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Land Use in Maine: Determinants of Past Trends and Projections of Future Changes

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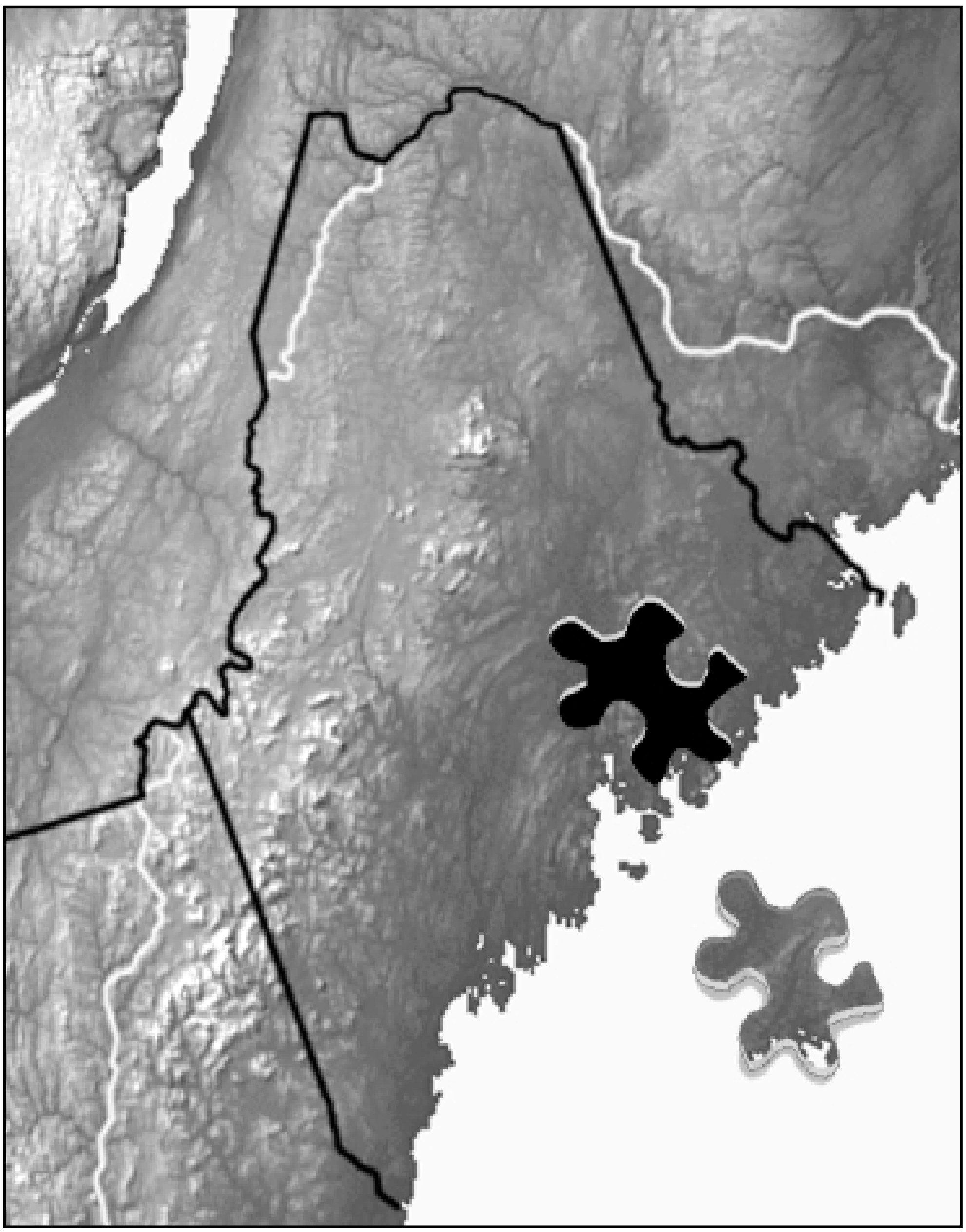

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Abstract

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About 90 percent of the land in Maine is in forests. We analyzed past land use trends in Maine and developed projections of future land use. Since the 1950s, the area of forest in Maine has increased by almost 400,000 acres; however, the trends differ among ownerships, as the area of nonindustrial private timberland declined by 800,000 acres since 1950, while private industrial area rose by 681,000 acres. We used econometric analyses to identify variables affecting land allocation, such as population density. Estimated equations were used to generate decadal land use projections to 2050. Our projections showed that private timberland area will decline by almost 3 percent by 2050, with urban areas increasing by 56 percent.

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

Summary

We examined past area trends for the major land uses in Maine as a basis for developing projection models of future areas by forest ownership. This study provides land use projections as input to the U.S. Department of Agriculture, Forest Service's periodic efforts to assess future trends in the Nation's forest resources, in accordance with the 1974 Resources Planning Act. Since the 1950s, the area of forest land in Maine has increased by almost 400,000 acres, while the area of crop and pasture land has declined by about 900,000 acres. The increase in forest area is partially due to the natural reversion of agricultural land to trees. In contrast to most states, the area of urban land in Maine has remained fairly stable over the past several decades, at about 2.5 percent of total land area.

Private owners control 96 percent of the timberland in Maine, with slightly less than half in private industrial ownership. The area of private industrial timberland has declined by almost 960,000 acres since the 1970s, while nonindustrial private area increased by 680,000 acres.

Our area projections indicated that private timberland area will decline by almost 3 percent by 2050. This change would reduce the land available for timber production and other forest-based ecosystem goods and services. We also projected continuing declines in agricultural areas.

Maine's population is projected to increase by 16 percent, which would result in urban land increases of 56 percent by 2050. The largest urban area increases are predicted for counties in southern and central Maine.

Our results supported theoretical and empirical findings that land use patterns are determined by relative rents and land quality. Land tends to be allocated to the use providing the highest land rents, and the rents associated with a given use may affect tradeoffs among other uses.

Contents

Introduction

Since the 1950s, the area of forest land in Maine has increased by almost 400,000 acres, while the area of crop and pasture land has declined by about 900,000 acres (table 1). The increase in forest area is, in part, the result of the reversion of agricultural lands to trees, a trend prevalent throughout New England since the turn of the 20th century. In contrast to urban land expansion in most states in the Nation, the area of urban land in Maine has remained stable over the past several decades at about 2.5 percent of total land area.

The purpose of this report was to analyze past land use trends in Maine and, based on these results, develop projections of future land use. The immediate purpose of this work was to provide input to the U.S. Department of Agriculture, Forest Service's nationwide effort to assess future trends in the Nation's forest resources in accordance with the 1974 Resources Planning Act (RPA) (e.g., Haynes and others 1995). Changes in land use, and particularly forest use, have important consequences for the future availability of timber, wildlife habitat, and other benefits provided by forests. These results also support timber supply research being conducted by the Maine Forest Service, analyses of urban sprawl by the Maine State Planning Office (1997), and studies of development pressures on the forests in the Northern United States (Northern Forest Lands Council 1994).

The next section of this paper discusses past trends in land use in Maine and reviews previous studies of the determinants of land use. Empirical evidence and land use theory are brought together under "An Econometric Model of Land Use." In "Projections of Land Use in Maine," projections are generated based on the estimation results of the econometric model section of this paper. Conclusions are contained in a final section.

Land Use in Maine: Historical Trends and Determinants

According to the most recent data, about 90 percent of the land in Maine is forest land (table 1). The remaining 10 percent of the land area is divided among agricultural uses (3 percent), urban uses (2 percent), and other uses (5 percent). Definitions for these land use categories are provided in table 1. Forest and agricultural land (crop and pasture land) are defined by the predominant vegetative cover. Urban land is defined by population concentrations, and 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 (i.e., suburban housing, farmsteads, and rural transportation uses), wetlands, and miscellaneous uses.

Between 1950 and 1995, forest land area in Maine increased by 377,000 acres, principally as the result of a 329,000-acre increase in timberland. Within the timberland category, private industrial land and non-Federal public land rose by 681,000 and 487,000 acres, respectively. These increases were partially offset by a loss of 802,000 acres of nonindustrial private timberland and a decline in Federal timberland of 37,000 acres.

Although the dominant trend in timberland ownership over the last four decades has been toward larger holdings by private industrial and non-Federal public land owners, during the last two decades, the opposite patterns have been observed. Private industrial timberland has declined by almost 960,000 acres since the 1970s. Since the 1980s, non-Federal public timberland has declined by about 45,000 acres, and private nonindustrial timberland has increased by over 650,000 acres.

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

Land use	1950s	1960s	1970s	1980s	1990s	Change 1950s to 1990s
			Thousand acres			
Forest land:[a]	17,312	17,489	17,749	17,607	17,689	+377
Timberland—	16,609	16,779	16,894	17,060	16,938	+329
Private industrial	6,617	6,521	8,255	8,016	7,298	+681
Private nonind.	9,810	10,053	8,328	8,353	9,008	-802
Federal	90	66	73	65	53	-37
Non-Federal public	92	139	238	625	579	+487
Other forest land	703	710	854	548	752	+49
Crop land[b]	1,272	894	642	611	559	-713
Pasture land	203	98	68	47	30	-174
Urban land[c]	410	556	471	581	476	+66
Other land[d]	556	716	824	907	999	+444

[a] Forest land is at least 1 acre in size, 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 utilization. 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. Sources: Ferguson and Kingsley 1972, Griffith and Alerich 1996, Powell and Dickson 1984, and Waddell and others 1989.

[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 wood land pastured (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.

[d] Other land is calculated as the difference between total land area and forest land, crop land, pasture land, and urban land. This category includes developed uses not classified as urban (e.g., suburban housing), wetlands, and miscellaneous uses.

The dominant forest type groups in Maine are spruce-fir and northern hardwoods (Griffith and Alerich 1996, Powell and Dickson 1984). On average, over the past several decades, 44 percent of Maine's timberland was in the spruce-fir group compared to 32 percent for northern hardwoods. The remaining timberland was in white-red pine (11 percent), aspen-birch (9 percent), oak-hickory (2 percent), and elm-ash-red maple (2 percent). From 1971 to 1995, the area of timberland in spruce-fir declined considerably from 8,400,000 to 6,000,000 acres, mirroring an increase in northern hardwoods acreage from 4,900,000 to 6,400,000 acres. This trend is due to the reclassification of spruce-fir stands as northern hardwoods following harvests of spruce-fir species.

Since the 1950s, agricultural land area has declined substantially, with crop land losing 713,000 acres and pasture land losing 174,000 acres. Most of these losses occurred during the 1950s and 1960s. Given the large increases in forest area during this time, it is probable that much of this land reverted to forest. It also seems that a considerable share of these agricultural lands were converted to uses classified as “other,” because other land area increased greatly. Notably, losses of agricultural acreage have diminished since the 1960s.

Urban land area has remained relatively stable at about 500,000 acres, reflecting Maine’s roughly constant population since the 1950s. The fluctuations in urban area reported in table 1 are the result of minor changes in the definition of urban land over time. Although in some decades urban land area seems to decline, only positive changes should be observed because land development tends to be irreversible. Lastly, other land area has almost doubled since the 1950s. In part, this may be the result of development in rural areas (Maine State Planning Office 1997).

Previous theoretical and empirical studies of land use offer insights into the determinants of land use change in Maine. Modern land use theory builds on the early contributions of Ricardo and von Thunen. 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 landowners allocate parcels to the use providing the highest rent. In his well-known model of a featureless plain, agricultural commodities are produced in concentric zones surrounding a market center. Commodities that are more costly to transport and more perishable tend to be produced closer to the market.

Recent analyses extended the earlier work by Ricardo and von Thunen. Barlowe (1958) specified rents for given uses as decreasing functions of a fertility and location index termed “use-capacity.” Found (1971) modified 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, Howard and Lutz 1991, 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.

Howard and Lutz (1991) estimated a land use model for the Northeastern United States (including Maine, New York, and Pennsylvania) and for each state individually. Their model specified the shares of land in urban and other uses, pasture, crop, industrial timberland, farmer-owned timberland, and all other private timberland as linear functions of urban population, rural population, per capita income, net farm income, a stock market index, and pulping capacity. The data consist of time-series and cross-sectional observations at the survey unit level. In the equations for Maine, few of the parameter estimates are significantly different from zero, and some have unexpected signs. Net farm income is positively related to shares of land in pasture and crop, but rural and urban population levels have negative and positive effects, respectively, on agricultural shares. In the forest land equations, only the coefficient on the urban population variable is significantly different from zero.

The results of previous studies dictate the specification of the econometric model in the following section. In particular, landowners were assumed to allocate parcels to the use providing the highest rent. Furthermore, land use patterns were influenced by soil quality. In general, we expected higher quality land to be allocated to agricultural uses and lower quality land to be in forests. No systematic relation was anticipated between urban land and soil quality. Finally, many agricultural commodities and wood products produced in Maine are transported by truck down Interstate 95, through New Hampshire, and to markets beyond. Accordingly, we expected the travel time to the New Hampshire border to be an important determinant of land use patterns.

Our approach departed in several important ways from earlier work on Maine by Howard and Lutz (1991). First, we developed explicit rent measures for forest and agricultural uses by using available data on timber and agricultural commodity prices and yields. Our hope was that these variables would provide a sharper measure of the monetary incentives for allocating land to these uses. Second, we included explicit measures of soil quality. Land quality measures were notably absent from the Howard and Lutz models. Plantinga (1995) demonstrated that the omission of land quality variables can account for mixed results in previous empirical studies of land use. Third, we used cross-sectional data on counties rather than survey units in an effort to use, to the greatest extent possible, homogeneous observational units.

An Econometric Model of Land Use in Maine

In this section, we specify and test a statistical model of land use in Maine. Observations of the shares of land in private timberland, agricultural land (crop and pasture land), and urban land in 16 counties and the years 1971, 1982, and 1995 were constructed from Forest Service inventories, Census of Agriculture reports, and the population census. The shares of land in forest, agriculture, and urban uses are denoted F_{it}, A_{it}, and U_{it}, respectively, where *i* indexes counties and *t* indexes time. According to table 1, these categories have accounted for roughly 90 percent of the total land area over the past several decades.

The remaining uses were not modeled explicitly, principally because suitable measures of explanatory variables were unavailable. For example, it is difficult to identify much less measure the determinants of public forest land area. Among the land uses considered, less aggregated measures were available in some cases. 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.

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 ($FRENT_{it}$). Values were estimated for each of the major forest species (white pine, spruce-fir, red maple, hard maple, and aspen) and averaged by using weights reflecting the species composition in each county.[1] For agricultural land, the rent proxy is a weighted average of revenues equal to the product of crop price and yield ($ARENT_{it}$). Weights reflect the shares of crop land in each county planted in the major crops (hay, potatoes, oats, and corn).[2] Urban land rents are represented by population density equal to total population divided by land area ($URENT_{it}$). We hypothesized that larger populations result, all else being equal, in greater development pressures and higher rents from developed uses.

Land quality measures were constructed from National Resources Inventory data (USDA Natural Resource Conservation Service 1996) on soil characteristics. $AVERLCC_{it}$ is the average land capability class (LCC) rating. The LCC system ranks soils (I to VIII, where I is highest) according to 12 characteristics (slope, permeability, etc.), and the overall LCC rating equals the lowest score in any category. The LCC rating is based on the assumption that the characteristic receiving the lowest rating is the limiting factor for agricultural production. $LCCI\&II_{it}$ equals the percentage of all land in LCCs I and II. Typically, high-quality land is allocated to agricultural uses, whereas lower quality land is put into forest.

The last variable was the travel time to Portsmouth, New Hampshire ($TRAVTIME_{it}$). Travel times were measured from the major city or town closest to the geographic center of the county by using the software package PCMILER.[3] Travel times correspond to the fastest route over major roads.

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[1] Stumpage prices are from the Maine Forest Service. A 3-year average lagged 4 years was used to account for expectations formation and stand establishment as in Plantinga (1996). The price average was used to account for the possibility that landowners need to see a sustained change in prices before committing their land to forest. The lag was used because decisions to put land in forest are observable only after trees have become established. Species weights were from U.S. Department of Agriculture, Forest Service (Haynes and other 1995); inventories and yields are from Birdsey (1992).

[2] Crop prices and yields are from New England Agricultural Statistics Service, personal communication, 1997. Farmers were assumed to have myopic expectations, namely, future prices equal last year's price (Wu and Segerson 1995). Weights were constructed from census of agriculture data on crop land acreages.

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

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 were specified as multinomial logistic functions of the explanatory variables, X_{it}, and unknown parameters, β_F, β_A, β_U :

$$F_{it} = \frac{e^{\beta_F' X_{it}}}{e^{\beta_F' X_{it}} + e^{\beta_A' X_{it}} + e^{\beta_U' X_{it}}}, \quad (1)$$

$$A_{it} = \frac{e^{\beta_A' X_{it}}}{e^{\beta_F' X_{it}} + e^{\beta_A' X_{it}} + e^{\beta_U' X_{it}}}, \text{ and} \quad (2)$$

$$U_{it} = \frac{e^{\beta_U' X_{it}}}{e^{\beta_F' X_{it}} + e^{\beta_A' X_{it}} + e^{\beta_U' X_{it}}} \quad (3)$$

where

F_{it} = share of land in forest use in county i and year t,
A_{it} = share of land in agricultural use in county i and year t,
U_{it} = share of land in urban use in county i and year t,
X_{it} = independent variables indexed to county i and year t, and
β = vector of unknown parameters.

Estimable models linear in the βs result from the transformations:

$$\ln [A_{it} / F_{it}] = (\beta_{0A} - \beta_{0F}) + (\beta_{1A} - \beta_{1F}) X_{1it} + (\beta_{2A} - \beta_{2F}) X_{2it} + \ldots + e_{it}^{AF}$$

$$\ln [U_{it} / F_{it}] = (\beta_{0U} - \beta_{0F}) + (\beta_{1U} - \beta_{1F}) X_{1it} + (\beta_{2U} - \beta_{2F}) X_{2it} + \ldots + e_{it}^{UF}$$

$$\ln [U_{it} / A_{it}] = (\beta_{0U} - \beta_{0A}) + (\beta_{1U} - \beta_{1A}) X_{1it} + (\beta_{2U} - \beta_{2A}) X_{2it} + \ldots + e_{it}^{UA}$$

where the e_{it} are heteroskedastic and, by assumption, normally distributed errors.[4]

The error terms are likely to be correlated across equations because each of the shares appear in two equations. Accordingly, we estimated the first two equations as a system by using Zellner's Seemingly Unrelated Regression approach. The third equation is redundant because the vector of parameters equals the parameter vector in the second equation minus the parameter vector in the first equation.[5] The time-series and cross-sectional observations are pooled, and fixed effects parameters for the 1971 and 1982 observations are included ($FE71_{it}$ and $FE82_{it}$). An intercept term ($INTER_{it}$) also is included and so the fixed effects parameter for 1995 is omitted to avoid perfect collinearity between regressors. The fixed effects

[4] 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.

[5] The third equation is not included in the seemingly unrelated regression analysis; however, parameter estimates and standard errors for the third equation can be calculated from the estimates for the first two equations: $(\beta_{0U} - \beta_{0A}) = (\beta_{0U} - \beta_{0F}) - (\beta_{0A} - \beta_{0F})$ and $Var(\beta_{0U} - \beta_{0A}) = Var(\beta_{0U} - \beta_{0F}) + Var(\beta_{0A} - \beta_{0F}) - 2Cov[(\beta_{0U} - \beta_{0F})(\beta_{0A} - \beta_{0F})]$.

Table 2—Seemingly unrelated regression estimation results for Maine land use equations

	Dependent variable		
Parameter	ln (A/F)	ln (U/F)	ln (U/A)
INTER	1.003	.682	-1.685
	(.79)	(-.17)	(-.47)
FE71	.135	.054	-.081
	(.85)	(.11)	(-.18)
FE82	.229	.537	.308
	(1.52)	(1.13)	(.72)
FRENT	-.041	-.229	-.188
	(-1.76)	(-3.13)	(-2.85)
ARENT	.002	.005	.004
	(2.79)	(3.16)	(2.51)
URENT	.002	.025	.023
	(1.22)	(5.21)	(5.34)
AVERLCC	-.675	.245	.921
	(-3.73)	(.43)	(1.79)
LCCI&II	2.45	-13.260	-15.705
	(1.12)	(-1.93)	(-2.53)
TRAVTIME	-.206	-.522	-.317
	(-2.16)	(-1.74)	(-1.17)
Variance of residuals	.178	1.75	
R^2	.750	.593	

Note: t-ratios are in parentheses. The variance of residuals is a measure of the dispersion of the distribution. The R-squared for the regression is a measure of the proportion of the total variance that is explained by the regression.

parameters are used to capture potential changes in the land use relations over time. The coefficients on FE71 and FE82 measure differences in land use patterns in 1971 and 1982 (relative to 1995) not explained by the other regressors.

Estimation results are presented in table 2. The coefficients on the fixed-effects parameters ($FE71_{it}$ and $FE82_{it}$) are not significantly different from zero at the 95-percent confidence level. This suggests that the estimated relations have been stationary over the past several decades and support our use of the estimated model for projecting land use change.

Most of the coefficients on the rent variables (FRENT, ARENT, URENT) were significantly different from zero (95-percent confidence level) and had the expected signs. Higher forest rents decreased the shares of agricultural and urban land relative to the forest share, all else being equal. This implied that where forest rents were higher, either agricultural and urban land shares tended to be lower or forest shares tended to be greater, or both. In the case of agricultural land, higher forest rents may have shifted the extensive margin between forestry and agriculture (i.e., those parcels providing the same returns to the two uses) in favor of forestry. With urban land, higher returns to forestry may have forestalled conversion to developed uses. Finally, forest rents affected the tradeoff between agricultural and urban lands. In counties with higher forest rents, the share of urban land relative to agricultural land tended to be lower.

Higher agricultural rents increased the share of agricultural land relative to the forest share, with all else being equal. As above, higher agricultural rents may have shifted the extensive margin between agriculture and forestry in favor of agriculture. Unexpectedly, higher agricultural rents increased the share of urban land relative to the agriculture share, all else being equal. We expect the coefficient to either be negative or not significantly different from zero if urban rents greatly outweighed those from agriculture. Lastly, counties with higher agricultural returns tended to have more urban land relative to forest.

Counties with higher rents for urban uses tended to have higher shares of urban land relative to shares of forest and agricultural land. In both cases, coefficient estimates were significantly different from zero. The coefficient on the urban rent variable in the ln (A/F) equation was relatively small and not significantly different from zero. This may indicate that the level of urban land rents has little effect on the tradeoff between agricultural and forest lands. Alternatively, higher urban rents may have affected agricultural and forest land shares in a manner that leaves the ratio of one to the other unchanged.

To a large degree, the coefficients on the land quality and travel time variables conformed to expectations. Counties with lower quality land (i.e., higher average LCC ratings) tended to have less agricultural land relative to forest. In contrast, there seemed to be no systematic relation between land quality and shares of urban land relative to forest and agricultural land. This is a plausible result because the rents from urban uses were not affected by soil quality. Counties with higher percentages of land in LCC I and II tend to have more agricultural land relative to forest and urban land, though the coefficient was not significantly different from zero in the ln (A/F) equation. Finally, the coefficients on the travel-time variable suggested that more remote counties (i.e., those farther from Portsmouth, New Hampshire) tended to have less agricultural and urban land and more forest.

Projections of Land Use in Maine

The estimated equations in table 2 were used to generate decadal land use projections for Maine to 2050. Among the variables in the model, only the rent variables could be expected to change in the future. Soil characteristics remained essentially constant even over long periods, and the travel variable is assumed to be invariant with respect to time. Changes in the rent variables implied changes in the land use share ratios. From equation (2), the coefficient on a rent variable measured the percentage change in the share ratio for a small increase in the rent. For instance, if population density increased by one person per square mile, A/F, U/F, and U/A would increase by about 0.2, 2.5, and 2.3 percent, respectively.

The effects of changes in the rent variables on the individual shares *A*, *F*, and *U* were not identified by the relations in equation (2); however, the shares were identified if the sum of the shares (i.e., $A + F + U$) is known. This value is equal to one minus the share of land in public timberland, other forest land, and other land (table 1). Over the past three decades, these lands (hereafter, referred to as non-AFU lands) have increased by about 20,000 acres per year on average. For our projections, we assumed an annual increase of 10,000 acres and tested the sensitivity of our assumption by considering 0- and 20,000-acre increases (table 3).[6]

We isolated the effects of changes in rents by considering population, stumpage price, and agricultural commodity price projection scenarios individually. State population projections were taken from U.S. Department of Commerce (1990), and county-level figures were derived by assuming that each county's share of population change during the 1980s remains constant in the future. County-level changes in the land use share ratios were calculated for the increases in population assuming the medium projection for non-AFU land acreage (table 3) and holding forest and agricultural rents constant at 1995 levels. Individual land use shares were recovered as described above.

The urban rent scenario implies that urban land acreage increases and forest and agricultural land acreages decline (table 4). Urban area is projected to increase by about 265,000 acres by 2050, with much of the increase occurring in the first two decades of the next century. Large losses of forest acreage are projected (declines by 2050 are about 804,000 acres), yet agricultural acreage losses are relatively low at about 50,000 acres. The low losses of agricultural acreage are due in part to the positive effect of urban rents on the share of agricultural land relative to forest (table 2).

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[6] Maine's governor, Angus King, recently formed the Land Acquisition Priorities Advisory Committee for the purpose of developing strategies to increase conservation lands in the state. The group has recommended increasing the area of conservation lands by 1,000,000 acres by 2020. Among the land types identified as conservation priorities are urban open space, undeveloped coastline, and large tracts of forest land in the northern part of the state. Some of these land uses (e.g., urban open space) are currently non-AFU lands, but others, including forest lands in the northern part of the state, are now classified as private timberland. Thus, achieving the goal of a 1,000,000-acre increase will likely require some increase in the area of non-AFU lands. If, for instance, 500,000 acres of private timberland are diverted to conservation uses by 2020, non-AFU land will, on average, increase by 25,000 acres annually.

Table 3—Price, population, and non-AFU land[a] trends used in projections

Parameter	2000	2010	2020	2030	2040	2050
				Number		
Sawtimber stumpage prices ($/mbf):						
White pine	115	186	225	267	298	333
Red maple	36	36	39	43	47	53
Hard maple	77	77	83	92	102	114
Pulpwood stumpage prices ($/cf):						
Spruce-fir	13	13	16	17	21	26
Aspen	5	6	6	6	7	7
Crop returns ($/acre):						
Hay	116	151	181	200	220	242
Potatoes	1,044	869	713	687	662	561
Oats	59	71	78	82	86	91
Corn	344	447	536	590	649	714
State population (x 1,000):	1,308	1,377	1,433	1,445	1,460	1,475
Non-AFU land (thousand acres):[a]						
Low	2,421	2,421	2,421	2,421	2,421	2,421
Medium	2,471	2,571	2,671	2,771	2,871	2,971
High	2,521	2,721	2,921	3,121	3,321	3,521

Note: All dollar figures are in constant 1982 dollars. The Department of Commerce projects state population by decade to 2040. We assumed the same increase in population from 2040 to 2050 as projected for 2030 to 2040.

[a] Non-AFU land = all land other than that in private timberland, agricultural land, and urban land; this consists of land in public timberland, other (nontimberland), forest land, and other miscellaneous land.

Sources: Haynes and others (1995) and U.S. Department of Commerce (1990).

Stumpage price projections were 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 used the percentage changes in these prices to project changes in stumpage prices for Maine forest types (table 3). The county-level weights for 1995 were assumed to apply throughout the projection period. Unlike the population scenario projections, we examined the effect of stumpage price changes only on the ratio of agricultural

Table 4—Land use projections for Maine: urban rent scenario

Land use	Year					
	2000	2010	2020	2030	2040	2050
	Thousand acres					
Private timberland	16,215	16,035	15,862	15,743	15,623	15,502
Agricultural land	563	557	551	547	543	538
Urban land	503	589	668	692	716	741
Non-AFU land[a]	2,471	2,571	2,671	2,771	2,871	2,971

Note: Forest and agricultural rents are assumed to remain constant at 1995 levels. Population increases according to figures in table 3, and the medium values of non-AFU land are assumed.

[a] Non-AFU land = all land other than that in private timberland, agricultural land, and urban land; this consists of land in public timberland, other (nontimberland), forest land, and other miscellaneous land.

land to forest. In the other equations, increases in forest rents imply large declines in urban land acreage.[7] Because it is plausible to assume that urban land area changes can only be positive, we focused on the effects of stumpage prices on the tradeoff between forest and agricultural land.

Increases in real forest rents were projected for all counties in Maine. Assuming the medium scenario for non-AFU land and agricultural and urban rents were constant at 1995 levels, we projected declines of about 170,000 and 390,000 acres in forest land and agricultural land, respectively, by 2050 (table 5). Urban land is projected to remain roughly constant.[8] Relative to the projections in table 4, forest declines are substantially lower. This result is due to increases in forest rents and the absence of gains in urban land acreage, which account for forest area reductions in the first set of projections. The forest rent increases appear to draw a considerable amount of land out of agriculture. Declines in agricultural acreage are considerably larger compared to the projections in table 4 that assume constant forest rents.

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[7] Because urban land shares are small relative to forest and agricultural land shares, there is considerable variation in the dependent variables ln(*U/F*) and ln(*U/A*). Consequently, the estimated coefficients on the forest rent variables in these equations are relatively large (table 2). The coefficients may simply represent differences across counties rather than measuring underlying causal effects.

[8] As discussed above, we expect future changes in urban land area to typically be positive and, thus, no significance should be attached to the small projected declines in urban land area reported in tables 5 and 6. Projected decreases are related to the assumption of constant urban rents and the requirement that the land shares sum to 1.

Table 5—Land use projections for Maine: forest rent scenarios

	Year					
Land use	2000	2010	2020	2030	2040	2050
			Thousand acres			
Private timberland	16,334	16,293	16,255	16,209	16,174	16,134
Agricultural land	488	432	372	320	258	200
Urban land	460	457	455	452	450	448
Non-AFU land[a]	2,471	2,571	2,671	2,771	2,871	2,971

Note: Stumpage prices are assumed to follow the projections in table 3. Agricultural and urban rents are held constant at 1995 levels and the medium values of non-AFU land are assumed.

[a] Non-AFU land = all land other than that in private timberland, agricultural land, and urban land; this consists of land in public timberland, other (nontimberland), forest land, and other miscellaneous land.

Table 6—Land use projections for Maine: agricultural rent scenarios

	Year					
Land use	2000	2010	2020	2030	2040	2050
			Thousand acres			
Private timberland	16,283	16,198	16,108	16,004	15,899	15,802
Agricultural land	539	526	519	525	533	532
Urban land	460	457	455	452	450	448
Non-AFU land[a]	2,471	2,571	2,671	2,771	2,871	2,971

Note: Agricultural returns are assumed to follow the projections in table 3. Forest and urban rents are held constant at 1995 levels, and the medium values of non-AFU land are assumed.

[a] Non-AFU land = all land other than that in private timberland, agricultural land, and urban land; this consists of land in public timberland, other (nontimberland), forest land, and other miscellaneous land.

Projections of agricultural returns were based on projections by the U.S. Department of Agriculture, Economic Research Service and Alig and others (1997) (table 3). Real per-acre returns are expected to increase for all commodities except potatoes. Accordingly, with the exception of Aroostook County where Maine potato production is concentrated, increases in agricultural rents are predicted for all counties. This had the effect of reducing declines in agricultural acreage relative to the scenarios assuming constant agricultural rents. When forest and urban rents are held constant at 1995 levels, agricultural land area remains stable (table 6).

Table 7—Land use projections for Maine: non-AFU land scenarios[a]

Land use	2000	2010	2020	2030	2040	2050
	Thousand acres					
Private timberland:						
Low	16,366	16,340	16,320	16,333	16,355	16,379
Medium	16,318	16,198	16,083	16,003	15,929	15,858
High	16,271	16,056	15,847	15,672	15,503	15,337
Agricultural land:						
Low	462	398	335	293	242	188
Medium	460	395	330	287	236	182
High	459	391	326	282	230	177
Urban land:						
Low	504	594	678	706	735	764
Medium	503	589	668	692	716	741
High	502	585	659	679	698	718
Non-AFU land:[a]						
Low	2,421	2,421	2,421	2,421	2,421	2,421
Medium	2,471	2,571	2,671	2,771	2,871	2,971
High	2,521	2,721	2,921	3,121	3,321	3,521

Note: Forest, agricultural, and urban rents follow the projections in table 3.

[a] Non-AFU land = all land other than that in private timberland, agricultural land, and urban land; this consists of land in public timberland, other (nontimberland), forest land, and other miscellaneous land.

The effects of higher urban, forest, and agricultural rents were evaluated simultaneously in a final set of projections (table 7). Urban, forest, and agricultural rents were changed according to projections in table 3, and we considered the three scenarios for non-AFU land. The medium scenario for non-AFU land might be regarded as the most likely. In this case, forest land declined by about 448,000 acres by 2050, and agricultural land declined by 407,000 acres from 1995 levels. Urban land increased by about 265,000 acres. Assumptions about future changes in non-AFU land had the greatest effect on projections of forest acreage. There was almost a 1,000,000-acre difference in forest area between the low and high non-AFU scenarios. Projections of agricultural and urban land area were much less sensitive to assumptions about non-AFU land.

There was considerable variation in projected land use changes at the county level. We reported net changes in land use for the period 1995-2050 for Maine counties (table 8). The projections to 2050 assumed the medium scenario for non-AFU land and projected changes in forest, agricultural, and urban rents. The largest declines in private timberland were projected for Cumberland, Piscataquis, and York Counties (fig. 1). In Cumberland and York Counties, large gains in urban area increases are expected. In these counties, timberland is primarily in white pine,

Table 8—Changes in land use projected for Maine counties, 1995-2050

County	Private timberland	Agricultural land	Urban land	Non-AFU[a] land
		Acres		
Androscoggin	-12,000	-20,000	27,000	6,000
Aroostook	60,000	-153,000	-3,000	96,000
Cumberland	-101,000	-22,000	101,000	23,000
Franklin	-15,000	-7,000	0	22,000
Hancock	-31,000	-6,000	2,000	35,000
Kennebec	6,000	-35,000	20,000	9,000
Knox	-10,000	-3	3,000	11,000
Lincoln	-6,000	-8,000	0	15,000
Oxford	-25,000	-19,000	0	43,000
Penobscot	-32,000	-29,000	7,000	54,000
Piscataquis	-100,000	-7,000	0	107,000
Sagadahoc	-10,000	-6,000	11,000	5,000
Somerset	-19,000	-19,000	1,000	38,000
Waldo	-13,000	-6,000	5,000	15,000
Washington	-44,000	-17,000	0	61,000
York	-94,000	-24,000	107,000	11,000
Total	-447,000	-38,4000	280,000	550,000

Note: Acreages for 2050 assume projected values of forest, agricultural, and urban rents and the medium scenario for non-AFU land.

[a] Non-AFU land = all land other than that in private timberland, agricultural land, and urban land; this consists of land in public timberland, other (nontimberland), forest land, and other miscellaneous land.

oak-hickory, and northern hardwood forest types and held primarily by nonindustrial owners. Agricultural land area declines the most in Aroostook County as the result of projected decreases in potato prices. Non-AFU increases are largest in Piscataquis County, where a large share of private timberland is expected to be reclassified as non-Federal public timberland and other land. Timberland in Piscataquis County is evenly split between spruce-fir and northern hardwoods forest types.

Lastly, we presented projections for disaggregated land use categories derived from the scenario reported in table 7. In spite of some recent changes mentioned above, industrial and nonindustrial shares of private timberland have remained roughly constant since the 1950s at 45 and 55 percent, respectively. We assumed these percentages apply throughout the projection period. The share of total agricultural land for crop land increased from about 85 percent in the 1950s to about 95 percent currently. We assumed that the share of agricultural land for crop land will continue to be 95 percent in the future, with pasture land accounting for the remaining 5 percent. The share of Federal timberland non-AFU land is assumed to remain at 2 percent until 2050 and, likewise, the share of other land is assumed to hold at 42 percent. In view of current efforts by the Maine State government to increase

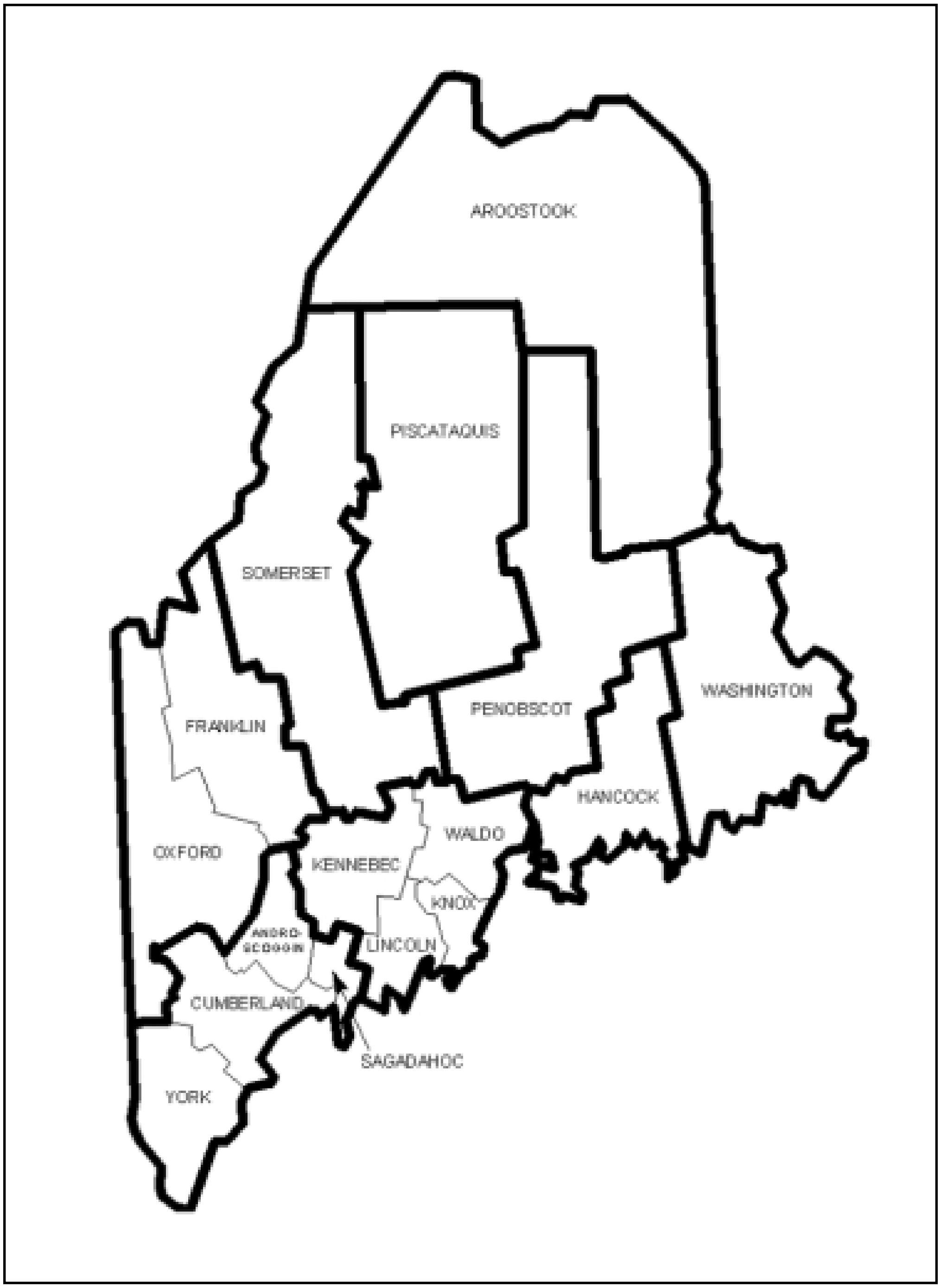

Figure 1—Maine counties.

Table 9—Land use projections for Maine: disaggregated land use categories

Land use	2000	2010	2020	2030	2040	2050
	Thousand acres					
Forest land:	16,961	16,841	16,725	16,640	16,561	16,482
Timberland—	16,318	16,198	16,083	16,003	15,929	15,858
Private ind.	7,343	7,289	7,238	7,201	7,168	7,136
Private nonind.	8,975	8,909	8,846	8,801	8,761	8,722
Federal	49	51	53	55	57	59
Non-Federal public	741	797	855	914	976	1,040
Other forest land	642	643	641	637	632	624
Crop land	437	375	314	273	225	173
Pasture land	23	20	17	14	12	9
Urban land	503	589	668	692	716	741
Other land	1,038	1,080	1,122	1,164	1,206	1,248

Note: The medium scenarios for non-AFU land is used.

land in conservation uses, the share of non-AFU land classified as non-Federal public timberland is assumed to increase to 30 percent by 2000 and increase by 1 percent each decade thereafter. Since the 1950s, the share of non-Federal public timberland has increased from 6 percent to 24 percent. Finally, the acreage of other forest land is assumed to remain roughly constant, implying annual 1 percent declines in the share of other forest land of non-AFU land.

The projections for disaggregated land uses are reported in table 9. Private industrial and nonindustrial timberland are projected to decline by about 160,000 and 250,000 acres, respectively. Federal timberland and other forest land show little change, and non-Federal public timberland increases by almost 500,000 acres by 2050, roughly doubling from 1995 levels. Crop and pasture land show significant declines, with the largest absolute losses in crop land area, and urban and other land increase by about 265,000 and 250,000 acres, respectively.

Conclusions

The land use projections presented in this analysis support the Resources Planning Act (e.g., Haynes and others 1995) analyses currently being conducted by the U.S. Department of Agriculture, Forest Service. Our results provided 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. Our projections show that in Maine, private timberland acreage will decline by almost 3 percent by the middle of the 21st century. This change will reduce the land available for timber production, though the effect on timber supply is not likely to be dramatic given that large acreages of timberland will still remain. The timberland area projections also provide input to current timber supply analyses by the Maine Forest Service.

Since the 1950s, the area of urban land in Maine has remained stable, yet if population increases according to Department of Commerce projections, this pattern may change dramatically. The population projections show a 16-percent increase in Maine's population by 2050, which results in urban land area increases of 56 percent. As evidenced, there is an elastic relation between urban land area and population (the elasticity equals 3.5). The largest urban area increases are predicted for counties in southern and central Maine. These changes may have potentially large fiscal impacts on local municipalities in addition to adverse effects on the character of rural communities and environmental quality (Maine State Planning Office 1997).

For the remaining land uses, we expect historical trends to continue.[9] Non-Federal public timberland is projected to increase by about 100 percent from 1995 levels by 2050, continuing the large increases starting in the 1950s. We also project continuing declines in agricultural acreage, though in absolute terms, changes are expected to be lower in the next 50 years compared to the previous 50 years. Finally, we project continuing increases in other land; however, average annual increases are expected to be about 50 percent lower than historical increases.

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 indicated that land tends to be allocated to the use providing the highest rents and that the rents associated with a given use may affect the tradeoff between other uses. Furthermore, we found 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. Lastly, our results support the von Thunen land use model in which distances to markets affect land use patterns.

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[9] It should be reemphasized that our projections of non-Federal public timberland and other land are based on past trends, rather than being generated from the estimates of our econometric model.

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About 90 percent of the land in Maine is in forests. We analyzed past land use trends in Maine and developed projections of future land use. Since the 1950s, the area of forest in Maine has increased by almost 400,000 acres; however, the trends differ among ownerships, as the area of nonindustrial private timberland declined by 800,000 acres since 1950, while private industrial area rose by 681,000 acres. We used econometric analyses to identify variables affecting land allocation, such as population density. Estimated equations were used to generate decadal land use projections to 2050. Our projections showed that private timberland area will decline by almost 3 percent by 2050, with urban areas increasing by 56 percent.

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

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