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Area Changes in U.S. Forests and Other Major Land Uses, 1982 to 2002, With Projections to 2062

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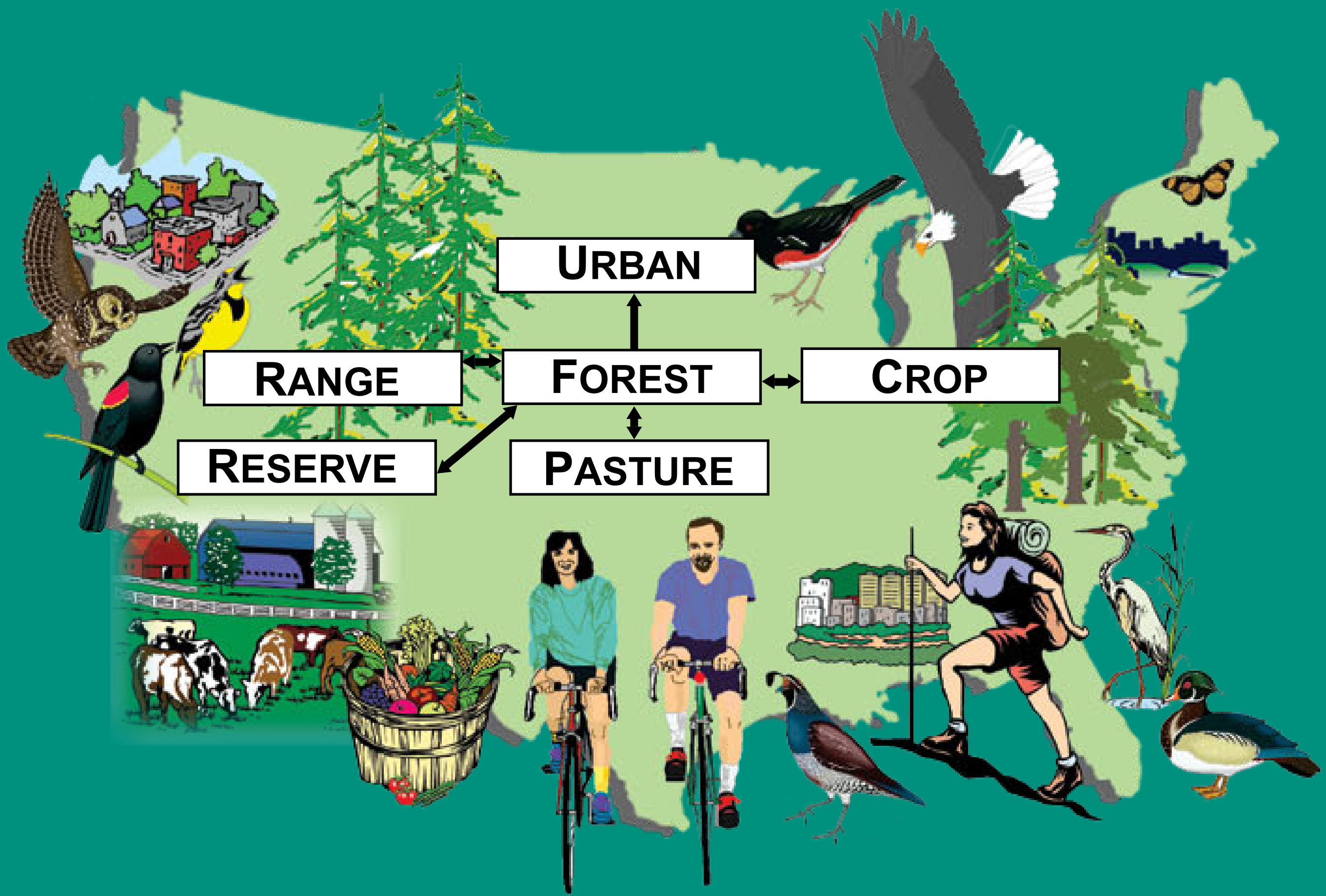

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Abstract

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This study updates an earlier assessment of the past, current, and prospective situation for the Nation's land base. We describe area changes among major land uses on the U.S. land base for historical trends from 1982 to 2002 and projections out to 2062. Historically, 11 million acres of forest, cropland, and open space were converted to urban and other developed uses from 1992 to 1997 on nonfederal land in the contiguous United States. The national rate of urbanization increased notably compared to the 1982-92 period. The largest percentage increase was in urban use, which grew by 10 percent or 7.3 million acres between 1997 and 2001. 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 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. Area of nonfederal forest-land cover in the United States is projected to decline over the next half-century, with a 7-percent reduction by 2062. Projected increases in urban and developed uses will likely intensify competition for remaining land between the agricultural and forestry sectors. Reversions to forest land have generally been from grassland used as pasture. All three major land use classes—cropland, forest land, and grassland—have lost area to urbanization, and that trend is projected to continue.

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

Summary: Land Base Assessment

The projection envisions a 7-percent reduction in nonfederal forest area in the contiguous 48 states by 2062, although projections differ by region. The reduction is primarily due to projected conversion of forest area to urban and developed uses. 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 the fastest in the West and South.

Historical Area Trends for Major Land Uses

- Of the 2.264 billion acres of land in the United States, 33 percent (751 million acres) is forest land and 67 percent (1,513 million acres) is nonforest land. Forest land is concentrated in the Pacific Coast, North, and South regions.
- The total area of nonfederal forested land remained relatively constant over the 10-year period from 1982 to 1992. Forest area then increased slightly from 1992 to 2002, from 403.1 million acres to 405.4 million acres. The largest gain in forest came from conversions of pasture to forest land.
- Area of urban and developed uses in the United States expanded by more than 1 million acres annually since 1982, as population and personal incomes increased significantly.

Projected Area Changes for Major Land Uses

- After a slight gain from 1982 to 2002, nonfederal forest area at the national level is projected to steadily decline from 2002 to 2062, from 405.4 million acres in 2002 to 375.3 million acres in 2062.
- The largest loss of forest will be due to urban development, leading to the conversion of 49.7 million acres of forest to urban use by 2062.
- Across rural land uses, a net gain in forest land is expected from conversions of pasture to forest, which will offset some of the forest area lost to urban development. Between 2002 and 2062, 59.3 million acres of pasture is projected to be forested, and 32.2 million acres of forest is projected to be converted to pasture, leading to a net gain of 27.1 million acres of forest.

Regional Changes

- Although overall forest area is projected to decrease, areas of increasing forest cover are projected for parts of the Pacific Coast, North, and South regions, indicating that in addition to an overall loss of forest, there will also be a redistribution of forested land in these regions.

- Considerable losses of forest can be seen along the Pacific Coast in Washington, Oregon, and northern California.
- For the Rocky Mountains region, the area of forest land in each county will remain fairly constant, in the range of decreasing by 4 percent to increasing by 5 percent. Some areas will see more extreme changes.
- Americans continue to move to the South and Pacific Coast, with cities such as Atlanta growing much faster than the national average. Growth in some metropolitan areas has led to increasing population densities in counties surrounding central cores. The top 20 percent of fastest growing U.S. counties are primarily in the South. The South is expected to grow by 61.0 million people by 2060. Additional development in coastal areas is substantial, leading to large increases in asset values along coastlines.
- Total forest area in the Pacific Northwest declined from 1982 to 2002, from 40.3 million acres to 39.4 million acres. Between 1982 and 1997, a significant amount of land moved into forest use from other uses, particularly pasture and range. However, from 1992 to 1997, forest land transitions were dominated by losses to urban and range uses, and this trend is expected to continue in the future.

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Introduction

We project changes in forest area and provide regional and national-level summaries. Changes in forest area can alter the goods and services derived from forests and can affect sustainable management options. Interest in sustainable management of the world's forest resources was heightened by the United Nations Conference on Environment and Development in 1992 (USDA FS 2001). Various countries have joined together to discuss and attempt to reach consensus on ways to evaluate progress toward the management of their forest ecosystems within a sustainability context. 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. More recently, concerns over global climate change have complicated assessing and evaluating a country's progress toward sustainability at the national level.

The complex dependence of humankind on ecosystem services generated by forest ecosystems includes a wide range of economic and ecological phenomena. Individually, these systems are quite complex. Integrating effects between these systems adds additional complexity. Considerable uncertainty also exists about projections of the future, particularly projections that look forward 50 years. Past land base assessments have typically focused on one "business as usual" future, although there have been variations of the "business as usual" future in analyzing additional scenarios. For example, varying assumptions about future population have been used to create high/medium/low trajectories of supply and demand. Now with the growing interest in markets for carbon as an ecosystem service, we are able to compare our results to those of other studies that explicitly include carbon price scenarios (e.g., Alig et al. 2010).

This land base assessment updates earlier ones in providing information about the current forest area situation and prospective changes over the next 50 years. Within rapidly changing social and biophysical environments, 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 changes can also provide inputs into a larger system of models that project forest resource conditions and harvests, wildlife habitat, and other natural resource conditions (e.g., USDA FS 2001). Current debates about sustainability and concerns about climate change involve both physical notions of sustainability and competing socioeconomic goals for public and private land management. The fixed land base necessitates 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 in this study update those reported by Alig and Plantinga (2004). Methods and data sources used in projecting area changes are described in the appendix. In general, since around 1980, land-use projections have moved from reliance on expert opinions (e.g., Wall 1981) to systematic models, as described in the appendix.

We discuss the land-use situation and give projections of land-use changes for the four Resources Planning Act (RPA) regions of the United States used by Alig and Plantinga (2004): North, South, Rocky Mountains, and Pacific Coast (fig. 1). Land-use changes were modeled for the 11 subregions shown in figure 1, and the results are aggregated to the four regions presented in this report. For each RPA region, we present historical changes in land uses depicted by USDA's National Resources Inventory (NRI). The NRI provides estimates of transitions among major land uses, including agriculture, forestry, and developed uses. We report projections of land-use changes for the nonfederal land base. We conclude with a discussion of other key driver variables such as land use and carbon sequestration policies and technology that may lead to futures different than those projected in this study.

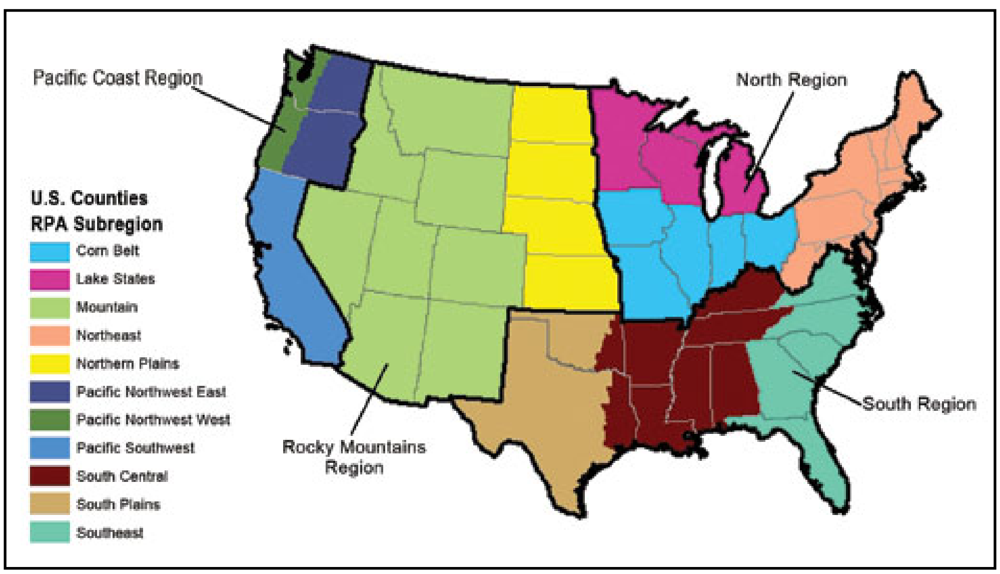

Figure 1—Resources Planning Act regions and subregions.

National Overview

Of the 2.264 billion acres of land in the United States, 33 percent (751 million acres) is forest land (see glossary) and 67 percent (1,513 million acres) is nonforest land (Smith et al. 2007). Forests are found in significant amounts in every region of the Nation. They range 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 (514 million acres) of the Nation's forests are classed as timberland (fig. 2), productive forests capable of producing 20 cubic feet per acre of industrial wood annually and not legally reserved from timber harvest. An additional 75 million

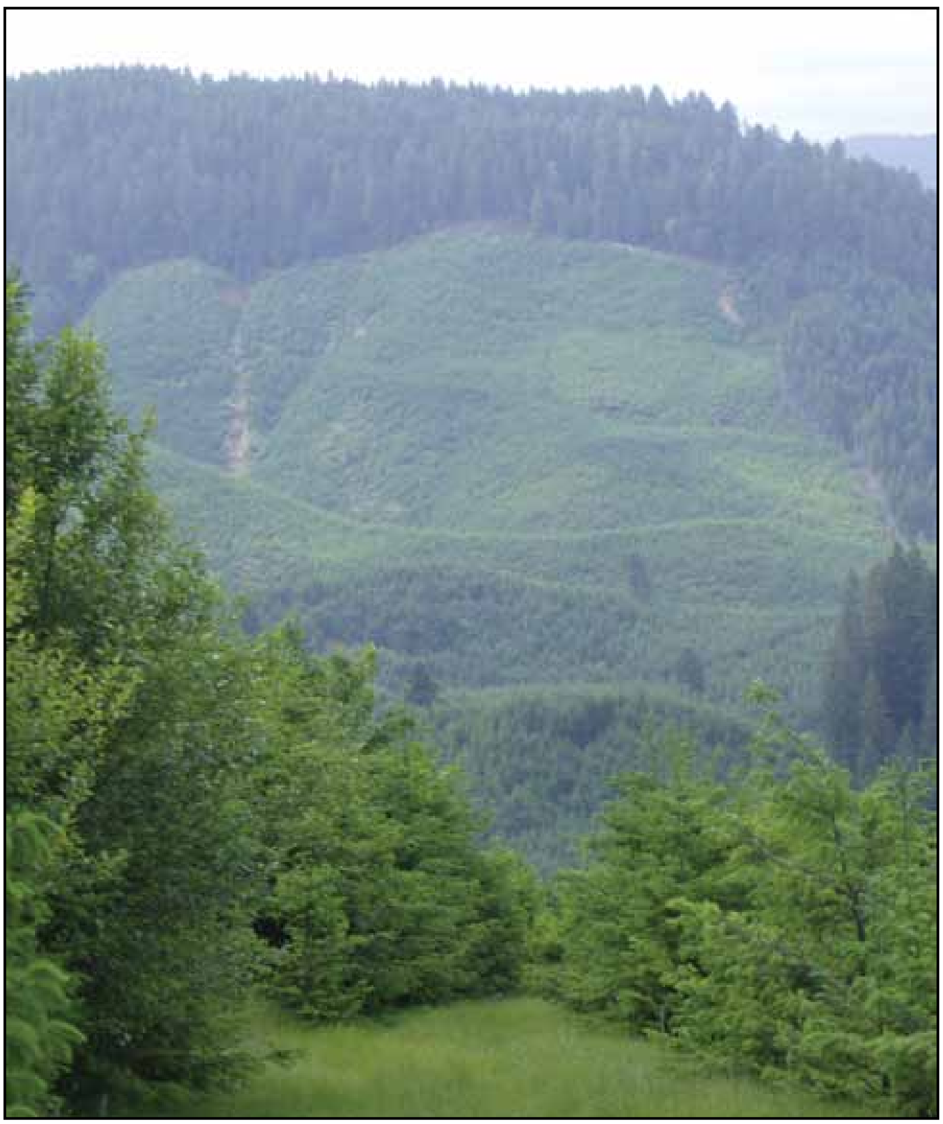

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Figure 2—Timberland is a subset of forest land, that portion that meets a productivity threshold and is available for timber management.

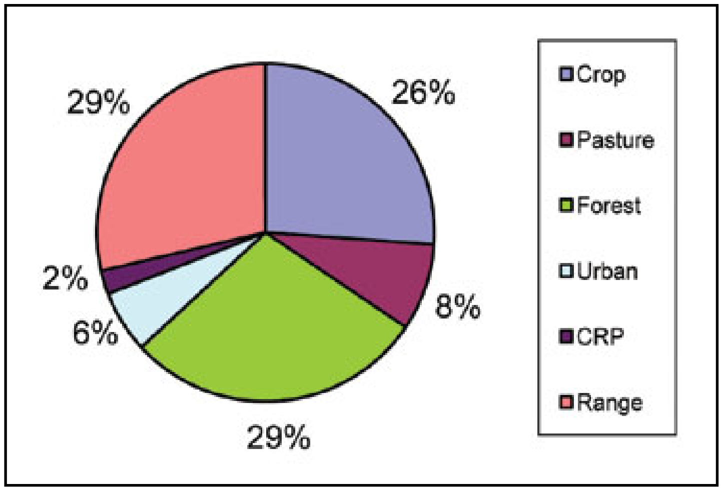


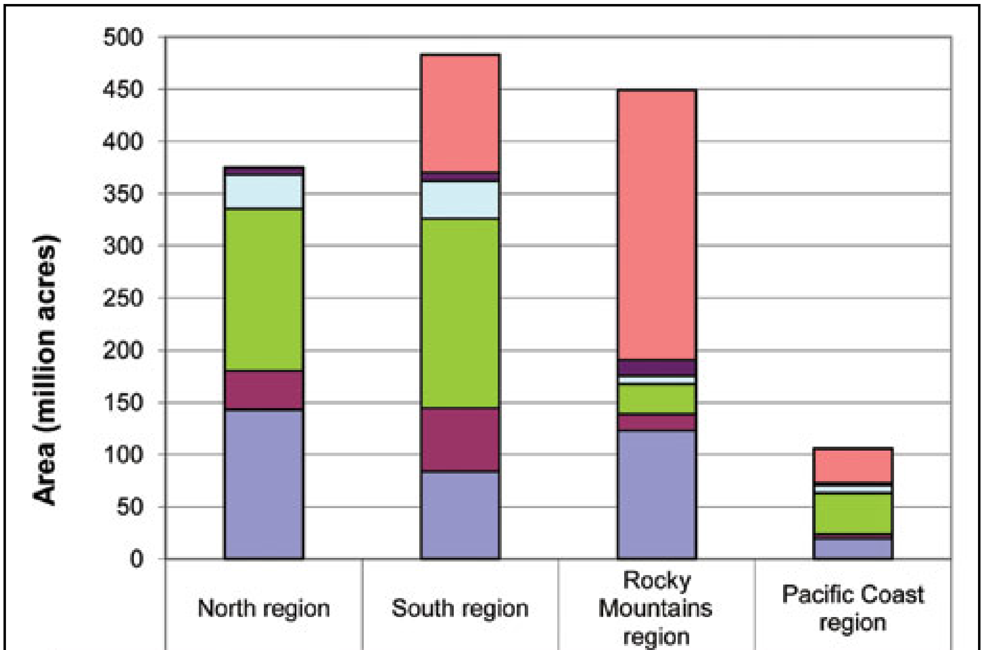
Figure 3—Allocation of U.S. nonfederal land to six major use categories, 2002. CRP = Conservation Reservice Program.

acres of forest, reserved for nontimber uses, is managed by public agencies as parks or wilderness areas. The remaining 162 million acres of forest land that is not timberland is not capable of producing 20 cubic feet per acre of industrial wood annually. However, such areas 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 currently 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 nontimberland forests, such as the pinyon-juniper forests of the southwestern portion of the country.

Land-Use Situation

The land base for this study is defined as all nonfederal land in the contiguous 48 states, a total of 1.4 billion acres. Although Alaska is home to a significant amount of forested land, NRI transitions data are not available for the state, so Alaska has been omitted from this analysis. The NRI is a longitudinal survey of land use, with the first estimates for 1982 as described in the appendix.

Figure 3 depicts the allocation of nonfederal land base into six major land-use categories. The vast majority (92 percent) of land is in rural uses, including forests, crops, pasture, and range. More than 90 percent of land-use changes on nonfederal lands in recent decades have been among these four rural land uses (USDA NRCS 2001). 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 are



	North region	South region	Rocky Mountains region	Pacific Coast region
Range	0.1	113.2	258.5	33.1
CRP	6.6	7.9	15.4	1.8
Urban	32.4	36.2	7.9	7.9
Forest	155.8	181.4	28.8	39.4
Pasture	36.8	61.0	15.5	4.1
Crop	142.9	83.6	123.0	19.7

Figure 4—Allocation of nonfederal land by major use by region for the United States, 2002.
CRP = Conservation Reserve Program.

also affected by technological improvements, and since World War II, increases in cropland yields per acre have been larger in general than corresponding changes in 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 decreased pressure to convert forest land.

The distribution of nonfederal land between uses differs considerably among the four RPA regions (fig. 4). For example, the North, South, and Pacific Coast regions have between 37 and 41 percent forest land, but the Rocky Mountains region has only 6 percent. Percentage of cropland ranges from 17 percent in the South region to 38 percent in the North region. The North region holds the largest share of cropland of the four regions in this study, and the South region is home to the largest area of nonfederal forest land in the country. The Rocky Mountains region is largely range and cropland and also has the largest area of land enrolled in the Conservation Reserve Program (CRP). The Pacific Coast region is by far the smallest of the four

Table 1—Historical allocations of land in the contiguous 48 states to major use categories, 1982 to 2001

	Land uses							
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range	Other[b]	Total
				Million acres				
1982	420.2	131.2	401.2	51.6	0.0	415.6	517.9	1,937.7
1987	406.0	127.3	403.1	57.7	13.8	410.0	519.8	1,937.7
1992	381.7	125.3	403.1	65.0	34.0	406.2	522.3	1,937.7
1997	376.4	119.5	404.7	75.9	32.7	404.8	523.6	1,937.7
2001	369.5	119.2	404.8	83.2	31.8	404.9	524.3	1,937.7

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.
[b] Includes all federal land. See table 2 for a full description of "other" land.
Data source: USDA National Resources Inventory.

Although pre-1930 trends in land-use shifts have moderated, rural land use remains mutable in the short term.

regions. As of 2002 (base year from NRI data, as described in the appendix), nonfederal land in the Pacific Coast region was primarily range and forest land. Each of these regions will be discussed in more detail in the following chapters.

Area Changes for Major Land Uses

Table 1 shows the historical use allocations of the land base for the contiguous 48 states of 1.9 billion acres. These figures are based on NRI data or estimates they assemble (e.g., federal ownership data from agencies), which include the six primary land-use categories as well as a category for "other land uses" (see glossary). This "other land uses" category includes federally owned land and other minor land-use categories (e.g., windbreaks, barren land), as shown in table 2. In previous NRI reports, land devoted to urban and rural transportation uses was considered to be part of a broader category called developed land. However, this study will focus only on the urban component of developed land. We do not attempt to project areas for "other" uses shown in table 2 because the underlying projection model relies on net financial returns to each use. The amount of land owned by the federal government or devoted to rural transportation or water uses is typically not determined by market forces and therefore cannot be modeled in this context. In the case of minor rural land use, the category itself is not precise enough to identify net returns to the use. The rest of this report will focus on the six major land-use categories: crop, pasture, forest, urban, CRP, and range.

Although pre-1930 trends in land-use shifts have moderated, rural land use remains mutable in the short term. Substantial land areas have shifted back and forth between uses. Based on a data times series longer than the NRI, 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

Table 2—Historical land uses included in "other" use class for the contiguous 48 states, 1982 to 2001

	Land uses				
Year	Minor land uses	Rural transportation	Water uses	Federal	Total other
		Million acres			
1982	49.0	21.2	48.6	399.1	517.9
1987	49.3	21.3	49.8	399.4	519.8
1992	50.0	21.4	49.3	401.5	522.3
1997	50.4	21.6	49.9	401.7	523.6
2001	50.2	22.0	50.3	401.9	524.5

Note: Data may not add to totals because of rounding.
Data source: USDA National Resources Inventory.

(Vesterby and Krupa 2001). At the same time, a combined total of 1.5 million acres per year has moved into or out of forestry.

According to the NRI land-use surveys, total cropland area has trended downward since 1982. Between 1982 and 2001 (table 1), total acreage of cropland decreased by 50.7 million acres. Trends in major field crops (e.g., corn, soybeans, and wheat) are relevant from a forestry perspective because of the competition for land. Food crop acres have tended to increase over the past 30 years, while livestock feed and other crops have declined (Daugherty 1995). Among crops used mostly for food, area in wheat production is higher now than in the 1960s, but down from the early 1980s. Harvested acres of soybeans reached a record high of about 75 million acres in 2006 after experiencing declines during the late 1980s and early 1990s. In 2007, 62.8 million acres of soybeans were harvested, and the 2008 harvested area was estimated to be about 74.5 million acres (USDA NASS 2008a). Among crops used primarily for feed grains, corn planting reached a high of 110 million acres in 1932, decreased to a little over 80 million acres in the late 1950s, and has since ranged from the low 60 millions to the low 80 millions through 2000. Use of corn for ethanol production pushed corn area to record levels, with 94 million acres planted in 2007 (USDA NASS 2009), the highest amount since 1946. Hay area has changed little since the late 1970s (Vesterby 2001).

Transitions between the major land use categories from the NRI surveys are shown in table 3. The primary conversions affecting cropland during this period were enrollment in the CRP and movements between crops and pasture. The CRP was established in 1985, so the transitions shown here include the initial enrollment period for the program. From 1982 to 1997, 27.6 million acres of cropland was converted to pasture while 23.4 million acres of pasture was converted to cropland, indicating that land frequently moves between these two uses.

Table 3—Nonfederal land-use transactions for major uses in the United States, 1982 to 1997

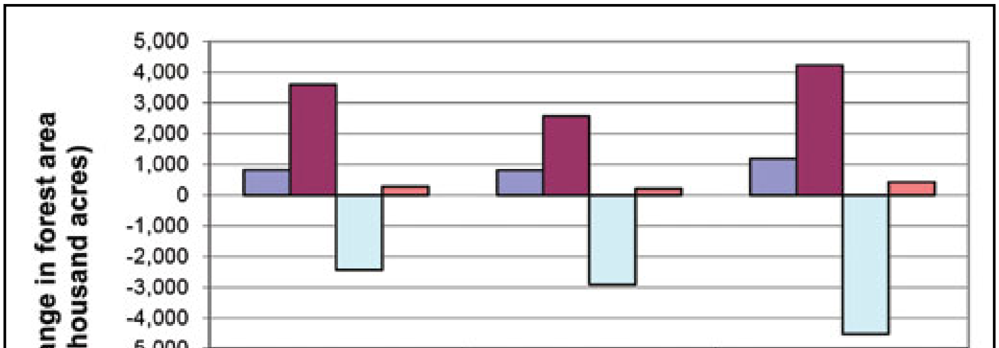
Initial land use	New land use					
	Crop	Pasture	Forest	Urban	CRP[a]	Range
	Thousand acres					
Crop	—	27,648	5,037	6,434	34,200	3,557
Pasture	23,391	—	14,797	4,074	1,401	2,859
Forest	2,223	4,417	—	9,888	126	2,266
Urban	3	2	3	—	0	1
CRP[a]	2,264	797	185	7	—	297
Range	7,872	2,961	3,176	2,984	471	—

[a] CRP = Conservation Reserve Program.
— = not applicable.
Data source: USDA National Resources Inventory.

Between 1982 and 1997, 14.8 million acres of pasture was converted into forest, while 4.4 million acres of forest was cleared to create new pasture.

The trend in U.S. pasture and range area has been downward for several decades. From 1982 to 2002, the area of land in pasture decreased more than 10 percent, or about 13.8 million acres. Rangeland has decreased in area by 10.7 million acres. Several reasons for the downward trend include improved productivity so that less pastureland and rangeland are needed to sustain grazing herds. A shift to animal confinement feeding has also contributed, giving the operators better control over animal diet (Blayney 2002). Also, the number of domestic farm animals, particularly sheep and draft animals, has declined in recent years, further reducing the need for pasture and range (Vesterby 2001). One of the factors affecting dynamics of the U.S. cattle population, which has undergone cycles since the 1880s, is the distribution of the size of the livestock operations (Mitchell 2000). The vast majority of U.S. cattle operations are too small to sustain economically without operators having other sources of income such as farming or outside jobs.

Total area of forested land at a national level remained relatively constant over the 10-year period from 1982 to 1992. Forest area then increased slightly from 1992 to 2002, from 403.1 million acres to 405.4 million acres. The largest gain in forest came from conversions of pasture to forest land (table 3). Between 1982 and 1997, 14.8 million acres of pasture was converted into forest, while 4.4 million acres of forest was cleared to create new pasture. National Resource Inventory transition data indicate that conversions from pasture have consistently been a significant net source of new forest in the recent past (fig. 5). However, 9.9 million acres of forest was lost to urban development from 1982 to 1997. Forest land was converted to urban development at an increasing rate during each 5-year NRI survey period from 1982 to 1997, from 2.4 million acres between 1982 and 1997 to 4.5 million acres between 1992 and 1997.



	1982–1987	1987–1992	1992–1997
Crop	818	810	1,186
Pasture	3,595	2,561	4,224
Urban	-2,440	-2,920	-4,524
Range	275	211	424

Figure 5—Historical net transitions of forest area to or from other major uses on nonfederal land in the United States, 1982 to 1997. For example, negative numbers represent loss of forest to other uses.

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 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).

The CRP has been effective in enhancing wildlife habitat in some areas (Brady and Flather 1998), such as the northern Great Plains, although costs of keeping land out of production are likely to determine the long-term fate of CRP lands. Mitchell (2000) indicated that a significant long-term increase in rangeland area for grazing owing to the CRP has not been forecast. Whether future additions of more 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 been available for tree planting. The amount of idled agricultural land affects market prices and can change competition for land among sectors. As of 2008, land idled under the CRP is at 34.7 million acres (Cowan 2008). This is down from a peak of 78 million acres idled by all federal programs in 1983, before the CRP was established. Acres idled through participation in the CRP differs greatly by farm production region, with the most area in the Northern Plains and Mountain States (Vesterby 2001). The Federal Agriculture Improvement and Reform Act of 1996 (the 1996 Farm Act) eliminated the authority of USDA to implement an

The national Farm Bills have increasingly included environmental provisions.

annual Acreage Reduction Program and other annual acreage diversions. As a result, after 1996 no land has been idled under annual commodity programs. This contrasts with 18 million acres in 1995 and a range of 13 to 60 million acres idled annually from 1986 to 1996. However, emergency aid provided to farmers through legislation in 1998-2001 reflected uncertainty about the direction of the policy transition. With lower agricultural prices than in the mid-1990s, debate about the 2002 Farm Bill was further evidence of interest in changing the thrust of the 1996 Farm Act, e.g., new types of countercyclical farm policies.

The national Farm Bills have increasingly included environmental provisions. The 2008 Farm Bill continued the CRP and affected all contracts due to expire from 2007 to 2010. Contracts were divided into quintiles based on the environmental benefit index. The highest quintile was offered new 10- or 15-year contracts, and the rest were offered 2- to 5-year extensions.

Although cropland area has trended downward over the historical period, the amount of surplus or idle agricultural land has been substantial at times. Between 1982 and 1997, the Census of Agriculture reported a figure solely for idled cropland. During these years, idled cropland ranged from a low of 13.7 million acres in 1982 to a high of 37.5 million acres in 1987. In 1997, the amount of idled cropland was about 19 million acres or 2 percent of all land in farms, and 13.5 million acres in a related category of cropland "used for cover crops or soil improvement but not harvested and not pastured or grazed." After 1997, the Census of Agriculture combined these two categories. Land in this category combination was about 37 million acres in both 2002 and 2007, or about 4 percent of 2007 farm land.

Estimates of idle cropland from the Census of Agriculture are largely consistent with those reported in the Economic Research Service major land uses data (USDA ERS 2009). Over that longer period going back to 1945, idled cropland ranged from 18 million acres in 1954, to 51 million acres in 1969, to 39 million in 2002.

The 1989 RPA Assessment (USDA FS 1989b) examined the availability of idle cropland as a possible source of new forest land under an "Alternative Future" (fig. 6). The Second Resources Conservation Act (RCA) Appraisal by the Soil Conservation Service (now the Natural Resources Conservation Service) (USDA SCS 1987) projected 128.5 million acres of cropland would be idle by 2030, in addition to 39.8 million acres assumed to be enrolled in the Conservation Reserve Program (CRP). The RCA model assumed relatively large increases in agricultural yields, thereby freeing up a substantial amount of cropland in the future, thus termed surplus cropland. Of the 128.5 million acres of surplus cropland, most was projected to revert to range cover, a total of 96 million acres. An additional 15.6 million acres was

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Figure 6—Land-use competition among forestry and agricultural uses is affected substantially by development influences, and this affects costs of terrestrial carbon storage to address climate change.

projected to revert to hardwoods, 15.4 million acres to hardwood/softwood, and 1.5 million acres to softwood types.

A notable trend among major land uses has been the increase in the area of urban and developed uses. The area of urban and developed uses steadily increased between 1982 and 2002, from 53.9 to 84.4 million acres, an increase of nearly 57 percent, accommodating a U.S. population increase of about 56 million people. Despite this growth, urban land remains a fairly small part of the national land base. In 2002, urban and other developed land occupied just over 5 percent of the nonfederal surface of the contiguous 48 states (USDA NRCS 2001). The fraction of the land base occupied by urban uses differs considerably among subregions of the country (table 4). The Northern Plains and Mountain subregions had the smallest percentage of land in urban use, at 1.2 and 2.1 percent, respectively. The Northeast and Southeast were the most developed with 12.7 and 14.0 percent of land, respectively, in urban use in 2002.

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. According to estimates from the U.S. Census Bureau (USDC Census Bureau 2009), the Nation's population grew from just over 200 million people in 1970 to more than 300 million in 2007 (fig. 7). A positive relationship between population and personal income and developed land area is consistent with earlier research findings (e.g., Alig and Healy 1987, Alig et al.

The area of urban and developed uses steadily increased between 1982 and 2002, from 53.9 to 84.4 million acres, an increase of nearly 57 percent, accommodating a U.S. population increase of about 56 million people.

Table 4—Percentage of nonfederal land in urban use by subregion, 1982 and 2002

	Urban use	
Subregion	1982	2002
	Percent	
Northern Plains	0.9	1.2
Mountain	1.1	2.1
Lake States	4.5	6.6
Corn Belt	5.0	7.0
Northeast	8.4	12.7
Pacific Northwest East	1.1	2.0
Pacific Northwest West	5.9	9.6
Pacific Southwest	7.1	10.8
South Central	3.6	6.4
South Plains	2.3	3.9
Southeast	7.0	14.0
Conterminous 48 states	3.6	5.9

Data source: USDA National Resources Inventory.

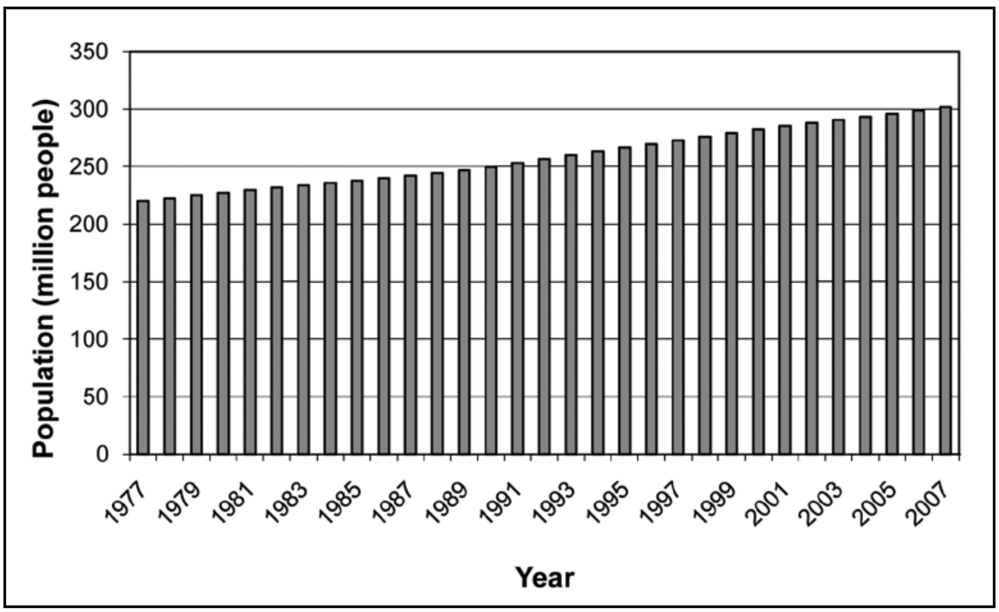


Figure 7—Historical population estimates for the United States, 1977 to 2007.

2004b). USDA's 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 annually from 1982 to 1992.

Increasing urbanization has reduced the supply of economically productive rural lands. Net areas of rangeland, pasture land, and cropland decreased between 1982 and 1997, while forest area grew slightly. Pressure from the growing urban

Ralph Alig

Figure 8—Changes in personal income can affect land values, affecting land conservation and sustainablity of forestry and agricultural ecosystem.

sector increases competition among the rural uses, in some cases, to replace land converted to developed uses.

According to NRI statistics, forests accounted for over one-third of rural land converted to urban and developed uses between 1982 and 1997 (USDA NRCS 2001). Outside urban areas, rural residential land conversion comes from rangeland, pasture land, and cropland, in addition to forest land. In addition to conversions to urban and rural residential uses, some rural land has been converted for infrastructure (e.g., roads), commercial and industrial buildings and parking areas, and miscellaneous and special uses (Vesterby 2001, Vesterby and Krupa 2001). Much of the expansion in urban area is near existing urban areas, although some fast-growth counties have been in largely rural areas (Heimlich and Anderson 2001).

According to NRI statistics, forests accounted for over one-third of rural land converted to urban and developed uses between 1982 and 1997.

Increased per-capita incomes can increase demand for developed land (fig. 8). During the last decade (1990s), the United States was in a period of substantial economic growth (e.g., stock markets with relatively large gains). As shown in figure 9, real (adjusted for inflation or deflation) per-capita personal income increased from just over $23,000 in 1996 to around $36,700 in 2006.

Land-Use Projections

Projections of land use by area are made for the major land-use categories: crop, pasture, forest, urban, CRP, and range. The projections are based on an

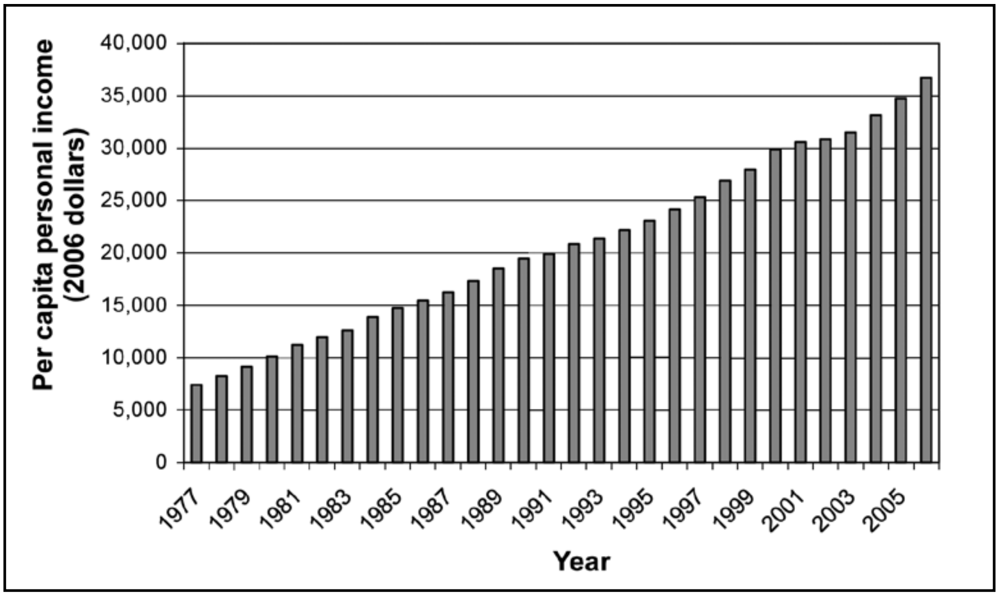


Figure 9—Estimates of historical per capita personal income for the United States, 1977 to 2006. Data source: U.S. Bureau of Economic Advisors (USDC BEA 2009).

econometric analysis of land-use change estimated with data on nonfederal land in the contiguous 48 states (Lubowski 2002). The model explains land-use changes in terms of economic returns and site characteristics such as land quality. Using the results of the econometric analysis, a projection algorithm was developed to generate land-use projections, by county, to 2062 (see appendix). For the present research as compared to that reported by Alig and Plantinga (2004), the land-use projection model has been updated by including separate econometric models for four regions where the national model did not fit the data well (see appendix) (Plantinga et al. 2007). Even with these modifications, the national and regional models will estimate county-level land use with error, and this should be kept in mind when interpreting the county-level projections.

The NRI is the primary data set used to estimate the national econometric land-use model used in this study. The NRI is a panel survey of land use and land characteristics on nonfederal lands conducted at 5-year intervals from 1982 to 1997 over the entire United States, excluding Alaska. The NRI provides information on land-use transitions over the three periods 1982-87, 1987-92, and 1992-97. The current land-use projection model also incorporates more recently available NRI data on state-level land use for 2003. For additional details of the land-use projection model, see Plantinga et al. (2007). The appendix to this report details the changes that were made to the model for this study.

Historical land-use trends are shown in figure 10, along with the projected trajectories through 2062. The reference case or initial conditions case we use in this

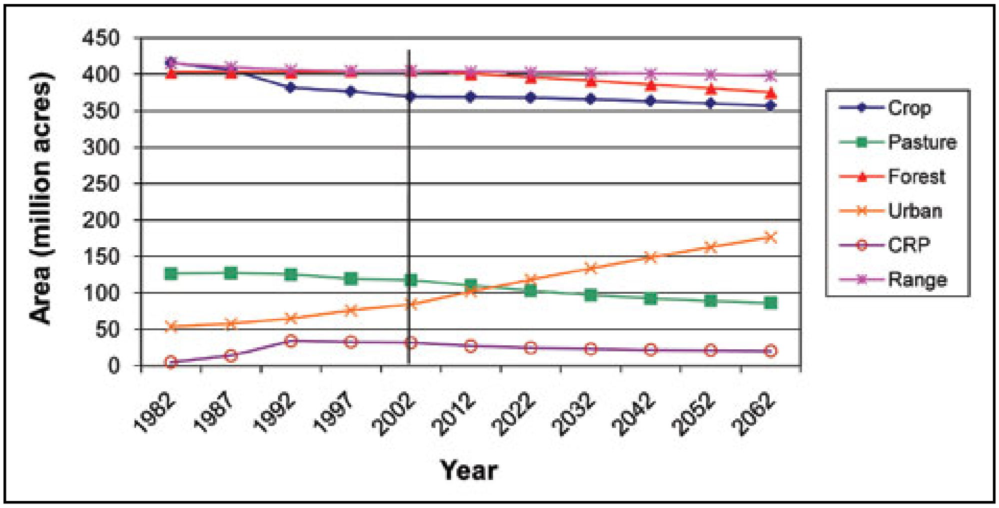


Figure 10—Historical and projected land-use trends (under initial conditions) on nonfederal land in the contiguous 48 states, 1982 to 2062.

study uses scenarios for the 2010 RPA Assessment that are linked to the 4th Intergovernmental Panel on Climate Change (IPCC) storylines (Langner, n.d.). The U.S. population projection is linked to the IPCC A1 storyline, updated to more recent projections done by the U.S. Bureau of the Census, and the income projection is an average of the income projections from the three RPA scenarios linked to the IPCC GDP projections A1, A2, and B2 storylines (Langner, n.d.). Areas of crop, forest, and range land are expected to decrease in the future; however, these three uses will continue to be the dominant land uses in the United States. Urban land is projected to increase dramatically, in line with urban development over the previous 20 years.

Areas of crop, forest, and range land are expected to decrease in the future; however, these three uses will continue to be the dominant land uses in the United States.

The land-use projection results shown in table 5 indicate that cropland is projected to decline from 369.3 million acres in 2002 to 356.7 million acres in 2062, a loss of 3.4 percent of cropland area. Projected transitions between land uses can be

Table 5—Projected areas for six major land uses on nonfederal land in the contiguous 48 states, 2002 to 2062, under initial conditions

	Land uses						
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range	Total area
			Million acres				
2002	369.3	117.4	405.4	84.4	31.7	404.9	1,413.1
2012	368.9	110.6	400.7	101.8	27.3	404.0	1,413.1
2022	367.9	103.1	396.2	118.2	24.7	403.0	1,413.1
2032	365.9	97.2	391.3	133.7	23.0	402.0	1,413.1
2042	363.2	92.6	386.1	148.6	21.8	400.8	1,413.1
2052	360.1	89.1	380.8	162.8	20.9	399.6	1,413.1
2062	356.7	86.2	375.3	176.4	20.2	398.2	1,413.1

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.

Table 6—Projected land-use transitions for major uses on nonfederal land in the contiguous 48 states, 2002 to 2062, under initial conditions

Inital land use	New land use: Crop	Pasture	Forest	Urban	CRP[a]	Range
	Thousand acres					
Crop	—	100,913	7,599	21,043	12,529	10,165
Pasture	100,145	—	59,281	14,508	824	14,323
Forest	12,868	32,188	—	49,719	358	7,977
Urban	0	0	0	—	0	0
CRP[a]	11,999	9,524	464	33	—	2,421
Range	13,936	15,178	5,449	6,673	214	—

— = not applicable.

[a] CRP = Conservation Reserve Program.

seen in table 6. Movements between cropland and pasture will continue at a relatively high rate in the future, with more than 100 million acres moving between the two uses but very little net change in the total area of either use. The largest net loss in cropland will come from urban expansion, as the model projects that 21.0 million acres of cropland will be developed for urban use.

Figure 11 maps the percentage of each county in the United States that is projected to be in cropland use in 2002 and 2062. This figure indicates that most of the Nation's cropland is located in the Midwest, which encompasses the eastern portion of the Rocky Mountains RPA region and the western portion of the North RPA region. Figure 12 shows the expected change in the percentage of each county allocated to crops over the 60-year projection period. Some of the larger percentage losses can be seen in eastern Oregon and Washington, where the percentage of each county in cropland is expected to decrease between 20 and 57 percent. Other areas facing significant cropland losses are shown in red and orange throughout California and Minnesota and along the Mississippi River in Arkansas and Mississippi. A smaller hotspot of rapid cropland loss can be seen in the area surrounding the city of Chicago, Illinois. Another notable feature of cropland changes in figure 12 is the areas in Missouri and Iowa where cropland is expected to increase significantly. The areas shown in blue indicate counties where the percentage of land devoted to crops will increase between 21 and 51 percent.

After a slight gain in acreage from 1982 to 2002, forest area at the national level is projected to steadily decline from 2002 to 2062, from 405.4 million acres in 2002 to 375.3 million acres in 2062. The transitions in table 6 indicate that the largest loss of forest will be due to urban development, leading to the conversion of 49.7 million acres of forest to urban use by 2062. A net gain in forest land is expected from conversions of pasture to forest, which will offset some of the forest acreage lost to urban development. Between 2002 and 2062, 59.3 million acres of pasture

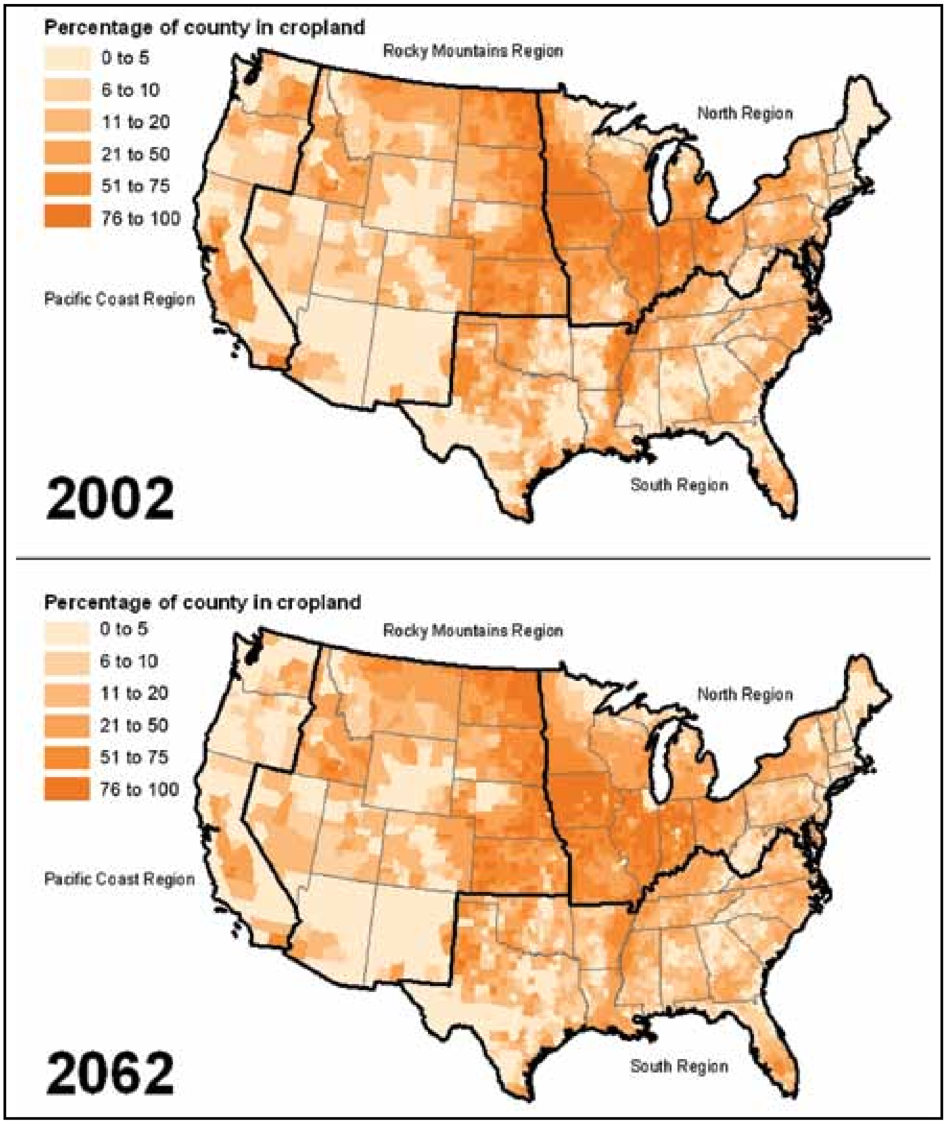


Figure 11—Cropland area projections at the county level, 2002 and 2062, under initial conditions.

is projected to be forested, while 32.2 million acres of forest will be converted to pasture, leading to a net gain of 27.1 million acres of forest from pasture. The maps in figures 13 and 14 show how these changes in forest area will be distributed across the United States at the county level.

Figure 13 shows that forest land in the contiguous 48 States is concentrated in the Pacific Coast, North, and South regions. For the Rocky Mountains region, the area of forest land in each county will remain fairly constant, in the range of decreasing by 4 percent to increasing by 5 percent. Some areas will see more extreme changes (fig. 14), where significant losses are shown in red and orange and gains are shown in blue. Considerable losses of forest can be seen along the Pacific Coast in

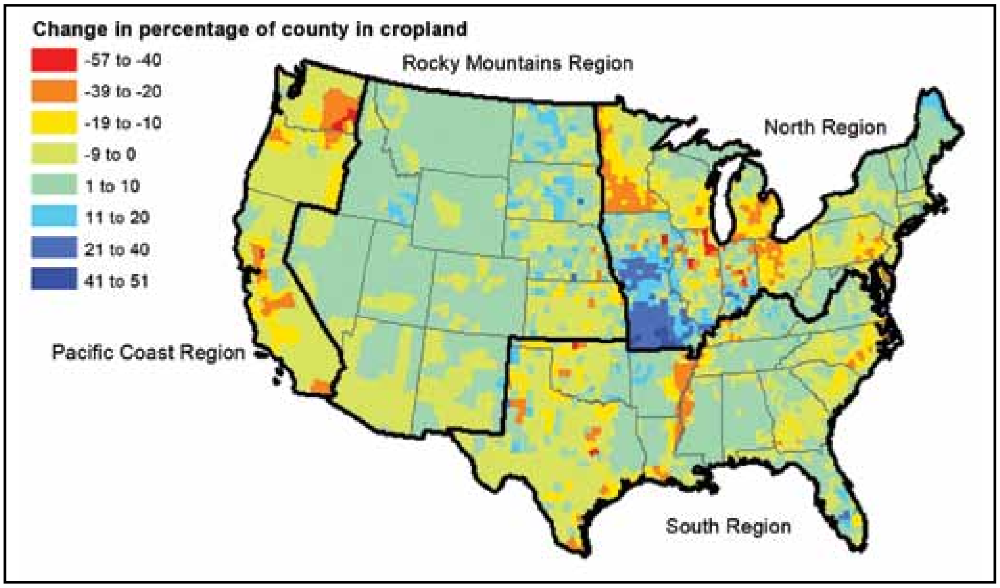


Figure 12—Projected changes in cropland at the county level, 2002 to 2062, under initial conditions.

In addition to losses of cropland and forest, urban development will lead to the essentially irreversible loss of 14.5 million acres of pasture and 6.6 million acres of rangeland.

Washington, Oregon, and northern California. Many counties where 41 to 100 percent of the land was forest in 2002 are expected to fall to the 11- to 40-percent range by 2062. Another area of significant forest loss can be seen in southern Missouri. However, there are also areas of increasing forest cover in the Pacific Coast, North, and South regions, indicating that in addition to an overall loss of forest there will also be a redistribution of forested land in these regions.

Urban area is projected to continue to increase substantially, to more than double the 2002 level by 2062. At 176.4 million acres, urban area will account for 12.5 percent of the total nonfederal land area in the conterminous United States by 2062. In addition to losses of cropland and forest, this urban development will lead to the essentially irreversible loss of 14.5 million acres of pasture and 6.6 million acres of rangeland (table 6, fig. 15). The land-use models underlying these projections assume that no significant amount of land will be converted from a developed use back into a resource use. As was evident in the historical data in table 3, those transitions occur very infrequently.

Figures 16 and 17 show the geographic distribution of this projected urban growth across U.S. counties. Figure 16 indicates that densely developed urban areas will continue to expand outward from 2002 to 2062. This is particularly clear in the Chicago area in northeastern Illinois and in southern California. In 2002, most of the land base in the United States fell into the 0 to 5-percent urban category, but much of this land will move into the 6- to 10-percent or 11- to 20-percent ranges by 2062. These changes, shown in figure 17, point to broad expansion of

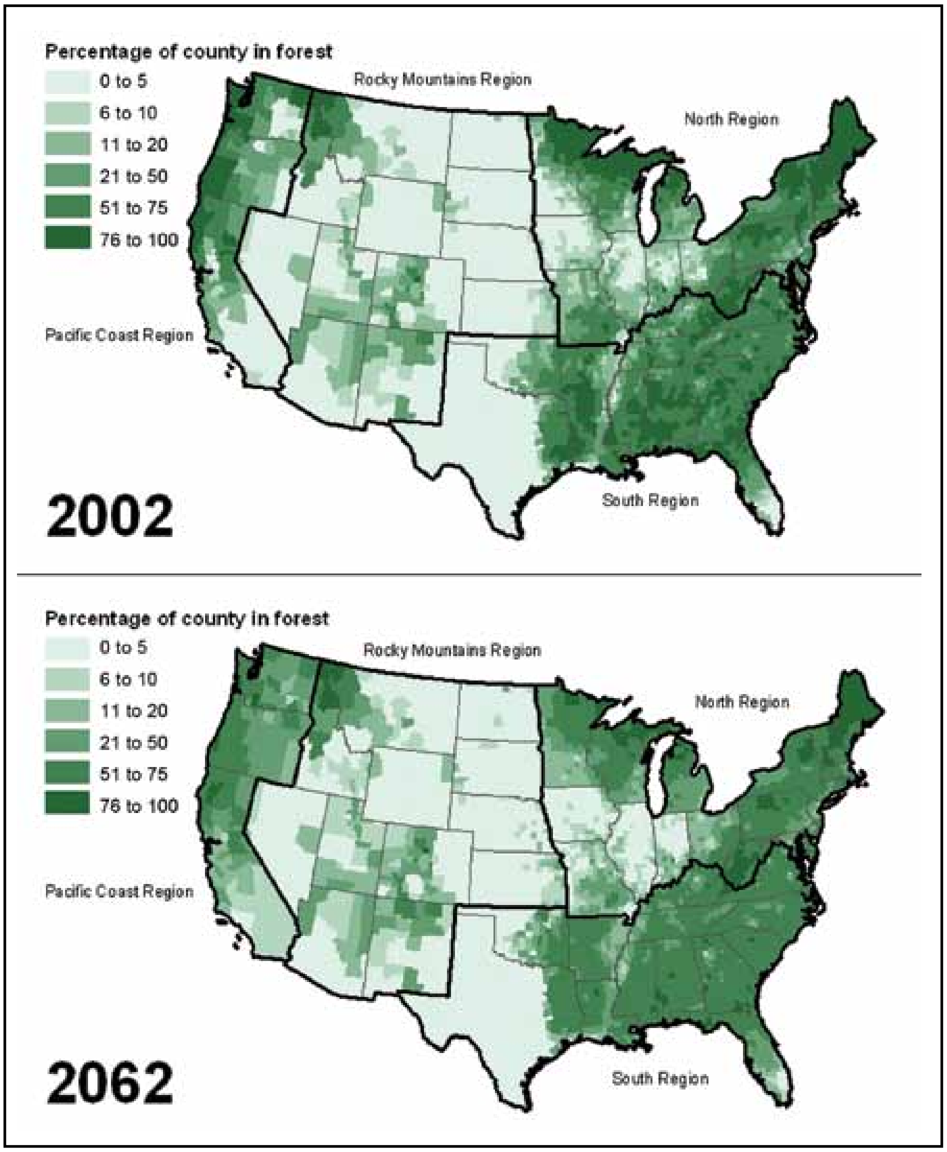


Figure 13—Forest area projections at the county level, 2002 and 2062, under initial conditions.

low-density development in the Pacific Coast, North, and South regions. Both figures imply that the Rocky Mountains region can expect to see less urbanization than the rest of the country. Figure 17 shows the most significant changes in urban area in orange and red. These areas are concentrated mostly along the Pacific Coast, but are also scattered throughout the North and South regions, particularly in some of the Corn Belt states such as Indiana and Illinois.

Urbanization has already had a major impact on all four regions since 1982 and will continue to significantly change the landscape in the future. The North and South regions were home to the vast majority of urban acreage in 2002, containing 32.4 and 36.2 million acres, respectively. Together, they accounted for more than 80

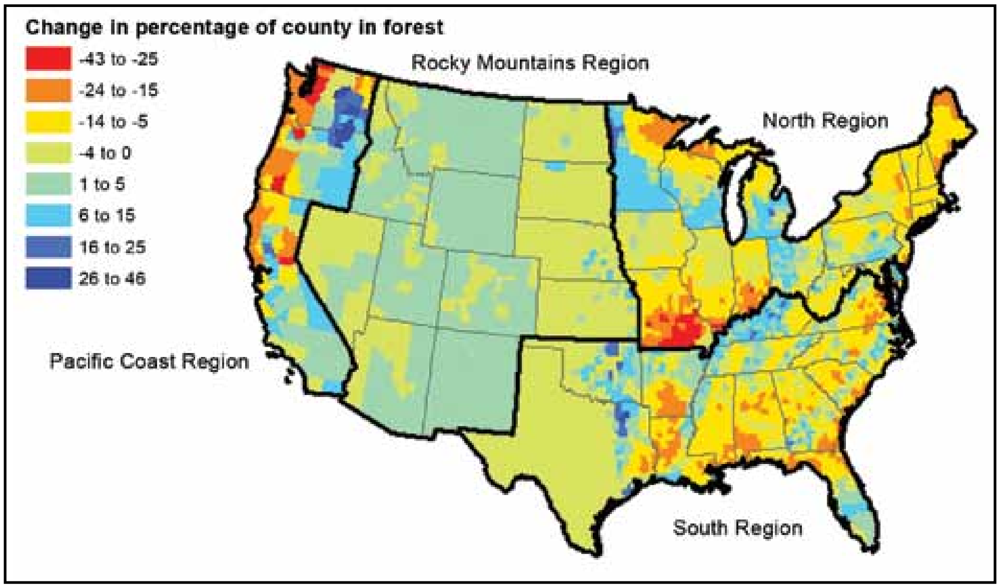


Figure 14—Projected changes in forest area at the county level, 2002 to 2062, under initial conditions.

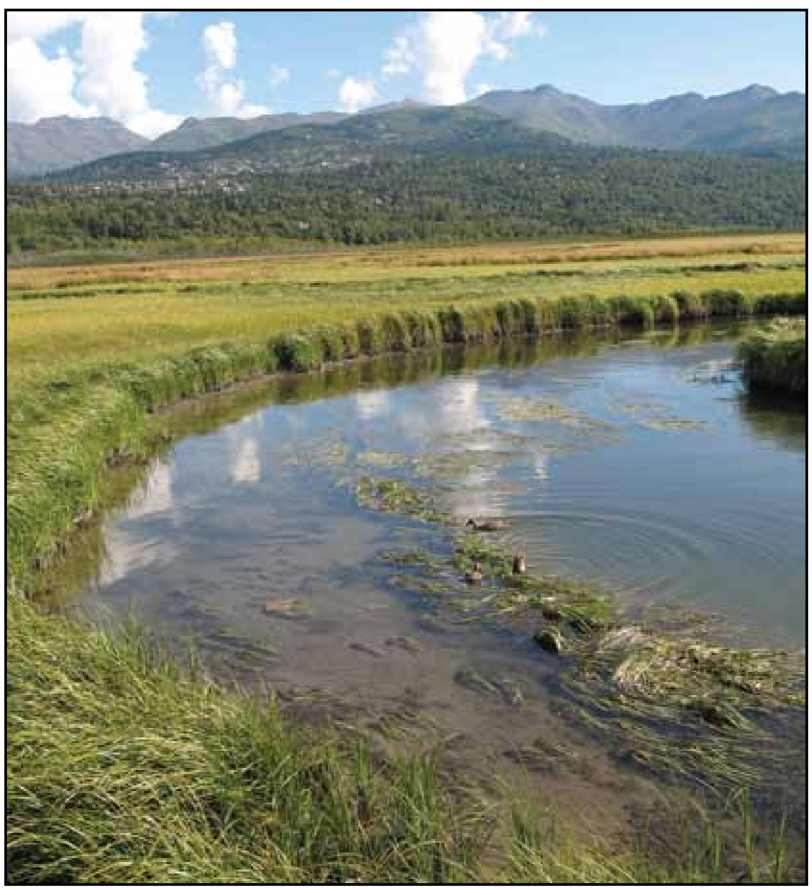


Figure 15—Land converted to developed uses includes wetlands, important for a variety of wildlife species and other ecological functions.

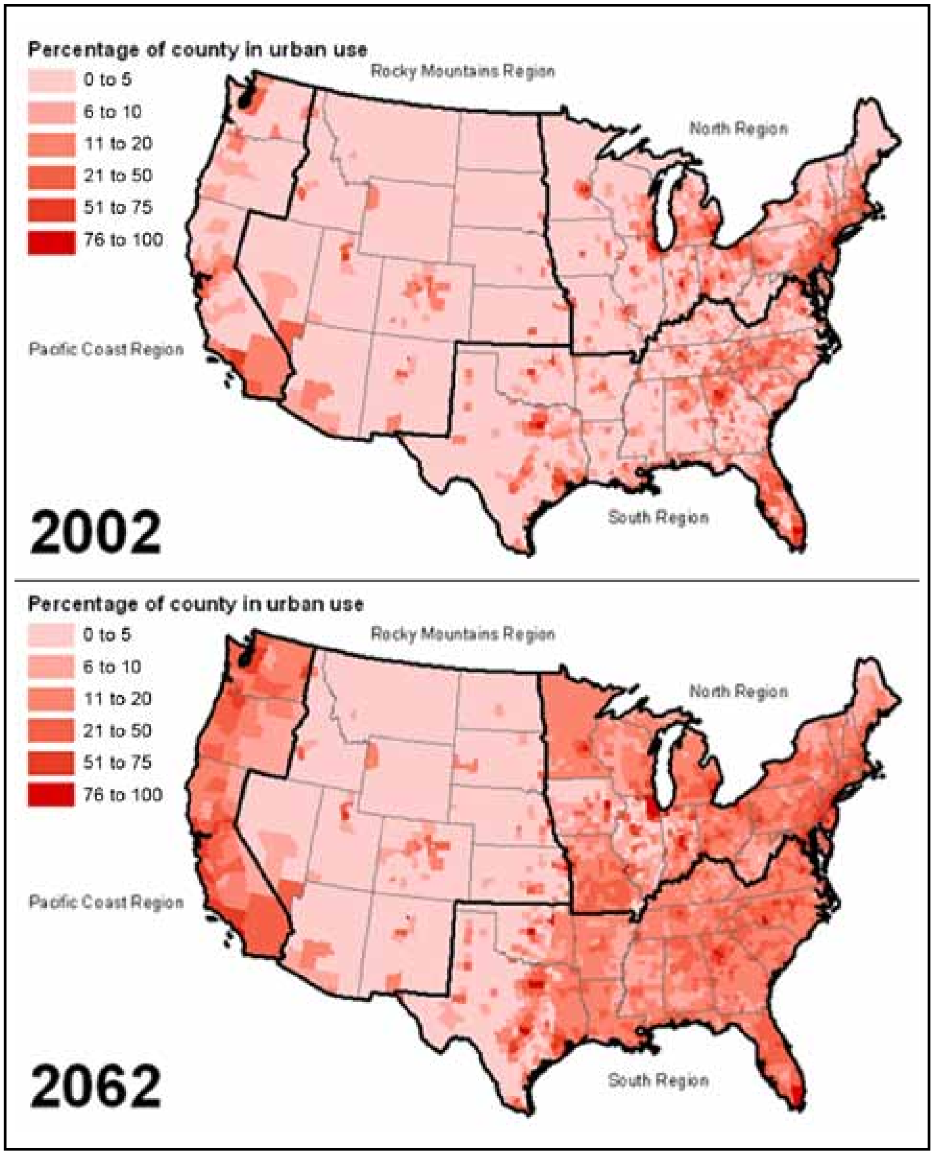


Figure 16—Urban area projections at the county level, 2002 and 2062, under initial conditions.

percent of the urban land in the Nation and this trend will continue into 2062 (fig. 18). However, the area of urban development in the Pacific Coast region is rapidly expanding, and urban land will account for nearly 25 percent of the region's total land base by 2062 (fig. 19). The Rocky Mountains region is expected to see the slowest urban growth from 2002 to 2062.

The South and Pacific Coast regions are particularly important forestry regions, so high rates of urbanization and forest loss in these areas may be cause for concern (Alig et al. 2004b). Many Americans continue to move to the South and Pacific Coast, with cities such as Atlanta growing much faster than the national average.

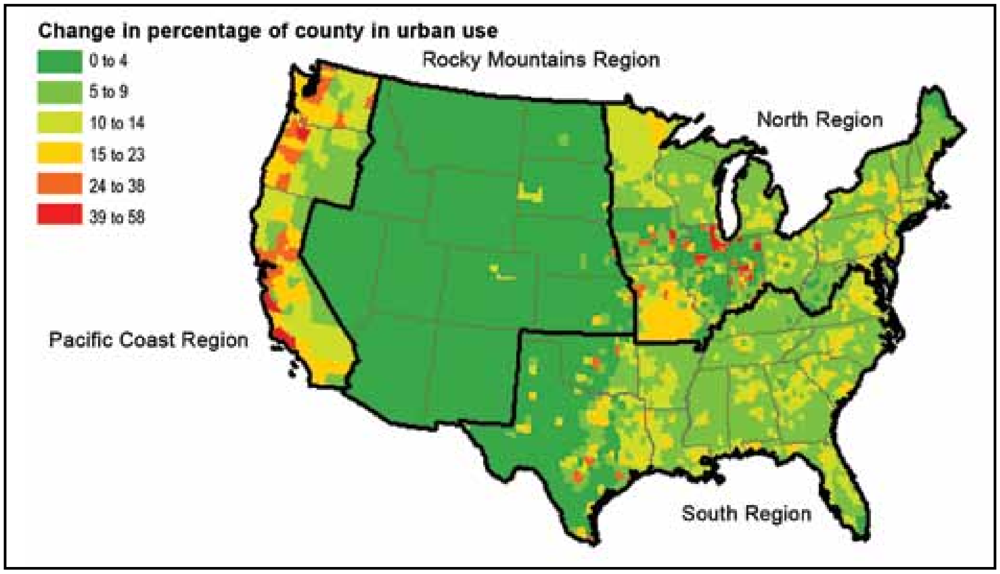


Figure 17–Projected changes in urban area at county level, 2002 to 2062, under initial conditions.

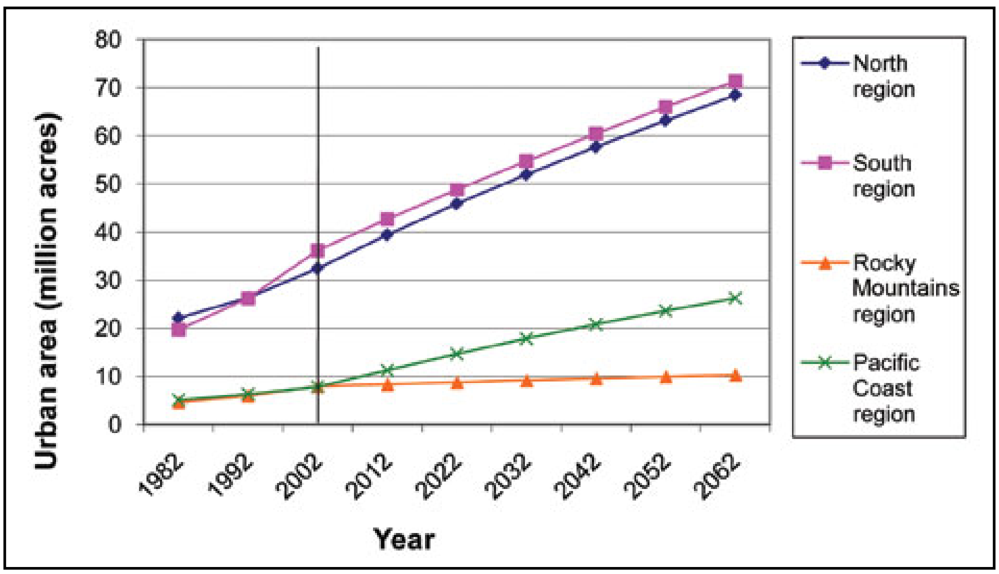


Figure 18—Area of nonfederal urban land by region, 1982 to 2062, under initial conditions.

Growth in some metropolitan areas has led to increasing population densities in counties surrounding central cores. The top 20 percent of fastest growing U.S. counties are primarily (56 percent) in the South. Such population trends are reflected in the regional population projections (table 7). The South is expected to grow by 61.0 million people, from 97.1 million people in 2006 to 158.1 million in 2060. The Pacific Coast, another area of rapid population growth, is projected to add an additional 26.2 million people from 2006 to 2060, a 56-percent increase.

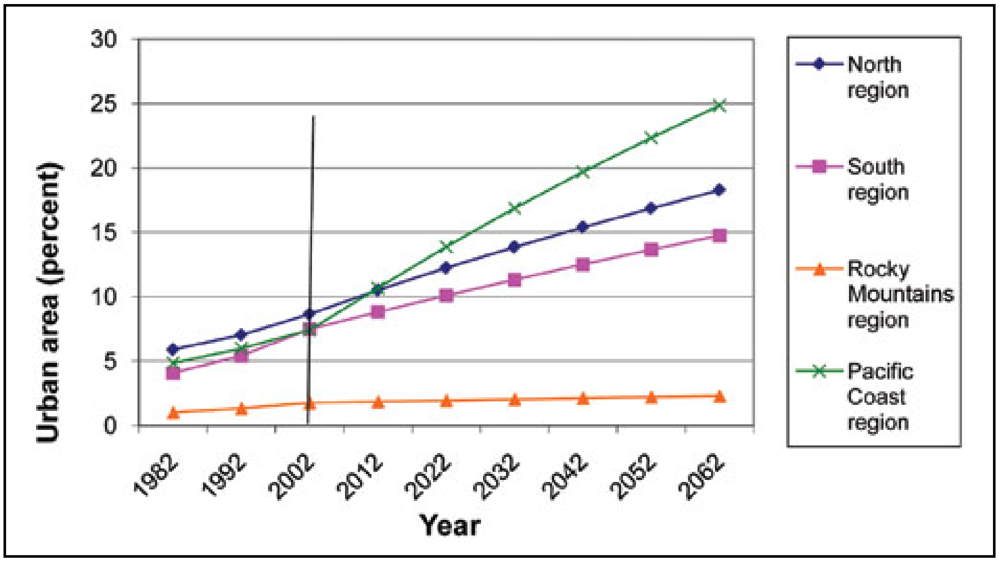


Figure 19—Percentage of nonfederal urban land by region, 1982 to 2062, under initial conditions.

Table 7—Regional population projections, 2006 to 2060, under initial conditions

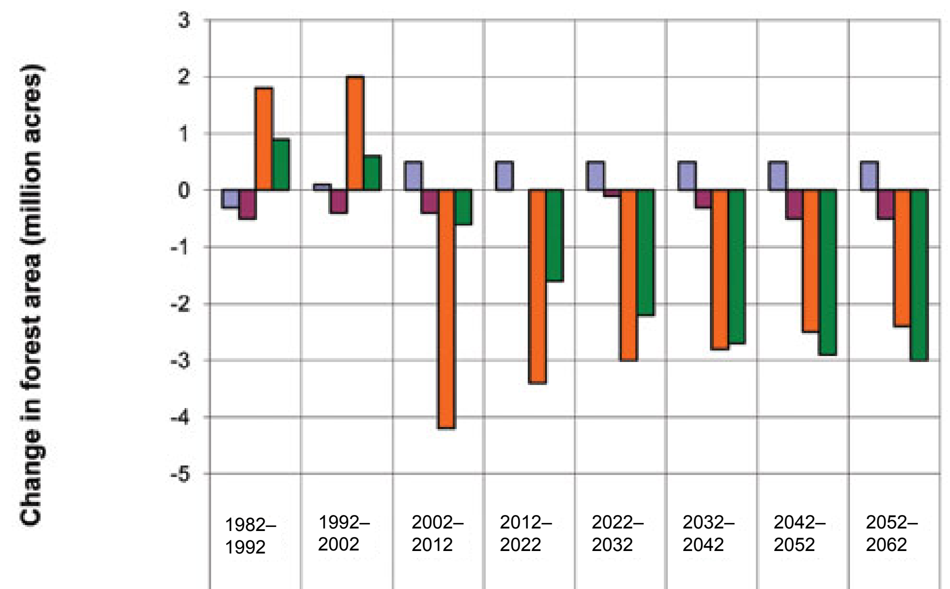
	Regions				
Year	North	South	Rocky Mountains	Pacific Coast	Total
			Millions		
2006	116.6	97.1	26.3	46.7	286.7
2010	118.0	100.8	27.7	48.2	294.7
2020	123.6	112.3	31.7	53.0	320.6
2030	129.8	124.0	35.8	57.9	347.5
2040	136.2	135.8	40.1	62.9	374.9
2050	142.6	147.1	44.4	67.9	402.0
2060	148.9	158.1	48.8	72.9	428.7

Note: Data may not add to totals because of rounding. Source is RPA common set of assumptions based on IPCC scenarios (Langner, n.d.).

With respect to sustainability issues, the South is seen by both the agricultural and forestry sectors as a region of expansion; however, population growth in that same region raises questions about whether all land uses can be sustained along those lines (Alig et al. 1999a, 1999b). The South is expected to lose forest land at an increasing rate in the future. The region is projected to lose less than 1 million acres between 2002 and 2012 but can expect a decline of 3.0 million acres between 2052 and 2062 (fig. 20). The North region is also expected to face significant forest land losses, with the largest decline in forest area in the region projected from 2002 to 2012.

At the national level, transitions of pasture are expected to be a source of new forest land. Average annual conversions of pasture to forest land are expected

With respect to sustainability issues, the South is seen by both the agricultural and forestry sectors as a region of expansion; however, population growth in that same region raises questions about whether all land uses can be sustained along those lines.



	1982–1992	1992–2002	2002–2012	2012–2022	2022–2032	2032–2042	2042–2052	2052–2062
Rocky Mountains	-0.3	0.1	0.5	0.5	0.5	0.5	0.5	0.5
Pacific Coast	-0.5	-0.4	-0.4	0	-0.1	-0.3	-0.5	-0.5
North	1.8	2	-4.2	-3.4	-3	-2.8	-2.5	-2.4
South	0.9	0.6	-0.6	-1.6	-2.2	-2.7	-2.9	-3

Figure 20—Historical and projected net changes per decade in forest area on nonfederal land by region, 1982 to 2062, under initial conditions.

Climate change can affect land-use patterns in the United States through a number of different channels.

to outpace conversions of forest to pasture by more than 400,000 acres (fig. 21). However, transitions with crop and range land will lead to net losses in forested area each year, and urban development is expected to occur on more than 800,000 acres of forest land annually from 2002 to 2062.

Figure 22 summarizes the historical and projected net land use changes in the six major categories at the national level. The historical period from 1982 to 1997 saw significant losses in cropland and pasture; however, some of this loss can be attributed to transitions into the CRP program established during that period. Between the time the CRP was created in 1985 and 1997, more than 30 million acres of environmentally sensitive agricultural land were enrolled in the program. The area of land in crops, pasture, and the CRP is projected to slowly decline in the future. In fact, the areas in all uses except for urban are expected to decline, indicating that urban expansion will have an impact across the entire U.S. land base (fig. 23). Except for urban and forest land, net changes in the major land uses are expected to be smaller in the future than they were in the historical period.

Climate change can affect land-use patterns in the United States through a number of different channels. A direct effect is to change the productivity of the land for producing agricultural and forest commodities, thereby changing the incentives

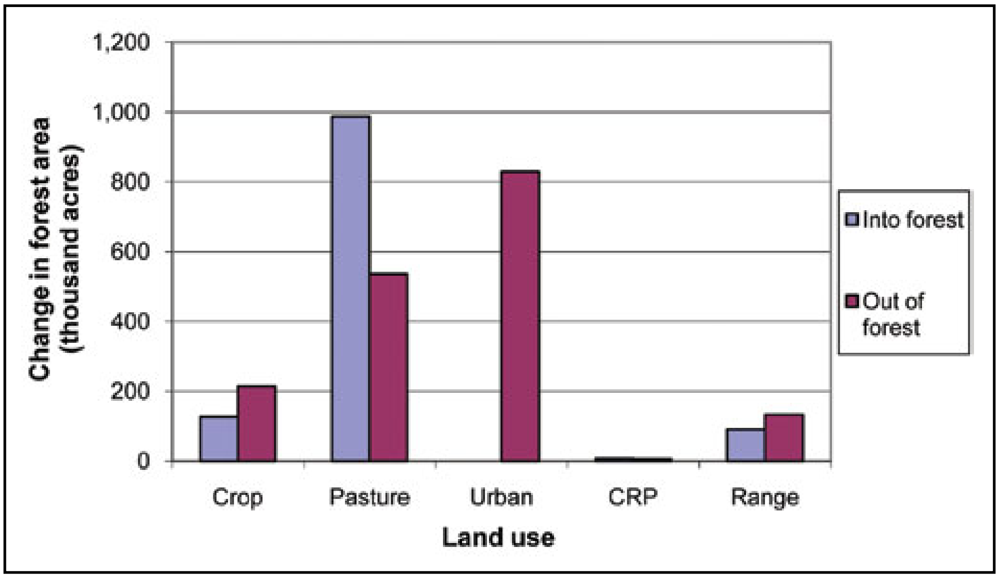
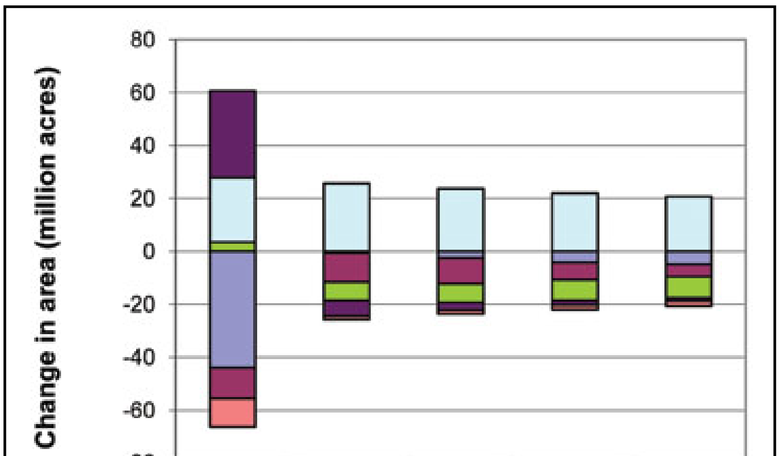


Figure 21—Projected average annual transitions involving forest area on nonfederal land in the contiguous 48 states, 2002 to 2062, under initial conditions.



	1982–1997	2002–2017	2017–2032	2032–2047	2047–2062
Range	-10.8	-1.4	-1.5	-1.8	-1.9
CRP	32.7	-5.8	-2.8	-1.7	-1.1
Urban	24.3	25.7	23.6	22.0	20.7
Forest	3.5	-6.9	-7.2	-7.8	-8.1
Pasture	-11.7	-10.8	-9.5	-6.4	-4.5
Crop	-43.8	-0.8	-2.6	-4.2	-5.0

Figure 22—Historical and projected area changes for 15-year periods, by major land use on nonfederal land in the contiguous 48 states, 1982 to 2062, under initial conditions.

Jeff Kline

Figure 23—Increases in population and personal income will contribute to additional projected conversion of forest land to developed uses.

landowners face when allocating their land to different uses. On a global scale, these induced changes in agricultural and forest land use will affect prices for associated commodities, further changing the incentives for land-use change. Changes in population and income trends within the United States are expected to affect the returns to urban development, but generally have less effect on the returns to agricultural and forest land because the related commodities are traded in global markets. We leave for future research an econometric investigation of the effects transmitted through productivity changes and international commodity markets; some information on possible land-use changes from climate change as projected by economic optimization models is provided by Alig et al. (2002a).

Given a fixed land base, changes in the relative returns to urban use will affect the area of land devoted to all uses. Urban net returns used in the estimation of the original land-use model under initial conditions reflect predictions that economic agents make about future population and income. Although we cannot know the exact predictions made by these economic agents, it is reasonable to select a scenario with moderate population and income growth to represent the most likely projection. Therefore, we assume the agents in this model make projections in line with midrange population growth, as reflected in RPA scenario A1, and the average income growth under the three RPA scenarios. We use the A1 population projection because it corresponds to the medium projection formulated by the U.S. Census Bureau.

Given a fixed land base, changes in the relative returns to urban use will affect the area of land devoted to all uses.

Ralph Alig

Figure 24—Responses to financial incentives and policies affect outcomes of land conservation efforts, such as efforts to conserve open space while maintaining sufficient working forest and agricultural lands and providing housing for new residents.

In comparing findings to earlier work, Alig (1985) varied crop and forestry rents by 20 percent from baseline cases to examine the sensitivity of land use changes to alternative financial returns from agricultural and forestry uses. He found that change in relative land rents would cause forest area to decline only slightly. Then, as now, land-use changes tend to follow the economic hierarchy of land use, where rents for developed uses (e.g., urban) typically dominate rents for forestry and agricultural uses.

A comparison of area change projections for the South from two more recent studies is also instructive regarding the sensitivity of projections to different assumptions. The 2000 RPA Assessment (Alig et al. 2003) and the Southern Forest Resource Assessment (Wear and Greis 2002) both relied on econometric models for projections of area changes for major land uses (Adams et al. 2005). Projections of the drivers of land-use change—population growth, economic growth, and agricultural rents—were derived from different sources in the two studies. In the base case, both studies projected a net loss of about 4 million acres of timberland area between 1995 and 2040. However, in an alternative projection, the model from the Southern Resource Assessment projected a net loss of 27 million acres for that same projection period under more elastic or responsive projections (Adams et al. 2005); more elastic means that rent changes have a bigger impact. This suggests that assumptions about behavior of people can have a large relative impact on land-use changes (fig. 24).

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North Region

The North region consists of 20 states, divided into three subregions (fig. 1). The Lake States subregion includes Michigan, Minnesota, and Wisconsin. The Corn Belt subregion includes five states: Illinois, Indiana, Iowa, Missouri, and Ohio. The Northeast subregion consists of 12 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia.

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 FS 1989a). Short growing seasons of 100 to140 frost-free days place limits on 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 Minnesota, Iowa, and Missouri, was originally forested, it tends to revert back to forest if disturbed and then allowed to stand idle. This has been the case in many instances with changes in the dairy industry, where declining profits from milk production and shifts in production to other parts of the country have led to afforestation of former pasture lands.

Seventy million people live within an 8-hour drive of the “Northern Forest,” and changing demographics and population growth illustrate implications of increasing multiple demands on forest land in such regions. The possible sale of some of these lands in the Northeast and possible fragmentation and development (fig. 25), along with perceived public values associated with the lands, prompted Congress to initiate the Northern Lands Study (Northern Forest Lands Council 1994). A report, *Finding 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, and control of inappropriate development, forest degradation, and fragmentation.

Changes in forest ownership have continued (e.g., Arnold 2003, Hagan et al. 2005, White and Mazza 2008). 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 relative lack, in many states, of existing public conservation lands.

Ralph Alig

Figure 25—Considerable urban expansion can result from economic growth, often fragmenting forest lands and affecting wildlife habitat and other ecosystem services.

Land-Use Situation

Figure 26 depicts the land-use allocation of the North region's total land base of 374.7 million acres as of 2002. The majority of land in the region is devoted to forest, at 41 percent, with cropland at 38 percent of the region's land base.

The Northeast is one of the most heavily urbanized parts of the United States, with 9 percent of land classified as "urban" by the NRI inventory (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 (Maudlin et al. 1999a), 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 Corn Belt subregion has less of its land base classified as urban, 7.0 percent, compared to the Northeast. Cropland is the dominant land use in the Corn Belt. As in the Northeast, the states of the Corn Belt subregion are quite heterogeneous with regard to land-use patterns. For example, Iowa has 75.7 percent of its land base in cropland and 6.8 percent in forest. In contrast, Missouri has 34.0 percent in cropland and 31.1 percent in forest.

Areas of urban and developed uses steadily increased in all three subregions of the North since 1982, when consistent NRI data were first assembled. Between

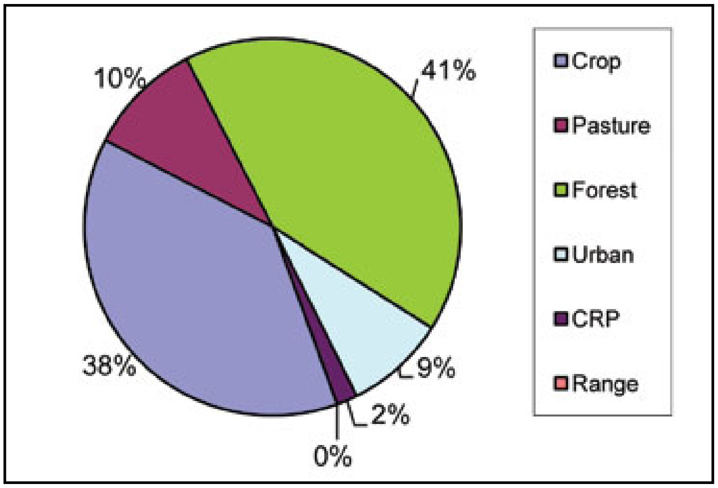


Figure 26—Allocation of nonfederal land in the North region to six major use categories, 2002. CRP = Conservation Reserve Program.

1992 and 2002, the area of urban and developed area in the Northeast increased from 10.4 percent to 12.7 percent of the land base. Corresponding increases in the Corn Belt and Lake States subregions were from 5.8 percent to 7.0 percent and from 5.4 percent to 6.6 percent, respectively.

The Lake States have significant second-home development involving forest areas. Forested areas in the Lake States attract the majority of the seasonal home development in the North Central region, affecting the regional landscape (e.g., Hammer et al. 2004, Stynes et al. 1997). This includes a number of homes around lakes and other water-related sites. Between 1982 and 2002, developed area in the subregion increased from 4.7 to 6.9 million acres, an increase of nearly 50 percent. Forest area in the Lake States increased from 46.0 to 47.5 million acres over the same period. At the same time, cropland area declined by 4.2 million acres and pasture decreased by 1.5 million acres.

Land-Use Area Changes

Table 8 shows the historical and projected areas for the major land-use categories in the North region. The region's amount of crop and pasture land was significantly reduced between 1982 and 2002, mostly because of the establishment of the Conservation Reserve Program as well as urban development on these lands (Choi et al. 2001). From 1982 to 2002, 7.3 percent of the 1982 acreage of cropland was converted to other uses along with 20.2 percent of pasture (table 9).

Dominating trends in forest transitions in the North region have been conversions of pastureland to forest, and urban development on forest land (fig. 27). Nearly 5.6 million acres of pasture transitioned into forest cover between 1982

The region's amount of crop and pasture land was significantly reduced between 1982 and 2002, mostly because of the establishment of the Conservation Reserve Program as well as urban development on these lands.

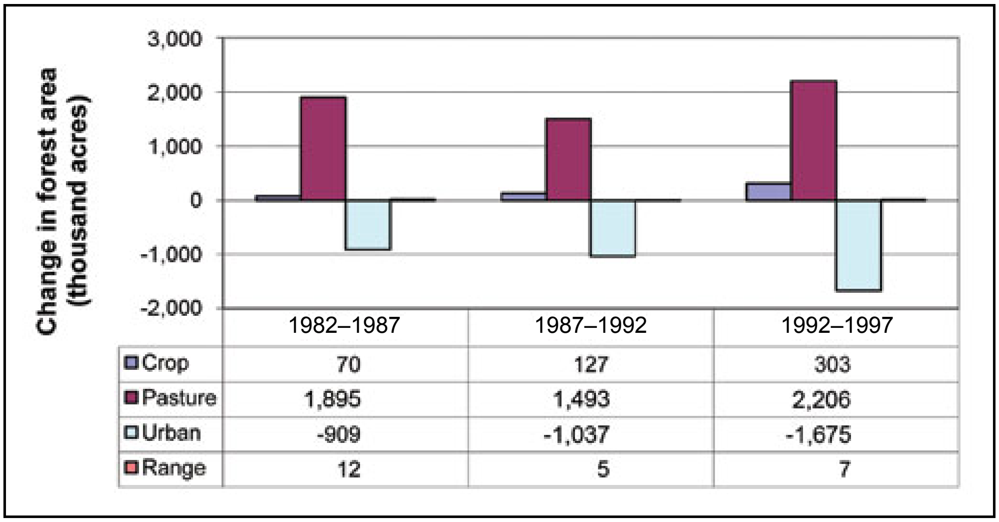


Figure 27—Historical net transitions of forest area on nonfederal land by period in the North region, 1982 to 1997.

Table 8–Historical areas, 1982 to 2002, and projections to 2062 for land uses on nonfederal land in the North region

	Land uses						
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range	Total area
			Million acres				
1982	154.2	46.1	152.0	22.1	0	0.1	374.5[b]
1987	151.3	42.5	153.2	24.2	3.2	0.1	374.4[b]
1992	145.7	40.1	153.8	26.4	8.1	0.1	374.1[b]
1997	144.8	36.7	155.2	30.1	7.5	0.1	374.4[b]
2002	142.9	36.8	155.8	32.4	6.6	0.1	374.7
2012	144.3	33.7	151.6	39.4	5.4	0.3	374.7
2022	144.5	31.1	148.2	45.9	4.6	0.4	374.7
2032	143.9	29.0	145.2	51.9	4.1	0.5	374.7
2042	142.7	27.4	142.4	57.7	3.8	0.6	374.7
2052	141.2	26.0	139.9	63.2	3.6	0.7	374.7
2062	139.5	24.9	137.5	68.5	3.4	0.8	374.7

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.
[b] Totals are not constant owing to omission of "other" category from historical data.

and 1997, while 3.6 million acres of forest land was converted to urban development. For example, in the Lake States subregion, conversions from agriculture have resulted in a net gain in forest area in some past years, exceeding the losses of forest to developed uses (Mauldin et al. 1999b).

Table 8 shows that forested area in the region is projected to steadily decline after 2002. Total forest area increased by 3.8 million acres over the 20-year period from 1982 to 2002 (table 9). However, this gain is followed by projected net losses. From 2002 to 2012, forest area is projected to decline by 4.2 million acres, and then

Table 9–Historical (1982 to 2002) and projected (2002 to 2062) land-use changes, by area and percentage, on nonfederal land in the North region

	Land uses					
Year	**Crop**	**Pasture**	**Forest**	**Urban**	**CRP**[a]	**Range**
			Million acres			
1982–1992	-8.5	-6.0	1.8	4.3	8.1	0
1992–2002	-2.8	-3.3	2.0	6.0	-1.5	0
2002–2012	1.4	-3.1	-4.2	7.0	-1.2	0.2
2012–2022	0.2	-2.6	-3.4	6.5	-0.8	0.1
2022–2032	-0.6	-2.1	-3.0	6.0	-0.5	0.1
2032–2042	-1.2	-1.6	-2.8	5.8	-0.3	0.1
2042–2052	-1.5	-1.4	-2.5	5.5	-0.2	0.1
2052–2062	-1.7	-1.1	-2.4	5.3	-0.2	0.1
Total historical change (1982–2002)	-11.3	-9.3	3.8	10.3	6.6	0
Total projected change (2002–2062)	-3.4	-11.9	-18.3	36.1	-3.2	0.7
			Percent			
1982–1992	-5.5	-13.0	1.2	19.5	0	
1992–2002	-1.9	-8.2	1.3	22.7	-18.5	
2002–2012	1.0	-8.4	-2.7	21.6	-18.2	
2012–2022	0.1	-7.7	-2.2	16.5	-14.8	
2022–2032	-0.4	-6.8	-2.0	13.1	-10.9	
2032–2042	-0.8	-5.5	-1.9	11.2	-7.3	
2042–2052	-1.1	-5.1	-1.8	9.5	-5.3	
2052–2062	-1.2	-4.2	-1.7	8.9	-5.6	
Total historical change (1982–2002)	-7.3	-20.2	2.5	46.6	0	
Total projected change (2002–2062)	-2.4	-32.3	-11.7	111.4	-48.5	

[a] CRP = Conservation Reserve Program.

Note: Data may not add to totals because of rounding. Rangeland percentages are omitted because areas in this region are too small to present meaningful percentage changes.

continue declining at a decreasing rate through 2062. Transitions between forest and pasture land will lead to a net gain in forested area (fig. 28). However, more than 300,000 acres of forest land are projected to be lost to urbanization each year from 2002 to 2062 (fig. 29).

The most striking feature of future land-use transitions in the North region is the amount of land that moves between cropland and pasture. As seen in table 10, more than 40 million acres of land will move back and forth between these two uses from 2002 to 2062. Considering that the region started with a total of 36.8 million acres of pasture in 2002, this indicates frequent turnover between pasture and cropland. Approximately 47 million acres of pasture are projected to be converted to cropland, while 41 million acres will move the other direction from cropland to pasture. This leads to a projected net gain in cropland of 6 million acres from converted

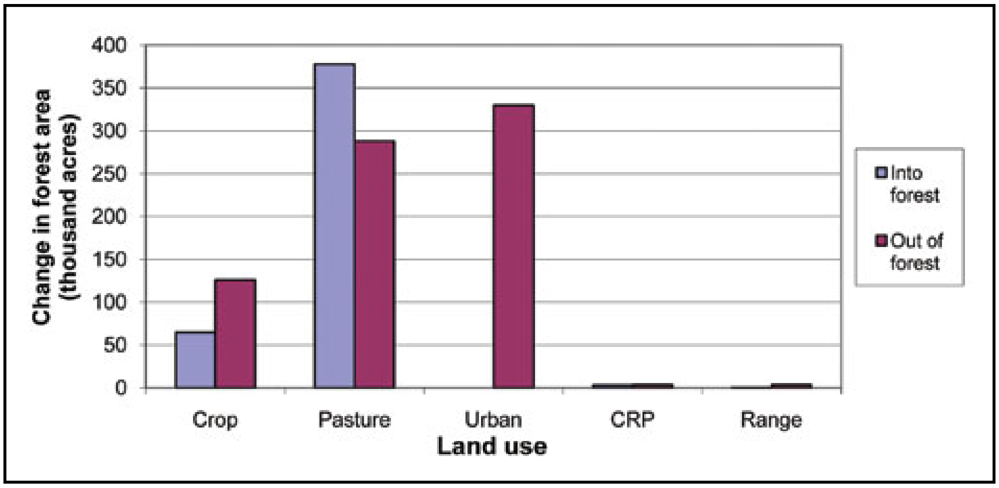


Figure 28—Projected average annual transitions involving forest area on nonfederal land in the North region, 2002 to 2062.

Figure 29—Changes in forest ownership have been relatively large in parts of the North compared to some other regions, involving a mixture of ownership and conservation groups and affecting the Northern Woods environment.

Urban area expanded rapidly in the North region from 1982 to 2002, increasing by 10.3 million acres or 46.6 percent over 20 years.

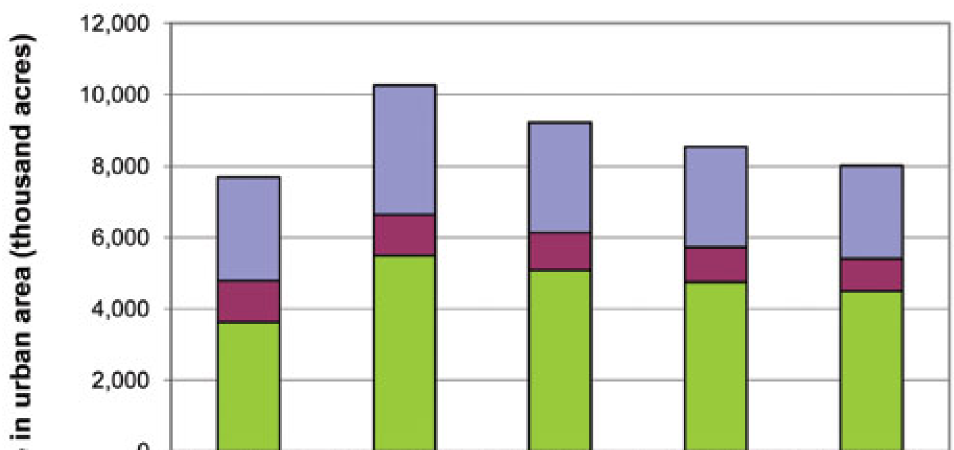
pasture. Overall, however, the region is facing a projected loss in cropland of 3.5 million acres.

Urban area expanded rapidly in the North region from 1982 to 2002, increasing by 10.3 million acres or 46.6 percent over 20 years. Urbanization will continue to have a big impact on the region in the future, as the area of land in urban use is expected to more than double from 2002 to 2062. This urban expansion is projected to be on 19.8 million acres of former forest land and 12.1 million acres of former cropland (fig. 30). Urban land would account for 18.3 percent of the total land base in the region by 2062, up from less than 9 percent in 2002.

Table 10—Historical (1982 to 1997) and projected (2002 to 2062) land-use transitions on nonfederal land in the North region

	New land use					
Initial land use	**Crop**	**Pasture**	**Forest**	**Urban**	**CRP[a]**	**Range**
			Thousand acres			
1982–1997:						
Crop	—	9,695	1,235	2,902	8,343	0
Pasture	11,481	—	6,695	1,155	651	0
Forest	734	1,101	—	3,621	28	2
Urban	1	1	0	—	0	0
CRP[a]	1,240	304	14	4	—	0
Range	12	21	25	0	0	—
2002–2062:						
Crop	—	40,726	3,877	12,131	5,391	281
Pasture	46,670	—	22,663	4,078	357	168
Forest	7,534	17,267	—	19,973	190	182
Urban	0	0	0	—	0	0
CRP[a]	4,699	3,872	179	14	—	337
Range	50	158	15	16	0	—

— = Not applicable.
[a] CRP = Conservation Reserve Program.



	1982–1997	2002–2017	2017–2032	2032–2047	2047–2062
Crop	2,902	3,633	3,092	2,808	2,598
Pasture	1,155	1,141	1,053	975	909
Forest	3,621	5,487	5,075	4,746	4,485
CRP	4	4	4	3	3
Range	0	2	4	5	6

Figure 30—Historical and projected sources of new urban land in the North region, by period from 1982 to 2062.

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South Region

The South stretches from Virginia southward and westward along the Atlantic and Gulf seaboards to Texas, and includes the interior states of Kentucky, Tennessee, Arkansas, and Oklahoma. In all, the South region includes 13 states, divided into three subregions (fig. 1). The Southeast subregion consists of five states including Florida, Georgia, North Carolina, South Carolina, and Virginia. The South Central subregion includes Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee, and small portions of eastern Oklahoma and eastern Texas. The South Plains subregion consists of western Oklahoma and western Texas.

This region is characterized by a variety of climatic and edaphic conditions that relate to its diverse physiography (USDA FS 1989a). The South covers portions of five physiographic divisions: Atlantic Plain, Appalachian Highlands, Interior Highlands and Piedmont, Delta, and 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 covers 38 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 Plains region contains large parts of Texas and Oklahoma that are not forested, so overall the South Plains subregion is only 2 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 (fig. 31).

Forest ownership changes among private owner groups have been important in the South in recent decades. Land held by the firms integrated to processing will continue to decline through sales to institutional investors (timberland investment organization [TIMOs] and real estate investment trusts [REITs]) (Clutter et al. 2005).

Land-Use Situation

The land-use situation in 2002 for the South region is depicted in figure 32. The South region is the largest region in the study at 483.4 million acres. The largest share of land in the region, 38 percent, is devoted to forest. Range, cropland, and pasture compose an additional 53 percent.

Given that two-fifths of the South is forested and has some of the most commercially important timber species (e.g., loblolly pine [*Pinus taeda* L.]), forestry

Figure 31—Rural land uses have shifted multiple times for some land parcels in the South because of the land's suitability for multiple land uses and changing economic conditions.

Land exchanges among sectors of the economy have been important in the South, which has had a relatively large amount of land-use change compared to other regions.

and timber products support an important industry in the region. Land exchanges among sectors of the economy have been important in the South, which has had a relatively large amount of land-use change compared to other regions. Much of the land in the region is suitable for different land uses, including the generally gentle topography in the coastal plain and piedmont areas. 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, 1988a, 1988b; Healy 1985), but conversions to developed uses have grown markedly in recent decades. 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 FS 1988). Around 1920, increases in forest area began as agricultural land was abandoned. The rate of agricultural land abandonment and succession to forest was especially high during the 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 FS 1989b).

The agricultural policy environment contributed to a decline in cropland acreage during a 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 (Alig et al. 1988a). The agricultural policy of the downsizing periods recognized that resources had to be moved out of crop agriculture (Alig et al. 1994). The Conservation Reserve Programs of the 1956 Soil Bank legislation and the Food Security Act of 1985 were designed to shift cropland

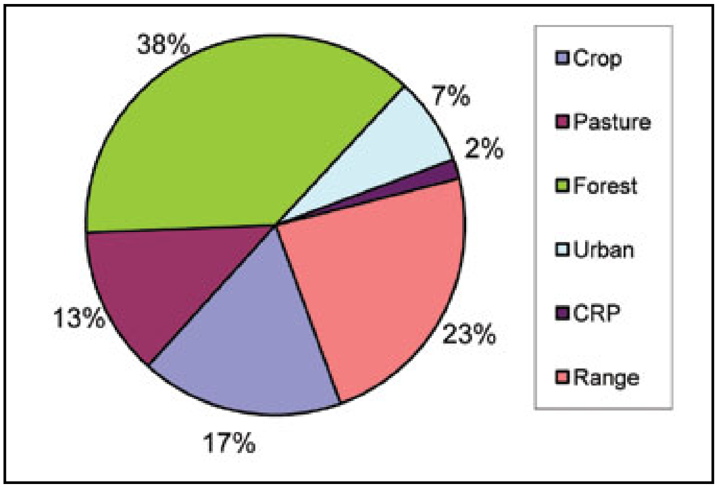


Figure 32—Allocation of nonfederal land in the South region to six major use categories, 2002.

to grassland or forest cover. Such programs had the largest impacts on forestry in the South (Alig et al. 1980) (fig. 33).

The South has more hardwood area than softwood area, but in recent decades an increasing emphasis on softwood production has led to marked changes in respective forest type areas (Alig and Wyant 1985). The South's proportion of the Nation's timber harvest has also increased significantly in recent decades (Wear and Greis 2002) fueled by increases in pine plantation area (Alig and Butler 2004); prospects of forest-based profits are important incentives for many private landowners in the region (Ahn et al. 2001). Simulations by Ahn et al. (2002) 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, USDA FS 2001). Both people and industry have migrated to the South in large numbers. Since the 1970s, most of the Southern States have experienced a net inmigration of people and increasing conversions of forests for living space, transportation infrastructure, and industrial sites.

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

Figure 33—A high percentage of government-subsidized tree plantations on former agricultural land in the South were retained well after establishment, even with financial changes in the agricultural sector over time.

With the rapid population growth in the South, the southern rural landscape has changed notably in recent decades.

With the rapid population growth in the South, the southern rural landscape has changed notably 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. National Resource Inventory data indicate that during 1992 to 1997, 6 of the top 10 states that lost the most cropland, forests, and other open spaces to urban development were in the South: Texas, Georgia, Florida, North Carolina, South Carolina, and Tennessee (USDA NRCS 2001).

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 grew from 7.0 percent to 11.6 percent of the state's nonfederal land base from 1982 to 2002. The developed proportion in nearby Florida is 19.3 percent of nonfederal land in the state.

The South had more counties reclassified as metropolitan in recent decades than has historically been the case, 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 metro counties. For example, Reynolds (2001) found that the amount for nonmetropolitan counties was more than double that for metro counties in north Florida.

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.

Land-Use Area Changes

Historical and projected areas for the major land-use categories for the South region are shown in table 11. The region experienced heavy cropland losses from 1982 to

Table 11–Historical areas, 1982 to 2002, and projections to 2062 for land uses on nonfederal land in the South region

	Land uses						
Year	**Crop**	**Pasture**	**Forest**	**Urban**	**CRP**[a]	**Range**	**Total area**
			Million acres				
1982	106.6	64.9	179.9	19.7	0	116.3	487.4[b]
1987	99.8	64.7	180.8	22.7	3.7	114.7	486.5[b]
1992	90.9	65.0	180.8	26.3	8.9	113.3	485.1[b]
1997	86.7	62.8	181.1	31.6	8.6	113.4	484.2[b]
2002	83.6	61.0	181.4	36.2	7.9	113.2	483.4
2012	83.3	53.8	180.8	42.7	7.4	115.5	483.4
2022	82.3	49.0	179.2	48.8	7.1	117.0	483.4
2032	80.9	45.7	177.0	54.7	6.9	118.1	483.4
2042	79.4	43.5	174.3	60.5	6.7	119.1	483.4
2052	77.7	41.9	171.4	66.0	6.6	119.8	483.4
2062	76.1	40.8	168.4	71.4	6.4	120.4	483.4

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.
[b] Totals are not constant owing to omission of "other" category from historical data.

Table 12—Historical (1982 to 2002) and projected (2002 to 2062) land-use changes, by area and percentage, on nonfederal land in the South region

Year	Crop	Pasture	Forest	Urban	CRP[a]	Range
	Land uses					
	Million acres					
1982–1992	-15.7	0.1	0.9	6.6	8.9	-3.0
1992–2002	-7.3	-4.0	0.6	9.9	-1.0	-0.1
2002–2012	-0.3	-7.2	-0.6	6.5	-0.5	2.3
2012–2022	-1.0	-4.8	-1.6	6.1	-0.3	1.5
2022–2032	-1.4	-3.3	-2.2	5.9	-0.2	1.1
2032–2042	-1.5	-2.2	-2.7	5.8	-0.2	1.0
2042–2052	-1.7	-1.6	-2.9	5.5	-0.1	0.7
2052–2062	-1.6	-1.1	-3.0	5.4	-0.2	0.6
Total historical change (1982–2002)	-23.0	-3.9	1.5	16.5	7.9	-3.1
Total projected change (2002–2062)	-7.5	-20.2	-13.0	35.2	-1.5	7.2
	Percent					
1982–1992	-14.7	0.2	0.5	33.5	0	-2.6
1992–2002	-8.0	-6.2	0.3	37.6	-11.2	-0.1
2002–2012	-0.4	-11.8	-0.3	18.0	-6.3	2.0
2012–2022	-1.2	-8.9	-0.9	14.3	-4.1	1.3
2022–2032	-1.7	-6.7	-1.2	12.1	-2.8	0.9
2032–2042	-1.9	-4.8	-1.5	10.6	-2.9	0.8
2042–2052	-2.1	-3.7	-1.7	9.1	-1.5	0.6
2052–2062	-2.1	-2.6	-1.8	8.2	-3.0	0.5
Total historical change (1982–2002)	-21.6	-6.0	0.8	83.8	0	-2.7
Total projected change (2002–2062)	-9.0	-33.1	-7.2	97.2	-19.0	6.4

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.

Forest land was lost to urban development at an increasing rate between 1982 and 1997. From 1982 to 1987, 1.3 million acres of forest land were developed, and 2.5 million acres were lost to urban development between 1992 and 1997.

2002. Over the 20-year period, 23.0 million acres of cropland were converted to other uses, a 21.6-percent decrease in total area (table 12). As in the North region, this loss can be attributed largely to increases in urban area and enrollment in the CRP. Cropland losses will continue into the future, ranging from a 0.4-percent decrease from 2002 to 2012 to a 2.1-percent loss between 2052 and 2062.

Total forested area increased slightly from 1982 to 2002, by 1.5 million acres or 0.8 percent. Historical transitions of forest land (fig. 34) indicate that new forest land was created primarily from cropland and pasture from 1982 to 1997. Forest land was lost to urban development at an increasing rate between 1982 and 1997. From 1982 to 1987, 1.3 million acres of forest land were developed, and 2.5 million acres were lost to urban development between 1992 and 1997.

Area of forested land was projected to decrease beginning in 2002 and continue to decline at an increasing rate through 2062 (table 12). Nearly 20 million acres of

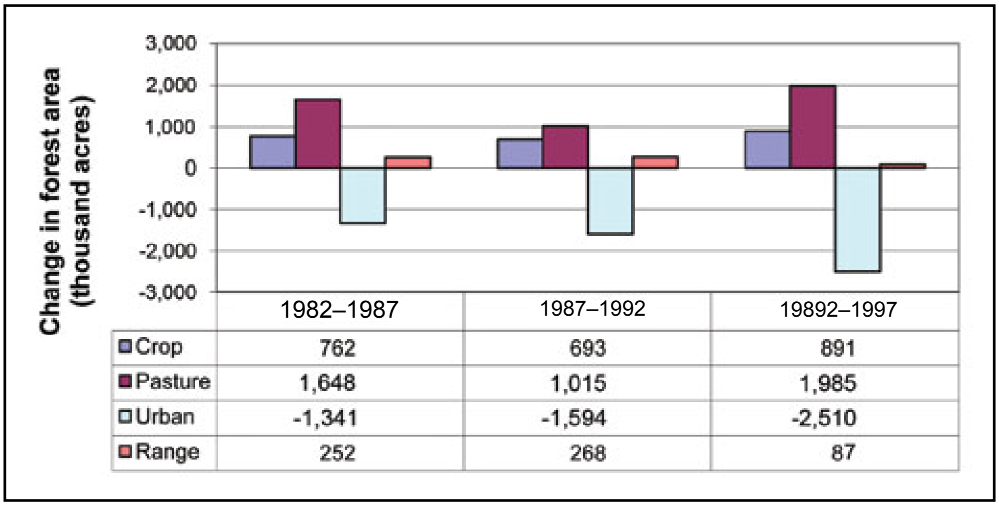


Figure 34—Historical net transitions of forest area on nonfederal land in the South, 1982 to 1997.

Table 13—Historical (1982 to 1997) and projected (2002 to 2062) land-use transitions on nonfederal land in the South region

	New land use					
Initial land use	Crop	Pasture	Forest	Urban	CRP[a]	Range
	Thousand acres					
1982–1997:						
Crop	—	12,781	3,764	2,293	8,685	1,613
Pasture	6,922	—	7,849	2,451	474	2,005
Forest	1,417	3,201	—	5,447	89	224
Urban	1	1	2	—	0	1
CRP[a]	307	240	170	3	—	102
Range	1,854	1,875	831	1,305	173	—
2002–2062:						
Crop	—	37,927	2,764	4,939	4,657	8,186
Pasture	36,264	—	28,478	6,498	328	11,883
Forest	5,021	14,093	—	19,962	160	6,342
Urban	0	0	0	—	0	0
CRP[a]	3,036	2,451	173	9	—	1,132
Range	6,607	8,728	1,120	3,759	175	—

— = Not applicable.
[a] CRP = Conservation Reserve Program.

forest is projected to be converted to urban development by 2062 (table 13). This is an average loss of more than 330,000 acres each year (fig. 35). An additional 11.4 million acres of forest land will be converted to cropland and rangeland. However, some of this loss will be offset by pasture land that is allowed to return to forest cover; 28.4 million acres of pasture are projected to be converted into forest over the 60-year period. With 14.1 million acres of forest being cleared to create new pasture at the same time, a net increase of 14.4 million acres of forest is projected owing to

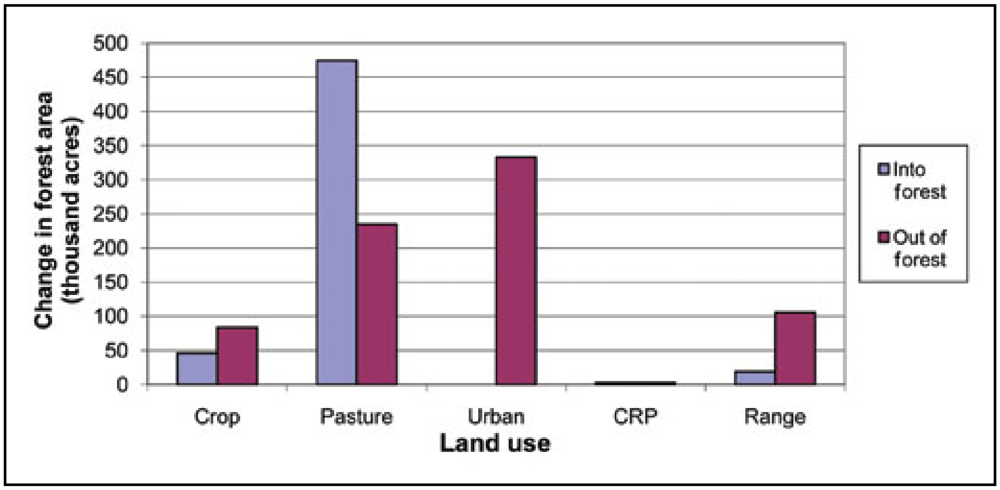
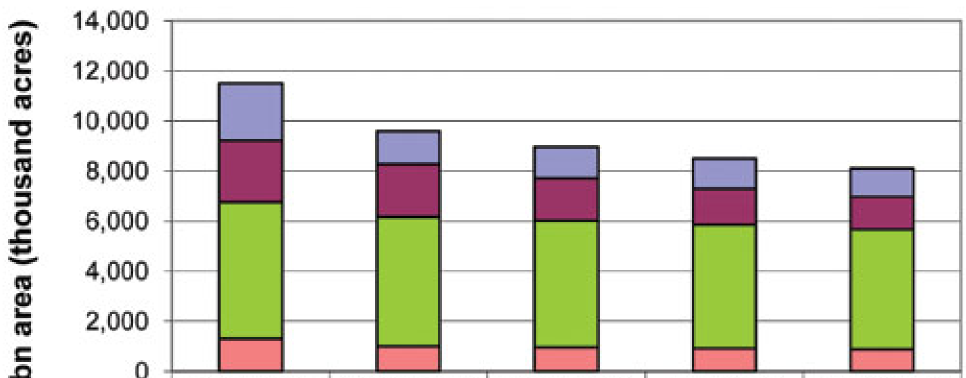


Figure 35—Projected average annual transitions involving forest area on nonfederal land in the South region, 2002 to 2062.

Figure 36—Pasture land has historically been the largest source of new forest land, often driven by shift in landowner objectives and natural successional forces.

pasture conversion (fig. 36). Average annual conversions of pasture to forest will outpace conversions of forest to pasture by 240,000 acres. The region on the whole can expect to see a significant loss of forest land in the future, 13.0 million acres or 7.2 percent of the 2002 level.

Urban growth was considerable in the region over the historical period. Urban area increased by 16.5 million acres or 83.8 percent between 1982 and 2002 (table 12). Projections for the South region show urban areas continuing to expand into



	1982–1997	2002–2017	2017–2032	2032–2047	2047–2062
Crop	2,293	1,322	1,264	1,205	1,148
Pasture	2,451	2,096	1,676	1,437	1,289
Forest	5,447	5,163	5,070	4,938	4,790
CRP	3	3	2	2	2
Range	1,305	1,007	956	915	881

Figure 37—Historical and projected sources of new urban nonfederal land in the South, 1982 to 2062.

the future. From 2002 to 2062, urban area will almost double, reaching 71.4 million acres in 2062. Urbanization is projected to have the biggest impact on the region's forest land (fig. 37). Nearly 20 million acres of forest will be permanently lost to development, while another 15 million acres of cropland, pasture, and rangeland will also be converted to urban use.

Nearly 20 million acres of forest, and 15 million acres of cropland, pasture, and rangeland will be lost to development.

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Rocky Mountains Region

The Rocky Mountains region includes 12 states, divided into two subregions (fig. 1). The Mountain subregion is composed of eight states: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. The Northern Plains subregion consists of four states: Kansas, Nebraska, North Dakota, and South Dakota.

Theses 12 states cover a vast area, 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 border 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 FS 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 the summers warm to hot, where moisture is often the limiting factor for plant growth.

The Rocky Mountains region contains 449.2 million acres of nonfederal land, and rangeland accounts for 58 percent of the region's land base.

Land-Use Situation

The Rocky Mountains region contains 449.2 million acres of nonfederal land, and rangeland accounts for 58 percent of the region's land base (fig. 38). Cropland is 27 percent of the total land. Forests compose only 6 percent of the land base and are mainly located in the Mountain subregion.

The dominant land use in the Mountain subregion is rangeland, at 69 percent. Cropland is a distant second at 13 percent, followed by forest, which covers 9

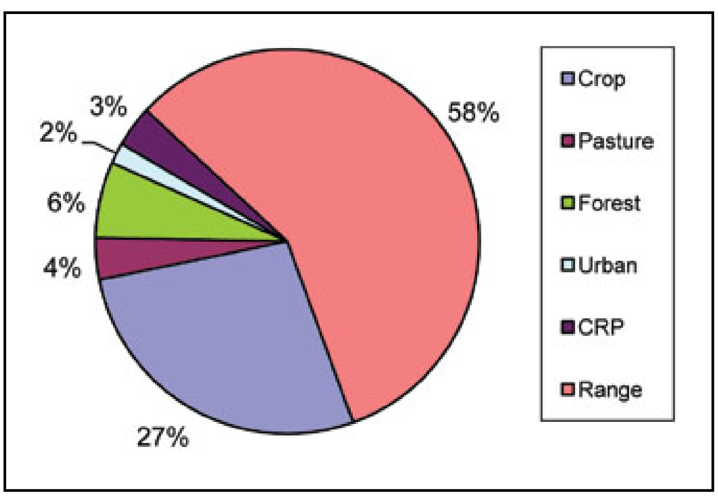


Figure 38—Allocation of nonfederal land in the Rocky Mountains region to six major use categories, 2002.

Figure 39—Forested land in the Rocky Mountains region often has important functions related to water quality, including runoff of snow in mountains.

percent of the land base in the subregion (fig. 39). The subregion has a total of 25.5 million acres of forest, compared to just 3.3 million acres in the Northern Plains. Tree planting has increased, in part through programs such as the CRP and more attention to trees for use in windbreaks and some agroforestry projects. Cropland and rangeland are both important land uses in the Northern Plains. Cropland (48 percent) and rangeland (40 percent) combine to cover 88 percent of land in the subregion.

The heterogeneity of the Rocky Mountains region makes it difficult to model land-use decisions in this area. We estimated a regional model (see appendix). Land quality for agricultural production, climate, elevation, and other factors can vary

Table 14—Historical areas, 1982 to 2002, and projections to 2062 on nonfederal land in the Rocky Mountains region

	Land uses						
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range	Total area
	Million acres						
1982	136.7	15.5	29.0	4.6	0	264.7	450.6[b]
1987	133.5	15.4	28.9	5.3	5.9	261.2	450.1[b]
1992	124.5	15.8	28.7	6.0	15.4	259.5	449.8[b]
1997	124.8	15.8	29.0	7.0	14.9	257.9	449.4[b]
2002	123.0	15.5	28.8	7.9	15.4	258.5	449.2
2012	125.4	15.5	29.3	8.4	13.5	257.2	449.2
2022	127.1	15.3	29.8	8.8	12.3	255.9	449.2
2032	128.4	15.3	30.3	9.2	11.4	254.5	449.2
2042	129.6	15.2	30.8	9.6	10.8	253.2	449.2
2052	130.5	15.2	31.3	10.0	10.3	251.9	449.2
2062	131.3	15.2	31.8	10.3	10.0	250.7	449.2

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.
[b] Totals are not constant owing to omission of "other" category from historical data.

greatly within small geographical areas. Because these factors significantly impact the net returns generated by alternative land uses, there can be considerable heterogeneity in net returns over small spatial scales. In many cases, our ability to account for fine-scale variations in net returns is limited, and this affects our success in modeling observed land-use changes (Broniak 2007). To provide a basis for comparison, we present both the econometric projections and an alternative set of projections based simply on a conditional extrapolation of land-use changes observed in the historical data.

Land-Use Area Changes

Table 14 shows historical and projected areas for the major land uses in the Rocky Mountains region. Total cropland and rangeland in the region declined substantially from 1982 to 2002, in part due to inception of the CRP program during that time. Cropland losses over this period were 13.7 million acres, a 10-percent loss (table 15). However, cropland area is projected to rebound in the future, increasing by 8.3 million acres from 2002 to 2062. Total cropland is projected to be 131.3 million acres in 2062, an increase of 7 percent from 2002. Rangeland will continue to steadily decline over the 60-year period. The projected land-use transitions indicate that much of the rangeland lost over this period will be converted to cropland (table 16).

The Rocky Mountains region is projected to see relatively small land-use changes in the future, including for forests. The Rocky Mountains region has a

Table 15—Historical (1982 to 2002) and projected (2002 to 2062) land-use changes, by area and percentage on nonfederal land in the Rocky Mountains region

	Land uses					
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range
			Million acres			
1982–1992	-12.2	0.3	-0.3	1.4	15.4	-5.2
1992–2002	-1.5	-0.3	0.1	1.9	0	-1.0
2002–2012	2.4	0	0.5	0.5	-1.9	-1.3
2012–2022	1.7	-0.2	0.5	0.4	-1.2	-1.3
2022–2032	1.3	0	0.5	0.4	-0.9	-1.4
2032–2042	1.2	-0.1	0.5	0.4	-0.6	-1.3
2042–2052	0.9	0	0.5	0.4	-0.5	-1.3
2052–2062	0.8	0	0.5	0.3	-0.3	-1.2
Total historical change (1982–2002)	-13.7	0	-0.2	3.3	15.4	-6.2
Total projected change (2002–2062)	8.3	-0.3	3.0	2.4	-5.4	-7.8
			Percent			
1982–1992	-8.9	1.9	-1.0	30.4	0	-2.0
1992–2002	-1.2	-1.9	0.3	31.7	0	-0.4
2002–2012	2.0	0	1.7	6.3	-12.3	-0.5
2012–2022	1.4	-1.3	1.7	4.8	-8.9	-0.5
2022–2032	1.0	0	1.7	4.5	-7.3	-0.5
2032–2042	0.9	-0.7	1.7	4.3	-5.3	-0.5
2042–2052	0.7	0	1.6	4.2	-4.6	-0.5
2052–2062	0.6	0	1.6	3.0	-2.9	-0.5
Total historical change (1982–2002)	-10.0	0	-0.7	71.7	0	-2.3
Total projected change (2002–2062)	6.7	-1.9	10.4	30.4	-35.1	-3.0

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.

small portion of its land base in forest use. As of 2002, 28.8 million acres of nonfederal land in the region were forested. Accordingly, forest land transitions indicate that movements between forest use and other uses are fairly small (fig. 40). Forest area was in decline from 1982 to 1992; however, a significant conversion of rangeland to forest between 1992 and 1997 reversed this trend. After another slight decline from 1997 to 2002, forest land is projected to continue increasing in area through 2062 (table 15).

Projected transitions involving forested land primarily involve rangeland in the region (fig. 41). Because the projection model is based on observed land-use changes between 1992 and 1997, the spike in conversions of range to forest observed during this period (fig. 40) has a significant impact on the projection results. This pattern of large areas of range being converted to forest is projected to continue

Table 16—Historical (1982 to 1997) and projected (2002 to 2062) land-use transitions on nonfederal land in the Rocky Mountains region

	New land use					
Initial land use	Crop	Pasture	Forest	Urban	CRP[a]	Range
	Thousand acres					
1982–1997:						
Crop	—	4,370	10	733	15,350	1,261
Pasture	4,152	—	72	248	262	624
Forest	50	33	—	227	8	1,046
Urban	1	0	0	—	0	0
CRP[a]	628	173	1	0	—	180
Range	5,490	914	1,443	1,002	280	—
2002–2062:						
Crop	—	5,513	43	1,319	1,771	978
Pasture	7,099	—	246	273	49	1,049
Forest	21	46	—	191	0	84
Urban	0	0	0	—	0	0
CRP[a]	3,526	1,902	44	5	—	853
Range	6,515	849	2,723	566	30	—

-- = Not applicable.

[a] CRP = Conservation Reserve Program.

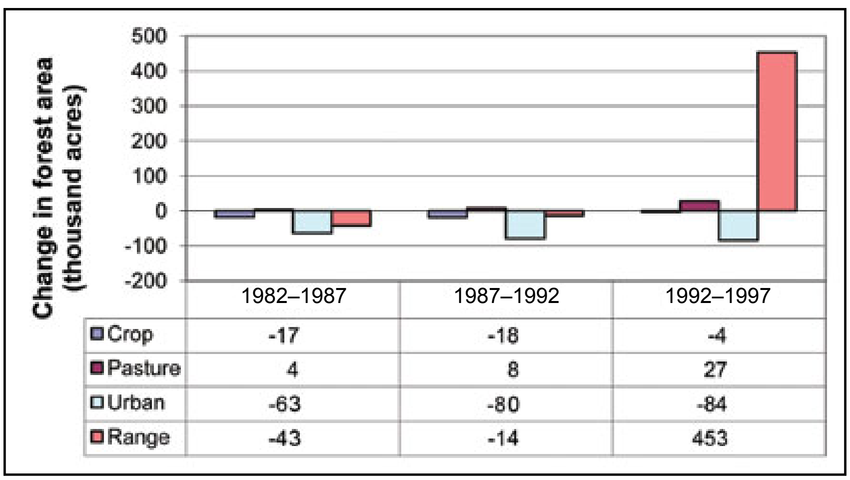


Figure 40—Historical net transitions of forest area on nonfederal land in the Rocky Mountains region, 1982 to 1997.

in the future (fig. 41). An average net increase of 45,000 acres of forest is projected each year in the region.

Among regions, the Rocky Mountains region has the smallest starting amount of urban area.

Among regions, the Rocky Mountains region has the smallest starting amount of urban area. In percentage terms, the region had some of the larger increases in urban area from 1982 to 2002 (table 15). Over 20 years, the region's urban acreage increased by 72 percent, from 4.6 million acres to 7.9 million acres. However, this is the only region that is projected to see significantly slower urban growth in the future than it has in the past. By 2062, the total urban area in the region will be

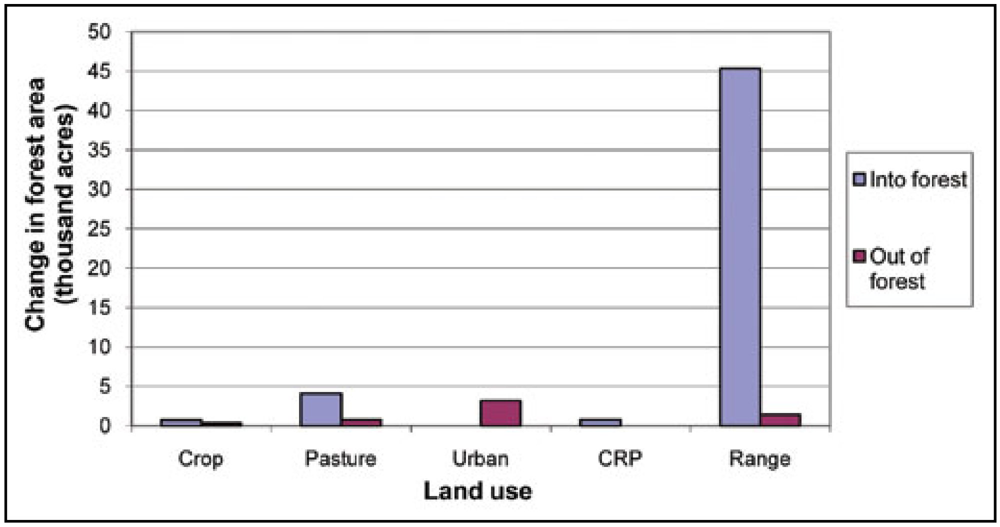
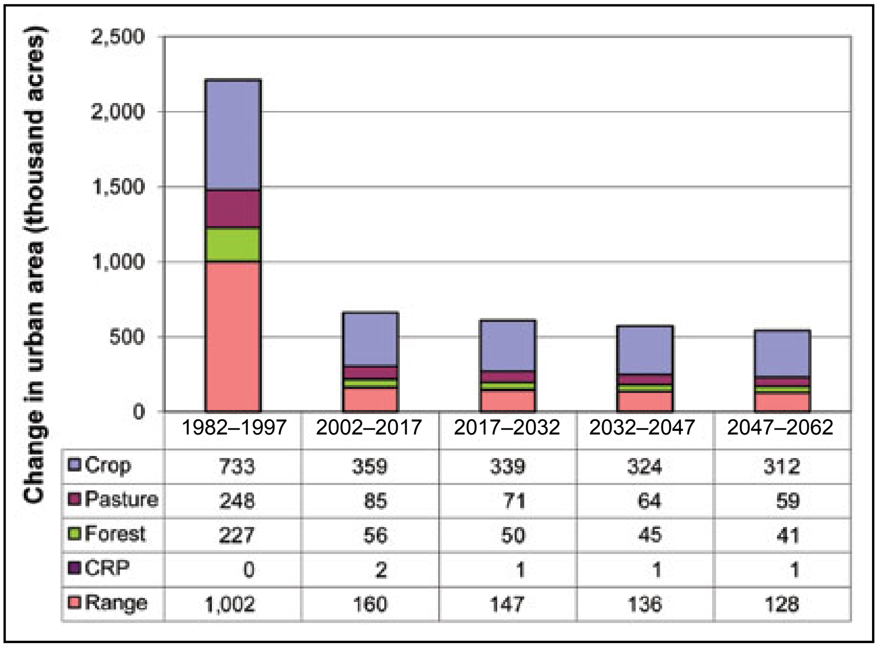


Figure 41—Projected average annual transitions involving forest area on nonfederal land in the Rocky Mountains region, 2002 to 2062.

10.3 million acres, an increase of just 2.4 million acres or 30.4 percent over the 60-year period from 2002 to 2062. This urban growth will still have a significant impact on the landscape, leading to the loss of 1.3 million acres of cropland and 566,000 acres of rangeland converted to urban uses from 2002 to 2062 (table 16).

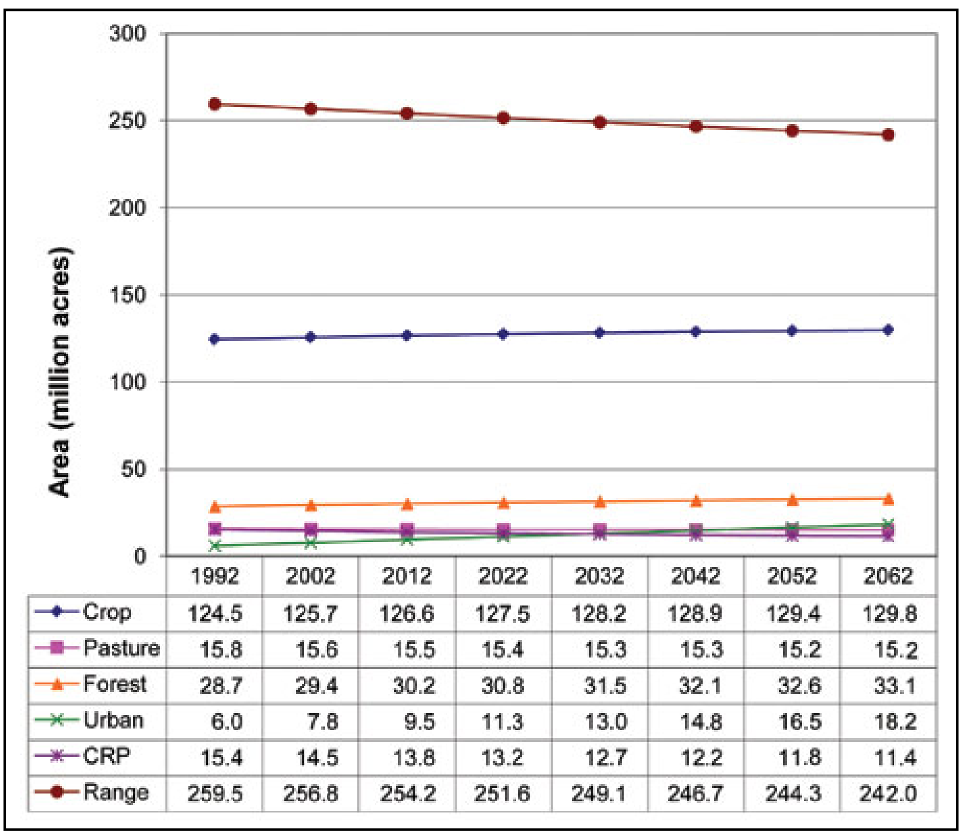
The land-use projection model employed here suggests a notable change in the trajectory of land-use changes in the Rocky Mountains region compared to the changes observed in the recent past. Figure 42 indicates that projected urban expansion will slow significantly from the rates observed from 1982 to 1997. Crop and forest lands are projected to consistently expand in the future, despite some of the recent declines in land area devoted to these uses (fig. 43). These results may indicate that a major shift in land-use decisions is occurring in the region, or they may be a sign of the difficulties associated with modeling land-use changes in this region because of the heterogeneity of the landscape (fig. 44).

Figure 43 depicts the projected land-use changes in the region if the trends observed from 1992 to 1997 were to continue into the future. If land-use changes remained on this trajectory, the amount of land in urban use would reach 18.2 million acres by 2062, compared to 10.3 million acres as predicted by the econometric model. Rangeland would be converted to other uses more rapidly than suggested by the econometric model, falling to 242.0 million acres by 2062 instead of 250.7 million acres. However, these variations are fairly minor in a region of nearly 450 million acres. Even with this higher rate of development, urban land is expected to account for just 4.1 percent of the land base in 2062, compared to 2.3 percent as predicted by the econometric model.



	1982–1997	2002–2017	2017–2032	2032–2047	2047–2062
Crop	733	359	339	324	312
Pasture	248	85	71	64	59
Forest	227	56	50	45	41
CRP	0	2	1	1	1
Range	1,002	160	147	136	128

Figure 42—Historical and projected sources of new urban nonfederal land in the Rocky Mountains region, 1982 to 2062.



	1992	2002	2012	2022	2032	2042	2052	2062
Crop	124.5	125.7	126.6	127.5	128.2	128.9	129.4	129.8
Pasture	15.8	15.6	15.5	15.4	15.3	15.3	15.2	15.2
Forest	28.7	29.4	30.2	30.8	31.5	32.1	32.6	33.1
Urban	6.0	7.8	9.5	11.3	13.0	14.8	16.5	18.2
CRP	15.4	14.5	13.8	13.2	12.7	12.2	11.8	11.4
Range	259.5	256.8	254.2	251.6	249.1	246.7	244.3	242.0

Figure 43—Conditional projection of land-use trends, 2002 to 2062, on nonfederal land in the Rocky Mountains based on extrapolation of changes observed from 1992 to 1997.

Figure 44—Topographical differences in the Rocky Mountains region affect land productivity and the mixture of ecosystem services, as well as costs of managing land for different products and land-based services.

Pacific Coast Region

The Pacific Coast region includes three states divided into three subregions (fig. 1). The Pacific Southwest subregion consists of one state, California. The western portions of Oregon and Washington (west of the crest of the Cascade Range) make up the Pacific Northwest West subregion, and the eastern portions of the two states compose the Pacific Northwest East subregion.

For the Pacific Coast region, latitude and environmental conditions differ widely across the region. 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 land form (USDA FS 1989b). The Hoh Rain Forest on Washington's Olympic Peninsula receives on average more than 135 inches of rain annually. Death Valley in California, on the other hand, receives less than 2 inches of rain per year and frequently reaches temperatures above 120 degrees F.

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 Mountains in Oregon and Washington are within the maritime zone (USDA FS 1989a). Growing conditions for forests differ widely within the region, as forests of eastern Oregon, Washington, and California are less productive on average than those in the maritime zone. The better sites, however, are quite productive (USDA FS 1989a).

Land-Use Situation

Of the Pacific Coast region's 105.8 million acres of nonfederal land, 37 percent was covered in forest and 31 percent was rangeland as of 2002 (fig. 45). An additional

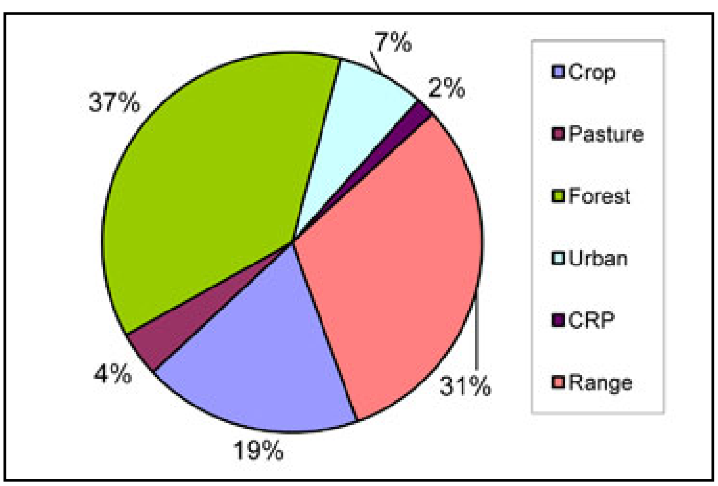


Figure 45—Allocation of nonfederal land in the Pacific Coast region to six major use categories, 2002.

Ralph Alig

Figure 46—Rainfall patterns differ markedly between the west and east side of the crest of the Cascades mountain range, affecting vegetation types and growth as well as forested setting around lakes and other water areas.

This region has experienced above-average growth in population, with many residents living along the coastal areas of the states or near the I-5 interstate corridor.

19 percent was devoted to cropland, and 7 percent of the region's land was in urban use in 2002.

Within the Pacific Coast region, the forest use percentage differs notably by subregion, from 79 percent in the western portion of the Pacific Northwest to 26 percent in the eastern Pacific Northwest (fig. 46). Urban and developed uses make up 11 percent of California, 10 percent of western Oregon and Washington combined, and 2 percent of eastern Oregon and Washington. This region has experienced above-average growth in population, with many residents living along the coastal areas of the states or near the I-5 interstate corridor. The region also has examples of state-level land use laws (e.g., Kline and Alig 1999) and states relatively active in seeking policy changes associated with urban sprawl and climate change considerations, as in California.

Forest ownership changes are also important in this region (Best and Wayburn 2001). Exchanges have involved a variety of ownerships, including TIMOs, REITs, forest conservation groups, and others. The federal Northwest Forest Plan addressed the issue of logging old-growth forests on public land, but it also indirectly altered incentives for forest management on private lands in the region. Unintended consequences have led to bifurcated forest management strategies on federal forests and

Table 17—Historical areas, 1982 to 2002, and projections to 2062 for land uses on nonfederal land in the Pacific Coast region

	Land uses						
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range	Total area
			Million acres				
1982	22.7	4.7	40.3	5.1	0	34.4	107.2[b]
1987	21.5	4.8	40.2	5.6	1.0	34.0	107.0[b]
1992	20.6	4.5	39.8	6.3	1.7	33.4	106.4[b]
1997	20.1	4.2	39.4	7.2	1.7	33.4	106.0[b]
2002	19.7	4.1	39.4	7.9	1.8	33.1	105.8
2012	15.9	7.6	39.0	11.3	1.0	31.0	105.8
2022	14.0	7.6	39.0	14.7	0.7	29.8	105.8
2032	12.6	7.1	38.9	17.9	0.6	28.8	105.8
2042	11.6	6.5	38.6	20.8	0.5	27.9	105.8
2052	10.7	5.9	38.1	23.6	0.4	27.1	105.8
2062	9.9	5.4	37.6	26.3	0.4	26.3	105.8

Note: Data may not add to totals because of rounding.

[a] CRP = Conservation Reserve Program.

[b] Totals are not constant owing to omission of "other" category from historical data.

private forests, with generally much shorter timber rotations now on many private forests in the region. At the same time, the change in rotation length is being compounded by increased loss of private forests to developed uses and rapidly changing forest ownership, such that about half of the land previously held by integrated forest product companies is now owned by institutions or companies associated with financial funds.

Land-Use Area Changes

Among major uses, the urban use showed the only net increase in area between 1982 and 2002 in the Pacific Coast region (table 17). Urban area increased more than 20 percent each decade between 1982 and 2002 (table 18). Additions to urban area were drawn from the other major uses, with forest, range, and crop uses being the largest sources (table 19).

Cropland losses from 1982 to 2002 totaled 3.0 million acres, a decrease of 13.2 percent (table 18). However, the greatest loss of cropland is projected from 2002 to 2012, during which time 3.8 million acres of cropland, 19.3 percent of the 2002 area, will be converted. A total of 9.8 million acres of cropland will be lost over the 60-year projection period, a decline of nearly 50 percent.

Total forest area in the region declined from 1982 to 2002, from 40.3 million acres to 39.4 million acres (table 17). Between 1982 and 1997, a significant amount of land moved into forest use from other uses, particularly pasture and range (fig. 47). However, from 1992 to 1997, forest land transitions were dominated by losses

Table 18—Historical (1982 to 2002) and projected (2002 to 2062) land-use changes, by area and percentage, on nonfederal land in the Pacific Coast region

	Land uses					
Year	Crop	Pasture	Forest	Urban	CRP[a]	Range
			Million acres			
1982–1992	-2.1	-0.2	-0.5	1.2	1.7	-1.0
1992–2002	-0.9	-0.4	-0.4	1.6	0.1	-0.3
2002–2012	-3.8	3.5	-0.4	3.4	-0.8	-2.1
2012–2022	-1.9	0	0	3.4	-0.3	-1.2
2022–2032	-1.4	-0.5	-0.1	3.2	-0.1	-1.0
2032–2042	-1.0	-0.6	-0.3	2.9	-0.1	-0.9
2042–2052	-0.9	-0.6	-0.5	2.8	-0.1	-0.8
2052–2062	-0.8	-0.5	-0.5	2.7	0	-0.8
Total historical change (1982–2002)	-3.0	-0.6	-0.9	2.8	1.8	-1.3
Total projected change (2002–2062)	-9.8	1.3	-1.8	18.4	-1.4	-6.8
			Percent			
1982–1992	-9.3	-4.3	-1.2	23.5	0	-2.9
1992–2002	-4.4	-8.9	-1.0	25.4	5.9	-0.9
2002–2012	-19.3	85.4	-1.0	43.0	-44.4	-6.3
2012–2022	-11.9	0	0	30.1	-30.0	-3.9
2022–2032	-10.0	-6.6	-0.3	21.8	-14.3	-3.4
2032–2042	-7.9	-8.5	-0.8	16.2	-16.7	-3.1
2042–2052	-7.8	-9.2	-1.3	13.5	-20.0	-2.9
2052–2062	-7.5	-8.5	-1.3	11.4	0	-3.0
Total historical change (1982–2002)	-13.2	-12.8	-2.2	54.9	0	-3.8
Total projected change (2002–2062)	-49.7	31.7	-4.6	232.9	-77.8	-20.5

Note: Data may not add to totals because of rounding.
[a] CRP = Conservation Reserve Program.

Net loss of forest land from 2002 to 2008 is projected to be 1.8 million acres or 4.6 percent of forest use in 2002.

to urban and range uses and this trend is expected to continue in the future. As shown in table 19, conversions of pasture into forested land are also projected to have an impact on total forested area. Total forest area is projected to increase by 7.1 million acres on net from conversions of pasture to forest land, but urbanization will lead to the permanent loss of 9.8 million acres of forest land. On average, more than 160,000 acres of forest land are expected to be lost to urban development each year from 2002 to 2062 (fig. 48). The total net loss of forest land from 2002 to 2062 is projected to be 1.8 million acres, or 4.6 percent of the area of land in forest use as of 2002 (fig. 49).

Urban area in the Pacific Coast region expanded from 5.1 million acres to 7.9 million acres, an increase of 54.9 percent, from 1982 to 2002. Of the four RPA regions, the Pacific Coast region is projected to be the area most affected percentage-wise by urbanization in the future (Alig and White 2007). Urban area will

Table 19—Historical (1982 to 1997) and projected (2002 to 2062) land-use transitions on nonfederal land in the Pacific Coast region

	New land use					
Initial land use	Crop	Pasture	Forest	Urban	CRP[a]	Range
			Thousand acres			
1982–1997:						
Crop	—	803	29	506	1,822	683
Pasture	836	—	180	220	14	231
Forest	22	82	—	593	1	994
Urban	0	0	1	—	0	0
CRP[a]	89	81	0	0	—	15
Range	516	152	877	677	18	—
2002–2062:						
Crop	—	16,748	915	2,654	711	720
Pasture	10,112	—	7,896	3,658	90	1,222
Forest	293	782	—	9,774	8	1,368
Urban	0	0	0	—	0	0
CRP[a]	738	1,298	68	6	—	99
Range	764	5,443	1,591	2,332	9	—

— = Not applicable.

[a] CRP = Conservation Reserve Program.

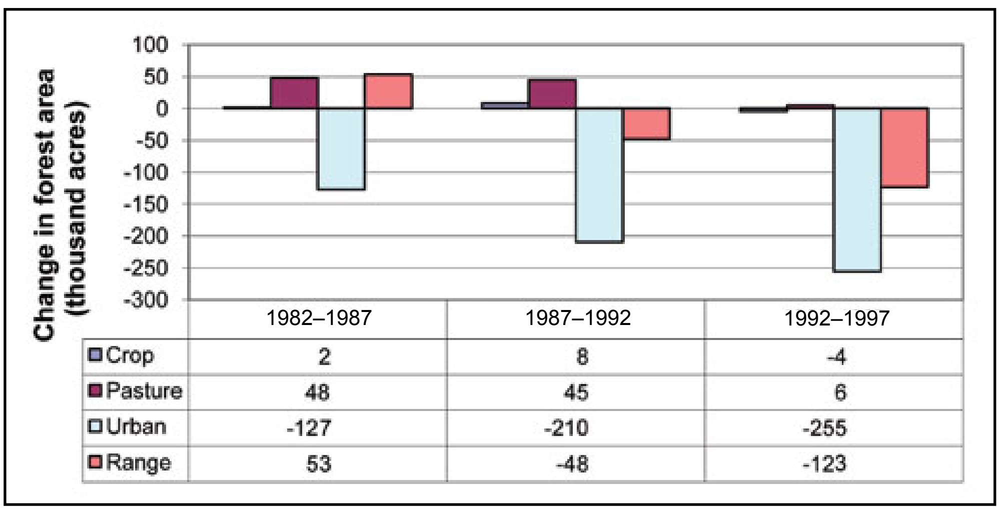


Figure 47—Historical net transitions of forest area on nonfederal land in the Pacific Coast region, 1982 to 1997.

increase from 7.9 million acres in 2002 to 26.3 million acres in 2062, an increase of nearly 233 percent. Urban land will account for almost 25 percent of the region's total land base by 2062. This projected urban development will affect forest land most significantly (fig. 50). Urbanization is expected to lead to the loss of 9.8 million acres of forest land, 3.7 million acres of pasture, 2.7 million acres of cropland, and 2.3 million acres of rangeland (table 19).

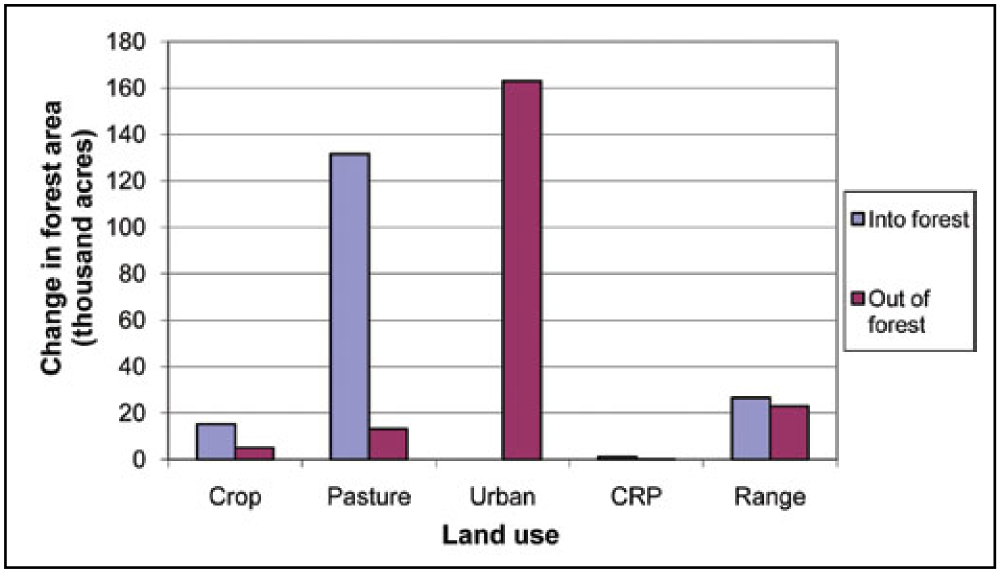
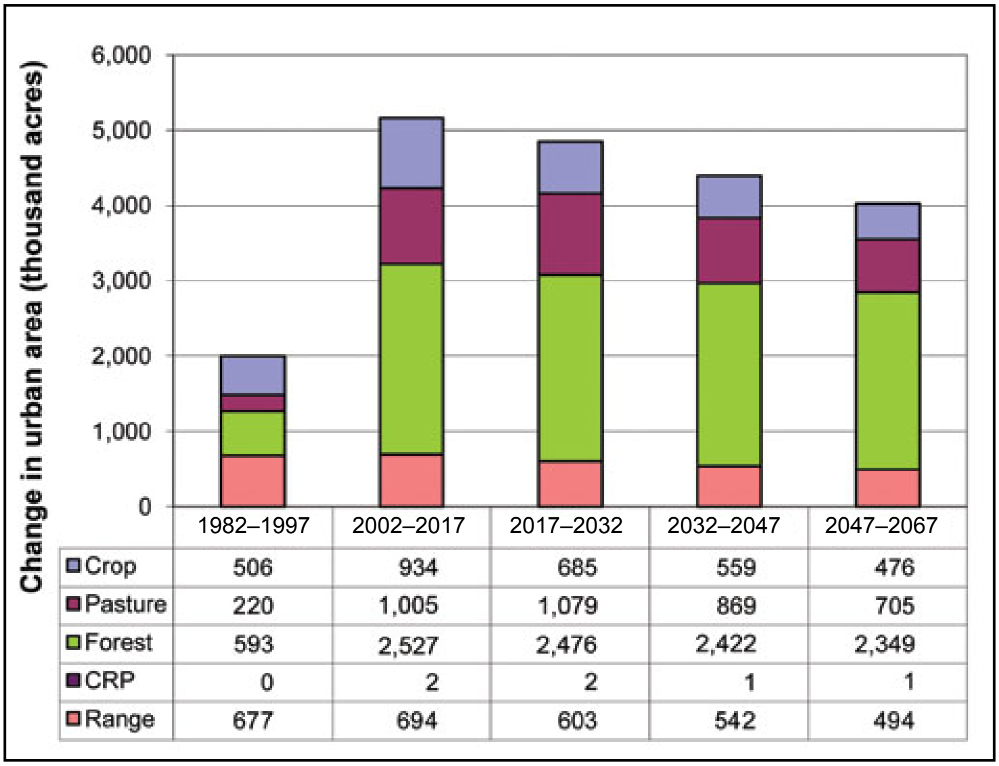


Figure 48—Projected average annual transitions involving forest area on nonfederal land in the Pacific Coast region, 2002 to 2062.

Figure 49—The Pacific Coast region contains some forest stands with relatively large amounts of biomass per acre, and conversion to other land uses can significantly reduce the potential for forests to sequester carbon in the region.



	1982–1997	2002–2017	2017–2032	2032–2047	2047–2067
Crop	506	934	685	559	476
Pasture	220	1,005	1,079	869	705
Forest	593	2,527	2,476	2,422	2,349
CRP	0	2	2	1	1
Range	677	694	603	542	494

Figure 50—Historical and projected sources of new urban nonfederal land in the Pacific Coast region, 1982 to 2062.

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Summary and Discussion

The number and complexity of land-use issues have grown appreciably since the first RPA land base assessment in the 1970s. Concerns about reduction in the area of productive timberland are long standing, with some of the earliest efforts in forest conservation inspired by rapid loss of forest stands to agriculture and logging, desires to protect water resources, and desires to preserve lands of extraordinary beauty and natural magnificence.

Forest area in the United States fluctuated notably in the 20^{th} century, with a net loss of 34 million acres, a land area larger than the state of Arkansas, representing a 4.4 percent loss (USDA FS 2009). Area of forest-land cover in the United States is projected to decline over the next half-century, with a 7-percent reduction by 2062. Increases in population and income are expected to further fuel conversion of forests to urban and developed 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 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, and that trend is projected to continue. In view of such land-use dynamics, land moving into forest will not be the same as older forest being converted to other uses. That is, just considering the total "net" number of forest acres on the landscape does not include the loss of many attributes people care about: ecosystem services, including wildlife habitat, carbon sequestration, water cycling, and many other attributes.

All three major land-use classes—cropland, forest land, and grassland—have lost area to urbanization, and that trend is projected to continue.

Trends in Population and Personal Income

Demand for land for developed use is driven by increases in both personal income and population as part of economic activities and socioeconomic changes. Although the Nation's economy has been in a recession starting in 2008, population growth has been stronger than was expected a few years ago. The preliminary estimate of births in 2007 rose 1 percent to 4,317,119, the highest number of births ever registered for the United States (Hamilton et al. 2009). The general fertility rate increased by 1 percent in 2007, to 69.5 births per 1,000 women aged 15 to 44 years, the highest level since 1990. At the same time, illegal immigration continues at significant rates, also affecting long-term demand for land in different uses, but associated impacts are difficult to assess because of the uncertainty about exact numbers and timing. The U.S. Federal Government in February 2009 said that after years of increases, the illegal-immigrant population in the United States dropped for the first time, between 2007 and 2008—about the time that both a recession and tougher immigration enforcement began. In a report, the Department of Homeland Security's Office of Immigration Statistics said the illegal-immigrant population in January 2008 was 11.6 million, or 200,000 smaller than a year earlier (Hoefer et al. 2009).

Historically, the NRI shows that about 1 million acres of forest land were converted to urban and other developed uses in their last periodic survey, as the national rate of urbanization increased 50 percent compared to the earlier survey period (USDA NRCS 2001). Urban and other developed areas are projected to continue to grow substantially, more than doubling in area by 2062. Area of urban and developed uses is projected to increase to 176 million acres by 2062, in line with a projected U.S. population increase of more than 130 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. Incomes of Americans have grown substantially since World War II, and projected increases in discretionary income will increase demands for renewable resources and also may lead to further conversion of forests for developed uses.

With the U.S. population expected to increase by at least another 130 million people by 2062, resource managers should expect and plan for continued development pressure on many of the Nation's private forests.

Although this analysis takes a long-term view of land use, it is also necessary to monitor changes in economic and social conditions that may persist for a considerable period. In 2009, this includes monitoring of changes in financial and credit markets (e.g., economic downturn) that can affect funding for new development, as well as physical changes to forests from climate change. Models of land use typically rely on past behavior and land-use patterns to inform expectations about future land use, and this land-use projection model is no exception. A number of factors may lead to changes in human behavior that result in future land-use changes that differ from current projections. Factors such as decreases in real incomes and tightening of credit markets, increasing energy costs and higher commuting costs, and changes in preferences may tend to reduce the demand for residential development in the coming decades.

Responses by people to the aforementioned changes in the economy and population growth and migration likely will result in residential development on forested lands that will differ by region (e.g., White et al. 2009b) (fig. 51). Although currently there is some uncertainty about the path of the U.S. economy and future housing markets, land development in the United States has been ongoing for decades. With the U.S. population expected to increase by at least another 130 million people by 2062, resource managers should expect and plan for continued development pressure on many of the Nation's private forests.


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Figure 51—Disturbances related to human activities are more frequent in total than natural disturbances in the context of affecting land use, although natural disturbances (such as this fire) can be significant in affecting land use or land cover in smaller locales.

More detailed analyses of the spatial allocation of places of residence within forest settings and watersheds are provided by the "Forests on the Edge" project. Stein et al. (2005) projected housing density changes on private forest land; Stein et al. (2007) projected changes on such private lands close to National Forests; and White et al. (2009a) investigated the sensitivity of such projections to different factors such as definitions of forest land, watershed classification criteria, and housing density classes or number of houses per square mile.

Forest Ownership Changes

Changes in forest ownership have also been substantial since the 2000 RPA Assessment. Although a national set of associated data are not yet available, some broad outlines of the changes are becoming evident. The South, in particular, has seen tens of millions of acres change hands in recent decades (Clutter et al. 2005). Traditional industrial ownership of forest land has shrunk considerably, as land divestitures by industry in the South are now owned by timber management investment organizations (TIMOs) and Real Estate Investment Trusts (REITs) and are classified as nonindustrial private forest (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. Most owners also do not have the same level of investment in forestry research or firefighting materials as traditional industrial owners.

At the same time, on average, owners of NIPF forest land are getting older, and non-heirs may take ownership of some land during transitions in families. This can also lead to smaller average forest parcel sizes (Butler 2008, Butler and Leatherberry 2004), as part of the parcelization process.

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. 1990b) and can have higher rates of forest fragmentation (Alig et al. 2005, Butler et al. 2004). 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, Alig et al. 2010). 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).

Nonindustrial private forest land ownerships are also affected by agricultural and land conservation policies. For example, the national farm bills have increasingly included environmental provisions. The 2008 Farm Bill continued the CRP and affected all contracts due to expire by 2010. Contracts were divided into quintiles based on the environmental benefit index. The highest quintile was offered new 10- or 15-year contracts, and the rest were offered 2- to 5-year extensions. Investment in land use and management to promote global climate change mitigation could be substantial in the decades ahead, but the future path is hazy. Legislation passed by the U.S. House of Representatives in 2009 includes incentives for tree planting on agricultural lands, including an option for 18 million acres by 2020, which would be the Nation’s largest tree-planting program ever (Watson 2009). Integration with other policies could culminate in expanded multifunctional landscapes, which will need to be monitored with respect to ecological benefits and the dynamics of the link between land-use patterns and market prices.

Land-Use Policies

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

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Figure 52—The diversity and number of efforts to slow or temper loss of open space, including forest land, have increased in recent years along with growth in population, average personal incomes, and development pressures.

timber harvest). Past policy-related interactions between the forest and agricultural sectors have included unintended consequences, such as effects of the agricultural Soil Bank Program resulting in more tree planting and subsequently more timber supplies (Alig et al. 1980). More targeted effects of later programs such as the Conservation Reserve Program resulted in the Nation's largest tree-planting program over a 5-year period. Further interactions are likely in the face of climate change and associated mitigation measures that may include afforestation on marginal agricultural land (Alig et al. 1998).

Developed uses can typically command land prices that far exceed those of traditional rural uses such as forestry.

Policies directed at slowing or tempering loss of forest land to developed uses include a wide variety (fig. 52), although the overall net effect is unclear in that the amount of urban and developed area has steadily increased over the last several decades, and the incremental amount of developed area per additional person increased over the last NRI remeasurement period (Alig et al. 2004b). Developed uses can typically command land prices that far exceed those of traditional rural uses such as forestry (Alig and Plantinga 2004), resulting in relatively large opportunity costs of keeping land in forest or other rural uses. A rapid increase in the number of land trusts across the Nation reflects the development pressures facing rural lands. Such land trusts often are part of conservation partnerships to address the rapid loss

With many choices to be made in the decade ahead, policy changes will continue to influence land reallocation, although outcomes across the various sectors of the economy are at times difficult to predict.

of open space (e.g., USDA FS 2007), including cooperating across ownership and other institutional boundaries to promote open space conservation. Conservation easements have been increasing in popularity as a tool for encouraging the protection of forests and other lands. Landowners receive tax benefits or are paid a lump sum in exchange for restricting the type and amount of development and other uses that may take place on their property. Restrictions on the easement are identified in a legal agreement signed by the landowner and a conservation recipient (usually a public agency or land trust). To qualify for tax benefits, an easement must be perpetual, with future owners bound by the same restrictions, and some landowners are reluctant to enroll land in such long-term agreements. With many choices to be made in the decade ahead, policy changes will continue to influence land reallocation, although outcomes across the various sectors of the economy are at times difficult to predict.

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 (Alig and Ahearn 2006). Private land-use decisions often give rise to significant external costs such as nonpoint source pollution, and external benefits such as habitat for wildlife or open space (e.g., Kline et al. 2004). One role of land-use policies is to narrow the divergences between privately and socially optimal land allocations by modifying the economic incentives faced by private landowners (Plantinga and Ahn 2002). Policies in the national 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 CRP afforestation or policies encouraging landowners to retain land in a desired use such as wetlands. In our reference projections, we froze in place current policies that affect land use.

Contemporary land-use policies as a whole are multiobjective in nature. Implementation of multiobjective policies is laden with tensions. One challenge involves a major contemporary focus of land-use policies, the management of the direction of development. Urban sprawl has been cited as one of the leading concerns of Americans (Pew Center 2000). According to the Pew report, approximately 1,000 measures aimed at changing planning laws and at making U.S. development more orderly and conserving were introduced in state legislatures in the late 1990s. Concerns about sprawl originate from both the disamenities associated with increased congestion as well as the loss of productive land for agriculture and forestry uses.

The situation in agriculture is sometimes one of surpluses and depressed markets, with agriculture historically cyclical in the long run (Alig et al. 1994). With a rapidly growing world population, projected to increase by more than 3 billion people by 2062 to 9 billion people, food and fiber demand is likely to increase in the future. Long-term loss of prime agricultural and forest land to urban uses arises in part because lands that are highly suitable for agriculture or forestry are often also desirable for urban expansion—gently sloped, fertile valleys, and flood plains. Urban conversion is generally “one-way”; the land is usually irretrievably lost for less intensive use within typical planning horizons.

In general, 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. 1998). With a projected increase of more than 120 million people in the United States over the next 50 years, projections in this study, earlier RPA Assessments, related special studies (e.g., USDA FS 1988), and other studies of additional developed land area and housing growth all point to substantial future forest conversion (e.g., Alig et al., in press; Nowak and Walton 2005; Radeloff et al. 2005; Stein et al. 2005).

Land-use policies will need to be monitored over time given the dynamics of land use and changes in other policies that affect land use. One example is the Energy Independence and Security Act of 2007, whose provisions were formulated and implemented after projections for this study were completed. In addition, given dynamics of the changing population and social values, some forest conversion can adversely affect provision of public goods by forests, such as the environmental service of storing terrestrial carbon to mitigate climate change, which falls outside private decisionmaking. Measuring and evaluating multiple forest benefits associated with public goods can be difficult owing to a general lack of information describing some forest-based services and outputs and their values (Smail and Lewis 2009). We have relatively little information about the value of benefits accruing from ecosystem services provided by private forests.

Climate Change: Impacts on Forests, Adaptation, and Mitigation

Implications of climate change include possible impacts on forest productivity (e.g., Alig et al. 2003), adaptation by ecosystems and people (e.g., Alig et al. 2004a), and use of forests and products (e.g., White 2010) as part of the mitigation strategy (e.g., Alig et al. 2010). 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 and short-rotation woody crops, have been proposed as having roles in international agreements to reduce net emissions or enhance sinks of greenhouse gases (Alig et al. 1997, 2001; Birdsey et al. 2001; Sohngen and Alig 2000).

Actions to mitigate climate change that directly bear on forests include forest management strategies to expand carbon storage in forests as an ecosystem service. At the same time, forestry's mitigation potential could be affected by institutional activities such as subsidized ethanol production from agricultural sources, such as corn, which can lead to increased deforestation for agricultural use (Alig et al. 2010). Such deforestation could occur especially in a relatively productive agricultural region such as the Midwest. Other environmental impacts may arise if additional corn is planted on land that was previously used as pasture or enrolled in the CRP (Westcott 2007). The land-use effects of this new biofuels market are just beginning to emerge, and should be monitored carefully in future assessments, along with prospects for changes in the overall energy arena that could affect production and transportation of forestry and agricultural products, as well as choices of location for residents, given impacts on commuting costs. This includes the expansion in "energy land" that includes windmill facilities, ethanol-producing areas such as the aforementioned corn production, oil and gas production, and solar energy production. Expanded use of land for energy production could increasingly affect wildlife habitat and biodiversity, including development not for making electricity but for biofuels production mandated under the Renewable Fuels Standards provisions of the national Energy Independence and Security Act of 2007. One tradeoff when it comes to land use is that production of renewable energy can have a significant footprint and in some cases can exceed that for fossil-fuel energy production. The footprint of new energy development, including wind, solar, and biofuels, could occupy nearly 80,000 square miles of land by 2030, an area larger than the state of Minnesota (Bodin 2009).

Actions to mitigate climate change that directly bear on forests include forest management strategies to expand carbon storage in forests as an ecosystem service.

In addition to land-use and environmental footprints, production of renewable energy can also affect costs and supplies of traditional forestry products. Over time, demand for traditional or nontraditional production from forests (e.g., cellulosic ethanol) may also increase, affecting the relative cost of roundwood from forest land for timber production or paper-related products as compared to use in the energy sector (Alig et al. 2010). In the future, this will depend in part on technological progress and breakthroughs, which are difficult to project. Impacts of climate change on forest growth and other processes may also alter costs of timber production in different regions, including shifts in species.

How landowners adapt to climate change, and how that will affect land use, is also quite uncertain and will interact with mitigation activities in ways that are largely unknown at present (Alig 2003). Climate change could alter forests from a number of different perspectives, affecting traditional timber growing (e.g., McCarl et al. 2000), quality-of-life dimensions for residential areas, biomass sources

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Figure 53–Land-use changes and reforestation after harvest can affect the amount of carbon stored in forests as society looks to address climate change. Such land-use changes can be influenced by policy.

for renewable energy (e.g., White 2010), recreation, water quality and quantity, wildlife habitat, and many other aspects (fig. 53). The 2010 RPA Assessment will examine some of these aspects under different climate change scenarios, and other studies are also investigating related topics (e.g., USDA FS 2009). Many strategies have been proposed to use forests to reduce the net amount of carbon dioxide going into our air, including expanded afforestation, reduced deforestation, altered forest management, storage of more carbon in wood products, and expanded use of woody biomass for renewable energy production (Alig et al. 2010).

Scenario analysis involving possible future markets for carbon under hypothetical cap-and-trade policies has shown that future forest area could vary markedly under different price assumptions for carbon dioxide (Alig et al. 2010). In comparison to a baseline projection of a reduction in timberland under business as usual, Alig et al. (2010) indicated that more than a $25 per tonne ($22.70 per ton) carbon dioxide price could be needed to eliminate the projected loss in timberland area. Higher carbon dioxide prices could induce enough afforestation to offset timberland area losses to other uses such as developed uses and agriculture. The temporal nature of climate change and variability add to the complications, which are sometimes not fully reflected in ecological assessments. In contrast to current effects from land-use

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change, impacts from climate change are viewed as farther in the future and significantly more uncertain concerning form and location. Future work can explore more fully the role of land-use change in climate change at different scales, such as for albedo effects.

Adaptation under climate change scenarios is another topic warranting increased research (Alig et al. 2004a). This includes the relationship between human settlement patterns and vulnerabilities to natural disasters. Natural disasters have many varied consequences, including damage to ecosystems and human communities. Recent trends in land use and housing growth not only create stresses on natural ecosystems, they also increase society's vulnerability to natural hazards. Human communities are both a source of, and a victim of, natural hazards.

Housing and infrastructure growth is perhaps the single most important factor behind increasing economic losses from natural disasters. The threat posed by most natural disasters has not changed significantly over time, although wildland fire is an exception as people encroach more on undeveloped areas. Global climate change has also been suggested as contributing to recent catastrophic weather events, and although scientific opinion is mixed regarding its role in current patterns, scientists agree that there is potential for significant change in the future. However, in the short run, i.e., over the past 50 years, the likelihood of natural hazards has been relatively stable but losses in the United States have increased because of increases in asset values and our increased vulnerability to these hazards. More houses and more wealth concentrated in regions of the country facing significant hazard levels, especially in coastal areas, has been the trend in the United States over the past 50 years.

Regional patterns of growth and decline in the United States have shifted population and property value to more vulnerable areas. By 1970, population and housing growth had shifted away from the cities of the Northeastern United States and into two regions facing considerable natural hazards: the Southeast, with its exposure to hurricanes from both the Atlantic and the Gulf; and the West where a wide range of hazards are present (Alig et al., in press). Colorado and California stand out as states where population and housing growth have been substantial (California earlier in the period, Colorado later) and both face the threat of catastrophic wildland fires. In California, earthquakes and landslides are also major threats to heavily populated cities. Coastal Oregon and Washington are exposed to tsunami risks; southwestern states (Arizona, and later in the period, New Mexico and Nevada) have grown tremendously and have active fire regimes.

Selective urban deconcentration, which has been the overarching pattern of settlement change in the late 20th century, has brought growth to many rural communities and to suburbs more distant from the urban core. In the 21st century, fluctuations in energy prices, climate change, and the economic downturn have given some pause to reconsider location and building decisions. If deconcentration does continue, the change from the centuries-long urban concentration pattern contributes to vulnerability in two ways. First, isolated communities and especially unincorporated areas have less infrastructure (e.g., roads and water supply systems) and fewer resources for providing protection services (e.g., police and fire protection). Rapid growth exacerbates the difficulties of providing adequate infrastructure. Second, wildland fire is a meaningful threat to homes in the wildland urban interface, which is typically found around the outer edges of metropolitan areas and throughout the countryside, the same areas where housing growth has been most dramatic (Stewart et al. 2003).

In the United States, society's response to natural disasters has been more oriented to reaction than to planning. When losses to human communities are substantial, the outcome is often new policy, reallocation of public spending, and regulation. To take an example familiar to the resource management community, the Healthy Forests Restoration Act can be seen as a policy response to the bad fire seasons of 2000 and 2002. With human community vulnerability and loss comes the prospect of more changes such as these. To date, few incentives or policies have addressed the root cause—the development of new housing units without regard to landscape patterns, ecological processes, or hazard exposure.

In the United States, society's response to natural disasters has been more oriented to reaction than to planning.

Land use will continue to change as private decisionmakers and society examine options to adjust to changing demands for and supplies of renewable resources and ecosystem services (e.g., Matthews et al. 2002) from the Nation's forest and aquatic ecosystems. Sustainability analyses will be enhanced if more recent and consistent nationwide data on land-use changes are made available and coordinated with information on associated changes in the suite of ecosystem services. Analyses should be explicit as to timing of tradeoffs and provide more information about spatial details. Further, sustainability analyses will be enhanced if both land use and land investment options are examined.

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Metric Equivalents

When you know:	Multiply by:	To get:
Acres	0.4047	Hectares
Cubic feet	0.0283	Cubic meters
Feet	0.3048	Meters
Miles	1.6098	Kilometers
Tons	0.907	Tonnes
Degrees Fahrenheit	.55(F - 32)	Degrees Celsius

References

Adams, D.; Haynes, R., eds. 2007. Resource and market projections for forest policy development: twenty-five years of experience with the U.S. Resources Planning Act (RPA) Timber Assessment. Dordrecht, The Netherlands: Springer. 589 p.

Adams, D.; Mills, J.; Alig, R.; Haynes, R. 2005. SOFRA and RPA: two views of the future of Southern timber supply. Southern Journal of Applied Forestry. 29(3): 123–134.

Ahn, S.; Plantinga, A.; Alig, R. 2001. Historical trends and projections of land use for the south central United States. Res. Pap. PNW-RP-530. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

Ahn, S.; Plantinga, A.; Alig, R. 2002. Determinants and projections of land use for the south central United States. Southern Journal of Applied Forestry. 26(2): 78–84.

Alig, R. 1985. Modeling forest acreage changes in forest ownerships and cover types in the Southeast. Res. Pap. RM-260. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 14 p.

Alig, R. 1986. Econometric analysis of forest acreage trends in the Southeast. Forest Science. 32(1): 119–134.

Alig, R. 2003. U.S. landowner behavior, land use, and land cover changes, and climate change mitigation. Silva Fennica. 37(4): 511–527.

Alig, R.; Adams, D.; Chmelik, J.; Bettinger, P. 1999a. Private forest investment and long run sustainable harvest volumes. New Forests. 17: 307–327.

Alig, R.; Adams, D.; Haynes, R. 1994. Regional changes in land uses and cover types: modeling links between forestry and agriculture. In: Newman, D.H.; Aronow, M.E., eds. Proceedings of the 24th Annual Southern Forest Economics Workshop: Forest Economics on the Edge. Athens, GA: Warnell School of Forest Resources, University of Georgia: 90–101.

Alig, R.; Adams, D.; Ince, P.; McCarl, B. 2001. Economic potential of short rotation woody crops for pulp production in the United States. Forest Products Journal. 63(3): 215–226.

Alig, R.; Adams, D.; Joyce, L.; Sohngen, B. 2004a. Climate change impacts and adaptation in forestry: responses by trees and markets. Choices. Fall: 7–11.

Alig, R.; Adams, D.; McCarl, B. 1998. Impacts of incorporating land exchanges between forestry and agriculture in sector models. Journal of Agricultural and Applied Economics. 30(2): 389–401.

Alig, R.; Adams, D.; McCarl, B. 2002a. Projecting impacts of global climate change on the U.S. forest and agriculture sectors and carbon budgets. Forest Ecology and Management. 169: 3–14.

Alig, R.; Adams, D.; McCarl, B.; Callaway, J.; Winnett, S. 1997. Assessing effects of mitigation strategies for global climate change with an intertemporal model of the U.S. forest and agricultural sectors. Environmental and Resource Economics. 9: 259–274.

Alig, R.; Ahearn, M. 2006. Effects of policy and technological change on land use. In: Bell, K.P.; Boyle, K.J.; Rubin, J., eds. Economics of rural land-use change. Burlington, VT: Ashgate Press: 27–40. Chapter 3.

Alig, R.; Benford, F.; Moulton, R.; Lee, L. 1999b. Long-term projection of urban and developed land area in the United States. In: Keep America growing, balancing working lands and development: conference proceedings [CD-ROM]. Washington, DC: American Farmland Trust. Additional information at: www.farmland.org/. (August 2008).

Alig, R.; Butler, B. 2002. Forest cover changes in the United States. In: Proceedings of the 2001 national convention of the Society of American Foresters. Washington, DC: Society of American Foresters: 93–115.

Alig, R.; Butler, B. 2004. Projecting large-scale area changes in land use and land cover for terrestrial carbon analyses. Environmental Management. 33(4): 443–456.

Alig, R.; Haynes, R. 2002. Sustainable forest management and land use changes. In: Proceedings of the 2001 national convention of the Society of American Foresters. Washington, DC: Society of American Foresters: 116–126.

Alig, R.; Healy, R. 1987. Urban and built-up land area changes in the United States: an empirical investigation of determinants. Land Economics. 63(3): 215–226.

Alig, R.; Hohenstein, W.; Murray, B.; Haight, R. 1990a. Changes in area of timberland in the United States, 1952-2040, by ownership, forest type, region, and state. Gen. Tech. Rep. SE-64. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 34 p.

Alig, R.; Knight, H.; Birdsey, R. 1986. Recent area changes in southern forest ownerships and cover types. Res. Pap. SE-260. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 10 p.

Alig, R.; Latta, G.; Adams, D.; McCarl, B. 2010. Mitigating greenhouse gases: the importance of land base interactions among forests, agriculture, and residential development in the face of changes in bioenergy and carbon prices. Forest Policy and Economics. 12(1): 67–75. DOI: 10.1016/j.forpol.2009.09.012.

Alig, R.; Lee, K.; Moulton, R. 1990b. Evidence from research studies pertaining to timber management by NIPF owners. Gen. Tech. Rep. SE-60. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 17 p.

Alig, R.; Lewis, D.; Swenson, J. 2005. Is forest fragmentation driven by the spatial configuration of land quality? The case of western Oregon. Forest Management and Ecology. 217(2-3): 266–274.

Alig, R.; Lichtenstein, M.; Kline, J. 2004b. Urbanization on the U.S. landscape: looking ahead in the 21st century. Landscape and Urban Planning. 69: 219–234.

Alig, R.; Mills, J.; Butler, B. 2002b. Private timberlands: growing demands, shrinking land base. Journal of Forestry. 100(2): 32–37.

Alig, R.; Mills, T.; Shackelford, R. 1980. Most Soil Bank plantings in the South have been retained; some need follow-up treatments. Southern Journal of Applied Forestry. 4: 60–64.

Alig, R.; Moulton, R.; Dicks, M. 1988a. Land use changes involving forestry in the South. In: Proceedings of the 1998 Southern Forest Economics Workshop. Raleigh, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 9–15.

Alig, R.; Plantinga, A. 2004. Future forestland area: impacts from population growth and other factors that affect land values. Journal of Forestry. 102 (8): 19–24.

Alig, R.; Plantinga, A.; Ahn, S.; Kline, J. 2003. Land use changes involving forestry for the United States: 1952 to 1997, with projections to 2050. Gen. Tech. Rep. PNW-GTR-587. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 92 p.

Alig, R.; Stewart, S.; Wear, D.; Stein, S.; Nowak, D. [In press]. Conversions of forest land: trends, determinants, projections, and policy considerations. In: Pye, J.M.; Rauscher, H.M.; Sands, Y.; Lee, D.C.; Beatly, J.S., tech.eds. Advances in threat assessment and their application to forest and rangeland management. Gen. Tech. Rep. PNW-GTR-802. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1–25. Vol. 1.

Alig, R.; Wear, D. 1992. Changes in private timberland: statistics and projections for 1952 to 2040. Journal of Forestry. 90(5): 31–36.

Alig, R.; White, E. 2007. Projections of forestland and developed land areas in western Washington. Western Journal of Forestry. 22(1): 29–35.

Alig, R.; White, F.; Murray, B. 1988b. Economic factors influencing land use changes in the south-central United States. Res. Pap. SE-272. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 23 p.

Alig, R.; Wyant, J. 1985. Projecting regional area changes in forestland cover in the U.S.A. Ecological Modelling. 29: 127–134.

Arnold, D. 2003. Hancock to sell Northern forest land. Boston Globe, March 17.

Best, C.; Wayburn, L. 2001. America’s private forests: status and stewardship. The Pacific Forest Trust. Washington, DC: Island Press. 268 p.

Birdsey, R.; Alig, R.; Adams, D. 2001. Mitigation options in the forest sector to reduce emissions or enhance sinks of greenhouse gases. In: Joyce, L.; Birdsey, R., eds. The impacts of climate change on America’s forests. Gen. Tech. Rep. RMRS-GTR-59. Fort Collins, CO: U.S .Department of Agriculture, Forest Service, Rocky Mountain Research Station: 112–131. Chapter 8.

Blayney, D. 2002. The changing landscape of U.S. milk production. Statistical Bull. No. SB978. Washington, DC: U.S. Department of Agriculture. 30 p.

Bodin, M. 2009. The green footprint. Nature Conservancy. 59(3): 44–53.

Brady, S.; Flather, C. 1998. Agricultural land use patterns and grassland nesting birds. Gibier Faune Sauvage (Game and Wildlife). 15: 775–784.

Broniak, C. 2007. Land use and land-use change in the Rocky Mountain West. Corvallis, OR: Oregon State University. 89 p. M.S. thesis.

Butler, B.; Leatherberry, E. 2004. America's family forest owners. Journal of Forestry. 102(7): 4–9.

Butler, B.; Swenson, J.; Alig, R. 2004. Forest fragmentation in the Pacific Northwest: quantification and correlations. Forest Management and Ecology. 189: 363–373.

Butler, B.J. 2008. Family forest owners of the United States, 2006. Gen. Tech. Rep. NRS-27. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 72 p.

Choi, S.; Sohngen, B.; Alig, R. 2001. Land-use change and carbon sequestration in the forests of Ohio, Indiana and Illinois: sensitivity to population and model choice. In: Proceedings of the annual meeting of the American Agricultural Economics Association. Chicago, IL: American Agricultural Economics Association: 115–123.

Clutter, M.; Mendell, B.; Newman, D.; Wear, D.; Greis, J. 2005. Strategic factors driving timberland ownership changes in the U.S. South. DRAFT version presented to the Southern Group of State Foresters. http://www.srs.fs.usda.gov/econ/pubs/southernmarkets/strategic-factors-andownership-v1.pdf. (September 2008).

Cowan, T. 2008. Conservation reserve program: status and current issues. CRS Report RS21613. Washington, DC: Congressional Research Service. 44 p.

Daugherty, A. 1995. Major uses of land in the United States, 1992. Washington, DC: U.S. Department of Agriculture, Economic Research Service. 47 p.

Hagan, J.M.; Irland, L.C.; Whitman, A.A. 2005. Changing timberland ownership in the Northern forest and implications for biodiversity. Rep. MCCS-FCP-2005-1. Brunswick, ME: Manomet Center for Conservation Sciences. 25 p.

Hamilton, B.; Martin, J.; Ventura, S. 2009. Births: preliminary data for 2007. National Vital Statistics Reports Vol. 57, No. 12. Washington, DC: National Center for Health Statistics. 23 p.

Hammer, R.B.: Stewart, S.I.; Winkler, R. 2004. Characterizing spatial and temporal residential density patterns from 1940–1990 across the North Central United States. Landscape and Urban Planning. 69: 183–189.

Healy, R. 1985. Competition for land in the American South. Washington, DC: The Conservation Foundation. 209 p.

Heimlich, R.; Anderson, W. 2001. Development at the urban fringe and beyond: impacts on agriculture and rural land. Agric. Econ. Rep. 803. Washington, DC: U.S. Department of Agriculture, Economic Research Service. 88 p.

Hoefer, M.; Rytina, N.; Baker, B. 2009. Estimates of unauthorized immigrant population residing in the United States. Washington, DC: U.S. Department of Homeland Security, Office of Immigration Statistics, Population Estimates. 7 p.

Intergovernmental Panel on Climate Change [IPCC]. 2007. Climate change 2007, the fourth IPCC Assessment Report. http://www.ipcc.ch/ipccreports/index.htm. (December 2008).

Kline, J.; Alig, R. 1999. Does land use planning slow the conversion of forest and farm land? Growth and Change. 30(1): 3–22.

Kline, J.; Alig, R.; Garber-Yonts, B. 2004. Forestland social values and open space preservation. Journal of Forestry. 102(8): 39–45.

Langner, L. [N.d]. Basic assumptions for the 2010 Resources Planning Act (RPA) Assessment. Supporting document by the RPA Management Group, Washington, DC. 33 p. Draft report. On file with: Linda Langner, USDA Forest Service, Research and Development, 4th floor RPC, 1601 North Kent Street, Arlington, VA 22209.

Lewis, D.; Hunt, G.; Plantinga, A. 2002. Public conservation land and employment growth in the northern forest region. Land Economics. 78(2): 245–259.

Lubowski, R. 2002. Determinants of land-use transitions in the United States: econometric analysis of changes among the major land use categories. Cambridge, MA: Harvard University. 172 p. (plus appendices). Ph.D. dissertation.

Matthews, S.; O'Connor, R.; Plantinga, A. 2002. Quantifying the impacts on biodiversity of policies for carbon sequestration in forests. Ecological Economics. 40: 71–87.

Mauldin, T.; Plantinga, A.; Alig, R. 1999a. Determinants of land use in Maine with projections to 2050. Northern Journal of Applied Forestry. 16(2): 82–88.

Mauldin, T.; Plantinga, A.; Alig, R. 1999b. Land use in the Lake States region: an analysis of past trends and projections of future changes. Res. Pap. PNW-RP-519. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

McCarl, B.; Adams, D.; Alig, R.; Chen, J. 2000. Effects of global climate change on the US forest sector: response functions derived from a dynamic resource and market simulator. Climate Research. 15(3): 195–205.

Mitchell, J. 2000. Rangeland resource trends in the United States. Gen. Tech. Rep. RMRS-GTR-68. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 84 p.

Northern Forest Lands Council. 1994. Finding common ground: the recommendations of the Northern Forest Lands Council. Concord, NH: Northern Forest Lands Council. 134 p.

Nowak, D.J.; Walton, J.T. 2005. Projected urban growth and its estimated impact on the U.S. forest resource (2000–2050). Journal of Forestry. 103(8): 383–389.

Osborn, C.; Llacuna, F.; Linsenbigler, M. 1995. The Conservation Reserve Program enrollment statistics for the sign-up periods 1–12 and fiscal years 1986–93. Statist. Bull. 925. Washington, DC: U.S. Department of Agriculture, Economic Research Service. 17 p.

Pew Center. 2000. Sprawl now joins crime as top concern. http://www.pewcenter.org/about/pr_ST2000.html. (October 2008).

Plantinga, A.; Ahn, S. 2002. Efficient policies for environmental protection: an econometric analysis of incentives for land conversion and retention. Journal of Agricultural and Resource Economics. 27(1): 128–145.

Plantinga, A.; Alig, R.; Cheng, H. 2001. The supply of land for conservation uses: evidence from the Conservation Reserve Program. Resources Conservation and Recycling. 31: 199–215.

Plantinga, A.; Alig, R.; Eichman, H.; Lewis, D. 2007. Linking land-use projections and forest fragmentation analysis. Res. Pap. PNW-RP-570. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Station. 41 p.

Radeloff, V.C.; Hammer, R.B.; Stewart, S.I; Fried, J.S.; Holcomb, S.S.; McKeefry, J.F. 2005. The wildland urban interface in the United States. Ecological Applications. 15: 799–805.

Reynolds, J. 2001. Land use change and competition in the South. Journal of Agricultural and Applied Economics. 33(2): 271–281.

Smail, R.; Lewis, D. 2009. Forest land conversion, ecosystem services, and economic issues for policy: a review. Gen. Tech. Rep. PNW-GTR-797. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 40 p.

Smith, W.B.; Miles, P.D.; Perry, H.; Pugh, S.A., coords. 2009. Forest Resources of the United States, 2007. Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service. 326 p.

Smith, W.B.; Vissage, J.; Sheffield, R.; Darr, D. 2001. Forest resources of the United States, 1997. Gen. Tech. Rep. NC-219. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 190 p.

Sohngen, B.; Alig, R. 2000. Mitigation, adaptation, and climate change: results from recent research on U.S. timber markets. Environmental Science and Policy. 3: 235–248.

Stein, S.M.; McRoberts, R.E.; Alig, R.; Nelson, M.D.; Theobald, D.M.; Eley, M.; Dechter, M.; Carr, M. 2005. Forests on the edge: housing development on America's private forests. Gen. Tech. Rep. PNW-GTR-636. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 16 p.

Stein, S.M.; Alig, R.J.; White, E.M.; Comas, S.J.; Carr, M.; Eley, M.; Elverum, K.; O'Donnell, M.; Theobald, D.M.; Cordell, K.; Haber, J.; Beauvais, T.W. 2007. National forests on the edge: development pressures on America's national forests and grasslands. Gen. Tech. Rep. PNW-GTR-728. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 26 p.

Stewart, S.; Radeloff, V.C.; Hammer, R. 2003. The wildland-urban interface in U.S. metropolitan areas. In: Kollin, C., ed. Proceedings of the 2003 National Urban Forest Conference. Washington, DC: American Forests: 254–255.

Stynes, D.J.; Zheng, J.J.; Stewart, S.I. 1997. Seasonal homes and natural resources: patterns of use and impact in Michigan. Gen. Tech. Rep. NC-194. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Research Station. 39 p.

Texas Forest Service [Texas FS]. 2009. Trees are the answer. http://texasforestservice.tamu.edu/uploadedFiles/Sustainable/fia/Publications/Articles/FIAWestTexas_2009.pdf. (March 23, 2009).

U.S. Department of Agriculture, Economic Research Service [ERS]. 2009. Major land uses database. http://usda.mannlib.cornell.edu/data-sets/land/89003/. (March 2009).

U.S. Department of Agriculture, Forest Service [USDA FS]. 1988. The South's fourth forest: alternatives for the future. For. Resour. Rep. 24. Washington, DC. 512 p.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1989a. An analysis of the land base situation in the United States: 1989-2040. Gen. Tech. Rep. RM-181. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 76 p.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1989b. RPA assessment of the forest and rangeland situation in the United States, 1989. For. Resour. Rep. 26. Washington, DC. 72 p.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2001. 2000 RPA assessment of forest and range lands. FS-687. Washington, DC. 78 p.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2007. Forest Service open space strategy: cooperating across boundaries to sustain working and natural landscapes. FS-889. Washington, DC. 16 p.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2009. Forest inventory and analysis: the Nation's forest census. http//:fia.fs.fed.use. (March 2009).

U.S. Department of Agriculture, National Agricultural Statistics Service [USDA NASS]. 2008a. Acreage. (September 8, 2008). http://usda.mannlib.cornell.edu/usda/current/Acre/Acre-06-30-2008.pdf. (March 2009).

U.S. Department of Agriculture, National Agricultural Statistics Service [USDA NASS]. 2008b. National agricultural crop areas. Washington, DC. 76 p.

U.S. Department of Agriculture, National Agricultural Statistics Service [USDA NASS]. 2009. Agricultural crop areas. http://www.usda.gov/nass/PUBS/TODAYRPT/acrg0608.pdf. (September 2009).

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2001. National resource inventory. Washington, D.C. 178 p.

U.S. Department of Agriculture, Soil Conservation Service [USDA SCS]. 1987. Second RCA appraisal. Washington, DC. 134 p.

U.S. Department of Commerce, Census Bureau. 2009. Census 2000. http://www.census.gov/main/www/cen2000.html. (July 2008).

U.S. Department of Commerce, Bureau of Economic Analysis. 2009. Personal income and outlays. http://www.bea.gov/national/index.htm#personal. (July 2008).

Vesterby, M. 2001. Land use. In: Agricultural, resource, and environmental indicators. Washington, DC: U.S. Department of Agriculture, Economic Research Service: 23–34. Chapter 1. http:/www.ers.usda.gov/Emphases/Harmony/issues/arei2000/. (October 6, 2001).

Vesterby, M.; Krupa, L. 2001. Major uses of land in the United States, 1997. Washington, DC: U.S. Department of Agriculture, Economic Research Service. 38 p.

Wall, B. 1981. Trends in commercial timberland area in the United States by state and ownership, 1952–77, with projections to 2030. Gen. Tech. Rep. WO-GTR-31. Washington, DC: U.S. Department of Agriculture, Forest Service. 26 p.

Watson, T. 2009. Climate plan calls for forest expansion. USA Today, August 19, page 1.

Wear, D.; Greis, J. 2002. Southern forest resource assessment: summary of findings. Journal of Forestry. 100(7): 6–14.

Westcott, P. 2007. U.S. ethanol expansion driving changes throughout the agricultural sector. U.S. Department of Agriculture, Economic Research Service, Amber Waves: 5(4). http://www.ers.usda.gov/AmberWaves/September07/Features/Ethanol.htm. (September 2008).

White, E.M. 2010. Woody biomass for bioenergy and biofuels in the United States—a briefing paper. Gen. Tech. Rep. PNW-GTR-825. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 45 p.

White, E.; Alig, R.; Stein, S.; Mahal, L.; Theobald, D. 2009a. A sensitivity analysis of "Forests on the Edge: Housing Development on America's Private Forests." Gen. Tech. Rep. PNW-GTR-792. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 35 p.

White, E.; Mazza, R. 2008. A closer look at on the edge: future development on private forests in three states. Gen. Tech. Rep. PNW-GTR-758. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

White, E.; Morzillo, A.; Alig, R. 2009b. Past and projected rural land conversion in the US at state, regional and national levels. Landscape and Urban Planning. 89: 37–48.

Appendix

In an earlier publication (Plantinga et al. 2007), we presented preliminary land-use projections, which motivated a discussion of ways to improve the land-use projection algorithm. In this appendix, we document recent changes made to the algorithm.

Regional Econometric Models

The major change was to estimate regional econometric land-use models and incorporate the new parameter estimates into the algorithm. We did this for four subregions (Corn Belt, Mountain, North Plains, and South Plains) in which the national econometric model appeared to overestimate increases in forest area (Plantinga et al. 2007). Using the same basic approach as Lubowski (2002), we estimated multinomial logit models for each of these regions. Within a region, separate models are estimated for plots that begin in a particular use (e.g., crops). Each model quantifies how net returns and soil quality affect the probability that land remains in its starting use or switches to an alternative use. Formally, denote j as the starting use, k as the ending use, $\mathbf{X}_{ik}$ as a vector of independent variables measured for plot i and ending use k, and $\hat{\boldsymbol{\beta}}_{jk}$ as the parameters for ending use k (starting use j). Then, the estimated probability that plot i remains in the initial use j is:

$$\hat{P}_{ijj} = \frac{e^{\hat{\boldsymbol{\beta}}_{jj}'\mathbf{X}_{ij}}}{\sum_{k=1}^{K} e^{\hat{\boldsymbol{\beta}}_{jk}'\mathbf{X}_{ik}}} \quad (1)$$

and the probability that it switches to use k is:

$$\hat{P}_{ijk} = \frac{e^{\hat{\boldsymbol{\beta}}_{jk}'\mathbf{X}_{ik}}}{\sum_{k=1}^{K} e^{\hat{\boldsymbol{\beta}}_{jk}'\mathbf{X}_{ik}}} \quad (2)$$

where K is the total number of land uses.

The $\hat{\boldsymbol{\beta}}_{jk}$ vectors for the Corn Belt region are reported in table 20. Models are estimated for land starting in crop, pasture, and forest. The ending uses are crop, pasture, forest, urban, CRP, and range. Models are not estimated for urban, CRP, and range starting uses. We do not observe land moving out of urban and there are too few range plots in the region to estimate a model. CRP lands are modeled using a different procedure, as discussed in Lubowski (2002). For the starting use, the independent variables are net returns, plot-level dummy variables for Land Capability Class (LCC),[1] and the interaction between net returns and LCC dummies. In an

[1] See the discussion of LCC ratings and indicator variables in Plantinga et al. (2007). LCC1 takes the value 1 if the plot has LCC rating I or II, LCC2 is 1 for III or IV ratings, LCC3 is 1 for V or VI ratings, and LCC4 is 1 for VII or VIII ratings. In all models, LCC1 is the omitted category.

Table 20—Econometric land-use model for the Corn Belt subregion

Variable	Coefficient	Variable	Coefficient
Starting use = crops		**Starting use = pasture**	
		Intercept	59.98
Crop net return	0.040	Pasture net return	0
Crop net return×LCC2	-0.011	Pasture net return×LCC2	0.007
Crop net return×LCC3	-0.019	Pasture net return×LCC3	0
Crop net return×LCC4	-0.036	Pasture net return×LCC4	-0.002
LCC2	0.565	LCC2	0.180
LCC3	0.504	LCC3	0.213
LCC4	1.992	LCC4	-0.264
X – coordinate	0.916	X – coordinate	0.451
Y – coordinate	-3.834	Y – coordinate	-1.842
X – coordinate squared	0.011	X – coordinate squared	-0.005
Y – coordinate squared	0.072	Y – coordinate squared	-0.014
(X – coord.)×(Y – coord.)	0.024	(X – coord.)×(Y – coord.)	-0.033
Ending use = pasture		**Ending use = crops**	
Intercept	-120.0		
Pasture net return	0.019	Crop net return	0.006
Pasture net return×LCC2	0.003	Crop net return×LCC2	0.001
Pasture net return×LCC3	0.002	Crop net return×LCC3	-0.006
Pasture net return×LCC4	0.024	Crop net return×LCC4	-0.018
Ending use = forest		**Ending use = forest**	
Intercept	-122.9	Intercept	-1.070
Forest net return	0.077	Forest net return	0.007
Forest net return×LCC2	0.006	Forest net return×LCC2	0.034
Forest net return×LCC3	0.023	Forest net return×LCC3	0.044
Forest net return×LCC4	0.064	Forest net return×LCC4	0.040
Ending use = urban		**Ending use = urban**	
Intercept	-121.1	Intercept	-3.191
Urban net return	0.001	Urban net return	0
Urban net return×LCC2	0	Urban net return×LCC2	0
Urban net return×LCC3	-0.001	Urban net return×LCC3	0
Urban net return×LCC4	-0.001	Urban net return×LCC4	0
Ending use = CRP[a]		**Ending use = CRP**[a]	
Intercept	-120.0	Intercept	-4.596
Ending use = range		**Ending use = range**	
Intercept	-138.1	Intercept	-19.95
Range net return	0.076	Range net return	-0.006
Range net return×LCC2	-0.117	Range net return×LCC2	-0.018
Range net return×LCC3	-0.279	Range net return×LCC3	-0.019
Range net return×LCC4	-0.303	Range net return×LCC4	-0.039
Starting use = forest			
Intercept	-75.89		
Forest net return	-0.037		
Forest net return×LCC2	0.033		
Forest net return×LCC3	0.021		
Forest net return×LCC4	0.035		
LCC2	0.297		
LCC3	0.214		

Table 20—Econometric land-use model for the Corn Belt subregion (continued)

Variable	Coefficient	Variable	Coefficient
LCC4	1.203		
X – coordinate	-1.661		
Y – coordinate	0.326		
X – coordinate squared	-0.010		
Y – coordinate squared	-0.003		
(X – coord.)×(Y – coord.)	-0.001		
Ending use = crops			
Crop net return	0.012		
Crop net return×LCC2	0.002		
Crop net return×LCC3	-0.002		
Crop net return×LCC4	-0.016		
Ending use = pasture			
Intercept	-0.242		
Pasture net return	0.036		
Pasture net return×LCC2	0.004		
Pasture net return×LCC3	-0.031		
Pasture net return×LCC4	-0.030		
Ending use = urban			
Intercept	1.069		
Urban net return	0		
Urban net return×LCC2	0		
Urban net return×LCC3	0		
Urban net return×LCC4	0		
Ending use = CRP[a]			
Intercept	-2.969		
Ending use = range			
Intercept	16.92		
Range net return	-0.068		
Range net return×LCC2	0.080		
Range net return×LCC3	0.040		
Range net return×LCC4	0.070		

[a] CRP = Conservation Reserve Program.

effort to improve the model's fit, we allow the intercept term for the starting use to vary spatially. This is done by including latitude (X coordinate) and longitude (Y coordinate) for the centroid of the county in which the plot is found. The squares of X coordinate and Y coordinate in addition to the product of X coordinate and Y coordinate are also included. For the ending uses, we include an alternative-specific constant,[2] the net return to that use, and net returns interacted with the LCC dummies.

Results for the Mountain region are reported in table 21. Starting uses include crops, pasture, forest, and range. Ending uses are crops, pasture, forest, urban, CRP,

[2] An alternative-specific constant is 1 for the chosen alternative and zero for all others. Note that the alternative-specific constant for crops is omitted from all models to avoid perfect collinearity.

Table 21—Econometric land-use model for the Mountain subregion

Variable	Coefficient	Variable	Coefficient
Starting use = crops		**Starting use = pasture**	
		Intercept	-197.9
Crop net return	0.003	Pasture net return	-0.006
Crop net return×LCC2	0	Pasture net return×LCC2	-0.027
Crop net return×LCC3	-0.005	Pasture net return×LCC3	-0.044
Crop net return×LCC4	-0.009	Pasture net return×LCC4	-0.049
LCC2	-1.045	LCC2	0.960
LCC3	-1.304	LCC3	1.224
LCC4	-1.006	LCC4	-1.397
X – coordinate	0.215	X – coordinate	-3.640
Y – coordinate	-0.361	Y – coordinate	-0.156
X – coordinate squared	0.002	X – coordinate squared	-0.017
Y – coordinate squared	0.011	Y – coordinate squared	-0.007
(X – coord.)×(Y – coord.)	0.004	(X – coord.)×(Y – coord.)	-0.006
Ending use = pasture		**Ending use = crops**	
Intercept	-25.39		
Pasture net return	0.004	Crop net return	0.001
Pasture net return×LCC2	-0.019	Crop net return×LCC2	-0.001
Pasture net return×LCC3	-0.006	Crop net return×LCC3	-0.011
Pasture net return×LCC4	-0.048	Crop net return×LCC4	-0.025
Ending use = forest		**Ending use = forest**	
Intercept	-33.20	Intercept	-3.912
Forest net return	0.177	Forest net return	-0.658
Forest net return×LCC2	-0.070	Forest net return×LCC2	0.663
Forest net return×LCC3	-1.008	Forest net return×LCC3	0.659
Forest net return×LCC4	-0.544	Forest net return×LCC4	0.107
Ending use = urban		**Ending use = urban**	
Intercept	-28.83	Intercept	-4.053
Urban net return	0.001	Urban net return	0
Urban net return×LCC2	0	Urban net return×LCC2	0
Urban net return×LCC3	0	Urban net return×LCC3	0
Urban net return×LCC4	0	Urban net return×LCC4	0
Ending use = CRP[a]		**Ending use = CRP**[a]	
Intercept	-26.37	Intercept	-4.538
Ending use = range		**Ending use = range**	
Intercept	-25.60	Intercept	-1.802
Range net return	-0.037	Range net return	0.048
Range net return×LCC2	-0.125	Range net return×LCC2	0.022
Range net return×LCC3	-0.003	Range net return×LCC3	0.031
Range net return×LCC4	-0.028	Range net return×LCC4	-0.090
Starting use = forest		**Starting use = range**	
Intercept	131.5	Intercept	196.1
Forest net return	-0.032	Range net return	0.039
Forest net return×LCC34	0.012	Range net return×LCC34	0.103
LCC34	-0.136		
X – coordinate	0.820	X – coordinate	4.165
Y – coordinate	-3.689	Y – coordinate	1.872
X – coordinate squared	-0.006	X – coordinate squared	0.022

Table 21—Econometric land-use model for the Mountain subregion (continued)

Variable	Coefficient	Variable	Coefficient
Crops		**Pasture**	
Y – coordinate squared	-0.020	Y – coordinate squared	-0.004
(X – coord.)×(Y – coord.)	-0.049	(X – coord.)×(Y – coord.)	0.015
Ending use = crops		**Ending use = crops**	
Crop net return	-0.003	Crop net return	0.002
Crop net return×LCC34	-0.007	Crop net return×LCC34	-0.010
Ending use = pasture		**Ending use = pasture**	
Intercept	-13.456	Intercept	-1.652
Pasture net return	-0.009	Pasture net return	0.036
Pasture net return×LCC34	0.006	Pasture net return×LCC34	0.008
Ending use = urban		**Ending use = forest**	
Intercept	-0.239	Intercept	0.279
Urban net return	0.001	Forest net return	-0.365
Urban net return×LCC34	0	Forest net return×LCC34	0.306
Ending use = CRP[a]		**Ending use = urban**	
Intercept	-0.411	Intercept	-2.989
		Urban net return	0
Ending use = range		Urban net return×LCC34	0
Intercept	3.622		
Range net return	-0.005	**Ending use = CRP**[a]	
Range net return×LCC34	0.067	Intercept	-6.299

[a] CRP = Conservation Reserve Program.

and range. For crop and pasture starting uses, we use the same set of independent variables as in the Corn Belt region. For forest and range starting uses, there are not enough high-quality plots to estimate separate effects for all four LCC variables. Instead, we use just two LCC variables: LCC12, an indicator variable for plots rated LCC I, II, III, or IV; and LCC34, an indicator variable for plots rated LCC V, VI, VII, and VIII.[3] In the range model, we encountered convergence problems that were remedied by omitting the LCC34 variable for the starting use.

We expect the coefficients on the net returns variables to be positive. This indicates that the probability that land remains in the same use or switches to an ending use is increasing in the respective own net return. This result is found in almost all cases (12 out of 15) in the Corn Belt model, but only in about one-half of the cases (11 out of 20) in the Mountain model. With forest use, the coefficients on forest net returns are generally negative, as Broniak (2007) found in her analysis of land use in this region. The interaction variables can be positive or negative depending on how the marginal effect of net returns changes with land quality. In the Corn Belt region, for example, the effect of forest net returns on the crop-to-forest transition

[3] LCC12 is the omitted category.

increases as land quality falls.[4] The coefficients on the LCC variables indicate how the respective transition probability changes relative to the probability for class I and II land. For example, in the Rocky Mountain region, the probability that cropland remains in the same use is lower on class III to VIII land compared to class I and II land.

Econometric models also were estimated for the North and South Plains regions. However, we found that forest area increases still appeared to be overestimated in these regions. Given that the North and South Plains are not a primary focus of the RPA assessments, we replaced the transition probability functions in the algorithm with sample transition probabilities. In particular, for each county we computed transition probabilities using the National Resources Inventory (NRI) plot data for the period 1992 to 1997. Define N_j as the number of plots in a given county in use j in 1992 and N_{jk} as the number of these plots that switched to use k by 1997, then the use j-to-k transition probability is given by $P_{jk} = N_{jk} / N_j$. This approach has the advantage that it replicates historically observed land-use change, but the disadvantage that the transition probabilities cannot adjust to endogenous changes in commodity prices.

Incorporating 2003 NRI Data

Beyond the 1997 NRI data, the Natural Resources Conservation Service (NRCS) has not made available plot-level data for subsequent inventories. Thus, we must use the projection algorithm to generate base-year 2002 acres by use. The NRCS did publish state-level land-use statistics for the year 2003. We adjusted 2002 projected acres to make them consistent with the 2003 state-level figures from the NRI. The first step is to use linear interpolation to derive 2002 estimates of state-level land use using the 1997 and 2003 NRI data.[5] Next, we derived adjustment factors equal to the 2002 NRI state acres divided by the 2002 projected state acres (table 22). These factors are used within the projection algorithm to adjust the plot-level acres of land in each use at the end of 2002.

The adjustment factors in table 22 also allow us to judge the out-of-sample forecasting accuracy of the projection algorithm.[6] If the adjustment factors are all

[4] The sum of the forest net return coefficient (0.077) and the interaction coefficient (e.g., 0.023 for LCC3) gives the marginal effect of forest net returns on class V and VI cropland.

[5] In the 2003 state-level data, only the total developed land area, equal to the sum of urban land and rural transportation land, is reported. However, the NRCS published estimates of rural transportation acres for 2001, which we subtracted from the 2003 developed land figure to estimate 2003 urban acres.

[6] The algorithm projects a business-as-usual scenario, reflecting land market conditions during the historical period 1992 to 1997. The model does not attempt to model the actual drivers of land-use change between 1997 and 2002 (e.g., the observed increase in the U.S. population over this period). As such, forecast errors may arise from modeling error and from changes in these drivers after 1997.

Table 22—Adjustment factors for 2002 projected areas

State	Crops	Pasture	Forest	Urban	CRP[a]	Range
Alabama	0.830	1.064	1.021	1.059	0.972	0.060
Arizona	0.790	1.962	0.980	1.303	0	0.999
Arkansas	0.981	1.088	1.002	0.922	0.638	0.033
California	1.091	0.322	1.011	0.919	1.782	1.111
Colorado	0.948	0.791	0.956	1.132	1.316	1.007
Connecticut	0.818	1.319	0.988	1.035	0	0
Delaware	1.075	0.350	0.967	1.114	0.578	0
Florida	0.960	0.915	1.017	1.061	0.742	0.934
Georgia	0.902	1.028	1.016	1.065	0.798	0
Idaho	0.957	1.008	1.009	1.089	1.491	0.981
Illinois	1.018	0.711	1.287	0.851	1.104	0
Indiana	0.998	0.940	1.135	0.902	0.748	0
Iowa	0.985	1.030	1.148	0.826	1.148	0
Kansas	1.000	1.022	1.001	0.974	0.928	1.010
Kentucky	0.976	1.118	0.956	1.024	0.968	0
Louisiana	0.974	1.017	1.019	0.954	1.315	0.696
Maine	0.734	0.739	1.012	0.937	6.354	0
Maryland	0.962	1.029	1.004	1.024	0.544	0
Massachusetts	0.912	1.267	0.987	1.026	0	0
Michigan	0.995	0.955	1.023	1.025	0.857	0
Minnesota	1.025	0.922	1.002	0.843	0.998	0
Mississippi	0.920	0.966	1.035	0.970	1.069	0
Missouri	0.849	1.239	1.063	0.799	1.013	0.858
Montana	0.955	1.025	0.981	1.051	1.260	1.001
Nebraska	0.995	1.061	0.964	0.947	0.948	1.004
Nevada	0.806	2.146	1.005	1.233	0.093	0.986
New Hampshire	0.813	0.999	1.005	1.012	0	0
New Jersey	0.946	0.963	0.974	1.037	0.027	0
New Mexico	0.820	0.676	0.994	1.250	2.092	1.000
New York	0.972	1.054	1.004	0.982	0.684	0
North Carolina	1.059	0.832	0.980	1.126	0.929	0
North Dakota	0.965	0.894	1.022	0.916	1.152	1.048
Ohio	0.999	1.090	1.011	0.916	1.152	1.048
Oklahoma	0.938	1.102	0.978	0.964	0.914	1.008
Oregon	1.179	0.577	1.000	0.722	1.685	1.105
Pennsylvania	1.019	0.998	1.006	1.000	0.764	0
Rhode Island	0.798	1.322	0.982	1.053	0	0
South Carolina	0.971	0.893	1.007	1.075	1.040	0
South Dakota	1.002	0.977	0.989	0.905	0.834	1.015
Tennessee	0.983	1.080	0.987	1.001	0.709	0
Texas	0.984	1.046	0.956	1.019	1.029	0.998
Utah	0.976	1.064	0.992	1.121	1.135	0.995
Vermont	0.945	1.018	1.004	0.944	0	0
Virginia	0.936	1.109	0.997	1.019	0.640	0
Washington	1.215	0.299	1.002	0.858	2.692	1.192
West Virginia	0.925	1.040	0.999	1.057	0.106	0
Wisconsin	0.986	1.046	1.002	0.959	1.036	0
Wyoming	0.969	0.977	0.919	1.015	1.219	1.009

Note: adjustments factors are set to zero in states that have no acreage in the given use.
[a] CRP = Conservation Reserve Program.

equal to 1, then the algorithm exactly forecasts the 2002 NRI state acres. The algorithm is quite accurate in predicting forest area. State-level adjustment factors range from 0.92 to 1.29, with a median value of 1.002. In 32 of the 48 states, the forest adjustment factor is between 0.98 and 1.02. Cropland and urban land areas are also predicted with a high degree of accuracy. Adjustment factors lie between 0.73 and 1.22 for cropland and 0.72 and 1.30 for urban land, with median values of 0.97 and 1.01, respectively. The pasture land forecasts are less accurate, with adjustment factors between 0.30 and 2.15. The median value, however, is 1.02. The accuracy of the CRP and range forecasts is harder to judge because some states have little or no land in these uses. In a state with a small amount of CRP land, for example, the adjustment factor can be large even when there is a small absolute difference in the NRI and projected acres.

Range Land in the Lake States and Northeast Regions

The logistic transition probabilities (equations 1 and 2) are strictly positive,[7] implying that a positive amount of land is projected to move between each of the land-use categories. In the Lake States and Northeast regions, the probability that cropland, pasture, forest, and CRP are converted to range is very small, but still positive. Thus, we project a positive amount of range in these regions even though, initially, the area of range land is zero. Because these results are an artifact of the econometric specification, we set the corresponding transition probabilities to zero and reallocate the probability mass to the other transition probabilities. For example, if *j* denotes the starting land use, *r* denotes range, and *k* denotes ending uses other than range, then the adjusted transition probabilities (denoted by *A*) equal $P_{jk}^{A} = P_{jk}^{U} / (1 - P_{jr})$ where *U* denotes the unadjusted transition probability.

Other assumptions used in making the projections pertain to the CRP area. Participation in the CRP depends on a different set of decisions than other land-use choices, because enrollment depends on both the landowner's bid, which includes a proposed rental rate, and the government's choice of whether to accept the bid, which depends on the environmental characteristics of a parcel as well as the cost. Because the program targets cropland, CRP rental rates are highly correlated with the profitability of cropping in a given locality (USDA NASS 2009). We account for the effect of crop net returns on the incentive to remain in cropland. Incentives to enroll in CRP are specified as a function of LCC, as lower land quality as measured by LCC has always been strongly associated with program eligibility. We would thus expect greater enrollment on lower quality lands.

[7] This exception is that land beginning in urban use remains urban with probability 1 (see Plantinga et al. 2007).

As far as the projected future of the CRP program, we are not explicitly modeling future changes in the CRP program but are assuming that it remains in place and operates in a fashion similar to the way it did during the historical period. In the projection period, land will move in and out of the CRP to the extent that economic conditions differ from those during the historical period.

Other Land-Use Data Issues

No one land-use database provides universal coverage over space and time for use in addressing all relevant land-use policy questions (Alig et al. 2003). Many databases pertain to land cover versus land use, where 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, e.g., oak-hickory forest. This report pertains to land use, and companion reports focused on forest cover changes (e.g., Alig and Butler 2002, 2004) in the United States.

Both land use and land cover are dynamic in view of the changes in response to human actions, climate change, natural succession, and other forces. Forest Inventory and Analysis (FIA) surveys conducted by the USDA Forest Service are designed to provide objective and scientifically credible information about forest-related changes, along with remeasurements of 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 nationwide. The FIA inventories provide consistent forest inventory data for the Nation back to 1952 (Smith et al. 2001).

For estimating land use change among the major uses, the National Resources Inventory (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 to be developed for data since 1982. With the exception of a few of the smaller land-use categories, such as for urban uses, land-use shifts occur in both directions across the 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 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. Also, the "Major Land Use Series" by the USDA's Economic Research Service (2009) summarizes some of the NRI land-use data and augments it with data from FIA and other sources.

The FIA inventories in conjunction with the Resources Planning Act (RPA) assessment are used to produce national summary databases (e.g., Smith et al. 2009) that draw upon the others and also incorporate other data from the U.S. Census Bureau (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. The combination of ground truthing and remote sensing helps minimize classification problems, as land use in some regions is difficult to discern remotely, such as houses under a forest canopy. Other areas have land cover types comprising a mixture of vegetation that can have different uses, such as large areas with fairly sparse tree cover and grass and forbs. An example is western Texas, where FIA recently identified more than 40 million acres of such land cover (Texas FS 2009).

We used population and income data drawn from analyses for the 2010 RPA Assessment that are linked to the global and regional socioeconomic data from the 4th IPCC Assessment storylines (Langner, n.d.). The IPCC 4th Assessment projections for U.S. population and gross domestic product (GDP) were updated to be consistent with recent projections from the U.S. Bureau of the Census and more recent historical data on GDP. National population and income projections were then downscaled to the county level over the 2010-2060 period to support analyses to evaluate U.S. resource conditions across three RPA scenarios.

Glossary

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

Conservation Reserve Program (CRP) land—A land cover/use category that includes land under a CRP contract. The CRP is a federal program established under the Food Security Act of 1985 to assist private landowners to convert highly erodible cropland to vegetative cover for 10 years (e.g., Plantinga et al. 2001).

cropland—A land cover/use category that includes areas used for the production of adapted crops for harvest. Two subcategories of cropland are recognized: cultivated and noncultivated. Cultivated cropland comprises land in row crops or close-grown crops and also other cultivated cropland, for example, hay land or pastureland that is in a rotation with row or close-grown crops. Noncultivated cropland includes permanent hay land and horticultural cropland.

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. This is a broader category than the "urban" land use considered in this study. This study has not attempted to model net returns to rural transportation use, so this report focuses only on the urban component of developed land.

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.

Intergovernmental Panel on Climate Change (IPCC)—The IPCC was established to provide decisionmakers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate-related data or parameters. Its role is to assess on a comprehensive, objective, open, and transparent basis the latest scientific, technical, and socioeconomic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts, and options for adaptation and mitigation. For more information, see http://www.ipcc.ch/.

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.

land cover/use—A term that includes categories of land cover and categories of land use. Land cover is the vegetation or other kind of material that covers the land surface. Land use is the purpose of human activity on the land; it is usually, but not always, related to land cover. The NRI uses the term land cover/use to identify categories that account for all the surface area of the United States. The six major land use categories considered in this study are (1) cropland, (2) pasture, (3) range, (4) Conservation Reserve Program (CRP), (5) forest, and (6) urban. These uses are described in this glossary.

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.

National Resources Inventory (NRI)—A statistical survey of land use and natural resource conditions and trends on U.S. nonfederal lands. The NRI is led by Natural Resources Conservation Service (NRCS). For more information, see http://www.nrcs.usda.gov/technical/NRI/.

other rural land—A land cover/use category that includes farmsteads and other farm structures, field windbreaks, barren land, and marshland. Some reports refer to this as NRI minor land cover/uses.

pastureland—A land cover/use category of land managed primarily for the production of introduced forage plants for livestock grazing. Pastureland cover may consist of a single species in a pure stand, a grass mixture, or a grass-legume mixture. Management usually consists of cultural treatments: fertilization, weed control, reseeding or renovation, and control of grazing. For the NRI, includes land that has a vegetative cover of grasses, legumes, and/or forbs, regardless of whether or not it is being grazed by livestock.

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

rangeland—A land cover/use category on which the climax or potential plant cover is composed principally of native grasses, grasslike plants, forbs, or shrubs suitable for grazing and browsing, and introduced forage species that are managed like rangeland. This would include areas where introduced hardy and persistent grasses, such as crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), are planted and such practices as deferred grazing, burning, chaining, and rotational grazing are used, with little or no chemicals or fertilizer being applied. Grasslands, savannas, many wetlands, some deserts, and tundra are considered to be rangeland. Certain communities of low forbs and shrubs, such as mesquite, chaparral, mountain shrub, and pinyon-juniper, are also included as rangeland.

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, that 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 (from FIA surveys) 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 U.S. Department of Commerce 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 estimated areas of 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 major 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 and built-up areas—These areas from NRI surveys consist of residential, industrial, commercial, and institutional land; construction and public administrative sites; and 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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