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Changes in the Non-Federal Land Base Involving Forestry in Western Oregon, 1961-94

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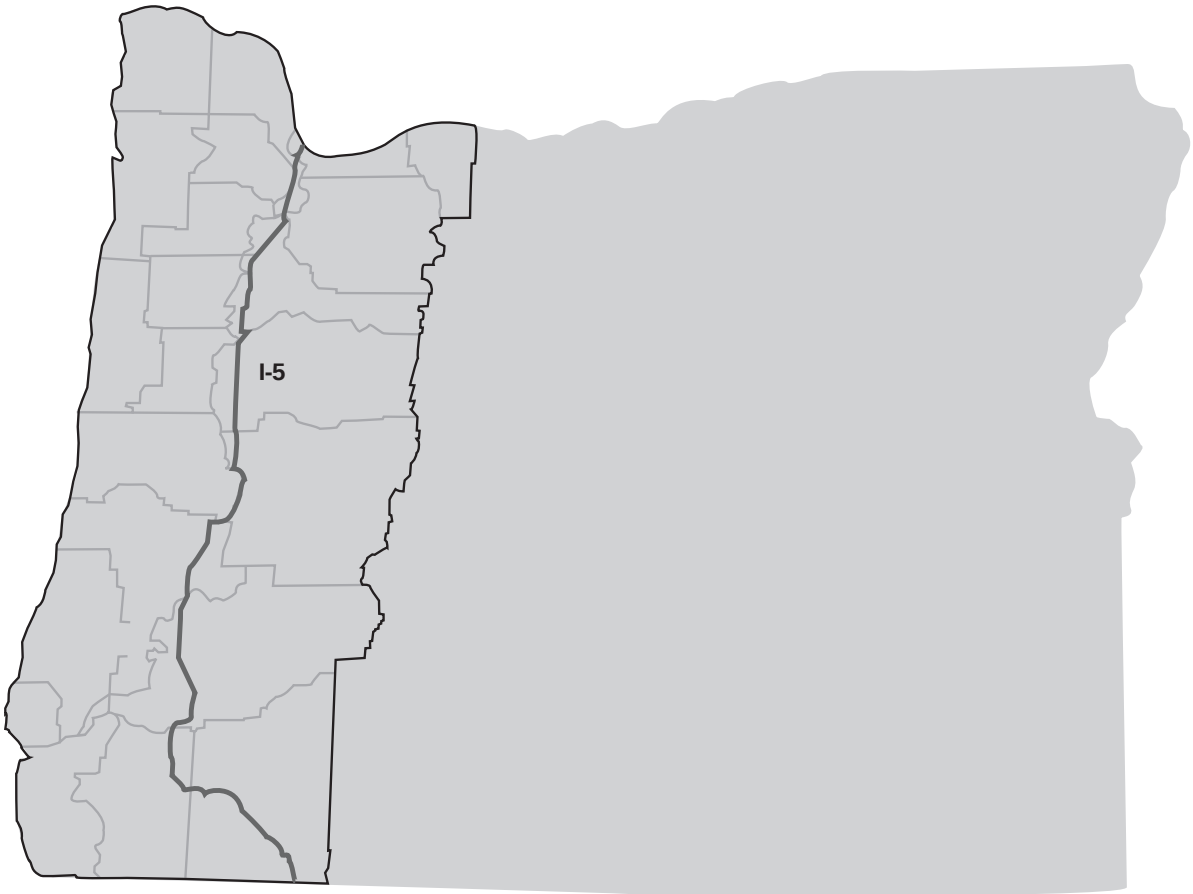

Authors

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Abstract

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Temporal and spatial analyses of land use changes on non-Federal lands in western Oregon between 1961 and 1994 were conducted. Two distinct changes in the region were a loss of forest lands and an increase in urban areas. Neither the rates of change over time nor the spatial distribution of land converted to urban use was evenly distributed in the region. The influence of socioeconomic factors, such as ownership, population growth, and personal income, as well as physical factors of land such as slope and location, on land use changes also was examined.

Keywords: Land use change, forestry, urban development, periodic surveys, temporal and spatial analyses.

Summary

We examined changes in the private forest land base between 1961 and 1994 in western Oregon. Periodic surveys by the USDA Forest Service indicate that land use changes and timber harvest activities on private lands are more frequent than on public lands (Gedney and Hiserote 1989). A significant shift in ownership of land from private non-industry to private forest industry was observed (252 000 hectares or 11.9 percent). The most frequent disturbance on private lands is some form of harvest, with clearcutting methods being most common. For forest management, clearcuts accounted for a higher portion of forest harvests in industrial forests than that in nonindustrial forests between 1973-76 and 1994.

In 1994, forests occupied about 65 percent of the non-Federal land base in the region, with crop and pasture land being the next two most common land uses (14 percent and 11 percent, respectively). Urban and other developed uses occupied about 4 percent of the non-Federal land base, with continuing growth fueled by increases in population and economic activity. Although changes in land use tend to occur slowly at the regional level, the cumulative impact on the ecosystems can be great. Over a 33-year period (1961-94), about 7.8 percent of non-Federal land (344 000 hectares) changed from one land use class to another. The two most distinct land use changes were (1) a 192 000-hectare net loss in forest land area, and (2) a 71 000-hectare increase in urban area. Most land use changes occurred between the mid-1960s and mid-1970s.

The rates of change in land use from that of forests to other uses slowed from 4 percent between 1961-63 to 1973-76 to 2 percent between the mid-1970s and mid-1980s. The rate slowed further to 1.3 percent between the mid-1980s and 1994. Increases in both population and income are correlated with urban expansion. Spatially, urban land conversion is not evenly distributed across the region, with most conversion occurring in places with slopes of less than 1 degree around metropolitan centers, such as Portland, Salem, and Eugene, as well as the Coos Bay area, in Oregon.

Contents

Introduction

Land use change and forest management are important to ecosystem management and community development. In western Oregon, land use competition among several sectors of the economy is expected to intensify as the human population and economic activity continue to grow (Keisling 1995). Investment in the management of private forest lands is expected to increase because of enhanced prospective financial returns associated with reduced timber production from public timberlands (Adams and others 1996). Implications for ecosystem management arise from shifts in use of land from forest to urban-related uses that remove many forest-related functions of the land such as timber production, wildlife habitat, and biodiversity. Similarly, change in the use of land from agriculture to urban-related uses can change existing tax patterns, transportation systems, and demand for educational and other services. Determining the kinds of changes resulting from human-caused landscape disturbance can provide information to help decisionmakers adjust current policies and enhance ecosystem management plans based on both short- and long-term considerations.

One question is how to attain a stable supply of goods and services within the ecological limits of the land. Temporal and spatial analyses of land-base changes over the past several decades are used to gain a better understanding of private land use and timber harvest behavior. These analyses shed light on how we got to where we are, and where current trends and policies might take us.

We examined trends in land use shifts between forest and nonforest uses, the management of forest land, and land exchanges among forest owners for western Oregon. Ecological and economic factors can predispose certain types of private lands to human-caused disturbances, and we examine such factors over space and time. Although the area of private timberland in western Oregon declined by 2 percent between 1984-86 and 1994 (Lettman 1995), the trends in area changes are not the same for industrial and other private landowners. Distinguishing among owners is important because timberland area has increased for industrial land ownerships since 1961, whereas nonindustrial private land ownership has declined by about one-third. The owner groups also tend to manage their lands differently (Gedney 1983).

Study Objectives

The specific objectives of this study were (1) to examine areas and rates of changes in land uses as well as effects of some socioeconomic factors on urban development in western Oregon; (2) to determine resource allocation in different land use zones and the extent of shifts among different land ownerships (public, private, forest industry, and nonindustry); (3) to show timber management and the extent of human-caused disturbance on private lands; and (4) to analyze some specific characteristics of land such as location and topography, which potentially influence the rate of urbanization.

Study Area

Western Oregon, containing 19 counties with a total of 7.7 million hectares of land, is characterized by highly productive forest ecosystems, strong aquatic-terrestrial links, and diverse forest policies (fig. 1). Sixty-five percent of non-Federal land in western Oregon was forested in 1994. More than 94 percent was classified as timberland, capable of productive use in timber growing. More than 42 percent of the timberland in western Oregon was under private ownership in 1994, with most of that under industrial land ownership. Private landowners have provided most of the timber harvests since 1953, with over half supplied by industrial owners (Sessions and others 1990). The nonindustrial private forest (NIPF) share of timber harvest has been rising and is now the second largest source of timber harvest.

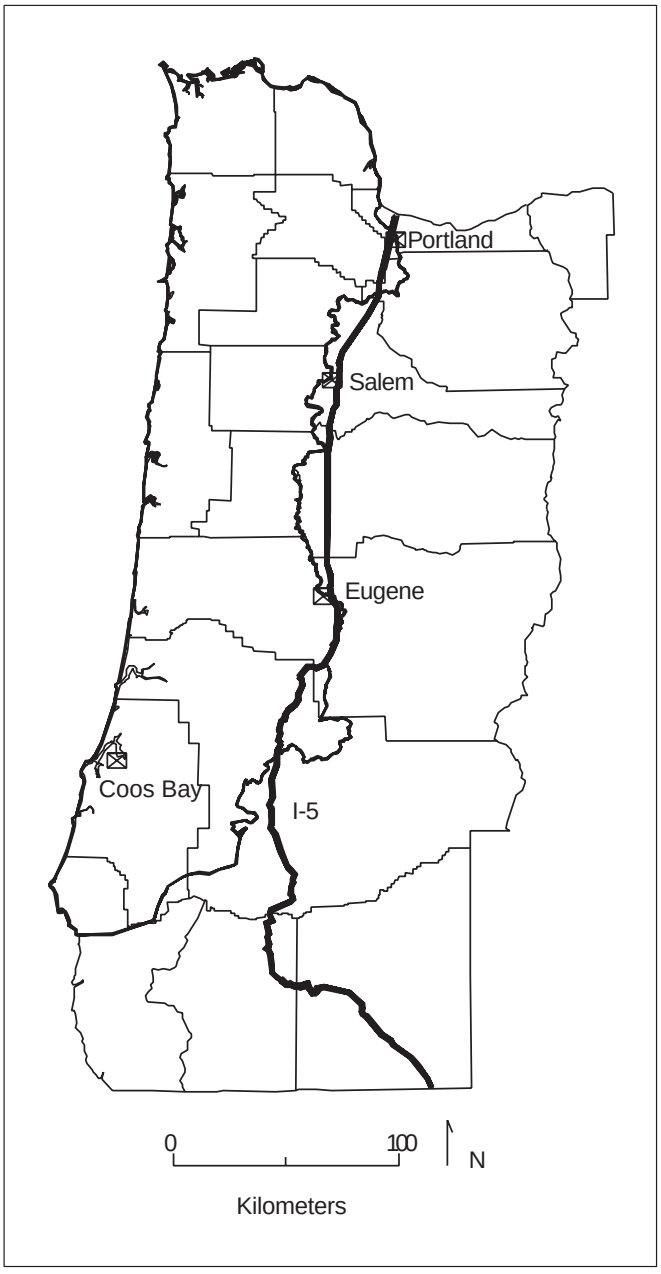

Figure 1—Orientation map for the study area.

Forests are important State-wide as the State ranks third nationally in terms of total timberland area. Oregon has the most growing-stock volume in total among states, and more than two-thirds of the State's timberland is located in western Oregon, which typically has relatively large volumes per hectare in older stands. Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) make up most of the softwood species that dominate western Oregon forests. Douglas-fir in particular is the commercially preferred species for use in construction and other building applications.

Data and Methods

We analyzed land use change for western Oregon on 1,465 field plots maintained by the Pacific Resource Inventory and Monitoring and Evaluation (PRIME) unit of the USDA Forest Service's Pacific Northwest Research Station in Portland, Oregon. We aggregated ground land classes into six categories: forest land, pasture land, crop land, urban use, other land uses, and water (see "Glossary" for specific land class definitions).

The location of land use changes was analyzed by using spatial data consisting of land use zone data from a sample-based inventory (Oswald 1984). The sample was a square grid of points located 1.37 kilometers apart, with the points first located on U.S. Geological Survey quadrangle maps and then transferred to aerial photographs (Gedney and Hiserote 1989). In addition to ground land classes identified on field plots, the PRIME unit determines land use zones from these aerial photographs. A photo-point was interpreted for each of the 24,000 grid points for non-Federal lands in western Oregon. Every photo grid point on non-Federal land, regardless of land use, was examined. Each grid point represents 186 hectares.[1] In this analysis, four dominant land use zones were identified: (1) primary forest, (2) primary agriculture, (3) low-density urban, and (4) urban (Gedney and Hiserote 1989, Oswald 1984).

We analyzed field plot data pertaining to land use and timber management to estimate rates of change over PRIME remeasurement periods. We used paired-plot analysis to estimate rates of change in ownership over the periods (The plots have to be in the same ownership class in both surveys). We followed MacLean (1990) in using recompiled inventory data that are based on current standards, definitions, and gross area estimates of PRIME.

Land Use Change Data

The primary land use data for western Oregon examined in this study came from surveys undertaken by the PRIME unit. The PRIME inventories of non-Federal lands in the Pacific Coast States are conducted periodically, and each requires several years to complete.[2] For western Oregon, the PRIME unit has estimated areas in major land uses from surveys conducted from 1961 to 1963 (occasion 1), 1973 to 1976 (occasion 2), and 1984 to 1986 (occasion 3) (MacLean 1990). An interim update was conducted in 1994[3] (occasion 4). However, information about afforestation to timberland and a change in land ownership of forest land from Federal to non-Federal owners is unavailable in updated data for 1994. The PRIME inventories consist of 1,465 permanent field plots located on a fixed grid across western Oregon and are maintained for comprehensive forest inventory purposes (MacLean 1990).

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[1] An expansion factor was developed by the PRIME unit by dividing the total number of grid points into the estimate of total land area for western Oregon from the 1980 census.

[2] Earlier PRIME forest surveys for western Oregon were conducted, but we do not have access to data for surveys before 1960. This analysis focuses on changes and trends in recent years and their implications for the future. The "survey period" in this report generally refers to the period between ground surveys.

[3] The interim survey was conducted in cooperation with the Oregon Department of Forestry. Forest Inventory and Analysis crews updated the inventory of 850 permanent field plots on private forest land in western Oregon in fall 1994.

Forest Ownership Data

For our analysis, we separated private land owners into two groups: forest industry and other private lands (see "Glossary"). Ownership changes are identified by PRIME from a study of ownership records at the county offices of assessors. The forest industry owns about 70 percent of private timberland in western Oregon (Lettman 1995). Forest industry timberland is generally more productive for timber growing than is nonindustrial private timberland, and the two groups of private owners also tend to behave differently in terms of intensity of timber management (Gedney 1983).

Forest Management Data

The PRIME unit collects data on a variable describing cultural treatments or kind of cultural activity since the previous remeasurement of a ground plot. Cultural activities that are recorded include planting, stocking control, stand conversion, and other treatments.

Socioeconomic Data

Four measures of county-level socioeconomic conditions were examined for western Oregon: (1) decadal change of population growth rate (from 1970 to 1980); (2) decadal change of unemployment rate (from 1970 to 1980); (3) rate of change in annual income per capita (from 1969 to 1981); and (4) absolute annual income per capita in 1981. We conducted a correlation analysis to examine the correspondence among the four selected variables and land use change from low-density urban to urban.

Results

The rate of conversion from forest land to other uses was higher between the first and second PRIME surveys (4 percent) than between the second and third surveys (2 percent), or between the third survey and the 1994 update (1.3 percent, table 1). The same trends existed in conversion of forest land to urban-related use, falling from 0.6 percent between the first two PRIME surveys to 0.4 percent between the third survey and 1994. For numbers of plots, 6 percent of the PRIME plots, or 90 plots, were involved in major land use changes between 1961 and 1994, 63 percent of which occurred between 1961-63 and 1973-76, 23 percent between 1973-76 and 1984-86, and 13 percent between 1984-86 and 1994 (table 2).

Land Use Changes and Urbanization

We compared rates of conversion of land from forest plots to urban plots between western Oregon and western Washington. Statistical analysis indicated that rates of conversion differed significantly ($p < 0.05$) between the first and second surveys, with the conversion rates of 0.6 percent (western Oregon) and 1.7 percent (western Washington), respectively (tables 1 and 3). Rates of conversion were not significantly different ($p > 0.05$) between the second and third surveys (0.5 percent and 0.8 percent for western Oregon and western Washington, respectively).

Table 1—Accumulated areas and transition possibilities (percentage) for land use changes among 6 classes in western Oregon, 1961-63 to 1973-76, 1973-76 to 1984-86, and 1984-86 to 1994

Land class	Total	Forest	Pasture	Crop	Urban	Others	Water
		Thousand hectares					
	1961-63			**Status 1973-76**			
Forest	3053	2929	48	18	18	34	6
		(96.0)	(1.6)	(0.6)	(0.6)	(1.1)	(0.2)
Pasture	503	10	423	50	15	6	0
		(2.0)	(84.0)	(10.0)	(2.9)	(1.1)	(0.0)
Crop	560	10	6	526	12	3	3
		(1.8)	(1.1)	(93.9)	(2.2)	(0.5)	(0.5)
Urban	113	0	0	0	113	0	0
		(0.0)	(0.0)	(0.0)	(100)	(0.0)	(0.0)
Others	158	0	6	0	0	152	0
		(0.0)	(3.7)	(0.0)	(0.0)	(96.3)	(0.0)
Water	25	0	0	0	0	0	25
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100)
Total		2949	482	594	158	195	34
	1973-76			**Status 1984-86**			
Forest	2949	2889	10	0	1	36	0
		(98.0)	(0.3)	(0.0)	(0.5)	(1.2)	(0.0)
Pasture	482	2	480	0	0	0	0
		(0.5)	(99.5)	(0.0)	(0.0)	(0.0)	(0.0)
Crop	594	0	0	594	0	0	0
		(0.0)	(0.0)	(100)	(0.0)	(0.0)	(0.0)
Urban	158	0	0	0	158	0	0
		(0.0)	(0.0)	(0.0)	(100)	(0.0)	(0.0)
Others	195	0	0	0	0	195	0
		(0.0)	(0.0)	(0.0)	(0.0)	(100)	(0.0)
Water	34	0	0	0	0	0	34
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100)
Total		2899	490	594	172	230	34

Table 1 continues on next page.

Table 1—Accumulated areas and transition possibilities (percentage) for land use changes among 6 classes in western Oregon, 1961-63 to 1973-76, 1973-76 to 1984-86, and 1984-86 to 1994 (continued)

Land class	Total	Forest	Pasture	Crop	Urban	Others	Water
		Thousand hectares					
	1984-86	**Status 1994**					
Forest	2899	2861	9	5	12	13	0
		(98.7)	(0.3)	(0.2)	(0.4)	(0.4)	(0.0)
Pasture[a]	490	0	490	0	0	0	0
		(0.0)	(100)	(0.0)	(0.0)	(0.0)	(0.0)
Crop	594	0	0	594	0	0	0
		(0.0)	(.0)	(100)	(0.0)	(0.0)	(0.0)
Urban	172	0	0	0	172	0	0
		(0.0)	(0.0)	(0.0)	(100)	(0.0)	(0.0)
Others	230	0	0	0	0	230	0
		(0.0)	(0.0)	(0.0)	(0.0)	(100)	(0.0)
Water	34	0	0	0	0	0	34
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100)
Total		2861	499	599	184	243	34

[a] Possible land use changes between agriculture and urban and other uses from 1984-86 to 1994 were not rigorously tracked according to PRIME personnel. Such estimates will be updated and improved in the ongoing PRIME occasion 4 survey.

Table 2—Number of plots involving major land use change classes from 1961 to 1994 according to 1,465 plots periodically surveyed by Pacific Resource Inventory and Monitoring and Evaluation in western Oregon

Change class	1961-63 to 1973-76	1973-76 to 1984-86	1984-86 to 1994
Forest to agriculture	22	4	5
Forest to urban	16	16	7
Agriculture to forest[a]	7	1	0
Agriculture to urban[b]	12	0	0

[a] Afforestation between 1984-86 and 1994 was not recorded in the current 1994 PRIME survey.
[b] Possible land use changes between agriculture and urban and other uses from 1984-86 to 1994 were not rigorously tracked according to PRIME personnel. Such estimates will be updated and improved in the ongoing PRIME occasion 4 survey.

Table 3—Accumulated land use changes and transition rates (0-1) between 1963-66 and 1977-79 in western Washington

Land class	Totals	Forest	Pasture	Crop	Urban	Others	Water
		Thousand hectares					
	1963-66	**Status 1977-79**					
Forest	3316	3199	20	3	57	27	10
		(0.965)	(0.006)	(0.001)	(0.017)	(0.008)	(0.003)
Pasture	342	7	223	91	19	2	0
		(0.019)	(0.654)	(0.266)	(0.055)	(0.005)	(0.000)
Crop	165	3	19	142	0	2	0
		(0.016)	(0.113)	(0.860)	(0.000)	(0.011)	(0.000)
Urban	151	0	0	0	142	7	3
		(0.000)	(0.000)	(0.000)	(0.935)	(0.043)	(0.022)
Others	158	0	13	3	8	133	0
		(0.000)	(0.081)	(0.021)	(0.053)	(0.845)	(0.000)
Water	33	0	0	0	0	0	33
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(1.000)
Total		3209	274	239	226	170	47

Results obtained from analyzing the PRIME data were largely consistent with those of earlier studies (MacLean 1990), but forest land changes differed in some cases from those estimated in the Natural Resources Inventory (NRI)[4] by the USDA Natural Resources Conservation Service (NRCS). Except for the urban category, trends for all other categories were opposite. For example, the NRI estimates indicated an increase in non-Federal forest area (0.4 percent) between 1982 and 1992 in contrast to the PRIME estimate of a decrease over the period 1984-86 to 1994 (1.3 percent). One explanation for this is that the PRIME update for 1994 does not include afforestation to timberland and shifts in forest land ownership from Federal to non-Federal. The absolute values of area changes in both surveys, however, were within the estimated margins of error (table 4).

[4] National Resources Inventory data from 1982 and 1992 in western Oregon were obtained from the NRCS regional office in Portland, Oregon. The NRI is an inventory of land cover and uses, as well as other natural resource characteristics, conducted at 5-year intervals on non-Federal rural land. The 1992 NRI is the most extensive inventory yet conducted, covering some 800,000 sample sites. The 1982 and 1992 NRI data were used to compare rates of change in major land use categories with those determined from 1984 to 1986 and 1994 PRIME data.

Table 4—Comparison of changes in area for major land use classes between National Resources Inventory (NRI) and PRIME data based estimates in western Oregon[a]

	PRIME		NRI	
Major land use class	1984-86	1994	1982	1992
	Thousand hectares			
Forest	2899	2861	3032	3044
	(173.9)	(171.6)	(186.2)	(177.3)
Pasture	490	499	466	428
	(29.4)	(29.9)	(46.5)	(44.4)
Crop	594	599	463	438
	(35.7)	(35.9)	(46.2)	(45.0)
Urban	172	184	197	243
	(10.3)	(11.0)	(31.4)	(35.5)

[a] Margins of error shown in the parentheses with 95-percent confident interval.

We examined the relation between the change of low-density urban to urban (1975-85) and the four selected socioeconomic variables in western Oregon. The results indicated that increases of population and personal income were positively correlated with the conversion from low-density urban to urban between 1975 and 1985, with an r^2 value of 0.66. The results were consistent with earlier findings by Alig (1986) in the South, Zheng (1989) in central Washington State, and Parks and Murray (1994) in the Pacific Northwest region. Further urbanization is expected if Oregon's population continues to grow (Alig and others 1990, Alig and Wear 1992, Keisling 1995).

Oregon's population increased 61 percent between 1960 and 1990 from 1.77 to 2.84 million, much faster than the national increase of 39 percent. Most of the increase occurred in western Oregon (fig. 2). Portland was one of the fastest growing cities in the United State during the last decade (Conservation Fund 1997). Similar forces are at work in western Washington (Adams and others 1992), as that State also has been experiencing population growth above the national average in recent years. One difference between western Oregon and western Washington regarding land use, however, is the type of land use legislation in place. In response to concerns about the conversion of forest and agricultural lands to urban-related uses, the Oregon legislature passed the Oregon Land Conservation and Development Act in 1973 to minimize unplanned losses of these lands to urban growth. Since the mid-1980s, comprehensive county land use plans have been in effect (Knaap 1994). For example, the law limits conversion of agricultural and forest lands by directing urban growth within urban growth boundaries. A Growth Management Act was passed in Washington in 1990 (Baker 1992). Goals pertaining to forest land included maintaining and enhancing natural resource-based industries and conserving productive forest lands possessing long-term commercial significance. In contrast to Oregon's land use law, the Growth Management Act gives local governments considerable discretion in implementing the provisions, and some suggest that a significant amount of forest land will not be covered under the act and could potentially be subject to conversion to other uses (Baker 1992).

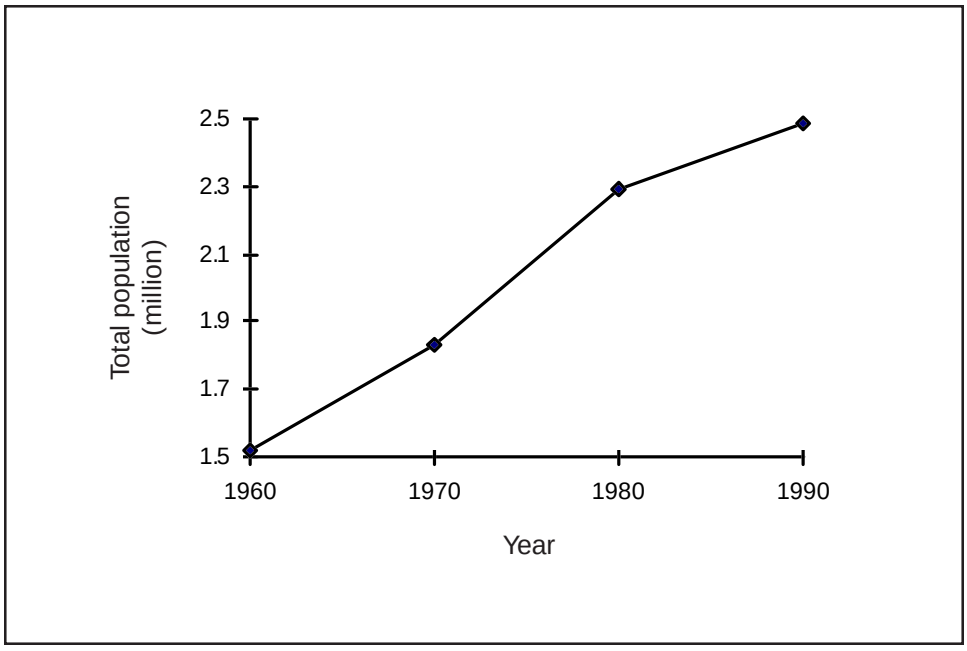

Figure 2—Changes in total population, 1960-90, in western Oregon.

For other private timberland, a key cause of timberland area change has been the expansion of urban and developed land uses (Alig 1986, Parks and Murray 1994). Urban areas have been expanding at a significant rate in recent decades in western Oregon. For example, between 1975 and 1985, area in the low-density urban zone increased by 12.6 percent, and area in the urban zone increased by 13.7 percent. On private land, where almost all of the urban expansion has occurred, low-density urban area increased by 14.7 percent and area in urban by 13.8 percent. Overall, 1.8 percent of western Oregon was in an urban zone, and an additional 3.8 percent was in a low-density urban zone by 1985. Total urban area increased by 63 percent, from 113 000 hectares between 1961 and 1963 to 184 000 hectares in 1994. More than 63 percent of the total increase was between the early 1960s and mid-1970s. The largest concentration of urban land was in the I-5 corridor, including many hectares interspersed with agriculture and forests.

Changes in Resource Allocation and Ownership

In western Oregon, according to 1984-86 survey data, 92 percent of industrial private timberland and 96 percent of other public timberland were in primary forest zones[5] that had little or no nonforest development. In contrast, 53 percent of other private timberland was in low-density urban zones, and 2 percent was in urban zones. Timberland in the low-density urban and urban zones, on average, contained less timber volume per hectare (61 cubic meters per hectare) than that in the primary forest zone (186 cubic meters per hectare, table 5). The low-density urban and urban areas are more likely to grow hardwoods and contain fewer conifer seedling and sapling stands.

[5] Timberland is classified by three forest zones to reflect the influence of other land uses (Oswald 1984); for example, the primary forest zone is characterized by large continuous tracts with little or no nonforest development.

Table 5—Mean timber volumes of non-Federal lands among the different land use zones in western Oregon, 1985

Land use zone	Area total	Softwood	Hardwood	Overall
	Percent	*- - - - - Cubic meters per hectare - - - - -*		
Forest	55.3	149.5	36.0	185.5
Agriculture	34.6	43.5	23.4	66.9
Low-density urban	6.4	40.2	20.7	60.9
Urban	3.7	7.6	1.9	9.4

On forest industry owned lands, timberland area declined within the low-density urban zone and stayed the same in the urban zone during the period 1975-85. More than 90 percent of the forest on industrial timberland was located in primary forest zone, compared to less than 50 percent for other private landowners (fig. 3). Whereas 43 percent of nonindustrial timberland was located in agriculture zones, it was 5 percent for industrial timberland in 1975. The percentages increased to 44 percent and 7 percent, respectively, by 1985.

General relations between the condition of timberland and land use zones in western Oregon appeared similar to what Oswald (1984) found for western Washington. The timber resource in the urban and low-density urban zones tended to differ from that in the primary forest zone in some notable aspects. Whereas conifer stands predominated in the primary forest zone, the low-density urban and urban areas were more likely to grow hardwoods. Within the primary forest zone, timberland in forest industrial lands have higher timber volumes in softwoods, lower timber volumes in hardwoods, and higher overall timber volumes than that in the other private lands according to the 1984-86 survey.

The total forest area involved in ownership changes generally has been larger than the area of land changing uses. Exchanges of land among ownerships has implications for how that land may be managed. The largest area of ownership change occurred on lands owned by NIPF owners. These have involved more than 5 percent of the NIPF timberland base in each of the survey periods.

Land exchanges among private owners have been more common than exchanges between public and private owners (table 6). There was a net shift of 309 000 hectares from NIPF owners to forest industry owners between 1961 and 1994, an average annual rate of >9000 hectares. The rate of change, however, was greater between the 1961-63 and 1973-76 inventories, with an average annual rate of 12 281 hectares, than between the 1973-76 and 1984-86 inventories, with an average annual rate of <7000 hectares. The average annual rate between 1984-86 and 1994 was slightly more than 7000 hectares. The net gain of industry lands from NIPF sources was about 252 000 hectares in western Oregon from 1961 to 1994 because a total of 56 000 hectares of industry lands changed to NIPF ownership during the same period.

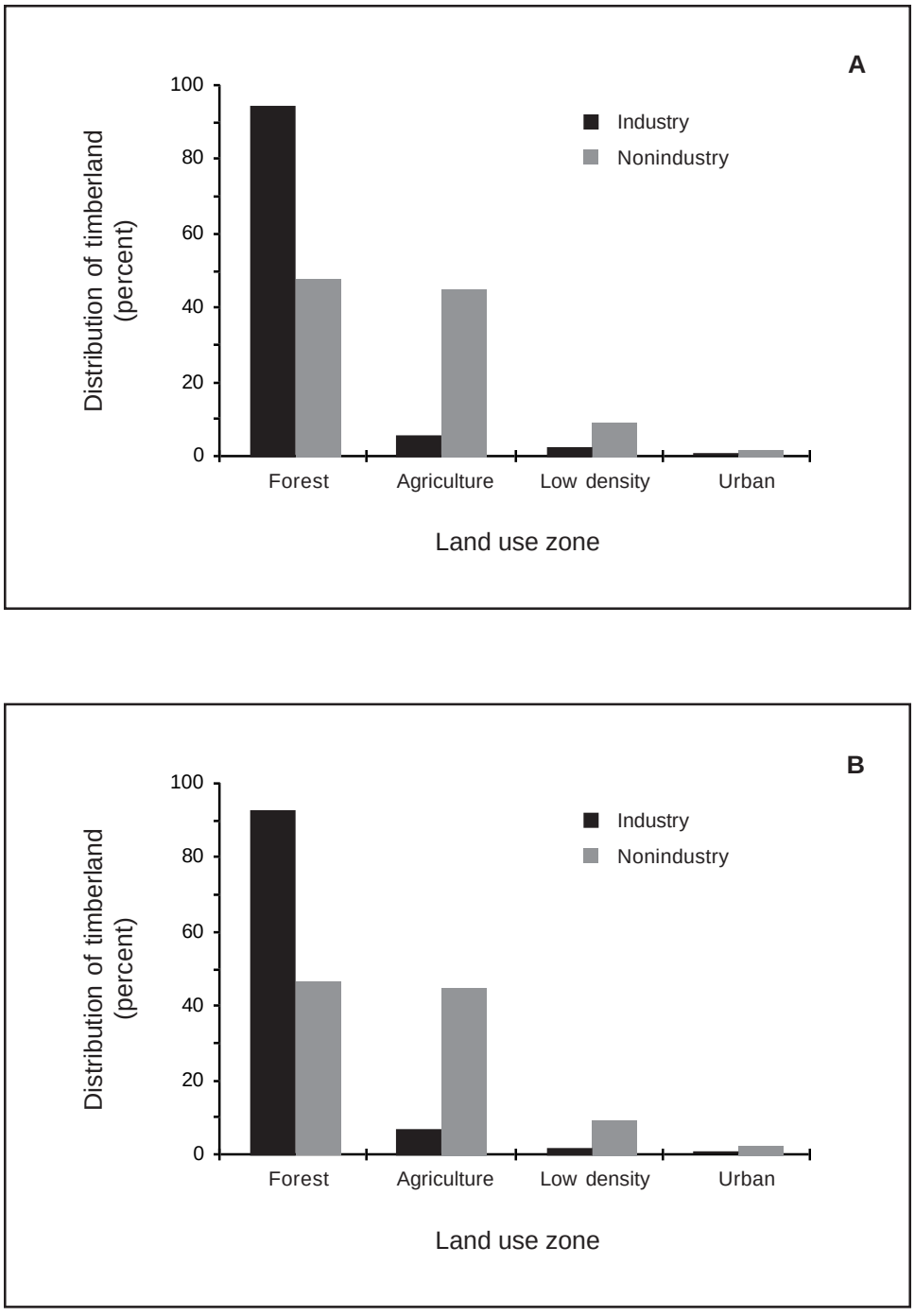

Figure 3—Distribution of timberland in different land use zones by ownership between (A) 1975 and (B) 1985.

Table 6—Exchange of land ownership (accumulated percentage of area) in western Oregon, 1961-63 to 1973-76, 1973-76 to 1984-86, and 1984-86 to 1994

Status	Forest industry	Other private	State and local	Federal
	- - - - - - - - - - - - - - - - *Percent* - - - - - - - - - - - - - - - -			
1961-63:			**Status 1973-76**	
Forest industry	98.9	1.0	0.0	0.1
Other private	8.7	90.6	.3	.4
State and local	1.5	1.6	96.9	.0
1973-76:			**Status 1984-86**	
Forest industry	99.2	0.8	0.0	0.0
Other private	6.2	93.3	.5	.0
State and local	3.3	.0	96.2	.5
1984-86:			**Status 1994**	
Forest industry	97.5	1.6	0.2	0.7
Other private	5.6	93.4	.3	.8
State and local	.0	.0	99.1	.9

Rates of Forest Management

Percentages of private timberland area that were harvested or otherwise treated between 1973-76 and 1984-86, by ownership and major forest type, are displayed in table 7. Overall rates of clearcutting were higher for forest industrial owners than for NIPF owners over that period. The same trend existed between 1984-86 and 1994 with lower rates. The rates of other types (including partial, incidental, and firewood harvests), however, were much higher for NIPF lands than for industrial forest lands for both two-survey periods, 1973-76 to 1984-86 and 1984-86 to 1994. Overall, harvested forest accounted for a higher percentage (27) in NIPF lands than 21 percent in industrial lands because of a much higher rate of other harvest type (table 7). Within the other harvest type, partial harvest method was prevalent. As a result, incidental harvest or firewood harvest represented only 2.2 and 4.6 percent of total harvests on forest industry and NIPF lands, respectively, between 1973 and 1994.

Table 7 also displays the percentage of timberland treated under four different treatment classes: no treatment, thinning (with precommercial and commercial shown separately within that column), planting, and other treatments. Forest industry owners treated a higher percentage of their total timberland than NIPF owners did, 30 percent compared to 14 percent for Douglas-fir and 22 percent compared to 7 percent for overall. Cultural treatments were applied most often to the commercially preferred Douglas-fir type, both by industry and nonindustrial private land owners. Thinning of stands was the cultural treatment most frequently applied.

Table 7—Accumulated percentage of area in western Oregon that was treated or disturbed by broad management and ownership classes, 1973-76 to 1984-86, and 1984-86 to 1994

Status forest type and ownership classes	Harvest types			Cultural treatments[a]			
	No harvest	Clearcut	Others	No treatment	Thinning[b]	Planting	Others
				Percent			
1973-76				**Status 1984-86**			
Douglas-fir:							
Forest industrial	77.7	16.2	6.0	70.4	13.1 (1.8)	13.6	1.1
Other private	74.2	10.1	15.7	85.7	2.6 (4.6)	4.8	2.4
Western hemlock:							
Forest industrial	65.5	34.5	0	83.7	8.6 (0.)	7.7	0
Other private	31.7	68.3	0	100.0	0	0	0
Other softwood:							
Forest industrial	82.1	9.6	8.2	93.5	5.1 (1.4)	0	0
Other private	64.0	10.6	25.4	100.0	0	0	0
Red alder:							
Forest industrial	82.9	15.0	2.1	95.3	0	0	4.3
Other private	74.5	19.8	5.9	97.4	0	2.6	0
Other hardwood:							
Forest industrial	82.8	7.5	9.7	81.4	0	5.6	13.0
Other private	76.7	5.5	17.7	94.7	0	3.7	1.6
Overall:							
Forest industrial	78.9	15.3	5.9	8.1	8.9 (1.3)	9.2	2.5
Other private	73.4	11.3	15.2	92.6	1.0 (1.8)	3.5	1.4
1984-86				**Status 1994**			
Douglas-fir:							
Forest industrial	80.0	12.6	7.3				
Other private	81.3	7.8	11.0				
Western hemlock:							
Forest industrial	85.5	14.5	0				
Other private	41.2	38.0	20.8				
Other softwood:							
Forest industrial	96.3	0	3.7				
Other private	84.8	4.4	10.8				
Red alder:							
Forest industrial	95.2	4.8	3.7				
Other private	87.7	4.4	8.0				
Other hardwood:							
Forest industrial	86.7	5.8	7.6				
Other private	88.2	0	11.8				
Overall:							
Forest industrial	83.7	10.6	5.4				
Other private	84.0	5.1	11.0				

[a] Cultural treatment data are not available for the 1994 interim update.
[b] Percentage indicated in parenthesis is for commercial thinning, otherwise, for precommercial thinning.

Relations Between Urbanization and Land Location and Topography

We examined spatial patterns of urbanization and their relation to topography between 1975 and 1985 in the coastal landscape analysis and modeling study (CLAMS)[6] area. The area was selected because most of the State's population is concentrated in western Oregon, and continued urbanization is expected in the area. Our analyses showed that, overall, 1.4 percent of land changed from one category to another during the 10-year period. The major conversions were from (1) agriculture to low-density urban area (0.6 percent), (2) forest to agriculture (0.4 percent), and (3) low-density urban to urban area (0.3 percent). Urbanization accounted for more than two-thirds of the total change during the period. Spatially, most of these conversions were around metropolitan centers, such as Portland, Salem, and Eugene along the I-5 corridor, as well as in the Coos Bay area, in Oregon (fig. 4).

Topograhy is important in land allocation decisions in western Oregon (Parks and Murray 1994). Our results indicated that forest land often is found on the steeper slopes. Mean slope values in degree are 1.3 for urban, 2.1 for low-density urban, 3.3 for agriculture, and 10.2 for forest (fig. 5). More than 65 percent of urban lands, 52 percent of low-density urban areas, 45 percent of agricultural lands, and 11 percent of forest lands were located in places with slope of less than 1 degree. About 23 percent of forest lands, 2 percent of agricultural lands, 1 percent of low-density urban areas, and 0.4 percent of urban areas were located in places with slope greater than 15 degrees. Information on location by slope class can provide insights into harvesting costs for timber (Bettinger and Alig 1996, Bettinger and Kellogg 1993), as well as the percentage of areas that may be prone to landslides and mudslides, and other landscape management concerns.

Discussion

The patterns of clearcut and partial harvest are thought to be affected by different socioeconomic variables, as well as the response of private owners to forest practice regulation. Stone (1995) reported that forest industry has a higher clearcut frequency than for NIPF lands in the north coast area, and his industrial model has higher explanatory power and reflects economic incentives (e.g., changes in log prices, discount rates) as well as sensitivity to level-of-growing-stock inventory.

One possible factor behind the significant difference in conversion rates from forest land to urban use before and after the 1973-76 survey is the enactment of Oregon's land use laws in the early 1970s. Note that the estimates in table 1 indicate that conversion of agricultural land to urban uses also slowed after passage of the land use laws in the early 1970s, consistent with findings by Daniels and Nelson (1986).

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[6] The CLAMS project is a large-scale ecosystem study involving investigation of forest succession, land use change, aquatics biodiversity, and socioeconomic factors influencing dynamics in the Oregon Coast Range.

Figure 4—Spatial patterns of land conversions from other uses to urban development areas in the coastal landscape and modeling study area, Oregon, 1975-85.

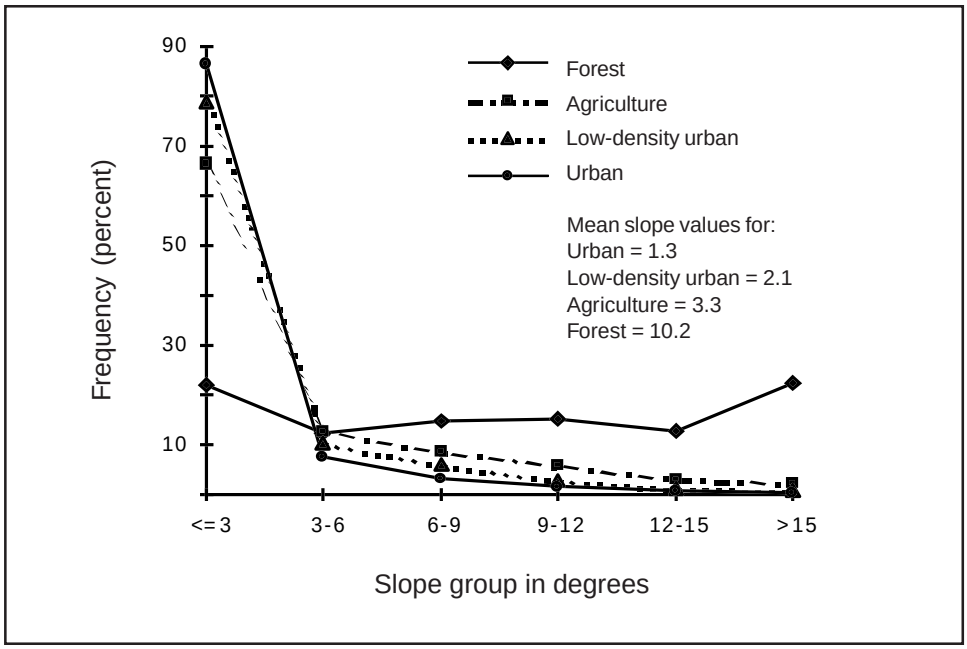

Figure 5—Frequency distribution of slope (degrees) in different land use zones in the CLAMS area.

Another disturbance-related question is whether the prospect of additional future forest regulations may cause some private owners to harvest sooner than originally planned. Given the relatively rapid changes in the forest policy setting in the Northwest, Johnson and others (1997) surveyed NIPF owners to gain a better understanding of owner responses to possible changes in public policy. Survey results indicated that most owners were not likely to harvest sooner. Those owners having larger holdings, however, were more likely to harvest sooner in response to the prospect of additional regulations, and these owners control a large portion of the NIPF timberland base. More frequent harvests imply a larger area of disturbance in the future, which may be counter to regulations intended to protect ecosystems. The Johnson and others (1997) survey also indicated that partial cutting is used more often than clearcutting by NIPF owners, with one possible reason being an attempt to reduce reforestation costs in view of forest practice regulation.

The future amount of timberland area will be impacted by several factors, including factors outside the forest sector such as increases in population and economic activity in other sectors (Alig and others 1990). Oregon's land use law and reforestation requirements both act to maintain land in trees. Oregon has some of the most well-developed forest practice regulations in the country. As with public land management, regulations affecting private forest lands continue to evolve (Oregon Department of Forestry 1992). Private landowners are required to reforest harvested areas if they reduce stocking below established thresholds that differ based on the relative productivity of the land. Foresters with the Oregon Department of Forestry perform compliance checks. For example, any operation on site classes I, II, or III that reduce the stocking to less than the combined equivalent of 494 free-to-grow seedlings per hectare, 297 free-to-grow saplings or poles per hectare, or 18.4 square meters of basal area per hectare must be reforested to the minimum standard.

Expansion of urban and developed areas into adjacent forest lands is affecting forest resources in the I-5 corridor in at least three notable ways (Alig and Healy 1987, Bradley 1984). First, some forest land is being converted to building sites, street networks, and other nonforest use. Second, the long-term future of forest land near developed areas, especially at the fringes of certain urban growth boundaries, is uncertain. Such areas are less attractive to investors in long-term timber production that may require at least several decades for just one timber rotation, but may be more attractive to developers. Investors may be waiting for land values to "ripen," and speculations regarding future development may result in higher land values, along with higher property taxes. Third, new urban owners may be more concerned with the amenity value of forest land than with its potential for commodity production. Conflicts also can arise among residents or neighbors of forested areas and those managing the land for commodity production or protecting it from fire or other hazards. Externalities affecting forest neighbors may be either positive (e.g., recreational value of nearby forested property) or negative (e.g., neighbors object to certain forest management practices such as prescribed burning).

The physical nature of the land influences the costs and benefits of land management, how silvicultural treatments might affect other forest resources and services, and the social acceptance of various land management alternatives and treatments. We showed that forests tend to occupy steeper slopes, an important physical accessibility consideration for realizing treatment opportunities. According to Bettinger and Kellogg (1993), slopes of 30 percent or less are potentially accessible for ground-based, in-woods mechanization, thereby suggesting that most of the timberland in western Oregon is suitable for such ground-based operations.

The conversion of forest land can often lead to more fragmented forest landscapes. For example, although suggesting that human-induced fragmentation of Pacific Northwest forests is increasing, McGarigal (1993) pointed out that the consequences of such landscape changes to vertebrate communities were not well understood. In western Oregon, McGarigal found that relations between bird abundance and landscape structure are generally weak and that most species are positively associated with more fragmented habitats. In a 260 000-hectare study area of western Oregon, Spies and others (1994) found that the percentage of conifer forest declined from 71 to 58 percent between 1972 and 1988. Declines were greatest on private land, least in wilderness, and intermediate in public nonwilderness. The lands were more fragmented on private land than on public land.

Increases in urbanization and development warrant greater attention in land use and forest resource inventories. Inventories could be usefully augmented to more closely assess how trends in land use and development change over time. As part of the ongoing PRIME inventory occasion 4 for western Oregon, the Oregon Department of Forestry and Pacific Northwest Research Station are cooperating to improve data collection pertaining to land use zones (Dunham 1996). For example, a new system is being designed that will record the attributes used to determine a land use classification, which should provide information about variation within categories. The information is intended to aid in the study of the effects of land use planning on resource utilization and on development trends. The PRIME occasion 4 information, whenever available, will allow related land use and disturbance estimates in this paper to be updated and facilitate an assessment of whether trends noted here have changed.

Further research is needed on how physical characteristics such as distance to roads, rivers, and metropolitan centers, as well as socioeconomic factors influence the conversion of land use from one category to another. A major limitation of using a spatially explicit modeling approach for a land use change study is the lack of detailed information with which to characterize socioeconomic variables for a given pixel or plot because most socioeconomic data are obtained on a broad scale.

Another research gap that remains is a set of tools for multiscale policy analysis. This information is particularly important from a landscape-analysis perspective in western Oregon where the primary forest disturbance regime in the last 100 years has been timber harvesting. Stated in terms of past approaches, the gap is the modeling link between aggregate analysis of land use changes and the likelihood of disturbance for spatially defined areas in the region. For example, robust methods are needed for disaggregating regional projections of land use change down to local levels. This information could then be used in further analyses of watersheds, wildlife habitat, vegetation modeling, and other spatially dependent analyses. In short, no known studies to date have integrated dynamic, behavioral land use analyses that reflect higher level market processes with spatially explicit analyses. The primary research problem is to examine spatial aspects of land use change in sustainability analyses. This type of model would be particularly useful for assessing the probable location of timber harvests with respect to the locations of other forest values such as scenic corridors, threatened and endangered wildlife species, and sensitive watersheds.

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Metric Equivalents

1,000 acres = 404.7 hectares
1,000 cubic feet = 28.3 cubic meters

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Appendix: Sampling Procedures

The Pacific Resource Inventory, Monitoring, and Evaluation (PRIME) Program, formerly the Inventory and Economics Research, Development, and Application Program, of the Pacific Northwest Research Station in Portland, Oregon, is responsible for inventories in Alaska, California, Hawaii, Oregon, and Washington. The PRIME inventories are part of a nationwide project of the U.S. Department of Agriculture, Forest Service, authorized by the Forest and Rangeland Renewable Resources Research Act of 1978. Work units, located at Forest Service research and experiment stations, conduct forest research.

Glossary

County and municipal lands—Lands owned by county and other local public agencies.

Crop land—All land in the crop rotation, including crop land used for crops, idle crop land, and crop land used for pasture only.

Even-aged—Stands where 70 percent or more of the stocking falls within three adjacent 10-year age classes.

Farmer-owned lands—Lands owned by the operators of farms.

Forest industry lands—Lands are owned by companies for the purpose of timber growing, including companies that either possess 2023.5 hectares or more or have more than 10 employees on a year-round basis.

Forest land—Land at least 10-percent stocked by live trees, or land formerly having such tree cover and not currently developed for nonforest use. The minimum area recognized is 0.4 hectare.

Forest types—Stands with 70 percent or more of the stocking in live conifer trees classed as pure softwood types; stands with 50 to 69 percent of the stocking in live conifer trees classed as softwood-hardwood types. Stands with 70 percent or more of the stocking in live hardwood trees classed as pure hardwood types; stands with 50 to 69 percent of the stocking in live hardwood trees classed as hardwood-softwood types. The specific forest type reflects the individual species of live softwood or hardwood tree with the greatest total stocking.

Hardwoods—Nonconiferous trees, usually broad leaved.

Industrial wood—All commercial roundwood products except fuelwood.

Land area—Area reported as land by the Bureau of the Census (MacLean 1990). Total land area includes dry land and land temporarily or partially covered by water such as marshes, swamps, and river flood plains; streams, sloughs, and canals less than 201 meters wide; and lakes, reservoirs, and ponds less than 16.2 hectares in area.

Land class—A classification of land by major use. The minimum area for classification is 0.4 hectare.

Low-density urban—Forest or agricultural land with more than eight developments per section. Subdivision with lot sizes greater than 0.4 hectare.

Miscellaneous Federal lands—Federal lands other than lands administered by the Forest Service.

Miscellaneous private owners—All private owners not otherwise classified.

National Forest lands—Federal lands that have been designated by Executive order or statute as National Forest or purchase units and other lands under the administration of the USDA Forest Service, including experimental areas and Bankhead-Jones Title III lands.

Native American lands—Tribal and allotted lands held in trust by the Federal Government. Native American lands are grouped with farmer and miscellaneous private lands as other private lands.

Nonforest land—Land that has never supported forests or formerly was forested and currently is developed for nonforest uses. Included are lands used for agricultural crops, Christmas tree farms, improved pasture, residential areas, city parks, constructed roads, operating railroads and their right-of-way clearings, powerline and pipeline clearings, streams more than 9.1 meters wide, and 0.4- to 16.2-hectare areas of water classified by the Bureau of the Census, U.S. Department of Commerce, as land. If intermingled in forest areas, unimproved roads and other nonforest strips must be more than 36.4 meters wide, and clearings or other areas must be 0.4 hectare or larger to qualify as nonforest land.

Nonstocked areas—Timberland less than 10-percent stocked with live trees.

Other forest land—Forest land incapable of growing 1.4 cubic meters per hectare per year (mean annual increment at culmination) of industrial wood because of adverse conditions such as sterile soils, dry climate, poor drainage, subalpine sites, steepness, or rockiness.

Other land uses—Nonforest, marsh, roads, pipelines, canals, powerlines, and railroads, but also contains barren areas (e.g., rock) and streams 10 to 35 meters wide.

Other private lands—Private lands not owned by forest industry. Native American lands, farmer-owned lands, and miscellaneous lands held by individuals or by companies holding forest lands for reasons other than timber production are included.

Other public lands—Lands administered by public agencies other than the USDA Forest Service. Other public lands do not include Native American lands, which are included with other private lands.

Pasture land—Improved pasture, natural rangeland, or abandoned farmland.

Reserved timberland—Land capable of growing 1.4 cubic meters or more per hectare per year (mean annual increment at culmination) but withdrawn from timber utilization through statute, ordinance, or administrative order.

Site class—A classification of the potential productivity of forest land expressed as mean annual increment at culmination.

Site index—A measure of the productivity of forest land expressed as the average height of dominant and codominant trees at a specified age.

Softwoods—Coniferous trees, usually evergreen, with needles or scalelike leaves.

Stand age—The 10-year age class that best characterizes the stand. See “Even-aged” and “Uneven-aged” for more detail.

Stand-size class—A classification of stands based on tree size. Stand-size classes are sawtimber, poletimber, and sapling and seedling stands.

State lands—Lands owned by states or administered by state agencies.

Timberland—Forest land capable of growing 1.4 cubic meters or more per hectare per year (mean increment at culmination) of industrial wood and not withdrawn from timber utilization.

Uneven-aged—Stands where less than 70 percent of the tree stocking falls in three adjacent 10-year age classes.

Urban use—Subdivided areas of at least 16.2 hectares. City road patterns and closely spaced buildings are indicators of the urban zone in PRIME analyses.

Zheng, Daolan; Alig, Ralph J. 1999. Changes in the non-Federal land base involving forestry in western Oregon, 1961-94. Res. Pap. PNW-RP-518. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

Temporal and spatial analyses of land use changes on the non-Federal lands in western Oregon between 1961 and 1994 were conducted. Two distinct changes in the region were a loss of forest lands and an increase in urban areas. Neither the rates of change over time nor the spatial distribution of land converted to urban use was evenly distributed in the region. The influence of socioeconomic factors, such as ownership, population growth, and personal income, as well as physical factors of land such as slope and location, on land use changes also was examined.

Keywords: Land use change, forestry, urban development, periodic surveys, temporal and spatial analyses.

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