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Does Land Use Planning Slow the Conversion of Forest and Farm Lands?

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ABSTRACT Land use planning often is implemented to control development on forests and farmland, but its impact on land use remains untested. Previous studies evaluating such programs have relied on anecdotal evidence rather than on data describing actual land use change. A model of land use is specified as a function of socioeconomic factors, land rent, and landowners' characteristics, to examine how well Oregon's land use planning program has protected forests and farmland from development. The empirical model describes the probability that forests and farmland in western Oregon and western Washington were developed to residential, commercial, or industrial uses, before and after Oregon's land use planning program took effect. Land use data are provided by the USDA Forest Service's Forest Inventory and Analysis program. Results suggest that Oregon's land use planning program has concentrated development within urban growth boundaries since its implementation, but its success at reducing the likelihood of development on resource lands located within forest use and exclusive farm use zones remains uncertain.

Introduction

As residential, commercial, and industrial land uses have expanded into rural areas, the protection of resource lands, such as forests and farmland, has become an increasingly important goal of public officials in recent years. Historically, these lands have been valued for their productive capability and their role in generating economic activity associated with the production and processing of forestry and agricultural commodities. More recently, demands have increased for reduced congestion, environmental protection, and outdoor recreation that contribute to the quality of life of both rural and urban residents. However in many parts of

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the country, resource lands often fall outside the jurisdiction of town or city planning agencies and remain vulnerable to unregulated development. As demands for competing land uses increase, public officials have sought to protect resource lands, either directly through open space and farmland preservation programs, or indirectly by regulating the pace, location, and character of development through state or regional land use planning. Although the success of preservation programs can be measured by the area of forests or farmland preserved, evaluating the success of a land use planning program compels us to compare existing land use to that which would have occurred without such a program.

Most studies that examine land use planning focus on the impact of growth controls on housing and land markets (see Brueckner 1990 or Fischel 1990 for a review). Other studies extend housing market models to include the supply of building permits (Bramley 1993a, 1993b). Several studies have evaluated how well land use planning protects land from development (Furuseth 1980, 1981; Gustafson et al. 1982; Leonard 1983; DeGrove 1984; Daniels and Nelson 1986; DeGrove and Stroud 1987; Nelson 1992; Pearce 1992; Pease 1992; Endicott 1993). However, these studies have been descriptive or relied on anecdotal evidence (Pease 1994) by examining historical trends in a single land use category, such as farmland acres reported by the *U.S. Census of Agriculture*. A weakness in this approach is the difficulty in knowing if downward trends, say in farmland, are due to development rather than conversion to other land uses. This study builds upon this literature by examining data describing actual conversions of forests and farmland to developed uses, with and without land use planning in effect.

The effect of Oregon's land use planning program on the conversion of forests and farmland to developed uses in western Oregon is examined. An empirical model is specified that describes the probability that forests and farmland in western Oregon and western Washington have been developed since 1961 as a function of socioeconomic variables, initial land use, ownership characteristics, and zoning adopted under Oregon's land use planning program. The study area includes 19 counties in each state, west of the crest of the Cascade Mountains. Land use data are from the USDA Forest Service's Forest Inventory and Analysis Program. Estimated model coefficients are used to compute marginal effects of Oregon's land use zones on the probability of development of forests and farmland since their adoption.

Oregon's Land Use Planning Program

During the 1950s and 1960s, unprecedented population growth in western Oregon raised concern for the loss of forests and farmland to development. Although existing legislation authorized local governments to manage urban growth, residential development of forests and farmlands outside of incorporated cities was often unplanned and unregulated (Gustafson et al. 1982). In response, the Oregon state legislature enacted the Land Conservation and Development Act in 1973. The Act required all cities and counties to prepare comprehensive land use plans consistent with a list of statewide goals, and established the Land Conservation and Development Commission to oversee the program (Knaap and Nelson 1992; Abbott et al. 1994). The program has been cited as a pioneer in land use policy for its statewide scope (Gustafson et al. 1982), has won national acclaim by the American Planning Association (DLCD 1997), and has served as a model for statewide planning in other states (Abbott et al. 1994).

Three goals of the program are: 1) the orderly and efficient transition of rural lands to urban uses, 2) the protection of agricultural lands, and 3) the protection of forests (Knaap and Nelson 1992; Abbott et al. 1994). To address these goals, cities and counties are required to maintain urban growth boundaries that restrict the expansion of urban land uses and to zone land outside these boundaries as exclusive farm use, forest use, or exception areas (Pease 1994). Exception areas are unincorporated rural areas where low density residential, commercial, and industrial uses prevail, and where development is allowed, pending approval by local authorities (Einsweiler and Howe 1994). Some development within forest use and exclusive farm use zones can be approved by local authorities and must be reported to the Land Conservation and Development Commission (LCDC 1996a, 1996b). The criteria defining such development vary across counties, but generally include minimum parcel sizes and limits on the number of new dwelling permits issued. The construction of personal residences by commercial farmers and forest owners is considered compatible with program goals. By 1986, land use plans had been acknowledged by the Land Conservation and Development Commission for all 36 counties and 241 cities in the state (Knaap 1994).

Meanwhile, statewide land use restrictions had not been imposed in neighboring Washington State. Although development had been eroding the rural land base for many years, statewide planning in Washington was only recently initiated with the Growth Management Act in 1990 (Baker 1992). With goals similar to Oregon's—protecting forests and farmland—the Act directs local governments to revise existing land use plans, establish urban growth areas, and adopt development regulations to conserve natural resources. Oregon and Washington are similar in climate, size, and population pressures (Daniels and Nelson 1986). The absence of land use restrictions in Washington during the time period analyzed in this study enables cross-sectional and cross-temporal analysis of forest and farmland development with and without statewide land use planning in effect.

Conceptual Framework

During the past century, the United States has changed from a predominantly rural to an urban nation. The percent of the nation's population living in urban areas rose from 26 percent in 1870 to 74 percent in 1970. Increasing population and real personal income and improved transportation have increased the demand for land in urban uses (Barlowe 1978). As land rents associated with residential, commercial, and industrial uses rise above those associated with resource uses, such as forest, crop, and livestock production, the opportunity costs associated with maintaining rural lands increase. Rural landowners become more likely to sell forest and farmland for development. From 1960 to 1990, the populations of western Oregon and western Washington increased by 64 percent and 85 percent. Median household income (adjusted to 1992 dollars) increased by 7 and 17 percent (U.S. Bureau of Census 1992). If Oregon's land use planning program has been effective at protecting forests and farmland, it would be expected that development on such lands would have lessened once the program was implemented.

A body of literature has examined the development and re-development of land in urban areas (see DiPasquale and Wheaton 1996 for a review). For example, Rosenthal and Helsley (1994) show how land rents and land prices can be specified in a system of equations in which land prices and individuals' urban re-development decisions are jointly estimated. In an analysis of forest and farmland conversion to developed uses, Bockstael (1996) combines a hedonic model of land prices and a probit model of development decisions to jointly estimate land value and the probability of development on forest and farmland. Such analyses depend on the availability of cross-sectional data describing the value of land in different uses. Unfortunately, land price data are rather difficult to obtain for large geographic areas such as western Oregon and western Washington. The *U.S. Census of Agriculture* does provide estimates of average farmland values on a county basis. However, many counties in western Oregon and western Washington have little farmland relative to forest land, so farmland values tend to poorly reflect forest land values. In the absence of adequate land price data with which to model land value endogenously using a system of equations, a single equation is specified to examine the influence of exogenous factors on the likelihood of development on forest and farmland, including proxy variables for the value of land in different uses.

Since Ricardo and von Thunen, land rent has been viewed as a function of land quality and location (Alonso 1964). These factors combined with others, such as landowner management, determine the use-capacity of land (Barlowe 1978). Empirical studies yield mixed results regarding the influence of forest and agricultural rents on land use. Parks and Murray (1994) find forest and agricultural rents to have little influence on forest land area. Other studies find that agricultural and urban rents influence landowners' decisions more than do forest rents (White and Fleming 1980; Alig 1986; Alig et al. 1988; Alig and Wear 1992). Brueckner and Fansler (1983) find that agricultural rents negatively influence the likelihood that land becomes urban, while Alig and Healy (1987) find agricultural rents to be statistically insignificant. Previous studies do tend to agree that proxy variables describing urban land rents, such as population and income, are statistically significant variables in predicting land use (Alig 1986; Alig et al. 1988; Plantinga et al. 1990; Parks and Murray 1994). Alig and Healy (1987) suggest that urban uses dominate resource uses in land markets. Also, landowners' characteristics are found to influence their land use decisions (Alig 1986; Alig et al. 1988; Plantinga et al. 1990).

The likelihood of development on forests and farmland generally is suspected to be a function of population and income growth, consistent with the economic hierarchy of land use (Alig and Healy 1987). Existing forest and agricultural production may indicate the prevailing use-capacity of land at a particular point in time when combined with forestry and agricultural returns, and also could influence landowners' decisions regarding whether or not to sell land for development. Land earning higher rents is less likely to be developed than land earning lower rents. Landowner characteristics may indicate differences in land management which may motivate land use decisions. Landowners possessing greater land management expertise or commitment to forest and agricultural land uses may be less likely to develop such lands.

Land Use Data

Few sources provide a comprehensive and consistent depiction of historical land use change. Though the *U.S. Census of Agriculture* is often cited to describe changes in the quantity of farmland, it provides no data on other nonagricultural land uses. Local tax records can often be used to construct a comprehensive history of land use, but collecting such data can be costly. National Resources Inventory data collected by the USDA Natural Resources Conservation Service provide a periodic and comprehensive report of historical land use, but land use definitions and sample plots have changed since Oregon's land use law was enacted (SCS 1991). A viable alternative is data provided by the USDA Forest Service's Forest Inventory and Analysis (FIA) program. FIA data consist of periodic nationwide assessments of non-federal land, as authorized by the Forest and Rangeland Renewable Resources Research Act of 1978. FIA inventories tend to focus on forest land, but do provide observations of agricultural and developed land uses as well. Data are gathered using photo-interpretation and ground-truthing on a systematic sampling of plots defined as a pinpoint on the ground, and include land use and ownership characteristics of sample plots among other data. The plot-level data can be converted to acreage equivalents using expansion factors. Detailed discussion regarding FIA sampling and sampling error can be found in USDA Forest Service reports (Gedney et al. 1986a, 1986b, 1987; MacLean et al. 1991a, 1991b, 1991c).

FIA inventories have been conducted in western Oregon during the years 1961-62, 1974-76, 1985-86, and 1994, and in western Washington for 1963-67, 1978-79, and 1988-89. The most recent inventory for which acreage expansion factors are available for western Oregon (1985-86) shows that private-owned forest land totaled over six million acres (66 percent of private land), while farmland comprised over 2.4 million acres (27 percent). In western Washington, private-owned forest land totaled just over 5.7 million acres (71 percent of private land), while farmland comprised over 1.2 million acres (16 percent). The forest industry and other corporate owners own much of the private land in both regions; 45 percent in western Oregon and 50 percent in western Washington (Table 1). The remainder is owned by farmers and miscellaneous private owners; 30 percent and 25 percent, in western Oregon, 11 and 39 percent in western Washington.

FIA inventories sample a fixed set of field plots and provide data that can be used to examine actual changes occurring among land uses on each plot between successive inventories. Land use data are available for four inventories (1961-62, 1974-76, 1985-86, and 1994) in western Oregon and provide three opportunities to observe beginning and ending land use for the time spanning successive inventories. Data are available for three inventories (1963-67, 1978-79, and 1988-89) in western Washington, and provide two opportunities to observe beginning and ending land

TABLE 1. LAND USE AND OWNERSHIP OF PRIVATE LAND IN WESTERN OREGON AND WESTERN WASHINGTON[a]

	Western Oregon		Western Washington	
Class	Acres	Percent	Acres	Percent
Land Use	(1,000s)		(1,000s)	
Forest	6,148	66	5,735	71
Farmland	2,470	27	1,268	16
Urban[b]	352	4	610	8
Roads[c]	321	3	316	4
Miscellaneous[d]	31	0	120	1
Ownership[e]				
Forestry industry and corporate	4,237	45	4,037	50
Farmer	2,791	30	874	11
Miscellaneous private	2,294	25	3,138	39
Total	9,322	100	8,049	100

[a] Data are from a 1985-86 FIA inventory for western Oregon and the 1988-89 FIA inventory for western Washington.

[b] Includes town sites, clustered suburbs, residential and industrial buildings.

[c] Includes constructed roads, power lines, pipelines, and railroads.

[d] Includes barren rock, sand, glaciers, marsh, lakes, streams, and reservoirs.

[e] Forest industry and corporate owners include individuals or companies who operate wood-using mills or manage forests for timber production. Farmers include individuals or corporations who produce agricultural products. Miscellaneous private owners include all other private owners not otherwise classified (Gedney et al. 1986a).

use. There are 1,466 field plots located within western Oregon and 1,405 field plots located in western Washington. Because the interest here is only in the conversion of private-owned forest and farmland to developed uses, those observations where beginning ownership was public and those where beginning land use was either urban, roads, or a miscellaneous use are omitted from the data set. In western Oregon, this yields 1,241 observations of beginning and ending land use for the time spanning the 1961-62 and 1974-76 inventories, 1170 observations for the time spanning the 1974-1976 to 1985-86 inventories, and 1,164 observations for the time spanning the 1985-86 to 1994 inventories. In western Washington, there are 1,009 observations for the time spanning the 1963-67 and 1978-79 inventories and 966 observations for the time spanning the 1978-1979 to 1988-89. The complete data set includes 5,550 observations of beginning and ending land use (Table 2).

Between successive inventories in western Oregon, 44 FIA plots in forest were converted to urban uses and roads, and 36 FIA plots in forest were converted to farmland and miscellaneous uses (Table 2). Meanwhile, 42 FIA plots in farmland were converted to forests, resulting in a net conversion of 38 FIA plots from forest to other uses. Similarly, 35 FIA plots in farmland were converted to urban uses and roads, 44 FIA plots in farmland were converted to forest and miscellaneous land uses, and 33 FIA plots in forest were converted to farmland, resulting in a net

TABLE 2. NUMBER OF FIA PLOT OBSERVATIONS OF BEGINNING AND ENDING LAND USE FROM ONE INVENTORY TO THE NEXT, ON PRIVATE-OWNED FOREST AND FARMLAND IN WESTERN OREGON AND WESTERN WASHINGTON[a]

	Ending land use[b]				
Initial land use[b]	Forest	Farmland	Urban	Roads	Misc.
Western Oregon					
Forest	2,488	33	14	30	3
Farmland	42	928	29	6	2
Western Washington					
Forest	1,581	14	25	25	2
Farmland	5	314	8	1	0

[a] Reports cumulative number of FIA plot observations of beginning and ending land use between the inventories of 1961-62, 1974-76, 1985-86, and 1994 in western Oregon, and 1963-67, 1978-79, and 1988-89 in western Washington. Total number of observations is 5,550. Data set does not include observations of public land that converted to private ownership and private land that converted to public ownership between inventories.

[b] Detailed land use definitions are given in Table 1.

conversion of 46 FIA plots from farmland to other uses. By tracking historical land use on individual FIA plots in the two regions, a cross-sectional and cross-temporal data set can be constructed, depicting where and when resource lands were converted to urban land uses in the presence and absence of statewide land use planning.

Empirical Model

A probit model is specified describing the likelihood that FIA plots were converted from forest or farmland to a developed use from one inventory occasion to the next, as a function of explanatory variables. It is assumed that there is a vector of unobserved response variables y_i^* describing the probability that each plot i is developed and defined by the relationship

$$Y_i^* = \beta' x_i + \mu_i \tag{1}$$

where x is a vector of explanatory variables, β is a vector of parameters, μ is a vector of error terms, and $i = 1, \ldots, N$,. Though the actual probabilities y_i^* are unobserved, a vector of dummy variables y_i can be observed, describing whether or not each plot was actually developed, and defined by

$$\begin{aligned} y_i &= 1 \textit{ if } y_i^* > 0 \\ y_i &= 0 \textit{ otherwise} \end{aligned} \tag{2}$$

From (1) and (2) we derive

$$\begin{aligned} Prob(y_i = 1) &= Prob\,(\mu_i > \beta' x) \\ &= 1 - F(-\beta' x_i) \end{aligned} \tag{3}$$

where F is the standard normal cumulative distribution function for μ_i (Maddala 1986). The likelihood function to be maximized with respect to β and σ^2 is

$$L = \Pi_{y_{i=0}} F(-\beta' x_i) \Pi_{y_{i=1}} [1 - F(-\beta' x_i)] \tag{4}$$

Because the FIA land use data set consists of multiple observations of individual plots at different points in time, there is the potential for correlation among observations across time to deflate standard errors and bias the estimated coefficients. An alternative method of estimation that accounts for the time-series nature of the data is random effects probit (Greene 1997). The random effects probit model assumes that the correlation between successive disturbances for individual plots can be reduced to a constant ρ (Butler and Moffitt 1982). The relationship (1) above is modified to account for multiple time periods t as

$$y_{it}^* = \beta_*' x_{it} + \mu_i + v_{it} \tag{5}$$

where $i=1, \ldots, N$, $t=1, \ldots, T$, and $\beta = \beta_* / \sigma_v$, and

$$Var[u_i + v_{it}] = Var[\in_{it}] = \sigma_u^2 + \sigma_v^2. \tag{6}$$

The correlation across time is estimated as

$$Corr[\in_{it}, \in_{is}] = \rho = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2) \tag{7}$$

and can be evaluated using a simple *t*-test (Greene 1995, p. 427).

There are two ways to define development in the model. One approach includes only those lands converting to urban uses as developed and excludes lands converting to roads. FIA classifies town sites, clustered suburbs, and residential and industrial buildings as urban; constructed roads, power lines, pipelines, and railroads are classified as roads. With this approach it is assumed that the conversion of forests and farmland to roads either maintains or enhances rather than diminishes their resource value. Much of the land classified by FIA as roads consists of roads built by the forest industry to provide access for timber harvesting. A second approach includes roads along with urban uses as developed. With this approach it is assumed that the conversion of forests and farmland to roads does diminish their resource value by precluding timber and agricultural production. Changes over time in FIA's definition of roads confound this choice. The 1961-62 western Oregon inventory classifies forest roads less than 120 feet wide as forest, while later inventories classify all forest roads, regardless of width, as roads (MacLean 1990). Thus, some conversions of forest to roads from the 1961-62 to the 1974-76 inventory may be due to this change in definition. In light of these difficulties, two models are estimated; one assuming that land is developed when it is converted either to urban uses or roads, and another assuming that land is developed when it is converted only to urban uses. It is not possible to distinguish new residences of commercial farmers and forest owners are from other developed uses.

The explanatory variables *x* include county-level variables describing population and income growth, forest stumpage prices, and net farm revenue per acre, and plot-level variables describing the land use and ownership characteristics of individual FIA plots (Table 3). The variable LAND USE LAW describes the proportion of time, from one inventory to the next, in each western Oregon county that a state-approved land use plan was in effect. Knaap (1988) uses a similar constructed variable describing the extent of land use plan acknowledgment to analyze the impact of Oregon's land use planning program on economic development. In this model, the LAND USE LAW variable is interacted with the variables FOREST ZONE, FARM ZONE, and URBAN GROWTH BOUNDARY, to describe the location of each FIA plot within either a forest use zone, an exclusive farm use zone, or an urban growth boundary following implementation of Oregon's land use law (Table 4). The sign, magnitude, and statistical significance of the estimated coefficients for these interaction terms provide a test of how the likelihood of development on land located within each zone has changed since the zones were established under Oregon's land use planning program.

The estimated models are highly significant (α<0.01) with chi-squared values of 88.852 and 139.125, each with 11 degrees of freedom (Table 4). Model estimation using random effects probit yielded a nearly identical set of estimated coefficient values, and α values of 0.030 and 0.000 with *t*-statistics of 0.02 (α>0.95) and 0.00 (α>0.99) suggesting no discernable random effects. The estimated coefficients for ΔPOPULATION are positive and statistically significant (α<0.05)

TABLE 3. DESCRIPTIONS OF EXPLANATORY VARIABLES TESTED IN THE PROBIT MODELS

Variable	Description
ΔPOPULATION	Absolute change in county population (100s) per square mile (U.S. Bureau of Census 1992) from one FIA inventory to the next. Population for FIA inventory years is derived by interpolating between census years.
ΔINCOME	Percentage change in median annual household income of county residents (U.S. Bureau of Census 1992) from one FIA inventory to the next adjusted to 1992 dollars. Income for FIA inventory years is derived by interpolating between census years.
FOREST	Variable equals 1 if plot is timberland or other forest; 0 otherwise
FARMLAND	Variable equals 1 if plot is cropland, pasture, or range; 0 otherwise.
FOREST RENT	Average sold stumpage price ($100s) per 1,000 board feet, Pacific Northwest west-side region (Sohngen and Haynes 1992) from one FIA inventory to the next (1992 dollars), times FOREST.
FARM RENT	Average annual net revenue per acre ($100s) in value of agricultural products sold less production expenses, by county (U.S. Bureau of Census 1994) from one FIA inventory to the next (1992 dollars), times FARMLAND. Annual net revenue for non-census years found by interpolation between census years.
FOREST INDUSTRY	Variable equals 1 if plot is forest industry or corporate-owned; 0 otherwise.
FARMER OWNED	Variable equals 1 if plot is farmer-owned; 0 otherwise.

TABLE 3. (CONTINUED)

Variable	Description
MISCELLANEOUS PRIVATE OWNED	Variable equals 1 if plot is miscellaneous private-owned; 0 otherwise.
OREGON	Variable equals 1 if plot is located in Oregon; 0 otherwise
LAND USE LAW	Variable equals proportion of time from one FIA inventory to the next that each Oregon county had a state acknowledged land use plan in effect; 0 otherwise. Acknowledgment dates from LCDC (1992).
FOREST ZONE	Variable equals 1 if plot is now located within a forest use zone, 0 otherwise. Also included under the forest zone variable are a small number of miscellaneous resource conservation zones.
FARM ZONE	Variable equals 1 if plot is now located within an exclusive farm use zone, 0 otherwise.
URBAN GROWTH BOUNDARY	Variable equals 1 if plot is now located within an urban growth boundary, 0 otherwise. Also included under the urban growth boundary variable are a small number of exception area and rural residential zones where developed uses also are allowed.

in both models. Forest and farmland located in counties with high rates of population growth are more likely to have been developed than land located in counties with low rates of population growth. The estimated coefficients for ΔINCOME are positive, but only the ΔINCOME coefficient in the model including roads as a developed use is weakly statistically significant ($\alpha<0.15$). The estimated coefficients for the FOREST RENT and FARM RENT variables are not statistically significant and suggest that land rents, as measured by these data, have little influence on the likelihood of development in these models.

The variable FOREST is omitted from both models to avoid perfect collinearity with the FARMLAND variable. The estimated coefficient for FARMLAND is positive in both models, but is not statistically significant in either model ($\alpha>0.20$ and $\alpha>0.95$). The variable FOREST INDUSTRY is omitted from both models to avoid perfect collinearity among the ownership variables. The estimated coefficient for FARMER OWNED is positive in both models and statistically significant in the model that excludes roads as a developed use ($\alpha<0.05$). This result suggests that farmer-owned land is more likely to have been developed than land owned by the forest industry (base case). The poor statistical significance of the FARMER OWNED coefficient ($\alpha>0.36$) in the model that includes roads as a developed use likely

TABLE 4. ESTIMATED COEFFICIENTS OF PROBIT MODELS DESCRIBING THE PROBABILITY THAT PRIVATE LAND IS CONVERTED TO DEVELOPED USES IN WESTERN OREGON AND WESTERN WASHINGTON

	Model that includes roads as a developed use		Model that excludes roads as a developed use	
Variable	Estimated coefficient	Marginal effect	Estimated coefficient	Marginal effect
Intercept	-2.671*** (- 6.34)	-0.129	-2.670*** (-4.34)	-0.046
ΔPOPULATION	0.246** (1.98)	0.012	0.547*** (3.75)	0.009
ΔINCOME	0.843 (1.52)	0.041	0.007 (0.01)	0.000
FOREST RENT	0.347 (1.26)	0.017	-0.130 (0.328)	-0.002
FARM RENT	-0.007 (-0.09)	-0.000	-0.010 (-0.12)	-0.000
FARMLAND	0.537 (1.26)	0.026	0.027 (0.04)	0.000
FARMER OWNED	0.110 (0.89)	0.005	0.452** (2.40)	0.008
MISCELLANEOUS PRIVATE OWNED	0.397*** (4.20)	0.019	0.776*** (4.90)	0.013
OREGON	-0.172* (-1.73)	-0.008	-0.245* (-1.74)	-0.004
LAND USE LAW * FOREST ZONE	0.032 (0.22)	0.002	0.068 (0.29)	0.001
LAND USE LAW * FARM ZONE	0.080 (0.46)	0.004	0.062 (0.27)	0.001
LAND USE LAW * URBAN GROWTH BOUNDARY	1.020*** (5.96)	0.049	1.251*** (6.50)	0.021

Notes: The number of observations is 5,550. The values of the log-likelihood functions are -601.657 and -332.017, and the χ^2 values are 88.852 and 139.125, both with 11 degrees of freedom. Alternate models estimated using random effects probit yielded ρ values of 0.030 and 0.000 with *t*-statistics of 0.02 (α>0.95) and 0.00 (α>0.99), suggesting no discernable random effects. The *, **, and *** indicate that the probability of the *t*-statistic (in parentheses) for each coefficient exceeding the critical *t* value is 90 percent, 95 percent, and 99 percent.

reflects the greater likelihood of development observed on forest industry lands (base case) when roads are treated as a developed use. The estimated coefficient for MISCELLANEOUS PRIVATE OWNED is positive and statistically significant in both models ($\alpha<0.01$). Land owned by miscellaneous private owners is more likely to have been developed than forest industry land, whether or not roads are treated as a developed use. Lower likelihood of development on forest industry and farmer-owned land may reflect greater land management expertise or commitment to commodity production among these owners.

Evaluating Oregon's Land Use Planning Program

The estimated coefficients for the two variables that interact LAND USE LAW with FOREST ZONE and FARM ZONE are positive in both models, but are not statistically significant ($\alpha>0.60$). An alternative variable which combines FOREST ZONE and FARM ZONE into one "protected zone" variable and interacts this with LAND USE LAW, also produced a positive, but not statistically significant coefficient. If the likelihood of development on resource lands located within forest use and exclusive farm use zones in western Oregon has been reduced since implementation of Oregon's land use planning program, it would be expected that the estimated coefficients for variables that interact LAND USE LAW with FOREST ZONE and FARM ZONE would be negative and statistically significant. To the contrary, positive estimated coefficients for these variables would suggest a potential increase in the likelihood of development on resource lands located within forest use and exclusive farm use zones following implementation of Oregon's land use planning program. The lack of statistical significance of these coefficients, however, suggests that the magnitude of any increase in the likelihood of development on resource lands, as depicted by the current FIA data, is not significantly different from zero.

The estimated coefficient for LAND USE LAW interacted with URBAN GROWTH BOUNDARY is positive in both models, and statistically significant at the 99 percent confidence level ($\alpha<0.01$) in both models. The positive and statistically significant variable suggests that the likelihood that FIA plots located within urban growth boundaries in western Oregon have been developed has increased following adoption of land use plans approved by the Oregon Land Conservation and Development Commission. This result suggests that Oregon's land use planning program has concentrated development within urban growth boundaries since its implementation.

Resource lands located close to existing cities are often more likely to be converted to developed uses than are lands located farther from cities. As a result, the greater likelihood of development observed on FIA plots within urban growth boundaries relative to that observed in forest use and exclusive farm use zones could be due to the spatial distribution of urban growth boundaries around existing cities. FIA plots located within urban growth boundaries may have been more likely to have been developed as much because of their spatial proximity to existing cities as by the establishment of urban growth boundaries under Oregon's land use planning program. Conversely, FIA plots located within forest use and exclusive farm use zones may have been less prone to development because they are farther from existing cities. Such location effects can be tested for by re-estimating the models using the variables FOREST ZONE, FARM ZONE, and URBAN GROWTH BOUNDARY separately, and in combination with the variable LAND USE LAW as before. The resulting coefficients enable us to compare the likelihood of development observed on FIA plots now located within each zone throughout the entire time period described by the data set, to the likelihood of development observed on FIA plots in the time since each zone's establishment.

Only the model including roads as a developed use provides a sufficient number of observations depicting FIA plots converting from resource uses to developed uses to be re-estimated using the three additional dummy variables. The alternative model is highly significant ($\alpha<0.01$) with a chi-squared value of 108.133, with 13 degrees of freedom (Table 5). Estimation using a random effects probit model yielded a ρ value of 0.383 and a *t*-statistic of 0.78 ($\alpha>0.40$), suggesting no strong random effects. However, because the estimated coefficient values of the random effects probit model differ somewhat from those of the probit model, the random effects probit coefficients are also reported. In all instances, the signs and magnitudes of the explanatory variable coefficients are roughly comparable to those estimated in the previous model that includes roads as a developed use (Table 4), and most are comparable in statistical significance as well.

The estimated coefficients for FOREST ZONE and FARM ZONE are negative in both models, and all are statistically significant at the 90 percent confidence level ($\alpha<0.10$) or better (Table 5). The negative coefficients for the FOREST ZONE and FARM ZONE variables suggest that FIA plots now located within forest use and exclusive farm use zones have always exhibited a lower likelihood of being converted to developed uses, both before and after each zone's establishment under Oregon's land use law. The coefficients for LAND USE LAW interacted with FOREST ZONE, FARM ZONE, and URBAN GROWTH show how the likelihood of development on FIA plots located within each zone has changed following implementation of Oregon's land use planning program. The estimated coefficients for LAND USE ZONE $\times$ FOREST ZONE and LAND USE ZONE $\times$ FARM ZONE again are positive in both models (Table 5), but are not statistically significant at a high level of confidence ($\alpha>0.15$). The poor statistical significance of the interaction coefficients again suggests that the likelihood of development on FIA plots now located within forest use and exclusive farm use zones has changed little since implementation of Oregon's land use planning program.

TABLE 5. ESTIMATED COEFFICIENTS OF ALTERNATIVE PROBIT AND RANDOM EFFECTS PROBIT MODELS DESCRIBING THE PROBABILITY THAT PRIVATE LAND IS CONVERTED TO DEVELOPED USES IN WESTERN OREGON AND WESTERN WASHINGTON, WITH ROADS INCLUDED AS DEVELOPED USE

	Probit		Random effects probit	
Variable	Estimated coefficient	Marginal effect	Estimated coefficient	Marginal effect
Intercept	-2.603*** (-5.93)	-0.119	-3.397*** (-2.97)	-0.045
ΔPOPULATION	0.221* (1.75)	0.010	0.297 (1.53)	0.004
ΔINCOME	0.778 (1.38)	0.036	1.150 (1.24)	0.015
FOREST RENT	0.329 (1.15)	0.015	0.489 (1.13)	0.006
FARM RENT	-0.007 (-0.09)	-0.000	-0.003 (-0.02)	-0.000
FARMLAND	0.474 (1.06)	-0.022	0.680 (1.03)	-0.009
FARMER OWNED	0.106 (0.81)	0.005	0.145 (0.85)	0.002
MISCELLANEOUS PRIVATE OWNED	0.346*** (3.56)	0.016	0.452** (2.59)	0.006
FOREST ZONE	-0.335*** (-2.64)	-0.015	-0.443** (-2.11)	-0.006
FARM ZONE	-0.351** (-2.03)	0.016	-0.457* (-1.77)	-0.006
URBAN GROWTH BOUNDARY	0.394** (2.55)	0.018	0.525* (2.02)	0.007
LAND USE LAW × FOREST ZONE	0.191 (1.13)	0.011	0.300 (1.17)	0.004
LAND USE LAW × FARM ZONE	0.280 (1.29)	0.013	0.420 (1.36)	0.006
LAND USE LAW × URBAN GROWTH BOUNDARY	0.432** (2.05)	0.021	0.685* (1.86)	0.009
Rho (ρ)	—	—	0.383 (0.78)	

TABLE 5 (CONTINUED)

Notes: The number of observations is 5,550. The values of the log-likelihood functions are -592.017 and -591.813, and the χ^2 values are 108.133 and 108.540 with 13 and 14 degrees of freedom. The *, **, and *** indicate that the probability of the *t*-statistic (in parentheses) for each coefficient exceeding the critical *t* value is 90 percent, 95 percent, and 99 percent.

The estimated coefficient for URBAN GROWTH BOUNDARY is positive and statistically significant at the 90 percent confidence level ($\alpha<0.10$) in both models (Table 5). This result suggests that FIA plots now located within urban growth boundaries have always exhibited a higher likelihood of being converted to developed uses, both before and after the establishment of urban growth boundaries under Oregon's land use law. The estimated coefficient for URBAN GROWTH BOUNDARY interacted with LAND USE LAW is positive in both models, and is statistically significant at the 90 percent confidence level ($\alpha<0.10$) in both models. This result suggests that FIA plots now located within urban growth boundaries have exhibited an even higher likelihood of being converted to developed uses since implementation of Oregon's land use planning program. This result further supports the conclusion that Oregon's land use planning program has concentrated development within urban growth boundaries, since they were established.

Conclusions

Results from probit models describing the likelihood of development on forests and farmland in western Oregon and western Washington suggest that Oregon's land use planning program has tended to concentrate the conversion of resource lands to developed uses within urban growth boundaries. Results also suggest that the likelihood of conversion of resource lands to developed uses has not been measurably different for lands located outside of urban growth boundaries and within forest use and exclusive farm use zones. This result appears to challenge the notion that Oregon's land use planning program has significantly reduced the likelihood of development on resource lands since it was implemented. Three possible explanations can be hypothesized for this result.

One possible explanation is that Oregon's land use planning program has not succeeded in slowing the conversion of forests and farmland to developed uses within forest use and exclusive farm use zones. This conclusion no doubt is advocated by opponents of land use planning. In fact, Daniels and Nelson (1986) warn of a proliferation of small "hobby farms" following implementation of Oregon's land use planning program, resulting from non-farmers moving onto minimum-sized lots allowable within exclusive farm use zones. It is conceivable that such effects could exist within forest use zones as well, as individuals purchase small forest holdings either as rural residences, or as second homes and hunting and fishing lodges. Similarly, Knaap and Nelson (1992) suggest that although urban growth boundaries may have spatially constrained urban growth, resulting in less development pressure on forests and farmland, a potential exists for low-density development to "leak" out of existing urban growth boundaries. Unfortunately, existing land use data do not provide sufficient detail regarding development density with which to test these hypotheses.

A second explanation is that this analysis does not distinguish between land developed by commercial forest owners and farmers as personal residences, from land that is developed for all other residential, commercial, and industrial uses. Planning proponents, including Oregon's Land Conservation and Development Commission, generally do not consider such residences as developed uses. This analysis treats any conversion of forest or farmland to a residential use as development, because it is difficult to distinguish land use conversions to developed uses by ownership type using FIA data.

A third explanation for the model results is more subtle, but likely given the data at hand. These results suggest that those resource lands now located within urban growth boundaries have always been more likely to have been developed to residential, commercial, and industrial uses, probably due largely to their close proximity to existing cities. Urban growth boundaries after all were drawn around existing cities. These results also suggest that resource lands now located outside of urban growth boundaries, and within forest use and exclusive farm use zones, have always been less likely to have been developed because they are more distant from cities. Oregon's land use law essentially confined the expansion of cities by drawing a line around those resource lands that already faced the greatest likelihood of being developed. Development has continued within these boundaries. It is plausible that little change is observed in the likelihood of development outside of urban growth boundaries and within forest and exclusive farm use zones, simply because so little development had been taking place there before Oregon's land use law was enacted that we are unable to detect a statistically significant change in the likelihood of development since the law was enacted. The fact that a relatively small number of FIA plots were actually converted from resource uses to developed uses during the time period analyzed in this study compounds this problem.

Such factors reveal the difficulties associated with analyzing land use change with available historical land use data. More research may be needed to determine whether land use planning programs such as Oregon's can actually reduce the likelihood of development on resource lands using zoning alone. Improved analyses of land use change and land use policies may require a more detailed, comprehensive, and consistent inventory of land use. The increasing use of geographic information systems, along with the development of empirical models which incorporate spatial heterogeneity of sample plots, may facilitate such improvements. Improved databases also may enable analysts to routinely incorporate land prices into land use models using systems of equations.

This analysis is not a comprehensive assessment of the benefits and costs associated with land use planning programs. For example, other benefits often attributed to land use planning, such as improved transportation and protection from natural hazards are not addressed, nor are costs associated with developing and administering land use plans. However, three goals central to many state and regional land use planning programs—more orderly growth, protecting farmland, and protecting forests—are addressed. Planning officials and the public may find substantial benefits in the greater control over development offered by urban growth boundaries. However, it also is possible that land use planning alone may be insufficient to protect resource lands in the long run. With better data and improved analyses, the promise and limitations of regional and statewide land use planning might more clearly be defined.

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