Cumulative Watershed Effects of Fuel Management in the Eastern United States

Chapter 4.

The Human Context: Land Ownership, Resource Uses, and Social Dynamics

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The forests and grasslands of the Eastern United States have been subject to more than two centuries of episodic change, generally characterized by forest clearing, agricultural use, abandonment, reforestation, and recovery. Today, rapid colonization of forests and other rural lands by people, the spread of many floral and faunal nonnative invasive species and, in some places, structural changes in forest product companies continue to alter forests. Historical legacies and ongoing disturbances define a complex landscape in the Eastern United States where no land is without substantial human influence. Opportunities for and the practice of forest management and fuels treatments are heavily influenced by this human history and by the human context of forest settings.

This chapter describes the history of eastern forest conditions and uses, and discusses the implications these dynamics hold for future uses, management, and conditions. In particular, I examine time trends in forest area, biomass, and ownership, juxtaposed with changes in human populations and uses of these vast forest resources. The changing human-forest interface holds implications for future forest uses, including opportunities for fuel treatments and other types of forest management, the availability of timber products and ecosystem services, and the values at risk from wildfire and other disturbances.

Conditions and Trends in Eastern Forests

One way to gauge change in forests is to examine how the area of forest cover has changed over time. Surveys of forest conditions conducted by the Forest Inventory and Analysis Program of the Forest Service, U.S. Department of Agriculture, since 1938 provide a basis for a systematic analysis of forest conditions including forest area. In addition, work by Kellogg (1909) provides estimates of forest area in the United States for 1907 and at the time of European settlement (~1630). These data are compiled for the country as a whole in a series of publications, the latest from Smith and others (2003), that provide the majority of forest data discussed in this chapter.

At the time of European settlement, forest area in the Eastern United States exceeded 650 million acres, with roughly 298 million acres in the Northeastern and North Central States and 354 million acres in the Southeastern and South Central States (fig. 1). By 1907, eastern forest area had fallen by about 43 percent to roughly 374 million acres

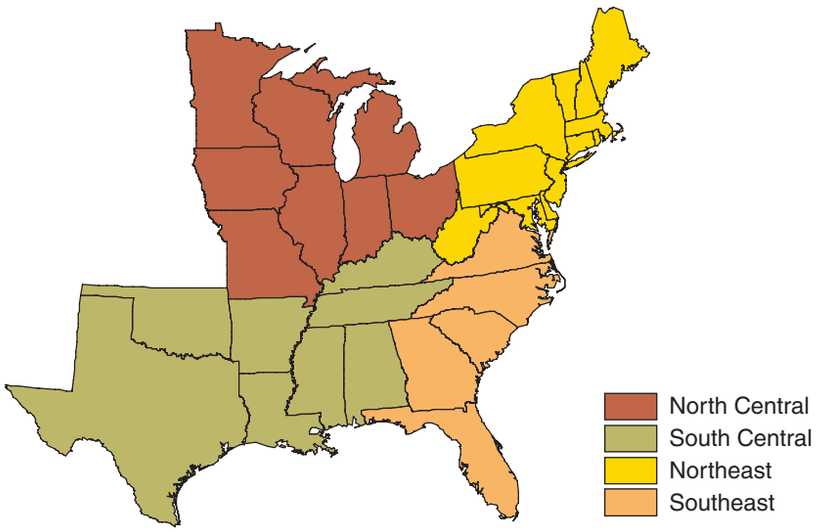

Figure 1. Four divisions of the Eastern United States.

overall with 139 million acres remaining in the North (a decline of about 53 percent) and 236 million acres in the South (a decline of about 33 percent). The spatial pattern of eastern deforestation was highly variable through the 19th century (fig. 2). Ohio, Indiana, and Illinois had lost at least 80 percent of their forest area by 1907, compared to <30 percent for Maine, Florida, Arkansas, and Oklahoma.

Changes in forest area from 1907 to 2002 reveal different patterns (fig. 3). In the 20th century, eastern forest losses were concentrated in Florida and west of the Mississippi River (Florida and Texas had the largest proportions of forest loss). In contrast, the more central States from Illinois to New York saw large proportional increases in forest cover, with moderate gains occurring in a few Southern States (Alabama, Georgia, Virginia, and Kentucky). Through much of the Eastern United States, extensive deforestation in

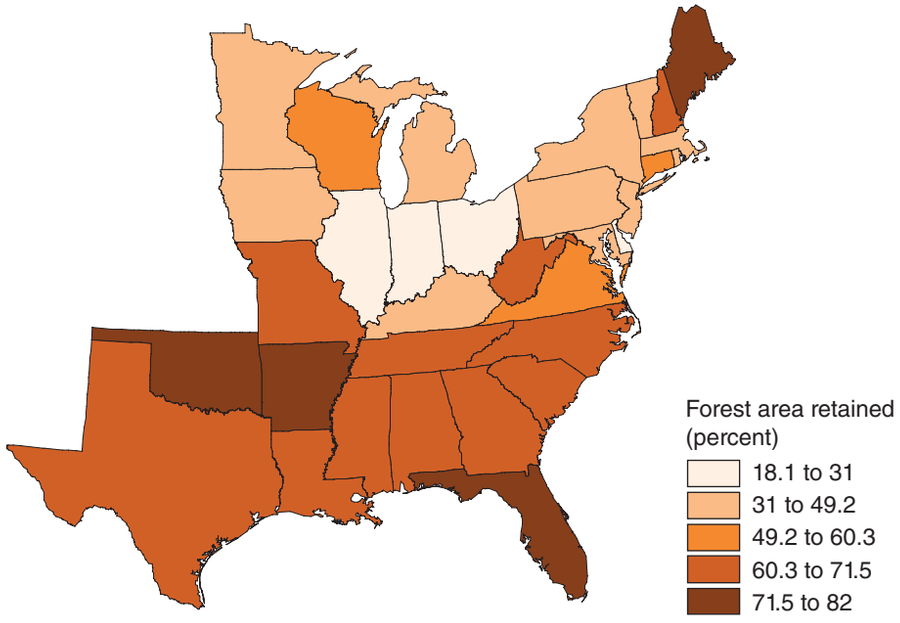

Figure 2. Eastern forest area in 1907 compared to 1630, by State (Smith and others 2003, Kellogg 1909).

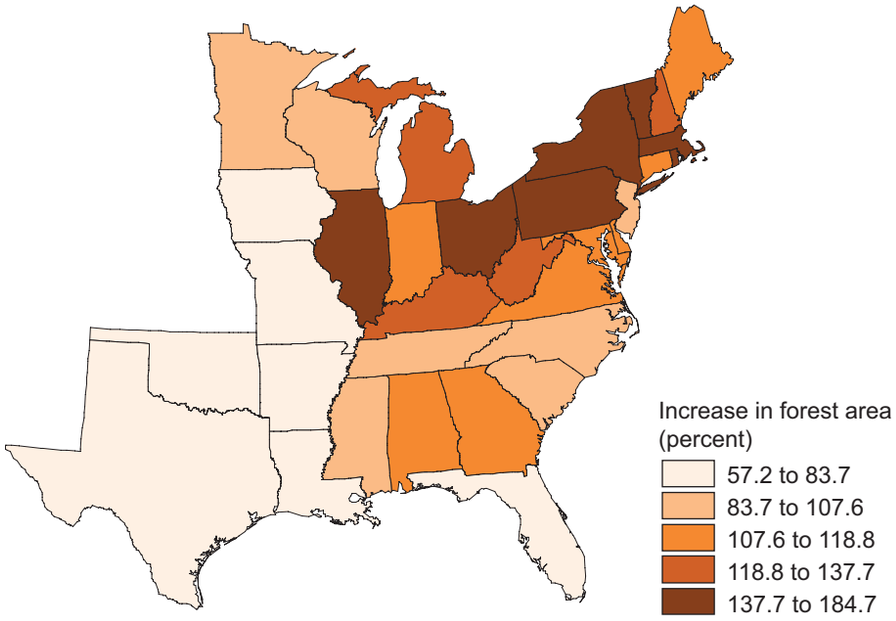

Figure 3. Eastern forest area in 2002 compared to 1907, by State (Smith and others 2003, Kellogg 1909).

the 19th century was followed by some forest area gains in the 20th century. In 2002, forest cover was 43 percent lower than presettlement levels in the North and 39 percent less in the South forest.

Net changes in forest area from 1630 to 2002 were highly variable among Eastern States (fig. 4). In 2002, 5 States (Maine, New Hampshire, Vermont, West Virginia, and Alabama) had more than 75 percent of their presettlement forest area; and 20 States—including 11 of the 13 Southern States—retained 50 to 75 percent. Less than 50 percent of their presettlement forest area was retained by the remaining 7 States, 3 of which are small eastern-seaboard States dominated by urban uses (Maryland, Delaware, and New Jersey). The lowest proportions of residual forests are in Texas and the territory stretching from Iowa eastward through Illinois, Indiana, and into Ohio—in these agricultural areas, residual forests are 23 to 41 percent of original forest area. From 1907 to 2002, 23 of the 33 Eastern States experienced a recovery of some forested area that had been lost before 1907. States with the greatest proportional recovery of forest area were mostly in New England (fig. 4).

The net loss of forest area understates the overall impact that European settlement and land exploitation has had on forest conditions. Even in areas where forest use was maintained over time, timber harvesting altered conditions substantially. Nearly every existing forested acre in the United States has been harvested at least once. So, in most eastern forest landscapes, biomass has been removed at least once since European settlement; in many places, several harvests have occurred. After harvesting, especially in the late 19th and early 20th centuries, a large share of cleared land had been briefly farmed before the economics of poor soils returned forest cover through land abandonment and natural regeneration. The second growth forests that remain reflect a different productivity, species composition, and structure than existed in presettlement forests.

The extent of harvest disturbances and recovery in eastern forests can be deduced from trends in tree biomass contained in these forests over time. Measures of biomass are available for only the second half of the 20th century, but they reflect the rapid recolonization and growth of cutover forests, a large portion of which was returned to forest cover after a brief agricultural exploitation between the 1920s and

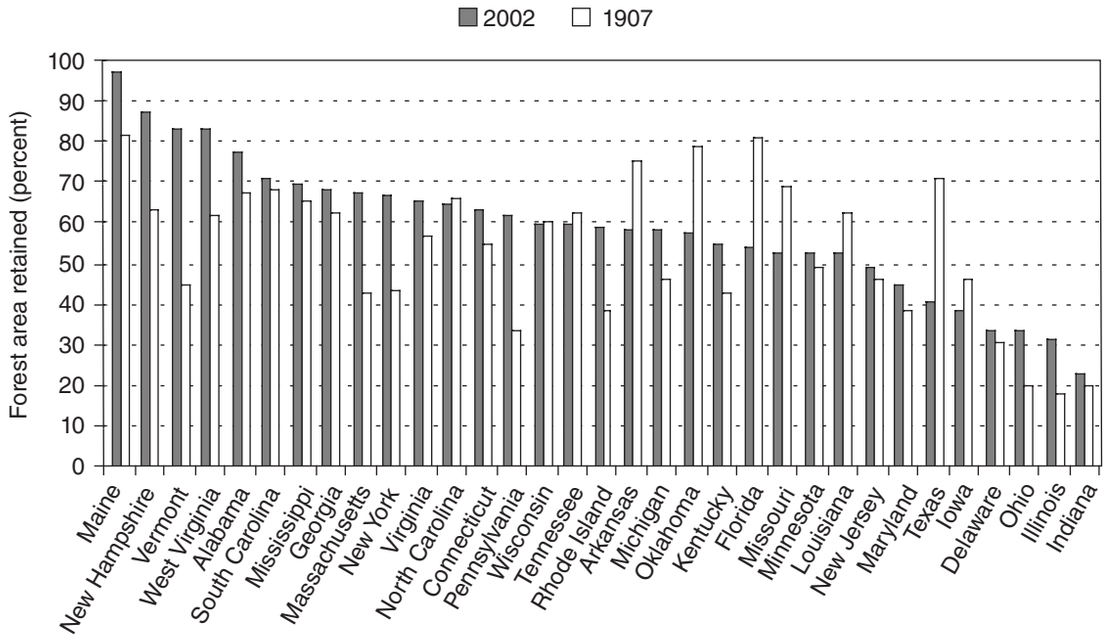

Figure 4. Eastern forest area in 1907 and 2002 compared to 1630, by State (Smith and others 2003, Kellogg 1909).

the Great Depression. Figures 5 and 6 show the evolution of standing biomass from the 1950s through 2002 for northern and southern forests (fig. 5) and for hardwoods and softwoods in the northern and southern forests (fig. 6). During this period, forest area was relatively stable but tree biomass (as estimated by growing stock inventories in Forest Service inventories) nearly doubled from 252 to 486 billion cubic feet. The rate of increase has slowed since the 1970s, indicating perhaps an approach to a capacity defined by soil conditions and ongoing human dynamics, including timber harvesting, and movement into and out of forest cover. However, the average biomass contained on eastern forest sites increased throughout the last half of the 20th century.

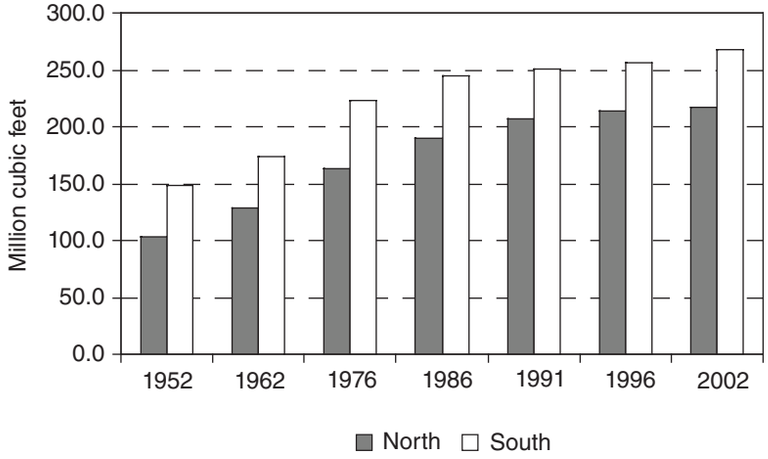

Figure 5. Accumulated tree biomass measured as growing stock inventory, 1952 to 2002, in the Eastern United States (Smith and others 2003).

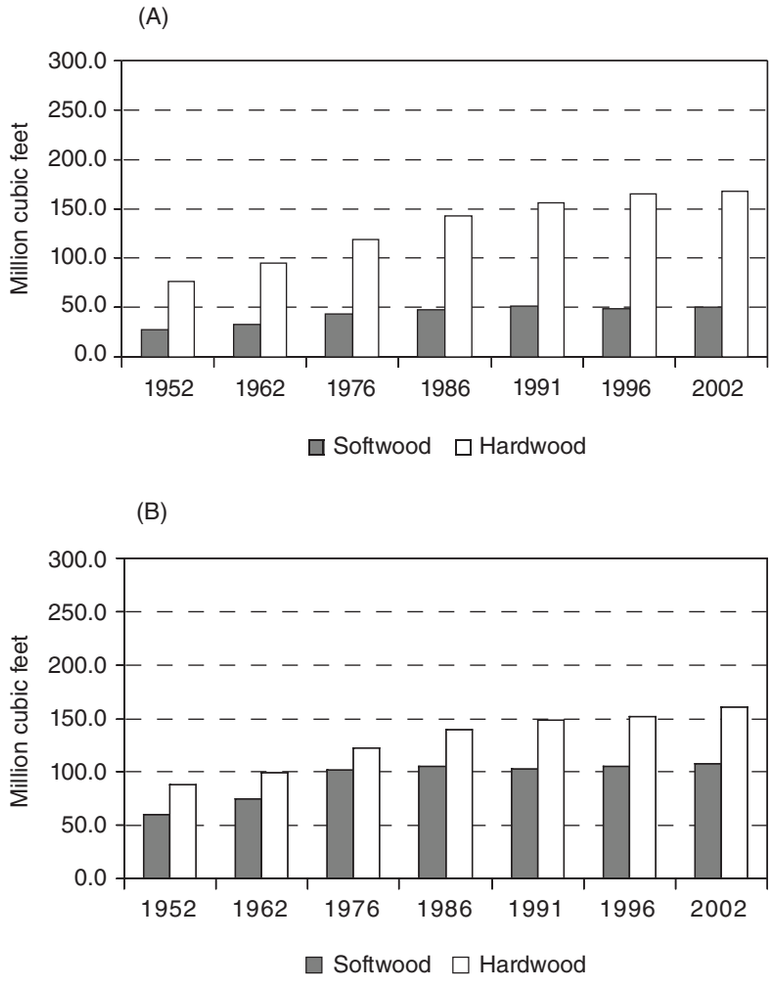

Figure 6. Accumulated tree biomass measured as growing stock inventory, 1952 to 2002, of softwoods and hardwoods (A) for the North and (B) for the South (Smith and others 2003).

Forest Ownership

Unlike their western counterparts, eastern forests are dominated by private ownership (fig. 7). Roughly 85 percent of the eastern forests were privately owned in 2002. Of the 15 percent that was in public management, 40 percent was in national forests; 47 percent was owned by States, counties, or municipalities; and the remaining 13 percent was in some other type of Federal ownership (predominantly military facilities). Ownership patterns vary somewhat between the South and North (fig. 7). The North has a higher proportion of public ownership (20 percent versus 14 percent), whereas the South has a higher proportion of private ownership (86 percent versus 80 percent).

Owner objectives and management styles differ substantially between public and private owners but also vary within the private ownership group. Forest Service surveys have tracked a private owner typology over time that, at its coarse grain, splits forest industry (defined as companies that hold both forest land and wood products processing facilities) from all other private owners. Forest industry owners have differed from other types of owners in that they generally have approached forest lands with a timber-profit motive and have adopted a distinct production style of forest management (Newman and Wear 1993). The result has been a higher level of forest investment and outputs with implications for forest structure—these lands were more heavily dominated by pine plantations, retained lower levels of standing biomass overall, and were generally younger than nonindustrial private forests. Forest industry lands have also traditionally represented some of the largest contiguous blocks of forest land in the Eastern United

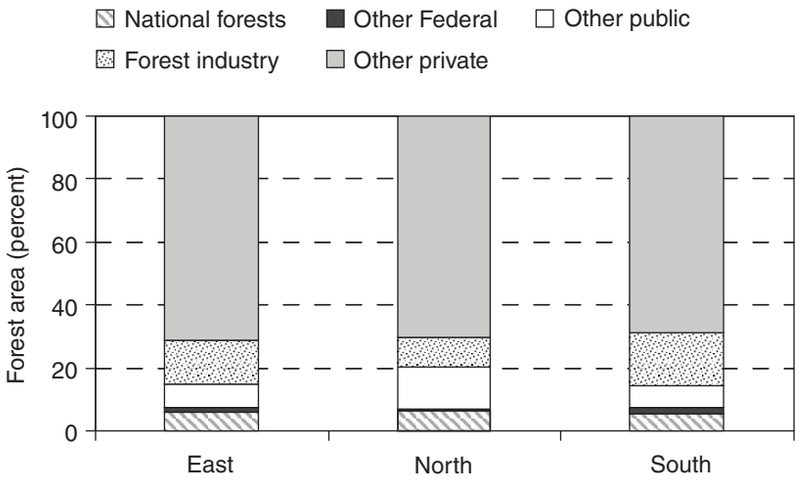

Figure 7. Distribution of forest area by broad ownership classes, 2002, for the Eastern United States, the North, and the South (Smith and others 2003).

States with associated values for protecting certain ecosystem services. Other, nonindustrial, private owners have a notoriously varied suite of motivations for owning forest land (Butler and Leatherberry 2004), with a perhaps less predictable management style and a more variable outcome.

During the 20th century, forest industry established and managed some of the most productive forest lands in the Eastern United States and was a fairly stable component of the forest products sector, especially in the Southeastern States (fig. 7). However, commencing in the late 1990s and accelerating since 2005, most large companies have divested their forest holdings (Clutter and others 2005). Figure 8 shows the beginning of this trend, with more recent estimates indicating a loss of about 80 percent since the late 1990s. These changes, driven by a variety of economic factors, have a new set of implications for forest structure. Many of the industry's vast holdings have been subdivided in the process of being sold, resulting in a more fractured ownership pattern. What is more, a variety of forest conditions—including those on environmentally sensitive land—had been bundled with production on industry tracts; these components are readily split apart as the land is sold in pieces, possibly removing some de facto protection. Where other uses compete for forests, the land has been sold for development.

Productive industry timberlands have largely been sold to private timber investors organized by Timber Investment Management Organizations (also known as TIMOs), which have a strong focus on a profit-maximizing forest management—not unlike the forest industry. This arrangement provides substantial capital for ongoing investment in the face of favorable markets, creating a state of investment inertia that currently keeps much land in forest production but that also has the potential for rapid land-use

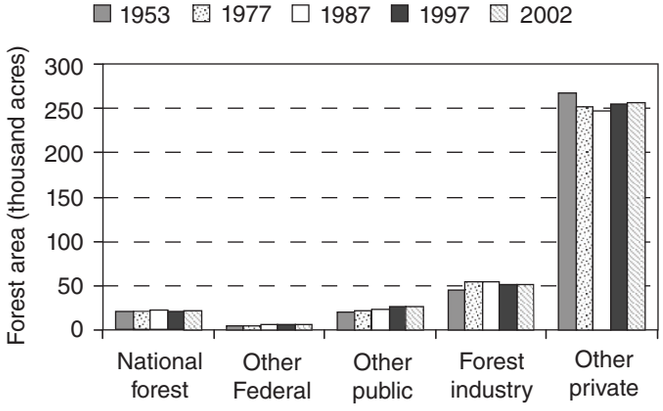

Figure 8. Area of timberland by broad ownership classes, 1952 to 2002 for the Eastern United States (Smith and others 2003).

switching when markets change. A general outcome of this new landownership arrangement then is a higher liquidity of land in the face of changing economic circumstances.

Another way of explaining this elevated liquidity is to contrast investor objectives and options. When companies owned land largely as a buffer against future supply shortages, they had a strong incentive to retain land over a long time frame even in the face of adverse short-term market conditions. Following divestiture, few options remained for providing this kind of timber supply insurance. Individuals are motivated to invest in timberland for returns, returns that are perceived to be countercyclical to equity markets. However, timberland is only one of many alternative investment instruments available for providing countercyclical returns, and new ownership arrangements may be less conducive for the long-term investment needed for effective forest land management.

This large-scale change in the ownership of the Nation's most productive timberlands will undoubtedly have an effect on landscape structure in some parts of the Eastern United States. TIMO holdings are often bundled for investors as closed end funds, which must be sold at the end of a fixed term. With 5- to 15-year terms, these investment vehicles imply a relatively rapid turnover of land ownership over time. What is more, each transaction offers an opportunity to split parcels and sell portions for different uses, thereby encouraging an ongoing fragmentation of forested lands with implications for the ecosystem services and management potential of remaining forest lands.

Federal forest lands also occupy a distinct portion of the landscape in the Eastern United States and provide an important suite of forest benefits. The eastern national forests were authorized by the 1911 Weeks Act and acquired through land purchases from private owners. The national forests acquired land piecemeal, mainly from 1911 until the end of the Great Depression, from cutover and unproductive lands in relatively remote areas where the value of land for any other use was very low. Referred to as the "lands nobody wanted" by Shands and Healy (1977), these forests were concentrated in mountainous areas (Ozark, Ouachita, Allegheny, and Appalachian ranges), and not in close proximity to population centers. As a result, of the way these lands were accumulated, eastern national forests are less contiguous than their western counterparts and are often interspersed with private forest holdings, where private and public good values commingle and define a challenging management context.

Taken together, these forest ownership dynamics yield several important implications. Public lands tend to be concentrated in areas that are the most remote and rugged and the least productive, and are not tightly consolidated. As amenity values increase in these areas, the value of private in-holdings and adjacent private lands also increases, and subsequent development can compromise the provision of several public values for which the public lands are especially important. Timber management and production are increasingly concentrated on productive rural lands that compete with agricultural uses of land. Forest industry set the stage for an increased concentration of production forestry on a smaller land base; with a new ownership structure, these lands are increasingly guided by shorter term market signals.

Social Context of Forests

Humans alter the structure and extent of forests, directly through the uses to which they allocate land and indirectly by changing atmospheric and hydrologic systems and introducing nonnative (and often invasive) flora and fauna. A simple index of the pressure that people place on natural systems is the areal density of human populations. In the 2000 census, the density of counties in the Eastern United States stood at about 244 people per square mile and ranged from less than 5 in Oklahoma to more than 55,000 in metropolitan New York. From 1970 to 2000, the average density grew by about 16 percent and the total population grew from 208 million to 274 million.

Of course, this growth in population was not spread evenly across the landscape. In 2000 (fig. 9), 46 percent of counties was in what we have labeled a rural category (0 to 50 people per square mile), 32 percent in a transitional category (51 to 150), 10 percent

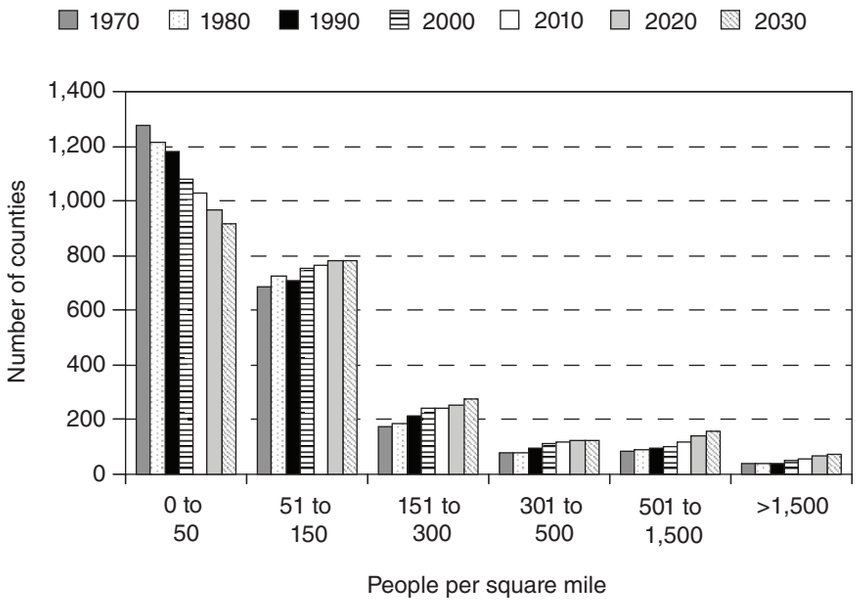

Figure 9. Distribution of counties by population density classes, 1970 to 2030, based on U.S. Census Bureau historical data and Woods and Poole Econometrics projections.

in a suburban category (301 to 500), and 12 percent in an urban (500 to 1500) or a high-density urban category (>1500). This distribution has changed as population has grown in the Eastern United States. The percentage of counties in the most rural category has declined substantially since 1970 (from 55 percent in 1970 to 46 percent of counties in 2000). Over the same period, the number of counties in transitional, suburban, and urban classes has increased. Figure 9 also shows that these patterns are expected to continue well into the future (to 2030) based on a set of county-level population forecasts for the United States. That is, we expect a continued movement from rural conditions toward transitional and urban conditions.

Patterns of population change differ as well. Although eastern populations have grown steadily, some areas experienced sizable depopulation from 1970 to 2000 (fig. 10). Among the areas with the largest population losses are the agricultural areas of

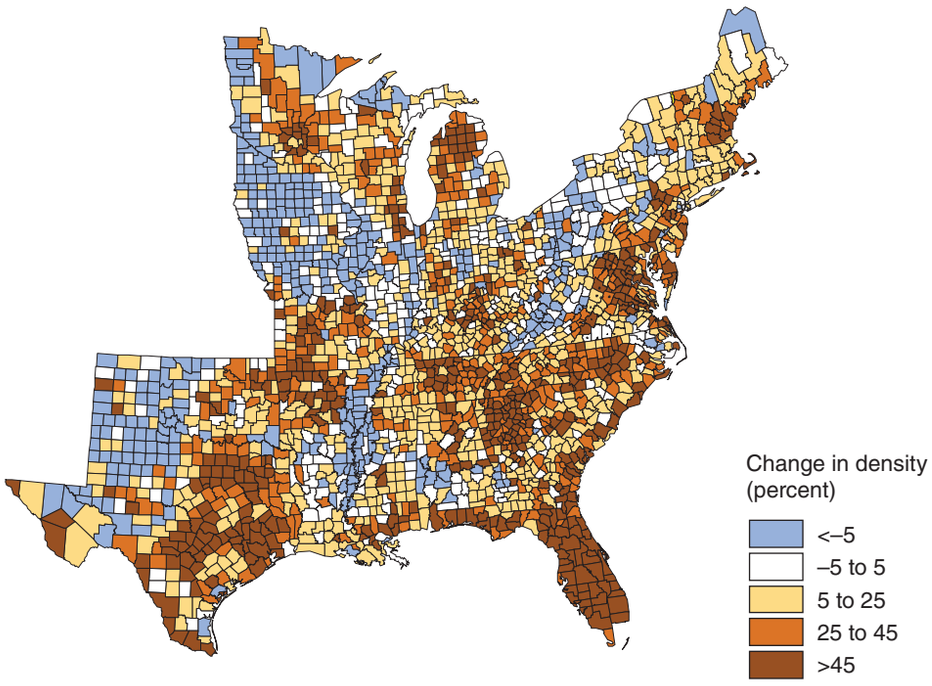

Figure 10. Change in population density by county in the Eastern United States, 1970 to 2000, based on U.S. Census Bureau data.

southern Minnesota, Iowa, and Illinois; the lower Mississippi Alluvial Valley from the confluence with the Ohio River to Louisiana; and the Allegheny Highlands from Kentucky and West Virginia into western New York. Smaller areas experiencing depopulation include an area north of Mobile Bay in Mississippi and Alabama; the northernmost counties in Minnesota, Michigan Upper Peninsula, New York, and Maine; and a grouping of counties in central Ohio.

Population gains were also concentrated, with three large areas experiencing the largest increases from 1970 to 2000: the metropolitan corridor stretching from Boston to Washington; the Piedmont of the Southern Appalachians from Raleigh, NC, to Atlanta; and peninsular Florida. Many moderately large cities have also experienced high rates of population growth, including Dallas, Houston, Detroit, Chicago, Minneapolis, and Nashville.

Competing Land Uses

Land use patterns reflect the distribution of human populations (such as the density of housing and urban uses) as well as the comparative productivity of land in a variety of rural uses (such as crops). The Economic Research Service of the U.S. Department of Agriculture maintains a consistent time series of State-level land use estimates from 1945 to 2002 in their Major Land Uses series, with the latest report from Lubowski and others (2005). The data on land use changes reported below, which are taken from this series, distinguishes among four major land use groupings: total cropland (including planted and fallow), pasture (land in a grazing use including range), forest land (consistent with the Forest Inventory and Analysis definition), and urban land in densely populated areas. An all-other category includes rural transportation, defense and industrial areas, rural parks, and miscellaneous farm and other special uses.

Land use in the Eastern United States reflects a diversity of these conditions. In 2002, cropland occupied 28 percent of the land base, pasture occupied 17 percent, forests occupied 38 percent, and urban and all other uses occupied 17 percent (fig. 11).

The distribution of land uses varies greatly (fig. 11). For example, crop production is predominant in the North Central States of Iowa, Illinois, and Minnesota—reflecting soil and climatic conditions that favor crop production. In addition, crop production is a dominant land use in the Lower Mississippi Alluvial Valley and Florida. Range and pasture uses are most predominant in the South Central States, especially Texas and Oklahoma. Agricultural uses represent an areal majority of States in the western half of the study area.

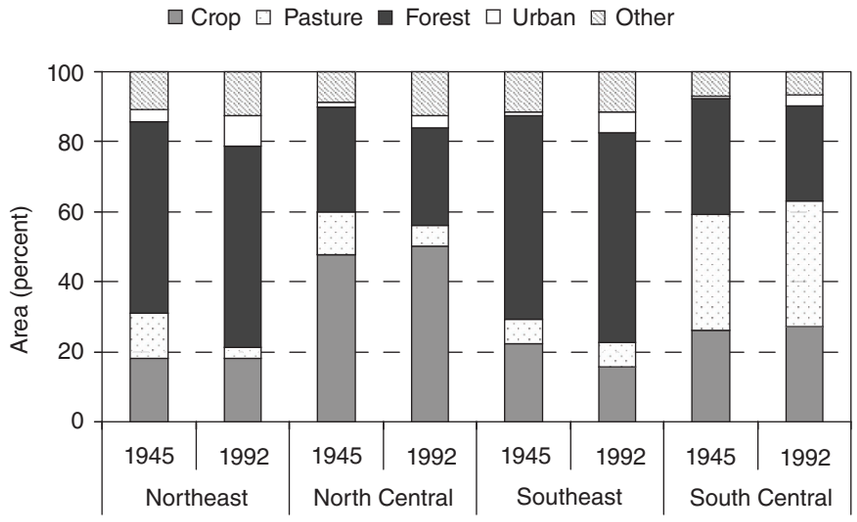

Figure 11. Distribution of land area by broad land use classes, 1945 and 2002, for Northeastern, North Central, Southeastern, and South Central States (Lubowski and others 2006).

Farther east, forests tend to dominate rural land uses, with comparable shares of forest land use in the Northeastern and Southeastern States. Urban and other land use (mainly transportation, parks, and rural developed area) generally make up 10 to 24 percent of the eastern landscape (fig. 11).

From 1945 to 1992, the share of land in non-rural uses expanded throughout the Eastern United States, with the greatest increase (from 10 to 17 percent) in the Northeastern States (fig. 11). The portions of States in rural uses shrank over this period and the distribution among rural uses changed as well. In the Northeastern States, pasture uses experienced the biggest losses (from 12 to 3 percent), and the area of cropland and forest remained relatively constant. In the North Central States, forest and pasture uses shrank slightly and cropland stayed constant. Conversely, cropland in the Southeastern States declined from 22 to 14 percent, and pasture and forest area remained relatively constant. The South Central States experienced a loss of forest land, and both pasture and cropland remained relatively constant.

Among the eight States that gained cropland area from 1945 to 2002, six were along the Mississippi River and the other two were Texas and Florida (fig. 12). Florida experienced the greatest gain in cropland area (29 percent). All other Eastern States lost some cropland, with the New England States experiencing the biggest losses (>50 percent). Total cropland was relatively constant across the Eastern United States, so these changes indicate a westward shift in and spatial consolidation of crop production.

The spatial distribution of pasture use also shifted from 1945 to 2002 (fig. 13). Total pasture in the Eastern United States declined slightly over the period (from 19 to 17 percent) but the distribution shifted to the south. Pasture gains were found in only five States: Florida and a four State south-central block composed of Texas, Oklahoma, Arkansas, and Louisiana. As with cropland, Florida experienced the greatest gains in pastureland use. All Northern States experienced substantial reductions in pastureland use.

The pattern of change in urban land use (fig. 14) is quite distinct from the patterns for cropland and pasture. Urban uses grew by at least 72 percent across all Eastern States and more than tripled in more than half of them. Percentage-growth rates for this period were substantially higher in the South than in the North (fig. 14) but the absolute changes in urban area were more evenly distributed between the regions (Northern States had much larger urban area at the beginning of the period). The result is expansion of metropolitan areas into formerly rural lands throughout the Eastern United States, changing the context for rural uses in many areas.

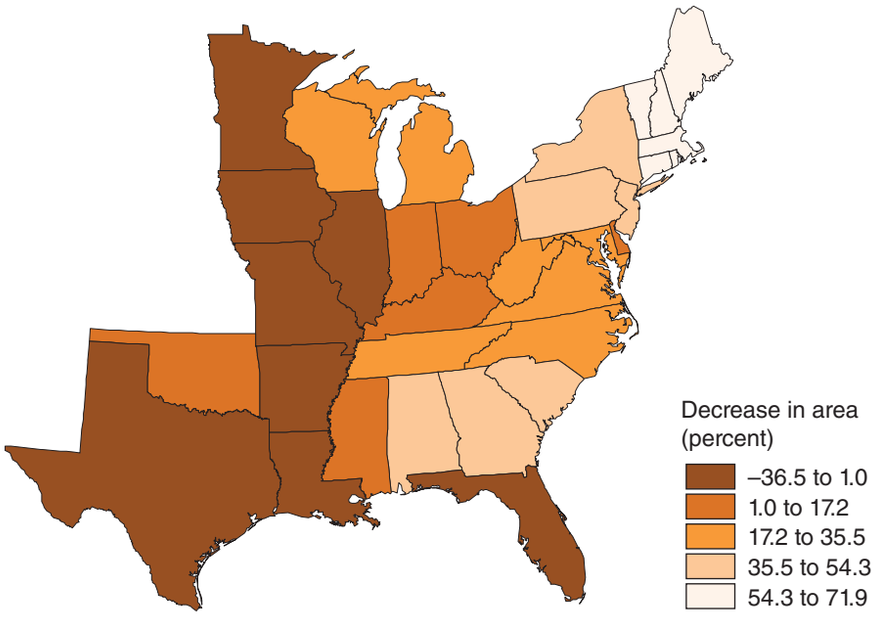

Figure 12. Change in cropland area, 1945 to 2002, by State in the Eastern United States (Lubowski and others 2006).

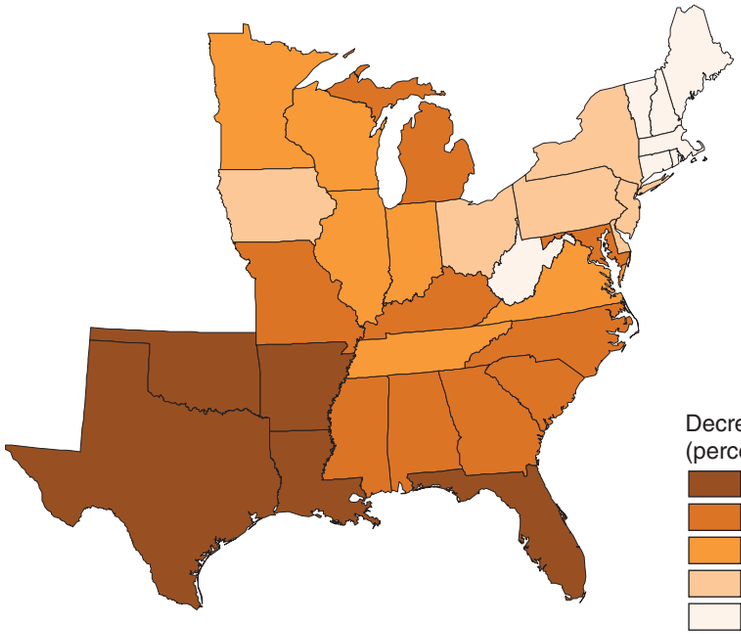

Figure 13. Change in pasture area, 1945 to 2002, by State in the Eastern United States (Lubowski and others 2006).

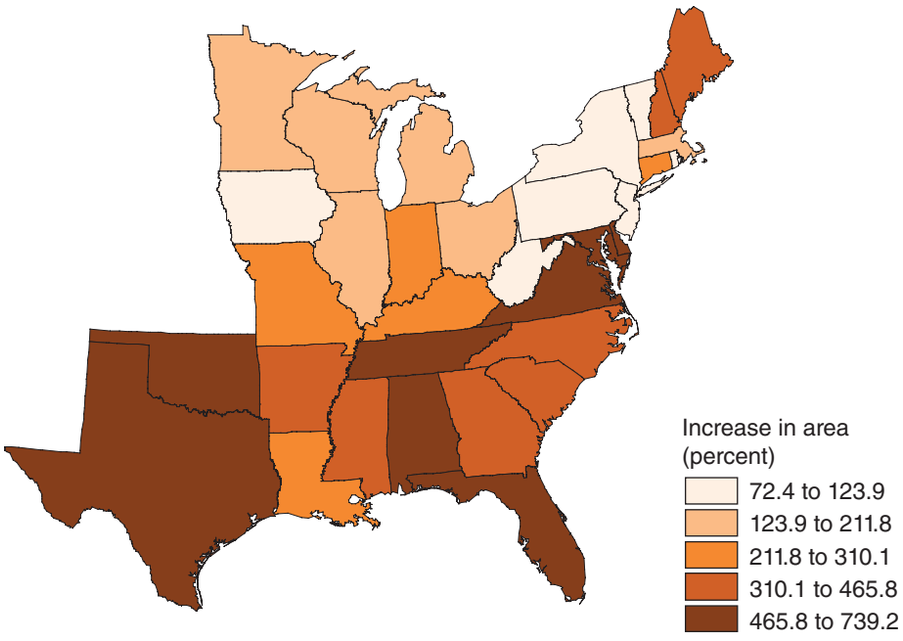

Figure 14. Change in urban area, 1945 to 2002, by State in the Eastern United States (Lubowski and others 2006).

Conclusions

Eastern forests have been subjected to a series of transformative changes since European settlement. Existing forests are generally the product of multiple human-based disturbances including timber harvesting, cultivation or grazing in a previous agricultural use, abandonment, and recolonization by tree species. The restoration of forest cover was especially strong in the 20th century as much agricultural land was abandoned beginning in the early 1900s. With passage of the Weeks Act national forests were established in a few areas, generally in remote places where land was less valuable for any other kind of use.

The dynamics most relevant to current forest structure and forest management include a fairly rapid growth in human populations along with associated land development throughout much of the Eastern United States. In addition to the direct effect of losing forested area (Wear 2002), the current pattern of development places more people in the proximity to residual forests. The ability to manage these forests is compromised by this human presence through reduction in tract size, increased prevalence of restrictive regulations on forest uses, and negative spillover effects for neighboring landowners (Wear and others 1999).

The magnitude of this change can perhaps be best summarized by examining the density of human populations with respect to forest area (forest population density). Figure 15 shows the forest population density of counties in the Eastern United States ranging from less than 40 to more than 750 people per square mile in 2000. Roughly 20 percent of the forested area has less than 40 people per square mile, about 40 percent has 40 to 250, and 40 percent has >250. High forest population density can reflect a small forest area or a large human population or both, but they unambiguously reflect the relative scarcity of forest services relative to the size of the local population and a lowered propensity to manage forests. High forest population density is found in areas surrounding the large metropolitan areas as well as in areas with a high concentration of cropland.

U.S. population growth is expected to continue for the next several decades. Figure 16 shows the implications of a forecast of population growth to 2030 in the Eastern States. Future forest population density predictions are conservative, calculated by dividing forecasted populations by the current forest area within each county without accounting for the loss of forest land that would likely accompany development associated with expected population growth. Even so, figure 16 demonstrates a substantial growth in the forest population density throughout the Eastern United States. Forest population density is projected to grow fastest along the eastern seaboard especially from Washington to Maine, in the Southern Appalachian Piedmont and Florida, and surrounding the Midwestern cities of Chicago and Minneapolis. Thirty five percent of the forested area in the Eastern United States is projected to realize a growth of at least 25 people per square mile, with 15 percent experiencing >100. In these areas, the opportunities to conduct most forest management practices will likely be diminished.

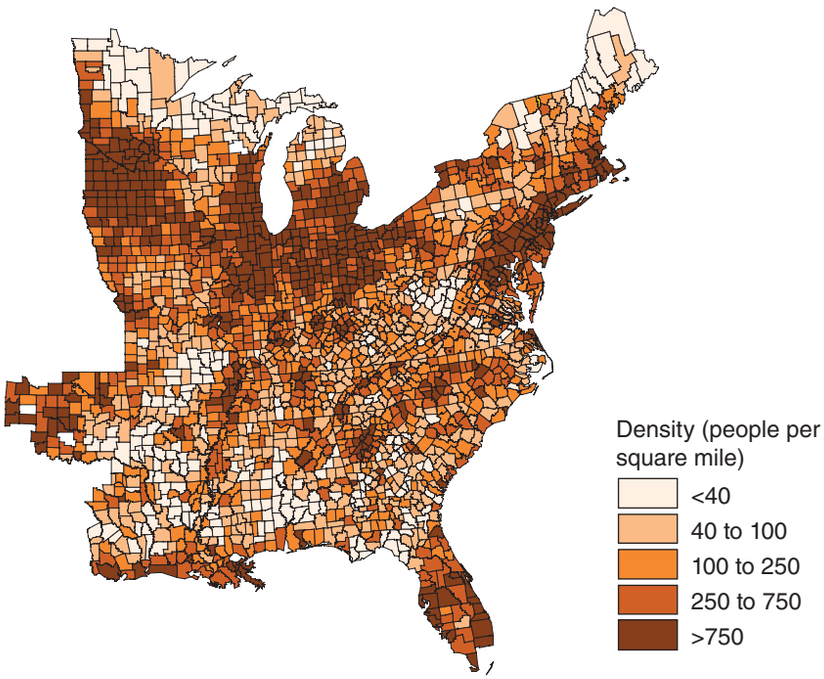

Figure 15. Forest population density in 2000, by county, in the Eastern United States, based on data from the U.S. Census Bureau and the U.S. Department of Agriculture, Natural Resources Conservation Service, National Resources Inventory.

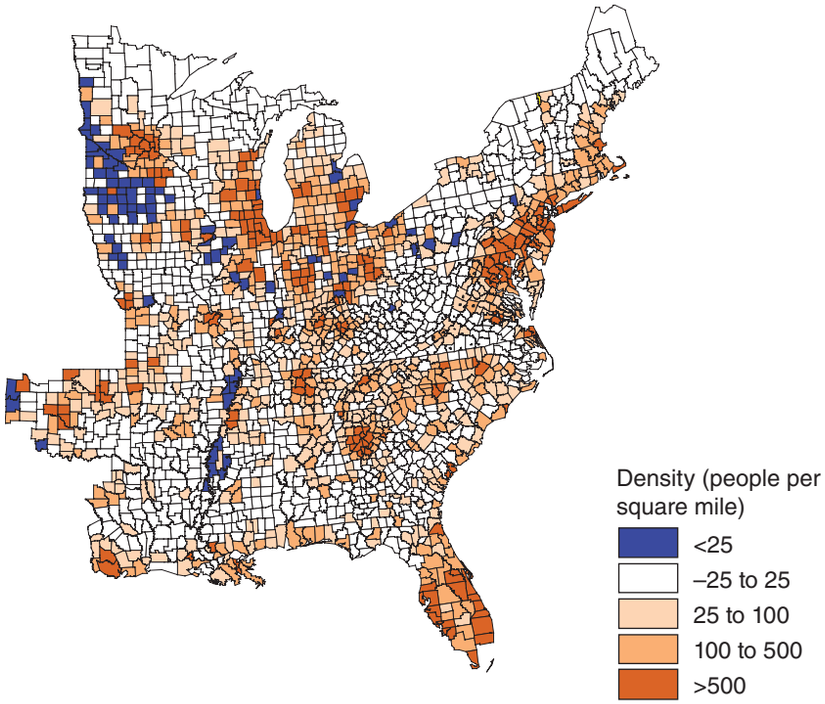

Figure 16. Forest population density forecast to 2030, by county, in the Eastern United States, based on Woods and Poole Econometrics projections.

In addition to population growth, changes in the forest products markets will affect the distribution of forest management in the Eastern United States. Beginning in the 1950s, the forest industry led the way in intensifying management and concentrating management on a smaller land base. This specialization of forest land uses, with some areas seeing more focus on timber production than other areas, will likely continue in spite of the sale of forest industry lands to new owners. The flow of investment capital to forests during a period when timber production and prices declined indicates a strong investor interest in forest growth and specifically in the returns to intensive management. To the extent that management becomes more concentrated on plantations and other intensively managed areas, the opportunities for management activities on the remainder of forest areas may become more limited.

These findings suggest that the practice of traditional forest management, or rural forestry, will be limited to a smaller portion of eastern landscapes. Outside the southern Coastal Plain, the Maine woods, and the northernmost counties of the Lake States, fuel treatments and other management activities normally applied in tandem with traditional forest management to support ecosystem services are not likely to occur. In rural lands throughout most of the Eastern United States, traditional management will be limited by a lack of markets for forest products and by an expanding forest population density. The greatest challenge for forest management will likely be to design practices that can be deployed in a cost efficient manner and can complement the increasingly nontimber management needs of landowners in these complex landscapes.

The potential application of fuel treatments needs to be evaluated in the context of this changing human-forest landscape:

1. An increasing human population density close to a large portion of eastern forests (rising forest population densities) is likely to result in less forest management, including fuel treatments.
2. Increased fragmentation and smaller parcels work against the economies of scale in fuel treatments, because treatments become more costly to implement on a per acre basis. As parcels become smaller, the effectiveness of treatments on management objectives also declines. Both these factors have a negative impact on the cost/benefit assessment of fuel treatments.

3. Increasing population densities and incomes in a commingled public and private ownership pose significant challenges for public forest managers. Administrative as well as management costs increase in the face of conflicting values and scale issues.
4. The trend toward forest specialization implies declining timber markets and timber management in many eastern rural areas. These areas are likely to experience increasing difficulties in applying fuel treatments or other management solely for the purposes of nontimber benefits.

All of these observations suggest challenges for the application of fuel treatments in the Eastern United States. However, expanding populations in rural lands also imply that the returns to fuel treatments, especially in the form of avoided costs of wildfire, may grow in commensurate ways, possibly leading to increased demand for the returns from fuel treatments. Realizing these returns will require innovative programs and policies to encourage management that spans parcels and coordinates the efforts of owners to deliver benefits at meaningful landscape scales.

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