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Abundance, distribution, trends, and ownership patterns of early-successional forests in the northeastern United States

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Abstract

Early-successional forests are ephemeral and distinct forest communities, maintained by disturbance and dominated by small-sized trees and shrubs. These structural and compositional conditions form a unique habitat that is preferred by many wildlife species. Various sources have indicated that there have been declines in early-successional forest area and in the populations of many wildlife species associated with these habitats across the northeast. Results of the Forest Inventory and Analysis (FIA) Program from four survey occasions were summarized for 11 states in the northeastern United States to identify recent trends in the area of early-successional forests. Early-successional forests were defined as sapling/seedling-size and non-stocked-size timberland. The area of total forest land has remained relatively constant in the northeast; however, the area of early-successional forests has declined since the first forest surveys (ca. 1950). Losses were greater in the coastal states than among interior states. The area of early-successional forest among coastal areas is approaching or below conditions that are estimated to have existed under disturbance regimes occurring prior to European settlement of the northeast; for interior areas, the current area of early-successional forest still exceeds estimated historic conditions. The majority of forest land in the northeastern United States have been privately owned by individuals since European settlement; this ownership pattern has affected forest change more than natural disturbances. Population increases in the northeast over the last 50 years have not resulted in the loss of forest land to residential and associated developments. However, the fragmentation of forest ownerships (i.e. parcelization) into ever smaller ownerships has imposed social and logistic restrictions on forest management options. The creation and maintenance of sufficient early-successional forests to sustain wildlife populations dependent on this habitat will require active intervention and management.
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Keywords: Early-successional forest; Forest Inventory and Analysis; Forest survey; Non-stocked-size class; Sapling/seedling-size class

1. Introduction

Early-successional habitats, including both successional and young forest conditions, are critical for a number of mammal and bird species of the northeastern United States (Hunter et al., 2001; Litvaitis, 2001; Dettmers, 2003; Fuller and DeStafano, 2003). These habitats are, for the most part, ephemeral and depend on natural or anthropogenic disturbance, principally wind and fire but also including beaver, insects, and disease, for their creation and retention (Askins, 2001; Lorimer, 2001; Lorimer and White, 2003). Early-successional forests were probably never naturally abundant in most of the northeast prior to European discovery, though the question of their historical extent is not completely resolved (Foster and Motzkin, 2003; Litvaitis, 2003; Lorimer and

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White, 2003). The exception would be coastal areas, where Native American agricultural practices and burning, and more frequent and destructive hurricanes, may have maintained extensive stands of young forests (Lorimer and White, 2003). European settlement resulted in the conversion of much of the northeastern forest to crop and pasture land by the middle of the 19th century (Foster, 1992; Trani et al., 2001). Subsequent abandonment of much of this farmland, lead to a period of relatively abundant early-successional forests between 1890 and 1950 (Lorimer, 2001). Across the eastern United States, there has been a general pattern of decline in the area of early-successional forests since 1950, with the exception of the pinelands of the coastal southeast (Trani et al., 2001).

In this paper, I report the area of early-successional forest of the northeastern United States between 1950 and the present, as identified in periodic surveys of the region's forest resources. The standardized forest surveys, conducted by the Forest Inventory and Analysis (FIA) of the United States Forest Service, provide periodic and comprehensive descriptions of the forest resources of the country and have previously been used to characterize forest wildlife habitat (Brooks and Birch, 1986, 1988; Trani et al., 2001). I also report on patterns and trends in forest ownership and their implications for using forest management for the creation and maintenance of early-successional forests.

2. Methods

The information for this analysis came from numerous forest and ownership survey reports of the northeastern FIA project of the USDA Forest Service. Forest surveys conducted by FIA have occurred in the northeast since the late 1940s (Table 1). Since that time, survey and sampling design, measurement standards, and definitions of resource parameters have changed several times. For this analysis, I used published statistics, recognizing that differences in the FIA process between survey occasions affect temporal changes, but I assumed that published numbers were sufficiently accurate for a large-scale (i.e. multistate) analysis. I aggregated the eleven states of the northeastern United States into four geographic regions (Table 1). Additionally, to present comparable summaries over time, state surveys were aggregated into four survey periods (1948–1959, 1968–1976, 1978–1987, and 1989–1999), based on the date of completion of the survey (Table 1). FIA surveys are published in English units and were converted to metric units for this paper.

Table 1
The dates of FIA surveys by region, state, and survey period and the first forest land owner survey by region and state

Region state	Survey period				Forest land owner survey
	1	2	3	4	
Northern New England states					
Maine	1959	1971	1982	1995	1982
New Hampshire	1948	1973	1983	1997	1983
Vermont	1948	1973	1983	1997	1983
Southern New England states					
Massachusetts	1953	1972	1985	1998	1972
Connecticut	1953	1972	1985	1998	1972
Rhode Island	1953	1972	1985	1998	1972
Coastal mid-Atlantic states					
Delaware	1957	1972	1986	1999	1972
Maryland	1950	1976	1986	1999	1977
New Jersey	1956	1972	1987	1999	1972
Interior mid-Atlantic states					
New York	1953	1968	1980	1993	1980
Pennsylvania	1958	1968	1978	1989	1978

I defined early-successional forests as sapling/seedling-size and non-stocked-size timberland. Forest land is defined by FIA as "land that is at least 10% stocked with trees of any size, or that formerly had such tree cover and is not developed for a non-forest use, with a minimum area of 1 acre (0.4047 ha)" and timberland is defined as "forest land capable of producing more than 20 ft^3 (1.4 m^3/ha) of wood per acre per year and not withdrawn from utilization". Stand size is defined as "a classification of forest land based on the size class of the stocking of all live trees". Sapling/seedling-size stands are defined as "forest land that is at least 10% stocked with live trees of which half or more of such stocking is in saplings (1.0 in. (2.54 cm) through 4.9 in. (12.45 cm dbh, diameter at breast height)) or seedlings (less than 1.0 in. dbh and at least 1 foot (30.48 cm) tall) or both." Non-stocked-size stands are defined as "forest land that is less than 10% stocked with live trees." Timberland area by stand size was tracked across all forest types occurring in the northeastern states. Investigation of changes in timberland area by both stand size and forest type could not be made as early publications did not consistently report these data and because small sample sizes (i.e. number of FIA plots) in minor forest types, especially when partitioned by stand size, resulted in poor precision of estimates. It is likely that more of the sapling/seedling-size and non-stocked-size forest would have been classed as "early-successional habitat" (Lorimer, 2001) in the early surveys, because at that time abandoned agricultural land was reverting to forest land, dominated by pioneer tree and shrub species. In the more recent surveys, forests of these stand sizes were more likely to be "young forest habitat", created by the disturbance of existing mature stands, and dominated by regenerating late-successional tree species.

Forest land ownership patterns were surveyed by FIA using questionnaires mailed to the owners of forest land where the forest survey plots occur. Ownership surveys were conducted less frequently than forest surveys, and were first conducted between 1972 and 1983 in the 11 northeastern states (Table 1). Private forest ownerships were re-surveyed in 1994 as part of a national survey (Birch, 1996). Private forest ownership included "all timberland other than that owned by federal, state, or local governments or their agencies" and constituted 88% of all timberland in the northeastern states in 1997 (Smith et al., 2001). Information from the human census came from the web pages of the Bureau of Census, Department of Commerce.

3. Results

3.1. Timberland area

Forest land was and remains the dominant land cover in the northeastern United States. Forest land covered 66% of the 45 million ha of the 11 northeastern states in the most latest national forest survey summary of 1997 (Smith et al., 2001). Forest land area is unchanged from previous national summaries and some 3 million ha greater than reported in an earlier national summary in 1953 (Smith et al., 2001). Timberland accounted for 91% of total forest land in the northeast in 1997, with the balance classified as nonproductive or reserved forest land (Smith et al., 2001).

Timberland area has remained stable over the 50-year history of northeastern forest surveys (Table 2). Regionwide, timberland area increased by less than 5% between the first survey period (1948–1959) and the second (1968–1976), remained stable through the third period (1978–1987), and then declined slightly in last period (1989–1999). While timberland area was stable across the northeast, there were compensating changes among the four regions. Timberland area was stable in northern New England over the 50 years, at about 10.5 million ha or 82% of total land area (Table 2). Timberland area declined slightly over this period in southern New England, from 64 to 58% of total land area, and from 44 to 38% in coastal mid-Atlantic states, reflecting a loss of about 400,000 and 300,000 ha of timberland, respectively. In the interior mid-Atlantic states, timberland area increased to 54% from 46% of total land area over the same time frame, a gain of 1.7 million ha.

3.2. Early-successional forest

While northeastern timberland area remained relatively constant over the past half century, the area of early-successional forest, the total area of sapling/seedling-size and non-stocked-size timberland, changed

Table 2
Total land area by state and region and timberland area by state, region, and survey period, northeastern United States, 1948–1999 (thousands of hectares)

State region	Total land area[a]	Timberland area			
		1948–1959	1968–1976	1978–1987	1989–1999
Maine	7994	6948	6837	6904	6855
New Hampshire	2323	1895	1899	1947	1825
Vermont	2396	1503	1793	1790	1814
Total, northern New England	12713	10346	10529	10641	10494
Massachusetts	2030	1319	1133	1186	1055
Connecticut	1255	798	731	719	689
Rhode Island	271	174	160	150	134
Total, southern New England	3556	2291	2024	2055	1878
New Jersey	1922	858	751	754	759
Delaware	506	158	156	152	152
Maryland	2548	1172	1021	981	960
Total, coastal mid-Atlantic	4976	2188	1928	1887	1871
New York	12231	4857	5780	6235	6235
Pennsylvania	11609	6106	6766	6444	6424
Total, interior mid-Atlantic	23840	10963	12546	12679	12659
Total, all states	45085	25788	27027	27262	26902

[a] Smith et al. (2001).

considerably. During the first forest survey period (1948–1959), early-successional forests accounted for about 22% of total timberland in the northeast, or approximately 5.8 million ha (Fig. 1). Early-successional forests increased in area by about 3.2 million ha by the second survey period (1968–1976), to about 33% of timberland. It then decreased dramatically to about 4.7 million ha, or 17% of timberland, by the third survey period (1978–1987). The area of these forests remained at these levels during the most recent surveys (1989–1999).

This general pattern of an increase in early-successional forest area between the first and second survey periods, and then a consecutive decline in area from the second through the third and fourth survey periods was observed in each of the four subregions of the northeast, except for the southern New England states where the decline in area occurred consistently since the first surveys (Fig. 1). In southern New England, early-successional forests comprised only 5% of total timberland area (92,000 ha) in the most recent survey period. This is down from 36% reported in the first survey period. The area of early-successional forests also declined precipitously in the coastal mid-Atlantic states, from 29% of timberland in the initial survey period to 12% in the most recent surveys, a loss of some 200,000 ha.

Declines in the area of early-successional forests in the interior mid-Atlantic states were less than those detected in the coastal states of the northeast. As of the last occasion surveys, there were some 2 million ha of early-successional forest in New York and Pennsylvania, or 16% of all timberland (Fig. 1). This area is down from the peak of 4.4 million ha reported during the second survey period. Changes in the area of early-successional forest in the northern New England states differed from the other subregions; the area increased by 0.9 million ha between the third and last survey periods, to 20% of timberland area. Closer examination of these findings revealed that the increase occurred almost exclusively in Maine, which experienced a 117% increase in area, while New Hampshire and Vermont experienced only a 4% increase.

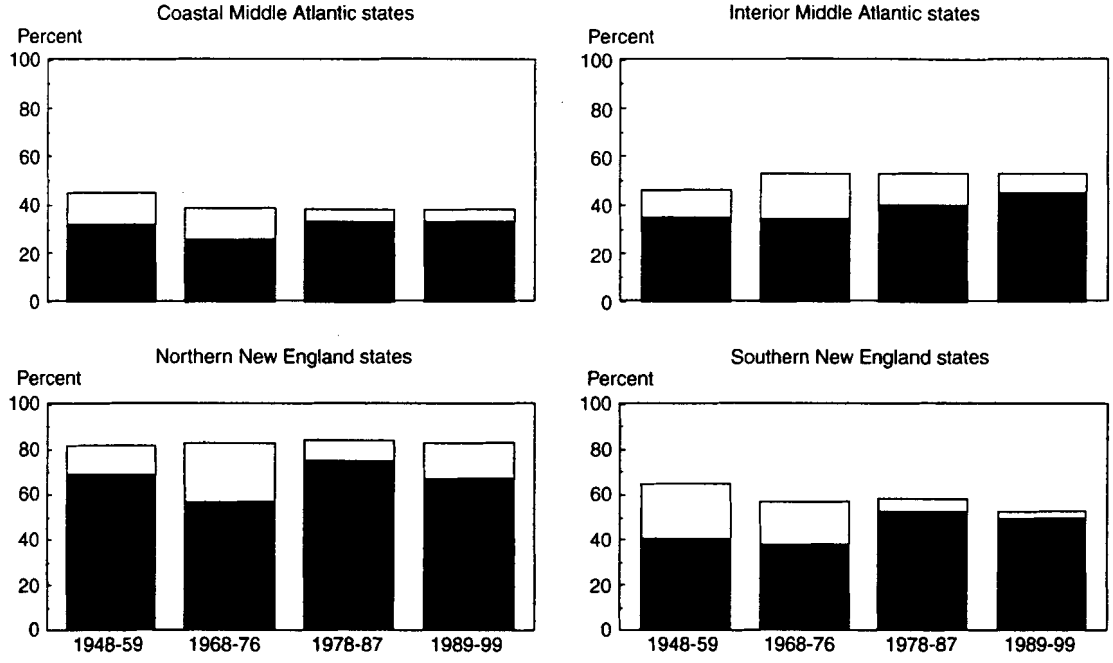

Fig. 1. Early-successional (open), other-sized timberland (solid) area as a percentage of total land area by subregion and survey period, northeastern United States, 1948–1999.

3.3. Timberland ownership

In the most recent national summary of forest surveys, individuals (non-industrial private forest (NIPF) owners) owned the timberland of the northeast, with only 12% in public ownership and 15% owned by forest industries (Smith et al., 2001). This pattern of ownership was essentially unchanged since the early 1950s (Smith et al., 2001). While the area of NIPF timberland in the northeast remained constant, the number of NIPF owners increased from less than 1.7 million to almost 2 million between the first forest ownership surveys of the 1970s and 1980s and the national ownership survey in 1992 (Table 3). In both ownership surveys, the majority of NIPF owners own less than 10 acres (0.4 ha; the smallest reported size-of-ownership), and their number increased from 56 to 60% of all NIPF owners between surveys (Fig. 2). The number of owners of larger parcels of forest land remained constant or decreased slightly between ownership surveys. Despite the large number of owners of small forest parcels, their collective ownership comprised only 5% of all NIPF timberland at both ownership survey occasions. Almost three-quarters of all NIPF timberland in the northeast was in ownerships of 50 acres (20 ha) or larger in both surveys.

Within the coastal New England and mid-Atlantic states, the number of NIPF owners of smaller forest parcels increased dramatically between ownership surveys (Fig. 2). In southern New England, the number of owners of the smallest forest parcels (<0.4 ha) increased from 57 to 82% of all NIPF ownerships between surveys, whereas the number of owners of all larger ownerships decreased. In the coastal mid-Atlantic states, the pattern was the same. In both regions, there was a small increase in the cumulative area of the smallest forest ownerships (Fig. 2), though changes in area of timberland by size of ownership are uncertain due to the small sample size and large variance in estimates from the second, national ownership survey. In the interior regions of the northeast, there was no apparent change in NIPF ownership patterns between surveys (Fig. 2).

Table 3
Estimated number (in thousands) of private forest owners and area (in thousand hectares) owned, by state, region and survey occasion, in the northeastern United States

State region	First occasion survey		1994 survey[a]	
	Owners	Acres	Owners	Acres
Maine	171	6460	256	6904
New Hampshire	88	1677	84	1677
Vermont	62	980	81	1616
Total, northern New England	321	9117	421	10197
Massachusetts	104	984	213	1023
Connecticut	66	675	102	628
Rhode Island	14	147	27	137
Total, southern New England	184	1806	342	1788
New Jersey	64	622	89	567
Delaware	11	150	17	140
Maryland	96	923	131	919
Total, coastal mid-Atlantic	171	1695	237	1626
New York	507	5839	475	5814
Pennsylvania	491	5040	514	5062
Total, interior mid-Atlantic	998	10879	989	10876
Total, all states	1674	23497	1989	24487

[a] Birch (1996).

3.4. Human population

Between 1950 and 2000, the human population of the coastal mid-Atlantic states increased 93%, to a population density of 2.9 persons/ha in 2000; in southern New England the increase was 44%, to an average density of 3/ha. The human population of northern New England also increased considerably, 71% over the 50 years, but population density in the region was still only 0.2/ha in 2000. Over the same time, human population in the interior mid-Atlantic states increased 23%, with an average density of 1.3/ha in 2000. Between the 1950 and 1970 census, the total population of the northeastern United States increased 27% and the rural population increased 24%. Between 1970 and 1990, the total population increased only 5% while the rural population increased 13%.

4. Discussion

Prior to European settlement, early-successional forests in the northeast were created or maintained by natural disturbances, principally windstorms, fire, and beavers (*Castor canadensis*), and by Native Americans. These disturbances, resulting in stand regeneration and the creation of early-successional habitat, were relatively rare in the northeastern United States, especially in inland areas (Lorimer and White, 2003). Although data are sparse, it seems that the cumulative effects of stand-regenerating disturbances were minimal in the northeast and that the long recurrence interval of severe disturbances resulted in the wide distribution of a climax, all-aged forests with gap-phase replacement (Lorimer, 1977). Excluding the effects of beavers, early-successional forests may have composed <3% of the pre-settlement, interior upland forest and upwards of 15% of the coastal landscape (Lorimer and White, 2003). However, Foster and Motzkin (2003), suggest that these percentages may be high for coastal areas.

European settlement of the northeast resulted in the widespread conversion of forest to agricultural use. The conversion reached a peak in the mid-1800s, earlier in coastal areas of the northeast and later in the interior (Foster, 1992). Following the opening of

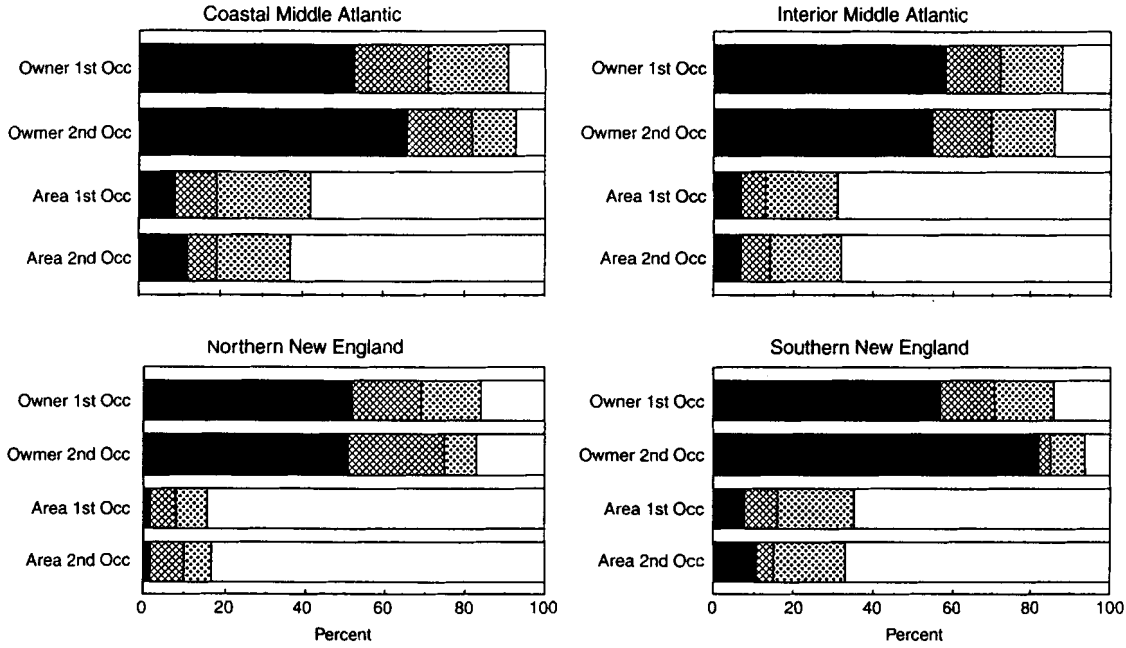

Fig. 2. Private forest owners and area of timberland owned as a percentage of total privately owned timberland, by size of ownership (1–9 acres (0.4–3.0 ha; solid), 10–19 acres (4–7.9 ha; heavy stipple), 20–49 acres (8–19 ha; light stipple), ≥50 acres (≥20 ha; open)), subregion, and survey period, northeastern United States, 1948–1999.

the Erie Canal, the California gold rush, the Civil War, and the settlement of the Midwest, northeastern agricultural lands were abandoned and rapidly succeeded back to forest (DeGraaf and Miller, 1996; DeGraaf and Yamasaki, 2001). Following a period of intensive timber harvesting in the 1890s and early 1900s and a second period of farm abandonment that occurred during the depression years of the 1930s, it is likely that regenerating and young forests were most abundant in the northeast during the first half of the 20th century (Bromley, 1935; Foster et al., 1998; Lorimer, 2001).

Since the middle of the 20th century, when periodic, standardized surveys of forest resources were first conducted in the northeast, the area of early-successional forests declined after peaking at 33% of timberland. Currently, early-successional forests were estimated to constitute about 17% of timberland area, a loss of almost 50% from the earlier maximum. The loss of early-successional forest was greatest in coastal states and less in interior states of the northeast (Fig. 1).

Regionwide, the current extent of early-successional forests still exceeds estimates under disturbance regimes occurring prior to European settlement. Lorimer and White (2003) estimated that early-successional spruce (*Picea* sp.)–northern hardwood forests comprised 2.5–4% of the forest type. In northern New England, where this type is most common, 28% was classified as sapling/seedling-size class in the most recent forest surveys. The northern hardwoods type is more widespread, occurring commonly in all regions except the coastal mid-Atlantic states. Historically, early-successional conditions were estimated to cover 1–3% of the type; currently early-successional stands constitute between 7.3% (southern New England) and 15.6% (interior mid-Atlantic) of the type. Lorimer and White (2003) distinguished between coastal and interior early-successional oak (*Quercus* sp.)–hickory (*Carya* sp.) forests; with a historic condition in the northeast of <3% in early-successional forest, but with upwards of 40–50% in coastal areas immediately following a severe (F2) hurricane. The 1990s era forest

surveys identified 4–5.2% of the type in early-successional conditions in the coastal regions and about 15% in interior regions. Pine (*Pinus* sp.)–oak barrens were most affected by disturbance prior to European settlement. Lorimer and White (2003) speculated that upwards of 85% of the pygmy pitch pine (*P. rigida* Mill.) plains of present-day New Jersey were in sapling/seedling conditions, 39–53% in other New Jersey pine barrens, and 14–31% in New England barrens. This type is poorly surveyed by FIA due to its limited extent. Using the pitch pine type, the most recent surveys identified 9.2% in sapling/seedling-size in New Jersey and 24% in southern New England states. In both cases, the sampling error on these estimates is 100%, and all that can be concluded with any confidence is that some sapling/seedling-size pitch pine forest exists in these states.

The loss of early-successional forest in the northeast was caused by the maturation of the forest, not by the loss of timberland to other land uses. Timberland area has remained stable over the past 50 years (Table 2) and natural disturbance factors, other than wind, have been largely controlled. However, the most recent forest surveys identified small but significant losses of timberland in the densely populated southern New England and coastal mid-Atlantic states. If timberland area is lost to other uses, such as residential and commercial development, early-successional forest will face the dual threats of a maturing forest on a declining land base.

Forest land in the northeastern United States is and has been a resource owned and controlled by individual private forest (NIPF) owners. This pattern of forest ownership is somewhat unique, public and/or industry ownership of forest land are more common in other regions of the United States (Smith et al., 2001). The dominance of NIPF ownership of forest land has been the major determinant of the extent and distribution of early-successional forests in the northeast (DeGraaf and Yamasaki, 2001). It has been the cumulative decisions of multitudes of individual forest owners that has determined the forest history of the northeast. Recent changes in forest ownership have been affected by the increase in human population and the resultant increases in residential and other developed land use (Sampson and DeCoster, 2000) and by the movement of people from urban to suburban and rural locations over the last half-century.

Although forest land remains the principal land cover in the northeast, the growth in the rural population resulted in the parcelization of forest ownerships and residential development of rural, principally forest land. While the actual area of forest lost to residential development remains small, parcelization results in the loss of wildlife habitat to homes, lawns, roads, and other developed land covers and negative impacts of residential use on the remaining, adjacent forest habitat. The parcelization of large forest ownerships into numerous smaller ones precludes the efficient use of silviculture to manage forest for wildlife resources (Kittredge et al., 1996). Additionally, recent arrivals to rural landscapes often are opposed to timber harvests, and are more likely to support local restrictions on timber harvesting (Dennis, 1992).

The creation and maintenance of early-successional forest habitat in the northeast will require the recognition and acceptance that these habitats and their associated wildlife are important and worthy of conservation and broad public support for their management (Litvaitis, 2003). Natural disturbance processes will not provide sufficient habitat to achieve this goal (DeGraaf and Yamasaki, 2003; Litvaitis, 2003). Other than natural disturbance, the most efficient means to create and maintain these habitats are through the use of silviculture (Thompson and Dessecker, 1997; Thompson and DeGraaf, 2001; DeGraaf and Yamasaki, 2003). To address the problem of the increasing number of smaller-sized ownership parcels, programs to manage for early-successional forest habitat will require the use of incentives such as voluntary tax savings programs with management stipulations (Dennis, 1992), the promotion of non-timber objectives for forest management (Roberts and Parker, 1998), and the aggregation of small parcels into more operable units (Dedrick et al., 2000; Barten et al., 2001).

5. Conclusions

For most of the northeastern United States, it is likely that early-successional forest habitat was uncommon prior to European settlement. For the interior of the northeast, the current extent of young forest habitat may be approaching pre-settlement conditions that had been historically maintained by natural disturbance factors. The coastal areas may have

been the exception, where primitive agricultural practices and the use of fire by Native Americans, as well as more frequent and damaging coastal storms, may have maintained significant areas of early-successional habitat. The current area of early-successional habitat in the coastal northeast has likely declined below pre-settlement conditions. The density of residential land use in coastal areas of the northeast, which defines the Boston-to-Washington urban corridor, is such that it is unlikely that historic levels of early-successional forest, under natural disturbance regimes, will reoccur.

Priority issues in forest conservation in coastal areas are the retention of functional blocks of forest land, fragmentation of existing blocks by residential development, and parcelization of forest land into ever smaller ownerships that preclude the cost-effective use of timber harvesting to create young forest habitat. Throughout the northeast, the maintenance of sufficient early-successional forest habitat to sustain populations of early-successional wildlife will require active intervention. The low frequencies of natural disturbance factors, and the high-density human population, even in relatively rural areas, preclude sustainable creation of these habitats without a conscious decision to manage for them. Programs for this purpose are occurring in Connecticut and Massachusetts (Rothbart, 1999; Oehler, 2003). To restore and maintain functional areas of early-successional forest, these and similar programs need to be aggressively adopted across the northeast.

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