Land Use Changes Involving Forestry in the United States: 1952 to 1997, With Projections to 2050

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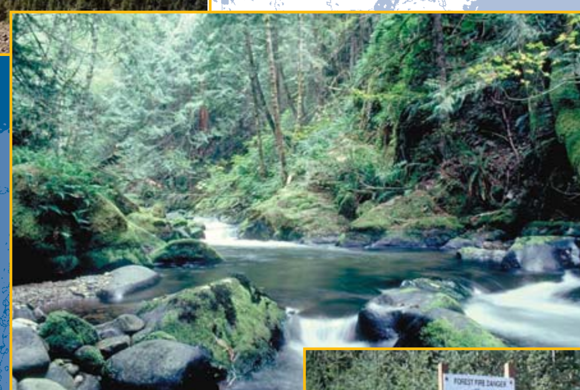

A Technical Document Supporting the 2000 USDA Forest Service RPA Assessment

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Authors

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Abstract

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About two-thirds (504 million acres) of the Nation's forests are classed as timberland, productive forests capable of producing 20 cubic feet per acre of industrial wood annually and not legally reserved from timber harvest. The USDA's 1997 National Resource Inventory shows that, nationally, 11 million acres of forest, cropland, and open space were converted to urban and other developed uses from 1992 to 1997, as the national rate of urbanization increased notably compared to the 1982-92 period. Forest land was the largest source of land converted to developed uses such as urbanization. Urban and other developed areas are projected to continue to grow substantially, in line with a projected U.S. population increase of more than 120 million people over the next 50 years, with population growth occurring the fastest in the West and South. Projected increases in population and income will, in turn, increase demands for use of land for residential, urban, transportation, and related uses. An overall net loss in forest area in the United States since the early 1950s has been due to a combination of factors, but in more recent decades has been primarily due to conversion to urban and developed uses. Total forest area in the United States is projected to decrease by approximately 23 million acres by 2050, a 3-percent reduction from the 1997 forest area. Consistent with the projected slow **net** decline in U.S. forest-land area, private timberland area is likewise projected to decline. Total area of U.S. private timberland is projected to decline by 4 percent by 2050. Industry timberland is projected to decrease by 3.0 percent by 2050, whereas timberland area on nonindustrial private lands is projected to decrease by 4.4 percent.

Keywords: Timberland area, forest-land area, land use shifts.

Contents

Introduction

The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 directs the USDA Forest Service to conduct a periodic review of the Nation's renewable natural resources. The act requires that the assessment include an analysis of present and anticipated uses; demand for and supply of the renewable resources of forest, range, and other associated lands; and an emphasis on pertinent supply, demand, and price relationship trends.[1] Land use change has important consequences for the future availability of timber, wildlife habitat, and other renewable resources and, therefore, is a critical component of this analysis. The major purpose of this document is to describe our projections of forest-land and timberland areas of the United States, in support of the 2000 RPA assessment.

This report focuses on land **use** and changes that involve forestry. Land use is the purpose to which land is put by humans, e.g., protected areas, forestry for timber products, plantations, row-crop agriculture, pastures, or human settlements (Di Gregorio and Jansen 1998). Land **cover** is the observed (bio)physical cover on the Earth's surface, e.g., oak-hickory forest. Alig and Butler (2002) and a companion report in progress (Alig and Butler, n.d.) document land cover changes on U.S. forests.

We provide land use projections involving forestry for RPA regions by decade out to 2050, for major forest ownerships. Land use changes involving forestry take place on a fixed land base, with "forest land" as one of the major land use classes.[2] Definitions of land uses can differ by source, and we use definitions and data for forest land and timberland from the Forest Inventory and Analysis units of the USDA Forest Service (e.g., Smith et al. 2001). Our 50-year projections of areas of forest-land cover and timberland areas are based on the historical data quantifying the areas of the major land use classes over the past 50 years.

Changes in the area of any of the major land use classes relate to demographic, economic, biophysical, and policy factors (Alig 1986). Our projections of forest land and timberland are based on projections of relevant demographic and economic factors, which are more likely to change in the future than biophysical factors.

Current policies are considered to be static (unchanging) so that we can examine where the current policy trajectory would lead, consistent with the approach in other parts of the RPA assessment. In standard theoretical models, private land is allocated to the use that provides the greatest value to its owner, as measured by the present value of the stream of net returns expected in the future (e.g., Alig 1986). In reality, land use choices often involve a complex interaction of factors, including the initial land endowment of the owner, landowner characteristics, institutional influences (e.g., local zoning), and the economic and policy context in which the land use choices are made. Hence, we also look at alternative futures in a later chapter, to examine sensitivity of projections to certain assumptions.

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[1] Web sites for the 2000 RPA assessment (USDA Forest Service 2001) are http://www.fs.fed.us/pl/rpa and http://www.fs.fed.us/pnw/sev/rpa.
[2] Definitions of "forest land" and "timberland" are found in the "Glossary."

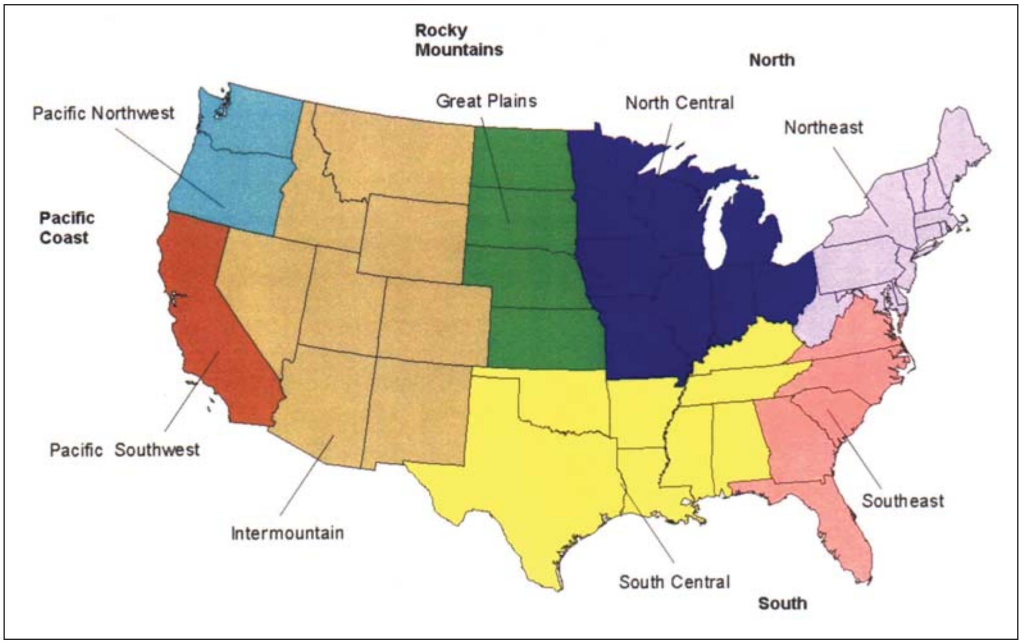

Figure 1—Regions used in the 2000 Resources Planning Act assessment (USDA Forest Service 2001).

The 2000 RPA assessment is the fourth prepared in response to the RPA legislation, with the first RPA assessment in 1975, and the context has broadened over time. Interest in sustainable management of the world's forest resources was heightened by the United Nations Conference on Environment and Development in 1992 (USDA Forest Service 2001). Since that time, various countries have met to discuss and try to reach consensus on ways to evaluate progress toward the management of their forest resources. The United States participates in the Montreal Process, designed to use a set of criteria and indicators for the conservation and sustainable management of temperate and boreal forests. The criteria provide a common framework for describing, assessing, and evaluating a country's progress toward sustainability at the national level. The 2000 RPA assessment provides a broad array of information about the Nation's forests and rangelands, including the current forest-area situation and prospective changes over the next 50 years. Such information can help shape perceptions about whether we can sustain both increasing consumption of forest products and forest resource conditions (Alig and Haynes 2002). Related data illustrate the dynamics of our Nation's land base and how adjustments are likely to continue in the future. The projections of land use and forest cover changes also provide inputs into a larger system of models that project timber resource conditions and harvests, wildlife habitat, and other natural resource conditions (USDA Forest Service 2001). Current debates about sustainability involve both physical notions of sustainability and competing socioeconomic goals for public and private land management. The land-base changes also indicate the importance of viewing "sustainability" across the entire land base and across sectors, in contrast to the current typical sector approach as in examining "sustainable forest management" (Alig and Haynes 2002).

Land use projections for the 2000 RPA assessment update those prepared for the 1989 RPA assessment (e.g., Alig et al. 1990a, Alig and Wear 1992). Since the 1989 assessment, additional land use data have been collected and assembled, and were used in

Table 1—Regions and subregions used in the national Resources Planning Act assessment

Region	Subregion	States	Study
North	Northeast	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia	Plantinga et al. (1999), Mauldin et al. (1999a)
	North Central	Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, Wisconsin	Mauldin et al. (1999b), Choi et al. (2001)
South	Southeast	Florida, Georgia, North Carolina, South Carolina, Virginia	Plantinga and Ahn (2000)
	South Central	Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	Ahn et al. (2001, 2002)
Rocky Mountains	Great Plains	Kansas, Nebraska, North Dakota, South Dakota	
	Intermountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming	
Pacific Coast	Alaska	Alaska	
	Pacific Northwest	Oregon, Washington	Zheng and Alig (1999), Kline and Alig (2001)
	Pacific Southwest	California, Hawaii	
United States			Alig et al. (1999a, 2002)

models and analyses for each RPA region. Methods and data sources used in projecting area changes are described in the "Appendix." In general, land use projections have moved from an expert opinion basis (e.g., Wall 1981) to systematic models, as described in the appendix. Recent data for forest-land cover and timberland are documented by Smith and others (2001) and also are provided at the Web site http://fia.fs.fed.us.

We discuss the land use situation and give projections of area of forest-land cover and timberland in four RPA regions of the United States: North, South, Rocky Mountains, and Pacific Coast (fig. 1). Table 1 lists the nine RPA subregions within the four regions.

For each RPA region we present historical changes in land uses after the Second World War, the period for which a consistent time series of data are available. We then provide projections for the land base classified as forest, and then the subset of forest land classified as timberland. Other models in the RPA assessment use forest land

and timberland area projections; however, timberland area is used in the more detailed models (e.g., Adams and Haynes 1996). We discuss the area and location of the forest-land base, ownership characteristics, productivity, and use of such lands. We conclude with a discussion of key driver variables such as land use policies and technology that may lead to alternative futures other than those projected under assumed initial or base conditions.

Chapter 1: National Overview

Introduction

This chapter begins with an overview of the Nation's land base of 2.3 billion acres, examining the current and historical allocation of the land base among the major uses. We then examine in more depth that portion allocated to forest land and the factors influencing forest-land area. This provides the basis for describing timberland area projections at a national scale.

Land Use Situation

Of the 2.263 billion acres of land in the United States, 33 percent (747 million acres) is forest land, and 67 percent (1,516 million acres) is nonforest land. Forests are found in significant amounts in every region of the Nation. They vary from sparse scrub forests of the arid, interior West to the highly productive forests of the Pacific Coast and the South, and from pure hardwood forests to multispecies mixtures, and coniferous forests. About two-thirds (504 million acres) of the Nation's forests are classed as timberland, productive forests capable of producing 20 cubic feet per acre of industrial wood annually and not legally reserved from timber harvest. An additional 52 million acres of forest, reserved for nontimber uses, are managed by public agencies as parks or wilderness areas. Other forest lands on the remaining 191 million acres are not capable of producing 20 cubic feet per acre of industrial wood annually but are of major importance for watershed protection, wildlife habitat, domestic livestock grazing, and other uses and services. More than 90 percent of the “other” forests are in the West, with more than half in Alaska. Although these other forest lands produce little industrial roundwood, they do produce other wood and tree products, which are often important for local use. Fuelwood is a primary use in many areas having nontimber forests, such as the pinyon-juniper forests of the Southwestern portion of the country.

The percentage allocation of land by major land use in the United States in 1997 is depicted in figure 2. The five major land use classes are (1) cropland, (2) grassland (pasture and range), (3) forest use, (4) special uses, and (5) “miscellaneous-other.” These are the major land use classes defined by the USDA Economic Research Service (ERS) (e.g., Vesterby and Krupa 2001). “Special-uses” land includes area in highways, road and railroad rights-of-way and airports; federal and state parks, wilderness areas and wildlife refuges; national defense and industrial uses; and farmsteads and farm roads. “Forest-use” land by the USDA ERS differs from the Forest and Rangeland Renewable Resources Planning Act's (RPA's) definition of “forest land” in that parks,

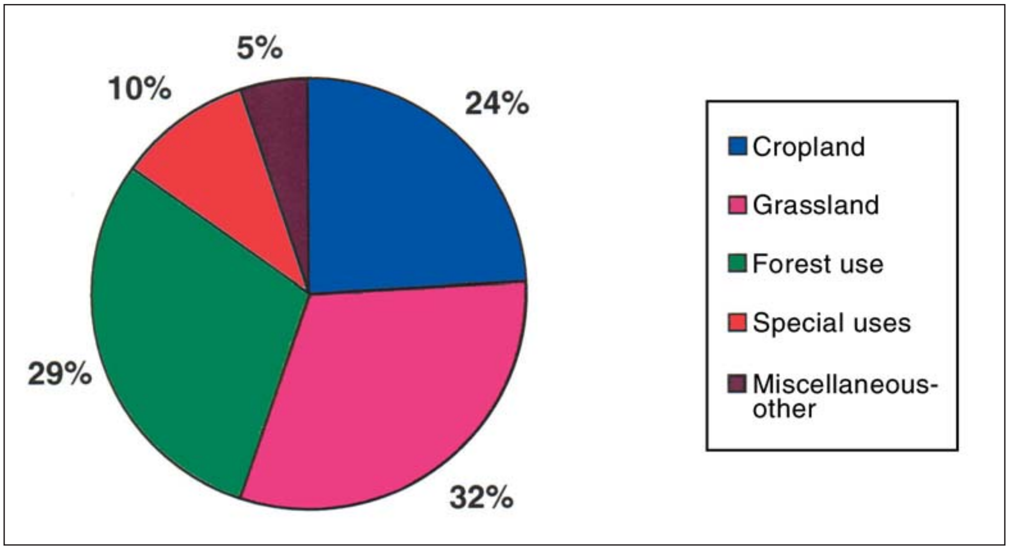

Figure 2—Percentages of U.S. land in major uses, 1997 (USDA ERS 2000).

wilderness areas, and similar potentially forested lands are excluded from “forest-use” land and are classified as “special uses.” Detailed definitions of these classes are given in the “Glossary.”

Grassland pasture and range make up the highest percentage of land (32 percent) in the contiguous 48 states, followed by forest-use land (29 percent) and cropland (24 percent). “Special-uses” (10 percent) and “miscellaneous-other” uses land (5 percent) make up the remainder.

About 84 percent of nonfederal land in the United States is in forests, crops, pasture, or range. Proportions of land in the various land use classes differ markedly among regions of the country (Vesterby and Krupa 2001). For example, the North has about 64 percent of the land base in forest use, the South 37 percent, the Pacific Coast 32 percent, and the Rocky Mountains 10 percent.

Next, we look at area trends for the major land uses. This leads to a focus on the forested part of the land base, shaped by interactions with different sectors of the economy. Given the overall zero-sum relationship among area changes for major land uses, changes in the area of all classes should be considered simultaneously.

Land Use Area Changes

Changes in agricultural area—More than 90 percent of land use changes on nonfederal lands in recent decades have been among rural land uses (USDA NRCS 2001): forests, crops, pasture, or range. Where climate and physiography permit, these rural uses can compete for the same land. Market forces often result in shifts in the use of rural lands between agricultural production and forest production. Increasingly global markets also are affected by technological improvements, and since World War II, increases in cropland yields per acre have been larger in general than for corresponding forestry yields. Although this has resulted in increased use of land for agriculture in some areas, increases in aggregate agricultural yields and downward pressure on agricultural market prices resulted in less pressure to convert forest land at broad scales.

Figure 3—Population growth has increased demands for use of land for developed uses, such as the conversion of this forest for residential use.

Although pre-1930 trends in interregional land shifts have moderated, rural land use remains mutable in the short term. Substantial land areas have shifted back and forth between uses. Over a recent 40-year period, an average of 1.8 million acres per year of cropland and the same area of pastureland have been converted either into or out of the agriculture base. At the same time, a combined total of 1.5 million acres per year has moved into or out of forestry (fig. 3) (USDA ERS 2000).

Figure 4 shows the trajectories between 1945 and 1997 of the area of the major land use classes in the contiguous 48 states. Between 1945 and 1997, the areas of both grassland and forest-use land contracted. Cropland area has gone up and down, but in net has been essentially constant. The area of urban and developed uses has steadily increased, as has the area of special uses.

The trend in U.S. grassland area has been downward for several decades. In 1945, the country had 660 million acres of either grassland pasture or range; this dropped to 580 million acres by 1997. Several reasons for the downward trend include improved productivity from grasslands so that less pasture and rangeland are needed to sustain grazing herds; a shift to animal confinement feeding, giving the operators better control over animal diet (Blayney 2002); a decline in recent years in the number of domestic farm animals, particularly sheep and draft animals, further reducing the need for pasture and range (Vesterby 2001); and the distribution of the size of the livestock operations, a factor affecting the dynamics of the U.S. cattle population, which has undergone cycles since the 1880s (Mitchell 2000). Most U.S. cattle operations are too small to sustain economically without operators having other sources of income such as farming or outside jobs.

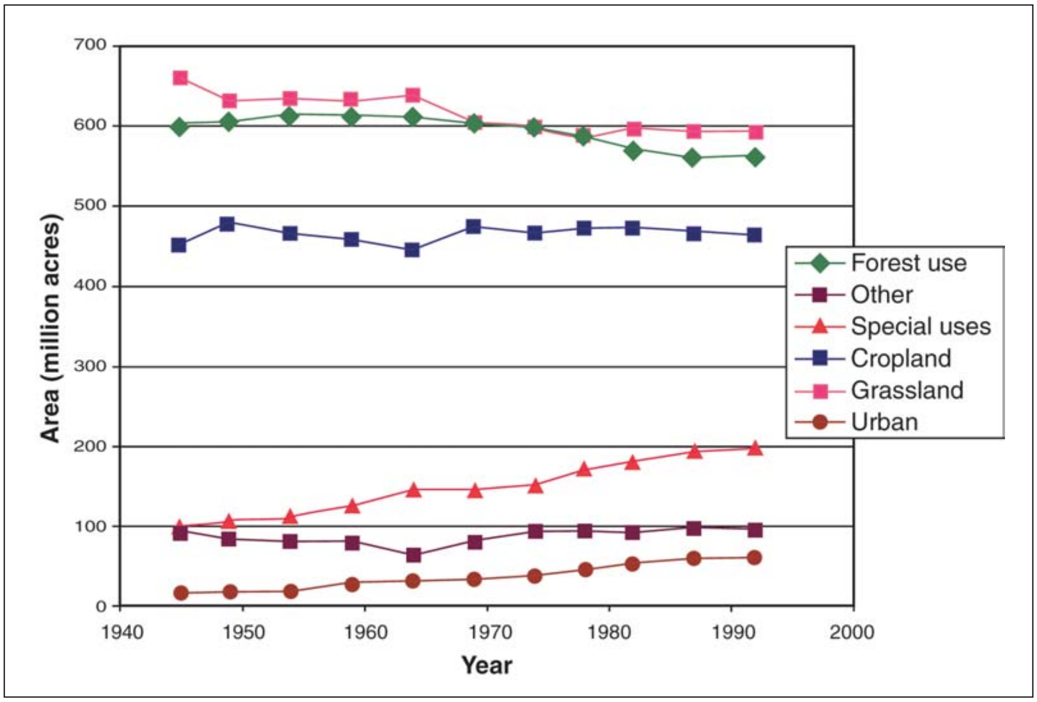

Figure 4—Area changes for U.S. land uses, 1945-97 (excludes Alaska and Hawaii) (USDA ERS 2000).

Total cropland (used for crops and pasture or idled) area has trended downward slightly since the late 1970s. Trends in major field crops (e.g., corn, soybeans, and wheat) are relevant from a forestry perspective because of the competition for land from agriculture (fig. 5). Food crop acres have tended to increase over the past 30 years, while feed and other crops have declined (Daugherty 1995). Among crops used mostly for food, area in wheat production now is more than in the 1960s, but less than in the early 1980s. Soybean acres harvested in 1999 were the most on record, after experiencing declines during the late 1980s and early 1990s. Among crops used primarily for feed grains, corn area reached a high of 110 million acres in 1932, decreased to a little over 80 million acres in the late 1950s, and since has ranged from the low 60- to the low 80-million-acre range. Area to produce corn was 77 million acres in 1999. Area of all hay has changed little since the late 1970s (Vesterby 2001).

Changes in the areas of cropland, forest land, and grassland during the last half century have clearly been affected by governmental policies. In recent decades, the Conservation Reserve Program (CRP) converted more than 30 million acres of erodible cropland to grass cover (Osborn et al. 1995, Plantinga et al. 2001). From 1987 to 1990, the CRP operated similarly to a competitive market for conservation lands in that farmers were allowed to enroll as many acres as desired at a specified price (Plantinga et al. 2001).

Congress then reauthorized the CRP in 1990, but relatively few acres were added as the program cap had largely been met. After 1990, more emphasis was placed on enrolling parcels with environmental benefits. The CRP was reauthorized again in 1996, with the intent that costs of newly enrolled land would be significantly less than

Figure 5—Conversion of forest land to agriculture in southern bottomlands.

payments for land currently in the program. The CRP bids were ranked after the 13th CRP signup by using an environmental benefits index that gave preference to lands that were considered highly erodible, cropped wetlands, lands subject to scour erosion, or lands in national or state CRP priority areas (Mitchell 2000). The CRP has been effective in enhancing wildlife habitat in some areas (Brady and Flather 1998) such as the northern Great Plains, and this along with opportunity costs and other factors may determine the long-term outcome of CRP lands. Mitchell (2000) indicates that a significant long-term increase in rangeland area for grazing because of the CRP has not been forecast. Whether future additions of grass cover will offset conversions of grassland to other uses elsewhere remains to be seen.

Some idled agricultural land in the past has reverted to forest through successional forces or has been available for tree planting, and the amount of idled agricultural land also can affect market prices that affect competition for land among sectors. As of 1999, land idled under the long-term CRP is at 30 million acres. This is down from a peak of 78 million acres idled considering all federal programs in 1983, before the CRP. The extent of idled acres from participation in the CRP differs greatly by farm production region, with most in the northern plains and Rocky Mountain states (Vesterby 2001). The Federal Agriculture Improvement and Reform Act of 1996 (the 1996 farm act) eliminated the authority of the USDA to implement an annual acreage reduction program and other annual acreage diversions. As a result, no land was idled under annual commodity programs. Since 1996, no land has been idled under annual commodity programs, compared with 18 million acres in 1995 and a range of from 13 to 60 million acres idled since 1986. However, emergency aid provided to farmers through legislation in 1998

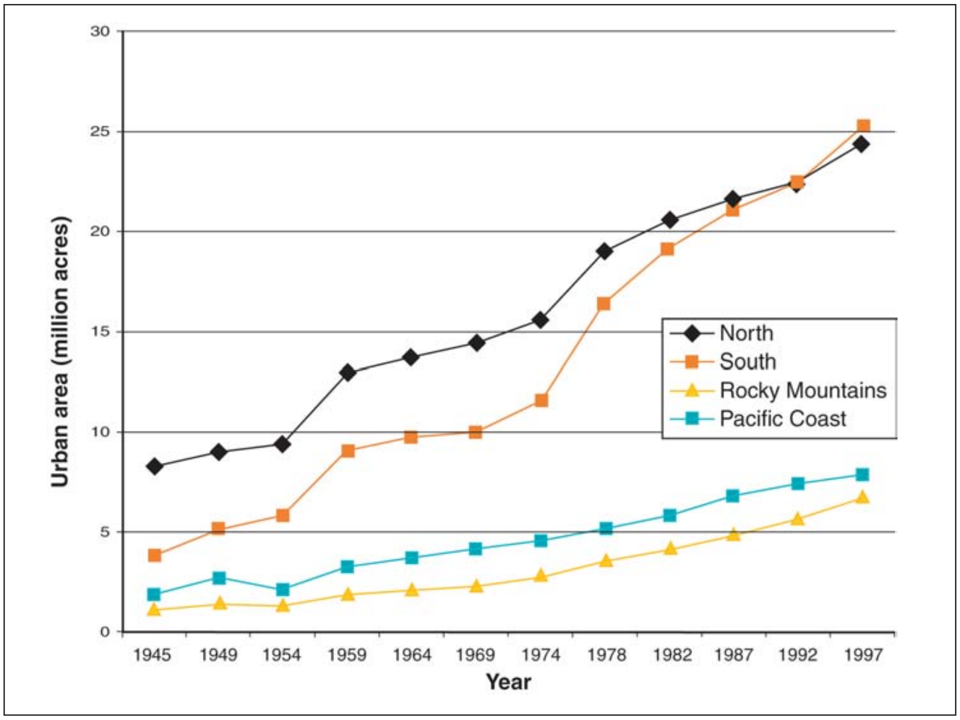

Figure 6—Urban area by Resources Planning Act region, 1940-97 (USDA ERS 2000).

through 2001 suggests that the direction of the current policy transition remains uncertain. With agricultural prices lower than in the mid-1990s, debate about the 2002 farm bill reflected some interest in changing the thrust of the 1996 farm bill, e.g., new types of countercyclical farm policies.[1]

Changes in urban and developed area—A notable upward trend among major land uses has been the increase in the area of urban and developed uses. Urban area increased in all regions, and overall more than doubled between 1960 and 1997, from 25.5 to 65.5 million acres (Vesterby and Krupa 2001) (figs. 4, 6, and 7), as the U.S. population increased by about 100 million people. In addition, area in transportation infrastructure—highways and roads, railroads, and airports—increased slightly over that same period, from 25.0 to 25.4 million acres. Land used for transportation purposes declined by 2 million acres from 1982 to 1992 owing to the abandonment of railroad facilities and rural roads, and the inclusion of some transportation uses into urban areas. A small increase from 1992 to 1997 was due to airport expansions reported in 39 states.

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[1] As this report was drafted, the 2002 farm bill and its provisions were still being finalized. Chapter 6 further addresses some of the uncertainty pertaining to future land use outlooks owing to changes in government programs in the unforeseeable future.

Figure 7—Developed area in the United States has more than doubled between 1960 and 1997.

Despite this growth, urban land remains a fairly small part of the United States. In 1997, urban and other developed land occupied just over 5 percent of the nonfederal surface of the contiguous 48 states (USDA NRCS 2001). The following tabulation shows that the fraction of the land base occupied by urban and other developed land varies considerably over subregions of the country:

Subregion	Developed, 1992	Developed, 1997
	Percent	
Great Plains	2.5	2.6
Intermountain	1.3	1.4
North Central	6.7	7.3
Northeast	10.5	11.9
Pacific Northwest	2.8	3.1
Pacific Southwest	3.7	4.1
South Central	4.8	5.4
Southeast	13.2	15.8
48 states	4.5	5.1

Area of urban and developed uses in the United States expanded by more than 1 million acres annually since 1982 (USDA NRCS 2001), as population and personal incomes increased significantly. A positive relationship between population and personal income and developed land area is consistent with earlier research findings (Alig and Healy 1987). The USDA's 1997 National Resource Inventory (NRI) shows that, nationally, nearly 11 million acres of forest, cropland, and open space were converted to urban and other uses from 1992 to 1997. The annual average rate of land conversion for those 5 years, 2.3 million acres, is 50 percent more than the rate of 1.4 million acres from 1982 to 1992. The United States in the last decade was in a period of substantial economic growth (e.g., stock markets with relatively large gains in the 1990s).

Increasing urbanization has reduced the supply of economically productive rural lands. The proportion of rural land was converted from forestry to urban and developed uses was over one-third of all such land conversions between 1982 and 1997, according to NRI statistics (USDA NRCS 2001). Rural residential land conversion comes from grassland and forest land, in addition to cropland. Although the net areas of grassland, forest land, and cropland have decreased, only a portion of this area has gone to urban and rural residential uses. Much has converted to miscellaneous and special uses (Vesterby 2001).

The South and West are important forestry regions that will continue to be affected by land use changes and urbanization. Americans continue to move to the South and West, with cities such as Atlanta growing at a rate much faster than that of the national average. Growth in some metropolitan areas has led to increasing population densities in counties surrounding central cores. The top 20 percent of the fastest growing U.S. counties are primarily in the South (56 percent). With respect to sustainability issues, the South is seen by both the agricultural and forestry sectors as a region of expansion, whereas population growth in that same region raises questions about whether all land uses can be sustained along those lines (Alig et al. 1999b).

Figure 8 shows the growth of the population of four U.S. census regions over the past century.[2] In 1900, the populations of the Midwest, South, and Northeast regions were comparable, and the population of the West region was considerably lower. The populations of the four regions grew almost in parallel until midcentury. The rate of growth of the population in the Midwest and Northeast tapered off after that, whereas the rate of growth of population in the South and West continued to accelerate. Consequently, by 1990 the South was by far the most populous region, and the West region had overtaken the Northeast in population and was quickly gaining on the Midwest.

The percentage of the U.S. population residing in urban areas grew notably during the 20th century, from 40 percent in 1900 to 75 percent in 1990. Figure 9 shows the trajectories of the proportions of the population living in urban areas in each of the four census regions and for the Nation. In 1900, the Northeast region (at 66 percent) clearly had the largest percentage living in urban areas, and the South (at 18 percent) had the smallest. The West, the Midwest, and the United States as a whole each had about 40 percent. By 1990, the percentage living in urban areas increased for each of the regions and the Nation as a whole, and the difference between the extremes of percentages in urban areas had shrunk. The percentage of Northeastern people living in urban areas stabilized at about 80 percent in 1950, and that for the Midwest region stabilized at about 71 percent in 1970. Percentages of the population living in urban areas in other regions continued to grow, so that by 1990, the West had the highest percentage. In 1990, the percentage for the South (69 percent) approximated that for the Midwest.

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[2] Demographic data in this report were extracted from the U.S. Census Bureau Web page http://www.census.gov/population/estimates/state.

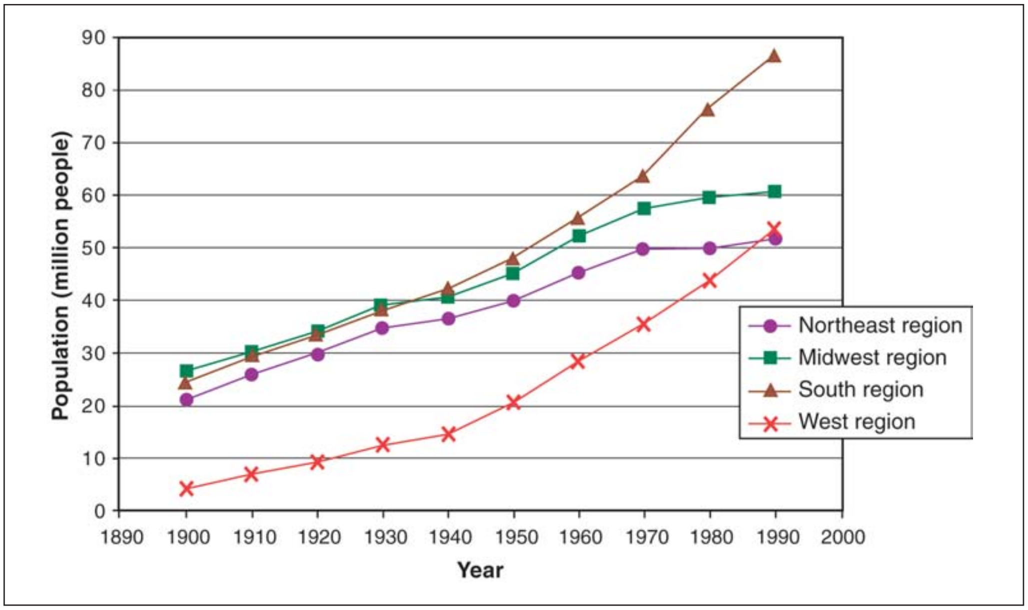

Figure 8—U.S. population by census region, 1900-90 (USDC Bureau of the Census 2001).

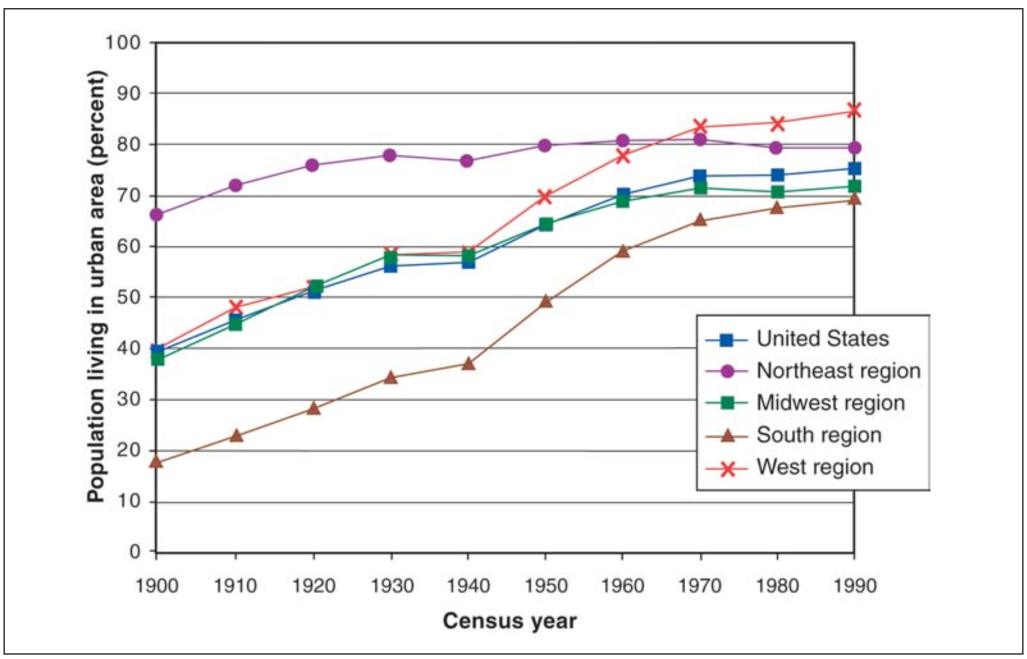

Figure 9—Percentage of the U.S. population living in urban areas, 1900-90 (USDC Bureau of the Census 2001).

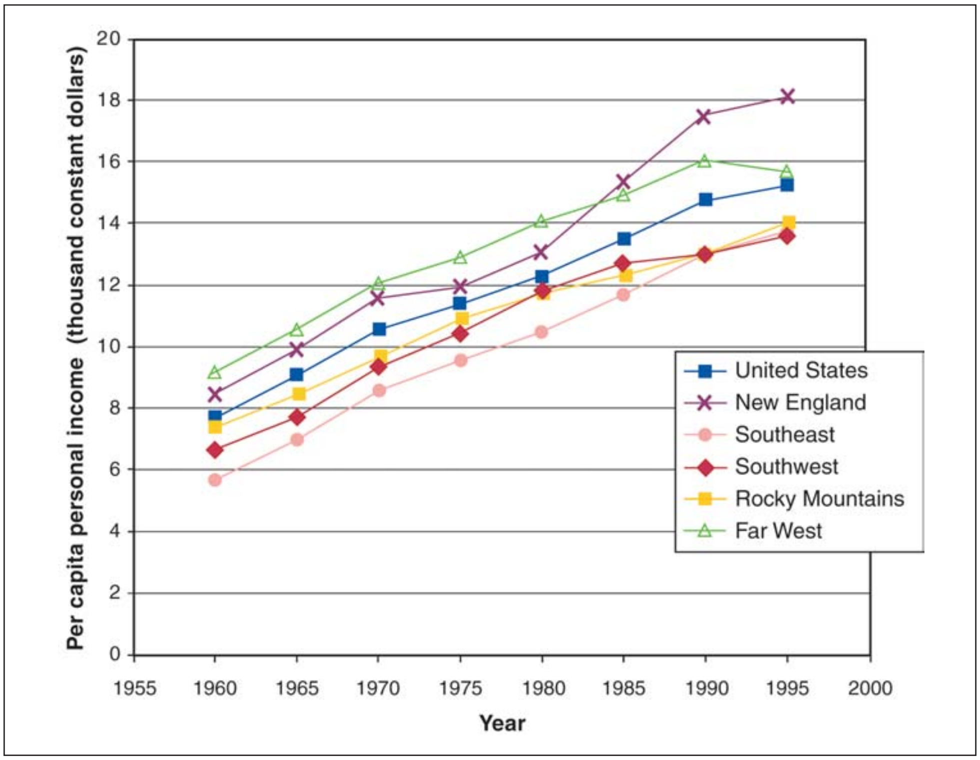

Figure 10—Real per capita income by selected U.S. regions, 1960-95 (USDC Bureau of Economic Analysis 2002).

Figure 10 shows the growth of real per capita personal income (PCPI) in five regions[3] of the country and in the United States as a whole between 1960 and 1995. Almost without exception, real PCPI in each region increased during each half decade. The trajectories of the five regions grew essentially in parallel until 1975; since 1980 there has been some divergence. Nonetheless, in percentage terms, the gap between the richest and poorest regions has decreased. At the extremes, in 1960, the PCPI for the Far West region exceeded that of the Southeast by 61 percent, whereas in 1995 the PCPI of New England exceeded that of the Southwest by 33 percent.

The distribution of the population is not uniform across the Nation. In addition to a concentration in coastal areas, shifts in population have occurred from the North to the South and the West in recent decades. For example, with the decentralization of the business office enabled by new computer and telecommunications technologies, some workers and businesses are now able to locate in places of their choosing.

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[3] To streamline the figure, data from the Bureau of Economic Analysis (BEA) showing trajectories of per capita personal income for three BEA regions (Mideast, Great Lakes, and Plains) were omitted. However, the trajectories of the omitted regions were all “median” in that none was ever the highest or the lowest.

The U.S. population is not only expanding but also is aging. Early in the 20th century, 1 in 25 Americans was over age 65. In 1990, one in eight was over 65. The aging population is also shifting to the warmer climates of the South. The South has experienced rapid population growth, and NRI data indicate that four of the top five states in terms of area developed from 1992 to 1997 were in the South (USDA NRCS 2001). The West has been another region with above-average population growth, as the West grew by 22.3 percent between 1980 and 1990, while the South grew by 13.4 percent. Among the 10 fastest growing states between 1990 and 2000 are the two with the largest timberland areas: Georgia and Oregon.

"Urban sprawl" in the late 1990s tied with crime as the leading local concern of Americans in a Pew Center poll (Pew Center 2000). In 1999, approximately 1,000 measures were introduced in state legislatures to change planning laws and to make development more orderly and conserving. Population growth often adds to the fragmentation or parcelization (breaking up of large ownership holdings into small holdings) of croplands and forest lands, affecting quality of life for some residents. Fragmentation and parcelization also can reduce the amount of economically harvestable forest area. Although the land use may still indicate a specific area devoted to a major category, the small size of holdings may prevent commodities from being harvested in some cases owing to higher per-acre costs and lower per-acre revenues. Forest fragmentation also has environmental implications, one example being declines in Neotropical migrant birds and other wildlife species with minimum patch requirements (Matthews et al. 2002).

Some Americans have a strong preference for spreading out development. Many Americans prefer to live in a less congested area and will commute additional minutes or hours for such living conditions, made possible by our extensive road system. Moreover, an increasing population of retirees has augmented outmigration from central cities and suburbs to rural areas that offer aesthetic amenities. Natural amenities may be a more important determinant of population growth than nearness to metropolitan centers or type of local economy (McGranahan 1999).

More than one-quarter of the 3,142 U.S. counties are currently classified as metropolitan (see "Glossary" for definition). That compares with less than one-tenth 50 years ago. Even with constant tastes and preferences, a larger population base with higher income will add up to greater consumption and demands for developed space for residences and shopping, but also for businesses, transportation, and other activities.

Area changes in other land uses—Land in special-use areas more than doubled between 1960 and 1997 (Vesterby and Krupa 2001). Land used for recreation and wildlife areas (federal and state parks, wilderness areas, and wildlife refuges) expanded 324 percent from 1945 to 1997 (an increase of 73 million acres). The increase was mostly from conversion on federal lands, previously in forest and grassland pasture and range uses. Land in defense and industrial uses declined 41 percent from 1945 to 1997 (a decrease of 10.1 million acres), primarily in Arizona and Nevada. Miscellaneous farmland uses declined 8 million acres between 1945 and 1997. Behind this decline were fewer farms; a trend toward larger, consolidated farms; and an increasing tendency for farm families to live off the farm (Vesterby 2001).

In 1780, 221 million acres of wetlands are estimated to have existed in what is now the contiguous 48 states. A recent estimate is less than 124 million acres (Vesterby 2001). Bringing land into agricultural production accounts for more than 80 percent of all wetlands lost since colonial times (U.S. Congress, OTA 1984). In recent years, the full range of ecological functions and economic benefits associated with wetlands has become much better understood; these include critical wildlife habitat, temporary stormwater storage, ground-water recharging, pollution control, sport hunting and fishing opportunities, wildlife viewing, and breeding grounds and nurseries for many commercially important fish, fur, and game species. As a result, federal wetlands policy has increasingly emphasized conservation, such as the swampbuster provisions in the 1985 farm bill. Much of the wetlands policy shift has been directed at agriculture. An example is the current Wetlands Reserve Program, which pays farmers and offers cost shares to encourage wetlands restoration.

Miscellaneous-other land consists largely of marshes, open swamps, desert, tundra, and minor acreage in uses not inventoried (Vesterby and Krupa 2001). Areas of this unclassified land are relatively large in Alaska, arid portions of the West, and several Atlantic and Gulf coastal areas. Alaska has over 56 percent of the total. Overall, the area of miscellaneous land has declined since 1960.

Projected changes in nonforest land uses—Urban and developed areas are projected to continue to grow substantially, in line with the projected population increase of more than 120 million people over the next 50 years (Alig et al. 1999b, 2002). This will be part of a global increase in population, as the world's population is projected to grow from 6 to 9 billion by 2050. The basic factors of increases in population and real incomes are important drivers for developed area (e.g., Alig and Healy 1987, Heimlich and Anderson 2001) and have significant impacts on land use change.

From 1950 to 2000, the U.S. population increased by 82 percent (151 million to 275 million) and is projected to grow another 47 percent (to more than 400 million) by 2050. Average family income (in inflation-adjusted dollars) has increased by more than 150 percent during this historical period, giving individuals more income to spend. The U.S. per capita disposable income in 1998 was $22,353, which represents more than a 10-percent increase, in real terms, during the 1990s alone. Further increases in personal income are projected but not at the level of increase in the 1990s (USDA Forest Service 2001). In the future, the average age of the population of the United States is expected to increase (USDC Bureau of the Census 2000), which in turn results in decreasing family size and increasing the number of homes per thousand persons. Projected increases in population and associated changes in personal income and other factors, such as number of homes per thousand people, could lead to about 40 million acres of rural land being converted to urban and developed uses by 2050. Forestry's share could be about 15 to 25 million acres.

Consistent with recent trends, population growth is expected to be fastest in the West and South. In the past, each additional household consumed about 1 acre of land. The average number of persons per U.S. household has been falling, from 3.14 persons per household in 1970 to 2.63 in 1990 (USDC Bureau of the Census 2001) and further decreases are anticipated. As the number of persons per household decreases and population continues to grow, this implies in general more households and more land converted for housing. If the number of persons per household continues to fall,

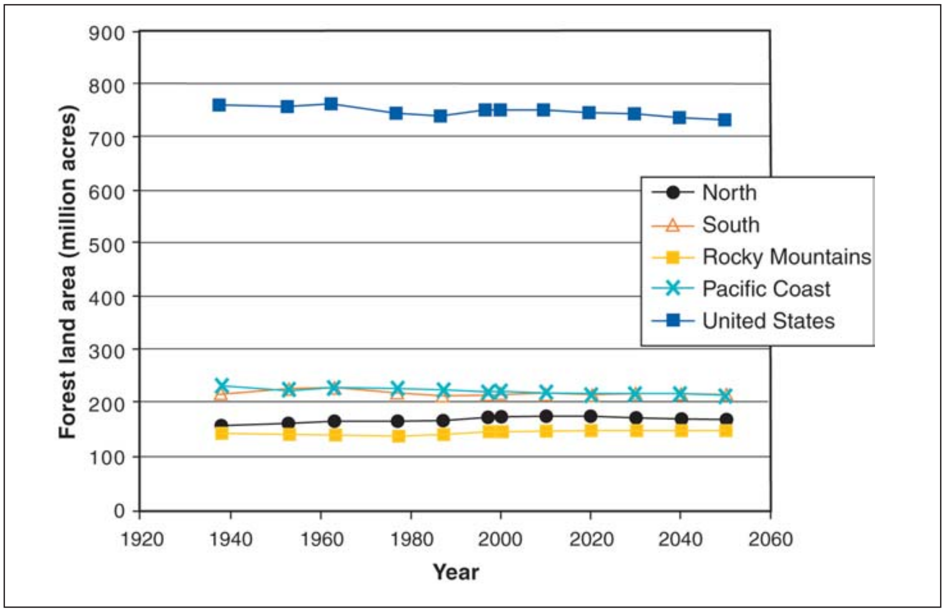

Figure 11—Historical and projected area of U.S. forest land cover, by region and total United States, 1937-2050 (Alig et al. 2002, Smith et al. 2001).

implications for forestry are that an even larger amount of forest land may be converted to urban and developed uses than with the historical number per household.

Agricultural area is projected to decrease by approximately 43 million acres or 4 percent by 2050. This is mostly grassland, in line with historical trends. Projections of U.S. grazed-forage use appear to be region specific (Van Tassell et al. 2000); however, use of grazed forages for U.S. beef cattle is anticipated to decline over the next several decades. In addition to conversion to urban and developed uses (e.g., ranchettes), some rangeland is projected to go to special uses such as parks, fish and wildlife areas, and wilderness areas.

Projected area changes for remaining land uses sum to a net increase of about 18 million acres by 2050. Most of this is in special uses such as parks, and fish and wildlife areas.

The total U.S. land base decreased by about 7 million acres between 1959 and 1997, owing to coastal erosion and flooding (Vesterby and Krupa 2001). This historical trend is expected largely to continue in terms of net area changes, such that by 2050 total land area would be about 8 million acres less than in 1997.

Forest Land

In 1997, about one-third of the Nation's land base (747 million acres) was classified as "forest land" cover type (Smith et al. 2001). Forest land is defined as land at least 10-percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially reforested (see "Glossary") (Smith et al. 2001). Included are forest areas adjacent to urban and built-up lands. In 1997, the South and Pacific Coast regions each had more than 200 million acres of forest land, each representing about 29 percent of the national total (fig. 11, table 2). The North had 23 percent, followed by the Rocky Mountains with 19 percent.

Table 2—Area of forest-land cover and timberland in the United States, by ownership and region, specified years, 1953-97, with projections to 2050

Ownership and region	1953	1963	1977[a]	1987[a]	1997	Projections 2010	2020	2030	2040	2050
					Million acres					
Forest land:										
Region—										
North	160.8	165.7	164.2	165.5	170.3	172.1	171.0	168.6	166.2	163.8
South	226.0	228.4	217.0	211.1	214.1	213.2	212.6	211.8	211.2	210.5
Rocky Mountains	141.6	140.4	138.2	139.6	143.2	144.3	144.2	143.8	143.2	142.5
Pacific Coast	227.8	227.4	224.2	220.1	219.3	216.3	213.9	211.6	209.4	207.1
Total	756.2	761.9	743.6	736.4	747.0	745.9	741.7	735.9	729.9	723.8
Timberland:										
Ownership—										
Public	145.4	146.2	138.2	131.0	146.0	146.1	146.1	146.1	146.1	146.1
Forest industry	59.0	61.4	68.9	70.3	66.9	66.4	66.1	65.6	65.2	64.9
NIPF[b]	304.4	307.5	285.3	283.6	290.8	289.6	287.0	284.4	281.0	278.1
Total	508.9	515.1	492.4	484.9	503.7	502.1	499.2	496.0	492.2	489.0
Region—										
North	154.3	156.6	153.4	154.4	159.4	159.4	157.9	155.6	153.1	151.0
South	204.5	208.7	199.6	197.3	201.0	200.3	199.6	199.3	198.6	197.8
Rocky Mountains	66.6	66.9	60.2	61.1	71.0	71.4	71.3	71.2	71.0	70.9
Pacific Coast	83.4	82.9	79.1	72.1	72.2	71.0	70.3	69.9	69.9	69.3
Total	508.9	515.1	492.4	484.9	503.7	502.1	499.2	496.0	492.2	489.0

[a] Data were revised after the 1989 Resources Planning Act assessment tables were developed.
[b] American Indian lands are included exclusively in the nonindustrial private forest (NIPF) owner group for 1997 and projections. For 1987 and earlier years, these lands may be included in the other public owner group (Smith et al. 2001).
Note: Data may not add to totals because of rounding. Only private lands are modeled, and public timberland area is assumed to be constant in the future (Mills and Zhou 2003)

Historical Changes in Forest Area

A consistent historical database pertaining to forest area and related timber resource conditions assembled by the USDA Forest Service covers the period 1952 to 1997 (Smith et al. 2001). Such data aid in examining sustainability indicators and help shape perceptions about whether as a society we can sustain both increasing consumption of forest products and forest resource conditions (Alig and Haynes 2002). These data illustrate the dynamics of our Nation's land base and how adjustments are likely to continue in the future.

The U.S. forest area increased from 1952 to 1963, reaching a peak since World War II at 762 million acres. Forest area declined to 737 million acres by 1992, and then increased between 1992 and 1997. The 1997 area is 1 percent less than in 1953, and 2 percent less than in 1938.

Over the longer term, the area of forest land in the United States steadily declined as the country was settled. From 1800 to 1930, forest-land area declined by 300 to 350 million acres according to the best estimates (Clawson 1979, Smith et al. 2001). Part of this reduction was attributable to an excess supply of timber in some cases. Prices for cleared land sometimes exceeded those for forested land of similar quality. Some converted forest land was used for urban and infrastructure developments, but most was cleared for agriculture.

Some land use changes before 1900 reflected federal policies of the time to transfer the original public domain to private ownership to expand agricultural production. With the closing of the public domain, establishment of permanent federal forest reserves, conversion of most suitable nongovernment forest lands to some form of cropping or pasture, and dramatic improvements in agricultural productivity, the net movement of land from forest use into agriculture has become far less marked. Between 1945 and 1992, U.S. cropland area increased by about 2 percent, grassland (pasture and rangeland) area decreased by 11 percent, forest-use land area decreased by 7 percent, and the area of land classified as "urban" increased by more than 285 percent (USDA ERS 2000).

Although the **net** area of forest land in the contiguous 48 states has been somewhat constant over the last 50 years, there has been significant variation within individual regions and over time (table 2). The North has had the largest percentage of gain, 5.9 percent, followed by the Rocky Mountains with a 1.1-percent gain. The South has had the largest loss, 5.3 percent, followed by the Pacific Coast with a 3.7-percent loss. Losses and gains reversed over time in all regions, except for the Pacific Coast, which had a steady loss over time.

From 1953 to 1997, a majority (26) of the states had a loss in forest area. Nine states had net losses of more than 1 million acres, with a range of 1.0 to 6.3 million acres. In descending order of net loss amount, the states are Texas, Florida, California, Oklahoma, Louisiana, Washington, Alaska, Missouri, and Minnesota. Seven states had net gains of more than 1 million acres, with a range of 1.1 to 4.1 million acres. In descending order of net gain amount, the states are New York, Ohio, Pennsylvania, West Virginia, Mississippi, Alabama, and Kentucky. The only RPA subregions with net gains in total were the Northeast, North Central, and the Intermountain.

The long-term historical loss in U.S. forest area since the early 1950s has been due to a combination of factors, but in more recent decades has been primarily due to conversion to urban and developed uses (fig. 12). Deforestation is the conversion from forest to nonforest use, and between 1982 and 1997, 23 million acres were deforested on nonfederal land in the United States. The destination of about half of the converted forest acres was to urban and developed uses. Between 1982 and 1997, more than 10 million acres of nonfederal forests were converted to developed uses according to NRI estimates, an area larger in size than the combined current forest area of five northeastern states (Connecticut, Delaware, Maryland, New Jersey, and Rhode Island).

The annual rate of conversion of rural to urban and developed uses during the last 5 years of this period was more than 50 percent higher than that of the previous 5 years, with about 1 million acres of forests converted to developed uses per year. The U.S. economy grew vigorously in the 1990s, with unprecedented stock market gains helping to fuel income increases that also contributed to expanded development.

Land use dynamics include multiple pathways involving changes in forest area, with the main two-way flows being between forestry and agriculture. The flow between forest land and urban and developed uses is primarily a one-way flow toward urban and

Figure 12—The largest net area loss of forests in recent decades has been to developed uses, such as to housing sites.

developed uses, although some land classified as urban and developed (e.g., corridors for electrical lines) may infrequently shift into forest or agriculture. Movement of land between forestry and agriculture in the last two decades has resulted in net gains from agriculture to forestry that have offset forest conversion to urban and developed uses.[4] From 1982 to 1997, forest conversion to cropland, pastureland, and rangeland was estimated by the NRI to be approximately 8 million acres (fig. 13). During the same period, about 23 million acres of agricultural land were afforested, resulting in a net gain from agriculture to forests of about 15 million acres. When all conversions of land into and out of forest are included, the net area of nonfederal forests increased by about 4 million acres in the contiguous 48 states between 1982 and 1997, according to NRI estimates.

Net changes (area into forest **minus** area out of forest) are typically much smaller than gross changes (area into forest **plus** area out of forest). Gross area changes totaled about 50 million acres involved in the multiple pathways of land use change for nonfederal forests for the contiguous 48 states between 1982 and 1997 (fig. 13). The **gross** change in forest area was more than 10 times as large as the net change in forest area.

Urbanization is a continuing trend, and the rate of urbanization is such that even the Nation's largest tree planting effort, the CRP that afforested 2.6 million acres of cropland between 1987 and 1992, could not offset the 3 million acres of forests converted during the same period (Alig et al. 1999b). Georgia led the Nation in CRP tree planting

[4] As shown in figure 13, another pathway is between forest and "other rural land." Other rural land includes farmsteads and other farm structures, field windbreaks, barren land, and marshland (USDA NRCS 2001).

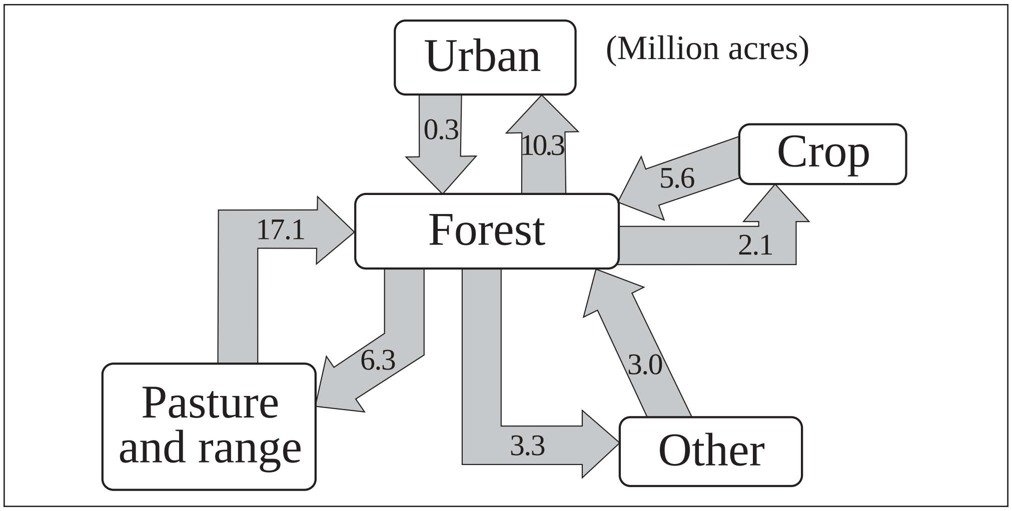

Figure 13—Area exchanges among major land uses in the United States, 1982-97 (USDA NRCS 2001).

but also ranked third in rate of urbanization from 1992 to 1997, leading to a net loss in forest area between 1992 and 1997. Although most government-subsidized tree plantings tend to be retained for relatively long periods (e.g., Alig et al. 1980, Kurtz et al. 1996), urbanization can quickly alter landscape conditions on other ownerships near growing urban centers such as Atlanta. Effects also can be both direct and indirect (Alig et al. 1998a). For example, a reduced supply of agricultural land due to urbanization can either result in indirect or "replacement" conversion of forest land to agricultural uses or direct conversion of forests to developed uses (Alig and Healy 1987).

Forest Area Projections

Total forest-land area in the United States is projected to decrease by approximately 23 million acres between 1997 and 2050 (table 2, fig. 11). This would be a 3-percent reduction. Projections of forest-land area are related to those above for the other major land uses. The main reason for the projected reduction in forest-land area is the conversion to urban and developed uses, given the projected increases in population and income discussed earlier.

All four regions are projected to have a net loss of forest-land area by 2050. The largest projected losses would be in the Pacific Coast and the North. The Rocky Mountain area has the smallest projected loss of forest area.

The projected loss in forest area is primarily on private lands, and especially for nonindustrial private lands. This is in line with historical trends. Forest area on national forests is assumed to have no significant net loss or gain (Mills and Zhou 2003).

Timberland

Forest land is classified according to its productivity and availability for timber production and harvesting operations. **Timberland** is defined as forest land capable of producing at least 20 cubic feet per acre per year of industrial wood in fully stocked natural stands and not withdrawn from timber utilization (see "Glossary" for further qualifications). Although no single measurement adequately describes the productivity of forest land for uses other than timber production, an estimate of biological productivity is sometimes useful in helping to determine the forest's capacity for other uses. Two-thirds

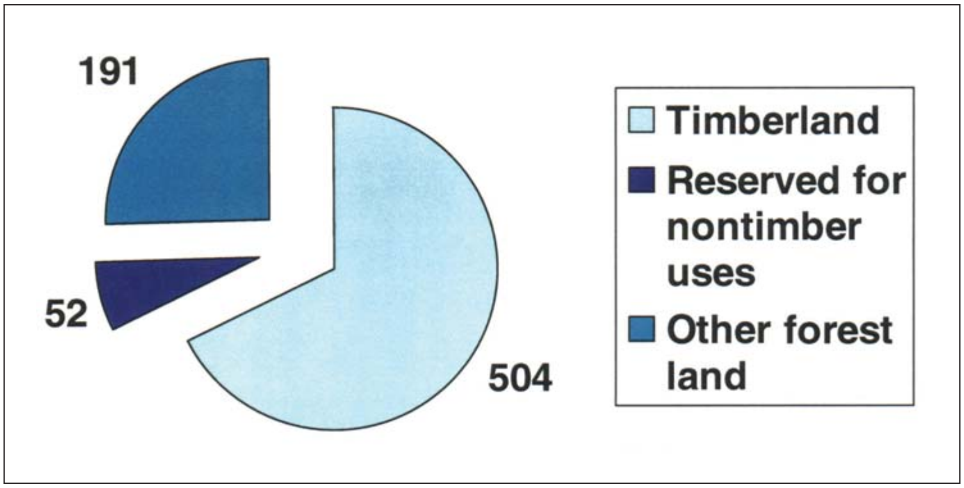

Figure 14—Composition of U.S. forest land in 1997 by timberland, reserved for nontimber uses, and other forest land that has lower timber productivity (Smith et al. 2001).

of all U.S forest land, or 504 million acres, qualified as timberland in 1997, 7 percent or 52 million acres were reserved (i.e., withdrawn from timber utilization), and 26 percent or 191 million acres do not meet the productivity standard for timberland (fig. 14). The most important natural factors that affect timber productivity are soil, climate, and topography. Investment also can greatly influence timber productivity, as through enhanced site preparation and tree planting or intensified silvicultural practices. From a timber-supply policy perspective, timberland area is the most important because it accounts for most of the timber harvested in the United States.

Ownership

Timberland is further classified into three ownership classes: public, forest industry, and nonindustrial private forest (NIPF). Forest industry and NIPF are the private ownership classes. A slightly expanded definition of timberland and definitions of the public, forest industry, and NIPF ownership classifications are given in the "Glossary." Area of total private timberland declined by approximately 6 million acres **in net** between 1953 and 1997 (Smith et al. 2001), equal to about 2 percent. In 1997, 58 percent of all timberland was NIPF, 29 percent was publicly owned, and 13 percent was owned by forest industry (Smith et al. 2001). Table 2 gives historical and projected timberland areas for some regions of the United States by ownership class.

Figure 15 shows the historical data and projections of U.S. timberland area by ownership class. Between 1953 and 1987, the trend of NIPF and public timberland was slightly downward, whereas the trend in the area of forest industry timberland was slightly upward. Note that the direction of all three of these trends switched between 1987 and 1997: both NIPF and public timberland areas increased, whereas forest industry timberland area decreased.

Since 1930, and continuing until the early 1960s, the area of timberland increased by about 50 million acres as the worked-out cotton lands in the South, cleared areas on hill farms in the East, and marginal farms in other regions reverted back to forests. During the 1960s, the upward trend in timberland area was reversed, and by the 1970s,

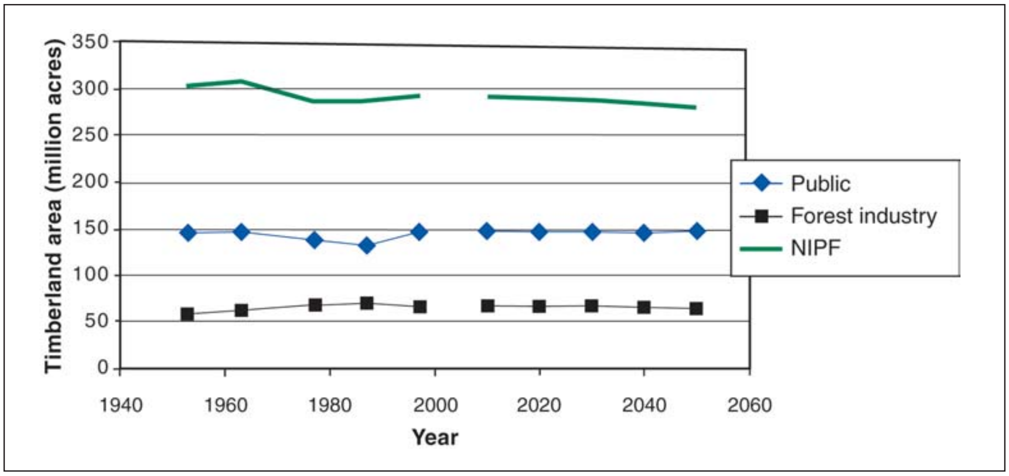

Figure 15—Historical and projected area of U.S. timberland by ownership, 1952-2050.

the rate of acreage loss began to accelerate. As a result, timberland area declined 4 percent between 1962 and 1977 to 492 million acres, and then dropped to 485 million acres by 1987. However, the decadal rate of decline in timberland area lessened to about 2 percent, in part because of surplus crop production in the agricultural sector.

Between 1987 and 1997, the net increase in U.S. private timberland area was 3.8 million acres, or about 1 percent. During this period, the CRP represented the Nation's largest tree planting program over a 5-year period. Under the CRP, trees were planted on about 3 million acres of erodible and environmentally sensitive cropland, primarily in the South. In the North, excess capacity in the agriculture sector resulted in natural reversion of some former agriculture land to trees. At the same time, continued urbanization converted several million acres of forest land (USDA NRCS 2001).

The largest net declines in timberland area were for the NIPF ownership class, with 14 million acres (about 5 percent of the total) lost between 1953 and 1997. The extent of the U.S. NIPF timberland area loss is equivalent to more than twice the size of Maryland.

More than 9 million NIPF owners manage forest land in the United States (Birch 1996). Of those, 77 percent manage fewer than 20 acres each, and 96 percent manage fewer than 100 acres each. These small ownerships have different management opportunities and may cost more per unit area to manage.

In the past, reduction in NIPF timberland area was attributable in part to transfers of land to forest industry; in recent years that trend has partially reversed. An increasing rate of turnover of industrial ownership has arisen in the face of takeovers, mergers, and land sales. When all types of dispositions are taken into account, an estimated 28 percent of industrial forest land—or some 20 million acres—changed hands in the 1990s (Best and Wayburn 2001). For example, Georgia-Pacific Corporation has spun off its lands into a separate operating unit known as the The Timber Company (a "letter corporation"), making it one of the largest private timberland owners in the Nation. The Georgia Pacific Corporation also has sold its California timberlands.

Ownership of timberland by institutional owners (such as pension funds, foundations, university endowments, and others) is a small but growing class of large, nonindustrial landowners. Institutional investment (e.g., Hancock Timber Resource Group[5]) has grown from an estimated $300 million to about $7 billion over a 15-year period (Best and Wayburn 2001). A variety of financial vehicles and products are available or evolving for such forest ownership.

Institutional investment in forests is undertaken largely by timber investment management organizations, the growing part of nonindustrial private ownership. Distinguishing forest ownership classes is important because forest management emphases and intensities can differ by ownership. For example, the timber investment management organizations tend to manage their timberland more intensively for timber production than the other private class (Zinkhan 1993).

The changes in ownership have resulted in decreases in industrial timberland area in most regions after decades of increase (Smith et al. 2001). For example, in the Southeast, industrial timberland area was reduced by 2.1 million acres or 13 percent between 1987 and 1997. Some land divestures by industry in the South are now under investment management or "institutional" ownership. The goal of institutional investors is a desired rate of return from the sale of timber and land while minimizing risk. Such owners do not have processing facilities (e.g., mills), which gives them more flexibility to move in or out of a specific forest type or region to fit financial goals. They tend to manage lands somewhat similarly to industrial owners. However, forest management practiced on industrial lands is influenced by the need to supply processing facilities, many of which are capital-intensive operations. Both institutional and industrial owners undertake forest stewardship activities and tend to operate at or above forest stewardship standards set by law (Best and Wayburn 2001). Community relations are important, and this also extends to providing recreational opportunities, some of which add revenue.

Timberland Area Projections

Projections of area changes for the timberland base were made by RPA region and the two private forest ownership classes—forest industry and NIPF. Consistent with the slow decline in net U.S. forest-land area over the projection period, private timberland area is likewise projected to decline. Total area of U.S. private timberland is projected to decline by 4 percent by 2050 (Alig et al. 2002).

Industry timberland is projected to decline 3.0 percent by 2050, whereas NIPF timberland area is projected to decline 4.4 percent. With the U.S. population projected to continue to grow, particularly in the southern and western regions, this suggests that more rural land will be converted to developed uses. Timberland has been the largest source of developed lands according to NRI surveys (USDA NRCS 2001). Projected increases in population and income will increase demands for use of land for residential, urban, transportation, and related developed uses. The incomes of Americans have grown substantially since World War II, and projected increases in discretionary income will likewise increase demands for renewable resources, and lead to further conversion of forests for developed uses.

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[5] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

The direction of the NIPF timberland projection is consistent with the long-term historical trend. The NIPF timberland area in the United States declined 13.4 percent between 1953 and 1997. The long-term projected rate of decline is smaller owing to a combination of factors, including altered agricultural policies as exemplified by the national farm bill legislation, a larger component of institutional owners described above, and enhanced markets for timber products resulting in part from reduced public timber availability (Adams et al. 1996). At the same time, the Nation's population is projected to grow by more than 120 million people over the next 50 years. Most forest land likely to be converted to residential and other developed uses during that period is in NIPF ownership. Loss of forested land through conversion to urban and developed uses in coming decades is likely to be significant and exceed gains in forested areas through afforestation.

Farmers make up an historically important component of the NIPF ownership class. Farmer ownership of timberland has declined for several reasons. Many owners of timberland who were farm operators sold or passed on their holdings to new owners, who were classified as other private owners because they did not secure their primary source of income from farming. In addition, many farmers increasingly secured their livelihood off farms and were subsequently classified as other private owners. Farm forest-land conversion to other uses, primarily agriculture, also has contributed to a reduction in farm forest area. Timberland area in farmer ownership is projected to continue declining. This trend is consistent across the South and in line with historical trends. However, about 3 million acres of highly erodible cropland under the CRP of the 1985 farm bill planted to trees on farm ownerships did temporarily slow the decline but likely will not be enough to stem forest-land area reductions.

Corporate private owners and other individuals have acquired many of the timberland acres that were once owned by farmers. Area under corporate ownership is projected to increase, partly because of investment in southern pine timberland (Alig and Wear 1992, USDA Forest Service 1988). It is uncertain how these corporate lands will be managed in the future. It remains to be seen whether some corporate owners will divest of timberland after harvest of the current rotation's crop, or if they will invest in longrun timberland management.

Individual owners, the other component of the miscellaneous private ownership group, are the largest ownership class. This diverse set of owners holds over one-third of the southern timberland base—almost four times as much as corporate owners. Unlike the corporate owners, individuals in the other private owner group are projected to reduce their timberland holdings in the future.

The projected reduction in industrial timberland area represents a departure from the longer term historical trend, although there has been a decline in most regions since 1987. In the past, many forest products companies have found it advantageous to own large amounts of timberland. Some of the recognized advantages include an assured wood supply for mills that represent large investments, augmentation of supplies of low-cost timber, an inflationary hedge, and certain tax advantages. In addition, some banks have required a certain amount of timberland to be owned as one condition for loans. As described above, some industrial land has been spun off to institutional or financial investors that are categorized as NIPF owners. This trend is expected to continue. Other factors include cashflow considerations, other investment opportunities, opportunities for land leasing and long-term harvesting rights, and the increased substitution of more intensive forestry practices on existing holdings in place of land acquisition. Timber management intensity is expected to increase on industrial lands. An example is the projected increase in planted pine on industrial lands in the South (Alig et al. 2002; Alig and Butler, n.d.), thereby lessening the need for timberland relative to other factors of production such as improved tree planting stock.

Summary, National Overview

Area of forest-land cover in the United States is projected to decline over the next 50 years, with a 2-percent reduction by 2050. Increases in population and income are expected to further fuel development, leading to conversion of forest to nonforest uses. Projected increases in urban and developed uses will likely intensify competition for remaining land between the agricultural and forestry sectors. In recent decades, cropland increases have come at the expense of grassland (pasture and range) and the decline in acres devoted to farmsteads as a result of declining farm numbers. Increases in forest land have also generally been at the expense of grassland. All three major land use classes—cropland, forest land, and grassland—have lost area to urbanization (Alig et al. 1998b). Shifts in land uses among cropland, forest land, and grassland depend in part on the differential rate of technological improvements in the different sectors.

The NRI shows that, nationally, 11 million acres of forest land, cropland, and open space were converted to urban and other uses from 1992 to 1997, as the national rate of urbanization increased 50 percent compared to the 1982-92 period (USDA NRCS 2001). Urban and other developed areas are projected to continue to grow substantially, in line with a projected U.S. population increase of more than 120 million people over the next 50 years. Consistent with recent trends, the population growth is fastest in the West and South. Projected increases in population and income will, in turn, increase demands for use of land for residential, urban, transportation, and related uses. The incomes of Americans have grown substantially since the Second World War, and projected increases in discretionary income will increase demands for renewable resources, and also may lead to further conversion of forests for developed uses.

Although the long-term historical trend had been downward, timberland area has increased since 1987. Between 1987 and 1997, the net increase in U.S. private timberland area was 3.8 million acres, or about 1 percent. During this period, the CRP's conversion of erodible croplands represented the Nation's largest tree planting program. In addition, national legislation was enacted that would reduce farm programs and potentially lessen related conversions of forest land. However, some of the farm programs have since been largely reinstated.

Changes in forest ownership resulted in a decrease in industrial timberland area in most regions between 1987 and 1997, after decades of increase. At a national level, area of industry forest-land ownership declined between 1987 and 1997 after increasing since 1953. Conversely, timberland area on nonindustrial private ownerships increased after decreasing since 1963. These trends are intertwined, with significant shifts of timberland between the two private ownership classes. In the Southeast, industrial timberland area was reduced by 2.1 million acres or 13 percent between 1987 and 1997. Some land divestures by industry in the South are now owned by timber management investment organizations and are classified as NIPF lands. Such owners do not have processing facilities (e.g., mills) that would require a steady supply of timber, and so they have more flexibility to move into or out of a specific forest type or region to meet financial goals.

The 1979 RPA assessment (USDA Forest Service 1982) suggested that the Nation had an adequate land base for meeting prospective increases in demand. However, a key question is whether the necessary investment in land management and related activities (e.g., recreation supply) took place over the next two decades. The 1989 Resources Conservation Appraisal (USDA SCS 1989) and the 1989 RPA assessment (USDA Forest Service 1989a, 1989b) pointed to increasing competition among major land uses, including growth in the forest sector in the South (USDA Forest Service 1988). At the same time, major policy changes have altered the competition for land between sectors, with policies sometimes originating in one sector having important implications for another (Alig et al. 1999a). Toward the end of the historical period, an important piece of agricultural legislation, the Federal Agricultural Improvement and Reform Act of 1996, was passed that has implications for future U.S. land use, with the federal government moving further away from direct involvement in farm commodity markets. However, threats of droughts and other elements that inject volatility in agricultural and forestry production have prompted some annual adjustments in the government intervention plans. Given the background of lower agricultural prices than in the mid-1990s, debate about the 2002 farm bill reflected some interest in changing the thrust of the 1996 farm bill, e.g., new types of countercyclical farm policies, and this will need to be monitored with respect to the dynamics of the link between land use patterns and market prices.

Chapter 2: North Region

Introduction

The North includes 20 states in the Northeast and North Central subregions of the United States (table 1). The North stretches from the Atlantic seaboard in the East to the farmland prairies in the Corn Belt; from the Ohio River, the Appalachian Highlands, and the northern Piedmont in the South to the Canadian border and the Great Lakes in the North. The more northern states of the region have moderately long, relatively severe winters. Annual precipitation is moderate and ranges from 25 to 45 inches; often half of this precipitation comes as snow (USDA Forest Service 1989a). Short growing seasons of 100 to 140 frost-free days limit agricultural production. Much of this area has been glaciated, and glacial landforms are common. Soils are generally well suited for forests, although soils with high water tables are common in some areas. Because much of the North, except for the prairie fringes in the western portions of Iowa, Minnesota, and Missouri, was originally forested, it tends to revert back to forest if disturbed and then allowed to stand idle.

The oak-hickory and maple-beech-birch forest cover types are the largest in the region, combining to represent 62 percent or 106 million acres of unreserved forest land (Smith and others 2001). Generally, the oak-hickory ecosystem grows in a wide band along the southern portion of the area and joins the maple-beech-birch ecosystem to the north (USDA Forest Service 1989a).

Most of the forest lands in the North remain in private ownership, most as timberland. Seventy million people live within an 8-hour drive of the “Northern Forest” and illustrate the increasing multiple demands on forest land in such regions (fig. 16). The possible sale of some of these lands in the Northeast and possible fragmentation and development, along with perceived public values associated with the lands, prompted Congress to initiate the Northern Lands Study (Northern Forest Lands Council 1994). The study was undertaken in 1989 and 1990, with the objective of developing public policy alternatives to development of the Northern Forest in four states (Maine, New Hampshire, New York, and Vermont). This group recommended that a more intense and public process be initiated by Congress, and that the governors of the four states develop specific recommendations for public policy changes. This effort was undertaken by the 17-member Northern Forest Lands Council that worked from 1990 to 1994. Their efforts resulted in 37 public policy recommendations. The council’s report *Finding*

Table 3—Area of forest-land cover and timberland in the North, by ownership and subregion, specified years, 1953-97, with projections to 2050

Ownership/subregion	1953	1963	1977[a]	1987[a]	1997	Projections 2010	2020	2030	2040	2050
					Million acres					
Forest land:										
Northeast	76.6	81.6	84.3	85.3	85.5	86.0	85.8	84.7	83.4	82.3
North Central	84.2	84.2	79.9	80.2	84.8	86.0	85.2	83.9	82.7	81.4
Total forest land	160.8	165.7	164.2	165.5	170.3	172.1	171.0	168.6	166.2	163.8
Timberland:										
Northeast—										
Public	7.3	7.5	8.2	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Forest industry	10.1	10.1	12.8	12.6	11.0	10.9	10.9	10.7	10.5	10.4
NIPF[b]	55.6	60.3	57.5	57.7	58.3	58.2	57.6	56.6	55.3	54.4
Total	73.0	77.9	78.6	79.8	78.9	78.7	78.1	76.8	75.5	74.4
North Central—										
Public	21.9	20.9	20.3	20.4	22.6	22.6	22.6	22.6	22.6	22.6
Forest industry	3.6	3.6	4.7	4.4	3.8	3.7	3.7	3.6	3.6	3.5
NIPF[b]	55.8	54.2	49.9	49.8	54.1	54.3	53.5	52.5	51.4	50.4
Total	81.2	78.7	74.9	74.6	80.5	80.7	79.8	78.8	77.6	76.6
North—										
Public	29.1	28..4	28.6	30.0	32.2	32.2	32.2	32.2	32.2	32.2
Forest industry	13.7	13.7	17.5	16.9	14.8	14.6	14.6	14.3	14.1	13.9
NIPF[b]	111.4	114.5	107.4	107.5	112.4	112.5	111.1	109.1	106.7	104.8
Total timberland	154.3	156.6	153.4	154.4	159.4	159.4	157.9	155.6	153.1	151.0

[a] Data were revised after the 1989 Resources Planning Act assessment tables were developed.
[b] American Indian lands are included exclusively in the nonindustrial private forest (NIPF) owner group for 1997 and projections. For 1987 and earlier years, these lands may be included in the other public owner group (Smith et al. 2001).
Note: Data may not add to totals because of rounding. Only private lands are modeled, and public timberland area is assumed to be constant in the future (Mills and Zhou 2003).

Common Ground was released in 1994 and set forth issues that people across the four-state region agreed on such as the need for improved education, good forest management practices, better local economies, control of inappropriate development, forest degradation, and fragmentation.

States such as Maine have funded purchases of some forest land. Throughout the Northern region, there is great interest in increasing the amount of forest land in public ownership (Lewis et al. 2002). This interest arises because of large urban population bases in the region and the lack, in many states, of existing public conservation lands. Environmental groups are promoting the creation of a national park in northern Maine and biodiversity reserve systems throughout the region. Voters in Maine and Michigan recently approved state ballot initiatives that provide funding for the acquisition of conservation lands.

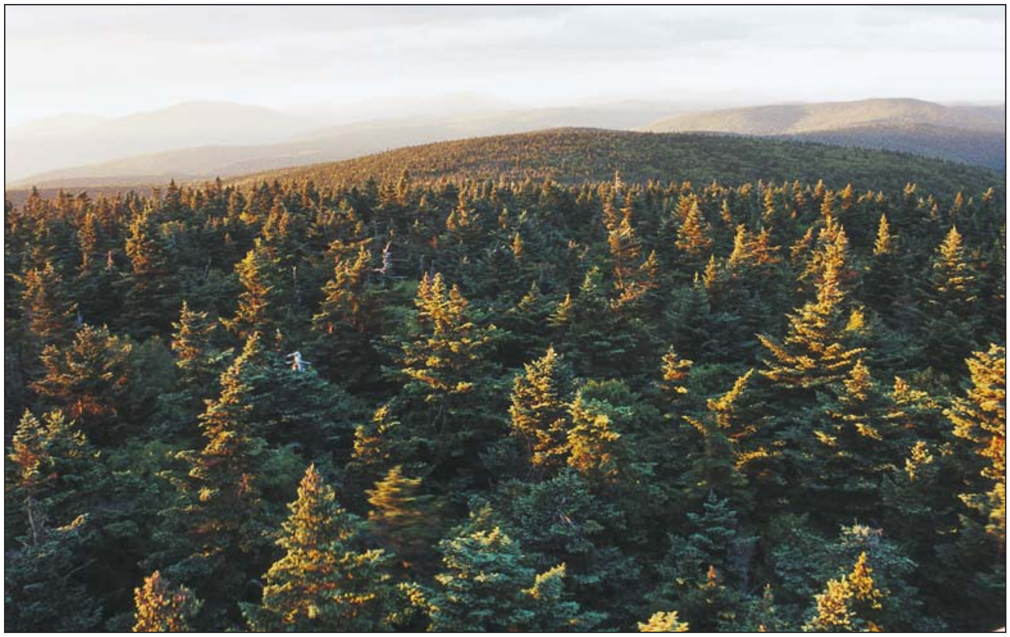

Figure 16—The Northern Woods in the Northeast contains relatively large blocks of forest land within driving distance of the heavily populated Northeast subregion. *Photo by David Lewis (Corvallis, Oregon)*

At the same time, land markets are dynamic. Timberland has been bought and sold for more than a century in the North Woods area, and more future sales appear likely. Land markets are sensitive to changes in forest product markets, and in the early 1990s, the sale of timberland to private investors was associated with a decline of the local pulp and timber market (Arnold 2003). Nearly 6 million acres of the Northern Forest have changed ownership in recent years, much of it in Maine, the Nation's most forested state. In fact, Arnold (2003) reports that one-quarter of the entire state of Maine has been sold in the past 4 years.

Land Use Situation

About two-fifths of the North is in forest use (fig. 17), with forest use a dominant land use (64 percent) in the Northeast in contrast to that for the North Central region (28 percent). Crop agriculture occupies about half of the land base in the North Central region (49 percent), about quadruple the percentage in the Northeast (12 percent). Special and other uses make up similar percentages in the Northeast (21 percent) and North Central (17 percent).

The Northeast is one of the most heavily urbanized parts of the United States, with 12 percent of land classified as "urban" by the National Resource Inventories (NRI) (USDA NRCS 2001). However, states in the Northeast are quite heterogeneous with regard to land use patterns. For example, Maine has 88 percent in forest cover and only 3 percent in cropland, whereas Delaware has 31 percent forest cover and 39 percent cropland. Just 2 percent of West Virginia is classified as urban, whereas 35 percent of New Jersey is so classified.

The North Central subregion has less of its land base classified as urban, 7 percent, compared to the Northeast. The North Central subregion contains the Corn Belt, with the states of Illinois, Indiana, and Iowa. Cropland is the dominant land use in this

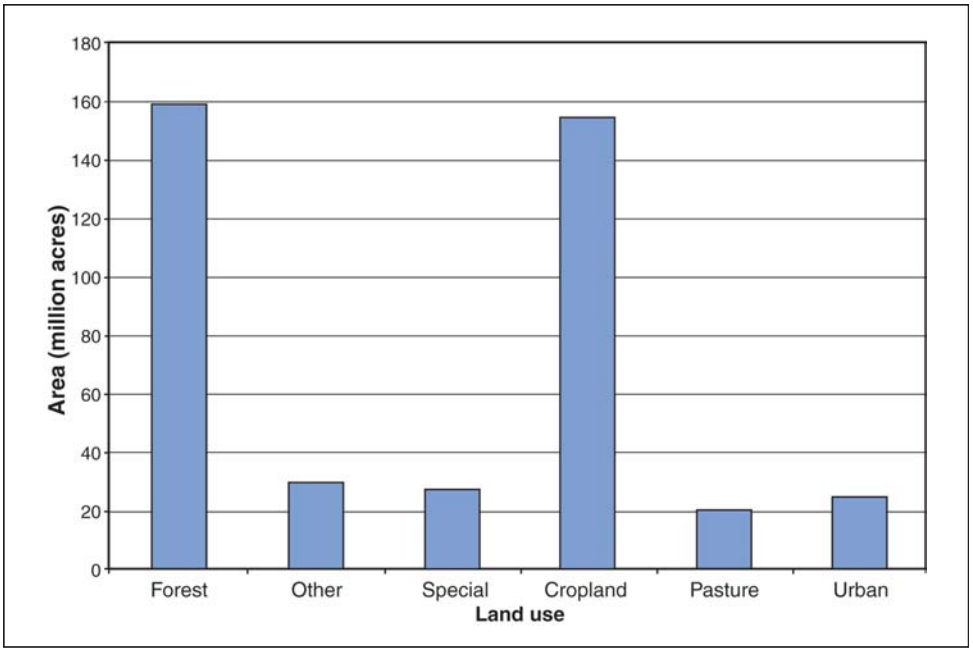

Figure 17—Area of major land uses in the North region, 1997 (USDA ERS 2000).

subregion. As in the Northeast, the states of the North Central subregion are quite heterogeneous with regard to land use patterns. For example, Iowa has 80 percent of its land base in cropland and 5 percent in forest. In contrast, Michigan has 24 percent in cropland and 48 percent in forest.

Figure 18 shows the historical records of areas of forest-use land, cropland, pasture-land, "special-uses" land, and urban land in this region, as classified by the USDA ERS (2000). Between 1959 and 1997, the net area of forest-use land in the region increased slightly, from 157.5 to 158.7 million acres. However, the area of forest use peaked in 1969 at 166.9 million acres. Over the historical period, areas in urban and special uses have increased. In particular, from 1959 to 1997, urban area increased from 13.0 to 24.4 million acres. Conversely, during the same period, the area of cropland decreased (from 163.1 to 154.1 million acres), and the area of grassland (pasture and range) dropped significantly from 40.6 to 19.9 million acres. The growth of urban and other special uses has come through a contraction of both cropland and grassland.

Areas of urban and developed uses steadily increased in both the Northeast and North Central subregions since 1982, when consistent NRI data were first assembled. Between 1992 and 1997, the area of urban and developed area in the Northeast increased from 10.4 to 11.9 percent of the land base. Corresponding increases in the North Central subregion were from 6.7 to 7.3 percent.

The Lake States contain some of the larger amounts of forest area in the North Central subregion, where second-home development is also noteworthy (Schmidt 2000). This includes a number of homes around lakes and other water-related sites. Between 1982 and 1997, developed area increased by 0.8, 0.5, and 0.4 million acres in the states of Michigan, Minnesota, and Wisconsin, respectively. Increases

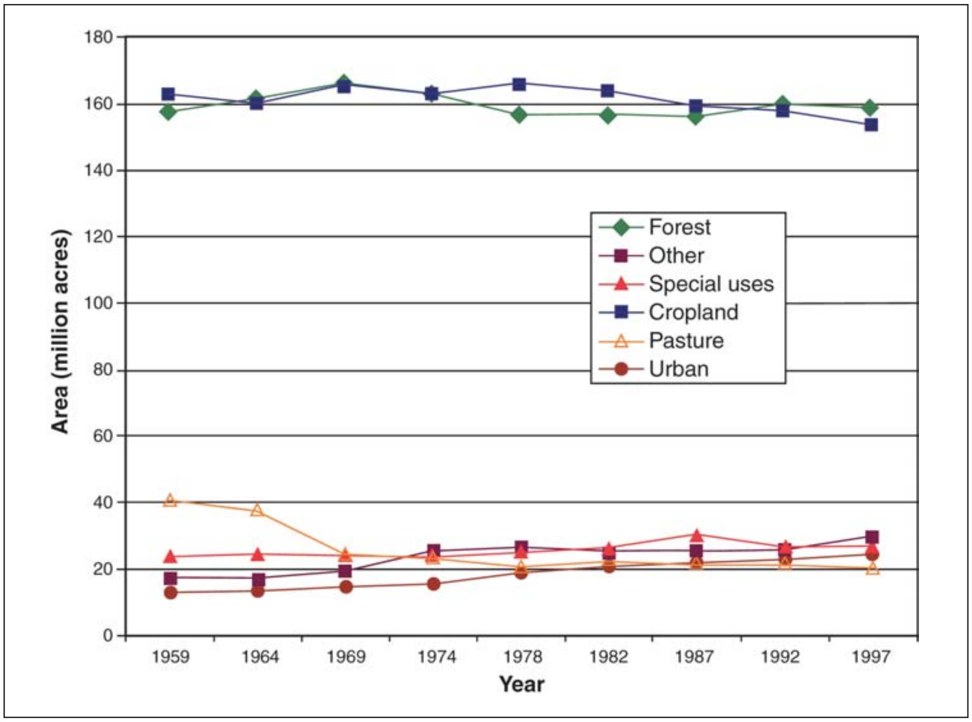

Figure 18—Area of major land uses in the North region, 1959-97 (USDA ERS 2000).

in developed area were larger than increases in forest land in each case. Forest area in Michigan, Minnesota, and Wisconsin increased by 0.6, 0.2, and 0.2 million acres, respectively.

Forest Land

The North contains 170 million acres of forest-land cover, as classified by the USDA Forest Service (Smith et al. 2001). For the North as a whole, forest area increased by 9.5 million acres between 1953 and 1997 (Smith et al. 2001). A large part of the increase in forest area was due to abandonment of pasturelands and other agricultural fields that reverted slowly to trees when dairy farms went out of business. Some also was due to reclassification in the forest resource survey (Smith et al. 2001).

Timberland

More than 90 percent of the forest land in the North is timberland, equal to 159 million acres (Smith et al. 2001). This percentage has fallen slightly over the past half century, from 94.9 percent in 1953 to 91.4 percent in 1997. We interpret this decrease as being accounted for by withdrawals of forested land from the timberland base for recreation, the conservation of biological diversity, and other purposes.

About half of the timberland is in the Northeast region, lies close to densely populated areas, and receives significant use from an array of forest users. Timberland in the Lake States receives similar pressures from Chicago and other urban areas.

In the Northeast, area of timberland increased from 1953 to 1987, then fell by about 1 million acres during the past decade (table 3, fig. 19). In the North Central region, the trends were essentially reversed (fig. 20). The amount of timberland declined

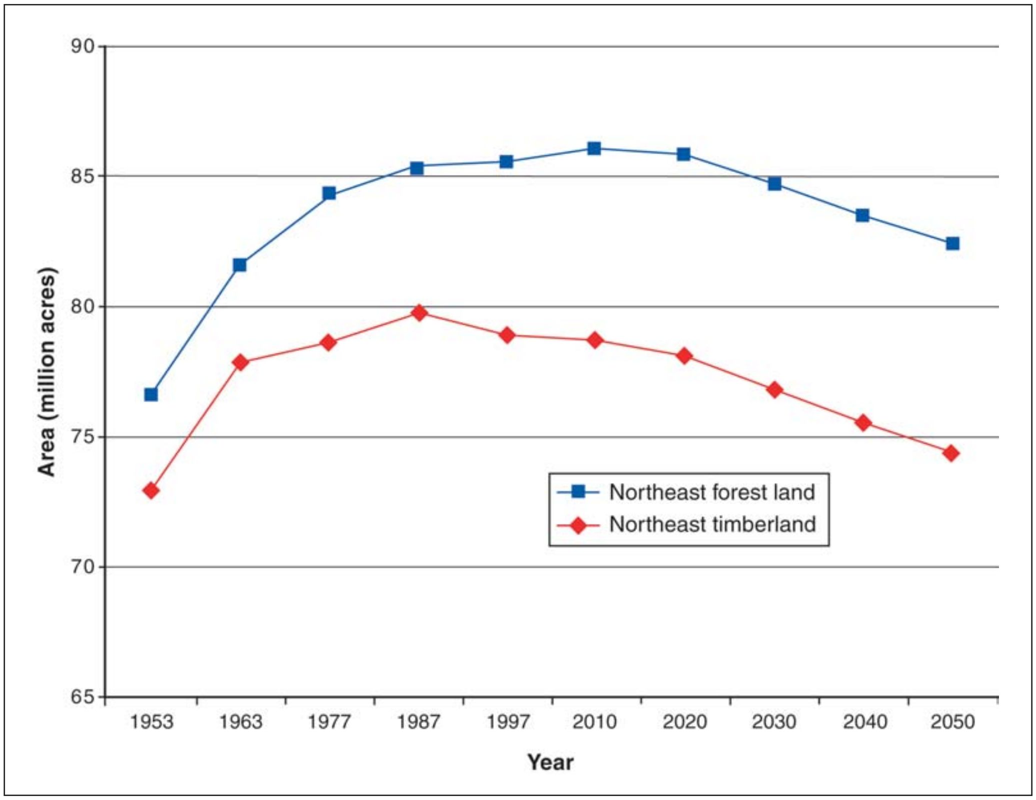

Figure 19—Historical and projected area of forest-land cover and timberland in the Northeast subregion, 1953-2050.

between 1953 and 1987, and then increased by 1997. The increase between 1987 and 1997 was largely on the nonindustrial private forest (NIPF) ownership, and secondarily on public lands that involved reclassification.

Ownership

Eighty percent of timberland in the North was privately owned in 1997. More than 88 percent of private timberland is in the hands of NIPF owners. These percentages are similar to those in 1953.

The percentage of private timberland is higher in the Northeast (88 percent) than in the North Central region (72 percent). However, NIPF owners in the North Central region hold a higher percentage of private timberland (93 percent) than those in the Northeast (84 percent).

Timberland Area Projections

The area projections of land uses for the North through 2050 are consistent with historical trends—forest and agricultural lands will decline, and urban and other land uses will increase. Timberland area projections for the North (table 3) are based on several studies and analyses, involving a blend of model-based and extrapolation methods, depending on the relative availability of data for a state or region (see “Appendix” for a description of the methods).

For the two subregions, area of forest land is projected to increase up to 2010, then decline slowly through 2050 (figs. 19 and 20). Timberland area follows a somewhat similar trajectory after leveling off between now and 2010. Total timberland for the North is projected to be 5 percent smaller in 2050 than in 1997.

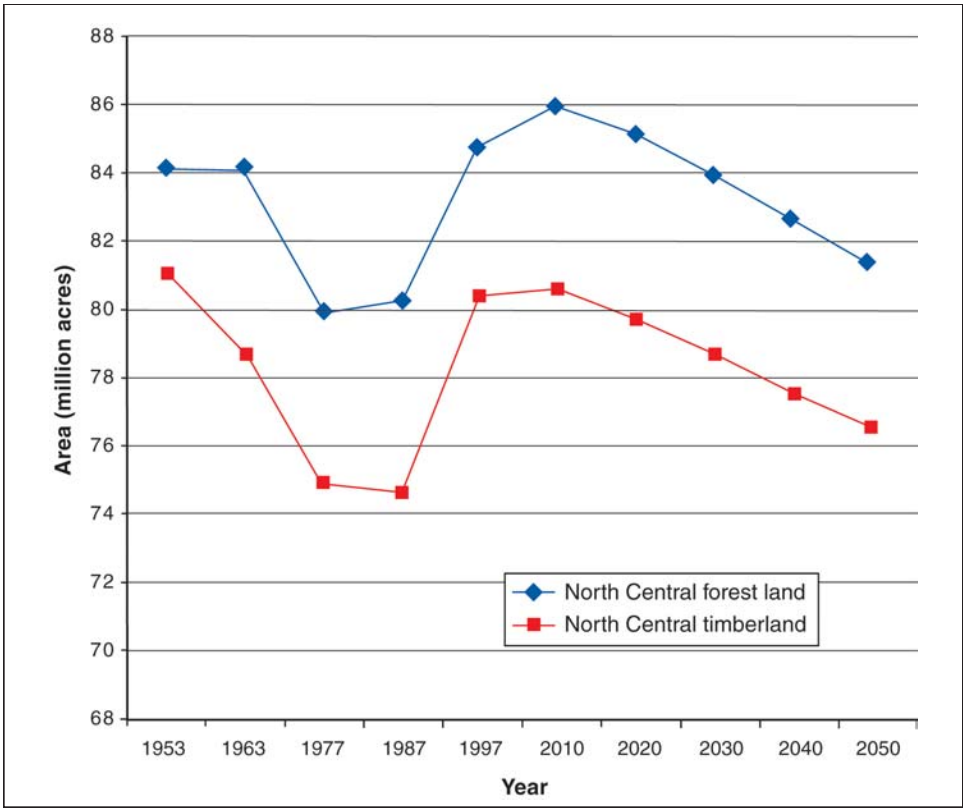

Figure 20—Historical and projected area of forest-land cover and timberland areas in the North Central subregion, 1953-2050.

As in most regions, population and personal income levels are projected to increase significantly in aggregate for the North. From 1945 until present, the population of the North grew steadily, and this growth is projected to continue through the next 50 years. Consequently, we expect the area of urban land in this region to grow steadily. Similarly, real per capita income for the region grew steadily over the period from 1960 until present, and this may reasonably be projected to continue. With per capita income positively correlated with developed area (e.g., Alig and Healy 1987), a projection of economic conditions indicates that the area of urban land should continue to increase.

Projected long-term loss of timberland area is driven by an anticipated continuation of the growth in area of "special-uses" land, and especially a continuation of the growth in area of urban land. As noted above, historically the growth of special-uses land appears to have come (in net) out of cropland and grassland. In the near future, we expect this pattern to continue, but in the longer run it seems likely that continued growth of special-uses land will increasingly erode forest-land area. Alongside a relatively small amount of grassland, a considerable amount of cropland is available for conversion to "developed" uses. However, the area of cropland in the region is much smaller than the area of forest land. We anticipate that the area of cropland will continue to decrease but at a slower rate. As grassland and cropland become more scarce, land conversion to special and urban uses will increasingly come from forest land.

For the North Central subregion, we project that the areas of forest land, total timberland, and NIPF timberland will continue to increase for the first few decades of the 21st century, and then begin a slow decline. The area of forest industry timberland is projected to fall very slowly throughout the next 50 years. Total private timberland area is projected to decline 7 percent by 2050. Land in forest industry ownership is projected to be 8 percent smaller, whereas NIPF land area declines by 7 percent.

Since the 1950s, the area of urban land in each of the Lake States more than doubled, while population has risen by over 50 percent. Population and urban expansion are projected to increase at a slower rate than in the past. Over the next 50 years, the Lake States population is projected to increase by approximately 6 to 8 percent every decade. Urban area is projected to increase at smaller rates for the Lake States.

Summary, North Region

The North is about two-fifths forested, and the area of forest cover increased by 9.5 million acres between 1952 and 1997 (Smith et al. 2001). A large part of the increase in forest area was due to abandonment of pasturelands and other agricultural fields that reverted slowly to trees when dairy farms went out of business. In 1997, 80 percent of timberland in the North was NIPF owned, 14 percent was public, and 6 percent was owned by forest industry. These shares have not changed markedly over the past half century. Land use change notably affects the NIPF ownership. Forest area is projected to increase up to around 2010 owing to net gains from agriculture. Forest area is projected to slowly decline thereafter to 2050. Timberland area is projected to be about 5 percent smaller in 2050 than in 1997. Population and income are expected to further fuel development in the region, leading to conversion of forest to nonforest uses.

The projected reduction in timberland area is less in the North Central subregion than in the Northeast subregion. In the near term, we expect the pattern seen in the North Central subregion in the last decade to continue: the area of forested land will increase, primarily through a reduction in cropland. In the longer run, however, we expect that the forces for the expansion of cropland and for expansion of forest land will reestablish an approximate balance. At that point, the continued expansion of special-uses land, driven by population and economic growth, will begin to force a contraction of both cropland and forest land. We do not project any significant changes in the shares of timberland in the different ownership classes during the next half century.

The Northeast is one of the most heavily urbanized parts of the United States, and a continued growth in area of special-uses land is projected. Continued growth of special-uses land would likely increasingly erode timberland area. About one-third of the private forest land is in ownerships greater than 500 acres, and about half of this belongs to owners who hold more than 10,000 acres of forest land. Most of these are forest-based industries or are groups that employ foresters and typically actively manage their forest lands. Concerns regarding forest fragmentation and the possible sale of some timberlands have increased interest in increasing the amount of forest land in public ownership or under conservation easements. The Northern Lands Study grew out of such concerns, with the objective of developing public policy alternatives to development in the Northern Forest spanning four northeastern states. The future of the region’s forests will be heavily influenced by private owners, who possess approximately 90 percent of the northeastern timberland.

Chapter 3: South Region

Introduction

The South includes 13 states of the Southeastern and South Central subregions (table 1). The area stretches from Virginia southward and westward along the Atlantic and Gulf seaboards to Texas, and includes the interior states of Arkansas, Kentucky, Oklahoma, and Tennessee. This region is characterized by a variety of climatic and edaphic conditions that relate to its diverse physiography (USDA Forest Service 1989a). The South covers portions of five physiographic divisions: the Atlantic Plain, the Appalachian Highlands, the Interior Highlands and Piedmont, Delta, and the Interior Plains. Elevations range from the coastal flats to mountains of the Blue Ridge province that have peaks over 6,000 feet. The climate ranges from subtropical with rainfall averaging 40 to 60 inches annually in parts of the coastal plains to more arid conditions in parts of the Interior Plains.

The South is heavily forested from Virginia to the forest's limit in Texas and Oklahoma. Forest land cover totals 214 million acres or 40 percent of the region's land area. Five of the Southern states are more than 60 percent forested. The Southeast is 60 percent forested, and most of the remaining states are at least 50 percent forested. The South Central subregion contains large parts of Texas and Oklahoma that are not forested, and overall, the South Central subregion is 32 percent forested. The fraction of forest land that is classified as timberland in the South has remained fairly constant at about 96 percent over the past half century, reflecting the inherent productivity of the forest-land base and the general availability of forest land for timber operations.

Land Use Situation

Given that two-fifths of the South is forested (fig. 21) and has some of the most commercially important timber species, such as loblolly pine (*Pinus taeda* L.), forestry and timber products support an important industry in the region. Land exchanges among sectors of the economy have been important in the South, which among regions has had a relatively large amount of land use change. Over the longer term, the most influential factor driving change in forest area was the expansion and contraction of the region's agricultural land base (Alig et al. 1986, 1988; Healy 1985). As the South was settled, agricultural land became an increasingly prominent part of the landscape. The associated reduction in forest area accelerated in the late 1800s with the harvesting of old-growth forests (USDA Forest Service 1988). Around 1920, increases in forest area began as agricultural land was abandoned. The rate of agricultural land abandonment

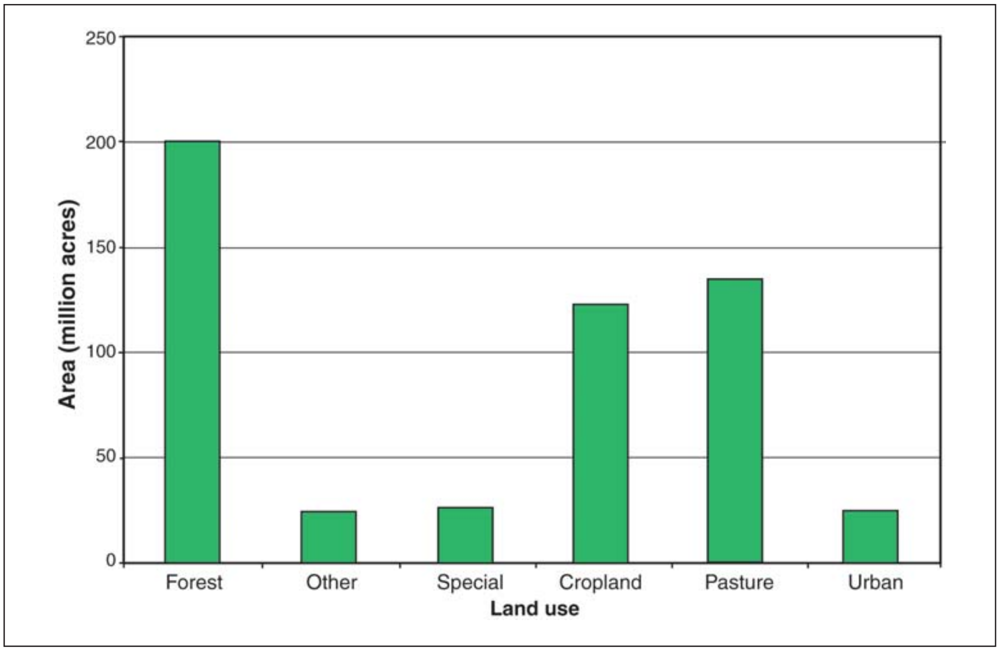

Figure 21—Area of major land uses in the South region, 1997 (USDA ERS 2000).

and succession to forest was especially high during the Great Depression years of the 1930s and after World War II. Much of the land reverting to forest on retired cropland and pasture was dominated by southern pine species (USDA Forest Service 1989a).

The South's proportion of the Nation's timber harvest also has increased significantly in recent decades (Wear and Greis 2002), and the prospects of forest-based profits are important incentives for many private landowners in the region. Simulations by Ahn et al. (2003) indicate that rising forest rents were the central factor preventing the loss of forest land to agricultural use in the South Central subregion from 1964 to 1997.

Although two-way flows of land between the forestry and agriculture sectors are important in the South, the rate of clearing of forests for urban and developed uses in the South accelerated during the last several decades and was of greater significance in overall land use change (e.g., Alig 1986, Alig and Wear 1992, Wear and Greis 2002). Both people and industry have migrated to the South in large numbers. Since the 1970s, most of the Southern states have experienced a net migration of people and increasing conversions of forests for living space, transportation infrastructure, and industrial sites.

Land Use Area Changes

Changes in agricultural area—Fluctuations in agricultural markets related to world-wide droughts, shocks in the energy sector (e.g., oil crisis of 1973), and other factors have resulted in notable shifts in cropland area over time and changes in national agricultural policy. Several cycles of downsizing and expansion in agriculture production occurred between 1959 and 1995 (fig. 22). Some world-wide droughts in the 1970s and 1980s led to world crop shortages. United States crop prices rose along with exports. Between 1972 and 1981, cropland area rapidly increased. Wheat acreage

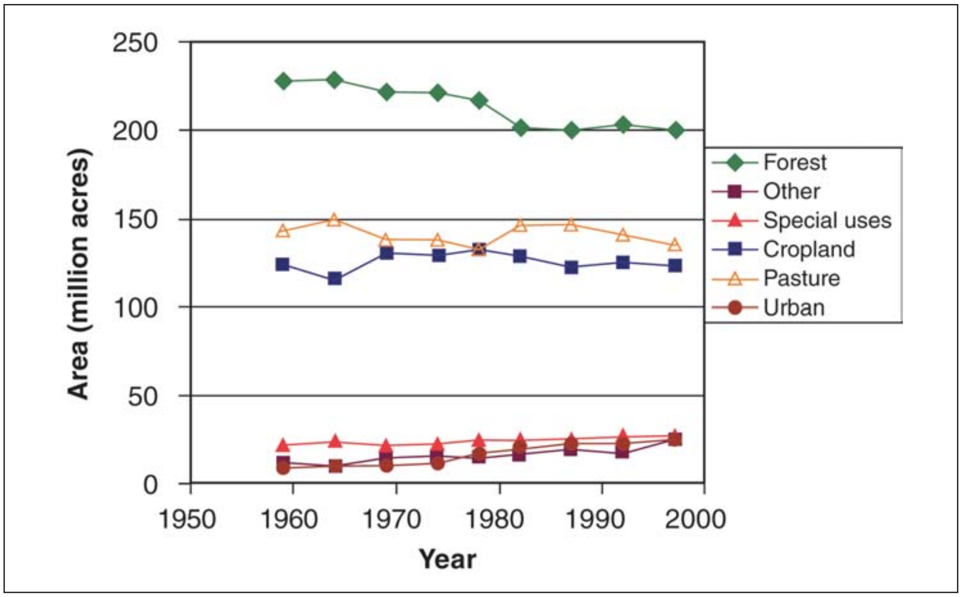

Figure 22—Area of major land uses in the South, 1959-97 (USDA ERS 2000).

increased nationally from 54 to 88 million acres, corn area increased from 64 to 84 million acres, cotton acres increased from 12 to 15 million acres, and soybean acreage increased from 43 to 71 million acres. In regions where there are large amounts of land with a forest-pasture-cropland interface, such as the Lake States, forest land declined during this period. However, the South has considerable acreage that is marginal for agriculture or not well suited for major U.S. field crops such as corn, soybeans, or wheat, and the region had only a slight drop in forest-land area during this period (Alig et al. 1998b).

The rate of cropland abandonment slowed noticeably during the 1960s; thus, fewer acres were available to add to the forest base. In a net reversal, forest clearing for new cropland and pasture increased over time. At first, much of the forest clearing was concentrated in the Mississippi Delta, where bottomland hardwood stands were cleared for soybean production. Later, during the 1970s and 1980s, concentrations of forest clearing for cropland spread more uniformly throughout the coastal plains of the South. Clearing of forests for pasture was mostly in the upland areas of the South.

Later in the 1980s, crop prices declined as agricultural stocks mounted owing to falling crop exports. Land again moved out of cropland, yielding a net increase in forest-land area. By 1987, 80 million acres of cropland were held idle nationally under various farm programs, with a significant amount in the South. Changes in world supply and demand for agricultural products led to land used for crops returning to the pre-1973 level of roughly 330 million acres nationally.

The agricultural policy environment contributed to the decline in cropland acreage during the downsizing from 1950 to 1972, the increase in cropland acreage during expansion from 1973 to 1981, and again the decline of cropland acreage during a downsizing period from 1982 to 1990. The agricultural policy of the downsizing periods

Figure 23—The area of planted pine in the South has increased more than 10 times since 1952, with some plantings subsidized through government programs.

recognized that resources had to be moved out of crop agriculture. The Conservation Reserve Programs (CRPs) of the 1956 Soil Bank legislation and the Food Security Act of 1985 were designed to shift cropland to grassland or forest cover (fig. 23). Such programs had the largest impacts on forestry in the South.

The passage of the Federal Agricultural Improvement and Reform Act of 1996 (FAIR96) represented substantial movement of the federal government away from direct involvement in farm commodity markets. The act phased in the elimination of target price and land retirement programs (except for the CRP). The absence of both the land retirement programs and the need to maintain crop base acreage to obtain government programs enables producers to choose among all potential agricultural production enterprises in the South (except for the production of fruits and vegetables). Thus, the link between land use patterns and market price was expected to be more dynamic as the need to maintain crop base was eliminated; however, actions by Congress since the 1996 farm bill have affected the initial objectives of that legislation, as will be discussed further in chapter 6, along with possible implications for forestry in the South.

Changes in developed area—The South has been experiencing relatively rapid population growth, especially around areas such as Atlanta, and this has led to deforestation and conversions to developed uses. The Southern Forest Resource Assessment (Wear and Greis 2002) identified urbanization as one of the primary threats to forests in the region.

The South has experienced rapid population growth, and the southern rural landscape in particular has changed in recent decades. As population increased, more land was needed for home sites, roads, airports, schools, commercial and industrial sites, parks, open space, and other uses to satisfy the demands of urbanizing areas. When urban areas expand into rural areas, competition for land in rural areas increases and the value of rural land rises (Reynolds 2001). The amount of land in urban and special uses increased more than 50 percent since the 1960s in the South. Land use data from the Natural Resource Inventory (NRI) indicate that during 1992 to 1997, 6 of the top 10 states that lost cropland, forests, and other open spaces to urban development were in the South. The states in descending order of amount converted are Texas, Georgia, Florida, North Carolina, Tennessee, and South Carolina (USDA NRCS 2001).

Within the South, most of the observed developed land and increase in developed uses was concentrated in the five states along the Atlantic Coast from Virginia to Florida. These states all had more than 7 percent of their nonfederal land in urban uses. These states plus Tennessee had the highest growth in the percentage of land in urban uses from 1982 to 1997 (USDA NRCS 2001). In these states, 3 to 6 percent of nonfederal land was developed over this period.

In the Southeast, the concentration of development has been in the area of the "urban Piedmont crescent," extending from Richmond to Atlanta. Within this area are the Interstate 85 and Interstate 40 corridors. This area has been the backbone of job growth in the Southeast, with an active manufacturing component. Many of the smaller cities are adjacent to larger urban areas, resulting in population concentrations in larger metropolitan areas. The urban areas of the Piedmont are likewise expected to witness the fastest growth, whereas the mountains and the coastal plain will experience most of their growth in nonmetropolitan areas.

Some key forested states are particularly affected by urbanization. Georgia has the most timberland in the country but now ranks third in rate of average annual development. Developed area in Georgia almost doubled between 1982 and 1997, growing from 7.0 to 12.3 percent of the state's nonfederal land base. The developed proportion in nearby Florida now approaches one-fifth of nonfederal land in the state.

The South had more counties reclassified as metropolitan in recent decades, similar to trends elsewhere in the United States. However, studies have found that the amount of urban land added per additional person is higher for nonmetropolitan than metropolitan counties. For example, Reynolds (2001) found that the amount for nonmetropolitan counties was more than double for metropolitan counties in north Florida.

The South is projected to experience above-average population growth over the next half century. In particular, the Southeast is projected to have a net loss of timberland, owing primarily to expanding urban and developed areas such as the Atlanta metropolitan area. In the larger South Central region, forest area could increase in the future if agricultural subsidies are reduced. Otherwise, increases in developed areas could lead to a net loss of forest area in the future as well.

Forest Land

Historical trends in southern area of forest cover by subregion are shown in figures 24 and 25 for the Southeast and South Central regions, respectively. The area of forest land in the South region peaked in 1963 and has slowly declined since then. Forest area in the South decreased by about 12 million acres or 5 percent between 1953 and 1997.

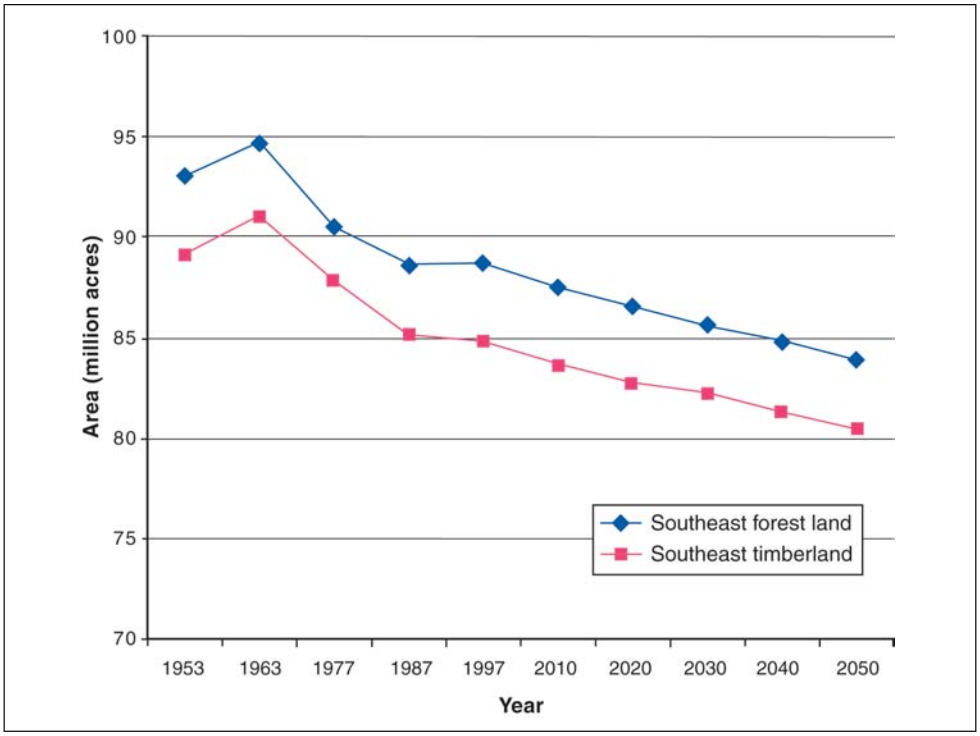

Figure 24—Historical and projected area of forest-land cover and timberland in the Southeast subregion, 1953-2050.

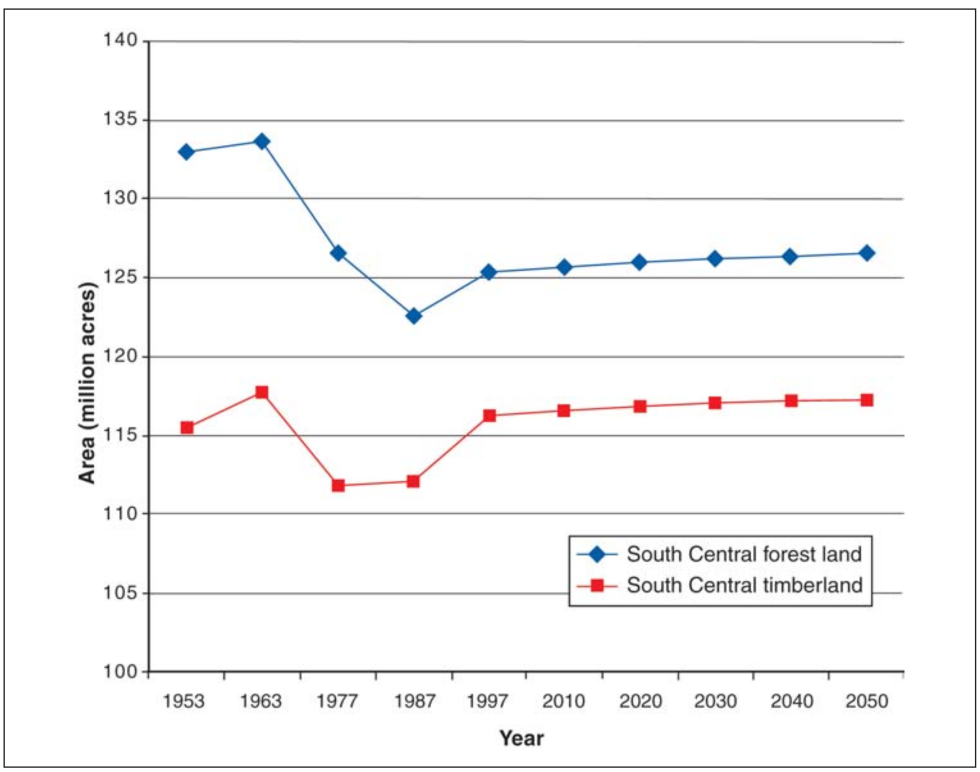

Figure 25—Historical and projected area of forest-land cover and timberland in the South Central subregion, 1953-2050.

Southern forests have undergone marked changes over the last century. A large area was cut over in the early part of the 20th century as timber harvesting attention shifted from the Northeast and the Lake States. Many forest acres were not actively regenerated, and many others were not protected from fire and livestock damage. With continued expansion of settlement and the harvest of timber, the area of cropland and pasture continued to increase, reaching a peak around 1920 (USDA Forest Service 1988). After that, the spread of the boll weevil (*Anthanamous grandis grandis* Boheman) and the agricultural depression of the early 1920s led to large areas of cropland and pastureland being idled. At the same time, because of uncontrolled fires and the lack of forestry programs, only part of the cutover and idle cropland and pasture came back to trees. Trees did regenerate in some areas, and the early 1900s marked the beginning of what was termed the South's "second forest" (USDA Forest Service 1988).

As the second forest was developing, concerns were growing among forest industry and the government about fires, lack of regeneration of large areas of cutover forests and idle croplands and pasture, and future timber supply prospects. Responses included (1) development of programs of fire protection, technical and financial assistance, research, and education; and (2) establishment of managed forests by the forest industry, the public sector, and other private firms and individuals (USDA Forest Service 1988). A large part of the cutover lands and idled cropland and pastureland regenerated naturally to pine, mixed pine-hardwood, and hardwood stands.

Later in the 20th century, relatively large investments by forest industry, other private individuals, and the government led to the development of a large timber inventory and an expanding forest area in the South (e.g., Alig 1985). The economic importance of forests continued to increase with the third and fourth forests of the South. In 1963, timberland area in the South reached a postwar peak but has since declined. Major causes of the decline in timberland areas have been clearing for cropland and pasture and continuing expansion of urban and other nontimber uses. In the late 1980s and early 1990s, about 90 percent of the CRP tree planting occurred in the South on private lands. This resulted in more than 2 million acres of afforestation on former cropland.

Forests in the U.S. South now provide more timber harvest than any other country (Wear and Greis 2002). Although hardwood types continue to dominate the forested landscape of the South, an increasing area of pine plantations has been an important part of the South's capability for providing a large share of the Nation's timber harvests (Alig and Butler 2002). At the same time, about three-fourths of the forests in the South have been naturally regenerated, and many areas provide wildlife habitat, watershed services, and other ecosystems services and goods.

The South's 63 million acres of pine forests continue to be a major source of softwood fiber for the world (USDA Forest Service 2001). Many natural pine stands are being replaced by managed pine plantations, especially on industrial lands (Alig 1985, Alig and Butler 2002, Alig et al. 2002). The loblolly-shortleaf pine (*Pinus taeda* L. - *P. echinata* Mill.) ecosystem is the South's prevalent pine ecosystem.

Timberland

More than 90 percent of the forest land in the South is classified as timberland. Timberland is capable of growing at least 20 cubic feet of industrial wood per acre per year and not reserved for other uses.[1]

Ownership

Trends in timberland area changes and land management can differ by ownership. Private owners control 90 percent of the timberland in the South, a total of 180 million acres (Smith et al. 2001). The remaining 10 percent is divided among public owners, including national forests, other federal, state, county, and municipal owners.

Private owners are divided into nonindustrial private forest (NIPF) and forest industry. The NIPF owners control 79 percent of total private timberland in the South. Approximately 5 million NIPF owners represent a highly diverse set of ownership objectives. In general, NIPF timberlands receive less active forest management than does forest industry timberland (Alig et al. 1990b). The NIPF lands are distributed relatively evenly across the region.

A growing part of the NIPF ownership is timberland investment management organizations. The class of miscellaneous corporate owners includes timber investment management organizations that tend to manage their timberland more intensively for timber production than the other private class and on average have a higher percentage of planted pine (Zinkhan 1993).

Forest industry controls 21 percent of the South's timberland. Forest industry stands are often concentrated on more productive sites with better stocking than NIPF stands. A much higher proportion of forest industry land is in intensively managed pine plantations (USDA Forest Service 1988). Forest industry's holdings are often either near a pulp mill or large sawmill, or situated on the more productive sites.

In 1997, about 72 percent of timberland in the Southeastern subregion was owned by NIPF, about 17 percent was owned by forest industry, and about 11 percent was publicly owned. The percentages of timberland in 1997 owned by NIPF, forest industry, and public owners in the South Central subregion are similar to those for the Southeast.

Timberland Area Projections

Total area of private timberland is projected to be reduced by 1.8 percent by 2050 (table 4). The forest industry area is projected to be reduced by 2.1 percent, whereas the NIPF area drops by 1.7 percent. In part, the larger industry percentage loss results from an assumed continuation of some lands being spun off or placed under "financial" ownership in line with recent trends. The movement of industry lands to miscellaneous corporate status (without processing facilities) would cause them to be placed in the NIPF class according to Forest Inventory and Analysis (FIA) definitions (see "Appendix" and "Glossary"). Such timberlands are likely to be managed in a manner intermediate between industry and other private lands.

The projected reduction in NIPF area for the entire South masks an increase for the South Central region (fig. 25) in contrast to the projected decline for the Southeast (fig. 24). We project that private timberland areas in the Southeast will decline by 6 percent over the next half century, with most of the loss on NIPF ownership (table 4). However, in contrast to the Southeast, the two private ownerships in the South Central

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[1] The South has more forest land that can produce 85 or more cubic feet of industrial wood per acre per year (91 million acres) compared to the Pacific Coast region with 44 million acres (Smith et al. 2001).

Table 4—Area of forest-land cover and timberland in the South, by ownership and subregion, specified years, 1953-97, with projections to 2050

Ownership/subregion	1953	1963	1977[a]	1987[a]	1997	Projections 2010	2020	2030	2040	2050
					Million acres					
Forest land:										
Southeast	93.0	94.7	90.5	88.6	88.7	87.5	86.6	85.6	84.8	83.9
South Central	133.1	133.7	126.6	122.6	125.4	125.7	126.0	126.2	126.4	126.6
Total forest land	226.0	228.4	217.0	211.1	214.1	213.2	212.6	211.8	211.2	210.5
Timberland:										
Southeast—										
Public	7.9	8.2	8.5	9.1	9.4	9.4	9.4	9.4	9.4	9.4
Forest industry	13.9	14.8	15.3	16.6	14.5	14.2	13.9	13.7	13.5	13.5
NIPF[b]	67.2	68.0	64.0	59.5	60.9	60.1	59.4	59.2	58.4	57.6
Total	89.1	91.0	87.8	85.1	84.8	83.7	82.7	82.2	81.3	80.5
South Central—										
Public	9.6	9.6	10.0	10.9	11.4	11.5	11.5	11.5	11.5	11.5
Forest industry	17.9	18.8	21.5	21.4	22.5	22.6	22.7	22.7	22.7	22.8
NIPF[b]	88.1	89.3	80.3	79.8	82.2	82.5	82.7	82.9	83.0	83.1
Total	115.5	117.7	111.8	112.1	116.2	116.6	116.9	117.1	117.2	117.3
South—										
Public	17.4	17.8	18.4	19.9	20.8	20.9	20.9	20.9	20.9	20.9
Forest industry	31.8	33.6	36.9	38.0	37.0	36.8	36.6	36.4	36.3	36.3
NIPF[b]	155.3	157.3	144.3	139.4	143.2	142.6	142.1	142.0	141.4	140.7
Total timberland	204.5	208.7	199.6	197.3	201.0	200.3	199.6	199.3	198.6	197.8

[a] Data were revised after the 1989 Resources Planning Act assessment tables were developed.
[b] American Indian lands are included exclusively in the nonindustrial private forest (NIPF) owner group for 1997 and projections. For 1987 and earlier years, these lands may be included in the other public owner group (Smith et al. 2001).
Note: Data may not add to totals because of rounding. Only private lands are modeled, and public timberland area is assumed to be constant in the future (Mills and Zhou 2003). The South here includes Kentucky in addition to the 12 states examined in the South's Fourth Forest Report (USDA Forest Service 1988).

subregion are projected to slightly increase their holdings of timberland. The total increase in private timberland area in the South Central subregion by 2050 is projected to be 1 percent (table 4).

Differences in population growth and economic activities contribute to the divergence in projected timberland area projections for the two southern subregions. About half of the U.S. population lives within coastal areas (50 miles from an ocean), and this holds true for the South as well, especially in fast-growing southeastern states such as Florida. Florida's growth in human population is part of the South's above-average growth compared to the national average over the last decade. The Southeast also has other fast-growing areas such as the Atlanta metropolitan area, with considerable conversion of forests to urban and developed uses. The Southeast has had larger reductions in timberland area during the past decade. The Southeast is expected to experience relatively fast population growth, with a larger percentage of increase in population by 2050, 65 percent, compared to 45 percent for the South Central subregion. The five southeastern states were each among the 12 fastest growing states between 1992 and 1997 relative to rate of urbanization (USDA NRCS 2001). The Southeast also is projected to continue to have higher per capita incomes than the South Central subregion.

The South Central subregion is more rural and is the likely location of most of any future net increases in timberland because of net gains from land exchanges with agriculture (e.g., Ahn et al. 2002, Wear and Greis 2002). The assumption about constant agricultural rents is crucial for the South Central projection of a slight increase in NIPF timberland area.

Compared to most other regions, timberland area in the South has historically been notably impacted by policies originating from concerns in other sectors, such as with agricultural surpluses. This may continue in some form in the future. For example, the South is often mentioned as having relatively large amounts of land suitable for tree planting to help mitigate global climate change (e.g., Birdsey et al. 2001). We will further discuss implications and uncertainty pertaining to such policy-related scenarios in chapter 6.

Summary, South Region

The South is about two-fifths forested, and the area of forest cover decreased by about 8 million acres between 1953 and 1997 (Smith et al. 2001). A large part of the decrease in forest area was due to conversion of forest to nonforest uses, as the South's population in recent decades has increased at rates above the national average. Approximately 90 percent of the forest land in the South is privately owned, with about 80 percent of that in NIPF ownership. Forest industry owns most of the remaining southern timberland acres, many of which are intensively managed. Forest area is projected to continue to decrease up to 2050, with timberland area projected to be about 6 percent smaller in 2050 than in 1997. Population and income are expected to further fuel development in the region, as population is projected to continue increasing at rates above the national average, leading to more conversion of forest to nonforest uses.

The projected reduction in timberland area is in the Southeast subregion, which has most of the region's population. There is a larger potential for agricultural land to shift to forest use in the larger South Central subregion. However, such land use shifts will be influenced by national farm programs, for which funding was recently increased for agricultural support payments and subsidies that may slow or reverse shifts from agriculture to forestry.

Chapter 4: Rocky Mountains Region

Introduction

The Rocky Mountains region consists of the Intermountain and Great Plains subregions (table 1). The region covers a vast area, about 742 million acres or about one-third of the entire Nation.

The region encompasses a variety of landforms and has diverse climatic conditions. Scenic landscapes of the Rocky Mountains stretch from the Canadian to the Mexican border, with plains rolling westward into the mountainous states. The Great Plains contain vast treeless areas and rangelands.

The Great Plains can have hot, dry summers and cold winters, especially in the northern tier of states (USDA Forest Service 1989a). Periodic droughts are not uncommon, and precipitation can be sparse. The Intermountain states also contain many dry areas, with extensive areas of arid desert in Arizona and New Mexico. Winters by and large are cold and dry, and summers warm to hot, where moisture is often the limiting factor for plant growth.

Land Use Situation

The Rocky Mountains region is nearly 50 percent (371 million acres) grassland, followed by 21 percent of the land base in croplands. Forests make up 16 percent of the land base and are mainly located in the Intermountain region. The "other" and "special" land uses have a combined land area of 100 million acres or 14 percent of the total land base.

The dominant land use in the Great Plains is cropland (58 percent), followed by grassland pasture or range (36 percent). Forests cover 2 percent of the subregion.

Grassland pasture and range (55 percent) dominate in the Intermountain region, followed by forests (21 percent). The region has a total of 143 million acres of forest cover, compared to only 5 million acres in the Great Plains.

Land Use Area Changes

Figure 26 shows the land use trends for the Rocky Mountains region between 1959 and 1997. Special land uses that include urban and developed areas have seen the most dramatic change since 1957, an increase of nearly 40 percent. This is coupled with a loss of 16 percent of the forested lands and 6 percent of the pasture and range lands. Pasture and rangelands and forest lands are typically the main sources of lands converted to developed uses. "Other" land uses have increased by 13 percent.

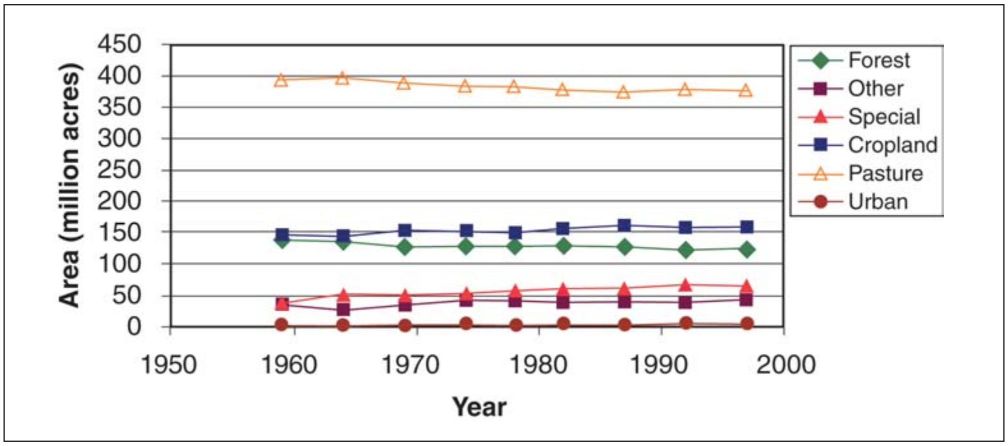

Figure 26—Area of major land uses in the Rocky Mountains, 1959-97 (USDA ERS 2000).

We examined historical land use changes for the Great Plains and the northern and southern portions of the Intermountain subregion, given the differences in climatic conditions for forests over the large area covered by the Intermountain subregion. The Great Plains subregion contains less than 1 percent of the Nation's timberland. Areas of land use changes involving forestry in that subregion have been relatively small, although area of forest use increased over the last decade after several decades of decline. Tree planting has increased, in part through programs such as the Conservation Reserve Program (CRP) and more attention to trees for use in windbreaks and some agroforestry projects.

The Northern Intermountain portion comprises the states of Idaho and Montana. Grassland is the dominant land use class (46 percent) in terms of area in the Northern Intermountain portion, followed by forest land (30 percent), cropland (16 percent), and special-uses land (8 percent).

In the past half century, the most conspicuous changes in the Northern Intermountain portion have been a decrease in the area of grassland (from 77 to 68 million acres), an increase in cropland (from 16 to 25 million acres), and an increase in the area of special-uses land (from 3 to 12 million acres). Urban land has grown considerably in percentage terms but remains a small fraction (about 0.3 percent) of the total land base. In contrast to these large changes, the area of forest land appears to have been essentially constant. The growth of the area of cropland and special-use land over the past half century has been accommodated principally (either directly or indirectly) by a reduction in the area of grassland.

The Southern Intermountain portion of the region comprises Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. Grassland is the dominant land use class (57 percent) in terms of area, followed by forest land (21 percent).

During the past half century, the most conspicuous changes in the Southern Intermountain portion have been a decrease in the area of grassland (from 288 to 260 million acres) and an increase in the area of special-uses land (from 27 to 48 million acres). Urban land has grown notably in percentage terms but remains a small percentage (about 1 percent) of the total land base. Historical trends in forest-land area

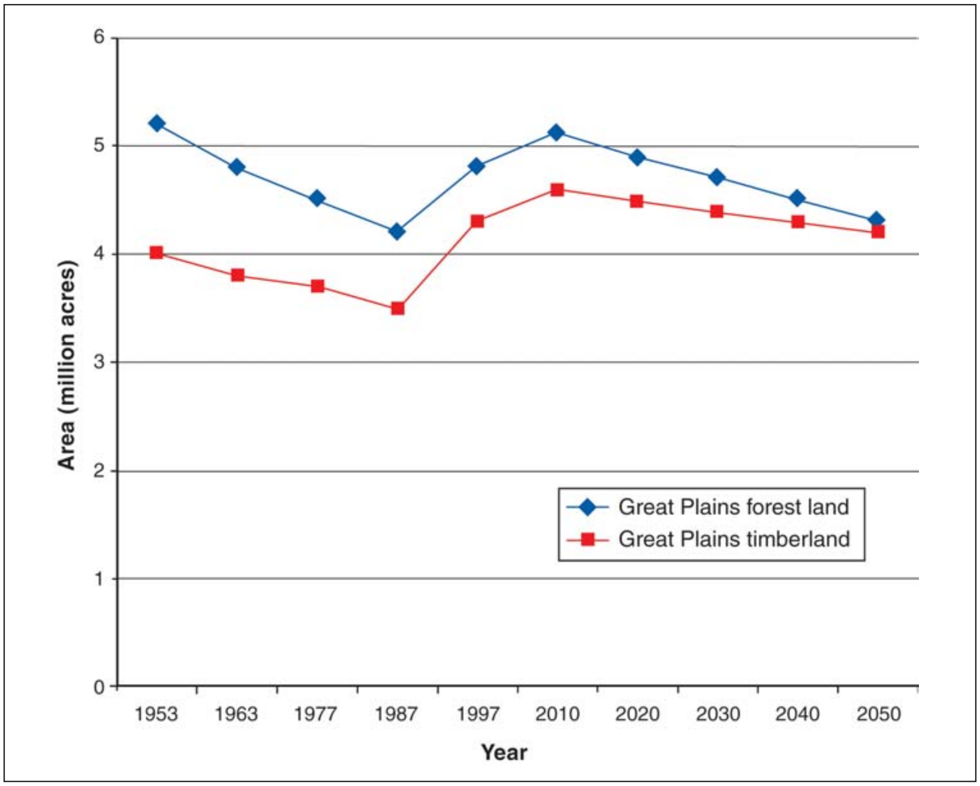

Figure 27—Historical and projected area of forest-land cover and timberland in the Great Plains sub-region, 1953-2050.

in the Southern Intermountain portion have the shape of a shallow "V," reaching a minimum in 1977. The increase in the area of forest land since 1977 is believed to be a result of ecological changes caused by a widespread policy of fire suppression (Johnson 1996). Historically, many areas in the Southern Intermountain portion were maintained as grassland by frequent naturally occurring fires. As a consequence, the policy of fire suppression resulted in the spread of forests into areas that historically had been grassland. Another consequence of a policy of fire suppression has been an increase in the density of some forests in the Southern Intermountain portion (Johnson 1996).

Forest Land

About half of the forest-land cover in the Rocky Mountains region is classified as timberland. The portion is lower in the southern part of the region, where only about one-third of the forest land in the Southern Intermountain portion is classified as timberland.

Net change in area of forest cover in the region is projected to be relatively small by 2050, less than 0.4 percent (table 5). This results in part from a small gain over the next decade in the Great Plains (fig. 27), where we project that forest area will increase by 0.3 million acres from 1997 to 2010. The increase is expected to result mainly from government programs that expand tree planting and natural succession to forests on agricultural land. As populations continue to grow, we project a decline of 0.8 million acres from 2010 to 2050. The forest area in 2050 is projected to be 10 percent smaller than in 1997.

Table 5—Area of forest-land cover and timberland in the Rocky Mountains region, by ownership and subregion, specified years, 1953-97, with projections to 2050

Ownership/subregion	1953	1963	1977[a]	1987[a]	1997	Projections 2010	2020	2030	2040	2050
					Million acres					
Forest land:										
Great Plains	5.2	4.8	4.5	4.2	4.8	5.1	4.9	4.7	4.5	4.3
Intermountain	136.3	135.6	133.7	135.4	138.4	139.3	139.3	139.1	138.6	138.1
Total forest land	141.6	140.4	138.2	139.6	143.2	144.3	144.2	143.8	143.2	142.5
Timberland:										
Great Plains										
Public	1.2	1.2	1.2	1.1	1.3	1.3	1.3	1.3	1.3	1.3
Forest industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NIPF[b]	2.8	2.6	2.4	2.4	3.1	3.3	3.3	3.2	3.0	2.9
Total	4.0	3.8	3.7	3.5	4.3	4.6	4.5	4.4	4.3	4.2
Intermountain—										
Public	45.3	45.8	39.4	40.3	48.6	48.6	48.6	48.6	48.6	48.6
Forest industry	2.2	2.2	2.1	2.9	2.9	3.0	3.0	3.0	3.0	3.0
NIPF[b]	15.1	15.0	15.0	14.4	15.1	15.2	15.2	15.2	15.2	15.1
Total	62.6	63.1	56.5	57.6	66.7	66.8	66.8	66.8	66.7	66.7
Rocky Mountains—										
Public	46.5	47.0	40.6	41.4	49.9	49.9	49.9	49.9	49.9	49.9
Forest industry	2.3	2.2	2.1	3.0	2.9	3.0	3.0	3.0	3.0	3.0
NIPF[b]	17.9	17.6	17.5	16.8	18.2	18.5	18.5	18.4	18.2	18.0
Total timberland	66.6	66.9	60.2	61.1	71.0	71.4	71.3	71.2	71.0	70.9

[a] Data were revised after the 1989 Resources Planning Act assessment tables were developed.
[b] American Indian lands are included exclusively in the nonindustrial private forest (NIPF) owner group for 1997 and projections. For 1987 and earlier years, these lands may be included in the other public owner group (Smith et al. 2001).
Note: Data may not add to totals because of rounding. Only private lands are modeled, and public timberland area is assumed to be constant in the future (Mills and Zhou 2003). The Rocky Mountains region includes the Great Plains states of Kansas, Nebraska, North Dakota, and South Dakota, in addition to the Intermountain States.

For the Intermountain subregion, area of future forest-land cover is projected to change in net by a relatively small amount (fig. 28, table 5). For the Southern Intermountain portion, we project that the area of forest land will increase slowly until 2020 and then begin to decrease. The fundamental assumption of this projection is that the policy of fire suppression will slowly give way to a more “natural” form of management, including more aggressive harvesting of small trees and an increased use of prescribed fires.

Area of forest-land cover in the Northern Intermountain portion is not expected to change significantly during the next 50 years. We have projected forest-land area in the Northern Intermountain portion as essentially constant at the 1997 level, with no significant net change.

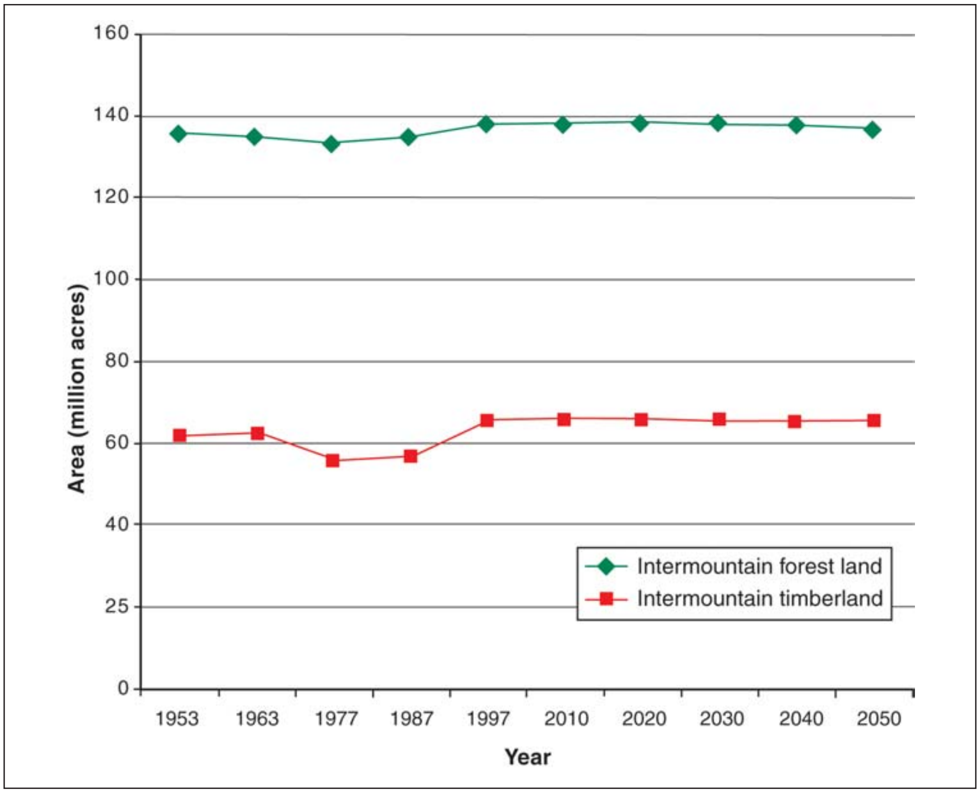

Figure 28—Historical and area of projected forest-land cover and timberland in the Intermountain subregion, 1953-2050.

Ownership

The majority of timberland (70 percent) in the Rocky Mountains region is in public ownership (table 5), with 94 percent of that on national forests. Private owners have 21.1 million acres of timberland, with 86 percent of that on nonindustrial private forest (NIPF) lands. These percentages have changed relatively little since 1953.

Timberland Area Projections

Timberland area in the Rocky Mountains region in 2050 is projected to approximate that in 1997 (table 5). Timberland area is projected to increase initially as forestry has a net gain from agriculture. However, in the longer term, population growth is projected to cause a net loss in timberland by 2050 as forest is converted to nonforest.

Projections by subregion are somewhat similar to those for the region. Basic assumptions of these projections are (1) the area of forest industry timberland in the Southern Intermountain portion remains essentially at its 1997 level of 25,000 acres, and (2) the ratio of NIPF timberland area to total forest-land area in the Southern Intermountain portion will remain at its 1997 level of about 9.5 percent.

For timberland in the Northern Intermountain portion, the area of NIPF timberland is not projected to change significantly in the next 50 years. We have projected NIPF timberland area as constant at the reported 1997 level of 6 million acres. We have projected forest industry timberland as increasing to a maximum of about 3 million acres in 2015 and then beginning a slow decline. This pattern is consistent with nationwide trends in the management of forest industry lands. There has been a movement to substitute "intensive" management practices for "extensive" timber holdings.

Figure 29—Second homes are increasingly found in scenic areas, including forested areas in the Rocky Mountains region.

The trend in “ranchettes” and subdivisions has been noted by some for the Rocky Mountains region (fig. 29). Inmigration of many residents desiring forested settings results in construction of primary or secondary homes in the forests. Although the amount of urban land in the Rocky Mountains is relatively small compared with the amount of forest land, having more people within the forested landscape will affect forest and timberland areas. The Rocky Mountains region also had the highest amount of developed area per additional person between 1992 and 1997 (Alig et al., in press; USDA NRCS 2001). Demographic changes and economic growth will continue to affect the distribution of people across the forested landscape, and thereby is a consideration in planning concerning the wildland-urban interface and wildfire risk.

Summary, Rocky Mountains Region

The Rocky Mountains region has about one-third of the country’s land area and is about one-fifth forested. Area of forest cover decreased by 1.6 million acres between 1953 and 1997 (Smith et al. 2001), including increasingly more land conversions in recent years for living sites as primary or secondary homes for inmigrants. In contrast to the East, only about 27 percent of the forest land in the region is privately owned, with more than 90 percent of that in NIPF ownership. Forest cover area is projected to increase for the next decade or so, then slowly decrease through 2050. Total timberland area for the region is projected to be essentially about the same in 2050 as in 1997.

Chapter 5: Pacific Coast Region

Introduction

The Pacific Coast region has three Forest and Range Renewable Resources Planning Act (RPA) subregions: Pacific Northwest consisting of Oregon and Washington, Pacific Southwest consisting of California and Hawaii, and Alaska (table 1). Latitude and environmental conditions vary widely across the region; e.g., boreal conditions of Alaska versus tropical conditions of the island state of Hawaii. Extremes of environmental conditions owing to the latitudinal differences are moderated in some areas and exaggerated in others, by influences of ocean currents, prevailing winds, and landform (USDA Forest Service 1989a). Annual precipitation varies across the region from 10 inches or less in the Arctic zone of Alaska's northern and western coastal plains to more than 150 inches in places in southern coastal Alaska and western Washington.

In the maritime zone are some of the tallest trees in the world, and the most productive coniferous forests in the Northern Hemisphere. The redwood belt of California, the spruce and hemlock forests of coastal Alaska, and the Pacific Northwest subregion west of the Cascade Range in Oregon and Washington are within the maritime zone (USDA Forest Service 1989a).

Growing conditions for forests vary widely within the region, as forests of eastern Oregon and eastern Washington and California are less productive on average than those in the maritime zone. The better sites, however, are quite productive, yielding high-quality ponderosa pine (*Pinus ponderosa* Dougl ex Laws.), western larch (*Larix occidentalis* Nutt.), true fir (*Abies* spp.), and inland Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) (USDA Forest Service 1989b).

The most important forest type, in terms of timber production, in the region is Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Douglas-fir is the major type in western Oregon and Washington (fig. 30), where it occupies about 60 percent of the forest area. Examples of other forest types that cover more than 10 million acres in a subregion are fir-spruce in Alaska and western hardwoods in the Pacific Southwest (Smith et al. 2001).

Figure 30—Douglas-fir is the dominant forest type in western Oregon and Washington, which contains some of the most productive forests in the world.

Land Use Situation

The Pacific Coast region has 57 percent of its land in special uses and miscellaneous other land uses, with most of the rest in forest use (fig. 31). About 29 percent of the region's land is allocated to forest use, as classified in the Major Land Use Series (USDA ERS 2000). By subregion, the forest-use percentage varies from 24 percent in Alaska to 43 percent in Oregon. The environmental conditions differ considerably across the broad region, which stretches over a wide spectrum of latitudes.

Urban and developed uses make up 4 percent of California and 3 percent of Oregon and Washington combined. This region has experienced above-average growth in population, with many residents living along the coastal areas of the states or near the Interstate-5 corridor.

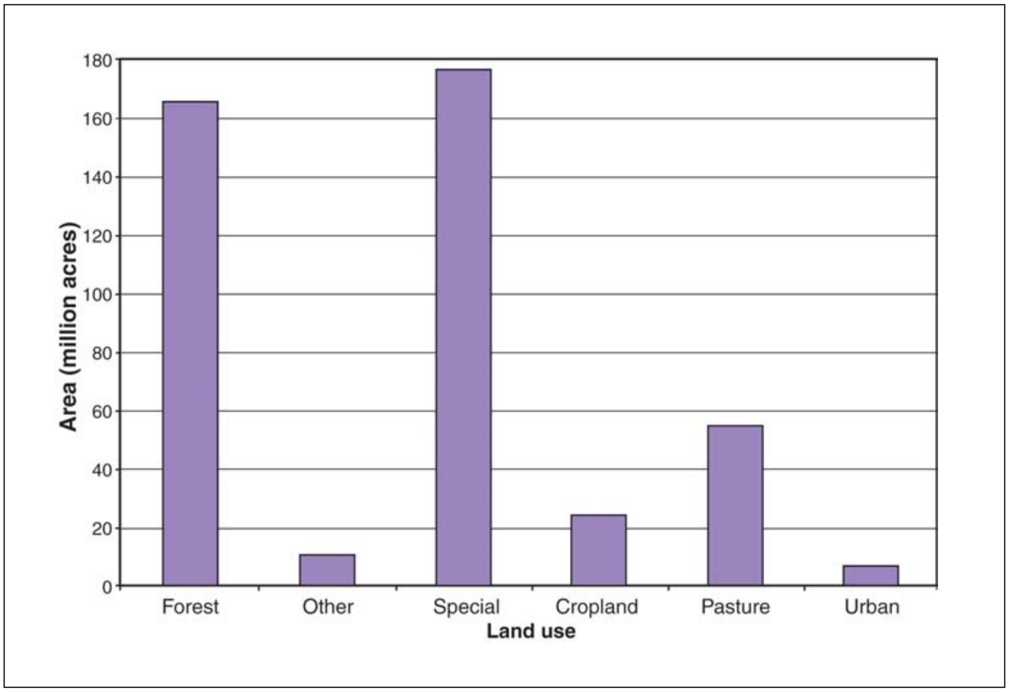

Figure 31—Area of major land uses in the Pacific Coast region, 1997 (USDA ERS 2000).

Forest-land cover occupies 38 percent of the Pacific Coast region, based on Forest Inventory and Analysis forest survey estimates (Smith et al. 2001). By state, this ranges from 35 percent of Alaska to 51 percent of Washington.

Timberland makes up about one-third of forest land in the region. This varies from 10 percent in Alaska to 80 percent in the Pacific Northwest, and 46 percent in the Pacific Southwest. Much forest land in Alaska does not meet productivity standards for timberland.

The largest percentage of change for a major land use in the three contiguous Pacific Coast States (California, Oregon, and Washington) was the 262-percent increase in urban area between 1960 and 1997. Most of that developed area is in California, where it increased 252 percent. Urban areas in Oregon and Washington increased 255 and 325 percent, respectively. Urban area as a percentage of total land also varies notably by state: 5.9 percent for California, 3.2 percent for Washington, and 1.0 percent for Oregon (Vesterby and Krupa 2001).

Forest use is the dominant land use class in California in terms of area, followed by grassland. The area of cropland slightly exceeded the area of special-uses land in 1945, but by 1992 the area of special-uses land exceeded the area of cropland by a considerable amount. Between 1938 and 1997, the area of forest land in the Pacific Southwest subregion decreased by 20 percent, from 48 to 38 million acres. During the period from 1945 to 1997, (1) the area of special-uses land increased by 110 percent (from 10 to 21 million acres), (2) the area of urban land increased by 293 percent (from 1.5 to 5.9 million acres), (3) the net area of cropland stayed around 11 million

Table 6—Area of forest-land cover and timberland in the Pacific Coast, by ownership and subregion, specified years, 1953-97, with projections to 2050

Ownership/subregion	1953	1963	1977[a]	1987[a]	1997	Projections: 2010	2020	2030	2040	2050
					Million acres					
Forest land:										
Alaska	129.1	129.1	129.1	129.0	127.4	126.1	125.1	124.1	123.1	122.1
Pacific Northwest	54.1	53.8	53.0	49.9	51.6	50.9	50.4	49.9	49.3	48.8
Pacific Southwest	44.5	44.5	42.1	41.1	40.3	39.3	38.5	37.7	36.9	36.2
Total forest land	227.8	227.4	224.2	220.1	219.3	216.3	213.9	211.6	209.4	207.1
Timberland:										
Alaska—										
Public	20.1	19.7	19.2	9.6	8.6	8.6	8.6	8.6	8.6	8.6
Forest industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NIPF[b]	0.3	0.4	0.6	6.2	3.8	3.3	3.0	2.9	2.8	2.8
Total	20.3	20.1	19.7	15.8	12.4	11.9	11.7	11.5	11.4	11.4
Pacific Northwest—										
Public	22.9	23.4	22.4	20.7	23.6	23.6	23.6	23.6	23.6	23.6
Forest industry	9.0	9.4	9.8	9.7	9.1	8.9	8.9	8.8	8.8	8.8
NIPF[b]	12.9	11.7	9.9	8.6	8.5	8.2	8.0	7.9	7.9	7.8
Total	44.9	44.5	42.1	38.9	41.2	40.7	40.5	40.3	40.2	40.2
Pacific Southwest[c]—										
Public	9.4	9.8	9.0	9.5	10.9	10.9	10.9	10.9	10.9	10.9
Forest industry	2.2	2.4	2.7	2.8	3.0	3.1	3.1	3.1	3.1	3.0
NIPF[b]	6.6	6.0	5.6	5.2	4.8	4.4	4.2	4.1	3.9	3.9
Total	18.2	18.3	17.3	17.4	18.7	18.4	18.2	18.0	17.9	17.7
Pacific Coast—										
Public	52.4	52.9	50.5	39.7	43.0	43.0	43.0	43.0	43.0	43.0
Forest industry	11.2	11.9	12.5	12.5	12.1	12.0	12.0	11.9	11.9	11.8
NIPF[b]	19.8	18.1	16.0	19.9	17.1	15.9	15.3	14.9	14.6	14.5
Total timberland	83.4	82.9	79.1	72.1	72.2	71.0	70.3	69.9	69.6	69.3

[a] Data were revised after the 1989 Resources Planning Act assessment tables were developed.
[b] American Indian lands are included exclusively in the nonindustrial private forest (NIPF) owner group for 1997 and projections. For 1987 and earlier years, these lands may be included in the other public owner group (Smith et al. 2001).
[c] Includes California and Hawaii.
Note: Data may not add to totals because of rounding. Only private lands are modeled, and public timberland area is assumed to be constant in the future (Mills and Zhou 2003).

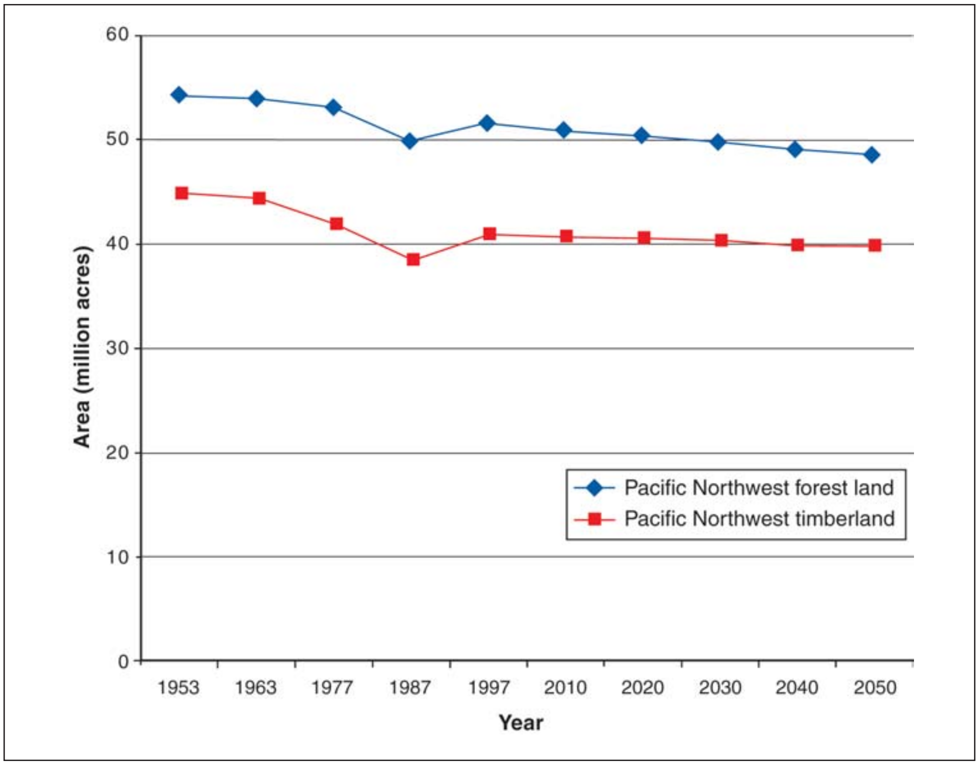

Figure 32—Historical and projected area of forest-land cover and timberland in the Pacific Northwest subregion, 1953-2050.

acres, and the area of grasslands decreased slightly (from 23 to 22 million acres). The “forest land” and “special-uses” classifications are not mutually exclusive on the ground, as there is some special-use forest land, which is placed in the special-uses category here. The area decrease for the forest land category is consistent with the growth of special-uses land, especially parks and wildlife areas.

Across the Pacific Coast region, total cropland and pastureland areas have shown small decreases from 1953 to 1997. Overall, pasturelands decreased by 5 percent, and cropland decreased by 8 percent.

Forest Land

Total area of forest cover in the region decreased by 8.5 million acres or 4 percent between 1953 and 1997 (Smith et al. 2001). Forest area declined in all five states in the region, with the largest reduction in California (4 million acres).

Forest-land area is projected to decline by 6 percent between 1997 and 2050 (table 6). Reductions are projected in all three subregions. For example, we project that the area of forest land in the Pacific Northwest subregion will continue to decrease slowly (fig. 32). Although the populations on both sides of the crest of the Cascade Range have grown considerably over the past 50 years, most of the major population centers of Oregon and Washington are on the west side.

In 1990, less than 20 percent of the population of the Pacific Northwest lived on the east side, although that side is considerably larger in area. Similarly, in 1990 average per capita personal income on the east side was 85 percent of the average per capita

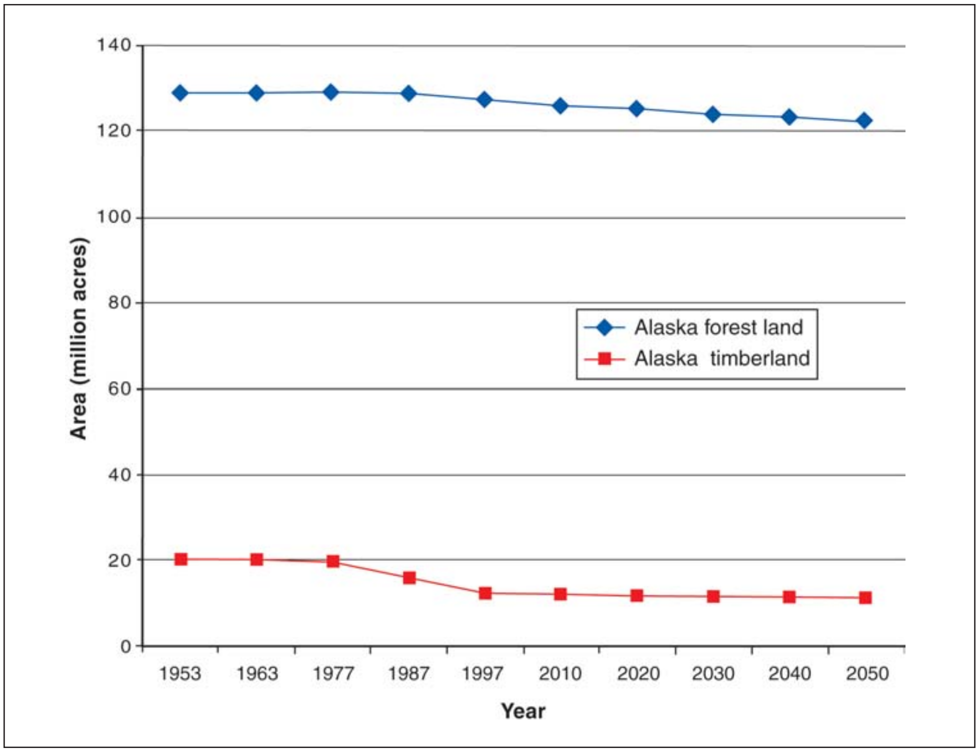

Figure 33—Historical and projected areas of forest-land cover and timberland in the Alaska subregion, 1953-2050.

personal income of the entire Pacific Northwest. Thus, we project less change in area of private timberland for the east side when compared to the west side.

Ownership

The majority of timberland (60 percent) in the Pacific Coast region is in public ownership, with most on national forests. Private owners have 29 million acres of timberland, with most on nonindustrial private forest (NIPF) lands. Forest industry in the Pacific Coast region owns the highest percentage of private timberland (41 percent) across any RPA region, although the 12 million acres of their timberland is only about one-third of that in the South.

In the Pacific Northwest (Oregon and Washington), currently more than 23 million acres (57 percent) of the timberland in these two states are publicly owned. More than 8 million acres (21 percent) are NIPF land, and 9 million acres (22 percent) are industrial private land (table 6). The Pacific Northwest has experienced relatively rapid declines in privately owned timberland area in recent years. For example, Pacific Northwest privately owned timberland area decreased by nearly 10 percent since 1980, roughly from 19 to 17 million acres.

Timberland

Timberland area is projected to drop from 72 million acres in 1997 to 69 million acres by 2050, a 4-percent reduction (table 6) (Kline and Alig 2001).

Timberland Area Projections

The reduction is mostly on the NIPF ownership. About 90 percent of the projected total loss of 3 million acres will be on NIPF lands. Historically, the NIPF timberlands have been the most affected by population growth (Kline and Alig 1999), and this is projected to continue in a region expected to experience above-average population growth.

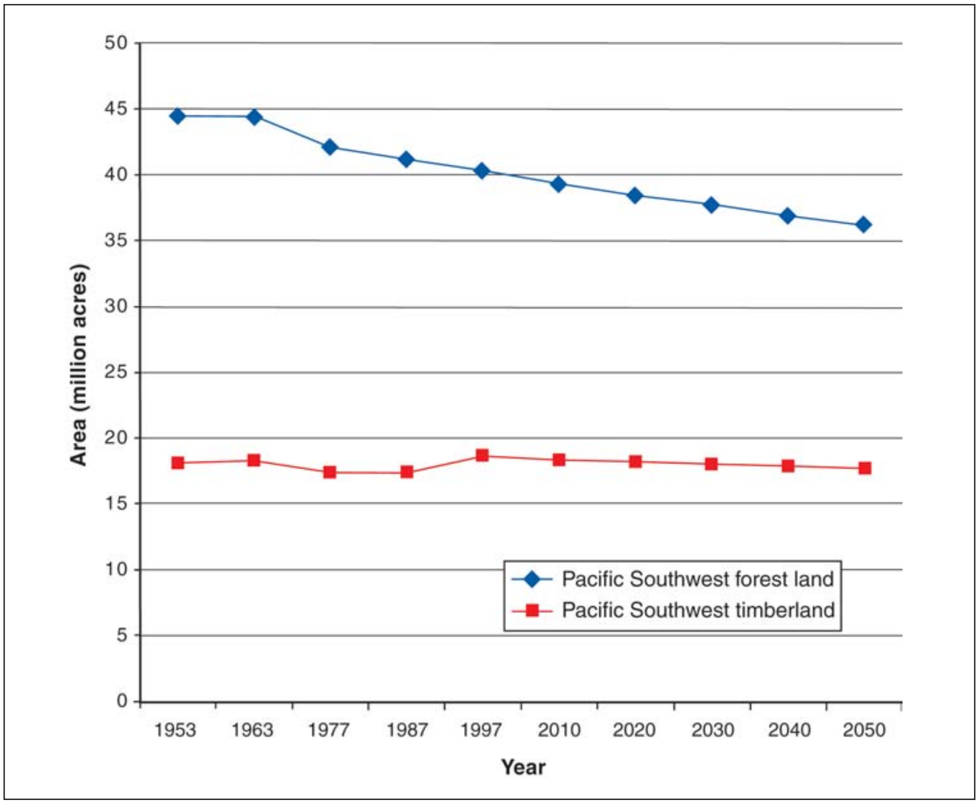

Figure 34—Historical and areas of projected forest-land cover and timberland in the Pacific Southwest subregion, 1953-2050.

The reduction in Pacific Coast timberland is also fairly evenly spread across the three subregions. Each subregion is projected to have a timberland area loss of about 1 million acres between 1997 and 2050 (table 6, figs. 32 through 34).

The Pacific Northwest subregion has distinct ecosystem zones: east and west. Areas of land in forest and farm uses in the west side of the Pacific Northwest subregion are projected to decrease as they are converted to urban land uses. Projected reductions in areas of forest land from the base year 1997 to 2050 are 1 percent in western Oregon and 1 percent in western Washington (Kline and Alig 2001). From 1997 to 2050, areas of timberland in western Oregon and western Washington are projected to decrease 0.3 and 0.0 percent for forest industry timberland and 1.8 percent and 2.5 percent for NIPF timberland, respectively.

Area of NIPF timberland in the east side of the Pacific Northwest subregion is projected to fall to about 3.1 million acres by 2050, less than the reduction between 1953 and 1987. However, a large proportion of the historical drop was due to the sale of tribal timberlands to the national forests and other public agencies. Because tribal lands are classified as NIPF, this sale increased the area of public timberland while decreasing the amount of NIPF timberland. The sum of public and NIPF timberland acreage did not change dramatically during this period.

The area of forest industry timberland in the east side of the Pacific Northwest subregion rose slowly but steadily from 1952 to 1987, but fell from 1987 until 1997. We believe that this reported decline is real and reflects some nationwide trends in forest industries. Specifically, forest industries are moving away from an “extensive” form of management toward an “intensive” form. That is, they are decreasing the number of acres of timberland they own but managing their timberland more intensively. We project that the area of forest industry timberland for this eastern part of the subregion will fall to slightly more than 1.9 million acres by 2050.

For the Pacific Southwest subregion, we project a continued decrease in the area of forest land cover, with a 5-percent reduction between 1997 and 2050. California has most of the timberland in the subregion, 18.0 million acres, compared to 0.7 million acres in Hawaii. Both states are projected to have reductions in future timberland area, with most of that on NIPF lands.

Most of the land that has been developed in the subregion over the past 50 years has come from forest land cover, either directly or indirectly. We project forest area to decline as the area of developed land continues to increase. This would largely follow historical trends.

The projection of a continued decrease in the area of forest-land cover in the Pacific Southwest subregion is reinforced by projections of population and per capita personal income for the subregion. California is expected to share in the above-average population growth in the West shown in figure 8. Between 1945 and 1990, California’s population tripled from 9.3 to 30.2 million. California is now the most populous state in the United States, and its population is projected to increase another 70 percent between 1997 and 2050. With 93 percent of its population living in urban areas, California is also the most heavily urbanized state in the union. With increases in urbanized area expected in line with the population projection, this implies a continued decrease in forest-land area.

Per capita personal income in California also has grown steadily over the past 50 years, and it is reasonable to suppose that this growth will continue. With per capita income positively correlated with developed area, the projection of economic conditions implies that forest land area in the Pacific Southwest will continue to decrease.

For Alaska, we project a decline in timberland area of about 1 million acres by 2050, or about an 8-percent reduction. This reduction is in the NIPF ownership. Alaska has over 127 million acres of forest land, but most is categorized as less productive “other forest” land. Alaska currently has 12.4 million acres of timberland, of which over 8 million acres (70 percent) are publicly owned and less than 4 million are nonindustrial private land. Alaska timberland area historically has fluctuated owing to revisions in forest productivity estimates used to categorize forest land into timberland and other forest categories. In the past, there also have been large shifts between ownerships, but we project only relatively small ownership changes over the projection period.

Summary, Pacific Coast Region

The Pacific Coast region is about two-fifths forested, and timberland as a percentage of total forest is the lowest (33 percent) among regions. About two-thirds of the forest land in the region is publicly owned, with about 80 percent of that in federal ownership. Area of forest in the region decreased by about 8.5 million acres between 1953 and 1997 (Smith et al. 2001). A large part of the decrease in forest area was due to conversion of forest to nonforest uses as a result of the region's population increase, which in recent decades has been increasing faster than the national rate.

Forest cover area is projected to continue to decrease through 2050, with timberland area projected to be about 6 percent smaller in 2050 than in 1997. Forest area is projected to decline in all three subregions. Population and income are expected to further fuel development in the region, as population is projected to increase at rates above the national average, leading to more conversion of forest to nonforest uses.

Chapter 6: Land Use in the 21st Century—Influences of the Policy Environment and Technological Changes

Introduction

In this chapter, we discuss in more depth certain key variables, such as technology and institution-related variables, which are involved in key assumptions and influence land use projections. Cropland, forest land, and grassland can compete for the same land base and are all subject to conversion to developed uses. Outcomes of this competition may be influenced by public policies and government regulations seeking to enhance certain services as urban populations and demands for environmental services, such as clean water and wildlife habitat, increase. In addition, technological developments (e.g., genetic improvements in planting stock) are difficult to forecast and may likewise affect land use outcomes through impacts on agricultural and forest productivity and other aspects.

Policies

Political and social institutions affect policy outcomes regarding land use in the United States, where millions of acres of land shift uses each year (USDA NRCS 2001). Land use changes in the United States result from billions of choices made by individuals, corporations, nongovernmental organizations, and governments. Utilization of the land resource by private owners is affected by diverse production and consumption activities, including urban growth and development, crop and livestock production, and timber production, in addition to policies. Responses of private owners to natural resource policies can markedly influence the outcomes of policies (e.g., Alig et al. 1998a). An example is how land use allocations on private lands are affected by public land policies, illustrated by Adams et al. (1996) in the case of public timber harvest levels. Reduced timber harvesting on the national forests, primarily in the Western United States, could affect private decisions to convert agricultural land to forests in the South (Alig et al. 1998a). Sohngen et al. (1999) also point out the international land use implications of conservation policies in the United States. Their study examined the future of global timber markets, and it suggests that forest conservation efforts in North America and Europe could lead to increased deforestation in tropical forests. As supply decreases through increased conservation efforts in North America, timber prices will rise, making it economically feasible to harvest trees from areas where it was previously too expensive.

With respect to policies, a recent national example of how the political system addressed market failure by the passage of legislation affecting land use is the 2002 farm bill. Although the farm bills of the past have in part addressed overproduction in agriculture and income support, environmental aspects have increasingly been addressed by legislation since 1970 (Plantinga and Ahn 2002, Portney 1978). Growing attention to interactions between the economy and the environment has included policies that regulate or constrain the economy so that production and consumption will fall within environmentally acceptable limits. Private land use decisions often give rise to significant external costs such as nonpoint source pollution, and external benefits such as habitat for wildlife. One role of land use policies is to narrow the divergences between privately and socially optimal land allocation by modifying the economic incentives faced by private landowners (Plantinga and Ahn 2002). Policies in the 2002 farm bill are designed to increase the relative net returns to land in socially desired uses, including by encouraging landowners to convert their land to the desired use as in promoting Conservation Resource Programs (CRP) afforestation or policies encouraging landowners to retain land in a desired use such as wetlands.

In our baseline projections, we froze in place current policies that affect land use. Next we will consider different types of policies that could change in the future, and alter economic incentives that affect the behavior of millions of decisionmakers that own or manage the Nation's land base.

Agricultural Policies

The United States has a long and varied history of influencing private land use through policies at the national, state, and especially local levels. These include agricultural and forest policies, public policies governing investment in public infrastructure, tax policies, and even trade policies. Among this group of policies, we will discuss agricultural and forestry policies as examples of the many policies that can affect land use.

The role of government in the agriculture sector is pervasive and has affected forestry in the United States. A significant phase began with major agricultural programs initiated after the Great Depression. Various types of farm support have been in place since 1933, aimed at ensuring farm viability by guaranteeing a minimum income level for farmers producing certain crops. Such programs have taken different forms over the years including production limits, acreage-reduction programs, deficiency payments, farm credit, and nonrecourse loans. During the expansionary period of the 1970s, agricultural policies promoted increased output through technical assistance and cost-share programs designed to increase the productivity and area of cropland. Low-interest loans were given federal backing for the purchase of new equipment and to convert forest land and pastureland to cropland, along with forested wetlands drainage by the U.S. Army Corps of Engineers (fig. 35).

By 1985, agricultural policy returned largely to the policy of the 1950s, attempting to gradually allow resources to move out of agriculture. The Food Security Act of 1985 also marked a major change in policy toward the elimination of direct federal involvement in farm commodity markets. Passage of the Federal Agricultural Improvement and Reform Act of 1996 represented substantial movement of the federal government away from direct involvement in farm commodity markets.

The goals of particular policies have not been constant over time. This is evidenced by the recent shift from the "Freedom to Farm" approach of the 1996 farm bill to the reversion in the 2002 farm bill to subsidies and support payments. The multiyear 1996 farm bill, initiated when prices were at relatively high levels, appeared to usher in a new

Figure 35—Up until the mid-1970s, wetland drainage and conversion was an accepted land use policy; however, loss of wetland area has slowed in recent decades (USDA Forest Service 2001).

period of increased reliance on market forces and improved risk-management education. However, emergency aid provided to farmers through legislation in 1998 through 2000 suggests that the direction of the current policy transition remains to be determined. Given the background of lower agricultural prices than in the mid-1990s, debate about the 2002 farm bill reflected some interest focused on new types of countercyclical farm policies and direct income transfers in addition to existing "safety net" programs such as subsidized crop insurance. When agricultural prices were depressed in subsequent years after passage of the 1996 farm bill, additional payments were provided to farmers at record levels. In 2000, direct government payments amounted to $23 billion, only $1.6 billion of which was for conservation programs. This compares to the total net farm income in 2000 of $46 billion.

Funding for farm programs has varied widely over time, depending on agricultural markets and on the programs in effect at any one time. Direct payments to farmers in 1986 were $11.8 billion. However, total policy transfers in the same year totaled $36 billion, including direct payments (producer subsidies) as well as consumer subsidies, such as higher prices resulting from import quotas or other policies (Kennedy 1990). The 2002 farm bill calls for a large increase in direct payments to farmers, with a projected total cost of $190 billion over the next decade.

This extensive transfer of wealth to the farm sector has significant impacts on land use. A major effect is that farm program payments lead to higher land prices. Several studies have used a variety of data and approaches to quantify this. Barnard et al. (1997) found that the rate of capitalization of payments into cropland values varied considerably over regions, from less than 10 percent to 69 percent of land values. Only about one-third of farming operations receive direct payments and have benefited from capitalization of payments, whereas other acres in the sector have not. Subsidies help to keep land in agricultural uses, relative to other uses.

Forest Policies

In contrast to spending on agriculture, in 1986, federal funding for forestry programs for private tree planting, forest stand management, and technical assistance totaled about $57 million. This was less than half a percent of direct agricultural payments to farmers (Lee and Alig 1991). From a land use perspective, policies that increase the land rent of agriculture, without affecting forest rents, are expected to increase the land in agriculture use (all other things held constant). Alig et al. (1998a) showed this empirically in a national analysis, where agriculture area increased and forest area decreased relative to a baseline, when simulating the restoration of farm programs after their proposed near elimination in the 1996 farm bill. Lubowski (2002) reported related results, finding that government crop subsidies led to less forest area in the United States between 1982 and 1997 than would have resulted without such government farm payments. Lubowski also reported that the government is directly competing with itself in providing incentives for landowners to retire environmentally sensitive crop lands. This involves government crop payments affecting enrolled acreage in the CRP, a case of unintended consequences of public policies. Plantinga (1996) also found consistent evidence that farm programs were competing with themselves. Milk price supports drew marginal agricultural lands into production, and the CRP paid farmers to take them back out of production.

Government policy involvement in land use has evolved somewhat over time, becoming more responsive to the market and incorporating some conservation goals in recent years. In 1990, a forestry title was added to the farm bill for the first time, and that bill also included forestry-related elements, such as tree-planting initiatives, in the conservation title. The 1996 farm bill also included funding for the purchase of conservation easements on farmland through the Farmland Protection Program. However, the major focus of the 1990s programs was managing agricultural production in times of surpluses and of transferring income to a subset of farmers and farm landlords. Annual direct payments to farmers have skyrocketed from less than $10 billion in the early 1990s to a record $32 billion in 2000. Through this period, annual conservation spending held constant at less than $2 billion, a decline from 20 to 6 percent of total direct payments to farmers.

Policies directed at the forest or agricultural sector can have significant impacts on the other sector. This is illustrated with land diversion programs designed for the agricultural sector, such as the Soil Bank Program and later programs, such as the CRP, that led to significant peaks in tree planting and additions to forest area (Alig et al. 1980, Moulton and Hernandez 1999). The intertwined responses of different sectors to land use policies will depend as well on the policy mechanism or instrument and the responses of private owners (Alig et al. 1998a).

The 2002 farm bill plans to increase spending on conservation practices when compared to the 1996 farm bill. The new farm bill reauthorizes the CRP through 2007 and increases enrollment to 39.2 million acres. The CRP tree planting is likely to remain below one-fifth of total CRP area.

Other conservation programs that may affect forest area include the Forest Land Enhancement Program, which replaces the Forest Incentive and Stewardship Incentive Programs. The Forest Land Enhancement Program will provide technical assistance and incentive payments to nonindustrial private forest (NIPF) owners, with a preliminary estimate of approximately $100 million total to be provided nationally between 2003 and 2007. The program includes policies that increase the area of forests in

Figure 36—During the 1990s, the rate increased at which U.S. farmlands and forest lands were converted to urban and suburban development, prompting more concerns about urban sprawl.

conservation uses, potentially with multiple goals such as land conservation for wildlife habitat enhancement and to promote carbon sequestration in view of climate change concerns.

Urban Sprawl Policies

A major contemporary focus of land use policies is to manage the direction of development. Urban sprawl and livability or quality of life are issues receiving increased attention around the Nation, as the United States becomes more urban and with more than 75 percent of U.S. residents now living in cities (Alig et al. 1999b). With the significant expansion in the 1990s in area of urban and developed uses, “urban sprawl” has been cited as one of the leading concerns of Americans (Pew Center 2000) (fig. 36). Around 1,000 measures were introduced in state legislatures in the late 1990s, attempting to change planning laws and to make development more orderly and land conserving. Implications of urban sprawl for forestry include the direct conversion, as forests are the largest source of land converted to urban and developed uses. Urban sprawl also can impose other costs on forests, such as increased cost of timber management and access restrictions.

Once urban development becomes economically feasible as a result of improved access or other factors, land rents for development are often notably higher than returns to other land uses (Alig and Healy 1987). Within the economic hierarchy of land uses, land prices for developable land in some cases may be a multiple of those for nondeveloped uses. This raises the question of whether efforts to restrain urban sprawl are likely to have long-term effectiveness. Lubowski (2002) found that increases in forest returns had fairly small effects on decisions to convert forest land to urban uses in the United States. This finding is consistent with others that suggest use value assessments and other preferential tax policies, used as a policy to encourage retention of cropland, have minimal effects in restraining urban development (Heimlich and Anderson 2001).

Technological Changes

Technological innovation is a major driver in land use change. Technology change affects all sectors of the economy, including agricultural and forest production. Technological innovations in transportation also can affect a broad set of economic activities and thereby influence land uses. Technological changes can affect both land supply and demand. At a macroscale, technology choices can be complex and are linked to a host of production and consumption choices being made throughout the economy.

Innovations in Agriculture and Forestry

Agriculture is a highly productive industry in the U.S. economy. Agricultural output grew at an annual average rate of nearly 2 percent over the past 50 years. During this period, there was a relatively constant use of land, while relative use of labor declined and use of intermediate inputs and capital increased. A major factor in this high level of productivity is payoff from the investment in research in the form of new technologies. Studies have shown that the social rate of return on investment in public agricultural research ranges from 40 to 60 percent. Rates of return on research investments in some forest products industries exceed 100 percent annually, whereas others such as in southern softwood growth and management research do not begin to approach this range of results or those for the agricultural sector (Boyd and Hyde 1989). Public and private research investments have led to the adoption of “labor-saving” new technologies. Other inputs, such as capital and farm chemicals, have been substituted for land and labor as part of this process.

Significant advances in agricultural and forest production technologies affect land use in various ways. First, new technologies have allowed the relatively fixed land base in agriculture to be farmed more intensively. New mechanical technologies have generally affected the cost structure and led to increasing economies of size. Biological technologies are generally considered to be size neutral. A constant feature of U.S. farm structure is a dwindling number of operations and an increasing average farm size. Although the total acres in agricultural uses has changed little since 1935, when the number of farms was greatest at 6.8 million, the number of farms fell to about 2.0 million in 1997.

There are significantly more private landowners in forestry than in agriculture, about 10 million in total, but the relationship between the distribution of production and the distribution of production units is somewhat similar. For example, less than 10 percent of forest-land owners own three-quarters of the forest land (Birch 1996). Between 1978 and 1994, there was a significant increase in the number of forest ownerships of less than 50 acres. With a continued pace of development into forest land in line with the recent national trends documented in the 1997 National Resource Inventories (NRI), average size of forest ownership is expected to decline further (Sampson 2000). Part of the reason for this is that there is an increasing number of smaller forest properties (less than 25 acres), whereas the number of larger properties is more stable.

One technological advance that may greatly impact both the agricultural and forest sectors is the use of genetically modified material. Yields per acre could be significantly increased under certain scenarios, and the use of environmentally degrading inputs could be reduced. Adoption of these technologies in the two land-intensive industries of agriculture and forestry could impact land exchanges between the two sectors. However, societal concerns may limit use of genetically modified organisms in some cases.

One example of use of genetically modified material that affects the competition for land between agriculture and forestry involves the production of short-rotation woody crops (SRWCs), such as hybrid poplars. A national-scale analysis by Alig et al. (2001)

showed that growing wood fiber demand and tightening supply could mean that introduction of SRWCs could act to temper market price rises and bolster reliable aggregate supplies of woody fiber. Expanded fiber farming could reduce management pressures on existing forest resources. Even without SRWCs, timber management intensification on private lands over the years has resulted in a significant share of U.S. timber harvest coming from plantations (e.g., Alig et al. 1999a, 2002). Although the total SRWC acreage projected will be a modest portion of the whole agricultural land base, expanded SRWC supply could reduce traditional forest plantation area in the United States and lead to lower forest-land values.

Innovations in Communication

Innovations in communication have been a driver behind changing land rents and uses because they have reduced the transaction costs of some businesses and households from locating outside of central cities. Before the current suite of telecommunication innovations existed, most businesses were required to operate in urban areas. The impact of the dispersion of businesses into less developed regions of the country is multiplied by the relocation of downstream industries and associated housing developments. Telecommunication-dependent firms are still more likely to cluster in urban areas, but some communication-dependent firms, such as catalog retail operations, can successfully function in rural communities.

In addition, although not many in number, some individuals are able to successfully conduct private consulting and other business pursuits from any location through telecommunication. Major communication innovations driving population dispersion are personal computers and the Internet. The percentage of households with personal computers and Internet users has increased substantially during the 1990s, although rural areas generally lag in adoption of these technologies. Improved telecommunications have enabled individuals to let quality-of-life factors, rather than access and city location, guide their location choices. Such changes potentially will contribute to increased migration to rural areas, with resulting land use changes.

Implications of the Outlook

If the past is used as a guide to the direction and magnitude of future land use shifts, then evidence suggests that a range of outcomes is possible in the dynamic setting. Accuracy of past projections has been affected by major changes in agricultural policy and goals, and to a lesser extent, forest policy (e.g., reduction in public timber harvest). Policy changes will continue to influence land reallocation. Public policies that could affect both agriculture and forestry in the future include any land-based mitigation activities to address global climate change. Forestry activities, such as afforestation, have been proposed as having roles in international agreements to reduce net emissions or enhance sinks of greenhouse gases (Birdsey et al. 2001, Sohngen and Alig 2000). For example, under the Bush Climate Change policy, a proposal would increase money for land conservation to promote carbon sequestration (see www.whitehouse.gov/news/releases/2002/02/climatechange.html).

Among forest ownerships, the NIPF ownership is generally the most affected by land use conversions and changes in land use policy affecting private land (Alig et al. 1990a). Change in total forest area is the net result of the conversion of forest land to nonforest and the shifting of nonforest to forest land by natural reversion or afforestation (Alig and Wear 1992). Ownership changes in the forest-land base may result in different land management objectives or new private owners with different available resources to invest in forest management. Changes in the areas of forest types often reflect differences in land management objectives among owners and indicate the differential influence of natural and management forces (Alig and Wyant 1985).

Demand for wood products is expected to keep growing, driven by the same population increases and economic development that affect demands for other major land uses. Efforts to better align commercial uses of the forests with conservation objectives have led to increased interest in what is being called "sustainable forestry," although there are similar efforts tied to other major competing interests in the land, such as "sustainable agriculture" or "sustainable communities." Human activities are significant drivers of environmental changes on the mosaic of land uses. Land use changes are critical inputs when evaluating indicators of conservation and sustainable management of forest, agricultural, and urban-based ecosystems. Human-caused changes in land uses and land covers are a primary force driving changes in ecosystem attributes, with such changes affecting criteria for sustainable forest, agricultural, and residential and other urban land management (Alig and Haynes 2002, Alig et al. 1998a).

Land use changes can provide options to help society adjust to changing demands for and supplies of renewable resources from the Nation's forest and aquatic ecosystems. Improvements in U.S. agricultural production technology allowed expanded agricultural production on a fairly constant land base. Less pronounced and in a more lagging fashion, forest volumes have increased on a timberland base that is 4 percent smaller than the one in 1952. Intensified timber management represents some of the largest projected changes involving private timberland (Alig et al. 1999a). Private timberlands have the biological potential to provide larger quantities of timber on a sustainable basis in the future than they do today. Many of the opportunities for intensified forest management can be undertaken with positive economic returns. Most of the timber management intensification opportunities are in the South and the Pacific Northwest west-side. Even if projected intensification was implemented, most of the NIPF timberland would still be concentrated in low management-intensity classes that involve naturally regenerated stands. Sustainability analyses will be enhanced if both land use and land investment options are examined. Analyses should be explicit as to timing of tradeoffs, in addition to the growing attention given to spatial details.

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Metric Equivalents

When you know:	Multiply by:	To get:
Inches	2.54	Centimeters
Feet	.3048	Meters
Cubic feet	.0283	Cubic meters
Acres	.4047	Hectares

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Appendix—Land Use Databases and Forest-Area Studies

We document the major land use databases that we drew upon in this study and discuss the multiple land use definitions that exist. First, we will define land use versus land cover, as sometimes they are used interchangeably, but the two terms are not the same. Land use is the purpose to which land is put by humans, e.g., protected areas, forestry for timber products, plantations, row-crop agriculture, pastures, or human settlements. Land cover is the observed (bio)physical cover on the Earth's surface (Di Gregorio and Jansen 1998), e.g., oak-hickory forest. This report focuses on land use, whereas Alig and Butler (2002) and a companion report in progress (Alig and Butler, n.d.) document land cover changes involving U.S. forests.

Data Sources

Land use data are collected by various agencies for a variety of purposes. Land use surveys generally differ in terms of statistical data-collection methods, scope, and other characteristics. No one land use database provides universal coverage over space and time for use in addressing all relevant land use policy questions. Thus, we drew upon multiple sources of data and will describe next three primary data sources that we used: the Forest Inventory and Analysis (FIA) data assembled to support the 2000 Forest and Rangeland Renewable Resources Planning Act (RPA) assessment by the USDA Forest Service (e.g., Smith et al. 2001); the National Resource Inventory (NRI) by the USDA National Resource Conservation Service (e.g., USDA NRCS 2001); and the Major Land Use Time Series (MLUS) by the USDA Economic Research Service (ERS) (e.g., Vesterby and Krupa 2001).

Forest Inventory and Analysis

The FIA surveys conducted by the USDA Forest Service are designed to provide objective and scientifically credible information on key forest attributes, such as forest stocks, growth, harvest, and mortality. Related data are collected by region, forest ownership category (e.g., forest industry vs. nonindustrial private forests), and cover type (e.g., oak-hickory), by using a sample of more than 70,000 permanent plots. The FIA inventories provide consistent forest cover inventory data for the Nation, back to 1952 (Smith et al. 2001).

The FIA inventories in conjunction with the RPA assessment have now resulted in four related databases in place: (a) east wide, (b) west-side standard forest inventory databases, (c) national timber products output database, and (d) a national summary database that draws upon the others and also incorporates other data from the U.S. Bureau of the Census (total land area, population, etc.). Although sampling techniques for the NRI and FIA are similar, different sampling grids make the estimates from the two inventory systems statistically independent.

The FIA inventory data are gathered by using photointerpretation and ground truthing on a systematic sample of plots defined as pinpoints on the ground. These data include land use and ownership characteristics of sample plots, among other data. The land use data were used in the Kline and Alig (2001) study of land use in the west side of the Pacific Northwest. However, the developed components of these land use data are not reported at a national level, so they are not included in the section below concerning differences in definitions between urban and developed area estimates.

National Resources Inventory

The NRI conducted by the USDA NRCS is designed to assess land use conditions on nonfederal lands and collects data on soil characteristics, land use, land cover, wind erosion, water erosion, and conservation practices (USDA NRCS 2001). In addition to collecting data on about 300,000 area segments and about 800,000 points within those segments, a geographic information system is used to control for total surface area, water area, and federal land. The NRI is conducted by the USDA's NRCS in cooperation with Iowa State University's Statistical Laboratory (USDA NRCS 2001).

As a result of its statistical design, the NRI allows land use transition matrices since 1982 to be developed. With the exception of a few of the smaller land use categories, such as urban uses, shifts occur in both directions across the land use categories. For example, some land moves out of the grassland category and into the cropland category during the same period that other cropland moves into grassland uses. This dynamic is captured in the so-called land use transition matrices (USDA NRCS 2001). One can prepare land use transition matrices for 5-year periods between 1982 and 1997 for major land use categories (e.g., Vesterby and Krupa 2001). Although the NRI data are not as comprehensive and are not fully compatible with the definitions of the MLUS by the ERS (e.g., Vesterby and Krupa 2001), transition matrices more fully develop our understanding of the dynamics of land use change over the past several decades.

Major Land Use Series

The MLUS is an inventory of land developed from a variety of land use surveys and public administrative records of land use. This long-term series was developed by the USDA ERS (Vesterby and Krupa 2001).

Many additional sources of data exist on land use and land cover that are not used in the MLUS because they are not the most suitable for the purpose of comprehensively inventorying U.S. land. For example, the U.S. Geological Survey of the U.S. Department of the Interior maintains satellite imagery of land cover at various points in time. Many of these data sources are better suited for other specialized purposes.

Differences in Definitions of Urban and Developed

One of the most widely watched statistics by land use experts is the number of acres converted from undeveloped uses to developed, or urban, uses on an annual basis. Two major sources of information at a national level on this topic, the MLUS and the NRI, have somewhat different definitions. The MLUS uses the official U.S. census definition of **urban** (USDC Bureau of the Census 2001), and the NRI data use a definition unique to that data system, namely **developed** land. Urban land is a subset of developed land. Developed land includes rural land that has been "built up." In short, although definitions and absolute numbers differ between change in urban land and change in developed land, the trend is toward an increase in the number of acres in this use, and the trend can be expected to continue.

The Census of Population and Housing is conducted every 10 years (USDC Bureau of the Census 2001). The U.S. census and the NRI provide the only nationally consistent historical series on urban or developed land. The precise definition of urban or developed differs between the two sources, with the U.S. census providing the official definition of urban used in government statistics. For this reason, and because the census series goes back to 1950, the census data and definition are used in the MLUS. The definition of rural is land that is not classified as urban. The census definition of urban is **cities, towns, and census designated places of 2,500 or more persons, including urbanized areas with populations of 50,000 or more.**

Although the census concept of urban land use has advantages for tracking change over time, it is clear that the NRI concept of developed uses has advantages, as well. The NRI concept of developed land consists of urban and built-up areas (classified as large and small) and land devoted to rural transportation. Hence, the NRI concept of developed land covers more land area than urban land. The NRI concept of developed land, in contrast to the census concept of urban areas, was able to capture the recent increase of development of rural land into rural residences. The 1997 NRI data revealed a significant increase in developed and built-up areas outside of urban areas during the 1990s. In large part, this new use of previously undeveloped rural land is for rural residences, often times on the fringe of urban areas and often times with large lot sizes. This is evidence of what is commonly called urban sprawl.

No technical definition of urban sprawl exists, but most definitions have elements of low-density development, geographic separation of essential places, and dependence on automobiles for travel (Heimlich and Anderson 2001). In response to the concerns about the growth in the use of rural land for rural residences, the USDA has added a new category to the MLUS for recent years. The data reveal that in addition to rural land shifting to urban areas, another 1.03 million acres of rural land was converted to rural residences between 1980 and 1997 (Vesterby and Krupa 2001).

Differences in Measures of Forest Area

Forest area is estimated differently across several of the major databases (fig. 37). The first measure is the RPA estimate of forest land area (see "Glossary"). The second measure is the estimate of "forest-use land" area given in the MLUS database of the ERS. The ERS classifies some forested land as "special-uses" land. In particular, "special-uses" land includes federal and state parks, wilderness areas, and wildlife refuges. Hence, "forest-use" land differs from the FIA/RPA "forest land" in that forest-use land excludes parks, wildlife areas, and similar special-purpose uses. The third measure of the area of forest land is the estimate presented in the NRI of the USDA NRCS.

Note that the area of "forest-use" land in figure 4 is lower than the area of "forest land" in figure 11 at all dates. This is consistent with the exclusion of parks and other special-purposes land from "forest-use" land. Note also that the gap between forest land and forest-use land has grown slightly over the past 60 years. This reflects the growth of wilderness areas and other forested special-uses land during this period. Second, note

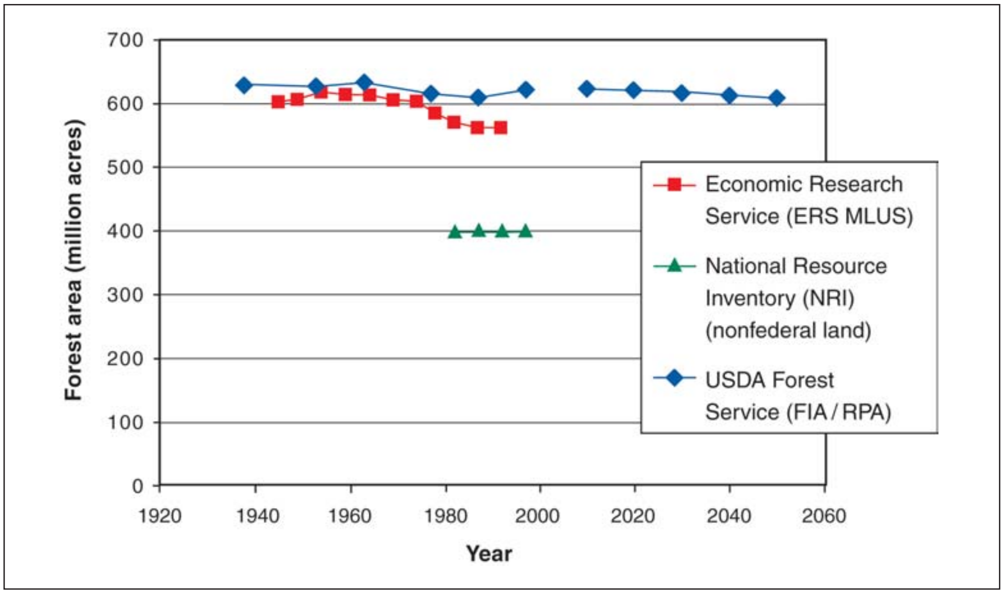

Figure 37—Different measures of U.S. forest area from three sources.

that the NRI measure of the area of forest land is only about two-thirds of the FIA/RPA measure, in that about one-third of the forested lands of the contiguous 48 states are federally owned. This fraction varies markedly between regions.

The second largest use of land in the contiguous 48 states is for forest use according to the MLUS database. This category is defined to exclude forested land that is not available for timber production because it is in special uses, such as national parks, but includes forested land that also is grazed. The 553 million acres in forest uses in 1997 account for almost 29 percent of the land in the contiguous 48 states. Approximately 140 million acres of this also is grazed.

The data sources differ in length of reporting period, complicating some comparisons of area changes across time. Both the FIA/RPA estimate of forest land area and the ERS estimate of forest-use area have decreased in the past half century. The RPA tables report that the area of forest land decreased by 1.7 percent between 1938 and 1997. The ERS reports that the area of forest-use land decreased by 7.2 percent between 1945 and 1992. Available only for a shorter period, the NRI estimate of nonfederal forest area increased by 0.2 percent between 1982 and 1997. Although the net area of forest land in the contiguous 48 states has been somewhat constant over the last 50 years, there has been significant variation within individual regions.

There also has been a trend toward less grazing of forest-use land. At the beginning of the ERS time series of data, 1945, the majority of forest-use land was grazed; the opposite was true by 1997.

Methods to Project Changes in Forest Area

Methods to project area changes for forest land and timberland differ by region of the United States. Methods differ depending on the likelihood of area changes affecting forests, the likely policy relevance of forest area changes, and the availability of time series of land use data with which to develop models of land use change. Table 1 in chapter 1 lists the supporting RPA-related studies by region, and next we will summarize study findings for each region.

North

Within the North, several studies were conducted to investigate relationships between changes in timberland area and socioeconomic variables. This involved developing a formal econometric model that relates the areas of forest industry and nonindustrial private forest (NIPF) timberland to economic and demographic variables. Econometric studies use statistical techniques to test economic hypotheses and develop empirical relationships between revealed landowner behavior, such as changes in land use, and explanatory variables such as government programs, timber prices, agricultural prices, and costs of different land management options (e.g., Plantinga et al. 1999). Assuming that these relationships will not change over time, we then used independent projections of the economic and demographic variables to project the area of privately held timberland.

For the North, there were three primary supporting studies for these subareas: Maine (Mauldin et al. 1999a, Plantinga et al. 1999), Lake States (Mauldin et al. 1999b), and Midwest (Choi et al. 2001).

Maine—Maine has the highest percentage of forest cover of all the states, approximately 90 percent. Since the 1950s, the area of forest land in Maine has increased by almost 400,000 acres, whereas the area of crop and pasture land has declined by about 900,000 acres. The increase in forest area is partially due to the natural reversion of agricultural land to trees. "Other land" increased by more than 400,000 acres, which includes developed uses not classified as urban (e.g., suburban housing), wetlands, and miscellaneous uses. In contrast to most states, the area of urban land in Maine has remained fairly stable over the past several decades, at about 2.5 percent of total land area (Plantinga et al. 1999). Urban land area has remained relatively stable at about 500,000 acres, reflecting Maine's roughly constant population since the 1950s. Private owners control 96 percent of the timberland in Maine, with slightly less than half in private industrial ownership.

Observations of the shares of land in private timberland, agricultural land (crop and pasture land), and urban land in 16 counties in 1971, 1982, and 1995 were constructed from Forest Service inventories, census of agriculture reports, and the population census. The shares of land in forest, agriculture, and urban uses have accounted for roughly 90 percent of the total land area over the past several decades. The remaining uses were not modeled explicitly, principally because suitable measures of explanatory variables were unavailable. Proxies for land rents associated with the three land uses are included as explanatory variables. For private timberland, rents are represented by a weighted average of bare land values equal to the present discounted value of an infinite series of rotations starting from bare ground. Values were estimated for each of the major forest species (white pine (*Pinus strobus* L.), spruce-fir, red maple (*Acer rubra* L.), hard maple, and aspen) and averaged by using weights reflecting the species composition in each county. For agricultural land, the rent proxy is a weighted average of revenues equal to the product of crop price and yield. Weights reflect the shares of cropland in each county planted in the major crops (hay, potatoes, oats, and corn). Urban land rents are represented by population density equal to total population divided by land area. We hypothesized that larger populations result, all else being equal, in greater development pressures and higher rents from developed uses.

Land quality measures were constructed from NRI data (USDA NRCS 2001) on soil characteristics. $AVERLCC_{it}$ is the average land capability class (LCC) rating. The LCC system ranks soils (I to VIII, where I is highest) according to 12 characteristics (slope, permeability, etc.), and the overall LCC rating equals the lowest score in any category. The LCC rating is based on the assumption that the characteristic receiving the lowest rating is the limiting factor for agricultural production. $LCCI\&II_{it}$ equals the percentage of all land in LCCs I and II. Typically, high-quality land is allocated to agricultural uses, whereas lower quality land is put into forest.

Counties with higher rents for urban uses tended to have higher shares of urban land relative to shares of forest and agricultural land. Counties with lower quality land (i.e., higher average LCC ratings) tended to have less agricultural land relative to forest. In contrast, there seemed to be no systematic relation between land quality and shares of urban land relative to forest and agricultural land. This is a plausible result because the rents from urban uses were not affected by soil quality. The last variable was the travel time to Portsmouth, New Hampshire. Travel times were measured from the major city or town closest to the geographic center of the county, with travel times corresponding to the fastest route over major roads. Coefficients on the travel-time variable suggested that more remote counties (i.e., those farther from Portsmouth, New Hampshire) tended to have less agricultural and urban land and more forest.

The results lend further support to the theoretical and empirical findings that land use patterns are determined by relative rents and land quality. The coefficients on rent variables in the econometric model indicate that land tends to be allocated to the use providing the highest rents and that the rents associated with a given use may affect the tradeoff between other uses. Furthermore, higher quality land tends to be allocated to agricultural uses, lower quality land tends to be forested, and land quality does not significantly affect urban land use patterns. In contrast to the companion study on land use in the Lake States region (Mauldin et al. 1999b), the econometric model for Maine explains a considerable portion of the variation in land use across counties. The coefficient estimates also have the expected signs, and, in most cases, are significantly different from zero. These improvements may be explained by the inclusion of variables measuring relative land rents and land quality.

The estimated equations were used to generate decadal land use projections for Maine to 2050 (Plantinga et al. 1999). Among the variables in the model, only the rent variables could be expected to significantly change in the future. Soil characteristics remained essentially constant even over long periods, and the travel-cost variable is assumed to be invariant as relates to time. Changes in the rent variables implied changes in the land use share ratios, with coefficients for rent variables measuring the percentage of change in the share ratio for a small increase in the rent.

Projections are that private timberland acreage will decline by almost 3 percent by the middle of the 21st century. This change will reduce the land available for timber production, although the effect on timber supply is not likely to be dramatic given that large acreages of timberland will still remain. Since the 1950s, the area of urban land in Maine has remained stable, yet if population increases according to Department of Commerce projections, this pattern may change dramatically. The population projections show a 16-percent increase in Maine's population by 2050, which results in urban land area increases of 56 percent. As evidenced, there is an elastic relation between urban land area and population (the elasticity equals 3.5). The largest urban area increases are predicted for counties in southern and central Maine.

For the remaining land uses, historical trends are expected to continue. We project continuing declines in agricultural acreage, although in absolute terms, changes are expected to be lower in the next 50 years compared to the previous 50 years. Finally, we project continuing increases in other land; however, average annual increases are expected to be about 50 percent lower than historical increases.

Lake States—Since the 1950s, the area of urban land in each of the Lake States has more than doubled while population has risen by over 50 percent. Over the next 50 years, the Lake States population is projected to increase by approximately 6 to 8 percent every decade. Urban area is projected to increase by only 2 to 3 percent in Wisconsin and Michigan and 9 percent in Minnesota. Although population is projected to increase at a slower rate in the future, urban expansion is expected to increase even less than past trends would imply.

Using an econometric model similar to that described for Maine above, Mauldin et al. (1999b) projected land use changes for Wisconsin, and then used simple extrapolation techniques to make land use projections in Michigan and Minnesota because of a lack of data (e.g., private stumpage prices are not available for either of these states). The econometric model is based on the theoretical and empirical observations that the distribution of land uses is strongly affected by land rents and land quality (Mauldin et al. 1999b). Allocations of land uses favor activities with the highest rents; land rents are a function of land quality. Land rent proxies were calculated for forest, agriculture, and urban lands.

For the Lake States—Michigan, Minnesota, and Wisconsin—currently about two-fifths of the region's land is in forests. Since the 1950s, areas of forest and farm land have been decreasing, and urban and other land uses have been increasing. For the entire region, forest, crop, and pasture land decreased by 3.2, 5.4, and 4.0 million acres, respectively, while urban and other land uses increased by 2.1 and 10.3 million acres, respectively. These increases and decreases were most pronounced in the 1950s and 1980s (Mauldin et al. 1999b). In 1953, more than 96 percent of the forest land of the Lake States was classified as timberland; by 1997 this fraction had fallen slightly to 94 percent. For our projections, we have assumed that the gap between forest-land area and total timberland area will continue to increase slowly.

The estimated model for Wisconsin was used to project land use to 2050. Because no econometric results are available for Michigan and Minnesota, the projections for these states are constructed by extrapolating historical trends in land use. These projections are also based in part on trends forecasted with the Wisconsin model. For example, the Wisconsin model projects that urban land will increase much more slowly than historical trends would indicate. Counties with higher rents for urban uses tend to have higher shares of urban land relative to shares of forest and agricultural land.

Midwest—Econometric land use models for three Midwestern states—Ohio, Indiana, and Illinois—were estimated with county-level data on land use proportions in crops, forests, and urban uses (Choi et al. 2001). This research uses the econometric framework suggested by Plantinga et al. (1999) to estimate models that predict the share of land in forest, agriculture, and urban uses in the Midwestern United States. The proportion in these uses is expressed as a multinomial logistic function with explanatory variables such as forest rent, agricultural rent, urban rent, land-quality indices, distance from the nearest city, and dummy variables for particular years.

Data for the regression analysis are from various sources for the 284 counties in the three states in the midwestern region investigated here. The shares of land in different uses in each county are gathered from the NRI data for 1982, 1987, and 1992. Estimates from these sample plots are aggregated to the county level. Focusing on the shares of agricultural, forest, and urban land, land rental values are estimated from other data sources for these three uses. Following Plantinga et al. (1999), population density is used as a proxy for urban land values. It is hypothesized that higher density increases development forces, which in turn increases the opportunity costs associated with maintaining agricultural land. The total area of each county is obtained from NRI data, and total population is determined from the Bureau of Census data for the same period (1982, 1987, and 1992).

The econometric models suggest that higher forest, crop, and urban land rental rates all increase the area of land in the respective uses. However, most conversion of land to urban uses in this region occurs at the expense of cropland rather than forest land. There also is evidence that conversion to urban uses occurs on the lowest quality land first. In general, the area of forest land is most sensitive to changes in forest-land rental rates, followed by cropland rental rates and population density. Cropland, in contrast, is most sensitive to changes in population density.

Results with a combined regional model are stronger than state-level models. Higher crop rents increase the proportion of cropland relative to forest land. Higher crop rents do not appear to influence the proportion of urban land to agricultural land. Higher forest rents increase the proportion of forest land relative to cropland and urban land. Higher forest-land rents increase the proportion of urban to agricultural use, and higher population density reduces the area of agricultural to forest land. As suggested by the state-level models, urban uses appear to prefer, all else equal, agricultural sites rather than forest sites. Choi et al. (2001) attribute this mainly to differences in construction costs associated with developing forested sites vs. agricultural sites.

As expected, higher soil quality (lower AVLCC) increases the proportion of agricultural to forest land. Higher soil quality reduces the proportion of urban land to agricultural land (LCC is negative and AVLCC is positive), suggesting that development does not choose the highest quality agricultural land for conversion. Higher soil quality, however, increases the proportion of urban land relative to forest land. Most of the development in the Midwest occurs near cities located in agricultural regions. Although there is some evidence that developers choose the lowest quality agricultural land for development, this land is still better for agriculture than regions where land is in forests.

The regional model suggests that under the baseline, both agricultural and forest land are expected to decline over the coming decades in the Midwest. These conversions are split about evenly across the region, although more forest land is lost in Indiana, more cropland is lost in Illinois, and the results are about even in Ohio. Larger increases in crop rents are shown to reverse the trends in cropland area. Higher forest-land rents reverse the trends in forest-land area but entail larger losses of agricultural land.

To summarize, first, as expected, higher cropland rents imply more cropland area; higher forest-land rents suggest more forest-land area; and higher population density suggests more urban land. Second, although conversions to urban uses are derived from both crop and forest land, at the margin, developers appear to prefer agricultural land to forest land. One explanation for this is that the cost of converting cropland to subdivisions and other developed uses is relatively less than the cost of forest land. On average, however, the study region tends to have more cropland than forest land, so for any random acre converted, one is generally more likely to convert an acre of cropland than an acre of forest land.

Third, developers seem to prefer lower value cropland to higher value cropland for development, all else equal. Thus, developers prefer cropland to forest land, but they also prefer lower quality cropland relative to higher value cropland. This result is somewhat sensitive to the empirical specification of the model. That is, for the state-level regressions, higher land quality increases the proportion of agricultural land relative to urban land, although the effect is only statistically significant for the Indiana regression.

Fourth, the models appear to be more sensitive to forest-land rents than to cropland rents. This is somewhat surprising, given the presumed importance of cropland rents. Cropland rents both increased and decreased over the period in question, whereas forest rents have tended to rise over time. Thus, it is entirely possible that rising forest-land rents are having an effect on landowner behavior, particularly in regions that are marginal for agricultural production. These results appear to vary by region: forest rents have the highest elasticity in Ohio, and the smallest in Indiana. Crop rents have the greatest elasticity in relation to forest-land area in Indiana and the lowest in Ohio.

South

Within the South, several studies were conducted to investigate relationships between changes in timberland area and socioeconomic variables. As in the North, econometric studies were used to test economic hypotheses and develop empirical relationships between revealed landowner behavior, such as changes in land use, and explanatory variables such as government programs, timber prices, agricultural prices, and costs of different land management options (e.g., Ahn et al. 2001). Assuming that these relationships will not change over time, we then used independent projections of the economic and demographic variables to project the area of privately held timberland.

South Central—A land use model was developed for the South Central region that describes the relationship between the areas of land in different uses—private timberland, agricultural land, and urban and other land—and determinants of land use (Ahn et al. 2001, 2002). Determinants include the net returns to land in forest and agriculture, population density, distance to closest metropolitan area, and land-quality measures. The model was developed from the point of view of a landowner allocating a fixed amount of land to alternative uses. The basic premise is that a landowner will allocate each land parcel to the use that gives maximum profit, all else being equal. Optimal land shares are expressed as a function of land rents and composite land-quality measures.

Econometric methods were applied to historical data to quantify the relationship between land area shares and land use determinants. The models were estimated by using ordinary least squares regression with pooled time series and cross-sectional data. The panel data set included 558 cross-sectional units (counties) and seven time points. Observations for the 558 counties in the South Central region were from FIA inventories conducted since the 1960s. The agricultural share of land was defined as that in cropland and pasture, and county-level observations were gathered from the census of agriculture for 1964, 1969, 1974, 1978, 1982, 1987, and 1992. The share of land in urban and other uses was defined as a residual category where the share was computed as the total land base in uses other than forestry and agriculture (e.g., suburban).

In many empirical land use analyses, population measures are used to account for the allocation of land to nonrural uses (e.g., Alig 1986). Ahn et al. (2001) used population density to explain the share of land devoted to urban and developed uses. In addition to population density, a distance measure was used to explain the share of urban and developed land. The rationale for the distance measure was the hypothesis that land in counties closer to a city (population $>$ 25,000) have more potential for conversion to developed uses than do counties farther away. The distance variable was calculated as the distance from the town located in the center of each county to the closest city.

The estimation results included that higher forest rents are expected to increase the forest share of the land base and decrease the agricultural share. An increase in agricultural rents tends to lead to the opposite effect, with an increase in agricultural area relative to forest area. Population density and distance were significant variables in explaining the share of land devoted to urban and other developed land. Population density has a positive effect on the ratio of urban and developed land to forest land. Conversely, the effect of the distance measure on the same share ratio is negative, indicating that a county closer to a metropolitan area tends to have more urban and developed land relative to forest land.

The fitted models were used to project future land use in the South Central region, given assumptions about future population and net returns to land enterprises such as forestry. Given the projected U.S. population increase of another 120 million people by 2050, the above-average growth rate for the South means that a substantial increase in population is projected. Given recent trends, we held real agricultural rents constant. Agricultural productivity per acre has continued to outpace such gains on the forestry side. However, any future increases in agricultural rents would temper the projected declines in agricultural land area projected here. The other land use determinants (e.g., land quality) are assumed to remain essentially constant in the future.

Southeast—The econometric results for the South Central region were used to generate land use projections for the Southeast (Plantinga and Ahn 2000). In doing so, we assumed that landowners in the two southern regions respond in similar ways to changes in land use determinants, specifically population and the net returns to forestry and agriculture. In support of this assumption, we note that the regions are similar in terms of forest species, agricultural crops, and demographic characteristics.

Rocky Mountains

Data limitations and limited resources dictated the use of informal models of forest area change for the Rocky Mountains region. The basic projection methods used for this region are a combination of graphical analysis and “expert opinion.” For each such region, we graphed historical data on forest-land area, timberland area (broken down by ownership class), the areas of the other major land use classes, population size,[1] and real per capita personal income.[2] We then examined the observed patterns in the trajectories of forest-land and timberland area in terms of the trends exhibited in the entire data set. The areas of forest land and timberland in each ownership class were then projected assuming a continuation of the patterns shown in the historical data.

These initial projections were then reviewed by various experts (from government, academics, and industry) who were familiar with the forestry situation in the region. Finally, we revised our projections on the basis of the comments received from the outside reviewers.

Pacific Coast

Within the Pacific Coast region, the west sides of Oregon and Washington have experienced above-average population growth, and land use changes have affected the forest land base. An empirical model was developed describing the probability that forests and farmland in western Oregon and western Washington were developed to residential, commercial, or industrial uses over a 30-year period, as a function of spatial socioeconomic variables, ownership, and geographic and physical land characteristics (Kline and Alig 2001). Geographically referenced data on historical land use were provided by the USDA Forest Service’s FIA Program. The FIA data report historical land use on a set of sample plots.

The model describes the probability that forest land and farmland plots were developed to urban uses since 1961, as a function of spatial socioeconomic variables, ownership, and geographic and physical characteristics. The analysis was restricted to examining conversions of forest land and farmland to urban uses (Kline and Alig 1999); conversions of forest land to farmland and farmland to forest land were ignored. Although historically in western Oregon and western Washington, land has moved between forest and farm uses, such shifts are difficult to measure.

The model was used to project future land use change in western Oregon and western Washington, based on projected values of population and other explanatory variables. The estimated model coefficients were used to compute the probability that sample plots would convert to an urban use over time. The computed probability that each plot is converted to an urban use is multiplied by the acreage expansion factor for each plot to estimate the area of land represented by each plot likely to be converted to an urban use. These estimates were aggregated for western Oregon and western Washington for the RPA summary years (Kline and Alig 2001).

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[1] The historical population numbers are Census Bureau data and can be found at http://www.census.gov/population/estimates/state.

[2] Data on nominal personal income were obtained from the Bureau of Economic Analysis (http://www.bea.doc. gov/). These figures were combined with the population figures and data on the consumer price index (obtained from the Bureau of Labor Statistics) to calculate real per capita personal income.

Areas of land in forest and farm uses are projected to decrease as they are converted to urban land uses. The most significant reductions in forest area occur on land classified as other forest. Because land use projections are based on data describing historical land use changes subject to past development density patterns, the projections necessarily assume that historical development patterns will continue.

Projections of Exogenous Variables

Assumptions pertaining to macroeconomic assumptions were provided by the USDA ERS (USDA Forest Service 2001). These included projections that real agricultural prices (at aggregate levels) would be constant to declining in the future, depending on the decade. Timber price projections were taken from the TAMM/NAPAP/ATLAS modeling system used in the 2000 RPA assessment (see footnote 1 in "Introduction" for Web sites).

Glossary

Afforestation—The forestation, either by human or natural forces, of nonforest land.

Developed land—In the National Resources Inventory (NRI), developed land consists of urban and built-up areas, as well as land devoted to rural transportation.

Forest industry—An ownership class of private lands owned by companies or individuals operating wood-using plants.

Forest land—Land at least 10-percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between heavily forested and nonforested lands that are at least 10-percent stocked with forest trees and forest areas adjacent to urban and built-up areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 feet wide.

Forest-use land—A "major land use class" of the USDA Economic Research Service (ERS). This class differs from forest land in that it excludes forested land that is classified as "special-uses" land, e.g., federal and state parks, wilderness areas, and wildlife refuges.

Land area—The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than 200 feet wide; and lakes, reservoirs, and ponds less than 4.5 acres in area.

Land use classes—The five major land use classes defined by the ERS are (1) cropland, (2) grassland pasture and range, (3) forest-use land, (4) special-uses land, and (5) other (or unclassified) land. Some details of the definitions of "forest-use land," and "special-uses land" are found in this glossary. For details on the definitions of the other major land use classes, see http://usda.mannlib.cornell.edu/data-sets/land/89003/.

Large urban and built-up areas—These areas include developed tracts of 10 acres and more.

Metropolitan area—The U.S. Office of Management and Budget uses a county-based definition where metropolitan areas are those counties with one or more major cities of at least 50,000 people or with a Census Bureau-defined urbanized area with a population of at least 100,000. In addition, those outlying counties that are economically and socially connected to the county-based metropolitan areas are considered a part of the metropolitan area.

Nonindustrial private forest (NIPF)—An ownership class of private lands where the owner does not operate commercial wood-using plants.

Public—An ownership class composed of land owned by federal, state, county, or municipal governments.

Reserved forest land—Forest land withdrawn from timber utilization through statute, administrative regulation, or designation.

Residential area—Residential area is the sum of acres in lots used for housing units. Estimates of residential area, urban and rural, are based on data from the American Housing Surveys.

Rural transportation land—This includes highways, roads, railroads and rights-of-way outside of urban and built-up areas.

Small built-up areas—These areas include developed tracts of 0.25 to 10 acres, which do not meet the definition of urban area but are completely surrounded by urban and built-up land.

Special-uses land—A major land use class of the ERS that includes area in highways, road and railroad rights-of-way, and airports; federal and state parks, wilderness areas, and wildlife refuges; national defense and industrial uses; and urban areas.

Timberland—Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included).

Urban area—Nationally, there are two main sources of data on urban area. First, the USDC Bureau of the Census compiles urban area every 10 years, coincident with the census of population. Second, the Natural Resources Conservation Service, U.S. Department of Agriculture, publishes developed land, including urban components, at 5-year intervals as part of the NRI. Although the U.S. Geological Survey, National Aeronautics and Space Agency, Housing and Urban Development Department, and several local, state, and federal agencies also collect data or conduct special-purpose studies on urban area, the census and the NRI provide the only nationally consistent historical series. Because of differences in data-collection techniques and definitions, the NRI estimates of “large urban and built-up areas” is usually higher than the census “urban area” estimates for nearly all states. The census urban area series runs from 1950, whereas the NRI started providing a consistent series in 1982. Historically, the ERS major land use time series (MLUS) has used census urban area numbers. Prior to 1982 census urban area was the only reliable national source of urban area data available. Since 1945, census urban area has been used in the MLUS time series to maintain a consistent series. For comparison purposes, census urban area is checked against the NRI to help project and interpolate census trends between decennial census years.

Urban area (census)—This area is technically defined by the Bureau of the Census and consists of cities, towns, and census-designated places of 2,500 or more persons, including urbanized areas with populations of 50,000 or more—central cities and their “urban fringe” (USDC Bureau of the Census 2001). Included in this definition are residential areas and concentrations of nonresidential urban area such as commercial, industrial, and institutional land; office areas; urban streets and roads; major airports; urban parks and recreational areas; and other land within urban-defined areas. The definition allows for exceptions and special cases and has changed slightly from decade to decade. Portions of extended cities that are essentially rural in character are excluded.

Urban and built-up areas—These areas consist of residential, industrial, commercial, and institutional land; construction and public administrative sites; railroad yards, cemeteries, airports, golf courses, sanitary landfills, sewage plants, water control structures, small parks, and transportation facilities within urban areas.

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