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Land Use in the Lake States Region: An Analysis of Past Trends and Projections of Future Changes

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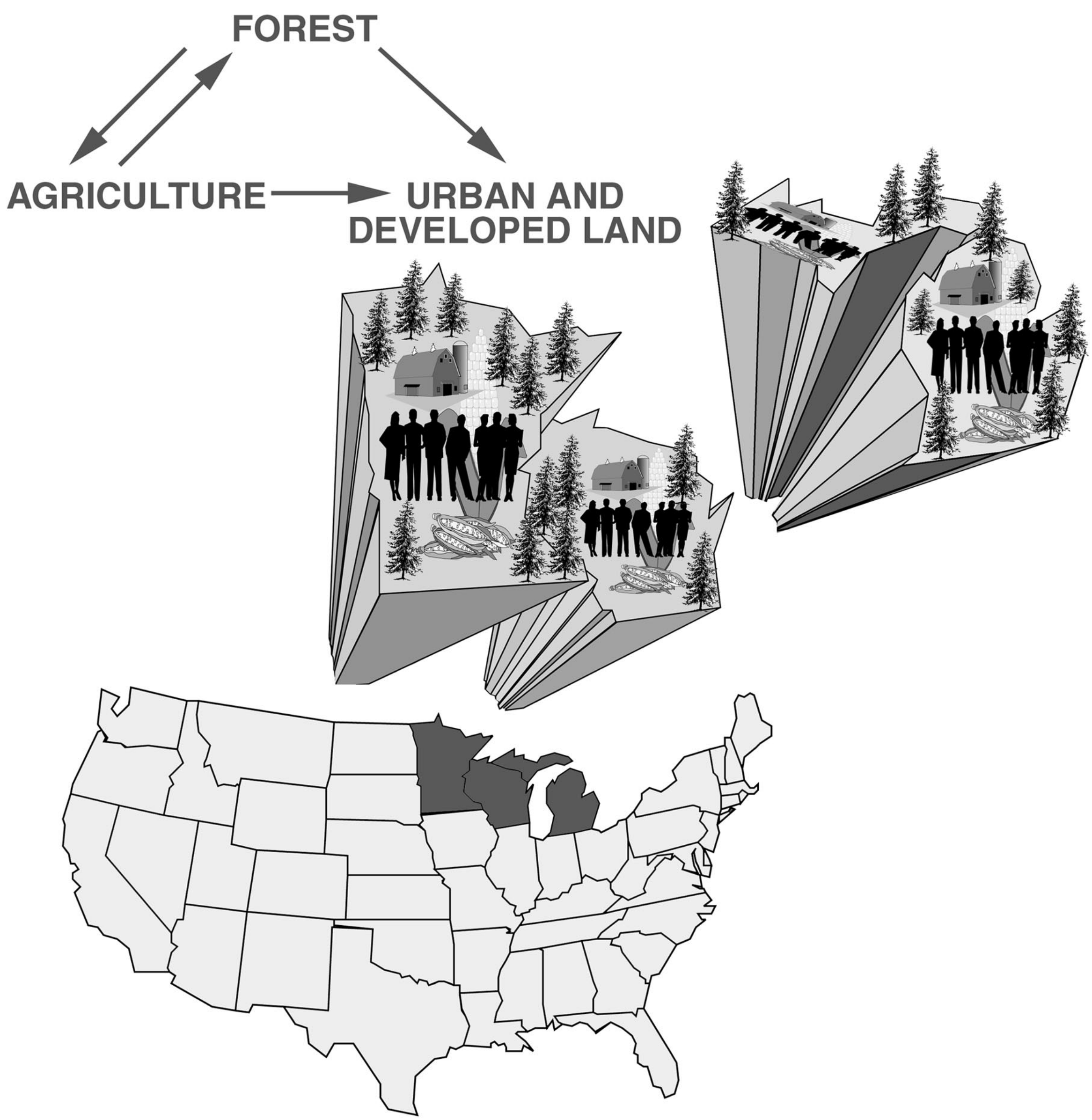

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Abstract

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This paper presents the historic trends and future projections of forest, farm, and urban land uses for the Lake States of Michigan, Minnesota, and Wisconsin. Since the 1950s, forest and farm land have been decreasing, and urban and other land uses have been increasing throughout the Lake States. Forest, crop, and pasture land have decreased in the region by 3.2, 5.4, and 4.0 million acres, respectively, whereas urban and other land uses have increased by 2.1 and 10.3 million acres, respectively. These decreases and increases were most pronounced during the 1950s and 1980s. Land rents and land quality were used to make projections of the distribution of Wisconsin's future land uses. In Michigan and Minnesota, forest and farm land use projections were based on the extrapolation of historic trends, and urban land use projections were adopted from Wisconsin's econometric projections; land rents and land quality were not used for all projections because of insufficient data. The projections of land uses through 2050 are consistent with historic trends—forest and agricultural lands will decline, and urban and other land uses will increase. Timberland is projected to be reduced by 13 percent in Wisconsin, 11 percent in Michigan, and 10 percent in Minnesota.

Keywords: Land use change, urban development, land rents, timberland area projections.

Summary

This paper presents historic trends and future projections of forest, farm, and urban land uses for the Lake States: Michigan, Minnesota, and Wisconsin. Currently, about two-fifths of the land in the region is in forests. Since the 1950s, forest and farm land have been decreasing, and urban and other land use have been increasing. For the entire region, forest, crop, and pasture land decreased by 3.2, 5.4, and 4.0 million acres, respectively, whereas urban and other land uses increased by 2.1 and 10.3 million acres, respectively. These increases and decreases were most pronounced in the 1950s and 1980s.

An econometric model was used to make land use projections for Wisconsin; simple extrapolation techniques were used to make land use projections in Michigan and Minnesota because of a lack of data. The econometric model is based on the theoretical and empirical observations that the distribution of land uses is strongly affected by land rents and land quality. Allocations of land uses favor activities with the highest rents; land rents are a function of land quality. Land rent proxies were calculated for forest, agriculture, and urban lands. Land quality was estimated from National Resource Inventory data and was assumed to remain constant through the projection period because the dominant attributes are soils and topography, which should remain relatively constant. A model based on land rent and land quality variables was used to make future projections out to 2050. The multinomial logistic functions of the model were solved by using ordinary least squares, and the model parameters showed the expected signs. The model indicated that increase of forest, agriculture, or urban rents, all other factors being held constant, tended to decrease the shares of the other land uses.

The projections of land uses through 2050 are consistent with historic trends—forest and agricultural lands will decline, and urban and other land uses will increase. Timberland is projected to be reduced by 13 percent in Wisconsin, 11 percent in Michigan, and 10 percent in Minnesota. The forest land of Wisconsin is projected to decrease by 2.2 million acres: 0.1 million acres of private industrial, 1.4 million acres of nonindustrial, and 0.6 million acres of public timberland. Areas of land used for crops and pastures are projected to decline, 0.6 and 0.1 million acres, respectively, and urban land is projected to increase by 0.2 million acres. In Michigan, forest land is projected to decline by 1.4 million acres, of which 1.3 million acres will be timberland; a decline of 0.2 and 1.3 million acres of private industrial and nonprivate industrial timberlands, respectively, and an increase of 0.2 million acres on public lands. Land used for crops and pastures are projected to decrease by 1.2 and 0.8 million acres, respectively, and urban land is projected to increase by 0.3 million acres. In Minnesota, forest land is projected to decline by 1.0 million acres, with a decrease of 0.5 million acres in timberland; a decline of 0.1 and 0.6 million acres on private industrial and private nonindustrial lands, respectively, and an increase of 0.2 million acres on public lands. Land used for crops and pastures are projected to decline, 3.2 and 0.3 million acres, respectively, and urban land is projected to increase by 1.8 million acres by 2050.

Contents

Introduction

The purpose of this report is to analyze past land use trends in the Lake States and, based on these results, develop projections of future land use. The results of this work provide input to the USDA Forest Service effort to assess future trends in the Nation's forest resources in accordance with the 1974 Resources Planning Act (RPA) (e.g., USDA Forest Service 1989). The act requires that the assessment include "an analysis of present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands with consideration of the international resource situation, and an emphasis of pertinent supply, demand and price relationship trends." Land use change has important consequences for the future availability of timber, wildlife habitat, and other renewable resources and, therefore, is a critical component of this analysis.

Since the 1950s, the predominant trend in land use in the Lakes States region has been declines in forest and agricultural land and increases in urban and other land. In the last 50 years, forest land in Wisconsin increased by almost 800,000 acres, yet crop and pasture land declined by about 3,600,000 acres (table 1). Urban land now covers about 3.0 percent of Wisconsin's land area, having doubled in size over the past several decades. Over the same period, the forests of Michigan decreased by about 600,000 acres, with crop and pasture land losing a combined 3,400,000 acres (table 2). Paralleling Wisconsin trends, urban land has more than doubled in Michigan, currently covering 4.8 percent of the state's land area. Over the last 40 years, forest land in Minnesota declined by over 3,200,000 acres, whereas agricultural lands have lost a total of about 2,400,000 acres (table 3). Urban land now occupies 2.2 percent of the land in Minnesota, having increased more than twofold since the 1950s.

The next section discusses past trends in land use in Wisconsin, Michigan, and Minnesota, and reviews previous studies of the determinants of land use. Empirical evidence and land use theory are brought together in the section, "An Econometric Model of Land Use in Wisconsin." The section, "Projections of Land Use in Wisconsin," provides projections based on the estimation results from the section, "An Econometric Model of Land Use in Wisconsin." In the section, "Projections of Land Use in Michigan, Minnesota, and the Lake States Region," land use projections are presented for Michigan and Minnesota, and projections for the Lake States region are summarized. Conclusions are contained in the final section.

Land Use in Wisconsin, Michigan, and Minnesota: Historical Trends and Determinants

In this section, we provide an overview of current land use patterns in the Lake States region and land use changes between the 1950s and 1990s. We then consider historical land use changes within each state in more detail. Particular attention is given to changes in forest land categories (e.g., industrial timberland, nonindustrial timberland) because disaggregated forest land projections are required for the RPA assessments. In addition, we present current patterns in forest species composition. In the following subsection, we review earlier land use analyses in order to identify the important determinants of land use change.

Table 1—Land use trends in Wisconsin, 1950-95

Land use	1950s	1960s	1970s	1980s	1990	Change 1950-90s
			Thousand acres			
Forest land:[a]	15,614	15,039	14,945	15,351	16,408	+794
Timberland—	15,349	14,693	14,536	14,759	15,701	+352
Private industrial	942	933	1,368	1,156	1,102	+160
Private nonindus.	9,308	8,878	8,642	9,082	9,710	+402
Federal	2,003	1,910	1,591	1,772	1,864	-139
Non-Federal public	3,096	2,972	2,933	2,749	3,025	-71
Other forest land	265	346	409	592	707	+442
Crop land[b]	12,906	12,043	11,669	11,769	10,949	-1,957
Pasture land	2,432	1,845	1,100	865	782	-1,650
Urban land[c]	466	616	766	902	1,053	+587
Other land[d]	3,343	5,218	6,281	5,874	5,569	+2,226
Total land	34,761	34,761	34,761	34,761	34,761	

[a] Forest land is at least 1 acre, with trees stocked at a minimum of 10 percent or formerly had such tree cover and is not currently developed. Timberland is forest land capable of producing crops of industrial wood greater than 20 cubic feet per acre per year and not withdrawn from timber use. Private industrial, private nonindustrial, Federal, and non-Federal public are different ownership types within the timberland category. Other forest land is calculated as the difference between timberland and forest land. From Waddell and others (1989), Spencer and Thorne (1972), and Spencer and others (1988).

[b] Crop land is defined as land from which crops were harvested or hay was cut; land in orchards, citrus groves, vineyards, nurseries, and greenhouses; crop land used for pasturing and grazing; land in cover crops, legumes, and soil-improvement grasses; land on which all crops failed; land cultivated in summer fallow; and idle crop land. Pasture land is land used for pasture or grazing other than crop land or woodland pastured. From the census of agriculture.

[c] The most recently used definition of urban land (Daugherty 1992) is (1) territory within an urbanized area or (2) a town with at least 2,500 people. An urbanized area comprises one or more places and the adjacent surrounding territory ("urban fringe") that together have a minimum of 50,000 people. The urban fringe generally has a density of at least 1,000 people per square mile. Urban land area may include urban forest, which also is counted in the other forest land category.

[d] Other land is calculated as the difference between total land area and forest, crop, pasture, and urban land.

Table 2—Land use trends in Michigan, 1950-95

Land use	1950s	1960s	1970s	1980s	1990s	Change 1950-90s
			Thousand acres			
Forest land:[a]	19,886	19,886	19,373	18,368	19,281	-605
Timberland—	19,121	19,121	18,800	17,490	18,616	-505
Private industrial	1,548	1,548	2,257	1,981	1,514	-34
Private nonindus.	11,263	11,263	10,102	9,242	10,511	-752
Federal	2,530	2,530	2,494	2,509	2,607	+77
Non-Federal public	3,780	3,780	3,947	3,758	3,984	+204
Other forest land	765	765	573	878	665	-100
Crop land[b]	10,788	9,455	8,005	8,458	8,156	-2,632
Pasture land	937	577	328	253	200	-737
Urban land[c]	865	1,017	1,286	1,540	1,760	+895
Other land[d]	3,882	5,423	7,366	7,739	6,961	+3,079
Total land	35,593	35,593	36,158	35,480	35,693	

[a] From Waddell and others (1989), Raile and Smith (1983), and Leatherberry and Spencer (1996).
[b] See footnote b, table 1.
[c] See footnote c, table 1.
[d] See footnote d, table 1.

Table 3—Land use trends in Minnesota, 1950-95

Land use	1950s	1960s	1970s	1980s	1990s	Change 1950-90s
			Thousand acres			
Forest land:[a]	19,896	18,494	17,394	16,709	16,681	-3,215
Timberland—	16,580	15,412	14,495	13,695	14,723	-1,857
Private industrial	578	716	814	772	751	+173
Private nonindus.	6,878	6,538	5,686	5,595	5,904	-974
Federal	3,055	2,818	2,784	2,336	2,503	-552
Non-Federal public	6,069	5,341	5,211	4,992	5,565	-504
Other forest land	3,316	3,082	2,899	3,014	1,958	-1,358
Crop land[b]	22,193	22,243	21,321	22,189	21,387	-806
Pasture land	2,594	2,118	1,537	1,127	973	-1,621
Urban land[c]	544	707	905	1,299	1,197	+653
Other land[d]	8,790	10,455	12,860	12,693	13,779	+4,989
Total land	54,017	54,017	54,017	54,017	54,017	

[a] From Waddell and others (1989), Jakes (1980), and Wiles (1995).
[b] See footnote 2, table 1.
[c] See footnote 3, table 1.
[d] See footnote 4, table 1.

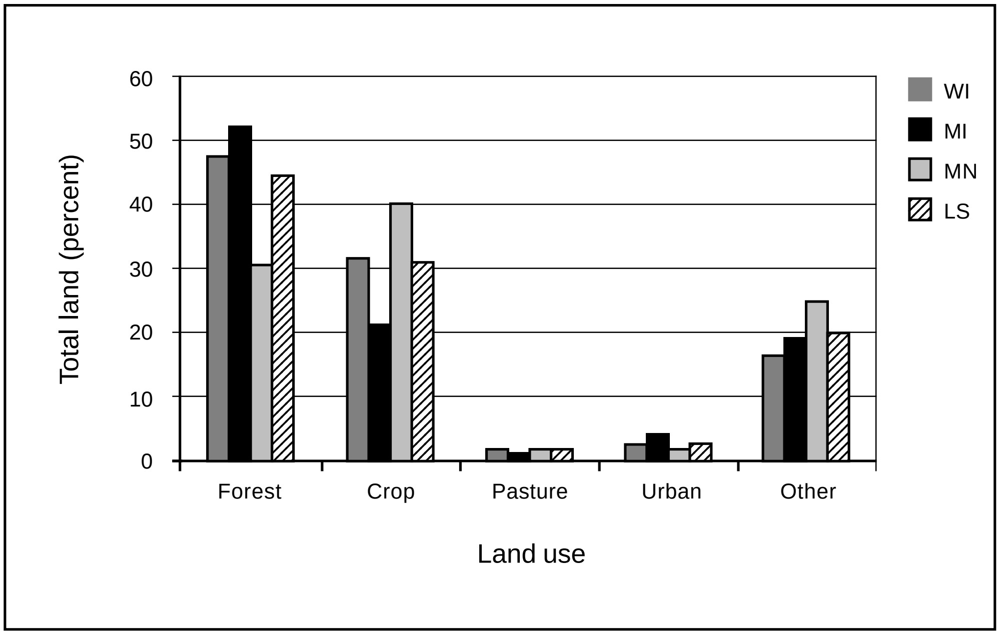

Figure 1—Current distribution of land use in the Lake States.

Overview

Figure 1 shows the current distribution of land uses in the three states as well as for the average of all three Lake States. About 47 percent of the land in Wisconsin is in forests, and another 32 percent is in crop land (table 1).[1] The remaining 21 percent of the land area is divided among pasture (2 percent), urban (3 percent), and other land uses (16 percent). In Michigan, currently 53 percent of the land is forest, 22 percent crop, 1 percent pasture, 5 percent urban, and 19 percent other uses (table 2). Forests now cover 31 percent of Minnesota's land area, with crop land occupying another 40 percent (table 3). The remaining 29 percent of Minnesota's land is comprised of pasture land (2 percent), urban (2 percent), and other land uses (25 percent).

As shown in figure 1, the present land use distributions for all three states are similar. Michigan leads with the highest proportion of forest and the least crop land. Minnesota is at the other extreme, with the most crop and least forest land. Wisconsin, with moderate amounts of forest and crop land, lies between Michigan and Minnesota. All three states currently have low proportions of pasture and urban land with similar amounts of other land.

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[1] Forest and agricultural land (crop and pasture land) are defined by the predominant vegetative cover. Urban land is based on population distributions. Other land is the difference between total land area and forest, agricultural, and urban land. Other land includes developed land not classified as urban land (e.g., suburban housing, farmsteads, and rural transportation uses), wetlands, lands in transition between uses (e.g., crop reverting to forest land), and miscellaneous uses.

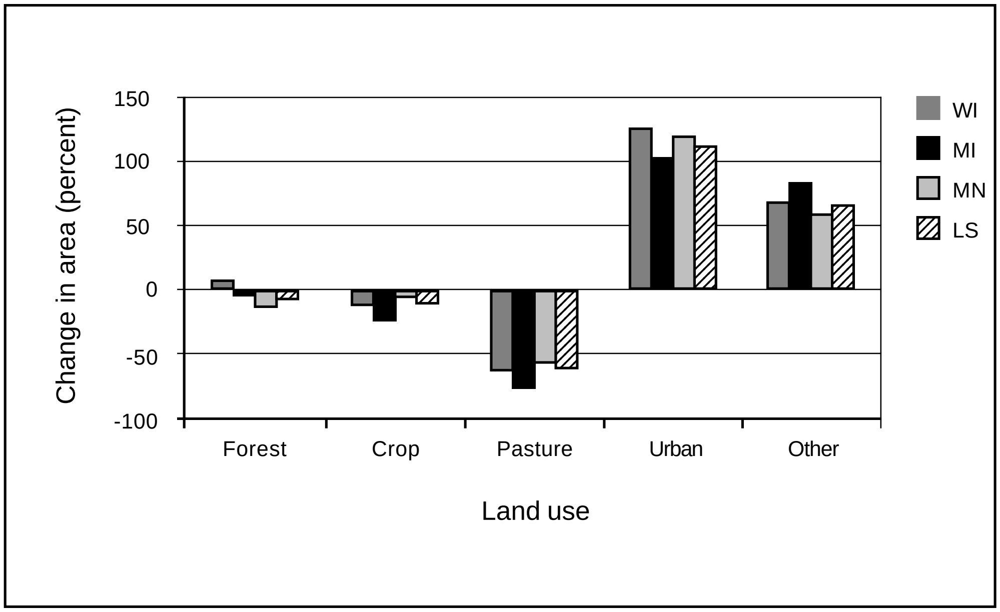

Figure 2—Historical changes in land use in the Lake States, 1950s-90s.

Between the 1950s and 1990s, forest and agricultural land in the Lake States declined, whereas urban and other land area increased (fig. 2). Regionwide, the absolute changes in forest, crop, pasture, urban, and other land were -3,026, -5,395, -4,008, +2,135, and +10,294 acres, respectively (tables 1, 2, and 3). Land area trends are similar in Michigan, Minnesota, and Wisconsin, except that forest area increased in Wisconsin since the 1950s.

Wisconsin—Between 1950 and 1995, forest land in Wisconsin increased by 794,000 acres, because of the combined effect of a 352,000-acre increase in timberland and a 442,000 acre jump in other forest land (table 1). Forest land decreased in the 1950s and 1960s, as did timberland, but both land uses regained and surpassed their earlier acreages during the 1970s and 1980s. Within the timberland category, private industrial land and private nonindustrial land rose by 160,000 and 402,000 acres, respectively. These gains were partially offset by losses of 139,000 acres in Federal timberland and 37,000 acres in non-Federal public timberland.

The dominant forest type groups in Wisconsin are maple-beech-birch and aspen-birch (Schmidt 1997, Spencer and others 1988). Over the past several decades, about 28 percent of Wisconsin's timberland has been in the maple-beech-birch group and 26 percent in the aspen-birch group. The remaining timberland is distributed among white-red-jack pine (8 percent), spruce-fir (9 percent), oak-hickory (19 percent), and elm-ash-cottonwood (9 percent). These percentages have remained relatively stable over the last 30 years, with only a moderate increase in the maple-beech-birch group and a corresponding decrease in the aspen-birch group.

Since the 1950s, agricultural land area in Wisconsin has declined substantially, with crop land losing 1,957,000 acres and pasture land losing 1,650,000 acres. Most crop land losses occurred during the 1950s and the 1980s, at the start and the end of our period of analysis, whereas pasture land declined primarily in the 1950s and 1960s, losing 55 percent of its original area during these two decades. This has been a common trend in all three of the Lake States: agricultural lands declining primarily during the 1950s and 1960s, with pasture land losing much more on a percentage basis than crop land. This trend may be related to the shift from pasturing to intensive cropping as the primary method of growing feed for livestock. The large increases in forest area during the 1970s and 1980s are likely the result of these agricultural lands reverting back to forest (Spencer and others 1988). During the 1950s and 1960s, these lands seem to have been classified as other land, as the other land category abruptly jumps during those years. The other land category then declines in the 1970s and 1980s as these lands are classified as forest. Urban land in Wisconsin has steadily increased from 466,000 acres in the 1950s up to 1,053,000 acres today.

Michigan—Since the 1950s, forest land in Michigan has declined by 605,000 acres, driven primarily by a 505,000-acre drop in timberland (table 2). Within the timberland category, private nonindustrial land lost 752,000 acres, and private industrial land lost 34,000 acres. Federal and non-Federal public timberland gains partially offset these losses with 77,000- and 204,000-acre increases, respectively. There was a significant decline in most of the forest land categories during the 1960s and 1970s, but these losses were largely offset by increases in the 1980s.

Over the last few decades, the dominant forest type group in Michigan has been maple-beech-birch, which accounts for about 34 percent of the State's timberland (Leatherberry and Spencer 1996, Raile and Smith 1983). The remaining timberland is divided among aspen-birch (21 percent), spruce-fir (15 percent), white-red-jack pine (10 percent), oak-hickory (11 percent), and elm-ash-maple (9 percent). As in Wisconsin, the maple-beech-birch forest type group has gained acreage during the last 30 years, whereas the aspen-birch group has shown a decline.

The area of agricultural land in Michigan has significantly decreased since the 1950s, with crop land losing 2,632,000 acres and pasture land losing 737,000 acres. Most of these losses occurred in the 1950s and 1960s, yet much slower rates of decline have prevailed since then. As in Wisconsin, pasture land declined precipitously, by 65 percent, during the 1950s and 1960s, whereas crop land lost only 26 percent of its acreage. Urban land has increased steadily, doubling its original area, so that it now covers 1,760,000 acres.

Minnesota—Over the last 40 years, forest land in Minnesota has declined by 3,215,000 acres because of losses of 1,857,000 acres in timberland and 1,358,000 acres in other forest land (table 3). Timberland, as well as total forest land, shows significant decreases between the 1950s and 1970s, with a leveling off or slightly positive trend prevailing since 1980. Over the last four decades, private industrial timberland has gained 173,000 acres, whereas private nonindustrial timberland has lost 974,000 acres. The Federal and non-Federal categories of Minnesota public timberland also have lost significant acreage, 552,000 and 504,000 acres, respectively.

Aspen-birch is the dominant forest type group in Minnesota, with an average coverage of 48 percent of timberland since the 1960s (Jakes 1980, Miles 1992). The remaining forest is composed of white-red-jack pine (7 percent), spruce-fir (19 percent), oak-hickory (7 percent), elm-ash-cottonwood (8 percent), and maple-beech-basswood (9 percent). As in Wisconsin and Michigan, most of the forest type groups have remained stable over the last several decades, except for a minor increase in spruce-fir and a slight decrease in aspen-birch coverage.

Although crop land in Minnesota has declined relatively little since the 1950s, losing only 806,000 acres, pasture land has declined substantially, losing 1,621,000 acres. This loss represents 63 percent of the 1950 pasture land area, whereas crop land has dropped by less than 4 percent. Minnesota's urban land shows the gradual increase in acreage that occurred in Wisconsin and Michigan over the last several decades. Since 1950, urban land has increased by 653,000 acres up to its present value of 1,197,000 acres.

Determinants of Land Use Change

Previous theoretical and empirical studies of land use offer insights into the determinants of land use change in Wisconsin, Michigan, and Minnesota. Modern land use theory builds on the early contributions of Ricardo and von Thunen (Plantinga 1995). Ricardo introduced the concept of land rent, the supranormal profits derived by owners of highly productive land, and von Thunen explained how land use patterns arise when land owners allocate parcels to the use providing the highest rent. In Thunen's well-known model of a featureless plain, agricultural commodities are produced in concentric zones surrounding a market center. Commodities that are costlier to transport and more perishable tend to be produced closer to the market.

Recent analyses extend the earlier work by Ricardo and von Thunen. Barlowe (1958) specifies rents for given uses as decreasing functions of a fertility and location index termed "use-capacity." Found (1971) modifies the basic von Thunen model to allow for soil productivity differences and more complicated topographical arrangements. In addition, the theories of Ricardo and von Thunen have been incorporated into structural models and tested empirically (e.g., Alig 1986, Caswell and Zilberman 1985, Lichtenberg 1989, Parks and Murray 1994, Plantinga 1996, Plantinga and others 1989, Stavins and Jaffe 1990, White and Fleming 1980, Wu and Brorsen 1995, Wu and Segerson 1995). The empirical studies support the central finding of the theoretical analyses that relative rents and land characteristics such as location and soil productivity determine land use.

Plantinga and others (1989) examine land use change in the Lake States region. In the first study, an econometric model is estimated that specifies changes in private timberland area in Wisconsin as a function of the level of timberland, changes in rural population, level of rural population, and household income. The model explains only a small share of the variation in timberland changes, and the coefficient estimates are not significantly different from zero in most cases. Plantinga (1996) examines land use change in a 14-county region of Wisconsin; however, in this study, explicit measures of land quality and economic returns to forestry and agriculture are included in the empirical model. The results reveal the important influences of land rents and land quality and suggest that these factors should be included in land use models for the Lake States region.

The results of previous studies dictate the specification of the econometric model in the following section. In particular, landowners are assumed to allocate parcels to the use providing the highest rent. Furthermore, land use patterns are influenced by soil quality. In general, we expect higher quality land to be allocated to agricultural uses and lower quality land to be in forests. No systematic relation is anticipated between urban land and soil quality. Earlier work on land use in the Lake States indicates the importance of normalizing land use measures as total county land area differs. Accordingly, we work with proportional measures of county land use shares.

An Econometric Model of Land Use in Wisconsin

In this section, we specify and test a statistical model of land use in Wisconsin. Land use models are not estimated for Michigan and Minnesota because of a lack of appropriate data on forest rents. Private stumpage prices are not available for either of these states. Public stumpage price data are only available for counties with Federal, state, or county forest lands and, therefore, some counties are not represented. Also, preliminary results suggest that public stumpage prices may not capture the economic incentives that influence the land use decisions of private forest landowners.

In the next section, the estimated model for Wisconsin is used to project land use to 2050. Because no econometric results are available for Michigan and Minnesota, the projections for these states are constructed by extrapolating historic trends in land use. These projections also are based in part on trends forecasted with the Wisconsin model. For example, the Wisconsin model projects that urban land will increase much slower than historic trends would indicate. This result is used to guide projections of urban land area in Michigan and Minnesota.

The focus of this section will be on the Wisconsin land use model because of the data problems described above. Observations of the shares of land in private timberland, agricultural land (crop and pasture land), and urban land in 71 Wisconsin counties for 1996 are constructed from Forest Service inventories, census of agriculture reports, and the population census. Menominee County is excluded from the analysis because its forests have been shaped by different historical factors than those in other counties. Most of Menominee county is a Native American reservation, whose forests were not extensively harvested in the early 1900s. Thus, Menominee County forest land differs from other Wisconsin forest land in species composition as well as in stand size. Currently, Menominee has about 64 percent of its forest land in the maple-beech group and 9 percent in the aspen-birch group compared to overall state figures of 34 percent and 22 percent, respectively. Menominee also has more land in the sawtimber stand-size class and much less land in the smaller poletimber and sapling classes compared to state averages.

We assume that future land use trends can be best explained by current use patterns and, therefore, use data for 1996 only.[2] Sufficient variation exists in the land use patterns among the 71 Wisconsin counties to adequately measure the effects of the

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[2] It may be preferable to use time-series data to generate long-term projections; however, only two earlier inventories are available for Wisconsin. Even if we had incorporated these data, variation in our land use shares would still come largely from our cross-sectional observations.

explanatory variables discussed below. Shares of land in private timberland, agriculture, and urban land uses are denoted F_i, A_i, and U_i, respectively, where i indexes the county. According to table 1, these categories have accounted for roughly 70 percent of the total land area in Wisconsin over the past several decades. In some cases, less aggregated measures are available. For instance, private timberland can be divided into industrial and nonindustrial categories. Corresponding measures of explanatory variables, however, cannot be constructed, thereby necessitating the use of the aggregate categories. The remaining uses include public timberland and other forest land as well as parklands, wetlands, developed lands outside urban areas, and lands in transition between uses. In many cases, these land uses are shaped by public policies, either because of public ownership (e.g., parks) or because government regulations restrict their use (e.g., wetlands). We refer to these lands as public lands and do not model their use explicitly. This is justified because the acreage of public lands is determined principally by factors other than market forces. These factors are difficult to identify, much less measure.

Proxies for land rents associated with the three land uses are included as explanatory variables. For private timberland, rents are represented by a weighted average of bare land values equal to the present discounted value of an infinite series of rotations starting from bare ground ($FRENT_i$). Values are estimated for each of the major forest species: red pine (*Pinus resinosa* A.t.), spruce (*Picea* spp.), red maple (*Acer robrum* L.), sugar maple (*Acer saccuarum* marsh.), northern red oak (*Quercus rubra* L.), cedar (*Thuja occidentalis* L.), and aspen (*Populus* spp.) and averaged by using weights reflecting the species composition in each county.[3]

We hypothesize that the effects of forest rents differ across regions of the state. For example, increases in forest rents probably have a greater influence on forest acreage in the heavily forested northern region compared to the predominantly agricultural southwestern part. We, therefore, allow the coefficient on the forest rent variable to differ across the five subregions of the state, corresponding to the USDA Forest Service survey units. Region-specific forest rent variables (NEFRENT, NWFRENT, CFRENT, and SWFRENT) are estimated for the northeast, northwest, central, and southwest units, respectively. For example, NEFRENT equals FRENT for counties in the northeast region and zero for all other counties. To avoid perfect collinearity with FRENT, the variable for the southeast region is not included in the model. Thus, the coefficients on the remaining regional variables are interpreted relative to the omitted southeastern region.

[3] Stumpage prices are from the Wisconsin Department of Natural Resources. A 3-year average lagged 4 years is used to account for expectations formation and stand establishment (Plantinga 1996). A landowner may need to see a sustained change in prices before commiting land to forest and, therefore, a price average is used. The lag accounts for the time delay before land committed to forest can become established with trees. Species weights are from USDA Forest Service inventories, and yields are from Birdsey (1992).

For agricultural land, the rent proxy is a weighted average of revenues equal to crop price multiplied by yield (ARENT). Weights reflect the shares of crop land in each county planted in the major crops (hay, soybeans, and corn).[4] Urban land rents are represented by population density, which equals total population divided by land area (URENT). We hypothesize that larger populations result, all else equal, in greater development pressures and higher rents from developed uses.

Land quality measures are constructed from National Resources Inventory data (Plantinga 1995, 1996) on soil characteristics. AVERLCC is the average land capability class (LCC) rating. The LCC system ranks soils (I to VIII, where I is highest) according to 12 characteristics (slope, permeability, etc.), and the overall LCC rating equals the lowest score in any category. The LCC rating is based on the assumption that the characteristic receiving the lowest rating is the limiting factor for agricultural production. The variable LCC I and II equals the percentage of all land in LCCs I and II. Typically, high-quality land is allocated to agricultural uses, whereas lower quality land is put into forest. Lastly, an intercept term, denoted INTER, is included.

Following Caswell and Zilberman (1985), Lichtenberg (1989), Parks and Murray (1994), Wu and Brorsen (1995), and Wu and Segerson (1995), the shares of land in forest, agriculture, and urban uses are specified as multinomial logistic functions of the explanatory variables, X_i, and unknown parameters, β_F, β_A, and β_U:

$$F_i = \frac{e^{\beta_F' X_i}}{\sum_{k=F,A,U} e^{\beta_k' X_i}} \quad , \quad A_i = \frac{e^{\beta_A' X_i}}{\sum_{k=F,A,U} e^{\beta_k' X_i}} \quad , \quad U_i = \frac{e^{\beta_U' X_i}}{\sum_{k=F,A,U} e^{\beta_k' X_i}} \quad , \qquad (1)$$

where

F_i = share of land in forest use in county i;
A_i = share of land in agricultural use in county i;
U_i = share of land in urban use in county i;
X_i = independent variables indexed to county i; and
β = vector of unknown parameters.

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[4] Crop prices and yields are from the Wisconsin Agricultural Statistics Service. Farmers are assumed to have myopic expectations, namely, future prices equal last year's price (Wu and Segerson 1995). Weights are constructed from census of agriculture data on crop land acreages. Hay revenues are a proxy for revenues from pasture land. If farmers allocate land to pasture up to the point where the value of pasture equals the value of purchased hay, hay revenues are an upper bound on pasture revenues.

Estimable models linear in the β result from the transformations:

$$\ln[A_i / F_i] = (\beta_{0A} - \beta_{0F}) + (\beta_{1A} - \beta_{1F})X_{1i} + (\beta_{2A} - \beta_{2F})X_{2i} + ... + e_i^{AF},$$

$$\ln[U_i / F_i] = (\beta_{0U} - \beta_{0F}) + (\beta_{1U} - \beta_{1F})X_{1i} + (\beta_{2U} - \beta_{2F})X_{2i} + ... + e_i^{UF} \text{ and}$$

$$\ln[U_i / A_i] = (\beta_{0U} - \beta_{0A}) + (\beta_{1U} - \beta_{1A})X_{1i} + (\beta_{2U} - \beta_{2A})X_{2i} + ... + e_i^{UA} . \qquad (2)$$

where the e_i are heteroskedastic and, by assumption, normally distributed errors.[5] Although there are other feasible approaches, we use the multinomial logistic specification for convenience. The logistic function restricts the shares to the unit interval and can be transformed to yield a model that can be estimated with standard econometric procedures.

We estimate the first two equations by applying ordinary least squares separately to each equation. Because the two equations have the same set of regressors, there are no efficiency gains from estimating the equations as a system. The third equation is redundant because the parameter vector from the third equation equals the parameter vector in the second equation minus the parameter vector in the first equation.[6]

Estimation results are presented in table 4. Many of the coefficients on the rent variables (FRENT, ARENT, and URENT) have the expected signs, and some are significantly different from zero (95 percent confidence level). The forest rent coefficient for each region is calculated by adding the FRENT coefficient to the regional FRENT coefficient (table 5). The coefficient for the southeast region equals the FRENT coefficient. Most of the coefficients have the expected negative sign in the ln(A/F) and ln(U/F) equations, although most are not significantly different from zero, with the exception of the northwest region coefficients.

Higher forest rents decrease the shares of agricultural and urban land relative to the forest share, all else equal (tables 4 and 5). This implies that agricultural and urban land shares tend to be lower or that forest shares tend to be greater in counties where forest rents are higher, all else equal. In the case of agricultural land, higher forest rents may shift the competitive situation in favor of forestry for parcels that previously provided the same returns for the two uses. With urban land, higher returns to forestry may forestall conversion to developed uses. Finally, in counties with higher forest rents, the share of urban land relative to agricultural land tends to be higher. The most likely explanation for this result is that higher forest rents decrease the agricultural share, thereby increasing the urban to agricultural land ratio.

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[5] The structure of the heteroskedasticity is known in the case of the binomial logit model (Zellner and Lee 1965) but unknown in the multinomial model.

[6] We do not estimate the third equation; however, parameter estimates and standard errors for the equation can be calculated from the estimates for the first two equations: $(\beta_U-\beta_A) = (\beta_U-\beta_F) - (\beta_A-\beta_F)$ and $Var(\beta_U-\beta_A) = Var(\beta_U-\beta_F) + Var(\beta_A-\beta_F) - 2Cov[(\beta_U-\beta_F)(\beta_A-\beta_F)]$.

Table 4—Estimation results for Wisconsin land use equations

	Dependent variable		
Parameter	ln(A/F)	ln(U/F)	ln(U/A)
INTER	-1.47	-5.51	-4.05
	(-.81)	(-1.16)	(-.93)
FRENT	-.003	.01	.02
	(-.62)	(.99)	(1.33)
NEFRENT	-.01	-.03	-.02
	(-.71)	(-1.17)	(-.99)
NWFRENT	-.02*	-.09*	-.07*
	(-2.03)	(-3.34)	(-2.81)
CFRENT	.002	-.02	-.03
	(.26)	(-1.43)	(-1.66)
SWFRENT	.01*	-.03*	-.04*
	(1.75)	(-2.08)	(-2.98)
ARENT	.02*	.01	-.01*
	(7.62)	(1.21)	(-1.80)
URENT	-.10	.79*	.89*
	(-.83)	(2.53)	(3.09)
AVERLCC	-.57*	-.21	.36
	(-1.82)	(-.25)	(.48)
LCCI&II	.52	4.79	4.27
	(.45)	(1.57)	(1.52)
Variance of residuals	.416	2.91	—
R^2	.835	.652	—

Note: T-ratios are in parentheses. An asterik (*) indicates that a coefficient estimate is significantly different from zero at the 95 percent confidence level.

Table 5—Estimates of regional forest rent coefficients

	Dependent variable		
Parameter	ln(A/F)	ln(U/F)	ln(U/A)
Northeast	-0.01	-0.02	-0.01
	(-1.01)	(-.69)	(-.34)
Northwest	-.02*	-.08*	-.05*
	(-2.14)	(-2.65)	(-2.01)
Central	-.001	-.01	-.01
	(-.17)	(-.62)	(-.61)
Southwest	.01	-.02	-.02*
	(1.14)	(-1.12)	(-1.68)
Southeast	-.003	.01	.02
	(-.62)	(.99)	(1.33)

Note: T-ratios are in parentheses. The parameter estimates are obtained by adding the regional forest rent coefficients in table 4 to the FRENT coefficient. An asterik (*) indicates that a coefficient estimate is significantly different from zero at the 95 percent confidence level.

As expected, higher agricultural rents increase the share of agricultural land relative to the forest share and the urban share, all else equal (table 4). The coefficient for agricultural rent is significantly different from zero at the 95 percent confidence level in the ln(A/F) equation but only at the 90 percent confidence level in the ln(U/A) equation. As above, higher agricultural rents may shift the extensive margin between agriculture and forestry in favor of agriculture. Counties with higher agricultural returns also tend to have more urban land relative to forest.

Counties with higher rents for urban uses tend to have higher shares of urban land relative to shares of forest and agricultural land. In both cases, coefficient estimates are significantly different from zero. The coefficient on the urban rent variable in the ln(A/F) equation is small relative to its value in the other two equations and not significantly different from zero. This indicates that changes in urban land rents have similar effects on agricultural and forest land shares, leaving the share ratio unchanged.

To a large degree, the coefficients on the land quality variables conform to expectations, although none are significant at the 95 percent confidence level. The AVERLCC coefficient in the ln(A/F) equation is significantly different from zero at the 90 percent level. Counties with lower quality land (i.e., higher average LCC ratings) tend to have less agricultural land relative to forest. In contrast, there seems to be no systematic relation between land quality and shares of urban land relative to forest and agricultural land. This is a plausible result as the rents from urban uses are not affected by soil quality. Counties with higher percentages of land in LCC I and II tend to have more agricultural land relative to forest but also more urban land relative to agricultural and forest land.

Projections of Land Use in Wisconsin

The estimated equations in table 4 are used to generate decadal land use projections for Wisconsin to 2050. Among the variables in the model, only the rent variables can be expected to change in the future because soil characteristics remain essentially constant even over long periods of time. Changes in the rent variables imply changes in the land use share ratios. From equation (2), the coefficient on a rent variable measures the percentage change in the share ratio for a small increase in the rent. For instance, if the population density in Wisconsin increases by one person per acre, A/F, U/F, and U/A will change by about –0.10, 0.79, and 0.89 percent, respectively. On a person-per-square-mile basis, the changes become –0.02, 0.12, and 0.14 percent, respectively.

The effects of changes in the rent variables on the individual shares A, F, and U are not identified by the relation in equation (2); however, the shares are identified if the sum of the shares (i.e., $A + F + U$) is known. This value is equal to one minus the share of public land (public timberland, other forest land, and other land) (table 1).[7] Over the past three decades, these public lands have increased by about 62,000 acres per year on average. For our projections, we assume an annual increase of 31,000 acres and test the sensitivity of our assumption by considering 0- and 62,000-acre increases (table 6). We isolate the effects of changes in rents by considering population, stumpage price, and agricultural commodity price projection scenarios individually; we then consider changes in all variables simultaneously.

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[7] Public land may not include all urban forest land if this land is included in the urban land area category (see table 1, footnote 3).

Table 6—Price and public land trends used in projections for Wisconsin

Parameter	2000	2010	2020	2030	2040	2050
	U.S. dollars per thousand board foot					
Sawtimber stumpage:						
Red pine	117	188	227	270	301	336
Red maple	118	119	127	141	156	174
Sugar maple	154	156	167	185	205	228
Red oak	227	229	246	272	302	336
	U.S. dollars per cubic foot					
Pulpwood stumpage:						
Cedar	6	6	8	8	10	13
Spruce	9	9	11	12	15	19
Aspen	7	7	8	9	11	14
	U.S. dollars per acre					
Crop returns:						
Corn	320	325	331	337	343	350
Soy	240	249	259	269	280	288
Hay	119	121	123	125	127	130
	Thousand acres					
Public lands:						
Low	11,500	11,500	11,500	11,500	11,500	11,500
Medium	11,622	11,925	12,229	12,533	12,837	13,141
High	11,743	12,351	12,959	13,566	14,174	14,782

Sources: Haynes and others (1993), U.S. Department of Commerce, Bureau of the Census (1992), and U.S. Department of Commerce, Bureau of Economic Analysis (1995).
Note: All dollar figures are in constant 1995 dollars.

Effects of Urban Rents

State population projections are taken from U.S. Department of Commerce, Bureau of the Census (1992) and U.S. Department of Commerce, Bureau of Economic Analysis (1995). Changes in the land use share ratios are calculated for low, medium, and high population scenarios (table 7) in each case assuming the medium projection for public land acreage (table 6) and holding forest and agricultural rents constant at 1996 levels. Individual land use shares are recovered as described above.

In all of the urban rent scenarios, acreages of private timberland and agricultural land decline (table 8). In the low population scenario, urban area remains stable, yet in the middle and high scenarios, substantial increases (170,000 and 360,000 acres, respectively) are projected. Significant losses of forest and agricultural land are projected in all cases (declines by 2050 range from about 990,000 to 1,030,000 acres and 990,000 to 1,310,000 acres, respectively). Changes in population have an understandably large proportional impact on urban land, a moderate effect on agricultural land, but only a minor influence on forest land.

Table 7—State population trends used in projections

Parameter	2000	2010	2020	2030	2040	2050
			Thousands			
Wisconsin:						
Low	5,235	5,376	5,458	5,472	5,408	5,311
Medium	5,300	5,686	6,099	6,521	6,956	7,406
High	5,368	6,008	6,761	7,616	8,619	9,755
Michigan:						
Low	9,575	9,514	9,617	9,488	9,206	9,041
Medium	9,695	10,063	10,747	11,309	11,840	12,606
High	9,818	10,633	11,911	13,206	14,670	16,579
Minnesota:						
Low	4,720	4,841	4,939	4,919	4,833	4,746
Medium	4,779	5,121	5,519	5,863	6,216	6,618
High	4,840	5,411	6,117	6,846	7,702	8,704

Sources: U.S. Department of Commerce, Bureau of the Census (1992), and U.S. Department of Commerce, Bureau of Economic Analysis (1995).

Table 8—Land use projections for Wisconsin: urban rent scenarios

Parameter	2000	2010	2020	2030	2040	2050
			Thousand acres			
Private timberland:						
Low	10,737	10,553	10,370	10,186	10,004	9,821
Medium	10,737	10,551	10,365	10,179	9,992	9,805
High	10,737	10,549	10,361	10,171	9,979	9,785
Agricultural land:						
Low	11,312	11,189	11,071	10,958	10,850	10,745
Medium	11,307	11,167	11,025	10,882	10,737	10,592
High	11,303	11,145	10,978	10,803	10,618	10,422
Urban land:						
Low	1,090	1,093	1,091	1,083	1,070	1,054
Medium	1,095	1,117	1,141	1,167	1,194	1,222
High	1,100	1,141	1,193	1,253	1,327	1,413
Public lands	11,622	11,925	12,229	12,533	12,837	13,141

Note: The medium values for public lands are assumed in all scenarios. Forest and agricultural rents are assumed to remain constant at 1996 levels. Low, medium, and high scenarios correspond to the population projections by the U.S. Department of Commerce, Bureau of Census (1992) and Department of Commerce, Bureau of Economic Analysis (1995) reported in table 7.

Effects of Forest Rents

Stumpage price projections are from Haynes and others (1995). They project softwood and hardwood sawtimber and pulpwood stumpage prices for the Northern United States, comprised of the north-central and northeast regions. We use the percentage changes in these prices to project stumpage prices for Wisconsin tree species (table 6). The county-level weights for 1996 are assumed to apply throughout the projection period. Unlike the population scenario projections, we examine the effect of stumpage and agricultural commodity price changes only on the ratio of agricultural land to forest. In the other equations, increases in forest and agricultural rents imply large declines in urban land acreage. We expect that forest and agricultural rents would have considerably less influence than urban rents would on the decision to convert lands to urban uses. Because it is plausible to assume that urban land area changes can only be positive, we focus on the effects of stumpage and agricultural price changes on the tradeoff between forest and agricultural land.

Increases in real forest rents are projected for all counties in Wisconsin. Assuming the medium scenario for public lands with agricultural and urban rents constant at 1996 levels, we project declines of about 700,000 acres in private timberland and 1,260,000 acres in agricultural land by 2050 (table 9). Urban land is projected to decline slightly, losing about 20,000 acres. Relative to the projections in table 8, forest declines are somewhat lower. This is due to increases in forest rents and the absence of gains in urban land acreage, which previously accounted for forest area reductions. Similar to the urban rent scenarios, the forest rent increases seem to draw some land from agriculture. The declines in agricultural acreage nearly equal those in the high urban rent scenario reported in table 8.

Effects of Agricultural Rents

Projections of agricultural returns are based on projections by the USDA Economic Research Service and Alig and others (1997) (table 6). Real per-acre returns are expected to increase for all commodities and, therefore, agricultural rents are predicted to increase in every county. In the agricultural rent scenario, forest and urban rents are held constant at 1996 levels with the medium scenario used for public lands (table 10). Private timberland is projected to decrease by 1,750,000 acres, whereas agricultural and urban land lose about 210,000 and 20,000 acres, respectively. The large decrease in forest land is understandable as increases in agricultural returns imply shifts of forest to agricultural land. Even though agricultural returns rise, agricultural lands still decline because of the increase in public lands.

Effects of Urban, Forest, and Agricultural Rents

The effects of higher urban, forest, and agricultural rents are evaluated simultaneously in a final set of projections for Wisconsin (table 11). The medium population scenario is used with forest and agricultural rents increasing as projected. In addition, the three scenarios for public land are considered, although the medium scenario might be regarded as the most likely. In this case, projections to 2050 indicate that private timberland loses roughly 1,460,000 acres, agricultural land declines by 690,000 acres, and urban land increases by 170,000 acres. Assumptions about future changes in public lands have the greatest effect on predictions of forest acreage. There is almost a 2-million-acre difference in forest area between the low and high public land scenarios. Projections of the remaining land uses are less sensitive to assumptions about changes in public lands, with differences across scenarios ranging from about 1 million acres for agricultural land to 100,000 acres for urban land.

Table 9—Land use projections for Wisconsin: forest rent scenarios

Parameter	2000	2010	2020	2030	2040	2050
				Thousand acres		
Private timberland	10,814	10,677	10,540	10,393	10,255	10,118
Agricultural land	11,252	11,094	10,935	10,786	10,629	10,470
Urban land	1,072	1,063	1,055	1,047	1,039	1,030
Public lands	11,622	11,925	12,229	12,533	12,837	13,141

Note: The medium values for public lands are assumed. Agricultural and urban rents are assumed to remain constant at 1996 levels.

Table 10—Land use projections for Wisconsin: agricultural rent scenarios

Parameter	2000	2010	2020	2030	2040	2050
				Thousand acres		
Private timberland	11,280	10,850	10,409	9,961	9,509	9,063
Agricultural land	10,787	10,921	11,066	11,218	11,375	11,525
Urban land	1,072	1,063	1,055	1,047	1,039	1,030
Public lands	11,622	11,925	12,229	12,533	12,837	13,141

Note: The medium values for public lands are assumed. Forest and urban rents are assumed to remain constant at 1996 levels.

Table 11—Land use projections for Wisconsin: public land scenarios

Parameter	2000	2010	2020	2030	2040	2050
				Thousand acres		
Private timberland:						
Low	11,430	11,227	11,016	10,790	10,572	10,369
Medium	11,353	10,960	10,561	10,148	9,745	9,357
High	11,276	10,693	10,105	9,506	8,918	8,344
Agricultural land:						
Low	10,732	10,903	11,080	11,271	11,451	11,614
Medium	10,690	10,757	10,828	10,911	10,984	11,040
High	10,649	10,611	10,576	10,551	10,516	10,465
Urban land:						
Low	1,098	1,129	1,163	1,198	1,236	1,276
Medium	1,095	1,117	1,141	1,167	1,194	1,222
High	1,091	1,105	1,120	1,136	1,152	1,169
Public lands:						
Low	11,500	11,500	11,500	11,500	11,500	11,500
Medium	11,622	11,925	12,229	12,533	12,837	13,141
High	11,743	12,351	12,959	13,566	14,174	14,782

Note: Forest, agricultural, and urban rents differ in the scenarios presented above (the medium growth projection is used for urban rents). Low, medium, and high refer to the assumed growth levels for public lands (table 6).

Projections for Disaggregated Uses

Lastly, we present projections for disaggregated land use categories in Wisconsin based on the medium public lands scenario. Industrial and non-industrial shares of private timberland have remained roughly constant since the 1950s at 11 percent and 89 percent, respectively. We assume these percentages apply throughout the projection period. The share of public land from both Federaland non-Federal public timberland is assumed to remain constant at the current values of 17 percent and 27 percent, respectively. The share of total agricultural land from crop land has increased from about 84 percent in the 1950s to about 93 percent currently. We assume that the share from crop land will continue to rise, but at a slower rate. The share from crop land is assumed to reach 94 percent in the future, with pasture land accounting for the remaining 6 percent.

A loss of about 2,240,000 acres is predicted for total forest land with a corresponding decrease in timberland of 2,080,000 acres (table 12). Private industrial timberland is expected to decrease by about 70,000 acres and nonindustrial timberland by 1,380,000 acres. Public timberland is predicted to drop by a total of 620,000 acres, with non-Federal timberland accounting for most of that decrease (350,000 acres). Crop and pasture lands are both projected to have moderate declines of 570,000 and 120,000 acres, respectively. Over the next 50 years, urban land is expected to increase by 170,000 acres.

Projections of Land Use in Michigan, Minnesota, and the Lake States Region

As noted previously, data problems with the forest rent variable prevented the estimation of land use models for Michigan and Minnesota. To generate land use projections for these states, we extrapolated historical trends in land use data gathered for the 1950s through the 1990s (tables 2 and 3). Agricultural and forest lands are expected to decline at similar rates as in the past, whereas urban land is expected to increase at slower rates than historical trends would suggest. Since the 1950s, urban land in Wisconsin has expanded by about 20 percent per decade with a 10-percent decadal increase in population. Over the next 50 years, urban area is projected to increase by only 3 percent per decade in Wisconsin, and population is expected to rise by 7 percent each decade. These projections are based on the econometric estimates of the urban land-population relations for Wisconsin. These lower urban expansion rates are assumed for Michigan and Minnesota, thereby reducing the projected rate of urban expansion in each state.

The land use projections for Michigan are presented in table 13. Total forest land is expected to lose about 1,410,000 acres by 2050, driven by a 1,280,000-acre drop in timberland. Private industrial timberland is predicted to decline by 190,000 acres, with private nonindustrial land losing 1,060,000 acres. Moderate gains in forest area are expected for the Federal timberland and non-Federal timberland categories (25,000 and 180,000 acres, respectively). Crop land is projected to decline by 1,150,000 acres and pasture land by 85,000 acres. By the year 2050, urban land is predicted to increase by about 300,000 acres.

Table 12—Land use projections for Wisconsin: disaggregated land use categories

Parameter	2000	2010	2020	2030	2040	2050
			Thousand acres			
Forest land:	17,222	16,621	16,010	15,379	14,764	14,171
Timberland—	16,496	15,936	15,355	14,766	14,179	13,623
Private industrial	1,192	1,206	1,162	1,116	1,072	1,029
Private nonindus.	10,161	9,755	9,399	9,032	8,673	8,327
Federal	1,953	1,885	1,806	1,735	1,657	1,591
Non-Federal public	3,190	3,091	2,989	2,882	2,777	2,676
Other forest land	727	685	655	614	585	547
Crop land	9,942	10,036	10,124	10,224	10,325	10,377
Pasture land	748	721	704	687	659	662
Urban land	1,095	1,117	1,141	1,167	1,194	1,222
Other land	5,753	6,265	6,780	7,302	7,819	8,327

Note: The medium scenarios for public lands and population are used.

Table 13—Land use projections for Michigan: disaggregated land use categories

Parameter	2000	2010	2020	2030	2040	2050
			Thousand acres			
Forest land:	19,474	19,279	18,893	18,516	18,415	17,873
Timberland—	18,596	18,393	18,202	17,918	17,594	17,332
Private industrial	1,529	1,483	1,468	1,410	1,360	1,320
Private nonindus.	10,406	10,198	9,994	9,744	9,452	9,215
Federal	2,597	2,608	2,615	2,623	2,628	2,631
Non-Federal public	4,064	4,104	4,125	4,141	4,154	4,166
Other forest land	878	886	691	597	551	541
Crop land	7,993	7,713	7,482	7,295	7,149	7,006
Pasture land	182	155	136	124	118	115
Urban land	1,795	1,867	1,923	1,981	2,020	2,061
Other land	6,914	7,344	7,924	8,443	8,926	9,303

Table 14—Land use projections for Minnesota: disaggregated land use categories

Parameter	2000	2010	2020	2030	2040	2050
			Thousand acres			
Forest land:	17,015	16,674	16,341	16,014	15,854	15,695
Timberland—	14,689	14,546	14,390	14,329	14,297	14,266
Private industrial	743	714	692	678	665	652
Private nonindus.	5,845	5,699	5,528	5,445	5,391	5,337
Federal	2,508	2,513	2,521	2,528	2,536	2,543
Non-Federal public	5,593	5,621	5,649	5,677	5,706	5,734
Other forest land	2,325	2,128	1,951	1,685	1,557	1,430
Crop land	20,959	20,121	19,517	18,932	18,553	18,182
Pasture land	915	814	749	704	676	662
Urban land	1,257	1,433	1,590	1,686	1,753	1,806
Other land	13,872	14,975	15,820	16,681	17,181	17,671

The disaggregated land use projections for Minnesota are reported in table 14. Total forest land is expected to decline by about 990,000 acres, with a decrease in timberland of 460,000 acres. Within the timberland category, losses of 100,000 acres are predicted for private industrial land and 570,000 acres for private nonindustrial land. By the year 2050, public timberland is projected to increase by a total of 210,000 acres, primarily because of a 170,000-acre gain in non-Federal land. Over the same time period, crop land is expected to decline by about 3,200,000 acres and pasture land by 310,000 acres. Urban land is predicted to increase by about 50 percent, up to 1,810,000 acres by the year 2050.

Our projections for the Lake States region are summarized in figure 3. Consistent with historical trends (fig. 2), we project declines in forest and agricultural land areas and increases in urban and other land area. In percentage terms, projected declines in forest and crop land acreage are similar to those observed during the 1950s to 1990s. Future declines in pasture land and increases in urban and other land areas are expected to be smaller than those seen from the 1950s to the 1990s.

Conclusions

The land use projections presented in this analysis support the RPA analyses currently being conducted by the USDA Forest Service. Our results provide area projections for private and public forest land and nonforest uses that will be incorporated into a national assessment of forest resources. An important component of the national assessment is the analysis of future timber supplies. By the year 2050, our projections show that private timberland acreage will decrease by 13 percent in Wisconsin, 11 percent in Michigan, and 10 percent in Minnesota. This change will reduce the land available for timber production in the Lake States, although the effect on timber supply is not likely to be dramatic given that large acreages of timberland will still remain. The impact on other forest resources such as wildlife habitat and recreation are more difficult to determine because these effects are closely related to site-specific conditions and forest fragmentation that our aggregate analysis cannot identify.

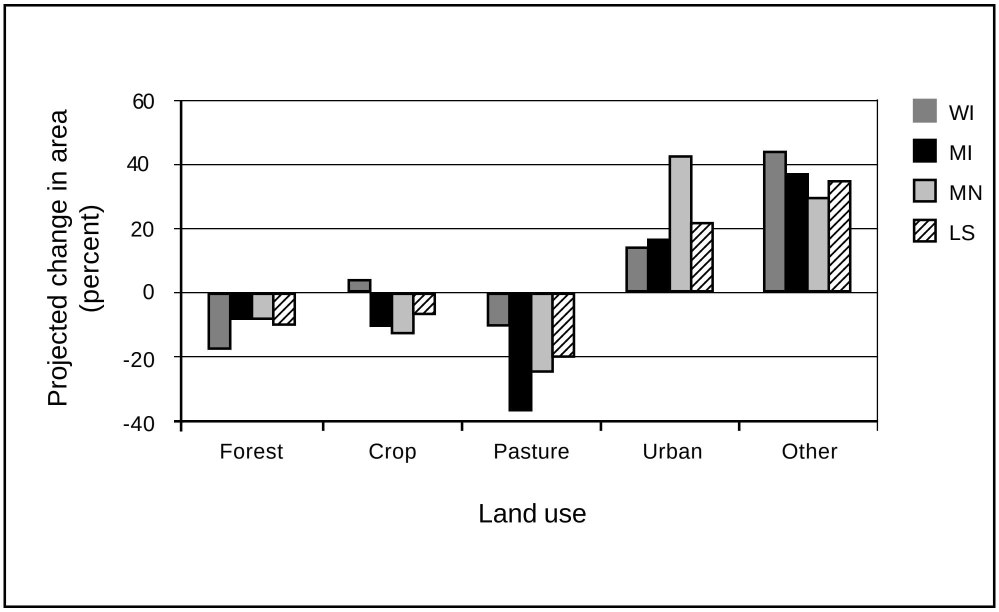

Figure 3—Land use projections for the Lake States, 2001-50.

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

For the remaining land uses, we expect historical trends to continue. Public timberland is expected to decline, although proportionately less than private timberland. We project continuing decreases in agricultural acreage, with slower rates of decline than in the past. Finally, we assume continuing increases in other land; however, average annual increases are expected to be lower than historical increases.

Our results lend further support to the theoretical and empirical findings that land use patterns are determined by relative rents and land quality. The coefficients on rent variables in the econometric model indicate that land tends to be allocated to the use providing the highest rents and that the rents associated with a given use may affect the tradeoff among other uses. Furthermore, we find that higher quality land tends to be allocated to agricultural uses, that lower quality land tends to be forested, and that land quality does not significantly affect urban land use patterns. In contrast to our earlier study on land use in the Lake States region (Plantinga and others 1989), our econometric model explains a considerable portion of the variation in land use across counties. The coefficient estimates also have the expected signs and, in most cases, are significantly different from zero. These improvements may be explained by the inclusion of variables measuring relative land rents and land quality.

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Land use changes can affect timber supplies, wildlife habitat, and other ecosystem goods and services. Since the 1950s, forest and farm land in the Lake States have been decreasing, while urban and other land uses have increased. Land rents and land quality variables were used in making projections of the distribution of Wisconsin's future land uses. The projections of land uses through 2050 are consistent with historic trends: areas of forest and agricultural lands will decline and urban and other land uses will increase. Timberland area is projected to be reduced by 13 percent in Wisconsin, 11 percent in Michigan, and 10 percent in Minnesota.

Keywords: Land use change, urban development, land rents, timberland area projections.

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