islands results in small effective population sizes. Population size is the best predictor of extinction probability. Population Viability Analysis (PVA) is a tool used to predict the likelihood that a population will persist through time (Gilpin and Soule 1986). Recent reviews of PVA (Soule 1987; Shaffer 1981, 1987; Menges 1992) conclude that, in general, effects attributable to environmental stochasticity are most likely to cause population extinction. Further, populations of fewer than 200 individuals are moderately susceptible to extinction through environmental stochasticity (Menges 1992). Because most Illinois forests are very small, many species may be restricted to small populations. Thus, fragmentation may increase the propensity for small, isolated populations to become locally extirpated.

Finally, the disjunction of forest patches may inhibit movement of individuals—particularly, several species of plants, insects, and small mammals—between isolated habitats. This spatial isolation may, in turn, result in genetic isolation. Genetic isolation can be detrimental to the long-term health of resident populations because it increases inbreeding, which can lead to an erosion of the genetic variability and, eventually, of the viability of these populations (see discussion in prairie chapter on genetic concerns). Inbreeding depression is likely to become a problem over the short term for certain types of organisms. Organisms that disperse well— such as birds, large mammals, trees, and many robust insects—are likely to maintain substantial gene flow despite habitat fragmentation. For organisms that live very long—such as trees, some shrubs, perennial herbs, and fungi—any increase in inbreeding is likely to take a very long time to erode local variability to the point where populations may become inviable. In contrast, organisms that do not disperse well and have short generation times (e.g., small mammals, sedentary insects, and short-lived herbs) may show severe inbreeding problems over the course of a few generations (Barrett and Kohn 1991). There is little direct evidence with which to gauge the magnitude of inbreeding depression effects in Illinois at the present time.

## Global Climate Change and Carbon Dioxide Sequestration

Because Illinois has undergone massive changes in total forest volume over the past several decades, the amount of carbon being sequestered into Illinois forest biomass has likewise changed considerably. From 1948 to 1962, there was a slight loss of total forest volume due to conversion of forestland to other uses (Figures 16, 30). This loss was compensated by the harvesting of wood products, which put 0.29 million metric tons of carbon into long-term storage. The result was that forestlands were a net sink of 0.2 million metric tons of carbon per year during 1948–1962. After 1962, there was a gain in forestland and especially a gain in forest volume per unit of forestland; in addition, carbon sequestration into long-term storage of wood products increased slightly. The net result was carbon sequestration of about 1.37 million metric tons of carbon per year from 1962 to 1985 (Figure 30). Even though the amount of carbon sequestered by Illinois forests has increased, however, this amount still represents only about 2.7% of the total carbon emissions that the people of Illinois contribute to the atmosphere each year.

## Ecological Response to Global Climate Change

Predictions of global warming suggest, barring extreme global restrictions on the use of fossil fuels, that atmospheric $CO_2$ levels will double during the next century. This doubling of $CO_2$ is predicted to result in a global increase in temperature of between 1.5°C and 4.5°C (Houghton et al. 1990). Average increases are expected to be from 0.2°C to 0.3°C per decade (Houghton et al. 1990). Temperature changes will not be evenly distributed around the globe, with the greatest temperature changes at high latitudes, and particularly during the winter months (Houghton et al. 1990). In addition, mid-continental regions should, in general, experience a decrease in growing season precipitation and an increase in the frequency of drought events. However, the predictions with respect to precipitation are much less firm than those for temperature.

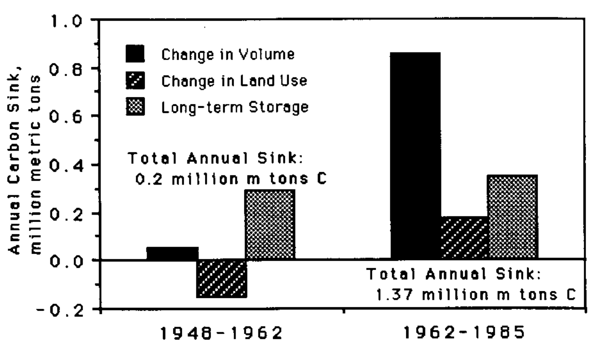



*Figure 30. Carbon sinks and sources related to Illinois forestlands, 1948–1985. Depicted are amounts of carbon sequstration due to changes in the volume of trees per unit of forest area, changes in land use, and changes in the long-term storage of carbon as a result of the harvesting of timber products.*

These climate changes may have several biological ramifications. First, warmer winter temperatures are likely to result in increased survivorship of over-wintering insects. This may pose problems with respect to both pests of forests and crop plants, some of which now over-winter south of Illinois. Second, increased drought frequency may result in increased frequencies of plant disease (Schoeneweiss 1975, 1978; Manion 1981). Given that the major identifiable sources of mortality in trees are insects and disease (Table 1), climate change is likely to exacerbate existing problems. In addition, climatic warming may result in earlier spring greening of vegetation (M.D. Schwartz 1990, 1992), enhanced net growth rates (Melillo et al. 1990), increased levels of herbivory (Melillo et al. 1990), and shifts in the competitive interactions among species (Melillo et al. 1990). All of these indirect effects are likely to alter the ability of Illinois forests to support timber production in, as yet, unpredictable ways.

The primary realm of uncertainty in these predictions of changes due to increases in temperature relates to the numerous direct effects of atmospheric $CO_2$ on plants (for reviews, see Melillo et al. 1990, M.W. Schwartz 1992). For example, an increase in atmospheric $CO_2$ levels: (a) decreases water stress (Farquhar and Sharkey 1982), (b) increases plant growth rates (Bazzaz and Carlson 1984, Idso et al. 1987), (c) alters nutrient uptake rates (Luxmoore et al. 1986), (d) alters phenology (Long and Hutchin 1991), and (e) changes plant tissue chemistry and subsequent rates of herbivory (Lincoln and Couvet 1989). Most of the changes in direct response of plants to increases in $CO_2$ levels will ameliorate the effects of climate change. We remain far from being able to predict these responses with any certainty.

Situated at the edges of southern and northern forests, and along the eastern edge of the prairie, Illinois is in a position—if climatic warming occurs as predicted—to lose many plant species from northern counties while acquiring new species in southern counties as range limits shift northward (Davis 1989). While the retraction of southern range boundaries may be rapid in response to climate change, the movement of northern edges of distributions is likely to be quite slow (M.W. Schwartz 1992, 1993). Thus, if warming proceeds as climate change models predict, Illinois may experience a net decrease in natural biological diversity.

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# AUTHORS AND CONTRIBUTORS

**Prairies**

Authors Ken R. Robertson, Mark W. Schwartz
Contributors V. Lyle Trumbull, Ann Kurtz, Ron Panzer

**Forests**

Authors Louis R. Iverson, Mark W. Schwartz
Contributors James E. Appleby, Jeffrey D. Brawn, Loy R. Phillippe, Richard E. Warner

**Agricultural Lands**

Authors Richard E. Warner, David W. Onstad
Contributor Charles G. Helm

**Wetlands**

Authors Stephen P. Havera, Liane B. Suloway
Contributors Sharon Baum, Joyce Hofmann, Dennis Keene, Marilyn Morris, Alicia Nugteren, Tony Shaffer, Scott Simon, John Taft, Patti Malmborg

**Lakes and Impoundments**

Authors Peter B. Bayley, J. Ellen Marsden, Douglas J. Austen
Contributor Dan Gavrilovic

**Flowing Waters**

Coordinators Steven L. Kohler, Lewis L. Osborne
Authors Steven L. Kohler, Mark F. Kubacki, Richard E. Sparks, Thomas V. Lerczak, Daniel Soluk, Peter B. Bayley, Kevin S. Cummings, Mitchell A. Harris, Lawrence M. Page, Steve G. Gough, Charles H. Theiling
Contributors Diane L. Szafoni, Dan Gavrilovic, Deborah Corti, Brian J. Swisher, Kyle Piller, Katherine J. Hunter, Glendy C. Vanderah, Carolyn Nixon, Deanne L. Krumwiede

**Resource Analysis**

Authors Robert A. Herendeen, Kenneth P. Pabich

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