Patterns and trends of early successional forests in the eastern United States

by Margaret K. Trani, Robert T. Brooks, Thomas L. Schmidt, Victor A. Rudis, and Christine M. Gabbard

Abstract We assessed the status of early successional forest conditions for 33 eastern states within the New England, Middle Atlantic, Great Lakes, Central Plains, Coastal South, and Interior South subregions. We used Forest Inventory and Analysis surveys to analyze trends from 1946 to 1998. Dramatic regional differences occurred in distribution of early successional forests. The northeastern region had the least proportion of young forest (16%), followed by the north-central (24%) and southern (29%) regions. The least amount of young forest occurred in the Central Plains (15%) and New England (16%), whereas the greatest occurred in the pine-dominated Coastal South (32%). Differences also existed among individual states, ranging from 3% (Illinois) to 38% (Alabama). Long-term declines also were evident within the northeastern and north-central regions. Selective harvesting, fire suppression, urban sprawl, and cessation of agricultural abandonment contributed to the present imbalance in distribution of young forests. Private ownership predominates in the East and presents a significant challenge to provide young forests. Absence of proactive management on private lands may promote continued declines in early successional forest within many eastern areas.

Key Words early successional forest, eastern forests, forest ownership, land-use change

The status and trends of early successional forest and associated wildlife species have emerged as a concern within the eastern United States (Askins et al. 1990, Droege 1998, Litvaitis 2001). Early successional habitats are an integral component of the landscape. Young forests are ephemeral, changing with forest growth and succession. These community types depend on repeated disturbance such as fire, storm, or timber harvest. Within the last several decades, there have been significant changes in disturbance patterns of these forests (Lorimer 2001).

The forests of the eastern United States provide an important environment for a diversity of species (Porter and Hill 1998). Nationwide estimates indicate that approximately 80–90% of vertebrate species rely on forests for part of their life requirements (Flather and Hoekstra 1989).

Eastern forests have developed in response to a complex array of processes. Prior to European settlement, natural disturbances (e.g., wildfire, wind, and storms) enabled the maintenance of early successional forests

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(Williams 1989, Lorimer 2001). In addition, Native Americans frequently burned forest areas to maintain open woods dominated by herbaceous vegetation, facilitating agricultural conversion and game hunting (Whitney 1994). European settlement resulted in extensive clearing of forest and conversion of the land to pasture or cropland (DeGraaf and Miller 1996). These lands were often managed with fire, which also was used to maintain savannas and other open areas in the East (Williams 1989). In particular, fire was used to create favorable grazing conditions for domestic animals (Healy 1985).

Providing young forests contributes to the biological diversity of the forested landscape. The continued maturation of timberland in eastern forests will contribute to the decline and potential loss of some of these species.

Today, fire suppression has allowed these areas to develop into forest. Forest land in many areas also has increased in the last century because of farm abandonment and recolonization by second-growth forests. As forests age, concerns related to seral structure and species composition are being raised (DeGraaf and Miller 1996). The distribution and abundance of young forests directly affects foraging and nesting opportunities for a variety of species.

Recent reports indicate that a number of early successional species are declining (Oliver and Larson 1996, Thompson and Dessecker 1997), including Bachman's sparrow (*Aimophila aestivalis*), Henslow's sparrow (*Ammodramus henslowii*), northern bobwhite (*Colinus virginianus*), prairie warbler (*Dendroica discolor*), blue-winged warbler (*Vermivora pinus*), New England cottontail (*Sylvilagus transitionalis*), and bobcat (*Lynx rufus*). Population declines of woodcock (*Philohela minor*) have been attributed to habitat loss and maturing of the nation's forests (McAuley and Clugston 1998). In addition, Probst and Weinrich (1993) found that declines in early successional avifauna have paralleled changes in land use as natural succession occurs. Fire suppression has substantially reduced the amount of young forest habitat available to wildlife.

We assessed early successional forest conditions for 33 eastern states. We present the current distribution, status, and ownership of young forest communities within a regional ecological context. We review temporal trends in abundance of young forest over a 6-decade interval and reference factors that have contributed to those trends. Finally, we discuss continuing concerns and the future outlook for young forests in the East.

Methods

We analyzed 3 major regions of the eastern United States. The northeastern region included the New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont) and the Middle Atlantic (Delaware, Maryland, New Jersey, New York, Ohio, Pennsylvania, West Virginia) subregions. The north-central region included the Great Lakes (Michigan, Minnesota, and Wisconsin) and the Central Plains (Illinois, Indiana, Iowa, and Missouri) subregions. The southern region was divided into the Coastal South (Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas, Virginia) and the Interior South (Arkansas, Kentucky, Oklahoma, Tennessee) subregions.

Forest resource data came from surveys conducted by the United States Department of Agriculture (USDA) Forest Service Forest Inventory and Analysis (FIA) between 1946 and 1998 (Table 1). FIA surveys, conducted on a periodic basis, report forest conditions based on the measurement and analysis of 0.4-ha plots stratified by county and state. Fixed-radius and variable-radius prism points select trees for measurement; area expansion factors are then assigned to each ground plot. These factors are used to extrapolate plot values from a per-acre basis to a population basis (i.e., an area expansion factor is basically the area that the plot represents for estimation purposes). These measurements form the basis of the FIA Eastwide Database (Hansen et al. 1992).

Ground plots are assigned to land-use classes using aerial photography and field sampling. Classes are established based on forest type, volume, age, size, density, or other parameters. Forest land was defined as land with 10% or more tree crown cover by trees of any size. Forest land was further classified into timberland for those areas capable of producing industrial wood at an annual rate greater than 1.4 m^3/hectare. Timberland does not include forests reserved from timber production, such as national parks and wilderness areas.

Inferences about changes in early successional habitat were made using stand-size class. Stand size is a structural classification based on predominant tree size and was used as a surrogate for stand age and development stage. Four classes are generally recognized: seedling–sapling (young successional stands with trees predominantly less than 12.7 cm diameter and at least 30.5 cm in high), poletimber (mid-successional stands between 12.7 cm and 27.9 cm diameter), and sawtimber (mid- to late

successional stands greater than 27.9 cm diameter). Nonstocked is an additional category and refers to timberland with less than 10% stocking with growing tree species (e.g., recent cutover areas and reverting agricultural fields).

We charted historical trends using seedling–sapling and nonstocked acreage to minimize definition differences among survey periods and FIA regions. Historical definitions of nonstocked forest have included variable aspects of seedling–sapling habitat. In the past, FIA surveys were conducted by state and summarized by region. Decadal summaries are influenced strongly by the portion of the region included. To mitigate this influence, graphical summaries were depicted as a temporal moving average encompassing surveys for years closest to midpoints needed to survey an entire region.

The National Forest Inventory and Analysis Program adheres to a national set of standards related to the accuracy of each inventory. These standards establish comparable information on forest resources across the country, with each state survey designed to meet sampling errors at the 67% confidence limit (one standard error). A 3% error per 404,700 ha (one million ac) of timberland is the maximum allowable sampling error for area estimates. We caution the reader against looking for small changes in forest area from information reported herein. The values used in preparing summaries are strongly affected by which states were surveyed, changes in analytical methods, and variable definitions between surveys. Detailed information concerning the accuracy of state inventories can be obtained from each respective FIA research unit.

Results

Eastern distribution of young forests

The eastern United States accommodates an array of land uses and ecological communities. The distribution of early successional forest varies by climatic subzones with common broad vegetation patterns, termed ecological provinces (McNab and Avers 1994). Using the most recently available standardized data from FIA (Hansen et al. 1992), the proportion of timberland and seedling–sapling diameter class was presented by ecological province (Figures 1, 2).

In regions with most land in forest cover, most seedling–sapling frequency occurred in the "Mixed Forest" provinces, (i.e., forests dominated by a mixture of needle-leafed and broad-leafed species). A notable exception was the mountain region of northern New England. Among southern states, the Coastal South contained the greatest proportion of young forest. The proportion of seedling–sapling timberland was least in the mountain broadleaf forest-dominated areas of Kentucky, Tennessee, and northern Arkansas. Regions dominated by nonforest uses contain the least proportion, e.g., the eastern edge of Arkansas, western edge of Mississippi, and southern tip of Florida. Notable exceptions were the sparse forests of the western portion of east Texas and east Oklahoma, whose forests are disturbed periodically by occasional livestock grazing and other uses (Rudis 1998).

Among the northern states, most young forest occurred within the northern tier of the region (eastern Maine, northern Wisconsin, northeastern Minnesota, and western Michigan), followed by the agricultural-dominated broadleaf forest areas (Indiana, western Ohio, southern Illinois, and southern Wisconsin). Lesser frequencies

Table 1. Forest Inventory and Analysis data used in the present analysis by state and year of survey (1946–1998).

Subregion and state	Year of survey
Middle Atlantic	
Delaware	1986, 1972, 1957
Maryland	1986, 1976, 1964, 1950
New Jersey	1987, 1972, 1956
New York	1993, 1980, 1968, 1953
Ohio	1991, 1979, 1968, 1952
Pennsylvania	1989, 1978, 1965
West Virginia	1989, 1975, 1961, 1949
Central Plains	
Illinois	1998, 1985, 1962, 1948
Indiana	1998, 1986, 1967, 1950
Iowa	1990, 1974, 1957
Missouri	1989, 1972, 1959, 1947
Great Lakes	
Michigan	1993, 1980, 1966, 1955
Minnesota	1990, 1977, 1962, 1953
Wisconsin	1996, 1983, 1968, 1956
Interior South	
Arkansas	1995, 1988, 1978, 1969, 1959, 1953
Kentucky	1988, 1975, 1963, 1949
Oklahoma	1993, 1986, 1976, 1966, 1955
Tennessee	1989, 1980, 1971, 1961, 1948
New England	
Connecticut	1998, 1985, 1972, 1953
Maine	1995, 1982, 1971, 1959
Massachusetts	1998, 1985, 1972, 1953
New Hampshire	1997, 1983, 1973, 1960, 1948
Rhode Island	1998, 1985, 1972, 1953
Vermont	1997, 1983, 1973, 1966, 1948
Coastal South	
Alabama	1990, 1982, 1972, 1963, 1953
Florida	1995, 1987, 1980, 1970, 1959, 1949
Georgia	1997, 1989, 1982, 1972, 1961, 1953
Louisiana	1991, 1984, 1974, 1964, 1953
Mississippi	1994, 1987, 1977, 1967, 1957, 1946
North Carolina	1990, 1984, 1974, 1964, 1955
South Carolina	1993, 1986, 1978, 1968, 1958, 1947
Texas	1992, 1986, 1975, 1965, 1953
Virginia	1992, 1986, 1976, 1966, 1956

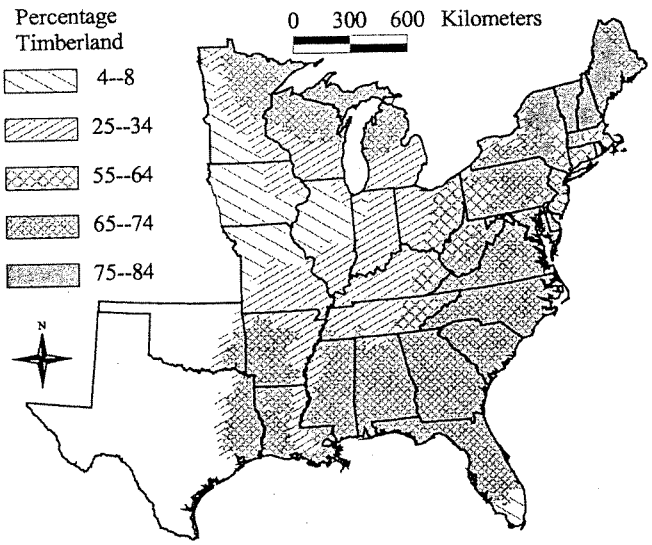

Figure 1. Percentage of eastern United States in timberland by ecological province, 1983–1998. Source: USDA Forest Service, Forest Inventory and Analysis Unit, Northeastern, North Central, and Southern Research Stations.

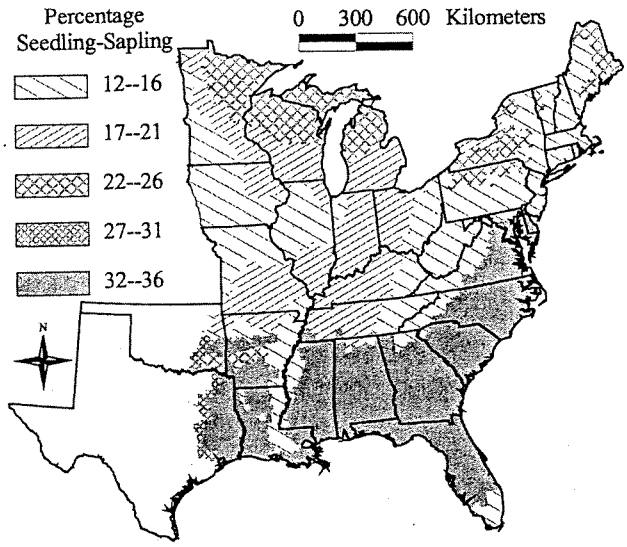

Figure 2. Percentage of timberland in the eastern United States in the seedling–sapling stand diameter class by ecological province, 1983–1998. Source: USDA Forest Service, Forest Inventory and Analysis Unit, Northeastern, North Central, and Southern Research Stations.

occurred in the mountain broadleaf forest-dominated mountains of eastern West Virginia and central Pennsylvania and the nonmountainous areas of southern New England, New Jersey, eastern Ohio, and western West Virginia. Least frequencies were in the agriculture-dominated areas of Iowa and northern Illinois and the mountain mixed forest-dominated areas of New York, New Hampshire, Vermont, and western Maine.

The status of young eastern forests: overview

Forest land comprised 40% (154 million ha) of the total land area within the eastern United States. Ninety-four percent (145 million ha) occurred as timberland encompassing a diversity of forest types. Forest types used herein reflect the species forming a plurality of live tree stocking based on the Society of American Foresters' Classification System (Eyre 1980). Oak–hickory (*Quercus–Carya*) forests were the predominant forest types within each region, occurring on approximately 52 million ha (Powell et al. 1993). On southern lands, oak–hickory has increased over 30% since the 1960s (Flather et al. 1999). Elm–ash–cottonwood (*Ulnus–Fraxinus–Populus*) forests also occurred throughout the eastern United States and were prevalent in bottomland and wetland areas. Northern hardwoods dominated the New England subregion, which also included white–jack–red pine (*Pinus strobus–Pinus banksiana–Pinus resinosa*) and spruce–fir (*Picea–Abies*) forests. Maple–beech–birch (*Acer–Fagus–Betula*) forests occurred on 20 million ha, predominantly in the northeastern and north-central regions. Over the last 4 decades, maple–beech–birch forests have increased over 40% in the North and South (Flather et al. 1999). Most aspen–birch (*Populus–Betula*) forests were located in the north-central region and consist of post-disturbance pioneer species. Aspen–birch forests have declined by 31% during the last 3 decades.

Forest composition in the South followed general ecological boundaries of the coastal plain and interior mountains. Loblolly–shortleaf pine (*Pinus taeda–Pinus echinata*) forests (20 million ha) occurred throughout the East, primarily in the South. This forest type has declined by 39% in the southern and by 13% in the northern United States since the 1960s. Longleaf–slash pine (*Pinus palustris–Pinus elliottii*) forests also have declined substantially (–45%) in the South during the last 4 decades (Flather et al. 1999). Oak–pine (*Quercus–Pinus*) forests occurred on 13 million ha and have increased throughout the East because of selective pine harvesting. Oak–gum–cypress (*Quercus–Nyssa–Taxodium*) forests were distributed over approximately 11 million ha; the extent of these hardwood forests has been reduced by 25% due primarily to agricultural conversion.

Within these eastern forests, most (67%) seedling–sapling timberland (24 million ha) was held in private ownership (e.g., individuals, corporations, and farmers). Private ownership included millions of small tracts. Industrial forests accounted for approximately 7 million ha (20%) of the seedling–sapling timberland. Companies and individuals operating wood-using plants own industry lands. The National Forest System managed 4% (1.6 million ha) of seedling–sapling timberland, whereas other

Table 2. Seedling–sapling distribution by primary ownership for timberland within the Northeastern United States, 1986–1998. Data provided in thousand hectares. (Source: USDA Forest Service, Northeastern Research Station, Forest Inventory and Analysis Unit).

State and Subregion	Survey year[a]	All land[b]	All timberland	Seedling–Sapling Timberland					
				Area	Percent[c]	National forest	Other public	Forest industry	Other private
Connecticut	1998	1,255	689	35	5	0	8[d]	0	27[d]
Maine	1995	7,994	6,855	1,706	25	0	27	861	818
Massachusetts	1998	2,030	1,055	47	4	0	8[d]	0	39[d]
New Hampshire[d]	1997	2,323	1,825	157	9	20	5	28	104
Rhode Island	1998	271	134	8	6	0	1[d]	0	7[d]
Vermont[e]	1997	2,396	1,814	178	10	5	6	15	153
New England		**16,269**	**12,372**	**2,131**	**17**	**24**	**55**	**904**	**1,148**
Delaware	1986	506	153	28	18	0	0	5	22
Maryland	1986	2,548	981	94	10	0	4	14	76
New Jersey	1987	1,922	754	101	13	0	23	0	78
New York	1993	12,231	6,235	1,028	16	0	40	33	954
Ohio	-1991	10,607	3,063	733	24	6	17	14	696
Pennsylvania	1989	11,609	6,424	965	15	28	144	28	764
West Virginia	1989	6,238	4,823	486	10	23	8	36	419
Middle Atlantic		**45,661**	**22,433**	**3,435**	**15**	**57**	**236**	**130**	**3,009**
Northeastern Region		**61,930**	**34,805**	**5,566**	**16**	**82**	**291**	**1,034**	**4,157**

[a] N = 16,482 forested plots.
[b] From Powell et al. (1993).
[c] Percent of total timberland area.
[d] Area estimates based on relative density.
[e] Estimates of area calculated by ratio of total stand-size area estimated using basal area: total stand-size area using relative density.

public ownerships comprised almost 3 million ha (8%). These lands included military reservations, national parks, and wildlife refuges.

Urban areas, including transportation networks, have displayed substantial gains within all 3 regions. Urban growth rose by 24% in the South between 1982 and 1992 (USDA Natural Resource Conservation Service 1994). In the northeastern and north-central regions, urban areas increased by 13%.

There also have been substantial changes in forest composition and structure throughout the eastern United States during the past 6 decades. These are presented below by specific region.

Northeastern region

Forest land covered 38 million ha (67%) of the total land area within the 13 northeastern states as of the last national assessment (Powell et al. 1993). Forest land was the dominant land cover in New England, accounting for 81% of the total land area. In the Middle Atlantic, forest land covers 54% of the total land base. Timberland accounted for 93% (35 million ha) of forest land in the Northeast, 96% in New England, and 91% in the Middle Atlantic.

The forest resources of the Northeast were surveyed most recently by FIA from 1987 to 1998 (Table 2). At that time, seedling–sapling timberland comprised over 5 million ha (16%) of timberland. The proportion of timberland classified as seedling–sapling was equivalent for the 2 northeastern subregions, with New England having a slightly greater percentage (17%) than the Middle Atlantic (15%).

The proportion of timberland classed as seedling–sapling varies considerably by state, especially within New England. Maine, with considerable forest industry ownership (Birch 1996) and its associated active forest management, had the greatest proportion of timberland (25%) in the seedling–sapling class. The young forest component was dramatically less in the other New England states (e.g., Connecticut, Massachusetts, and Rhode Island). Seedling–sapling area in the Middle Atlantic ranged 10–24% of total timberland area. Ohio had the greatest proportion of young forest (24%) and reflected the active reversion of agricultural land into forest land, a phenomenon that occurred earlier in the eastern seaboard states.

Forest landownership was dominated by non-industrial private (NIPF) owners (Birch 1996). Except for Maine, seedling–sapling timberland was owned principally by individuals (Table 2). This has important implications for the use of timber harvesting for the retention of early successional forest land in the Northeast: 1) individual

private forest landowners are resistant to using even-aged regeneration methods resulting in early seral stands, 2) NIPF owners are often interested in forest resources other than wood products and perceive timber harvest as detrimental to those interests, and 3) NIPF ownerships are increasingly fragmented into smaller tracts, impeding use of commercial harvest to manage forest resources

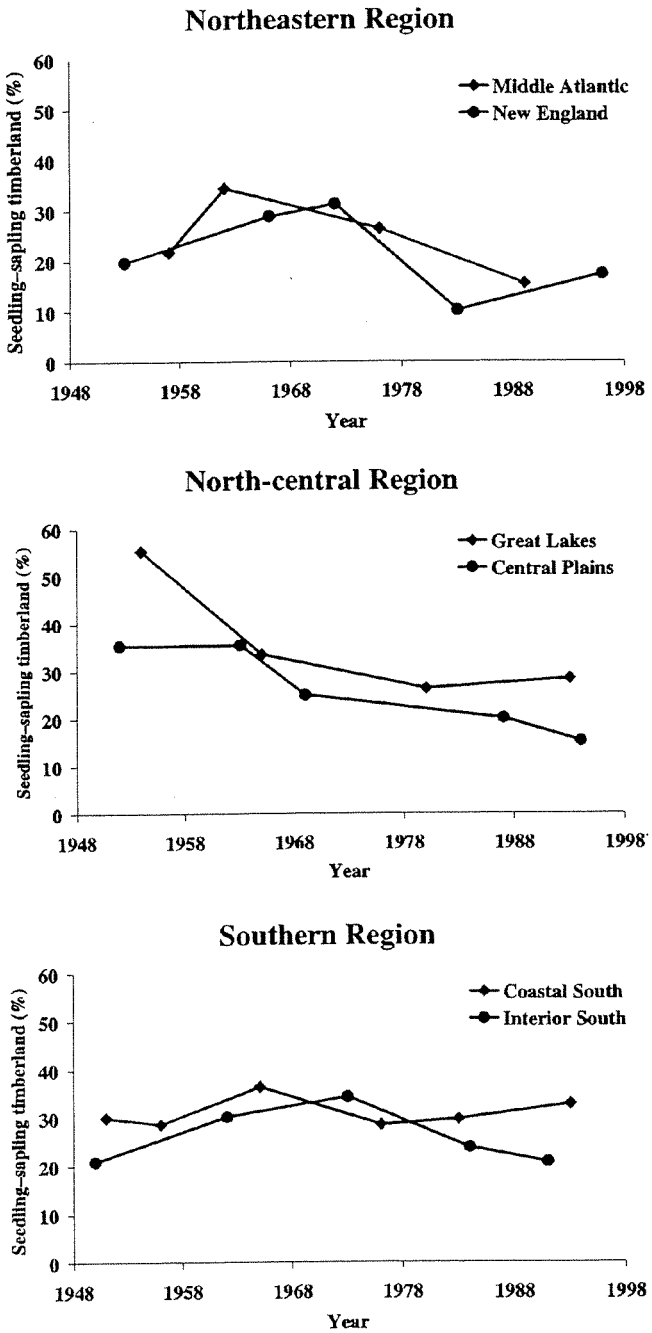

Figure 3. Temporal trends in seedling–sapling area for the eastern United States. Seedling sapling area is depicted as a percentage of total timberland area and includes nonstocked lands to minimize definition inconsistencies among survey periods. Source: USDA Forest Service, Forest Inventory and Analysis Unit.

(Brooks and Birch 1986, 1988; Kittredge et al. 1996).

Area of timberland in the Northeast increased by approximately 3.2 million ha between 1952 and 1987 (Alig et al. 1990). This occurred in the Middle Atlantic, with timberland area in New England remaining stable at 12.5 million ha. With the 1990s economic recovery and associated residential development, there has been an estimated timberland loss of 33,000 ha in New England. Projections of future development indicate declines (–1.6 million ha) in northeastern timberland over the next 4 decades (Alig et al. 1990).

Seedling–sapling availability within the New England and Middle Atlantic subregions peaked during the 1960–1970 period, followed by a decline that continues to the present day (Figure 3). However, the increase in seedling–sapling area observed in New England during the latest surveys reflects the influence of timber harvest occurring in Maine. Except for Maine, the area of seedling–sapling timberland in New England continued to decline in the 1990s. The forest surveys from the '90s showed that seedling–sapling timberland increased to 25% of total timberland in Maine, from 11.4% in the 1980s survey, but had declined to 7.9% from 8.6% in the other New England states.

The forest history of the Northeast since European settlement is one of relatively rapid and widespread change (DeGraaf and Miller 1996). There is no consensus about the full extent of Native American clearing of forest in the Northeast for agricultural purposes prior to the arrival of Europeans. However, there is agreement that agriculture was locally important along the Atlantic coast and along floodplains of major eastern rivers and that cleared areas, often maintained by fire, were extensive. Disease and conflict with Europeans decimated Native American numbers, resulting in the reforestation of the openings and shrub lands that had been maintained for agriculture and berry production.

European settlement resulted in the extensive clearing of forest and conversion of the land to pasture or cropland. In New England, it is estimated that forest land was most limited at about 1830, covering about 25% of the area (DeGraaf and Miller 1996). With the settlement of the Midwest, marginal farmland was abandoned in New England and reverted to forest cover. The abandonment accelerated following the Civil War, with federal government incentives for settlement of the western territories. The same pattern of land-use history occurred elsewhere in the Northeast, but at different dates and extent of forest loss.

The recent pattern of early successional forests across the Northeast reflects land-use change and forest succession occurring over the last 6 decades (DeGraaf and

Table 3. Seedling–sapling distribution by primary ownership for timberland within the north-central United States, 1989–1998. Data provided in thousand hectares. (Source: USDA Forest Service, North Central Research Station, Forest Inventory and Analysis Unit).

State and Subregion	Survey year[a]	All land[b]	All timberland	Seedling–Sapling Timberland					
				Area	Percent[c]	National forest	Other public	Forest industry	Other private
Illinois	1998	14,410	1,655	50	3	3	3	0	44
Indiana	1998	9,298	1,759	97	6	2	7	0	88
Iowa	1990	14,506	787	117	15	0	6	0	111
Missouri	1989	17,871	5,415	1,163	21	95	55	19	994
Central Plains		**56,085**	**9,616**	**1,427**	**15**	**100**	**71**	**19**	**1,237**
Michigan	1993	14,725	7,539	1,795	24	260	448	140	947
Minnesota	1990	20,619	5,963	1,800	30	234	795	131	640
Wisconsin	1996	14,078	6,360	1,953	31	158	491	178	1126
Great Lakes		**49,422**	**19,862**	**5,548**	**28**	**652**	**1,734**	**449**	**2,713**
North Central Region		**105,507**	**29,478**	**6,975**	**24**	**752**	**1,805**	**468**	**3,950**

[a] N = 33,424 forested plots.
[b] From Powell et al. (1993).
[c] Percent of total timberland area.

Miller 1996, Litvaitis et al. 1999). The period between the start of the Great Depression and the end of World War II was one of persistent agricultural abandonment. The loss of cropland and its reversion to forest was particularly evident in New England, where only 16% of the farms (and 37% of the croplands) that existed in 1945 remain today (Bureau of Census 1977, National Agricultural Statistics Service 1999). During the same period, 26% of the farms (and 70% of croplands) remain in the Middle Atlantic.

In the Northeast, abandoned agricultural land rapidly returns to forest cover. With the cessation of land abandonment and suppression of forest fires, creation of early successional forests originates from timber harvest and the occasional severe storm. However, extent of timber harvesting in the Northeast is limited, typically for intermediate silvicultural treatments (i.e., thinnings) and uneven-aged regeneration (Kittredge 1996). Neither harvest method results in creating adequate early successional forest habitat. The decline in forest products from the Northwest is occurring when northeastern forests are maturing to the stage where commercial operations are feasible. Within the constraints imposed by state regulations and ownership patterns, timber harvests may increasingly contribute to the retention of young forest.

North-central region

The Central Plains covered approximately 56 million ha of land. Seventeen percent was timberland, of which 15% occurred as young forest (Table 3, Brand and Walkowiak 1991, Hahn and Spencer 1991, Schmidt et al. 2000). In the past 15 years between FIA surveys, timberland has increased by 600,000 ha, whereas seedling–sapling timberland has declined by approximately 300,000 ha.

Most timberland was populated by deciduous species. Primary forest types in this region were oak–hickory, maple–beech–birch, and elm–ash–cottonwood. Depending on site factors, oak–hickory and maple–beech–birch forests were replacing early successional forests such as elm–ash–cottonwood.

Large-diameter trees dominated this subregion. Stand-size class distribution consisted of sawtimber (59%), poletimber (26%), and seedling–sapling (15%). In earlier surveys, 19% of the timberland area was classified as seedling–sapling (Figure 3). Selective harvesting methods that are generally used throughout the subregion often do not create the type of disturbance that can facilitate the creation of young forests. High-grading hardwood stands leaves lesser-quality cull trees that hasten the transition to a later seral stage.

Timberland ownership in the Central Plains was comprised of private and corporate landowners (85%), forest industry (3%), federal (7%), and state and local (6%). Two-thirds of all private landholdings were under 8 ha (Birch 1996). With expanding human population and timberland stabilization, forest resources in this subregion will continue to shrink in average tract sizes, which influences potential harvest and limits management options. In addition, only 1% of the landowners indicated that timber harvest was their primary reason for ownership (Birch 1996). It is projected that the current decline in area of early successional forest area will continue in this subregion.

Timberlands were predominantly on mesic sites. Less than 10% of the total area of timberland was on

hydromesic (bottomland) sites of critical importance among a wide variety of interests. These bottomland hardwoods (or riparian forests) have historically received the most pressure for conversion to agricultural use. Current pressures included demands for urban space, second homes, and recreational facilities. Although trees often remain with development, forest characteristics change and natural regeneration is curtailed (Schmidt 2000). Stocking is lessened, snags and hollow trees are removed, and species composition is altered.

Prior to European settlement, the major disturbances in this region were flooding and wildfire. Windthrow has historically been of minor importance, with little impact on the forest resource. Bottomland sites of elm–ash–cottonwood were historically subjected to periodic floods. These disturbance events removed older stands and created riparian forests that were maintained in an early seral stage. Flood-control measures initiated over the past 50 years have caused a shift from early successional to mid-successional riparian forests throughout much of the Central Plains (Schmidt 2000). In addition, suppression of wildfires has promoted forest succession. Prior to European settlement, this region was exposed periodically to wildfires that maintained young forests and diverse species compositions. After World War II, expanded transportation networks and improved fire management resulted in dramatic wildfire declines (and thus minimal disturbance for early seral maintenance). The control of floods and fires, in combination with agricultural conversion, has greatly reduced the magnitude of forest disturbance (Schmidt et al. 2000). If this continues, seedling–sapling timberland will continue to decline over the next 2 decades.

The Great Lakes states covered approximately 49 million ha, 40% of which are classified as timberland (Table 3, Leatherberry et al. 1995, Schmidt et al. 1997, Schmidt 1998). Timberland has increased 1.3 million ha during the 1980–1993 survey period. This net increase in timberland area began in the 1970s from the conversion of agricultural lands and the reversion of "stumpland" areas (i.e., forest lands that have been cutover and left for natural regeneration to occur).

This subregion differed from the Central Plains relative to the proportion of young forest. Currently, 28% of total timberland exists as seedling–sapling stands. This contrasts with 25% in the 1980s, 28% in the 1960s, and 36% in the 1950s (Figure 3). There also have been dramatic shifts in nonstocked areas that comprised 19% in the 1950s and now cover less than 1% of current timberland.

Stand-size class distribution was relatively even within the Great Lakes subregion. Thirty-seven percent was classified as sawtimber, 35% as poletimber, and 28% as seedling–sapling. In the 1980s, 28% of the timberland area was classified as sawtimber, 46% poletimber, 25% seedling–sapling, and 1% nonstocked. This distribution is attributed to the harvesting techniques used in this subregion.

Coniferous and deciduous species occurred within this subregion. Dominant hardwoods included maple–beech–birch, oak–hickory, aspen–birch, and elm–ash–cottonwood. Depending on site factors, oak–hickory and maple–beech–birch forests replace undisturbed early successional forest types (i.e., elm–ash–cottonwood). With harvest, aspen–birch stands are self-replacing; without disturbance, these forests advance to mid-successional seres such as maple–beech–birch.

For many forest types, timber harvest creates a sufficient disturbance to allow regeneration of early successional species. For example, one method of harvesting aspen–birch stands is by using clearcutting techniques that ensure adequate regeneration and harvest efficiency. Selective hardwood harvesting methods (also used in the Northeast) do little to change successional stage.

The future levels of young forest depend greatly on which harvest techniques are used in the Great Lakes. Timberland was found on a variety of physiographic sites ranging from swamps and bogs to dry sandy plains; these sites are unlikely candidates for land-use conversion. Similar to other areas within the north-central region, former timberlands with agricultural potential have been converted, whereas flood and fire control have promoted forest expansion.

Forty-nine percent of seedling–sapling timberlands were in private ownership; 8% were managed by forest industry. National forests (12%) and other public agencies (31%) represent the remaining ownership sectors. Over 50% of private owners have less than 8 ha of timberland (Birch 1996). This region is a national vacation destination, with continual pressure for recreational cabins, second homes, and other recreational facilities. With the region's projected rise in population levels, current timberland resources may continue to become fragmented with reduced tract sizes. Development is currently the greatest land-use threat to the Great Lakes subregion.

Interior and Coastal South regions

Upland hardwoods dominated the Interior South, whereas a mixture of conifers and hardwoods populated the Coastal South. The South is bisected by the mountains (Georgia, Virginia, the Carolinas, Kentucky, and Tennessee) and by the Mississippi Alluvial Basin (Arkansas, Louisiana, and western Mississippi). Pine forests are concentrated on the coastal plain and on the

Table 4. Seedling–sapling distribution by primary ownership for timberland within the southern United States, 1988–1997. Data provided in thousand hectares. (Source: USDA Forest Service, Southern Research Station, Forest Inventory and Analysis Unit).

State and Subregion	Survey year[a]	All land[b]	All timberland	Seedling–Sapling Timberland					
				Area	Percent[c]	National forest	Other public	Forest industry	Other private
Arkansas	1995	13,488	7,443	1,768	24	97	55	505	1,111
Kentucky	1988	10,291	4,997	821	16	21	28	20	752
Oklahoma	1993	17,788	1,981	564	28	24	40	111	388
Tennessee	1989	10,676	5,368	947	18	22	41	116	768
Interior South		**52,243**	**19,789**	**4,100**	**21**	**164**	**164**	**752**	**3,019**
Alabama	1990	13,145	8,876	3,374	38	44	62	912	2,356
Florida	1995	13,986	5,929	2,190	37	141	187	813	1,049
Georgia	1997	15,001	9,630	3,298	34	34	87	805	2,374
Louisiana	1991	11,284	5,578	1,377	25	53	33	503	788
Mississippi	1994	12,151	7,522	2,831	38	87	67	553	2,125
North Carolina	1990	12,618	7,572	1,821	24	59	72	286	1,405
South Carolina	1993	7,799	5,040	1,805	36	64	44	377	1,321
Texas	1992	67,838	4,765	1,569	33	44	44	686	820
Virginia	1992	10,256	6,252	1,228	20	50	29	228	920
Coastal South		**164,078**	**61,164**	**19,493**	**32**	**576**	**625**	**5,163**	**13,158**
Southern Region		**216,321**	**80,953**	**23,593**	**29**	**740**	**789**	**5,915**	**16,177**

[a] N = 49,137 forested plots.
[b] From Powell et al. (1993).
[c] Percent of total timberland area.

piedmont. In the more productive areas of the South, the coastal plain has supported a "fourth" forest since the large-scale clearing of the late 1800s (USDA Forest Service 1988).

Dates of the most recent statewide surveys are between 1988 (Kentucky) and 1997 (Georgia). The regional composite of state surveys has an average survey date of 1992 (Table 4). Within the southern region, there were 216 million ha of land, 37% of which was timberland. Seedling–sapling stands accounted for 29% of the total timberland area.

The greatest proportion of young forest was in the Coastal South (32%). Alabama, Florida, Mississippi, and South Carolina each maintained over 35% of timberland in seedling–sapling. The Coastal South included approximately 10 million ha of plantations, 40% of the world's total (Hyde and Stuart 1998). The region's timber production continues to retain steady recruitment of young forest, largely in loblolly and slash pine plantations. Elsewhere, forests are succeeding to oak–pine, mixed hardwoods, and other late successional types (Rudis 1991). In the pine regions of the Gulf coastal plain, intensive plantation management has influenced forest composition and stage of stand development. Pine management was intensive in southwestern Alabama, southern Mississippi, southwestern Louisiana, southwestern Arkansas, southeastern Oklahoma, and southeastern Texas. The Ouachita Mountains of Arkansas and Oklahoma contain a large proportion of shortleaf pine and oak–pine community types.

In contrast, the Interior South contained 21% of timberland in seedling–sapling (Table 4). Within this subregion, Kentucky (16%) and Tennessee (18%) had the least amounts of seedling–sapling timberland; Arkansas (24%) and Oklahoma (28%) had the most. Recruitment of young forest has declined slowly in the Interior South (and other areas with few conifers).

Private ownership predominated in the South, as elsewhere. Sixty-nine percent of seedling–sapling timberlands were privately owned. Forest industry managed 25% of young forest timberland, largely in the Coastal South's pine-growing areas that were acquired during the Great Depression (Williams 1989). National forest (3%) and other public agencies (3%) represented the remaining ownership sectors within seedling–sapling timberland, located primarily in the mountain and lowland areas of the Coastal South (Rudis 1998).

Fire frequency and intensity were once dominant throughout the South. Effective fire suppression over the last 50 years has led to changes in forest ecosystems, including expansion of forest land within former open habitats (White and Wilds 1998). Tropical storms continue to provide recurrent disturbances in coastal areas, along with tornadoes in the interior. The heavy rainfall

that accompanies these storms, an important natural disturbance, creates open areas within the forested landscape.

During the 1920s, southern forests consisted primarily of pines (*Pinus spp.*), oaks (*Quercus spp.*), cypress (*Taxodium Rich.*), tupelo (*Nyssa L.*), and sweetgum (*Liquidambar L.*). Presettlement fires and periodic droughts were the dominant ecological forces that gave rise to vast areas of southern pine forests (Williams 1989). In later decades, fire suppression and timber harvests, followed by land clearing for farm uses, reduced the extent of forest. However, a major period of farm abandonment occurred during the 1880–1940 period, with many old fields reverting initially to pine, which resulted in expanded areas of forest. During the following decades, forest area and early successional stand increases varied very little (Figure 3), with many of the losses balanced by gains elsewhere. Old-field natural pine types succeeded to upland hardwoods and older stands with time, fire suppression, and selective pine harvests. Pine plantation area has increased (Powell et al. 1993), particularly in the Coastal South.

In both portions, river bottom forests were drained and converted to cropland, notably in the Mississippi alluvial plain. Elsewhere, declines in forest land were the result of human settlement, animal agriculture, and urban uses (Healy 1985). Recent surveys indicate that net forest area has stabilized (McWilliams et al. 1997, Flather et al. 1999), with some of the stability due to incentive programs for private land reforestation.

By the 1990s, most forests in the Mississippi Alluvial Plain (71%), Central Appalachians (61%), and Eastern Broadleaf (57%) provinces were in the sawtimber-size class (Rudis 1998). Elsewhere, sawtimber-size class represented 30 to 45% of the forestland, with disturbances associated with forest fragmentation of nonforest cover (roads, agriculture, and urban land), and timber management activities the likely contributors to regional differences (Rudis 1998). Within subregions, localized prospects are less certain, as southern forests near urban developments and high population densities are tied to lesser harvest rates (Barlow et al. 1998). The South has become one of the nation's most rapidly growing areas, presenting an ever-increasing challenge to forest resource management.

Conclusion

There are dramatic regional differences in the distribution of early successional forests in the East. Sawtimber-sized trees currently dominate the northeastern and north-central regions. The proportion of timberland in young forest was smallest in the northeastern region (16%), followed by the north-central (24%) and southern (29%) regions. Within the Northeast, percentage of seedling–sapling forest remains relatively equal among the states comprising New England (17%) and the Middle Atlantic (15%). The proportion of seedling–sapling in the Great Lakes (28%) was almost double that in the Central Plains (15%) of the north-central region. The proportion of young forest in the Coastal South (32%) exceeds that found within the Interior South (21%). The distribution of young forest also varies considerably by state (Tables 2, 3, and 4).

The availability of seedling–sapling timberland in the East reflects the influence of land-use conversion, ownership, and minimal disturbance. Prior to European settlement, wildfires and other natural disturbances enabled maintenance of early successional forests (Lorimer 2001). Selective harvesting, effective fire suppression, and cessation of agricultural abandonment have contributed to the present distribution of young forests. The current distribution of young forest and of other shrubland habitats may be below that needed to sustain desired population levels of some wildlife and at the low range of historic conditions (Askins 2001, Thompson and DeGraaf 2001). The greatest concerns are in the Northeast and Central Plains. Concerns related to species composition and future condition also are being raised (McWilliams et al. 1997). Although forest area has increased in the North, the sites where this has occurred are often quite different from those sites where forest has been lost.

The magnitude of private ownership also presents a significant challenge for the provision of young eastern forests. Individual landowners are changing the characteristics of future forest resources. The absence of management on private lands may result in declines in early successional habitat within many eastern areas. Public agencies, including national forest systems, manage a very small proportion of available young forest in the East.

Urban areas have appreciably changed the character of the forested landscape. For example, urban land comprises a significant portion of the Northeast and has increased 53% during the 1960–1987 interval (Porter and Hill 1998). Population expansion also has resulted in ownership fragmentation. The small tracts typical of present land-use patterns provide little opportunity for forest management and natural disturbance sufficient to create early successional forest. This will continue to influence a myriad of wildlife species, positively for some species and negatively for others.

Wildlife species differ in their response to forest

change and have unique preferences for forest characteristics. Many wildlife species rely on the seedling, shrub, and understory characteristics associated with younger stages. As the composition and structure of the forest change, so do the species that depend on these communities (DeGraaf 1991). There are several early successional species of management or conservation importance within eastern forests (Dessecker and McAuley 2001, Litvaitis 2001). Young forests provide quality habitats for many species, including several of conservation concern (Hunter et al. 2001). Other species use a variety of forest communities and seres. Providing young forests contributes to the biological diversity of the forested landscape. The continued maturation of timberland in eastern forests will contribute to the decline and potential loss of some of these species.

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