Illinois Report on Sustainable Forest Management: Criteria and Indicators

Summary Report Prepared for the Illinois Forestry Development Council

Lyle J. Guyon
John Edgington

Illinois Report on Sustainable Forest Management: Criteria and Indicators

Summary Report Prepared for the Illinois Forestry Development Council

Lyle J. Guyon, Ph.D. Candidate
Department of Natural Resources and Environmental Sciences
University of Illinois at Urbana-Champaign

and

John M. Edgington, Principal Research Specialist in Forestry
Department of Natural Resources and Environmental Sciences
University of Illinois at Urbana-Champaign

June 2004

Acknowledgements

Funding and support for this report were provided by the Illinois Forestry Development Council, Illinois Department of Natural Resources and the Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign.

Design and graphics:

Lyle Guyon

Cover photos:

John Edgington
Jeremy Shafer

Cover map:

Adapted from: IDNR GIS Database; Luman et al., 1996.

The authors would like to extend their thanks and gratitude to:

Dick Little, Illinois Forestry Development Council
Dr. Gary Rolfe, Chair, Illinois Forestry Development Council
Stewart Pequignot, Illinois State Forester (retired)

Citation:

Guyon, L.J., and J.M. Edgington. 2004. Illinois report on sustainable forest management: criteria and indicators – summary report. Illinois Forestry Development Council. 59 p.

Table of Contents

Preface

The 1992 United Nations Conference on Environment and Development (UNCED), also known as the "Earth Summit," focused world attention on the importance of sustainable forest management as a key component of sustainable development. As a result of this international conference, the United States and 144 other countries adopted a non-binding Statement of Forest Principles that recognized the importance of sustainably managing all types of forests in order to meet the needs of present and future generations.

In 1993, a United Nations committee convened an international seminar in Montreal, Canada on the sustainable development of boreal and temperate forests. This conference resulted in subsequent initiatives to develop and implement internationally agreed upon criteria and indicators for sustainable forest management.

In 1994, the United States and nine other nations formed the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. This working group soon became known as the "Montreal Process."

The ten original Montreal Process countries met in Santiago, Chile in 1995 to endorse a statement of political commitment, known as the "Santiago Declaration," along with a comprehensive set of seven criteria and 67 indicators for the conservation and sustainable management of temperate and boreal forests.

Montreal Process countries currently number twelve and include Argentina, Australia, Canada, Chile, China, Japan, the Republic of Korea, Mexico, New Zealand, the Russian Federation, the United States of America, and Uruguay. These countries encompass five continents and together contain 90 percent of the world's temperate and boreal forests, 60 percent of all forests globally, and 35 percent of the world’s population.

Recently, efforts have been undertaken in the United States to assess the use of the Montreal Process Criteria and Indicators at regional, state and local levels. The following report summarizes the initial application of the Montreal Process Criteria and Indicators to the assessment of sustainable forest management in the State of Illinois.

Lyle J. Guyon

John M. Edgington

Introduction

The Montreal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests collectively provide an understanding and implicit definition of what is meant by sustainable forest management. They are tools for assessing trends in forest conditions, and they provide a common framework for describing, monitoring and evaluating progress toward sustainability. It is important to note that the Montreal Process Criteria and Indicators are not performance standards for certifying management or products.

Sustainable forest management is an evolving concept, and various definitions have arisen over the past couple of decades (USDA Forest Service, 2004). Although they may differ with regard to specific details, most incorporate the general concept of sustainability elucidated in the 1987 Brundtland Commission Report (WCED, 1987), which defines sustainable development as:

> *...development that meets the needs of the present without comprising the ability of future generations to meet their own needs.*

For example, the Sourcebook on Criteria and Indicators of Forest Sustainability in the Northeastern Area (USDA Forest Service, 2002) states that forest sustainability involves:

> *...the continued existence and use of forests to meet human physical, economic and social needs; the desire to preserve the health of forest ecosystems in perpetuity; and the ethical choice of preserving options for future generations while meeting the needs of the present.*

In addition, the Dictionary of Forestry not only incorporates a land stewardship ethic in its definitions of sustainable forest management, but also specifically includes the seven Montreal Process Criteria in one of them (Helms, 1998).

Criteria are large-scale categories that represent a reflection of scientific principles and public values. They serve to define conditions or processes by which sustainable forest management can be assessed, and are characterized by the set of indicators that they comprise. Indicators in turn provide the means for measuring an aspect of a criterion. They represent quantitative or qualitative variables that can be used to describe present characteristics and to demonstrate trends when monitored over time. In addition, indicators are intended to be flexible elements of resource monitoring that can be periodically adjusted to provide the most accurate assessment of changing environmental, economic and social conditions.

The Montreal Process countries identified the following seven criteria, which contain a total of 67 indicators, as essential components in the sustainable management of forest ecosystems:

1. Conservation of biological diversity (9 indicators)
2. Maintenance of productive capacity of forest ecosystems (5 indicators)
3. Maintenance of forest ecosystem health and vitality (3 indicators)
4. Conservation and maintenance of soil and water resources (8 indicators)
5. Maintenance of forest contribution to global carbon cycles (3 indicators)
6. Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies (19 indicators)
7. Legal, institutional and economic framework for forest conservation and sustainable management (20 indicators).

The USDA Forest Service has committed to work with State, local, and other partners to use criteria and indicators to report on the status of forested landscapes throughout the nation. In addition, the National Association of State Foresters, in a 1997 resolution passed at their national meeting,

endorsed the seven criteria established by the Montreal Process. Also in 1997, the USDA Forest Service published the First Approximation Report for Sustainable Forest Management based upon the Montreal Process Criteria and Indicators. Findings from this report indicated that some information was available for most indicators, but that data was completely lacking for others. In some cases, data was only available for recent years making it impossible to determine trends. In other cases, data had not been measured using consistent definitions or methodologies at different locations or at different times. These types of data issues made it inappropriate or impossible to draw conclusions at that time.

The USDA Forest Service's 2003 National Report on Sustainable Forests represents a follow-up to the First Approximation Report. To facilitate the preparation of this report, the USDA Forest Service and other federal agencies entered into a Memorandum of Understanding (MOU) on Sustainable Forest Management Data. This MOU provided a forum for federal agencies to coordinate activities and resolve issues related to collecting, monitoring, analyzing, and reporting data related to the Montreal Process Criteria and Indicators. Other parties that entered into this MOU include the Bureau of Land Management, the National Park Service, the U.S. Geological Survey, the Natural Resources Conservation Service, the U.S. Fish and Wildlife Service, the National Agricultural Statistics Service, the Cooperative State Research, Education and Extension Service, the Bureau of Indian Affairs, the Office of the Deputy Under Secretary of Defense (Environmental Security), and the Office of Policy Analysis.

The intention of the development of the Illinois Report on Sustainable Forest Management was to provide a source of reference information for state legislators, other policy makers, resource managers and concerned citizens, as well as to evaluate the usefulness of the Montreal Process Criteria and Indicators for assessing sustainability at the state level. The technical report, completed in 2003, presented a comprehensive overview of Illinois' forests and provided information for further analysis and discussion about the sustainable use of our forests for present and future generations. In addition, the project identified shortfalls in data and other resource issues that must be addressed before we can assure the sustainability of Illinois' forest resources. This summary report is intended to be less technical in nature and was developed to facilitate the sharing of information contained in the technical report with a wider audience.

The Montreal Process Criteria and Indicators were designed for national and international use and are therefore sometimes rather broad in scope. However, they have proven to be useful tools for assessing trends in forest conditions as well as providing a common framework for describing, monitoring, and evaluating progress towards sustainable forest management in the state of Illinois.

Readers are encouraged to refer to the sources listed below for further information and updates concerning the Montreal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests and their application. The authors would like to reiterate that the Montreal Process Criteria and Indicators are not designed to be static. Rather, they represent a dynamic set of variables that can be adapted to ever-changing environmental, economic and social conditions.

- The Montreal Process. Website available at: http://www.mpci.org/ (May, 2004).

  The Montreal Process is the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. The Montreal Process website provides background and current information concerning the development and implementation of criteria and indicators for sustainable forest management at the international level.

- The Roundtable on Sustainable Forests. Website available at: http://www.sustainableforests.net/ (May, 2004).

  The Roundtable on Sustainable Forests represents a partnership of public agencies and private organizations in the United States. The Roundtable supports the goal of sustainability through the implementation of criteria and indicators for sustainable forest management. It serves as a forum for the sharing of information to facilitate better decision-making at the national level.

- USDA Forest Service. Sustainable Resource Management. Website available at: http://www.fs.fed.us/sustained/msie4.html (May, 2004).

  The USDA Forest Service was designated as the lead agency in the development of the 2003 National Report on Sustainable Forests. This report and other relevant information concerning sustainable forest management in the United States are available at the Forest Service's Sustainable Resource Management website.

- USDA Forest Service. Northeastern Area State and Private Forestry (NASPF). Sustainability of the Northeastern Area. Website available at: http://www.na.fs.fed.us/sustainability/ (May, 2004).

  The NASPF sustainability effort presents a comprehensive summary of information that addresses the issue of measuring forest sustainability at regional and state levels. It provides an invaluable source of information concerning such efforts, and is responsible for a number of publications relevant to this issue. The NASPF website is a very useful starting point for states and other organizations in their efforts to use criteria and indicators to assess forest sustainability.

- Illinois Report on Sustainable Forest Management: Criteria and Indicators – Technical Report. Available at: http://ifdc.nres.uiuc.edu/publications.htm (May, 2004).

  The technical report upon which this summary report is based is available at the Illinois Forestry Development Council's website.

Criterion 1: Conservation of Biological Diversity

Criterion 1 contains nine indicators related to the conservation of biological diversity in forest ecosystems. The first five fall under the subheading of ecosystem diversity. These indicators define the extent of forest area by forest type and successional stage, the degree to which forested ecosystems are protected from anthropogenic disturbance or conversion, and the degree to which forested ecosystems have been spatially fragmented across the landscape. These indicators are measures of forest habitat diversity and also landscape diversity, both of which have implications for the successful maintenance of forest dependent species. Indicators 6 and 7, under the subheading of species diversity, are a direct measure of the number of species in the state that depend on forested habitat to successfully complete their life cycles, as well as the percentage of those species that are at risk of not maintaining viable breeding populations in the state. Indicators 8 and 9, under the subheading of genetic diversity, address monitoring protocols for forest dependent species. Declining population numbers or restrictions in range may indicate that changes in habitat availability or other factors may be negatively influencing wildlife populations.

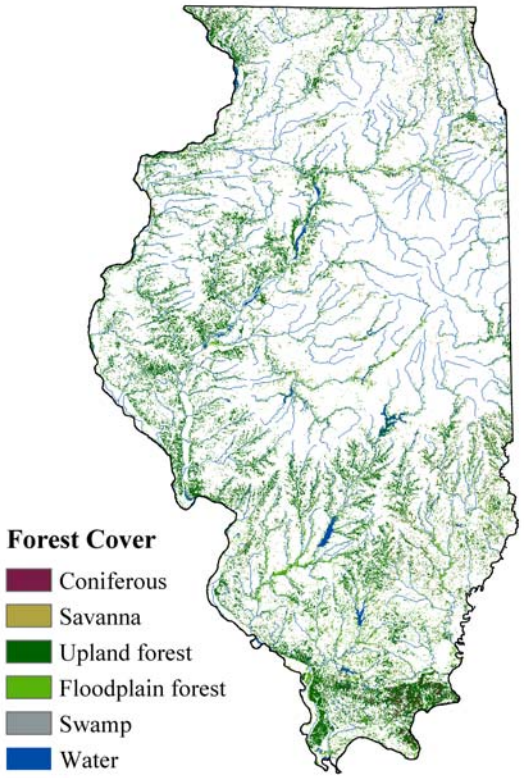
Forest Ecosystem Diversity

Landcover in Illinois is heavily dominated by agricultural production, and cropland accounts for approximately 70% of the state's 35.6 million acres (Schmidt et al., 2000). Forestland, at just over 4.3 million acres, accounts for 12% of Illinois' landcover. Nonforest land without trees covers another 15% of the state. This category includes urban and other areas such as improved pastureland, idle farmland, and water. The remainder is also considered nonforest land, but it does contain some trees. This classification includes areas such as windbreaks, wooded strips, and urban forests. Figure 1 shows the spatial distribution of forestland in Illinois.

The majority of forestland in Illinois is classified into three distinct forest types under USDA Forest Service definitions. Upland oak-hickory forests compose 53% of the total forestland acreage in Illinois and are the most common forest type throughout the state (figure 2). Trees commonly associated with this forest type include white oak, black oak, northern red oak, post oak, bur oak, shagbark hickory, pignut hickory, and white ash (Bretthauer and Edgington, 2002). White oak was selected as Illinois' state tree in 1972.

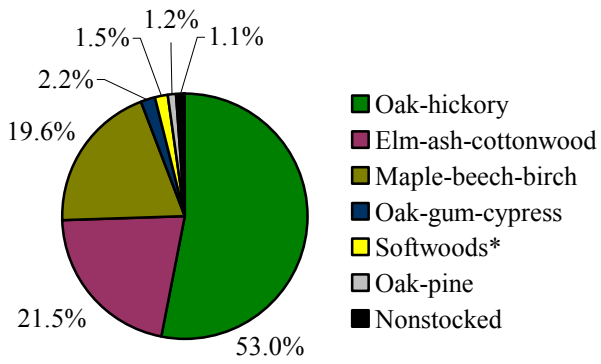
Elm-ash-cottonwood forests make up 21.5% of Illinois' forestland. These are bottomland or floodplain forests typically associated with river

Figure 1. Illinois forest cover: 2000.



Adapted from: INHS, 2003a; USGS, 2003a; USGS, 2003b; INHS, 1995 & 1996.

Figure 2. Relative forestland area by forest type in Illinois: 1998.[1]



[1] Numbers may not add to 100 due to rounding.
* White–red–jack pine and loblolly–shortleaf pine forest types.
Source: USDA Forest Service Forest Inventory and Analysis Database (FIADB).

and stream systems. They are commonly found along the Illinois and Mississippi rivers, for example. Trees that are associated with this forest type include silver maple, American sycamore, green ash, hackberry, eastern cottonwood, American elm, black willow, and red maple (Bretthauer and Edgington, 2002).

Maple-beech-birch forests account for an additional 19.6% of Illinois' forestland. These forests generally occupy mesic upland sites. Trees commonly associated with this forest type in Illinois include sugar maple, American elm, black walnut, Ohio buckeye, and American basswood. American beech is actually a relatively minor component of this forest type in Illinois, and yellow birch occurs rarely and only in the northern part of the state.

Several other forest types are present in Illinois but compose a relatively minor percentage of overall forest coverage. Oak-gum-cypress forests occur primarily in southern Illinois and consist of bottomland forests and swamps (figure 3). For example, the Cache River State Natural Area encompasses nearly 13,000 acres, portions of which are well known for their wetlands and baldcypress-water tupelo swamps. This area was identified by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1996 as one of 15 wetlands of international importance, placing it in the same category as the Florida Everglades and Okefenokee Swamp (IDNR, 2003a). This area is primarily managed to conserve its unique attributes and benefits to wildlife and migratory waterfowl. The state champion baldcypress tree, estimated to be over 1,000 years old, resides at this location. Other trees associated with this forest type include swamp white oak, swamp chestnut oak, sweetgum, cherrybark oak, and pin oak.

Softwoods account for only about 1.5% of total forestland in Illinois, and can be broken down into two distinct forest types. The white–red–jack pine forest type is found mostly in northern Illinois. Eastern white pine is the most common tree found in these forests. In southern Illinois, pine forests are represented by the loblolly–shortleaf pine forest type. Shortleaf pine occurs naturally, but loblolly pine is confined to small plantations scattered throughout the area in and around Shawnee National Forest. Oak-pine forests can be found throughout the state and are composed primarily of eastern redcedar or shortleaf pine and several oak species, including blackjack oak.

Historical Trends

The General Land Office conducted surveys of Illinois in the early 1800's. These surveys resulted

Figure 3. A baldcypress swamp in southern Illinois.

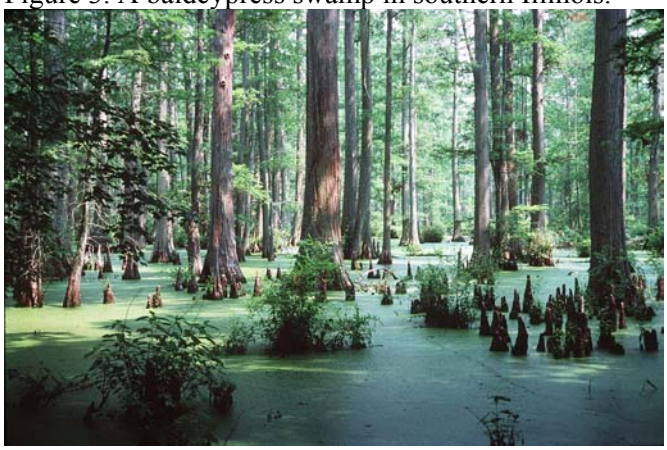
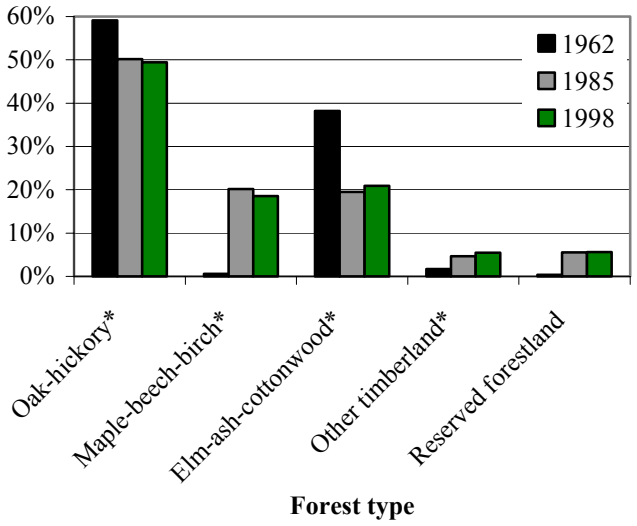


Photo: John Edgington.

in the production of maps that were later used to derive the relative presettlement coverage of forests, prairies, and water bodies in the state. These records indicate that prior to about 1820, forests covered approximately 13.8 million acres in Illinois, or nearly 39% of the state (Anderson, 1970). Forest coverage was heaviest in southern Illinois. The western part of the state was also heavily forested, especially the lower Illinois River valley, as were portions of northern Illinois. Throughout much of the state, forest cover has historically been associated with river and stream systems. Illinois became known as the "Prairie State" for the extent of prairieland in presettlement times. Prairies occupied nearly 61% of the state and were most dominant in the east-central part of the state known as the Grand Prairie Region (Bretthauer and Edgington, 2002).

The original landcover of Illinois saw drastic changes over the next 100 years, as increasing population pressure and conversion to agriculture resulted in the loss of significant amounts of both forest and prairie. By 1924, forests covered just over 3 million acres, or about 22% of their original extent, and most of this was now second-growth (Telford, 1926). Since the 1920's, forestland has been gradually increasing as evidenced by periodic forest surveys. Illinois' original prairieland was more severely impacted, however, and today less than 1% of it remains in small prairie remnants, the majority having long since been converted to agricultural production (IDENR, 1994).

Figure 4. Relative forest cover in Illinois by forest type: 1962-1998.



* Includes commercial forestland only.
Adapted from: Schmidt et al., 2000; Iverson et al., 1989.

Although total forestland has been increasing in area, the past 40 years have seen dramatic changes in the overall composition of Illinois' forests (figure 4). While oak-hickory forests have remained the dominant type of forest community in Illinois over time, their relative coverage has decreased somewhat since 1962. Elm-ash-cottonwood forests showed a greater decrease in relative coverage since 1962. Maple-beech-birch forests, on the other hand, increased dramatically in relative coverage between 1962 and 1985. Other forest types and reserved forestland have both increased in relative coverage since 1962.

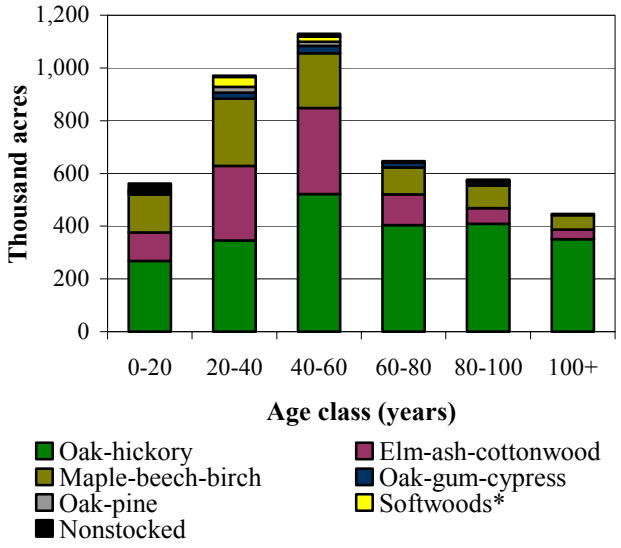
Forest Age

Illinois contains a substantial amount of younger forestland, with nearly 50% of its forests between the ages of 20 and 60 years (figure 5). Although oak-hickory forests decline slightly in terms of absolute coverage, they constitute a progressively higher percentage of forestland as age classes increase. In fact, nearly 80% of forests greater than 100 years old are oak-hickory forests. By contrast, younger forestland contains significantly more elm-ash-cottonwood and maple-beech-birch forests. This fact has led many scientists and resource professionals to speculate that oak-hickory forests are being slowly replaced by other forest types over time in Illinois. There is some cause for concern over the long-term implications of this phenomenon, often called "maple takeover".

Protected Forest

The USDA Forest Service classifies reserved forestland as forestland that is withdrawn from timber utilization through statute, administrative

Figure 5. Illinois forestland by forest type and age class: 1998.



* White–red–jack pine and loblolly–shortleaf pine forest types.
Source: USDA Forest Service Forest Inventory and Analysis Database (FIADB).

regulation, or designation (Schmidt et al., 2000). As of 1998, over 244 thousand acres of forestland in Illinois were classified as reserved. Statewide, this represents 5.6% of the total amount of forestland in Illinois. The majority of public forestland in Illinois is considered to have some degree of protected status, and is managed to conserve or enhance natural attributes, unique features, and benefits to wildlife. Extractive activities such as logging are generally restricted to federal lands such as those contained in Shawnee National Forest. Figure 6 shows the spatial extent of public lands in Illinois.

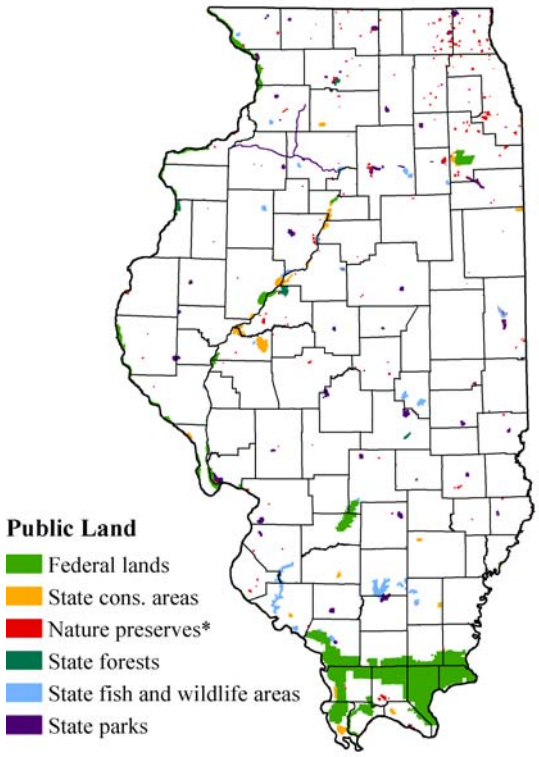
Forest Fragmentation

Forest fragmentation is a serious issue in Illinois. Fragmentation can be detrimental to plants and animals that require large blocks or interior forest for successful completion of portions of their life cycle. Fragmentation results in high edge-to-center ratios, which favor edge-adapted (often invasive or generalist) species over interior-adapted species. Fragmentation can also result in small effective population sizes and inhibits movement between habitats. These factors can lead to genetic isolation, inbreeding depression, and greater susceptibility to population extinctions (IDENR, 1994).

Many species of forest birds, in particular neotropical migrant species, are sensitive to the size of forested parcels (Brawn and Robinson, 1994). Forest fragmentation may impact the diversity of forest bird populations not only through habitat loss, but also through increased rates of nest predation and brood parasitism (Brawn and Robinson, 1994). Much of the forested landscape in Illinois consists of small isolated patches or riparian zone forests (figure 7).

Based on a survey of forestland owners (Birch, 1996), 36% of separately owned forested parcels of land in Illinois are less than 10 acres in size (table 1). Furthermore, over 80% of these parcels are less than 50 acres in size. It should be noted that this survey did not distinguish true forest patches from

Figure 6. The spatial distribution of public lands in Illinois.



* Includes both public and private lands.
Adapted from: INHS, 1995 & 1996.

Figure 7. An aerial view of forest fragmentation in central Illinois.

Photo: John Edgington.

separately owned forested parcels that may be adjacent to one another and thus form contiguous forest tracts. Nevertheless, this situation clearly presents a challenge to those agencies responsible for coordinating management activities on the numerous separately owned parcels of forested land in Illinois.

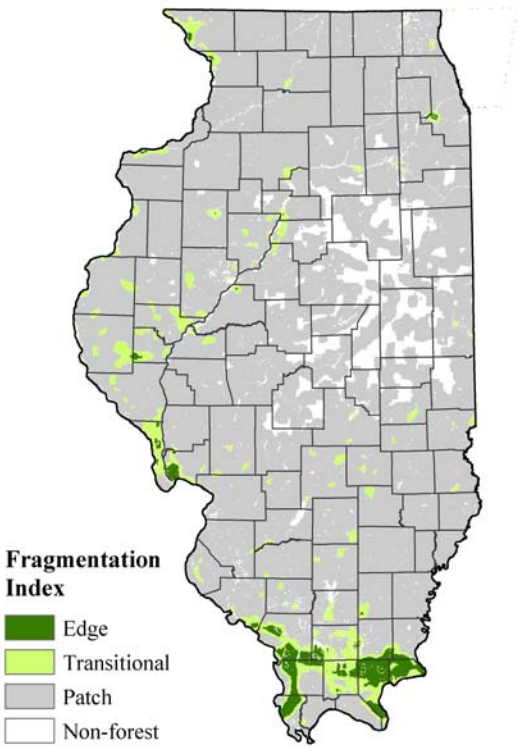
The analysis of GIS data allows for the delineation of spatially distinct forested parcels of land and thus provides a mechanism for quantifying forest fragmentation across the landscape. The USDA Forest Service Southern Research Station's Landscape Analysis and Assessment Project developed an index of forest fragmentation that characterizes individual units of land by assessing the proportional land cover in the surrounding landscape. For example, each pixel in figure 8 represents a 30x30 meter (0.09 ha) parcel of land that has been characterized by the assessment of a surrounding "window" that encompasses 243x243 pixels (5314.41 ha). The "window" of landscape assessment, referred to as landscape assessment size, in figure 9 has been narrowed to 9x9 pixels (7.29 ha) and allows for a more detailed analysis of spatial trends. Note that in figure 8 no interior forest is present in the state of Illinois. At the finer scale of resolution in figure 9 the occurrence of interior forest, inside and outside forest edges, and transitional areas are all readily apparent. It should be noted that at this time this analysis applies only to overall forest fragmentation and not to fragmentation of different forest types.

Table 1. Number of ownership units and acres of forestland by parcel size class in Illinois: 1993.

Size class	**Ownership units**		**Acres**	
Acres	Number	Percent	Number	Percent
1-9	41,000	36	229,000	6
10-19	26,900	23	330,000	9
20-49	25,700	22	713,000	20
50-99	13,500	12	929,000	26
100-199	5,100	4	635,000	17
200-499	1,900	2	525,000	14
500-999	200	*	139,000	4
1,000-4,999	100	*	105,000	3
5000+	*	*	34,000	1
Total	114,500		3,641,000	

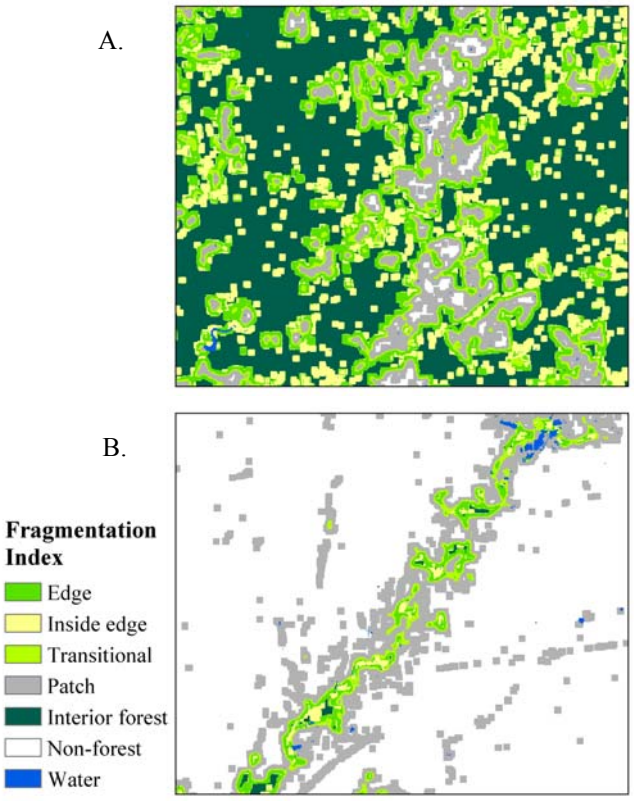
* Fewer than 50 owners or less than 0.5 percent.
Adapted from: Birch, 1996.

Figure 8. Forest fragmentation in Illinois at a landscape assessment size of 5314.41 hectares.[1]



[1] See text for explanation of landscape assessment size.
Adapted from: USDA Forest Service Southern Research Station, 2003; INHS, 1995 & 1996.

Figure 9. Fragmentation in a forested and non-forested landscape in Illinois.



A: Landscape pattern in the Southern Unglaciated Region (Pope County).
B: Landscape pattern in the Grand Prairie Region (Piatt and Champaign Counties).
Adapted from: USDA Forest Service Southern Research Station, 2003.

Species Diversity

The Illinois Plant Information Network (ILPIN) provides information on the taxonomy, ecology, biology and distribution of the vascular flora in the state of Illinois (Iverson et al., 1999a). Previous analyses utilizing the information contained in this database have revealed some important findings regarding the distribution of forest-associated plant species in Illinois. Primarily, nearly 50% (1,588) of the 3,209 taxa of vascular plants identified in the database are associated with forested ecosystems (Iverson et al., 1997). Approximately 89% of these forest-associated species are considered to be native (IDENR, 1994). Table 2 summarizes the occurrence of the 517 native and non-native woody plant species found in the state. The tree or shrub category includes species such as eastern redbud and hawthorn that could be classified as either a tree or a shrub depending on various factors. The shrub/liana category includes climbing shrubs such as red honeysuckle.

Higher vascular plant diversity occurs in the northern and southern portions of the state (IDENR, 1994). The common explanation for this phenomenon relates it to the latitudinal range of the state. Northern counties are rich in species characteristic of the northern temperate flora, and southern counties are likewise rich in species characteristic of the Appalachian flora. The highest number of threatened and endangered species, as well as exotic species, also occurs in the northern and southern portions of the state.

Iverson and Prasad (1998) used the ILPIN database to spatially assess regional vascular plant species diversity in the state as affected by landscape pattern and various other parameters. The authors found that, at the county level, plant species richness increased with the proportion of forest cover. Conditions where agricultural land was distributed in small or irregular shaped patches also contributed to higher species richness, as did conditions where multiple land-use categories were relatively evenly distributed across the landscape.

Previous studies based on the development of a habitat evaluation index (Graber and Graber, 1976; Iverson et al., 1989) have shown that forests account for over 75% of total wildlife habitat in the state of Illinois (IDENR, 1994). Forests are therefore a key source of habitat for a multitude of wildlife species throughout the state (figure 10),

Table 2. Occurrence of woody plant species in Illinois.

Growth habit	Native	Introduced	Total
Tree	157	43	200
Tree or shrub	53	20	73
Shrub	133	63	196
Shrub/Liana	3	0	3
Woody vine	34	11	45
Total	380	137	517

Source: Robertson, 1994 & 2003.

Table 3. Wildlife species in Illinois requiring forested habitat.

Species	Total number in Illinois[1]	Percent requiring forested habitat[2]
Birds	339	62.8
Reptiles	78	79.7[3]
Amphibians	47	
Mammals	61	82.5
Fishes	195	---

[1] Source: NatureServe, 2002. [2] Source: IDENR, 1994. [3] Reptiles and amphibians combined.

and their importance for the maintenance of wildlife diversity is readily apparent. Table 3 shows the total number of wildlife species that have been documented in Illinois and the percentage of each species group that are known to require forested habitat for at least a portion of their life cycle.

Genetic Diversity

This section addresses the need to monitor both the population levels of forest dependent species as well as their habitat. Declining population levels can be indicative of serious issues that may be affecting wildlife. Restrictions in range or available habitat can be strong indicators that a given population may be experiencing pressures that could contribute to future population declines.

The Illinois GAP Analysis Project (IL-GAP) was initiated to identify species and vegetational communities that are not adequately represented in conservation lands or programs. Results from the Vertebrate Distribution and Mapping element of this project will include maps of species distributions throughout the state and information on how these distributions are related to potential habitat. The Illinois Breeding Bird Survey has also been incorporated into IL-GAP.

The North American Breeding Bird Survey is responsible for monitoring the status and population trends of North American bird species and provides data at the state level. These records go back to the mid 1960's, so population trends can be assessed over a relatively long period of time. Table 4 shows long-term population trends for neotropical migrant bird species in Illinois. Neotropical migrants contain a greater number of species that are decreasing in population size than other species groups. A long-term study of bird population trends from two woodlots in central Illinois also reported a decrease in the relative abundance of neotropical migrants over time (Brawn and Robinson, 1994; IDENR, 1994).

Threatened and Endangered Species

The Illinois Endangered Species Protection Board is charged with the responsibility of listing, delisting, or changing the status of state threatened and endangered species in Illinois. The Board maintains a list of such species and updates this list every five years. The last revision took place in 1999, and the next revised list will become available in 2004. Federally threatened or endangered species are automatically included in the state list. Factors related to the threatened or endangered status of forest species in Illinois commonly include loss or degradation of habitat and human exploitation (Herkert, 1994).

Table 5 lists the occurrence of state and federal threatened and endangered species in Illinois, along with the percentage of forest dependent species in each category. As of 1999, there were a total of 478 threatened and endangered species in

Figure 10. A whitetail deer.

Photo: John Edgington.

Illinois, 41.4% of which are forest dependent species. The majority of state threatened and endangered species are plants (69%), 48.9% of which are forest dependent species. Approximately 75% of state threatened and endangered (T&E) mammals, 60% of state T&E reptiles, 71% of state T&E amphibians, and 35% of state T&E birds are forest dependent species. Excluding fish and the invertebrate group, half of the state's T&E animal species are forest dependent. Illinois has 27 species on the federal threatened and endangered list. A little over 25% of these are forest dependent species.

Table 4. Population trends of neotropical migrant bird species in Illinois: 1966-2002.[1]

Decreasing		**Increasing**	
Significant	Nonsignificant	Significant	Nonsignificant
Bobolink	Whip-poor-will	Chipping sparrow	Blue grosbeak
Grasshopper sparrow	Lark sparrow	Cliff swallow	Yellow-throated vireo
American redstart	Scarlet tanager	Yellow warbler	Blue-gray gnatcatcher
Common nighthawk	Wood thrush	Upland sandpiper	Kentucky warbler
Yellow-breasted chat	Bell's vireo	N. rough-winged swallow	Prothonotary warbler
Dickcissel	Willow/Alder flycatcher	Ruby-thr. hummingbird	Baltimore oriole
Yellow-billed cuckoo	Black-billed cuckoo	Northern parula	Bank swallow
Chimney swift	Common yellowthroat	Summer tanager	Red-eyed vireo
Acadian flycatcher	Grt. crested flycatcher	Warbling vireo	Gray catbird
Purple martin	Orchard oriole	Rose-breasted grosbeak	Eastern wood-pewee
Eastern kingbird	White-eyed vireo	House wren	
Indigo bunting		Barn swallow	

[1] Columns are ranked from most extreme to least extreme trend; significance at $p<0.1$. Adapted from: Sauer et al., 2003.

Table 5. State and federal threatened and endangered species in Illinois.

Listed Species	**State (1999)**					**Federal (2002)**
	Endangered	Threatened	*Total*	Forest species	*Percent of total*	
Fish	21	10	31	---	---	1
Reptiles	8	7	15	9	*60.0*	1[a]
Amphibians	3	4	7	5	*71.4*	0
Birds	26	8	34	12	*35.3*	4[b]
Mammals	5	3	8	6	*75.0*	2
Invertebrates	39	13	52	4	*7.7*	10
Animal sub-total	102	45	147	36	*24.5*	18
Plants	265	66	331	162	*48.9*	9[c]
Total	367	111	478	198	*41.4*	27
Forest species	153	45	198	---	---	7
Percent of total	*41.7*	*40.5*	*41.4*	---	---	*25.9*

[a] Candidate species – eastern massasauga rattlesnake (*Sistrurus catenatus*).
[b] Includes 1 non-essential experimental population – whooping crane (*Grus americana*).
[c] Includes 1 species recently presumed extirpated from Illinois – Price's potato-bean (*Apios priceana*).
Sources: Illinois Endangered Species Protection Board, 1999; USFWS, 2003a; Chicago Academy of Sciences, 2003; Herkert, 1994; Illinois Natural Heritage Database; Illinois Natural History Survey, 2003b & 2003c; Iverson et al., 1999a; Robertson, 1994; NatureServe, 2002.

Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

Criterion 2 contains five indicators related to the capacity of forested ecosystems to produce extractive goods and services for the benefit of society in a sustainable manner. Indicator 10 is a measure of the percentage of total forestland in Illinois that is available for the production of timber, herein referred to as timberland. Indicator 11 addresses the number and volume of growing stock trees on timberland. This indicator also addresses issues such as timber quality and species desirability by incorporating the concept of merchantability. Indicator 12 addresses the extent of timberland that exists as plantations in the state. Indicator 13 directly addresses the rate of removal of timber products from timberland, and whether or not such rates of removal are considered to be sustainable. Indicator 14 is concerned with the extraction of non-timber products from forests in Illinois such as mushrooms, medicinal or otherwise edible plants, game animals, etc. Together these five indicators are designed to measure the degree to which natural resources found on forestland within the state of Illinois are being utilized.

Timberland

Illinois has just over 4.3 million acres of total forestland, of which just under 4.1 million acres is classified as timberland by the USDA Forest Service (Schmidt et al., 2000). In other words, approximately 94.4 percent of all forestland in Illinois is available for timber production. The percentage of timberland acreage by forest type is very similar to that of forestland acreage by forest type (see Criterion 1).

There were a total of approximately 2.4 billion live trees on timberland in Illinois as of 1998. Approximately 80% of these trees qualified as growing stock according to USDA Forest Service definitions. Growing stock trees are commercial species that meet specific size, quality and merchantability standards. Rough cull trees of poor form or nonmerchantable species accounted for 19% of total live trees on Illinois timberland, and trees unsuitable for timber due to rotten wood accounted for 1%. Hardwood species accounted for 98% of both total live and total growing stock trees. Oak species accounted for 11% of total live trees and 13% of growing stock trees. The total number of growing stock trees on Illinois timberland increased by about 19% between 1985 and 1998 (Schmidt et al., 2000).

The volume of all live trees on timberland in Illinois was approximately 6.7 billion cubic feet in 1998 (table 6). Growing stock volume accounted for just over 89% of total volume. Rough trees accounted for 9% of total volume, and rotten trees 2%. Hardwoods accounted for 97% of both total and growing stock volume. Although oak species accounted for only 11% and 13% of total live and growing stock trees, respectively, they accounted for approximately 39% and 40% of total live and growing stock volume, respectively. Between 1962 and 1985, growing stock volume increased by approximately 37% (Iverson et al., 1989). Growing stock volume increased by about another 26% between 1985 and 1998 (Schmidt et al., 2000).

The majority of Illinois timberland was moderately to fully stocked in both 1985 and 1998 (figure 11). There was a noticeable shift in timberland from the medium to fully stocked stocking classes between these two inventories, as well as slight increases in the other three stocking classes. Approximately 7% of timberland in Illinois was overstocked in 1998, and about 15% was poorly stocked. In a general sense, stocking class refers to the degree to which timberland is being utilized to its full potential by the timber growing upon it.

Sustainable Removals of Wood Products

The accepted methodology for interpreting and reporting on the sustainable removal of wood products involves the comparison of annual rates of net growth and removals of growing stock volume

Table 6. Volume of live trees on timberland in Illinois: 1998.

Species Group	Total	Growing stock
	Volume (thousand cubic ft)	
Loblolly and shortleaf pine	69,076	68,492
Other yellow pines	4,821	3,750
Eastern white and red pine	68,370	67,508
Jack pine	2,714	2,444
Spruce and balsam fir	1,074	1,042
Cypress	8,284	8,284
Other eastern softwoods	21,990	17,339
softwoods subtotal	176,329	168,860
Select white oaks	1,091,751	985,499
Select red oaks	397,403	374,761
Other white oaks	150,358	137,749
Other red oaks	965,623	908,262
Hickory	673,941	647,310
Hard maple	240,750	206,739
Soft maple	590,113	519,673
Beech	19,556	14,866
Sweetgum	75,558	74,733
Tupelo and blackgum	23,030	21,783
Ash	352,341	312,155
Cottonwood and aspen	250,545	233,596
Basswood	79,295	71,418
Yellow-poplar	83,375	81,709
Black walnut	180,242	158,392
Elm	285,342	236,235
Other eastern soft hardwoods[1]	781,944	639,655
Other eastern hard hardwoods[2]	201,949	149,484
Eastern noncommercial hardwoods[3]	80,941	0
hardwoods subtotal	6,524,056	5,774,019
Total	6,700,385	5,942,879

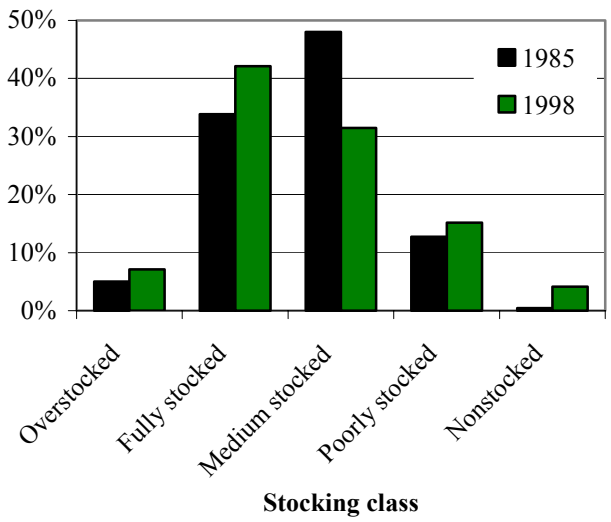
[1] Includes: hackberry, sycamore, black cherry, black willow, box-elder, birch, sassafras, Ohio buckeye, northern catalpa, mulberry, and butternut. [2] Includes: honeylocust, black locust, Kentucky coffeetree, persimmon, and flowering dogwood. [3] Includes: osage-orange, ailanthus, pawpaw, American hornbeam, eastern redbud, hawthorn, apple, eastern hophornbeam, wild plum, and peachleaf willow.
Sources: USDA Forest Service FIADB; Bretthauer and Edgington, 2002; Schmidt et al., 2000.

on timberland. The rationale behind this approach is that if net growth of growing stock exceeds removals over a given time period, then the harvest of wood products in the region of question is sustainable (USFS, 2003a). It should be noted that mortality rates are already incorporated into net growth (i.e., net growth equals total growth minus mortality).

In Illinois average annual removals of growing stock on timberland were less than 40% of average annual net growth from 1985 to 1997 (figure 12). This means that during this time period, net growth exceeded removals by a factor of over 2.5. Growth of softwoods on Illinois timberland during this time period was over 5 times the rate of softwoods removal. Net growth exceeded removals for all major species groups except beech, which is a very minor component of timberland in Illinois. Elm species had relatively high mortality rates, most likely due to the effects of Dutch elm disease (Bretthauer and Edgington, 2002).

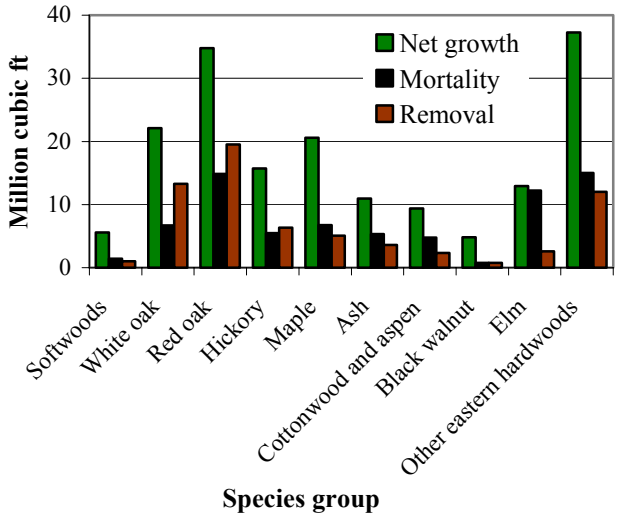
Oak species accounted for 50% of total annual hardwood removals in Illinois, and nearly 33 million cubic feet of growing stock were removed from the white and red oak species groups per year. Net growth of these species exceeded 56 million cubic feet per year. Oak is a valuable timber species in Illinois, and this is reflected in the relatively high annual harvest rates for oak species. Although over half of the increase in growing stock volume for the oak groups is removed annually, these species are still accumulating substantial

Figure 11. Percentage of Illinois timberland in growing-stock stocking classes: 1985 and 1998.



Source: USDA Forest Service FIADB.

Figure 12. Net growth, mortality and removal of growing stock on Illinois timberland.[1]



[1] Net growth, mortality and removals represent average annual values from 1985-1997. Sources: USDA Forest Service FIADB; Bretthauer and Edgington (2002); Schmidt et al. (2000).

growing stock volume over time. Additionally, standing growing stock volume for oak species is exceptionally high for the state, and less than 2% of this total volume is harvested on an annual basis.

The relative amount of growing stock volume removed on an annual basis from 1985 to 1997 declined substantially from that removed from 1962 to 1985. From 1962 to 1985, annual removals were approximately 71% of annual net growth (Iverson et al., 1989). Annual removals decreased to 38% of annual net growth from 1985 to 1997. Absolute removals decreased only slightly between the two time intervals, however, meaning annual net growth was much greater from 1985 to 1997.

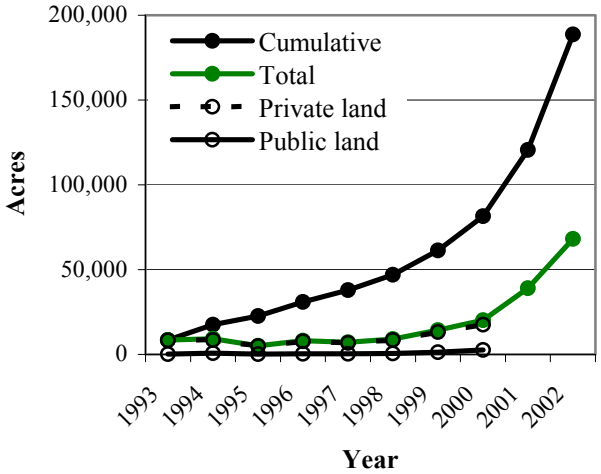
Plantations

The 1998 inventory conducted by the USDA Forest Service Forest Inventory and Analysis Program delineated just over 140,000 acres of timberland in Illinois (3.4%) for which there was clear evidence of artificial regeneration, an accepted reference to area in plantations (Schmidt et al., 2000). Although softwoods accounted for less than 3% of total timberland area in the state, they accounted for about 54% of total plantation area. Virtually all of the eastern white pine, shortleaf pine, and other pine–hardwood forest types in Illinois were artificially planted. Both the eastern redcedar and eastern redcedar–hardwood forest types originated under natural conditions, as did about half the shortleaf pine–oak forest type. Overall, 69% of timberland acreage containing softwoods was artificially planted.

Plantations accounted for approximately 3.9% of total growing stock volume in 1998, and over 80% of softwood growing stock volume. A few hardwood species groups had a relatively high proportion of growing stock volume in plantations, including select white oaks, sweetgum, yellow-poplar, and black walnut. Total growing stock volume on plantations increased by about 41% between 1985 and 1998.

Tree planting and direct seeding on public and private land increased from under 10,000 acres per year throughout the early to mid 1990's to just over 20,000 acres per year in 2000. Almost 40,000 acres were planted in 2001, and nearly 70,000 acres in 2002 (figure 13). The majority of tree planting takes place on private land with the assistance of programs such as the Conservation Reserve

Figure 13. Tree planting and seeding on public and private land in Illinois: 1993-2002.[1]



[1] Only total tree planting acreage was available for 2001and 2002. Sources: USDA NASS, 1994-2003; NRCS, 2002.

Program (CRP), the Conservation Reserve Enhancement Program (CREP), and the Illinois Forestry Development Cost-Share Program (NRCS, 2002). Cumulatively, almost 190,000 acres have been planted or direct seeded in Illinois over the past decade. Two state forest nurseries in Mason and Union counties produce about 4 million seedlings per year (NRCS, 2002). Private nurseries also provide a significant amount of seedlings for tree planting in Illinois.

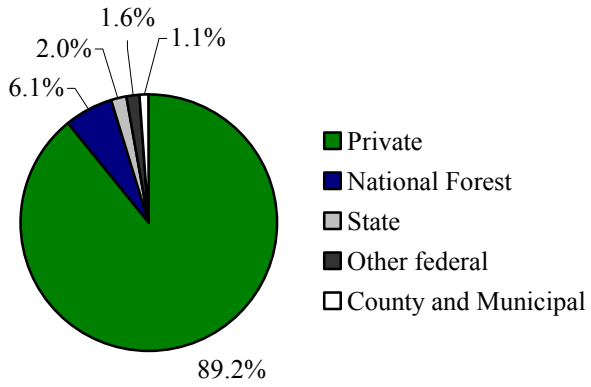
Exotic tree species do not account for a significant amount of timberland acreage or growing stock in Illinois, either overall or on plantations. Loblolly pine is not native to Illinois but it accounts for about 5% of the loblolly and shortleaf pine species group (Bretthauer and Edgington, 2002). Its occurrence is mainly restricted to the southern portion of the state (Mohlenbrock, 1990). Many of the Christmas trees planted in Illinois are also not native to the state. The 1997 Agricultural Census reported a total of 521 Christmas tree farms operating on a total of 2,714 acres in Illinois.

Ownership

Similar to many other states in the North Central Region (Shifley and Sullivan, 2002), private forest landowners own a significant amount of timberland in Illinois. As shown by figure 14, 89% of the timberland acreage in the state is privately owned. Corporations own about 7%, meaning 82% of all timberland in the state is owned by private non-industrial landowners.

Most of these private landowners own relatively small units of timberland, and accompanying such a large, diverse group of individuals is a diverse set of management objectives (Birch, 1996). Previous surveys of private landowners in Illinois have revealed that timber production is ranked low on a list of reasons for owning forested land. In fact, only 3% of private landowners in Illinois listed timber production as the primary reason for owning forestland, and less than 1% listed timber production as a secondary reason (Birch, 1996).

Figure 14. Ownership of timberland in Illinois: 1998.



Source: USDA Forest Service FIADB.

Although timber production did not rank high among primary or even secondary reasons for owning forested land, approximately 46% of survey respondents had some past timber harvest experience. Furthermore, approximately 55% stated an intent to harvest timber at some point in the future. This 55% of respondents owned about 75% of the total timberland acreage pertinent to the study. About 42% of respondents, who collectively owned about 22% of the total timberland acreage, stated that they never intended to harvest timber from their property.

The fact that the majority of timberland in Illinois is owned by a multitude of private individuals with different values and management goals poses a complicated scenario for those agencies responsible for ensuring that the state's forests are managed in a responsible manner. The importance of integrating sustainable forest management efforts with the needs of private landowners cannot be over-emphasized if the goal of sustainable forest management is to be realized in Illinois.

Non-Timber Forest Products

Non-timber forest products (NTFPs) are becoming an increasingly important facet of sustainable forest management in Illinois and elsewhere in the United States. The scope of this issue is quite broad, as NTFPs include a great variety of different

products from game animals to medicinal plants. One of the inherent difficulties in reporting on this issue is a lack of documentation concerning the removal of the various products described as NTFPs. Although data is available for certain products, it is virtually nonexistent for others. For example, wild mushrooms (figure 15) are often collected from private land by private landowners for their own use, and are generally unregulated. The Illinois Department of Natural Resources requires licensing for harvesting natural populations of wild ginseng, thereby providing some degree of regulation and documentation for this NTFP.

Annual harvest information for game animals such as deer and wild turkey is collected by the Illinois Department of Natural Resources. In 2002, over 100,000 deer were harvested in the state during firearm season. Nearly 15,000 wild turkeys were also harvested in the spring of 2002. Harvests of both of these game animals have been on the increase in recent years.

Figure 15. Non-timber forest products (NTFPs) include items such as morel mushrooms.

Photo: Jeremy Shafer.

Furbearing animals such as beaver, muskrat, raccoon and foxes in Illinois are fairly well monitored throughout the state. While some are protected, harvesting is often a method used to control population levels of others. Information pertaining to the management of the 14 animals classified as furbearers in Illinois, including hunting and trapping regulations, can be found at the Illinois Department of Natural Resources' website.

Along with a number of private organizations, the Northeastern Area State and Private Forestry branch of the USDA Forest Service has recognized the importance of both documenting and increasing the level of active management of the nation's non-timber forest resources. These organizations serve to facilitate the sharing of information about NTFPs among relevant parties and represent an important first step towards the sustainable management of non-timber forest resources.

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

Criterion 3 contains three indicators related to the overall health and condition of forest ecosystems. Emphasis is generally placed upon the impacts of stressors that are known to impair the ecological functionality of forest ecosystems. Indicator 15 addresses all biotic and abiotic agents that may negatively impact forests except air pollution. For example, biotic factors that are addressed by this indicator include insect outbreaks, diseases that attack tree species (e.g., Dutch elm disease), and invasions by exotic species. Abiotic factors that may negatively impact forest ecosystems include events such as fires and storm damage. The effects of air pollution on forest ecosystems are addressed in indicator 16. For example, the deposition of nitrogen and sulfur compounds may affect forest ecosystems by altering their chemical and nutrient cycling processes, among other factors. Indicator 17 addresses forest ecosystem components and processes. Diminished biological components that are otherwise characteristic of normally healthy ecosystems may serve as an early warning system that factors or processes, either known or unknown, are negatively impacting forest ecosystems.

Forest Health

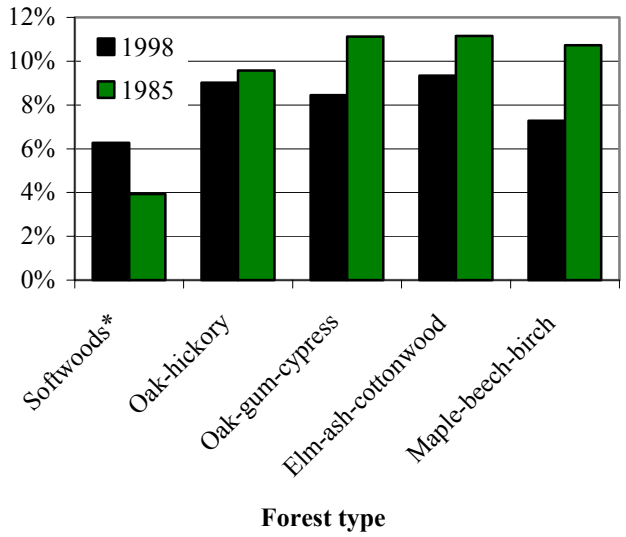
Tree diseases continue to have a negative effect on forest ecosystems in Illinois. Historically, Dutch elm disease had a significant impact throughout the state. Although elm trees continue to be killed by this pathogen, they are able to reproduce and are very numerous in younger age classes. Insect outbreaks, although affecting a smaller proportion of trees in the state, are also continually a cause for concern. The recent Asian longhorned beetle outbreak in Chicago illustrates the destructive potential of such exotic pests and the need for aggressive management techniques. The gypsy moth, another exotic insect pest that is very detrimental to oak species in particular and also a species of national concern, is steadily gaining ground in northeastern Illinois despite intensive control efforts.

The USDA Forest Service's Forest Inventory and Analysis (FIA) Program collects data related to damaged trees as part of its inventory process. According to this inventory, approximately 17% of the 2.4 billion trees in Illinois had enough visible damage to be categorized as a damaged tree. The cause of damage could not be ascertained for 40% of those damaged trees. Disease was responsible for about 31% of the damage reported for live trees, and anthropogenic causes were responsible for about 18% of reported damage. Insects were responsible for about 4% of reported damage on live trees in Illinois. Fire was a relatively negligible source of damage to trees in Illinois. Total damage reported by forest type was approximately 15% for oak-hickory forests, 19% for elm-ash-cottonwood and maple-beech-birch forests, 21% for oak-gum-cypress forests, 6.5% for oak-pine forests, and 2.5% and 12% for white–red–jack pine and loblolly–shortleaf pine forests, respectively.

Figure 16 shows the percentage of trees within major forest types in Illinois that were reported as damaged in the 1985 and 1998 inventories. Trees for which the cause of damage was listed as unknown/other were excluded from this figure due to the extreme amount of variation within that category between inventory years. Damage to softwoods declined by over 1/3 between 1985 and 1998, but damage increased between inventories for all other forest types. This increase was less pronounced for the oak-hickory forest type than the other three major forest types. Disease was by far the most prevalent damaging agent in both inventories, although its relative magnitude decreased somewhat in 1998. Damage due to insects, animals, and anthropogenic sources such as logging operations increased between inventories.

The USDA Forest Service National Forest Health Monitoring Program (now merged with the FIA program) collects a variety of information related to the health and status of forests across the country. This information is distributed in the form

Figure 16. Percentage of damaged live trees on Illinois timberland by forest type.[1]



[1] Damaging agents: insect, disease, fire, animal, weather, and logging/human.
* Includes the white–red–jack pine, loblolly–shortleaf pine, and oak-pine forest types.
Source: USDA Forest Service FIADB.

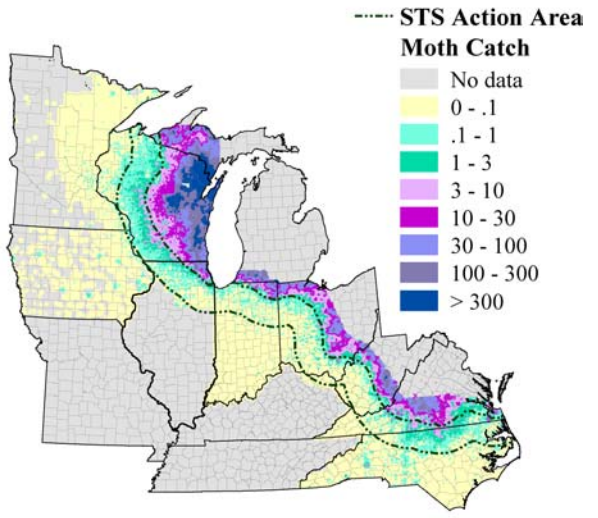
of annual forest health highlight reports, available by region or state. Recent forest health issues in Illinois include pests such as the eastern tent caterpillar, bagworm, pine shoot beetle, Japanese beetle, gypsy moth, and the Asian longhorned beetle.

The Asian longhorned beetle is a forest pest with the potential for causing widespread damage throughout the United States due to its wide range and host preference (Cavey, 2000). This highly destructive insect was discovered in Chicago in 1998, where control measures included treatment with insecticide injections as a preventative measure and removal and destruction of infested trees. Initial efforts to control the Asian longhorned beetle in Chicago appear to have been highly successful, with the number of infested trees reported in the 2002-2003 season reduced to 6 from over 900 in the first year of suppression. Costs for eradication and control measures for the Asian longhorned beetle have already run into the millions of dollars nationally (APHIS, 2003).

The gypsy moth is another pest species of national concern that has begun to make its impact felt in Illinois. Gypsy moths commonly defoliate a number of different host species, but damage to oaks may be especially severe. Impacts to the forests of Illinois, many of which are dominated by oak species, could be severe. The national "front" of gypsy moth infestation now runs through the northeastern portion of the state, and national containment efforts are more or less reduced to slowing the spread of this exotic forest pest (FHM, 2001). Thus far, Lake County in northeastern Illinois is the state's only county to be included in the national gypsy moth quarantine area (GMDigest, 2003).

The "slow the spread" (STS) program has had a moderate amount of success in Illinois as evidenced by a decline in gypsy moth catch numbers from over 40,000 moths in 1998 to just over 10,000 moths in 2002 (STS, 2003). The spatial extent of the gypsy moth infestation in Illinois is illustrated in figure 17. The STS action area identifies where the containment and eradication efforts of the program are concentrated along the infestation front.

Figure 17. Gypsy moth Slow the Spread (STS) Action Area and 2003 trap catch.



Adapted from: STS, 2003.

Illinois ForestWatch, a volunteer forest-monitoring program, is part of the Illinois EcoWatch Network and is coordinated by the Illinois Department of Natural Resources. Illinois ForestWatch is responsible for collecting a variety of data related to forest health including the presence of invasive shrubs, evidence of gypsy moths, evidence of dogwood anthracnose, and other indicators of forest condition such as canopy cover. Data collected as a part of this program indicate that invasive shrubs are a serious problem in Illinois' forests. The percentage of shrub species in forest understories that are considered invasive species are exceedingly high throughout the ForestWatch monitoring sites. The magnitude of the relative presence of invasive species in the shrub layer indicates the immediate importance of this management issue. Shrubs that were recorded as invasive in this study include shrub honeysuckle, buckthorn, European highbush cranberry, autumn olive, multiflora rose, and Missouri gooseberry.

Illinois ForestWatch also monitors 22 indicator ground cover species at all study sites in the state. These indicator species are differentially sensitive to various types of disturbances and include a representative number of exotic/invasive species (table 7).

Air Quality

Air quality and atmospheric deposition data for the state of Illinois are available from a variety of sources. However, at this point in time there exists no readily available means for the bridging of this data to the area and percent of forestland that may be directly or indirectly affected by such processes. In order to fully address this issue, air quality and atmospheric deposition data will have to be spatially coupled with forestland data, then integrated with information related to the susceptibility of forest vegetation to the quantities of air pollutants it may be acutely or chronically exposed to.

The Illinois Environmental Protection Agency (IEPA) publishes emissions data and trends for major air pollutants in Illinois in the Illinois Annual Air Quality Report (IAAQR). Indicators of ambient air quality, such as ozone (O_3) levels and air quality index ratings, are also included in this report. Emission levels of most major air pollutants, especially sulfur dioxide and nitrogen oxides, have been decreasing over the last two decades. Although this trend is not as apparent for particulate matter, volatile organic material, or carbon monoxide, 2001 levels for all three of these compounds were less than half of what they were in 1981. Chemical reactions in the atmosphere transform sulfur dioxide and nitrogen oxides into sulfuric and nitric acid, which can then be precipitated back to terrestrial ecosystems. Nitrogen oxides and volatile organic materials are key inputs in the chemical formation of tropospheric ozone (O_3). Problem areas in the state are associated with heavy industrial zones such as the Chicagoland area, the St. Louis Metro-East area, and several mid-state regions including Macon, Sangamon, Peoria, and Tazewell Counties.

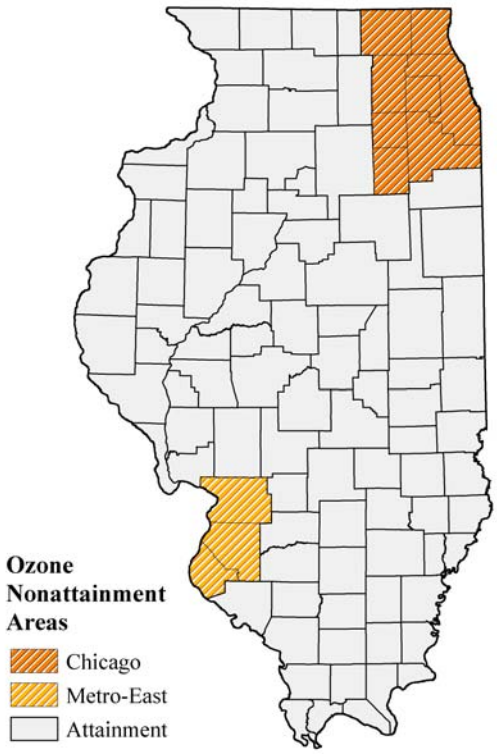
Table 7. Indicator species monitored in the Illinois ForestWatch program.

Common native plants	Disturbance-sensitive plants	Exotic/invasive plants
Virginia bluebells	Blue cohosh	Garlic mustard
Wild columbine	Maidenhair fern	Dame's rocket
Blue phlox	Large-flowered bellwort	Moneywort
Red trillium	White trillium (all species)	Ground ivy
Blue-eyed Mary	Squirrel corn; Dutchman's breeches	Japanese honeysuckle
Wild geranium	Doll's eyes (both species)	Missouri gooseberry
Sensitive fern	Virginia spiderwort	
Swamp buttercup	Hepatica (both varieties)	

Source: Illinois ForestWatch.

Ground level or tropospheric ozone (O_3) was one of the leading causes of unhealthy ambient air quality in Illinois in 2001 and 2002 (IEPA, 2003a and 2002). Portions of the state of Illinois in the Chicagoland and St. Louis Metro-East regions have been designated as nonattainment areas for ozone in terms of compliance with the Clean Air Act (figure 18). This means that ozone levels in these areas have consistently exceeded National Ambient Air Quality Standards or have contributed to other areas exceeding NAAQS standards. Animated daily maps of ozone levels in the midwest, available from the US Environmental Protection Agency's AIRNow website, commonly show a plume of ozone across Illinois originating from the St. Louis area. The effects of ozone are detrimental to vegetation as well as to people, and the National Forest Health Monitoring Program has initiated a protocol to monitor foliar ozone damage in sensitive species as part of the Forest Inventory and Analysis (FIA) Program. For the eastern region, these species include black cherry, white ash, yellow poplar, sassafras, sweetgum, pin cherry, blackberry, common milkweed, spreading dogbane, and big leaf aster (FHM, 2003). Initial results suggest that ozone-induced foliar injury has been detected on indicator species throughout Illinois (FHM, 2003).

Figure 18. Counties containing designated ozone nonattainment areas in Illinois.



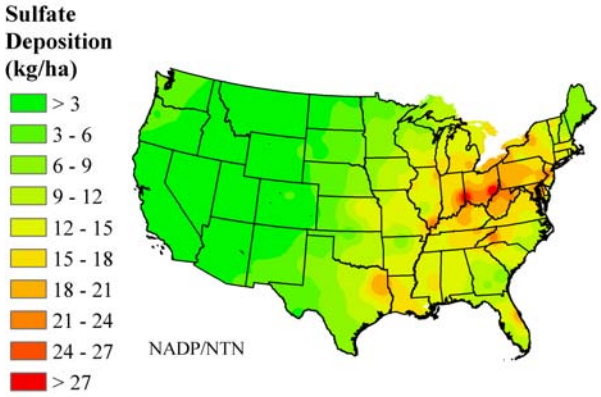
Sources: IEPA, 2003a. INHS, 1995 & 1996.

The National Atmospheric Deposition Program/ National Trends Network monitors the deposition of various compounds throughout the United States. There are currently six active NADP/NTN monitoring sites in Illinois. National spatial trends are available in the form of isopleth maps of deposition rates. Sulfate deposition rates in 2001 were highest in southern Illinois and in the Chicagoland area (figure 19). Inorganic nitrogen deposition rates were highest in the northeast, northwest, and southern portions of Illinois. Trends in deposition rates indicate a decline in sulfate deposition, not much change in nitrogen deposition, and an increase in field pH for Illinois over the past two decades (NADP/NTN, 2003).

Oak Regeneration

In the state of Illinois, an issue that points to widespread changes in fundamental ecological process and/or continuity involves a phenomenon known as "maple takeover". This phenomenon refers to the replacement of oak-hickory species by shade-tolerant maple species over time. Oak

Figure 19. Sulfate (SO_4^{2-}) deposition: 2001.



Sources: National Atmospheric Deposition Program/National Trends Network (NADP/NTN); National Weather Service.

seedlings are intolerant of heavy shade on the forest floor, and are unable to survive without adequate light levels created by periodic disturbances. A century or more of fire suppression in oak-hickory forests has also been linked to a lack of successful oak regeneration (figure 20). Maple species are generally unable to survive periodic fires, unlike oak species (IDENR, 1994).

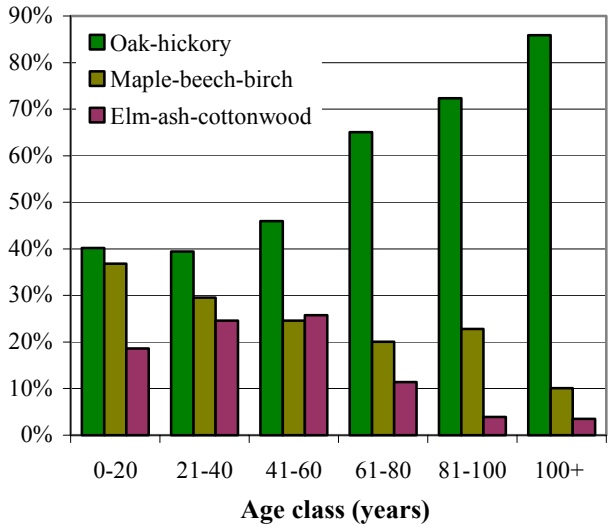
The extent of this phenomenon is apparent when age class distributions of major forest types are examined (figure 21). Older age classes in Illinois are dominated by oak-hickory forests. Progressing into younger age classes, the relative dominance by oak and hickory species steadily declines. The age class distributions of maple-beech-birch and elm-ash-cottonwood forests reflect opposing trends. These forest types constitute a small proportion of older age classes in Illinois, but their dominance increases significantly in younger age classes.

Schmidt et al. (2000) reported a decline in the number of small diameter white oak trees on Illinois timberland between statewide USDA Forest Service Forest Inventory and Analysis Program inventories in 1985 and 1998. White oak is a valuable timber species in Illinois and any reduction in successful white oak regeneration is a cause for concern for economic as well as ecological reasons. The number of red oak saplings in the same diameter classes increased between the two inventories.

Figure 20. Prescribed fires may promote oak regeneration.

Photos: John Edgington.

Figure 21. Relative age class distribution of the three major forest types in Illinois by number of live trees on timberland: 1998.



Source: USDA Forest Service FIADB.

Criterion 4: Conservation and Maintenance of Soil and Water Resources

Criterion 4 addresses the conservation and maintenance of soil and water resources in forested ecosystems. Indicator 18 specifically addresses the issue of soil erosion on forestland that either occurs naturally or as a direct or indirect result of forest management activities. Indicators 21 and 22 respectively address chemical and physical properties of forest soils that may be altered by forest management activities, such as the loss of soil organic matter and soil compaction. Indicator 25 specifically addresses the issue of accumulating toxic substances such as heavy metals or pesticides in forest soils. Indicators 20, 23, and 24 address aquatic issues in forested ecosystems. These include changes in stream flow and timing, aquatic biological diversity, and other water quality parameters such as sedimentation, temperature changes, dissolved oxygen, and pollutants. Indicator 19 addresses the protective functions or benefits of forestland as they relate to soil and water resources. For example, forested riparian zones provide a protective function by filtering sediment and agricultural chemicals from runoff entering streams and rivers from adjacent farmland.

Soil Erosion

Soil erosion is a natural process inherent to global geophysical and geochemical cycles, resulting from the weathering of parent material over time by various physical and chemical forces. However, excessive rates of soil erosion can be detrimental to the terrestrial ecosystems experiencing an accelerated loss of soil substrate. Aquatic ecosystems that transport sedimentary substances and which ultimately serve as a sink for eroded soil can also be negatively impacted. Rates of soil erosion from undisturbed forest ecosystems are generally low compared to other forms of land use in Illinois. However, timber harvesting operations and other forest management activities can result in temporary increases in soil erosion rates from forested watersheds. Although data is currently lacking to sufficiently address this issue, forest soil monitoring protocols have been incorporated into the Forest Health Monitoring element of the USDA Forest Service's Forest Inventory and Analysis Program. Data collected from this program will be instrumental in the future assessment of this issue (USDA Forest Service, 2003b).

Rural land use in Illinois is heavily dominated by agricultural production, and most soil conservation programs in the state are focused on cropland. Soil Conservation Service data from the late 1980's indicate that forests accounted for only 6% of total soil loss in rural Illinois, compared to 86% for cropland (Iverson et al., 1989). Erosion rates for ungrazed forestland on a per acre basis were the lowest of five rural land use categories. However, erosion rates for grazed forestland were the highest of those five categories and over eight times the rate for ungrazed forestland. This illustrates the potential of various forms of disturbance to greatly increase rates of soil erosion on forestland, and the need for careful planning when implementing forest management activities.

The State Soil Geographic (STATSGO) database contains spatially referenced baseline information on the physical and chemical properties of soils in Illinois. This database also includes interpretative parameters for the purpose of facilitating various activities related to engineering, water management, recreation, and woodland and wildlife management, among others (IL NRCS, 2003). One of these parameters, referred to as woodland erosion risk, specifically indicates the probability that erosion damage may occur as a result of site preparation and harvesting operations where soil is exposed (USDA SCS, 1994). Figure 22 displays a map of this STATSGO parameter for the state of Illinois. For this representation, erosion risk ratings for woodland soils were converted to a numerical scale, spatially weighted at the soil component level, and then aggregated to the map unit level. Areas of moderate erosion risk are associated with areas of greater topographical relief

such as in the Shawnee Hills region in southern Illinois, bluffs along the Mississippi River, and the unglaciated region in extreme northwestern Illinois. Other areas of moderate risk are generally associated with river systems in some portions of central and northern Illinois. The two areas of severe risk occur in extreme southeastern and southwestern Illinois.

Soil Properties

The chemical properties of forest soils are strongly related to their nutrient availability and therefore their potential productivity. The accumulation of soil organic matter (OM) through the decomposition of leaf litter and other organic materials is an important component of nutrient cycling in forested ecosystems. Soil OM not only acts as a reservoir for nutrients by providing exchange sites but also improves some physical properties in forest soils such as aeration and infiltration. The removal of forest soil OM may adversely affect the soil's nutrient availability and productivity, as well as altering other chemical properties. Soil pH plays an important role in regulating chemical processes in soils, and may provide information related to soil weathering and the impact of events such as acidic atmospheric deposition on the nutrient holding capacity of soils. Cation exchange capacity (CEC) is a measure of the ability of a soil to retain positively charged nutrients (cations) and generally increases with soil OM. Baseline data related to the these parameters is available from the STATSGO database and were used to create maps, similar to figure 22, that were incorporated into the technical version of this report.

Figure 22. Soil erosion risk associated with woodland management activities.

Adapted from: USDA STATSGO; INHS 1995 & 1996.

Changes in soil physical properties (e.g., soil compaction) can limit aeration and the infiltration and drainage of water, as well as impede root growth of trees and other vegetation. These factors can in turn limit site productivity. Forest soil compaction due to human activities is usually associated with management practices such as harvesting and related activities that utilize heavy machinery, create skid trails, or require road construction. The use of forests for livestock grazing can also lead to soil compaction. The STATSGO database contains a woodland equipment limitation rating component, similar to the woodland erosion risk rating, that assesses the risk of physical damage to woodland soils from site preparation and cutting operations. A map displaying this parameter for the state of Illinois can also be found in the technical version of this report. Again, soils data currently being collected by the USDA Forest Service's Forest Inventory and Analysis Program will be instrumental in fully assessing issues related to forest soil properties in the future (USDA Forest Service, 2003b).

Water Quality

The chemical, physical and biological components of aquatic systems can be impacted by land use in the surrounding watershed. For example, the impacts of various forest management activities

may negatively affect aquatic organisms through resultant increases in sedimentation rates and alteration of aquatic habitat and riparian vegetation. Most of the watersheds in Illinois are dominated by agriculture, making an assessment of water bodies in forested areas somewhat limited. For example, both the Upper and Lower Illinois River Basins are included in the National Water Quality Assessment Program (NAWQA) and are heavily monitored, but the percentage of each watershed that is forested is only 5% and 7%, respectively (USGS, 2002 & 2000). Also, many streams and rivers in Illinois pass through a variety of different land uses along their courses, making an assessment of the impacts of any single one of them on aquatic systems difficult. Furthermore, although the United States Geological Survey (USGS) and the Illinois Environmental Protection Agency (IEPA) both maintain an extensive network of monitoring sites throughout the state, little information is available from these agencies that directly assesses water quality in forested catchments. For these reasons, as well as the ambiguity associated with what constitutes deviation from the "historic range of variation", this issue can only be partially assessed at this time.

A recent summary of water quality throughout the state of Illinois is available in the Illinois Water Quality Report – 2002 (IEPA, 2002). The IEPA assesses the quality of water bodies throughout the state by the degree to which they support designated uses (e.g., aquatic life, swimming, drinking water, etc.). Aquatic life is considered by the IEPA to be the most comprehensive reflection of overall resource quality, and for nearly all Illinois streams is the overriding factor utilized in use-support assessments (IEPA, 2002). The evaluation of parameters related to aquatic life is therefore an integral component of water quality assessments throughout the state. Water bodies that only partially meet their designated uses or fail to meet them are classified as impaired.

Table 8 lists the sources/causes of impairment in Illinois in 1998, and the relative contribution of each to the total number of impairments reported. Sedimentation, nutrient loads, and organic enrichment/low dissolved oxygen are the leading causes of impairments to water quality in Illinois. More detailed maps and information about individual water bodies statewide can be found in the Illinois Water Quality Report – 2002 (IEPA, 2002), at the Illinois Water Quality Information – 2002 Mapping Tool website, and at the Illinois State Impaired Waters Program website.

Hydrological Regimes and Channelization

Deforestation and/or reforestation can have impacts on the hydrological regime in a watershed. Common impacts of deforestation include increases in average stream flow, low flows, and flooding (IDENR, 1994). These impacts are primarily the result of increases in overland flow due to soil compaction and reduced infiltration, and decreases in evapotranspiration due to the loss of trees and other vegetation (IDENR, 1994). In

Table 8. Sources/causes of impairments to water quality in Illinois: 1998.

Impairment type	**Impairments reported**	
	Number	Percent of total
Sedimentation	917	32.0
Nutrients	634	22.1
Organic enrichment/low DO[1]	309	10.8
Metals	187	6.5
Other habitat alterations	165	5.8
Noxious aquatic plants	146	5.1
Flow alteration	84	2.9
Priority organics[2]	83	2.9
Salinity/TDS[3]/chlorides	79	2.8
Other inorganics[4]	61	2.1
Un-ionized ammonia	49	1.7
Pathogens[5]	41	1.4
pH	30	1.1
Other[6]	78	2.7
Total	2,863	

[1] Dissolved oxygen; [2] e.g., phenols, pesticides; [3] total dissolved solids; [4] e.g., fluoride; [5] e.g., fecal coliform bacteria; [6] pesticides, thermal modifications, taste and odor, nonpriority organics, chlorine, oil and grease, and unknown. Source: USEPA, 2003.

Illinois, most of the conversion of forestland to cropland and other uses occurred over a century ago. Since this happened well before stream-gauging stations were established throughout the state, the extent to which current stream flow and timing deviates from the "historic range of variation" is impossible to assess.

The impacts of channelization on hydrological regimes can include increased downstream flooding and sedimentation. Channelization also commonly has detrimental effects on stream vegetation and habitat (IDENR, 1994). Studies suggest that approximately 27% of the stream miles in Illinois may be channelized, primarily in northeastern urban areas and the east-central portion of the state that is dominated by agricultural production (IDENR, 1994). Other than localized studies related to flooding impacts, however, little information is readily available (IDENR, 1994).

Riparian Zones

Forestland in Illinois is closely associated with river and stream systems. This occurs both in the more heavily forested portions of the state and in the more sparsely forested portions of the state where agricultural production is the dominant land use. For example, a study looking at the spatial association of forests with streams in a 13 county region in south-central Illinois found that 22% of the forests existed within 30 meters of streams and that a full 78% of the forests existed within 300 meters of streams (IDENR, 1994).

Forested riparian zones are known to provide multiple ecological benefits to river and stream systems (Welsch, 1991). Of primary importance in ecosystems that are heavily dominated by agricultural production is the ability of riparian zones to intercept nonpoint source pollution (e.g., nutrient, sediment, and pesticide runoff from agricultural fields) and reduce the input of chemicals and sediments to aquatic systems. Forested riparian zones are also important in maintaining appropriate light and temperature regimes in aquatic systems through the effects of shading, as well as directly providing food inputs and habitat for aquatic communities. In Illinois, contiguously forested riparian zones also provide essential wildlife habitat and "corridors" for the movement of resident and migratory wildlife.

Although it is known that forested riparian zones provide important benefits to aquatic ecosystems in Illinois, and that a substantial amount of forestland in Illinois exists in close proximity to river and stream systems, little quantitative information is currently available to fully assess this issue. Although the protective functions provided by forested riparian zones are important, whether or not riparian forests are managed primarily for the ecological benefits provided by those functions is unclear. For example, in Illinois 82% of timberland is owned by private non-industrial landowners (see Criterion 2). A survey of these landowners in the early 1990's identified a number of primary and secondary reasons these landowners stated were important factors related to their ownership of forestland (Birch, 1996). None of the reasons listed included protective functions of any kind.

The degree to which the spatial extent of forested riparian zones in Illinois has been fully and quantitatively identified is also unclear. The closest approximation to a statewide analysis of the spatial extent of streamside forests available to date is a watershed-scale approach undertaken by the United States Environmental Protection Agency in 1990. This assessment identified the percentage of forestland in a 1 km grid adjacent to streams. This data is available through the USEPA Watershed Information Network's Watershed Atlas program and is presented in figure 23.

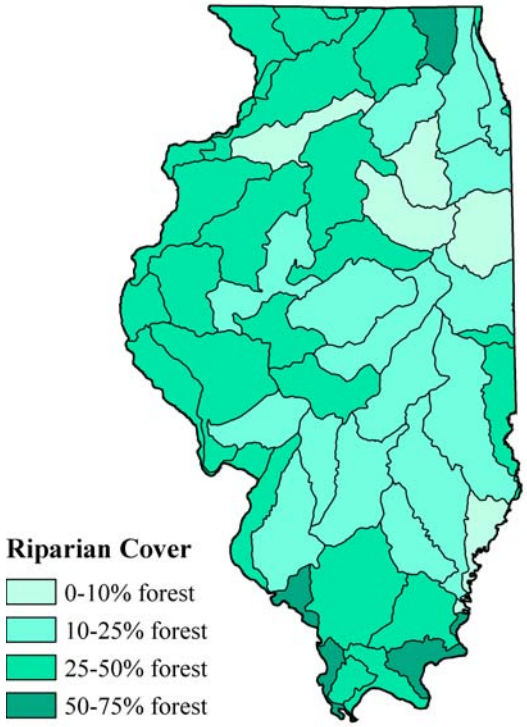
Toxic Substances

Toxic substances deposited on forestland from atmospheric, aquatic, and/or terrestrial sources have the potential to adversely affect ecosystem functions and forest productivity. These types of

substances may originate off site as air pollutants from industrial or urban sources, which then accumulate on forestland through atmospheric deposition, or as point or nonpoint source water pollutants that may be carried downstream and accumulate in floodplain or bottomland forests. Toxic substances may also originate on site through the application of various pesticides, fertilizers, or other chemicals. Although the accumulation of toxic substances can be detrimental to forest ecosystems, soils can also mitigate the effects of toxins through processes such as microbial decomposition and the adsorption of metals and other substances.

There are currently no data to sufficiently address this issue either nationally or for the state of Illinois. However, data collection protocols that explicitly apply to toxic substances have been incorporated into the USDA Forest Service Forest Inventory and Analysis Program's Soil Quality Indicator (USDA Forest Service, 2003b). In the future, soils data from this program should enable the complete assessment of this issue.

Figure 23. Riparian land cover adjacent to streams in Illinois by watershed: 1990.



Source: USEPA Environmental Information Mgmt Systems (EIMS).

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

Atmospheric carbon dioxide (CO_2) concentrations have been increasing since the industrial revolution, and this increase has been largely attributed to anthropogenic sources such as fossil-fuel combustion (Malhi et al., 1999). Carbon dioxide, along with other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O), has been identified as a possible cause of climate change leading to global warming (IDNR, 1999). Attempts to balance the global carbon budget have led researchers to the possibility that sequestration of carbon by temperate forests, which have been expanding in both land area and volume in past decades, may account for a significant portion of the global terrestrial carbon sink (Sedjo, 1992). The carbon budgets of forest ecosystems essentially represent a balance between carbon uptake in the process of photosynthesis, allocation to living tissues (biomass), accumulation in soils through litterfall and root turnover, and carbon loss through autotrophic and heterotrophic respiration as well as the decomposition of soil organic matter (Malhi et al., 1999). Productive or aggrading forests typically uptake and store more carbon in biomass than less productive or degrading forests. The management of productive forested ecosystems for carbon sequestration may at least partially mitigate the effects of increasing atmospheric CO_2 concentrations.

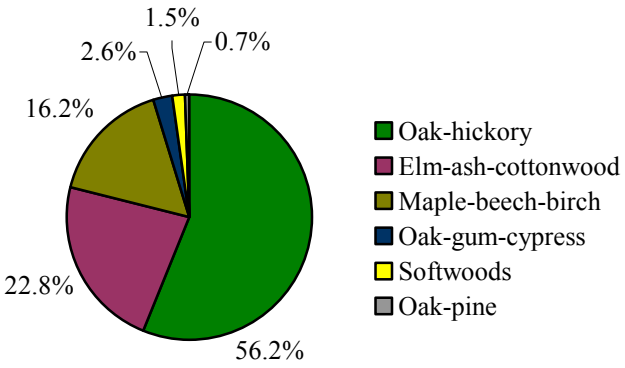
Criterion 5 contains three indicators related to the contribution of forests to the global carbon cycle. Indicator 26 is a measure of forest biomass and carbon pools, or the amount of carbon that is stored in forests. Increases or decreases in forest ecosystem carbon pools over time reflect whether forests in a given area are a net sink of carbon from the atmosphere or a net source of carbon to the atmosphere. Indicator 27 is a measure of the change in carbon stored in forests over time. Finally, indicator 28 includes the long-term storage of carbon in wood products. This carbon comes from trees that are harvested from timberland, is not accounted for in indicators 26 or 27, and completes the forest carbon budget as measured by Criterion 5.

Forests in Illinois have been increasing in both coverage and biomass for nearly half a century, and as a result have been a net sink for carbon during the same time period. However, as of 1996 the state of Illinois ranked 6th in the nation in terms of annual carbon emissions (IDNR, 1999), and annual carbon sequestration by forests represents only a small fraction of total carbon emissions statewide.

Although the available data pertaining to this issue describes only timberland and not total forestland, reserved forestland only constituted 5.6% of total forestland in Illinois in 1998 (see Criterion 1). In addition, the majority of reserved forestland is young in age and therefore may not contain as much biomass per hectare as older stands. Biomass estimates from timberland therefore represent approximately 94.4% of total forestland in the state and are likely to be fairly comprehensive in terms of total forestland biomass. Total aboveground tree biomass data is available from the USDA Forest Service's Forest Inventory and Analysis Database (FIADB). Belowground tree biomass was calculated using a regression equation for temperate forests developed by Cairns et al. (1997) and used in Brown et al. (1999). Total tree biomass is the sum of aboveground and belowground biomass. Carbon content is derived by multiplying total biomass by the proportion of carbon contained in tree biomass, which is generally estimated as 0.521 for softwood species and 0.498 for hardwood species (Birdsey, 1992; Turner et al., 1995).

Timberland in Illinois supports a total aboveground biomass of just over 175 million metric tons. Total tree biomass on Illinois timberland is nearly 222 million metric tons, and the carbon content of this biomass equates to 110.6 million metric tons. Oak-hickory forests contain approximately 56% of the total biomass and carbon stored in Illinois timberland (figure 24). Elm-ash-cottonwood and

Figure 24. Relative carbon content on Illinois timberland by forest type: 1998.



Sources: USDA Forest Service FIADB; Cairns et al., 1997; Brown et al., 1999; Birdsey, 1992; Turner et al., 1995.

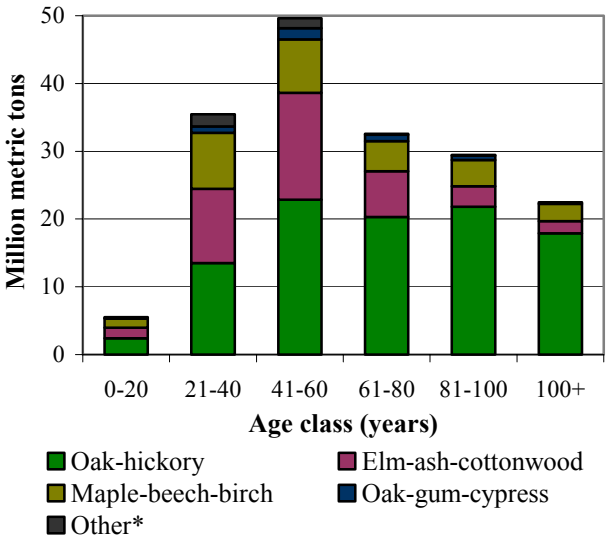
maple-beech-birch forests account for about 23% and 16% of the carbon in Illinois timberland, respectively. Oak-gum-cypress forests have the highest biomass per hectare, and oak-hickory forests also have a relatively high biomass density. Counties with the most timberland biomass are generally located in the southern and western portions of the state.

The distribution of aboveground tree biomass on Illinois timberland by age class and forest type is shown in figure 25. The greatest amount of biomass occurs in timber stands that are 41-60 years old. Oak-hickory forests account for an increasing percentage of aboveground biomass with increasing timberland age. Over half of the aboveground biomass on Illinois timberland is contained in relatively young stands less than 60 years in age, which means that biomass should continue to aggrade in these stands over time.

Carbon storage also occurs in other forest ecosystem components besides trees. Average carbon storage rates in forest soils, detritus on the forest floor, and understory vegetation have been reported on a per acre basis for Illinois (Birdsey, 1992). These average carbon storage rates were multiplied by the total number of timberland acres in Illinois to provide a gross estimate of relative carbon storage by ecosystem components statewide. Approximately 55% of the carbon in forest ecosystems in Illinois is stored in forest soils. Total tree biomass accounts for 37% of stored carbon, the forest floor component accounts for 7%, and understory vegetation accounts for only about 1%. When all forest ecosystem components are combined, forests in Illinois contain approximately 300 million metric tons of carbon.

Between the 1985 and 1998 USDA Forest Service Forest Inventory and Analysis (FIA) statewide inventories, the amount of tree biomass on timberland in Illinois increased by approximately 29.6 million metric tons, corresponding to an increase of 14.7 million metric tons of carbon. The tree component here represents total tree carbon (aboveground and belowground). Annual carbon sequestration is simply the total carbon gain between inventories divided by the number of years between them. Total tree carbon therefore increased by approximately 1.13 million metric tons per year during this time period. Total forest ecosystem carbon gain was 17.4 million metric tons, or about 1.34 million metric tons per year.

Figure 25. Aboveground tree biomass on Illinois timberland by age class and major forest type: 1998.



* Includes the oak-pine, white–red–jack pine, loblolly–shortleaf pine, and nonstocked forest type groups.
Source: USDA Forest Service FIADB.

Although the largest carbon pool lies in forest soils, the greatest total and annual carbon gain is achieved by trees in forest ecosystems in Illinois.

Long-term carbon storage in wood products represents another important contribution of forests to the global carbon cycle. Total annual sequestration of carbon in Illinois includes long-term carbon storage in wood products harvested from timberland in addition to carbon stored in living biomass on timberland. The carbon content of roundwood products harvested from timberland in Illinois was calculated from data obtained by the USDA Forest Service Forest Inventory and Analysis (FIA) and Timber Products Output (TPO) databases (see the technical version of this report for details). Including mill residues, sequestration of carbon in wood products in Illinois amounted to over 430 thousand metric tons per year. Removals of hardwoods accounted for approximately 99% of all carbon sequestered in wood products, and oak species alone accounted for about 61%.

Table 9 presents the 1998 and 1985 carbon pools and the carbon gain between those inventory years with the addition of carbon sequestered in long-term storage in wood products. With this addition, annual carbon sequestration by trees on Illinois timberland equates to approximately 1.56 million metric tons per year. Total carbon sequestration by non-soil forest ecosystem components equates to 1.59 million metric tons per year, and total ecosystem carbon sequestration equates to 1.77 million metric tons per year. Figure 26 shows the relative annual carbon sequestration by forest ecosystem components including annual long-term storage of carbon by conversion to wood products. The importance of long-term carbon storage in wood products can be seen in that it accounts for nearly a quarter of total annual carbon sequestration in Illinois. Carbon sequestration by the tree ecosystem component in Illinois timberland still accounts for the majority of total annual carbon uptake, which can be attributed to the aggradation of biomass and the increase in timberland acreage between 1985 and 1998.

The non-soil forest carbon pool of the conterminous United States has been estimated at approximately 24.3 billion metric tons (USDA Forest Service, 2003a). At approximately 134.8 million metric tons, Illinois' non-soil forest carbon pool represents about 0.55% of the national forest carbon pool. Annual non-soil net carbon gain by forests in the conterminous United States has been estimated at approximately 135 million metric tons between 1987 and 1996 (USDA Forest Service, 2003a). Illinois' annual non-soil forest carbon

Table 9. Carbon sequestration in Illinois by forest ecosystem components and wood products.

	Trees	Soil	Forest floor	Understory	Non-soil components	Total
Year			Thousand metric tons			
1998 carbon pool	110,615.3	165,095.5	21,580.2	2,577.8	134,773.3	299,868.8
1985 carbon pool	95,868.0	162,785.9	21,278.3	2,541.7	119,688.0	282,473.9
Measure of carbon gain						
Carbon gain between inventories	14,747.3	2,309.6	301.9	36.1	15,085.3	17,394.9
Annual carbon accumulation	1,134.4	177.7	23.2	2.8	1,160.4	1,338.1
Annual long-term carbon storage in wood products	430.2				430.2	430.2
Total annual carbon sequestration plus long-term carbon storage	1,564.6				1,590.6	1,768.2

Adapted from: USDA Forest Service FIADB; Birdsey (1992); USDA Forest Service Forest Inventory and Analysis Timber Products Output (TPO) Database, 1997.

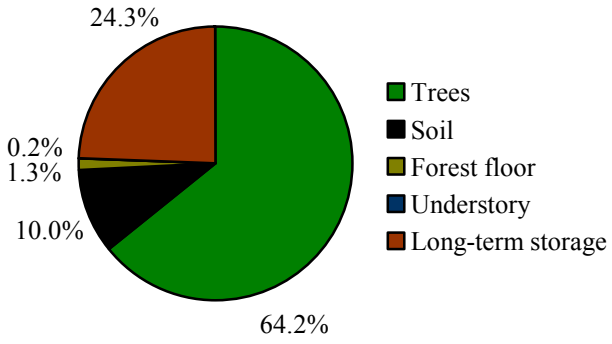
sequestration during approximately the same time period, at about 1.16 million metric tons, represents about 0.9% of this national non-soil forest carbon sink.

The amount of carbon stored in wood products nationally has been estimated at 25.0 million metric tons per year for the year 2000 (USDA Forest Service, 2003a). At about 430 thousand metric tons per year, carbon stored in wood products from Illinois timberland represents less than 2% of the national total. Estimating total annual national carbon sequestration in non-soil forest ecosystem components (135 Mt C yr^{-1}) plus storage in wood products (25 Mt C yr^{-1}) at approximately 160 million metric tons per year (USDA Forest Service, 2003a), carbon sequestration in non-soil forest ecosystem components plus storage in wood products in Illinois represents about 1.0% of the national annual carbon sink (excluding soil carbon).

Carbon dioxide emissions in the state of Illinois were approximately 58.5 million metric tons carbon equivalent in 1998 (IDNR, 2000a), or 3.8% of national 1998 CO_2 emissions of 1.5 billion metric tons carbon equivalent (EIA, 2002). Carbon sequestration by forests in Illinois accounts for only about 2.3% of state carbon emissions on an annual basis. At 1.77 million metric tons per year, the total annual carbon sink in forests and wood products in Illinois amounts to approximately 3% of state carbon emissions (IDNR, 2000a).

Based on results of past studies, carbon sequestration by forests and wood products in Illinois has been increasing over the past 55 years. Previous estimates of the total annual carbon sink by forests in Illinois have included changes in forest volume, changes in land use, and long-term storage in wood products in their calculations. From 1948 to 1962 the total annual carbon sink was estimated at 0.2 million metric tons. From 1962 to 1985 the total annual carbon sink was estimated at 1.37 million metric tons (IDENR, 1994).

Figure 26. Relative annual carbon sequestration by forest ecosystem components and long-term storage in wood products in Illinois.



Adapted from: USDA Forest Service FIADB; Birdsey (1992); USDA Forest Service Forest Inventory and Analysis Timber Products Output (TPO) Database, 1997.

Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socio-Economic Benefits to Meet the Needs of Societies

Criterion 6 addresses the long-term socio-economic benefits provided to societies by forests. Descriptions of sustainability are generally consistent with the following statement by the Brundtland Commission (WCED, 1987), which defines sustainable development as:

> *...development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

Thus, sustainable forest management must not only address forest ecosystem conditions and processes but also meet the needs and values of society, both at the present and indefinitely into the future. These societal needs and values encompass a diverse array of issues such as the provision of forest products, opportunities for recreation, maintenance of cultural and spiritual values, and the maintenance of community needs including local employment opportunities.

Criterion 6 contains a total of 19 indicators grouped into 5 subheadings. The first six indicators (29-34) address the production and consumption of wood and non-wood forest products both in terms of volume and economic value, as well as associated issues such as the recycling of wood and paper products. Indicators 35-37 address recreation and tourism issues in relation to forestland. Indicators 38-41 address the level of investment in the forest sector including components such as forest health and management, tree plantings, wood processing, and recreation and tourism. Rates of return on investment are also addressed in this suite of indicators. Indicators 42-43 address the various cultural, social and spiritual needs and values placed on forests by society including non-consumptive values. Finally, indicators 44-47 address employment and community needs including wage and injury rates, the viability of forest dependent communities, and the use of forestland for subsistence purposes.

Wood Products

Trends in the volume and value of wood products reflect the economic health of the wood products industry statewide. The economic health of the wood products sector in turn reflects factors such as trends in consumer demands and can impact local economies and forest management objectives.

Detailed state timber removals data are periodically available from the USDA Forest Service Forest Inventory and Analysis Timber Products Output (TPO) Database. In 1996, approximately 173.5 million cubic feet of timber were removed from Illinois' forests. Roundwood products accounted for nearly 102 million cubic feet or 58.7% of this total. Logging residue (trees or residual portions of trees left on the ground after harvesting) accounted for about 17.7% of total removals. Other removals due to processes or activities not directly associated with timber harvests (e.g., timber stand improvements or land use change) accounted for an additional 23.6% of total removals. Oak species accounted for approximately 54% of total removals, with select white oaks continuing to be the most intensively harvested tree species in the state. Softwood removals accounted for less than 1% of total removals in 1996.

Table 10 presents a detailed look at the volume of timber removed for roundwood products in Illinois. Saw logs accounted for just over 36 million cubic feet or 35% of roundwood products removed in 1996 (figure 27). Approximately 60% of total saw log volume was composed of oak species. Fuelwood accounted for about 58% of total roundwood products, with nearly a third of this coming from the select white oak species group. Pulpwood and veneer logs accounted for 3% and less than 1% of total roundwood products, respectively. Other products (e.g., cooperage and charcoal) accounted for approximately 2% of total roundwood products.

Table 10. Volume of roundwood products from Illinois timberland by species group and type of product: 1996.

Species Group	Saw logs	Veneer logs	Pulpwood	Fuelwood	Posts-poles-pilings	Other products	All products
	Thousand cubic feet						
Total softwoods	60	0	328	252	18	0	658
Select white oaks	7,335	389	101	18,521	40	444	26,831
Other white oaks	1,425	31	22	800	0	135	2,413
Select red oaks	2,910	18	41	4,121	8	165	7,263
Other red oaks	10,136	36	119	7,845	13	558	18,706
Hickory	1,644	2	264	5,006	19	197	7,132
Hard maple	1,111	25	45	765	0	49	1,995
Soft maple	2,645	8	516	5,004	0	114	8,286
Elm	252	1	498	4,208	1	16	4,975
Cottonwood	2,682	0	812	1,128	0	337	4,959
Ash	1,840	19	35	2,648	0	116	4,659
Black walnut	844	143	0	726	2	35	1,750
Black cherry	393	7	0	1,119	0	16	1,536
Sycamore	772	16	5	373	0	81	1,246
Yellow-poplar	937	31	42	1	6	98	1,115
Other hardwoods	1,056	8	449	6,439	286	97	8,334
Total hardwoods	35,979	734	2,948	58,703	375	2,459	101,198
All species	36,039	734	3,276	58,955	393	2,459	101,856

Source: USDA Forest Service Forest Inventory and Analysis Timber Products Output (TPO) Database, 1997.

According to the 1997 US Economic Census, the value of wood products sector shipments in Illinois was approximately $1.14 billion. The value added by manufacture for this sector was nearly $500 million. The value of paper products manufacturing sector shipments in Illinois was closer to $6 billion, with approximately $2.8 billion added by manufacture. The value of paper products shipments was over 5 times greater than wood products shipments in Illinois. Nationally, this trend was less pronounced, with the value of paper products shipments only about 1.7 times greater than wood products shipments. Forestry and logging businesses with payrolls were not included in the 1997 US Economic Census, but those without payrolls were included in the nonemployer economic statistics. In 1997 there were 719 forestry and logging businesses with no employees that collectively generated over $25 million in receipts. Another 152 businesses that provided support activities for forestry (e.g., consulting) generated an additional $2.9 million. Nonemployer receipts including the wood and paper products sectors totaled nearly $60 million in 1997.

The Annual Survey of Manufactures provides a continuous disclosure of trends in the wood and paper products sectors in Illinois. Although data before and after 1997 cannot be directly compared

Figure 27. Harvesting timber at a logging site.

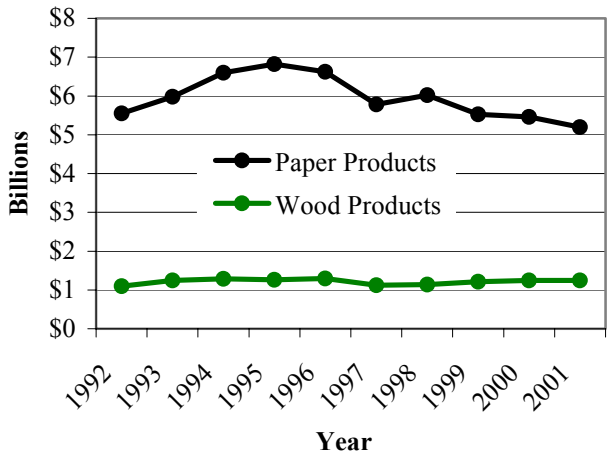
Photo: John Edgington.

due to discrepancies in methodology (the North American Industrial Classification System replaced the Standard Industrial Classification system in 1997), some interesting facts emerge nonetheless. The value of paper products shipments declined by 10% between 1997 and 2001, while the value of wood products shipments increased by 11% during the same time period (figure 28). Similarly, value added by manufacture declined by 19% between 1997 and 2001 for the paper products sector, while it increased by 19% for the lumber and wood products sector during the same time period.

Supply and Consumption

Trends in supply versus consumption indicate the degree to which the economy is dependent on the importation of wood products to meet the demand for those products. Illinois ranks 37th among states in total timberland area at just over 4 million acres, 32nd among states in average annual growing stock removals at about 66 million cubic feet per year, and 5th among states in total population and therefore consumption of wood products (Shifley and Sullivan, 2002). It follows that consumption demands exceed the supply of wood products from timberland in the state, and that much of the wood products used in Illinois are imported.

Figure 28. Value of shipments for the paper and wood products sectors in Illinois.

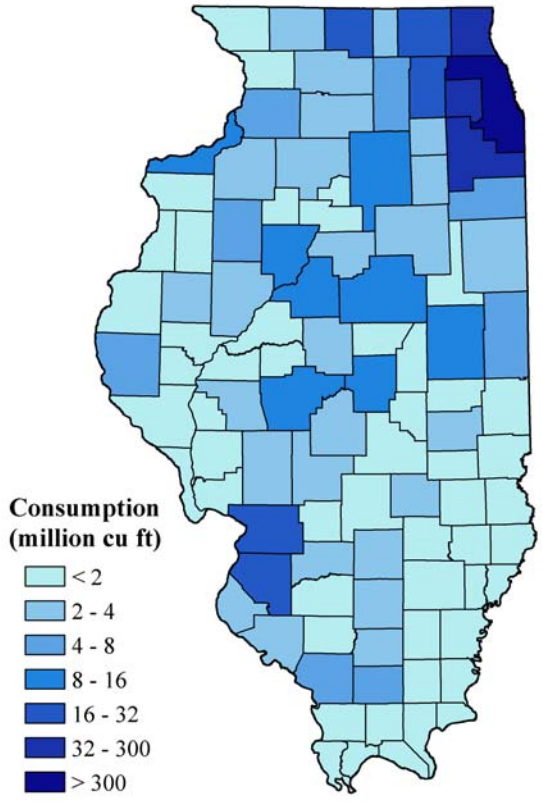


Note: Data before and after 1997 are not directly comparable (see text). Sources: US Census Bureau; Annual Survey of Manufactures.

Based on a national estimate of per capita wood consumption of 73 cubic feet per year excluding recycled material, Illinois consumes approximately 900 million cubic feet of wood in wood products annually (Shifley and Sullivan, 2002). Domestic (i.e., within-state) average annual growing stock removals account for only just over 7% of annual consumption rates, and some of this is exported. Figure 29 shows statewide trends in consumption patterns, based on annual per capita consumption and county population estimates. Counties with high consumption rates accordingly correspond with areas that have high population densities.

Illinois retained approximately 73% of the saw log volume that was harvested within the state in 1996. The remainder was exported to surrounding states (Iowa, Indiana, Kentucky, Missouri, and

Figure 29. Consumption of wood products in Illinois by county.



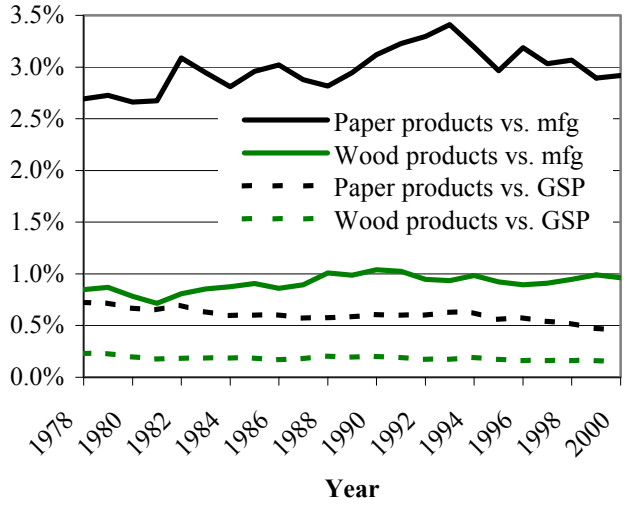
Note: Consumption estimates are based on US annual per capita consumption of 73 cu ft. Sources: USDA Forest Service FIADB; US Census Bureau; Shifley and Sullivan, 2002; INHS 1995 & 1996.

Wisconsin) for processing (Hackett and Sester, 1998). A relatively small amount of saw log volume was imported into Illinois from surrounding states for processing. By contrast, only 17% of veneer log volume produced in Illinois was retained in the state for processing. Illinois pulpwood production averaged approximately 77 thousand cords per year during the 1990s. Mill residues contribute to a significant proportion of pulpwood production, about 39% in 1998 (Piva, 2002). There were no primary woodpulp or particleboard mills in operation in Illinois as of 1998, so all pulpwood has been exported out of state for processing (Piva, 2002). About a quarter of the pulpwood produced in Illinois was exported to other central states (Iowa, Indiana, and Missouri) and the rest to southern or lake states in 1998.

Gross State Product (GSP)

The absolute dollar contribution of the paper products and wood products economic sectors towards GSP has more than doubled over the past two decades. However, their relative contribution declined from a combined 0.95% in 1978 to a combined 0.61% in 2000 (figure 30). This situation mirrors the national trend in the declining relative contribution of these economic sectors towards gross domestic product (GDP) (USDA Forest Service, 2003a). When compared to the manufacturing sector and not total GSP, however, the relative contributions of both industries have actually increased since 1978. The relative contribution of the manufacturing sector towards Illinois GSP declined from about 27% in the late 1970s to about 16% in 2000 (US BEA, 2003).

Figure 30. Wood and paper products industries as a percentage of Illinois GSP.



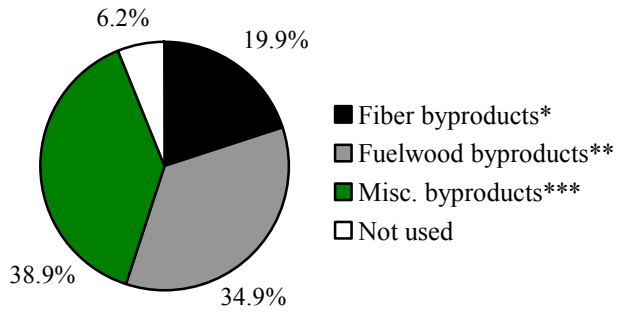
Source: US Bureau of Economic Analysis (US BEA).

Recycling

The recovery of wood and paper products for recycling and for use as energy has an effect on several related sectors of the forest products industry. For example, increased use of recycled materials as inputs to industry production may decrease the demand for raw materials thereby affecting timber harvest rates. Increased use of recycled products also reduces the amount of generated waste that ends up in landfills. The use of recovered wood products such as mill residue for alternative energy use by various sectors of the forest products industry could affect emissions rates and carbon cycles. The recovery and use of wood product residues in Illinois is fairly well documented. State data concerning the recovery and use of post-consumer paper products is notably lacking. Nationally, rates of recovery and recycling of paper products have been increasing steadily since the 1980s, and approximately 48% of paper products were recovered in 2001 (AF&PA, 2003).

Data obtained from the USDA Forest Service Forest Inventory and Analysis Timber Products Output (TPO) Database indicate that in 1996, 18.6 million cubic feet of mill residues were produced in Illinois. Coarse wood residue accounted for about 46% of this total, fine wood residue about 24%, and bark residue about 30%. Approximately 94% of the mill residues produced in Illinois at primary timber processing mills are recovered and used for various other products or for fuel (figure 31). This recovery rate matches the national average for recovery of wood residues generated by timber processing mills (AF&PA, 2002).

Figure 31. Relative volume of mill residues in Illinois by use: 1996.



* Mill residues used in the manufacture of wood pulp or composite products (particle board, chip board, flake board, engineered lumber products, etc.). ** mill residues used for industrial, residential, and institutional fuel. *** mill residues used for products such as mulch, bedding, charcoal, small dimension lumber, etc.
Source: USDA Forest Service Forest Inventory and Analysis Timber Products Output (TPO) Database, 1997.

The Green Illinois Program was established in 2000 for the purpose of promoting waste reduction, the use of alternative fuels, improved energy efficiency, and the use of environmentally sustainable products and procedures in the state of Illinois (IEPA, 2003b). A major component of Green Illinois is the Green Government Program, which calls on state agencies to find ways to incorporate environmentally sustainable practices into their daily operations, thereby setting an example for communities throughout the state. The Illinois Department of Natural Resources has won several Green Government Awards for outstanding environmental achievements and leadership in preventing pollution and conserving natural resources in state government operations (IWMRC, 2002; IGGCC, 2002).

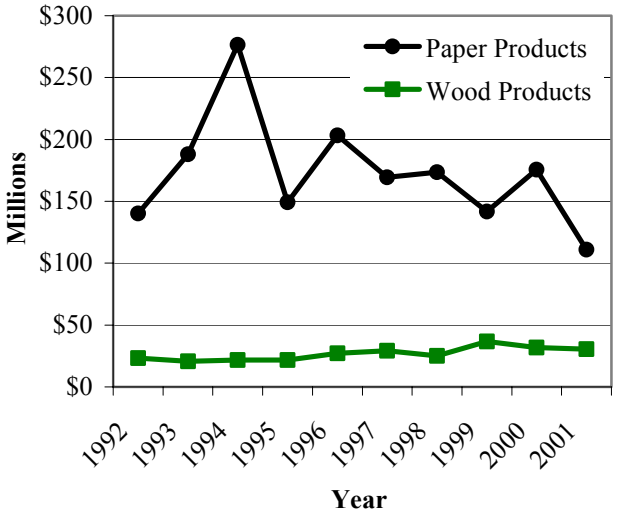
Investment

Investment in the forest sector may take the form of capital investments by various components of the forest products industry, tree plantings to increase the amount of timberland able to produce benefits, timber stand improvements or other forest management practices that improve the health, productivity or quality of forests, and investment in facilities that increase the potential of forests to provide a setting for outdoor recreation. Investment in these and other types of activities is necessary to ensure that the supply of economic, social and environmental benefits from Illinois' forests continues to be sustainable.

Data pertaining to capital expenditures of the wood and paper products sectors are compiled annually by the US Census Bureau and published in the Annual Survey of Manufactures by state. Although the numbers are somewhat variable, a trend of declining capital expenditures is readily observable in the paper and allied products industries in Illinois (figure 32). This trend is not discernable in the lumber and wood products industries.

State and federal cost-share programs available to forestland owners in the state of Illinois provide an incentive for them to invest in forest and land management practices that will provide a variety of long-term benefits. The Illinois Forestry Development Cost Share Program makes cost-share funds available to timber growers for the implementation of acceptable forestry management practices, which include activities such as forest stand improvements, tree plantings, and the

Figure 32. Capital expenditures in Illinois by sector.



Note: Data before and after 1997 are not directly comparable (see text). Source: Annual Survey of Manufactures.

preparation of forest management plans approved by the state Division of Forestry. Pursuant to the Illinois Forestry Development Act and the availability of funds, this program receives an annual grant from the Illinois Forestry Development Fund.

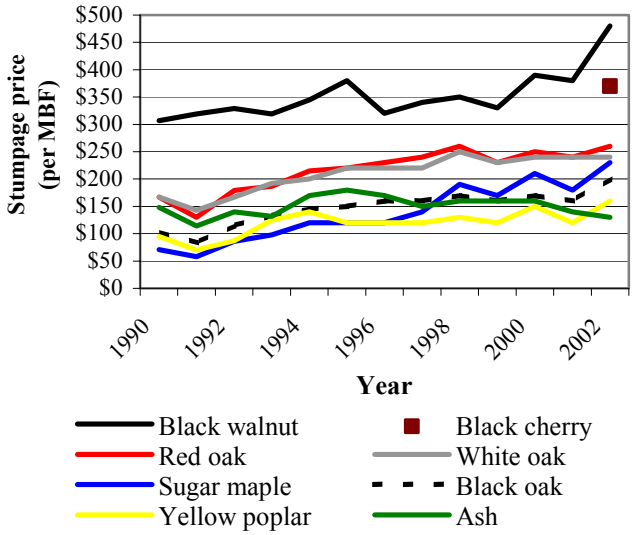
The federal Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) also provide cost-share funds to landowners in Illinois for forest-related practices such as tree planting, implementation of permanent wildlife habitat, and the establishment of riparian buffer zones (USDA FSA, 2003). Nearly 30,000 CRP tree practice acres were enrolled in active contracts in 2001, and approximately 21,500 CREP acres were enrolled in 2002. Total tree practice acres enrolled in the Conservation Reserve Program in Illinois passed 150,000 in 2002. The Forest Land Enhancement Program (FLEP) replaced the Forestry Incentives Program (FIP) and the Stewardship Incentives Program (SIP) in the most recent Farm Bill (2002), and is currently in its initial stages. During the last ten years nearly 190,000 acres of trees have been planted in Illinois, the majority on private land (see Criterion 2).

The rate of return on investment is an indicator of the financial competitiveness of the forest sector and the degree that it can remain viable in terms of attracting capital. Rates of return may affect resource management decisions by affecting the economic viability of alternative management options. For example, revenues generated from outdoor recreation in an area adjacent to a population center might exceed those that would be generated from harvesting timber. On the other hand, sustainable timber harvests may be the more economically viable option in remote areas with few alternative options for generating revenues.

Long-term rates of return on investment for major timberland tree species were calculated using the method described in the Draft 2003 National Report on Sustainable Forests (USDA Forest Service, 2003a). Stumpage prices were used to calculate the ratio of revenues from timber sales over the value of timber assets on timberland. The long-term rate of return on investment for timberland tree species in Illinois was estimated at 1.1% without capital gains. Including capital gains, this figure was estimated at 7.4%.

Timber prices in Illinois have generally been increasing over the past decade or more (figure 33). The most valuable tree species in Illinois have consistently been black walnut and black cherry. Stumpage prices for these two species were $480 and $370 per thousand board feet (MBF) in 2002, respectively. Veneer quality black walnut and black cherry were worth $1,660 and $930 per MBF in the same year, respectively (IASS, 2002). Red oak and white oak have consistently been the next most valuable species since at least 1990, and are also used for face veneer. Sugar maple stumpage prices increased by over 200% between 1990 and 2002. Prices paid for stumpage and F.O.B. mill cooperage, which refers to the price paid for timber delivered to the mill, were $210 and $490 per MBF in 2002, respectively. White oak is the principal cooperage species in Illinois. Stumpage and F.O.B. mill prices paid for pulpwood in 2002 were $3.33 and $21.50 per ton, respectively.

Figure 33. Average stumpage prices paid by timber buyers in Illinois.



Source: Illinois Agricultural Statistics Service (IASS).

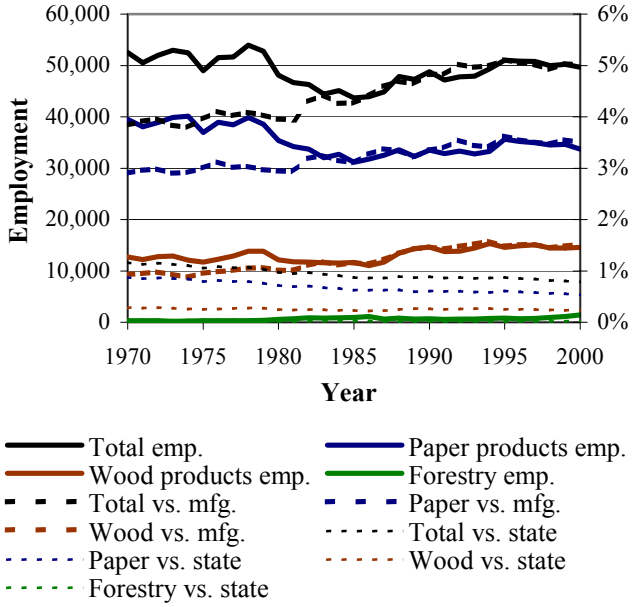
Employment

Employment in the forest sector is a measure of the extent to which forests in Illinois support the livelihood of Illinois residents through the provision of jobs directly or indirectly related to forest products or other forest-related industries. Trends in employment rates in the forest sector may reflect the degree to which forests can provide sustained economic inputs to local communities as well as larger-scale shifts in employment trends across the manufacturing sector.

Long-term records of employment rates in the forest sector in Illinois can be found in the Illinois Statistical Abstract. Employment in the paper and allied products, lumber and wood products, and forestry sectors from the years 1970 to 2000 is presented in figure 34. In the year 2000 approximately 33,700 people were employed in the paper and allied products industry in Illinois, 14,600 people were employed in the lumber and wood products industry, and 1,400 people were employed in the forestry sector for a total employment of nearly 50,000.

Employment in these three sectors combined as a percentage of total employment in Illinois has steadily declined since the 1970's. In the year 2000 employment in the forest sector represented approximately 0.8% of total wage and salary employment in Illinois. Employment in the forest sector as a percentage of total employment in the manufacturing sector has increased over the past three decades. Employment in the manufacturing sector as a whole has been declining relative to total employment in the state of Illinois.

Figure 34. Employment in the forest sector in Illinois.



Source: Illinois Statistical Abstract.

Wage and Injury Rates

Trends in the wage rates of various occupational categories within the forest sector provide an indication of the economic viability of those occupations as well as a reflection of their ability to supply a competitive income to forest sector employees. Trends in injury rates within the forest sector reflect occupational safety and health issues. Improvements in occupational safety records in the forest sector are important to document as on-the-ground forestry operations (e.g., logging) have historically been viewed as inherently dangerous occupations associated with high injury rates.

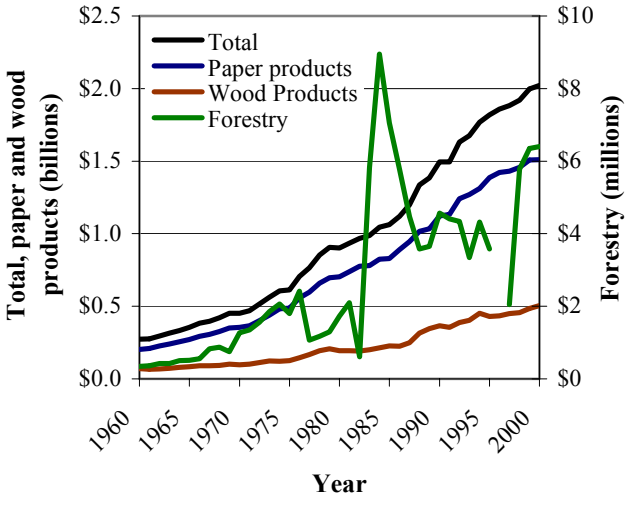
Records from the Illinois Statistical Abstract indicate that total annual personal income and earnings in the forest sector in Illinois increased from approximately $1.5 to $2 billion between 1990 and 2000 (figure 35). Personal income and earnings in the forestry sector were fairly erratic during that decade and totaled about $6.4 million in the year 2000. Whether this is an accurate reflection of unpredictable earnings within that sector or an artifact of the methodology as applied to such a small employment category is unclear.

Data pertaining to wage rates within the forest sector are compiled and made available to the public by the Bureau of Labor Statistics, US Department of Labor. The highest paid jobs in the forest sector in Illinois are foresters and conservation scientists. Average annual salaries within the paper products sector have consistently

been about $10,000 or 30% higher than within the wood products sector. Field or on-the-ground positions such as logging equipment operators and forest or conservation workers are typically the lowest paid. Forestry positions such as those providing forestry services (e.g., consulting) are often part-time or secondary positions thus lowering their average annual salaries. Average hourly wages within the paper products sector were only about 15% higher than within the wood products sector in 2001.

Injury and illness rates for the paper and allied products and lumber and wood products sectors in Illinois are also available from the Bureau of Labor Statistics. Injury rates per 100 workers in the wood products sector in Illinois went from 12 in 1998 to 17 in 1999, and then declined to about 8 in 2001. In the paper products sector, injury rates per 100 workers fell from 6.4 in 1998 to 4.5 in 1999, and then climbed to 5.4 in 2001. National injury rates declined by 20% and 17% between 1998 and 2001 in the wood and paper products sectors, respectively. Averaged over this time period, national injury rates were approximately 89% higher in the wood products sectors than in the paper products sector.

Figure 35. Personal income and earnings in the forestry sector in Illinois: 1960-2000.



Source: Illinois Statistical Abstract.

Viability and Adaptability

The issue of economic viability and adaptability addresses the socioeconomic stability of communities that are geographically, economically or culturally connected to forestland. Forest management decisions can affect economies and employment opportunities in local communities. For example, communities adjacent to national parks may derive a significant amount of revenues generated from tourism and associated recreational activities. Other communities adjacent to forests that support timber production may generate significant revenues from various components of the wood products industry. Shifts in management goals on publicly managed forestland may result in associated shifts in the type of resource base that is available for economic development.

Recreation

Illinois has an extensive network of outdoor recreation sites and programs supported by various federal, state and local agencies. Many outdoor recreation sites in the state contain a variety of landcover types, making distinctions between forested and non-forested sites difficult if not impossible to assess. For example, a state park may contain forestland as well as other natural features such as lakes, rivers, or wetlands, all or some combination of which may have influenced the decision of a recreation participant to visit that particular site. For this reason the recreation section of Criterion 6 applies to outdoor recreation in general in the state of Illinois, operating under the assumption that most outdoor recreation takes place in or near wooded or forested habitat.

Approximately 1.34 million acres of land in Illinois were available for outdoor recreation as of 2002 (IDNR, 2003b). The majority is managed by federal and state agencies, responsible for about 36% and 33% each. Shawnee National Forest in southern Illinois contains the majority of federal land available for outdoor recreation (figures 36 & 37). The US Fish and Wildlife Service manages

Figure 36. Lake Glendale – a popular recreation site in southern Illinois.

Photograph: John Edgington

10 National Wildlife Refuges in Illinois (USFWS, 2003b). Other federal agencies with relatively minor land holdings available for recreation include the National Park Service and the US Army Corps of Engineers. County forest preserve and conservation districts manage approximately 14% of outdoor recreation lands in Illinois, private interests controlled about 8%, and local park districts and municipalities managed about 7%. The remainder was managed by public schools and nonprofit organizations (IDNR, 2003b).

Approximately 445 thousand acres of state-managed lands are available for outdoor recreation in Illinois (IDNR, 2003b). State fish and wildlife areas account for approximately 46% of this outdoor recreation acreage. Approximately 21% is classified as state parks, 13% as recreation areas, 12% as natural areas, 6% as state forests, and 2% as other and miscellaneous sites. It should be noted that although outdoor recreation opportunities may be available on most state-operated lands, they are not necessarily the primary management goal on all of them. For example, state natural areas are managed primarily to protect natural resources or features while also supporting some outdoor recreation opportunities. Other lands such as state parks may place a more equitable emphasis on the combination of natural resource preservation and outdoor recreation opportunities (NASPD, 2003).

While the majority of outdoor recreation acreage is found on federal and state-managed land in Illinois, the majority of outdoor recreation sites occur on locally managed land (e.g., park districts and municipalities). In fact, state and federal agencies, while accounting for nearly 70% of outdoor recreation acreage in the state, account for only about 7% of outdoor recreation sites. Private groups own and/or operate the overwhelming majority of camps, cabins and lodges in Illinois, and local park districts and municipalities manage the majority of day-use facilities such as picnic shelters and interpretive centers (IDNR, 2003b).

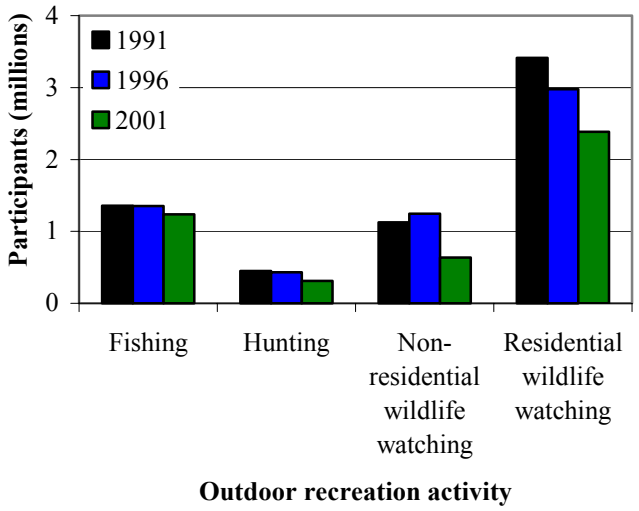
A survey of outdoor recreation visitation and participation in Illinois found that the majority of visits to outdoor recreation sites also occurred locally (O'Rourke, 1997). 64% of visitation was found to occur on sites such as a friend or neighbor's property, city parks, schoolyards, and county forest preserves. 26% occurred on commercial recreation areas and private clubs. Only 10% of total outdoor recreation visitation in Illinois was occur on federal or state lands.

The US Fish and Wildlife Service conducts a national survey of fishing, hunting, and wildlife-associated recreation every five years and publishes the results in reports available by state. In terms of participation, residential wildlife watching

Figure 37. Garden of the Gods – a popular recreation site in Shawnee National Forest.

Photo: John Edgington.

Figure 38. Recreation participants by wildlife-associated outdoor recreation activity in Illinois.



Sources: USFWS, 2003c & 1998.

has continually been the most popular form of outdoor recreation in Illinois (figure 38). Hunting consistently had the lowest participation rates but still attracted 310,000 participants in 2001. Big game animals such as deer continue to draw the most hunters in the state. Overall, participation in outdoor recreation declined in 2001.

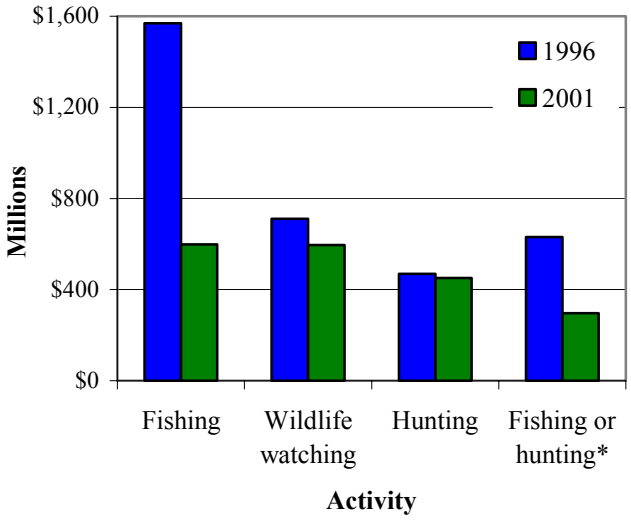
Revenues generated from outdoor recreation in Illinois are presented in figure 39. Fishing, hunting and wildlife-associated recreation participants spent a total of $1.9 billion in Illinois in 2001, down from $3.4 billion dollars in 1996. The majority of expenditures are associated with equipment, especially so for fishing expenditures. The majority of in-state hunting trip and equipment expenditures were associated with big game in both 1996 and 2001. Outdoor recreation participants spent nearly $600 million in 2001 on non-consumptive forms of recreation categorized as wildlife watching in Illinois. Similar to consumptive forms of outdoor recreation, the majority of wildlife-watching expenditures are also associated with equipment. Wildlife-watching equipment includes items such as cameras and other photography equipment, bird food, bird feeders, birdhouses, and binoculars (USFWS, 2003c).

Non-Consumptive Use Values

Comparisons of participation rates for various types of recreation activities can be interpreted as a reflection of the values that the public places on those types of activities. Types of non-consumptive outdoor recreation activities that consistently rank highest in terms of participation include pleasure walking or driving/sightseeing, observing wildlife, and picnicking (table 11). Moderate participation rates are found for more strenuous activities such as hiking, bicycling, and swimming. Lower participation rates are found for activities such as horseback riding, water-skiing, and the use of off-road vehicles. Consumptive recreation activities such as fishing and hunting also receive moderate rates of participation in Illinois.

Two forms of outdoor recreation included in the most recent survey were gardening and mushroom hunting. Gardening had a participation rate of 56%, which has implications for the multi-billion dollar Illinois Green Industry. A participation rate of 21% for mushroom hunting also has implications for the importance of quantifying the use of non-timber forest products in Illinois.

Figure 39. In-state fishing, hunting, and wildlife-associated recreation expenditures in Illinois.



* Unspecified equipment used for either fishing or hunting.
Sources: USFWS, 2003c & 1998.

Table 11. Outdoor recreation participation rates in Illinois by activity.

Outdoor recreation activity	1985	1987	1989	1991	1996	2002
Non-consumptive	Percentage of respondents participating					
Pleasure walking	---	73.5	68.6	74.9	76.0	81.0
Pleasure driving/sightseeing	---	66.6	58.8	62.3	66.0	64.0
Gardening	---	---	---	---	---	56.0
Observing wildlife/birdwatching	14.3	27.3	28.1	50.9	40.4	53.0
Picnicking	---	58.2	50.3	56.1	49.2	51.0
Bicycling	46.9	43.8	40.2	42.6	44.2	37.0
Swimming - other outdoor	29.2	31.3	23.9	28.3	33.1	36.0
Hiking	19.0	13.9	12.4	18.5	21.3	32.0
Tent camping*	20.6	14.4	11.5	14.6	14.6	28.0
Vehicle camping*	---	8.1	7.0	8.0	8.9	---
Mushroom hunting	---	---	---	---	---	21.0
Motorboating	22.9	28.4	20.6	24.9	23.6	16.0
Canoeing	9.2	9.5	8.6	8.6	7.0	11.0
Off-road vehicle	9.1	11.6	6.9	12.2	12.7	8.0
Horseback riding	11.2	10.0	8.1	7.6	9.8	8.0
Water skiing	---	11.8	10.4	12.2	8.2	8.0
Ice skating	7.9	9.3	9.2	9.1	14.0	6.0
Backpacking	4.1	3.3	3.0	5.7	6.7	5.0
Sailing	8.7	6.3	8.0	6.9	5.2	3.0
Cross-country skiing	4.8	5.4	5.4	3.6	3.5	2.0
Downhill skiing	6.9	8.8	7.6	7.6	7.6	---
Snowmobiling	4.7	4.8	3.9	3.9	3.1	---
Consumptive						
Fishing	28.8	30.0	26.6	30.8	27.1	39.0
Hunting	5.8	6.7	6.6	7.4	6.9	15.0
Trapping	0.9	0.6	0.6	0.8	0.2	1.0
Ice fishing	2.5	2.5	2.1	2.9	1.9	---

* Tent and vehicle camping were not separated in 1985 or 2002. Adapted from: IDNR, 2003b; O'Rourke, 1997.

Criterion 7: Legal, Institutional and Economic Framework for Forest Conservation and Sustainable Management

Criterion 7 addresses the legal, institutional and economic frameworks in Illinois that support the sustainable management of its forest resources. The legal framework for sustainable forest management refers to the body of conservation laws (e.g., compiled statutes and administrative rules) that authorize or direct actions that are related to the state's natural resources. The institutional framework for sustainable forest management refers to public and private organizations (e.g., state agencies, not-for-profit organizations, etc.) that implement and/or enforce the guidelines set forth at least in part by the legal framework. The economic framework for sustainable forest management refers to taxation, investment and trade policies that influence the market systems whereby forest products and services contribute to local, state and national economies. Sound legal, institutional and economic frameworks are essential in the establishment and function of a system that supports the sustainable management of forest resources.

Criterion 7 is composed of 20 indicators grouped into five subheadings. Indicators 48-52 address the legal framework for sustainable forest management. Topics in this section include: property rights; land tenure arrangements; forest planning, assessment and policy review; public involvement; best forest practice codes; traditional rights of indigenous peoples; and the conservation of special environmental, cultural, social or scientific areas. Indicators 53-57 address the institutional framework for sustainable forest management, including its capacity to provide for: forest planning, assessment and policy review; public involvement activities; public education and extension programs; the development of human resource skills; the development of sufficient physical infrastructure; and the enforcement of laws, regulations and guidelines. Indicators 58 and 59 address the economic framework for sustainable forest management, including: investment policies; taxation policies; the regulatory environment as related to natural resources; and trade policies. Indicators 60-62 address the capacity to measure and monitor changes in the conservation and sustainable management of forests, including issues such as the availability and reliability of up-to-date data and compatibility with other efforts in measuring and reporting on indicators. Finally, indicators 63-67 address the capacity to conduct and apply research and development related to sustainable forest management, including: the development of scientific understanding of forest ecosystems; the development of economic methodologies that integrate environmental and social factors into state or national accounting systems; the development and assessment of new technologies; and the enhancement of abilities to predict impacts of human intervention and potential climate change on forests.

Legal Framework

Examples of legislation that directly addresses situations having to do with forestry, forested property or timber management in Illinois are outlined in table 12. Other relevant state statutes can be found under Chapter 20 (Executive Branch), Articles 801-880 (Department of Natural Resources) and Articles 3405-3440 (Historic Preservation), and Chapter 525 (Conservation), Illinois Compiled Statutes. Administrative rules that are relevant to this indicator can be found under Title 17 (Conservation), Illinois Administrative Code.

Best Management Practices (BMPs)

Best practice codes for forest management, otherwise referred to as forestry best management practices (BMPs), are defined in the Illinois Forestry Best Management Practices Manual (IDNR, 2000b). These are practices that protect forest, soil, and water resources while allowing

Table 12. Legislation related to forests and forestry in Illinois.

Illinois Forestry Development Act (525 ILCS 15)	Supports sustainable forest management in the state by providing for forest-related planning, assessment and policy review. Specifically, this act created the Illinois Forestry Development Council, the Illinois Forestry Development Cost-Share Program, and the Illinois Forestry Development Fund. It also amended the Timber Buyer's Licensing Act to instate a 4% timber harvest fee, and property tax code to provide tax relief for landowners with approved forestry management plans. The 4% timber harvest fee goes into the Illinois Forestry Development Fund, which supports the cost-share program and the activities of the Council.
Timber Buyers Licensing Act (225 ILCS 735)	Persons buying timber are required by this Act to have a valid timber buyer's license. Specific provisions of this Act are designed to protect the timber grower/owner/seller from unregulated and therefore potentially unsustainable harvesting activities. These provisions are directed at timber buyers who knowingly and willfully fail to pay for timber purchased, appropriate any timber without consent of the timber grower, fail to fully account for timber purchased or cut, or commit any fraudulent act related to the purchasing or cutting of timber.
Forest Products Transportation Act (225 ILCS 740)	This Act protects the rights of the owners of trees and forest products, as well as the interests of the public with respect to trees and forest products existent on public lands. Specific provisions of this Act prohibit the transport of any trees or other forest products on Illinois highways without either proof of ownership or the written consent of the timber grower or seller.
Wrongful Tree Cutting Act (740 ILCS 185)	This Act provides for compensation to timber growers/owners for the unlawful removal of timber or individual trees from their property.
Urban and Community Forestry Assistance Act (30 ILCS 735)	This Act directs the Illinois Department of Natural Resources to promote the development of programs for the establishment, management and conservation of urban and community forests in the state, as well as to provide assistance and information to the appropriate parties with regard to urban and community forestry.
National Forest Mgmt Act (NFMA)	Mandates forest planning for federal forests (e.g., Shawnee National Forest in southern Illinois).
National Environmental Policy Act (NEPA)	Also applies to Shawnee National Forest, and requires that environmental impacts of plans and projects on federal land be fully evaluated.
Property (765 ILCS)	The resolution of property disputes is generally defined by case law and due process in the United States.

their appropriate use. Timber management activities, especially those related to the on-site transport of raw timber products, have the potential for causing extensive site damage. This in turn can lead to severe erosion problems. Eroded material has the potential to seriously degrade water quality in adjacent streams, rivers and other water bodies. The utilization of forestry best management practices ensures that forests managed for timber utilization are otherwise minimally disturbed, and that water bodies associated with those forests are not degraded by timber harvesting activities.

State and federal regulations generally provide for the utilization of forestry BMPs in the management of state and federal forestland. The use of forestry BMPs on private forestland is generally voluntary, and guidelines for such practices are available from both state and federal sources. In addition, many state and federal cost-share programs related to forestry activities require the development and use of approved forest management plans incorporating BMPs prior to the disbursement of funds, and have provisions for rescinding funds if those plans are not implemented appropriately.

Institutional Framework

The institutional framework in Illinois provides for resource management in addition to public involvement activities, public education and awareness programs, extension programs, and the dissemination of information related to forests and other environmental issues. Examples of representative institutions that play a major role in these types of activities in Illinois are presented below. Many of these institutions and/or programs are overseen by or are at least affiliated with the Illinois Department of Natural Resources.

Illinois Department of Natural Resources (IDNR)

The institution in Illinois most directly related to the suite of indicators organized into the institutional framework section of Criterion 7 is the Illinois Department of Natural Resources (IDNR). Not only does the IDNR manage forested lands in Illinois directly through the Division of Forest Resources, it also provides administrative support to other agencies and institutions involved in the management of forests in the state. For example, the IDNR is mandated to provide assistance to the Illinois Forestry Development Council, whose activities and responsibilities are described below.

IDNR Division of Forest Resources

The mission of the Illinois Division of Forest Resources (IDNR, 2003c) is to:

> *protect, perpetuate, restore, conserve and manage the forest and related resources of Illinois… and to ensure for future generations the greatest economic, scientific and social benefits that can only be provided through a forest ecological system.*

Through its network of district foresters and regional administrators, the Division also provides much-needed technical assistance to the state's non-industrial private forestland owners, who own approximately 82% of the timberland in Illinois. These district and regional foresters are responsible for approving forest management plans that are developed for private landowners and required by many cost-share assistance programs.

Illinois Forestry Development Council

The Illinois Forestry Development Act created the Illinois Forestry Development Council. The Council's responsibilities in general consist of the study and evaluation of the state's forest resources and forestry industry. The publication entitled "Realizing the Forests' Full Potential: Assessment and Long-Range Action Plan for Forest Resources in Illinois" (IFDC, 1999) is an example of the type of output resulting from the Illinois Forestry Development Council's involvement in forest planning and assessment in the state. In addition to providing a comprehensive assessment of the forest resource base in Illinois, this report identified a number of key concerns and management goals.

Specifically, responsibilities of the Council include:

- Determining the magnitude, nature and extent of the state's forestry resources
- Determining current uses and future demand for forest products, services and benefits in Illinois
- Determining the ownership characteristics of forests in Illinois, the motives for forest ownership, and the success of incentives intended to stimulate the development of forest resources
- Determining the economic development and management opportunities that could result from improvements in forest product marketing and from the establishment of new or additional wood-related businesses in Illinois
- Determining opportunities for increased employment and economic growth through the development of forest resources
- Determining the effects of governmental policies and regulations on the management of woodlands and the location of wood products markets
- Determining staffing and funding needs for forestry and other conservation programs
- Determining the needs of forestry education programs in Illinois
- Conferring with and offering assistance to the Department of Natural Resources relating to the implementation of urban forestry assistance grants pursuant to the Illinois Urban and Community Forestry Assistance Act
- Determining soil and water conservation benefits and wildlife enhancement opportunities that could be promoted through forest management plans
- Conferring with and offering assistance to the Illinois Farm Development Authority relating to the implementation of forest industry assistance authorized by the Illinois Farm Development Act
- Reporting its findings and recommendations to the Illinois General Assembly every year.

IDNR Division of Education

The Division of Education was created by the Illinois Department of Natural Resources in 1995 upon recommendations by the Illinois Conservation Congress. Responsibilities of the Division of Education include: the development of environmental education programs and the provision of these programs to state park visitors; the administration of safety education programs in Illinois related to boating, hunting, trapping and snowmobiles; the operation of interpretive centers and programs in state parks; and the distribution of environmental education materials for classrooms throughout the state.

Illinois Conservation Congress

The Illinois Conservation Congress is a voluntary stakeholder consultation process that allows constituents to make formal recommendations to state policy makers regarding the conservation of the state's natural resources. Illinois Conservation Congress is composed of representatives from a variety of organizations and interest groups including businesses, non-profit organizations and other concerned groups. This program is overseen by the Illinois Department of Natural Resources.

Illinois Forest Resource Center

The Illinois Forest Resource Center is located in southern Illinois adjacent to Shawnee National Forest, and is part of the Department of Natural Resources and Environmental Sciences, College of Agricultural, Consumer and Environmental Sciences, University of Illinois. The Illinois Forest Resource Center is a teaching, research and outreach center for forest landowners in Illinois. The Center also provides a variety of environmental education programs. For example, the Center's Stewardship Week for Students program attracts thousands of participants from grade schools throughout the state who learn from activities coordinated by a variety of resource professionals.

Conservation 2000 Ecosystems Program

Conservation 2000 (C2000) was initiated in 1995 by the Illinois General Assembly. C2000 began as a $100 million initiative designed to take a holistic, long-term approach to managing and protecting the natural resources of Illinois. The C2000 Ecosystems Program is a voluntary incentives program designed to incorporate the participation of local communities and landowners in the protection and enhancement of entire watersheds in Illinois through ecosystems-based management. Ecosystem Partnerships are coalitions of local stakeholders including landowners, businesses, environmental organizations, and policy makers. There are currently 39 Ecosystem Partnerships that collectively incorporate 82% of the state's land area into the Ecosystems Program.

Illinois EcoWatch Network

The Illinois EcoWatch Network is a volunteer-based environmental monitoring program overseen by the Illinois Department of Natural Resources. Under this program, volunteers are trained to conduct biological monitoring of the state's forests, rivers, prairies and other natural features. The EcoWatch Network contains five core programs known as ForestWatch, RiverWatch, PrairieWatch, WetlandWatch and UrbanWatch. Data collected by EcoWatch volunteers are monitored for accuracy and are submitted to a statewide database used by scientists to gauge long-term trends in Illinois' natural ecosystems.

Development and Maintenance of Physical Infrastructure

Several offices and specific divisions within the Illinois Department of Natural Resources (IDNR) are responsible for developing and maintaining infrastructure that facilitates the supply of products and services from, as well as supports the sustainable management of, the state's natural resources. These include the Office of Realty and Environmental Planning, the Office of Capital

Development, the Office of Land Management and Education, and the Office of Resource Conservation.

It should be noted that two key issues identified by the IDNR in the Illinois Forest Resource Fact Sheet (NASPF, 2003) are a lack of forestry-related staffing to meet the varied forestry needs within the state and a lack of management on non-industrial private forestland. Without adequate field staffing, the implementation of many programs and activities essential to sustainable forestry is invariably hindered. This type of situation is obviously counterproductive to the goals of sustainable forest management.

Economic Framework

An economic framework that recognizes the long-term nature of investments in the forest sector presently exists in the state of Illinois. Legislation allows for the valuation of forestland under management plans, riparian forest buffers, and land encumbered under conservation rights at reduced rates relative to other farmland, so that property taxes owed on such land are reduced. This provides a monetary incentive for landowners to participate in sustainable forest management in Illinois. Legislation also provides for monetary assistance for the establishment or expansion of forestry-related businesses. State and federal cost-share programs that provide incentives for various types of investments in forestry practices such as tree planting are also available in Illinois.

Illinois Forestry Development Cost-Share Program

The Illinois Forestry Development Cost-Share Program was established by the Illinois Forestry Development Act. This program provides cost-share assistance for the purpose of implementing forest management practices to timber growers with approved forestry management plans. Appropriate forest practices that are eligible to receive cost-share funding include planting trees, direct seeding, tending forest stands (e.g., thinning, pruning, and vine removal), building fencing to protect forests and plantations, establishment of firebreaks, wildlife damage control, and site preparation for natural regeneration.

Illinois AgriFIRST Program

The Illinois AgriFIRST Program is designed to provide monetary assistance to qualifying agribusinesses that are engaged in processing, packaging or otherwise enhancing the value of farm products or by-products produced in Illinois. Included in the definition of agribusinesses are facilities and equipment for processing and supplying forestry products, including: sawmill operations; wood chip operations; timber harvesting operations; and the manufacture of prefabricated buildings, paper, furniture, or other goods derived from forestry products.

Capacity to Measure and Monitor Changes

A description of the availability and extent of data, statistics and other information important to measuring or describing the Montreal Process Criteria and Indicators as applied to the state of Illinois is presented in figure 40. For each indicator there is a description of the availability, spatial scale, and incidence (i.e., degree to which the data is currently or consistently monitored) of the data or information used to describe that indicator. A quick overview this figure reveals that less than a third of the indicators have enough data or information to completely support their assessment. Furthermore, over half of those are associated with criterion 7 and are qualitative in nature, meaning that they do not call for quantitative data to support them. The implication is that significant data gaps in the support and description of these indicators for sustainable forest management are not the exception but rather the status quo. This was also generally the case in the national assessment of forest sustainability (USDA Forest Service, 2004).

Figure 40. Characteristics of data, statistics and other information important to measuring or describing the Montreal Process Criteria and Indicators in Illinois.

		Data status		
Criterion	**Indicator**	**Availability**	**Scale**	**Incidence**
1. Conservation of biological diversity	1. Area of forest land by forest type			
	2. Area by forest type and age			
	3. Area by forest type - protected			
	4. Area by forest type and age - protected			
	5. Forest fragmentation			
	6. Number of forest dependent species			
	7. Status of forest dependent species			
	8. Forest dependent species – restricted range			
	9. Population levels of representative species			
2. Maintenance of productive capacity of forest ecosystems	10. Area of timberland			
	11. Growing stock on timberland			
	12. Area and growing stock in plantations			
	13. Annual vs. sustainable removal of wood products			
	14. Annual vs. sustainable removal of NTFPs			
3. Maintenance of forest ecosystem health and vitality	15. Area affected by insects, disease, fire, etc.			
	16. Area affected by air pollutants			
	17. Area with diminished biological components			
4. Conservation and maintenance of soil and water resources	18. Area with significant soil erosion			
	19. Area managed for protective functions			
	20. Forest streams with altered flow & timing			
	21. Area with diminished soil organic matter			
	22. Area with significant soil compaction			
	23. Water bodies with change in biodiversity			
	24. Water bodies with change in chemistry			
	25. Area with accumulation of toxic substances			
5. Contribution of forests to global carbon cycles	26. Total forest biomass and carbon pool			
	27. Contribution of forests to carbon budget			
	28. Contribution of wood products to carbon budget			
6. Maintenance and enhancement of long-term multiple socio-economic benefits	29. Value and volume of wood products			
	30. Value and quantity of NTFPs			
	31. Supply and consumption of wood products			
	32. Value of products as percentage of GSP			
	33. Degree of recycling of forest products			
	34. Supply and consumption of NTFPs			
	35. Area managed for recreation			
	36. Number and type of recreational facilities			
	37. Number of recreation visitor days			
	38. Value of investment in the forest sector			
	39. Expenditures on research and education			
	40. Use of new and improved technology			
	41. Rates of return on investment			
	42. Area managed for cultural values			
	43. Non-consumptive-use forest values			
	44. Employment in the forest sector			
	45. Wage and injury rates in the forest sector			
	46. Viability of forest-dependent communities			
	47. Area used for subsistence purposes			
7. Legal, institutional and economic framework	48. Clarification of property rights, etc.			
	49. Planning, assessment and policy review			
	50. Public participation in policy, etc.			
	51. Best practice codes for forest management			

52. Conservation of special environmental etc. areas			
53. Public education, extension, etc.			
54. Planning, assessment and policy review			
55. Develop & maintain human resource skills			
56. Develop & maintain physical infrastructure			
57. Enforcement of laws, regulations and guidelines			
58. Investment and taxation policies			
59. Non-discriminatory trade policies			
60. Availability of up-to-date data, etc.			
61. Statistical reliability of inventories, etc.			
62. Compatibility in reporting on C&I			
63. Development of scientific understanding			
64. Development of economic methodologies			
65. New technologies and their assessment			
66. Ability to predict human impacts on forests			
67. Impacts of climate change on forests			

KEY

Symbol[1]	Availability	Scale	Incidence
	Complete	Multiple	Recurrent[4]
	Partial[2]	State	Up-to-date[5]
	Lacking[3]	National	Dated
	Not applicable	Local/NA[6]	Modelled/NA[6]

[1] Example of multiple colors interpretation: yellow and red in the incidence column indicates that some up-to-date data is available but that other data is dated. [2] Indicates the existence of data or information that partially describes the indicator, but that more is necessary to completely describe the indicator. [3] Indicates that data is generally not available to describe the indicator, or that some data is available but that it may be inconsistent or only slightly relevant to the indicator. [4] Indicates that data is regularly collected as part of an existent monitoring program. [5] Indicates that data has been collected recently, but there is currently no monitoring program in place. [6] NA = Not Available.

Compatibility Issues

The Montreal Process Criteria and Indicators were developed by an international consortium to provide a common framework for communicating the degree to which forests were being managed in a sustainable and responsible manner. The criteria and indicators incorporated into the Montreal Process were designed to be flexible enough so that individual countries or other governmental units could utilize existing data and monitoring programs in their assessment (USDA Forest Service, 2003a). However, the effective exchange of information across political boundaries or hierarchical levels of management (e.g., local, state, regional, national, and international) requires that some commonality in terms of collecting and reporting on data be retained if the overall goal of the program is to succeed.

It is acknowledged that the purpose of the Montreal Process Criteria and Indicators may ultimately be better served by adapting them to more accurately reflect the spatial scale at which they are applied. However, as this "first approximation" report represents the initial application of the Montreal Process Criteria and Indicators to forest sustainability in the state of Illinois, it was considered appropriate to utilize the full set without alteration. This approach ensures full compatibility with the national assessment undertaken by the USDA Forest Service as well as any other regional, state or local assessment using these specific criteria and indicators. Deviating substantially from the given set of criteria and indicators developed by the Montreal Process at such an early stage in their application could result in an inability to compare, aggregate or integrate information across different spatial scales and/or political boundaries.

Capacity to Conduct and Apply Research

The ability to conduct and apply research and development aimed at improving the scientific understanding of forest ecosystem characteristics and functions is an important aspect of sustainable forest management. The results of scientific research and the development of new technologies provide resource managers and decision-makers with essential knowledge and tools for the sustainable management of forests and other natural resources. The Science, Education and Culture Program in the Illinois Department of Natural Resources collects and analyzes scientific data for the purpose of advancing the understanding and appreciation of the state's natural and cultural resources (ICO, 2003). IDNR science institutions include the Illinois Natural History Survey, Illinois State Water Survey, Illinois State Geological Survey, Illinois State Museum, and Illinois Waste Management Center. Universities, colleges and technical schools that support research in natural resources, conservation and related disciplines are also extremely important in advancing the scientific understanding of forest ecosystems. In Illinois, five public universities and eighteen independent not-for-profit colleges and universities have academic degree programs related to conservation and natural resources

Anthropogenic and Climate Driven Change

Anthropogenic disturbances and/or management practices (e.g., timber harvests, introduction of invasive species, urbanization, fire suppression, etc.) have the potential to temporarily or even permanently alter forest resources. An example of a research question in Illinois related to these types of events involves the use of prescribed fire to control maple takeover, coupled with improvements in the scientific understanding of the ecology of historical fire and other disturbance regimes throughout the Midwest. Another research and forest management issue that has justifiably received recognition in Illinois concerns the introduction, spread, eradication and overall management of exotic or invasive species in woodlands throughout the state. For example, part of the Illinois ForestWatch volunteer monitoring program's data collection protocol involves the quantification of the extent to which invasive shrubs are present in Illinois' forests.

Climate change has the potential to impact forests in a number of ways, including shifts or alterations in: disturbance regimes including pests and fire; forest productivity; the distribution of both individual tree species and entire forest associations; the ranges of wildlife species; rates of carbon sequestration and ecosystem carbon fluxes; water cycles; and other parameters related to forest health (USDA Forest Service, 2003a; Iverson et al., 1999b). Efforts to predict the effects of climate change on forests and other terrestrial, aquatic, oceanic and atmospheric systems have been undertaken by a number of scientific researchers and institutions located throughout the world, including Illinois.

The Illinois Global Climate Change Project represents an ongoing effort to monitor developments in scientific research and public policy related to global climate change. The project is also involved in assessing how these developments might impact Illinois physically, economically and socially. In addition, the project also identifies mitigation and adaptation options that might enable the state of Illinois to respond to climate change. The Illinois Global Climate Change Project consists of three core groups:

- The Illinois Task Force on Global Climate Change monitors climate change developments, considers response options and makes recommendations for state climate change policy
- The Illinois Energy and Environmental Assessment Division – provides research and staff support to the Illinois Task Force on Global Climate Change
- The Illinois Global Climate Change Program – serves as scientific advisors to the Illinois Task Force on Global Climate Change.

Data and Resource Issues

Criterion 1: Conservation of Biological Diversity

Reserved Forestland – USDA Forest Service Forest Inventory and Analysis (FIA) data related to reserved forestland in Illinois has a relatively high degree of uncertainty associated with it. FIA data becomes less accurate when applied to finer spatial scales, and reserved forestland makes up such a small percentage of overall forestland in Illinois that this may have affected the accuracy of the data. This fact combined with the disjunctive occurrence of reserved forestland throughout the state suggests that an independent inventory and monitoring program initiated at the state level may be necessary to completely assess the indicators associated with reserved forestland in Illinois.

Forest Fragmentation – Much of the forested landscape in Illinois consists of small isolated patches or riparian zone forests that essentially have little or no forest interior, making forest fragmentation a serious issue in Illinois. Some data is available to assess forest fragmentation in Illinois, but further refinement of GIS data is necessary to completely assess this issue. The fragmentation metrics developed by the USDA Forest Service need to be integrated with digital maps of forest cover by forest type in Illinois in order for fragmentation to be quantified by forest type. In addition, this type of analysis could be expanded to more thoroughly address the effects of urbanization on forest cover.

Forest Dependent Species – Further collection and refinement of data related to forest dependent species is necessary to completely assess this suite of indicators, particularly with respect to monitoring population levels, restrictions in range, or other fluctuations in available habitat. The Illinois GAP Analysis Project, in particular the Vertebrate Distribution and Mapping Program, may address a significant number of concerns related to these issues in the future.

Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

Non-Timber Forest Products (NTFPs) – Data pertaining to non-timber forest products (NTFPs) are significantly lacking at the state (and national) level at this time. The development of a statewide program to document and monitor the value and quantities of NTFPs removed from Illinois' forests on an annual basis will be required if this issue is to be fully assessed in the future.

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

Invasive Species – Further quantification of the extent to which invasive species are impacting forests statewide is highly recommended. For example, data from the Illinois ForestWatch monitoring network shows an alarming trend with respect to invasive shrubs, and exotic insects continue to be a cause of great concern. Monitoring and control efforts related to invasive species need to be implemented and/or expanded statewide.

Air Pollutants – Air quality and atmospheric deposition data for the state of Illinois are available from a variety of sources. At this time, however, bridging this data to the area and percent of forestland that may be directly or indirectly affected by such processes is not readily feasible. In order to fully assess this issue, air quality and atmospheric deposition data needs to be spatially coupled with data related to the occurrence of forestland. This information then needs to be integrated with data related to the susceptibility of forest vegetation to the quantities of pollution it may be acutely or chronically exposed to. The USDA Forest Service Forest Inventory and Analysis (FIA) Program is partially addressing this issue through the collection of data related to ozone damage, but this type of effort needs to be extended to other potentially damaging pollutants.

Oak Regeneration – A decline in successful oak regeneration in some of Illinois' forests continues to be a concern. Maple takeover refers to the replacement of relatively shade-intolerant oak species by shade-tolerant maple species over time. Fire suppression and other alterations to historical disturbance regimes have been linked to this issue. Continued monitoring and research into the ability of periodically prescribed fire in oak-hickory forests to mediate this problem, as well as the feasibility of using prescribed fire as a management tool over the long term, is recommended.

Criterion 4: Conservation and Maintenance of Soil and Water Resources

Soil Resources – There are a significant number of data gaps related to statewide forest soils in Illinois. However, many of these data gaps have been addressed at the national level by the USDA Forest Service Forest Inventory and Analysis (FIA) Program and incorporated into data collection protocols. The complete assessment of this issue will be contingent upon the future availability of FIA soil quality data for the state of Illinois.

Water Resources – Rivers, streams, and other water bodies throughout the state are monitored by both the United States Geological Survey (USGS) and the Illinois Environmental Protection Agency (IEPA). However, water quality in forested catchments or stream reaches is not specifically addressed. This issue is confounded by the fact that many of Illinois' streams and rivers continually flow from non-forested reaches into forested reaches and vice-versa. The complete assessment of this issue will likely be contingent upon the development and implementation of more rigorous monitoring protocols by those agencies that already have water quality monitoring networks in place.

Riparian Zone Management – Much of the forestland throughout Illinois is closely associated with river and stream systems. Although it is known that forested riparian zones provide important benefits to aquatic ecosystems in Illinois, the spatial extent of forested riparian zones in Illinois has not been fully and quantitatively identified. The complete assessment of this issue will rely upon the analysis of GIS data combined with an investigation into spatially correlated trends in ownership patterns and management goals as they relate to forested riparian zones throughout the state.

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

A number of parameters related to the three indicators in Criterion 5 need to be further refined in order to increase the accuracy of this assessment. For example, a better understanding of carbon pools and fluxes related to the belowground portions of trees as well as non-tree forest ecosystem components (e.g., forest soils) is needed. Further research into the potential impacts of utilizing biomass plantings for fuel and carbon sequestration is also recommended. In addition, more frequent monitoring of the quantities of timber removed from Illinois' forests that are used for wood products and other purposes could enhance estimates of long-term carbon storage in wood products.

Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socio-Economic Benefits

Production and Consumption – The recovery and use of wood mill residues in Illinois is relatively well documented. National data concerning the recovery and use of post-consumer paper products is also readily available. However, statewide data related to post-consumer recycling is notably lacking. Given that Illinois ranks 5th in the nation in consumption of wood products based on population estimates, the initiation of a study to more accurately determine statewide post-consumer recycling trends is recommended.

Recreation and Tourism – Outdoor recreation sites and facilities in Illinois have been surveyed by a number of different sources over the years and data

is readily available to support this issue with one caveat. Many outdoor recreation sites in the state are located on a variety of landcover types including forests, making it difficult to distinguish between forested and non-forested recreation areas. For this reason the recreation section of Criterion 6 was applied to outdoor recreation in general in the state of Illinois. Any statewide programs initiated to inventory and monitor protected forestland in Illinois (see recommendations for Criterion 1) should be adapted to also include forested portions of outdoor recreation areas, many of which have protected status.

Investment in the Forest Sector – Annual expenditures on various forms of outdoor recreation (e.g., wildlife observation) in Illinois are significant enough to merit a closer look into not only their impacts on the state economy, but also ways in which to further develop them. A study to ascertain how new and improved technologies have specifically impacted the forest industry and related socio-economic factors in Illinois is also recommended. Finally, although state and federal cost-share programs in Illinois do currently support a variety of forest-related activities, these programs could be expanded in both type and extent.

Employment and Community Needs – Data and other information concerning the economic viability of forest dependent communities in Illinois are extremely limited. Furthermore, exactly what constitutes a forest dependent community is unclear. Although the forest and paper products and related industries constitute a relatively small percentage of the overall state economy, their effect on local economies could be significant. This issue is likely strongly related to rural and community development in Illinois, and certainly requires further study. The extent to which forestland in Illinois is used for subsistence purposes also requires further study. Currently no data on that topic exists, although the issue could feasibly be linked to studies related to the use of non-timber forest products (NTFPs).

Criterion 7: Legal, Institutional and Economic Framework for Forest Conservation and Sustainable Management

Two key issues relevant to Criterion 7 are a lack of forestry-related staffing to meet the varied forestry needs within the state and a lack of management on non-industrial private forestland (NASPF, 2003). At the time of writing a number of district forester and other positions throughout the Division of Forest Resources and the Office of Resource Conservation in general are vacant and unable to be filled due to shortfalls in the state budget. Similarly, the University of Illinois currently does not support an extension forester position. This presents a serious obstacle for the goal of sustainable forest management in the state of Illinois. Without adequate field staffing, many programs essential to sustainable forest management are inevitably sidelined. For example, private non-industrial forest landowners, who own 82% of the forestland in the state, require approved forest management plans to be eligible for many forestry assistance programs. Without an adequate number of district and regional foresters to develop and approve such plans, the backlog of landowners on waiting lists could significantly lengthen. Although private consulting foresters can develop and submit management plans for approval, many landowners are unwilling to spend the extra money to hire these professionals. The end result is that the development of approved forest management plans will be delayed indefinitely, perhaps permanently, for a significant amount of forestland in Illinois. This situation is obviously counterproductive to the goals of sustainable forestry.

References

American Forest & Paper Association (AF&PA). 2003. Statistical highlights. Available at: http://www.afandpa.org/ (April, 2003).

American Forest & Paper Association (AF&PA). 2002. Wood recovery FAQs. Available at: http://www.afandpa.org/ (April, 2003).

Anderson, R.C. 1970. Prairies in the prairie state. *Trans. of the Illinois State Academy of Science* 63: 214-221.

Animal and Plant Health Inspection Service (APHIS). 2003. Pest Detection and Management Programs: Asian Longhorned Beetle. Available at: http://www.aphis.usda.gov/ppq/ep/alb/ (August, 2003).

Annual Survey of Manufactures. Geographic Area Statistics. Available at: http://www.census.gov/mcd/asmhome.html (April, 2003).

Birch, T.W. 1996. Private forest-land owners of the Northern United States, 1994. USDA Forest Service Northeastern Forest Exp. Station Res. Bulletin NE-136. Radnor, PA. 293 p.

Birdsey, R.A. 1992. Carbon storage and accumulation in United States forest ecosystems. General Technical Report WO-59. USDA Forest Service, Washington, D.C.

Brawn, J.D., and S.K. Robinson. 1994. Forest birds in Illinois: changes in abundance and breeding ecology. *Erigenia* 13: 109-116.

Bretthauer, S.M., and J.M. Edgington. 2002. The forest resources of Illinois: 2002. Department of Natural Resources and Environmental Sciences, University of Illinois. 88 p. Available at: http://ifdc.nres.uiuc.edu/publications.htm (June, 2004).

Brown, S.L., P. Schroeder, and J.S. Kern. 1999. Spatial distribution of biomass in forests of the eastern USA. *Forest Ecology and Management* 123: 81-90.

Cairns, M.A., S. Brown, E.H. Helmer, and G.A. Baumgardner. 1997. Root biomass allocation in the world's upland forests. *Oecologia* 111: 1-11.

Cavey, J.F. 2000. Anoplophora glabripennis (Motschulsky) – Asian Longhorned Beetle. Available at: http://www.exoticforestpests.org (March, 2003).

Chicago Academy of Sciences. 2003. Threatened and endangered Illinois forest species. Available at: http://www.chias.org/www/edu/mitc/forte.html (July, 2003).

Energy Information Administration (EIA), US Dept. of Energy. 2002. Emissions of Greenhouse Gases in the United States 2001: Carbon Dioxide Emissions. DOE/EIA-0573(2001). Washington D.C. Available at: http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html (April, 2003).

GMDigest (Gypsy Moth Digest). 2003. Available at: http://fhpr8.srs.fs.fed.us/wv/gmdigest/gmdigest.html (July, 2003).

Graber, J.W., and R.R. Graber. 1976. Environmental evaluation using birds and their habitats. Illinois Natural History Survey Biological Notes 97. 39 p.

Hackett, R.L., and J.A. Sester. 1998. Illinois timber industry – an assessment of timber product output and use, 1996. USDA Forest Service North Central Research Station Resource Bulletin NC-192. St. Paul, MN: 67 p.

Helms, J.A. (ed.) 1998. The Dictionary of Forestry. Bethesda, MD: Society of American Foresters. 210 p.

Herkert, J.R. 1994. Endangered and threatened animal species of Illinois forests. *Erigenia* 13: 122-128.

Illinois Agricultural Statistics Service (IASS). 1990-2002. Illinois Timber Prices. Available at: http://www.agstats.state.il.us/website/reports.htm (May, 2003).

Illinois Comptroller's Office (ICO). 2003. State of Illinois Comprehensive Annual Financial Report 2001 (Illinois CAFR). State of Illinois. Available at: http://www.comptroller.state.il.us/Office/index.cfm (May, 2003).

Illinois Department of Energy and Natural Resources (IDENR). 1994. The Changing Illinois Environment: Critical Trends. Summary Report and Volumes 1-7 Technical Report. Illinois Department of Energy and Natural Resources. Springfield, IL, ILENR/RE-EA-94/05.

Illinois Department of Natural Resources (IDNR). 2003a. The Cache River Basin. Online version (2/5/03). Available at: http://dnr.state.il.us/orep/c2000/assessments/cacheweb/index.htm (June, 2003).

Illinois Department of Natural Resources (IDNR). 2003b. Illinois Statewide Comprehensive Outdoor Recreation Plan (SCORP) 2003-2008 (draft). 47 p. Available at: http://dnr.state.il.us/OCD/scorp/scorpform5.htm (May, 2003).

Illinois Department of Natural Resources (IDNR). 2003c. Division of Forest Resources Mission Statement. Available at: http://dnr.state.il.us/conservation/forestry/index.htm (July, 2003).

Illinois Department of Natural Resources (IDNR). 2000a. Illinois inventory of greenhouse gas emissions: 1998. Available at: http://dnr.state.il.us/orep/INRIN/EQ/ICCP/ICCP.HTM (April, 2003).

Illinois Department of Natural Resources (IDNR). 2000b. Forestry Best Management Practices for Illinois. Available at: http://www.siu.edu/%7eilbmp/ (June, 2003).

Illinois Department of Natural Resources (IDNR). 1999. Climate change developments: Kyoto and beyond – report of the Illinois task force on global climate change. Available at: http://dnr.state.il.us/OREP/inrin/eq/cc/index.htm (April, 2003).

Illinois Endangered Species Protection Board. 1999. Endangered and threatened species list. Available at: http://dnr.state.il.us/espb/index.htm (July, 2003).

Illinois Environmental Protection Agency (IEPA). 2003. Air Quality Information. Available at: http://www.epa.state.il.us/air/air-quality-menu.html (March, 2003).

Illinois Environmental Protection Agency (IEPA). 2003. Green Illinois: about the Green Illinois Program. Available at: http://www.epa.state.il.us/green-illinois/ (April, 2003).

Illinois Environmental Protection Agency (IEPA). 2002. Illinois Annual Air Quality Report 2001. IEPA Bureau of Air. Springfield, Illinois. 89 p. Available at: http://www.epa.state.il.us/air/air-quality-report/index.html (March, 2003).

Illinois Environmental Protection Agency (IEPA). 2002. Illinois Water Quality Report 2002. IEPA Bureau of Water Publication IEPA/BOW/02-006. Springfield, IL. Available at: http://www.epa.state.il.us/water/water-quality/index.html (April, 2003).

Illinois Forestry Development Council (IFDC). 1999. Realizing the Forests' Full Potential: Assessment and Long-Range Action Plan for Forest Resources in Illinois. 60 p.

Illinois ForestWatch. Illinois EcoWatch Network. Available at: http://dnr.state.il.us/orep/ecowatch (May, 2004).

Illinois General Assembly. Illinois Compiled Statutes, Administrative Rules, Bills and Resolutions, Public Acts, etc. Available at: http://www.legis.state.il.us/ (June, 2003).

Illinois Green Government Coordinating Council (IGGCC). 2002. Green Illinois: 2002 annual report. Available at: http://www.epa.state.il.us/green-illinois/index.html (April, 2003).

Illinois Natural Heritage Database. Database available at: http://dnr.state.il.us/conservation/naturalheritage/inhd.htm (July, 2003).

Illinois Natural History Survey (INHS). 2003a. Illinois Natural History Survey's 1999-2000 1:100,000 Scale Illinois Gap Analysis Land Cover Classification, Raster Digital Data, Version 2.0, September 2003. Available at: http://www.agr.state.il.us/gis/index.html (May, 2004).

Illinois Natural History Survey (INHS). 2003b. INHS amphibian and reptile collection: Illinois species. Available at: http://www.inhs.uiuc.edu/cbd/collections/amprep/ilspecies.html (July, 2003).

Illinois Natural History Survey (INHS). 2003c. INHS mammal collection: mammals of Illinois. Available at: http://www.inhs.uiuc.edu/cbd/collections/mammal/ilmammals.html (July, 2003).

Illinois Natural History Survey (INHS), 1995 & 1996. INHS GIS Database. Illinois Natural Resources Geospatial Data Clearinghouse. Available at: http://www.isgs.uiuc.edu/nsdihome/webdocs/browse.html (June, 2003).

Illinois Natural Resources Conservation Service (IL NRCS). 2003. State Soil Geographic Data Base (STATSGO). Available at: http://www.il.nrcs.usda.gov/ (March, 2003).

Illinois Statistical Abstract. Available at: http://www.igpa.uillinois.edu/Abstract/ (July, 2003).

Illinois Waste Management and Research Center (IWMRC). 2002. Annual report 2002. Available at: http://www.wmrc.uiuc.edu/ (April, 2003).

Iverson, L.R., D. Ketzner, and J. Karnes. 1999a. Illinois Plant Information Network (ILPIN). Available at: http://www.fs.fed.us/ne/delaware/ilpin/ilpin.html (February, 2003).

Iverson, L.R., A.M. Prasad, B.J. Hale, and E.K. Sutherland. 1999b. Atlas of Current and Potential Future Distributions of Common Trees of the Eastern United States. USDA Forest Service, Northeastern Research Station. General Technical Report NE-265. 245 p.

Iverson, L.R., and A. Prasad. 1998. Estimating regional plant biodiversity with GIS modelling. *Diversity and Dist*. 4:49-61.

Iverson, L.R., A. Prasad, and D.M. Ketzner. 1997. A summary of the Illinois flora based on the Illinois Plant Information Network. *Transactions of the Illinois State Academy of Science* 90:41-64.

Iverson, L.R., R.L. Oliver, D.P. Tucker, P.G. Risser, C.D. Burnett, and R.G. Rayburn. 1989. The forest resources of Illinois: an atlas and analysis of spatial and temporal trends. Illinois Natural History Survey Special Publication 11. 181 p.

Malhi, Y., D.D. Baldocchi, and P.G. Jarvis. 1999. The carbon balance of tropical, temperate and boreal forests. *Plant Cell and Environment* 22: 715-740.

Luman, D., M. Joselyn, and L. Suloway. 1996. Critical trends assessment land cover database of Illinois, 1991-1995: IDNR GIS database (CD-ROM). Champaign: Illinois Department of Natural Resources.

Mohlenbrock, R.H. 1990. Forest Trees of Illinois. Illinois Department of Natural Resources. Springfield, IL. 331 p.

National Association of State Park Directors (NASPD). 2003. The 2003 Annual Information Exchange. NASPD. Tucson, AZ. Vol. 24: 54 p.

National Atmospheric Deposition Program /National Trends Network (NADP/NTN). 2003. NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820. Available at: http://nadp.sws.uiuc.edu/ (May, 2004).

National Weather Service. OST/SEC GIS Map Group. US States and Territories. Available at: http://www.nws.noaa.gov (May, 2004).

Natural Resources Conservation Service (NRCS). 2002. Illinois tree planting sets a record in 2002! Illinois Forestry Development Council News, V.3 No. 4, p. 1.

NatureServe. 2002. NatureServe Explorer. Database available at: http://www.natureserve.org/explorer/ (July, 2003).

O'Rourke, D. 1997. Illinois Outdoor Recreation Activities. Survey Research Laboratory, University of Illinois at Chicago. 26 p. (plus appendices).

Piva, R.J. 2002. Pulpwood production in the North-Central Region, 1998. USDA Forest Service North Central Research Station Resource Bull. NC-207. St. Paul, MN: 59 p.

Robertson, K.R. 2003. List of Woody Plants Native or Naturalized in Illinois. Available at: http://www.inhs.uiuc.edu/~kenr/woody.html (February, 2003).

Robertson, K.R. 1994. Woody plants of Illinois. *Erigenia* 13: 20-38.

Sauer, J. R., J. E. Hines, and J. Fallon. 2003. The North American Breeding Bird Survey, Results and Analysis 1966 - 2002. Version 2003.1, USGS Patuxent Wildlife Research Center, Laurel, MD. Available at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html (August, 2003).

Schmidt, T.L., M.H. Hansen, and J.A. Solomakos. 2000. Illinois' Forests in 1998. USDA Forest Service North Central Research Station Res. Bull. NC-198. St. Paul, MN. 133 p.

Sedjo, R.A. 1992. Temperate forest ecosystems in the global carbon cycle. *Ambio* 21(4): 274-277.

Shifley, S.R., and N.H. Sullivan. 2002. The status of timber resources in the North Central United States. General Technical Report NC-228. St. Paul, MN: USDA Forest Service North Central Research Station. 47 p.

Slow the Spread (STS) of the Gypsy Moth Project. 2003. STS Operations Portal. Available at: http://www.gmsts.org/operations/ (May, 2004).

Telford, C.J. 1926. Third report on a forest survey of Illinois. Illinois Natural History Survey Bulletin 16-1. 102 p.

Turner, D.P., G.J. Koerper, M.E. Harmon, and J.J. Lee. 1995. A carbon budget for forests of the conterminous United States. *Ecological Applications* 5(2): 421-436.

US Bureau of Economic Analysis (US BEA). 2003. Gross State Product data. Available at: http://www.bea.doc.gov/ (April, 2003).

US Census Bureau. Available at: http://www.census.gov/ (May, 2004).

USDA Farm Service Agency (USDA FSA). 2003. Summary of active CRP and CREP contracts by state and year. Available at: http://www.fsa.usda.gov/dafp/cepd/crp_reports.htm (May, 2003).

USDA Forest Service. 2004. National Report on Sustainable Forests – 2003. FS – 766. USDA Forest Service. 139 p.

USDA Forest Service. 2003a. National Report on Sustainable Forests – 2003: final draft. Available at: http://www2.srs.fs.fed.us/2003/2003.htm (April, 2003).

USDA Forest Service. 2003b. Forest Inventory and Analysis Soil Quality Indicator: FIA Fact Sheet Series. Available at http://fia.fs.fed.us/library/Factsheets/Soils.doc (March, 2003).

USDA Forest Service. 2002. Sourcebook on criteria and indicators of forest sustainability in the Northeastern Area. NA-TP-03-02. Newtown Square, PA: USDA Forest Service, Northeastern Area State and Private Forestry. 64 p. Available at: http://www.na.fs.fed.us/sustainability (May, 2004).

USDA Forest Service Forest Inventory and Analysis Database (FIADB). Database and documentation available at: http://www.ncrs.fs.fed.us/4801/fiadb/ (July, 2003).

USDA Forest Service FIA Timber Products Output (TPO) Database, 1997. Available at: http://www.ncrs.fs.fed.us/4801/fiadb/ (July, 2003).

USDA Forest Service Southern Research Station. 2003. Landscape Analysis and Assessment: National Land-Cover Pattern Data. Available at: http://www.srs.fs.fed.us/4803/landscapes/index.html (June, 2003).

USDA Forest Service National Forest Health Monitoring Program (FHM). 2003. Ozone Biomonitoring. Available at: http://www.na.fs.fed.us/spfo/fhm/ozonetrng/biozone.htm (March, 2003).

USDA Forest Service National Forest Health Monitoring Program (FHM). 2001. Illinois Forest Health Highlights. Available at: http://www.na.fs.fed.us/spfo/fhm/index.htm (August, 2003).

USDA Forest Service, Northeastern Area State and Private Forestry (NASPF). 2003. Illinois Forest Resource Fact Sheet, Fiscal Year 2003. Available at: http://www.na.fs.fed.us/stateadvice/FactSheets/il.pdf (July, 2003).

USDA National Agricultural Statistics Service (NASS). 2003. Agricultural Statistics. Available at: http://www.nass.usda.gov/census/ (July, 2003).

USDA Soil Conservation Service (USDA SCS). 1994. State Soil Geographic (STATSGO) Data Base--data use information. National Soil Survey Center Misc. Pub. Number 1492 (rev. ed.): Fort Worth, Texas.

United States Environmental Protection Agency (USEPA). 2003. 1998 Section 303(d) List Fact Sheet for Illinois. Available at: http://oaspub.epa.gov/waters/state_rept.control?p_state=IL (April, 2003).

United States Environmental Protection Agency (USEPA). Environmental Information Management System. Available at: http://www.epa.gov/eims/index.html (July, 2003).

United States Environmental Protection Agency (USEPA). Watershed Information Network, Watershed Atlas. Available at: http://www.epa.gov/wateratlas/ (July, 2003).

United States Fish and Wildlife Service (USFWS). 2003a. Region 3 Endangered Species: Illinois List of Threatened, Endangered, Proposed and Candidate Species. Available at: http://midwest.fws.gov/Endangered/lists/state-il.html (July, 2003).

United States Fish and Wildlife Service (USFWS). 2003b. 2003 Illinois State Fact Book. Available at: http://midwest.fws.gov/maps/illinois.htm (May, 2003).

United States Fish and Wildlife Service (USFWS). 2003c. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Illinois. FHW/01-IL-Rev. Available at: http://www.fws.gov/ (May, 2003).

United States Fish and Wildlife Service (USFWS). 1998. 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Illinois. FHW/96-IL. Available at: http://www.fws.gov/ (May, 2003).

United States Geological Survey (USGS). 2003a. 1:2,000,000-scale Digital Line Graph files of streams. USGS Geospatial Data Clearinghouse, Water Resources NSDI Node. Available at: http://mapping.usgs.gov/nsdi/ (May, 2004).

United States Geological Survey (USGS). 2003b. Streams and Waterbodies of the United States. Available at: http://nationalatlas.gov/ (May, 2004).

United States Geological Survey (USGS). 2002. National Water Quality Assessment (NAWQA) Program: The Upper Illinois River Basin NAWQA Study Unit. Available at: http://il.water.usgs.gov/nawqa/uirb/ (April, 2003).

United States Geological Survey (USGS). 2000. National Water Quality Assessment (NAWQA) Program: The Lower Illinois River Basin. Available at: http://il.water.usgs.gov/proj/lirb/ (April, 2003).

Welsch, D.J. 1991. Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources. USDA Forest Service NASPF, Forest Resources Management Pub. NA-PR-07-91. Radnor, PA. Available at: http://www.na.fs.fed.us/spfo/pubs/n_resource/buffer/cover.htm (March, 2003).

World Commission on Environment and Development (WCED). 1987. Our Common Future. Oxford, United Kingdom: Oxford University Press. 383 p.

Appendix A

Montreal Process Criteria and Indicators for the Sustainable Management of Temperate and Boreal Forests

Criterion 1: Conservation of biological diversity

Ecosystem Diversity

1. Extent of area by forest type relative to total forest area.
2. Extent of area by forest type and by age class or successional stage.
3. Extent of area by forest type in protected area categories as defined by IUCN or other classification systems.
4. Extent of areas by forest type in protected areas defined by age class or successional stage.
5. Fragmentation of forest types.

Species Diversity

6. The number of forest dependent species.
7. The status (rare, threatened, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment.

Genetic Diversity

8. Number of forest dependent species that occupy a small portion of their former range.
9. Population levels of representative species from diverse habitats monitored across their range.

Criterion 2: Maintenance of productive capacity of forest ecosystems

10. Area of forest land and net area of forest land available for timber production.
11. Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production.
12. The area and growing stock of plantations of native and exotic species.
13. Annual removal of wood products compared to the volume determined to be sustainable.
14. Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable.

Criterion 3: Maintenance of forest ecosystem health and vitality

15. Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinization, and domestic animals.
16. Area and percent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate,ozone) or ultra violet B that may cause negative impacts on the forest ecosystem.
17. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil, nutrient cycling, seed dispersion, pollination) and/or ecological continuity.

Criterion 4: Conservation and maintenance of soil and water resources

18. Area and percent of forest land with significant soil erosion.
19. Area and percent of forest land managed primarily for protective functions. e.g. watersheds, flood protection, avalanche protection, riparian zones.
20. Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation.
21. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties.

22. Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities.
23. Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability.
24. Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change.
25. Area and percent of forest land experiencing an accumulation of persistent toxic substances.

Criterion 5: Maintenance of forest contribution to global carbon cycles

26. Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages.
27. Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon.
28. Contribution of forest products to the global carbon budget.

Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies

Production and consumption

29. Value and volume of wood and wood products production, including value added through downstream processing.
30. Value and quantities of production of non-wood forest products.
31. Supply and consumption of wood and wood products, including consumption per capita.
32. Value of wood and non-wood products production as percentage of GDP.
33. Degree of recycling of forest products.
34. Supply and consumption/use of non-wood products.

Recreation and Tourism

35. Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land.
36. Number and type of facilities available for general recreation and tourism, in relation to population and forest area.
37. Number of visitor days attributed to recreation and tourism, in relation to population and forest area.

Investment in the forest sector

38. Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism.
39. Level of expenditure on research and development, and education.
40. Extension and use of new and improved technology.
41. Rates of return on investment.

Cultural, social and spiritual needs and values

42. Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values.
43. Non-consumptive-use forest values.

Employment and community needs

44. Direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment.
45. Average wage rates and injury rates in major employment categories within the forest sector.
46. Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities.
47. Area and percent of forest land used for subsistence purposes.

Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it:

48. Clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process.
49. Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors.
50.Provides opportunities for public participation in public policy and decision making related to forests and public access to information.
51. Encourages best practice codes for forest management.
52. Provides for the management of forests to conserve special environmental, cultural, social and/or scientific values.

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to:

53. Provide for public involvement activities and public education, awareness and extension programs, and make available forest related information.
54. Undertake and implement periodic forest-related planning, assessment, and policy review including cross-sectoral planning and coordination.
55.Develop and maintain human resource skills across relevant disciplines.
56. Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management.
57. Enforce laws, regulations and guidelines.

Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through:

58. Investment and taxation policies and a regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic valuations, and public policy decisions in order to meet long-term demands for forest products and services.
59.Non-discriminatory trade policies for forest products.

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including:

60. Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1-7.
61. Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information.
62. Compatibility with other countries in measuring, monitoring and reporting on indicators.

Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services, including:

63. Development of scientific understanding of forest ecosystem characteristics and functions.
64. Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest related resource depletion or replenishment in national accounting systems.
65. New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies.
66. Enhancement of ability to predict impacts of human intervention on forests.
67. Ability to predict impacts on forests of possible climate change.