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Changes in Land Use and Housing on Resource Lands in Washington State, 1976–2006

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Cover photograph: Agricultural area near Sequim, Washington, with recent urbanization and dispersed housing development in the nearby forest. Photo by Andrew Gray.

Abstract

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Changes in human land use patterns have wide-ranging social, economic and ecological implications. How urban and residential areas develop to accommodate population increase can have varying effects on forest and agricultural production from resource lands. Estimates of the amount and type of land use change differ substantially with definitions and analytical methods used. The purpose of this study was to apply a robust manual image classification method to assess changes in land use and housing density across Washington state for a 30-year period. Digital imagery from 1976, 1994, and 2006 was classified to land use, classifications were assigned to a systematic-random grid of 44,554 photointerpretation points on nonfederal lands, and houses were identified within 80-ac circles around each nonurban point. Population in the state increased by 2.5 million people (66 percent) over the 30-year period, during which time 1.16 million acres were converted from forest and agriculture land use classes to residential and urban land uses. The greatest changes were in western Washington, where forest lands declined at a rate of 0.2 percent per year and intensive agricultural lands declined at a rate of 0.7 percent per year. Twenty percent of nonfederal land in western Washington was in developed land uses in 2006. The density of housing structures on lands that remained in forest and agricultural land uses also increased over the period of interest, particularly in areas close to developed land uses. The rate of housing increase on resource lands was greater from 1994 to 2006 than from 1976 to 1994 in eastern Washington, but declined in western Washington. This method of assessing land use change compared favorably with other approaches, and had the advantage that it could be applied consistently to a longer period of time and allowed detailed assessment of patterns at local scales.

Keywords: Land use change, housing density, image classification, forestry, agriculture.

Introduction

The amount and spatial pattern of human land use on the landscape have many social, economic, and ecological implications. These patterns change as the basis of local economies, regulation, and human population change. Common causes for these changes are peoples' responses to economic opportunities, as mediated by institutional factors; for example, it may be a better investment to build houses than grow trees (Lambin et al. 2001). A common concern with current land use change in the United States is with the growth of housing and its effects on traditional economic production from rural lands (Kline et al. 2004, Wear et al. 1999) and on natural habitats and the ecosystem services they provide (Alig and Plantinga 2004, Brown et al. 2005, Radeloff et al. 2010). The obvious effect of land use conversion is magnified when rural or forested areas give way to urban uses, because the ecological function of the surrounding areas can also be affected (Gimmi et al. 2011). The area where such conversion is taking place is often called the wildland-urban interface (WUI). In Washington state, 66 percent of the net housing unit growth in the 1990s was in the WUI (Hammer et al. 2007).

In response to these concerns, some states in the Western United States have established planning efforts to develop land use plans, often at the county or multicounty level, to guide the location and nature of development. Consideration is usually given to preferred rural land uses, housing density in new developments, and dispersal of new residences in an area. In Washington, the Growth Management Act of 1990 required counties to adopt comprehensive plans and regulations to plan for and address the impacts of growth. The goals of county land use plans included conserving farm and forest land, reducing suburban sprawl, providing for open space and recreation, and sustaining natural-resource-based industries. In 2007, the state legislature prioritized the acquisition of valuable timberlands in danger of conversion to keep them in productive status.

Most of Washington's population is found west of the crest of the Cascade Mountains. Monitoring of field plots by the U.S. Forest Service Forest Inventory and Analysis (FIA) program detected rapid conversion of forest land to nonforest land uses in western Washington in recent decades, with 5 percent of private timberland (270,000 ac) being converted between 1990 and 2000 (Gray et al. 2005), and a similar rate of loss in the previous decade (MacLean et al. 1992). These estimates are reliable because they are based on field measurements of a systematic sample of points on the landscape. However, with a density of sample points of one per 7,400 ac and a 10-year remeasurement period, the field plots do not allow for accurate estimates at spatial or temporal scales smaller than several counties over

several years. The inventory plot measurements also do not provide information on housing density in rural areas and their changes over time.

An alternative approach assessed impacts of land use on management of forested plots in western Washington by delineating land use of surrounding areas on aerial photos (Oswald 1984). This approach was expanded by attributing the land use zone of thousands of photointerpretation points (roughly one point per 475 ac) at two points in time to describe changes in land use (MacLean and Bolsinger 1997). In recent years, this approach has been expanded, refined, and improved with the use of geographic information systems (GIS) and digital photography, allowing evaluation of changes over multiple time periods to assess the effectiveness of land use policy (Cathcart et al. 2007, Kline et al. 2004, Lettman et al. 2011).

It is important to distinguish land use from land cover. Areas in forest land use are periodically harvested (e.g., clearcut) and have little or no tree cover for several years. Alternatively, areas in urban or farm use may have substantial tree cover. Although land cover can be classified fairly well with coarse resolution satellite imagery (e.g., Homer et al. 2004, Powell et al. 2008), interpreting land use can be problematic. For example, distinguishing clearcuts from new developments and whether shrubby areas are young forests or brush fields can lead to errors in interpreting land use (e.g., Kline et al. 2009). Census estimates of population change have also been useful in assessing land use change, often in concert with analyses of satellite imagery (Northwest Environment Watch 2002, Radeloff et al. 2005), although they are often limited by the size of the census blocks and by image classification errors.

Fragmentation is an important attribute of forest area that has implications for the practicability and social acceptability of timber management, risk of homes to wildfire in the WUI, the spread of undesirable invasive plants and animals, and the quality and amount of habitat. One aspect of fragmentation and land use change that can be difficult to assess is the construction of dispersed home sites in forest land and other resource lands. Although the physical footprint of such houses can be relatively small and difficult to detect with satellite imagery, the social, economic, and environmental impact can be quite large. For example, residents may object to industrial forestry practices on adjoining lands, or domestic pets may harass or kill wildlife in surrounding lands.

The objectives of this study were to describe the amount and distribution of different land uses and housing structure densities in Washington and their changes from 1976 to 2006. We used the established methods reported in Lettman et al. (2011) and compared our results with estimates derived from other studies.

Methods

Study Area

The study area consisted of all 39 Washington counties, which are grouped in some analyses into five areas: Puget Sound, Olympic Peninsula, and southwest Washington west of the crest of the Cascade Mountains, and Central and Inland Empire east of the crest of the Cascade Mountains (fig. 1). Many other analyses summarize information by areas east and west of the Cascades. Elevations range from sea level to more than 14,000 ft, with most of the human population in the low elevations along the Puget Sound, Pacific coast, or lower Columbia Valley on the west side, and along the Columbia, Yakima, or Spokane River valleys on the east side. Most of the land area on the west side can support forest vegetation, except for high elevations with long-lasting winter snowpacks. On the east side, most forest vegetation is found in the higher elevations above the Columbia Plateau and major river valleys. A 12.2-million ac portion of the Columbia Basin was traditionally considered the “nonforest zone” in past FIA analyses, and consisted of most or all of Adams, Benton, Douglas, Franklin, Grant, Lincoln, Walla Walla, and Whitman Counties.



Figure 1—Washington study area with the 39 counties identified and grouped into five regions for analysis.

The lands in Washington are managed by a variety of owners and agencies. Although summaries of land use across all owners are provided, the analyses of land use change excluded lands managed by the U.S. Forest Service and National Park Service because their mandate was to maintain natural land cover, and any development (e.g., for ski areas or visitor facilities) was relatively small in area. Lands managed by these two agencies are referred to as “federal.” All other lands are referred to as “nonfederal,” although scattered areas amounting to 4.0 percent of the land area were managed by other federal agencies (81 percent of that was east side nonforest land). These other federal lands were included with state and local government lands in the “other public” owner group. The remaining nonfederal lands were managed by state and local government, forest industry, and other private owners, including Native American tribes. Although changes in ownership between national forest and other owner groups did occur during the period of interest, they were small compared to the changes in land use (Gray et al. 2005, 2006). For simplicity, land ownership as determined for the 1990 forest inventories of eastern and western Washington (MacLean et al. 1992, McKay et al. 1995) was used for all analyses. For these inventories, private landowners were classified as being either forest industry (i.e., with large landholdings and intensive management) or “other private” (which included lands managed by Native American tribes).

Land Classification

The land use classes used for this study were the same categories used for the studies of land use change in Oregon (Lettman et al. 2011). Land use classes were defined by a combination of land cover, density and spatial pattern of human structures, road density, and the amount of area in contrasting, contiguous land uses. Small areas of apparently different land use could be included in an overall land use polygon. The term “structure” is meant to represent individual dwellings, thus multiple associated buildings were counted only once. For example, an adjoining rural house, barn, shed, and pumphouse would all count as a single structure. Examples of land use types are shown in figures 2 and 3. Land use class definitions were:

Wildland forest: Polygon $\geq 1 \text{ mi}^2$ (640 ac); structures (if any) were scattered across the area; >80 percent of the area was forest land and included managed and unmanaged lands.

Wildland range: Polygon $\geq 1 \text{ mi}^2$; structures (if any) were scattered across the area; <51 percent of the area was forest land; <20 percent was agricultural land, and the remainder was nondeveloped rangeland and included managed and unmanaged lands.

Mixed forest/agriculture: Polygon ≥ 1 mi²; structures were scattered across the area; 20 to 80 percent of the area was agricultural; and forest land was ≥ 50 percent of the remainder. Improved roads were typically $\frac{1}{2}$ mile apart or more.

Mixed range/agriculture: Polygon ≥ 1 mi²; structures were scattered across the area; 20 to 80 percent of the area was agricultural; and rangeland was ≥ 50 percent of the remainder. Improved roads were typically $\frac{1}{2}$ mi apart or more.

Intensive agriculture: Polygon ≥ 1 mi²; structures were scattered across the area; >80 percent of the area was agricultural.

Low-density residential/commercial: Polygon of any size, but must have had at least nine structures within it. Housing developments were generally less than 80 ac. Improved roads were typically $\frac{1}{4}$ mi apart or less. House lots were usually >1 ac. The polygon could have also met urban qualifications but was <40 ac.

Urban: Polygon ≥ 40 ac, consisting of commercial, service, or residential subdivided area with city road patterns and closely spaced buildings. House lots were usually <1 ac.

Other: Polygon ≥ 640 ac, consisting of lava, sand, reservoirs, lakes, and mountaintop rock, snow, and ice.



Figure 2—Example of land use class classification on aerial photography of western Washington, illustrating the differences in housing density, road patterns, and land cover patterns used to delineate class boundaries.

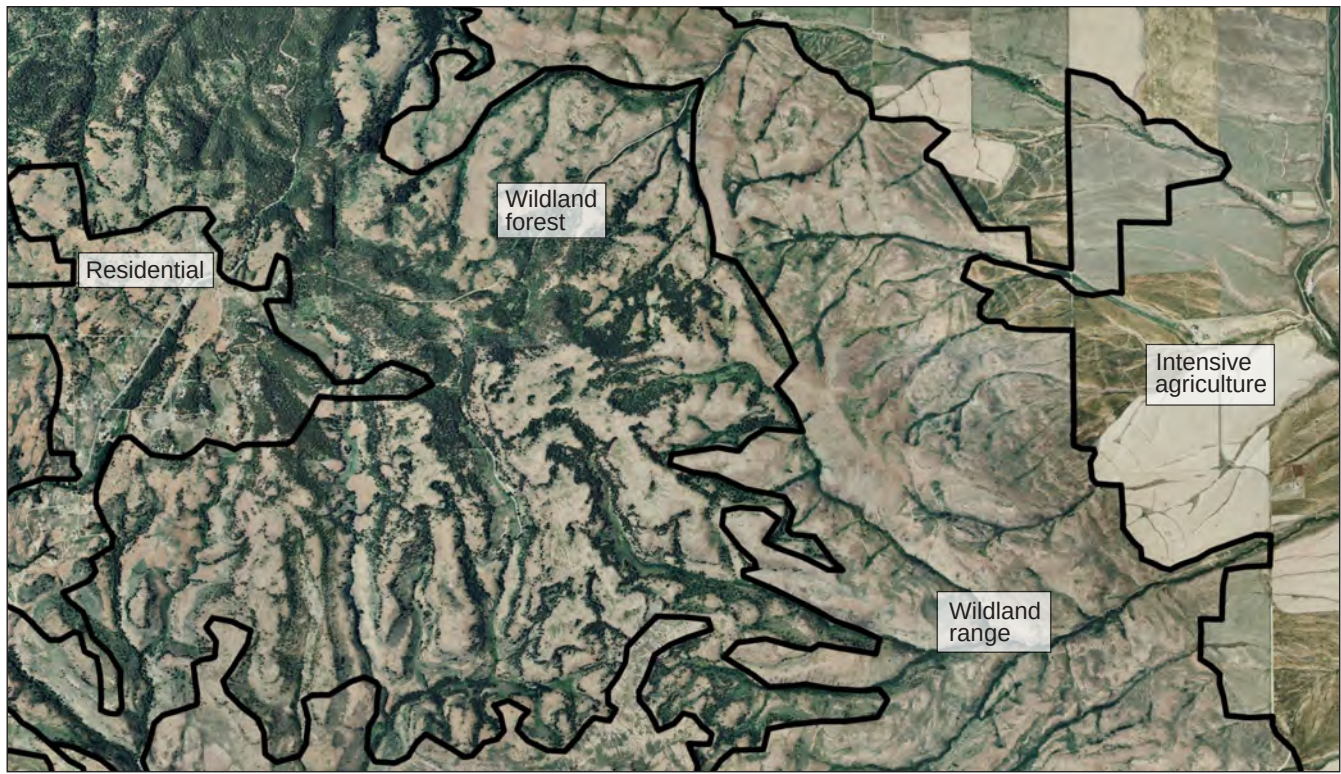


Figure 3—Example of land use class classification on aerial photography of eastern Washington, illustrating the differences in housing density, road patterns, and land cover patterns used to delineate class boundaries.

In some analyses, the wildland forest, wildland range, mixed forest/agriculture, mixed range/agriculture, and intensive agriculture classes were identified as “resource lands” and low-density residential/commercial and urban classes were identified as “developed areas.” Although structure density was included as a criterion in the land use definitions for resource land classes, the apparent land use was the overriding factor. There were many cases in western Washington where structure densities were greater than eight structures per square mile, but the land cover indicated resource use, and the road density and scattered housing did not meet the low-density residential definition.

Golf courses, industrial parks, airports, maintained parks, mills or other industrial complexes, quarries, and dams adjacent to or within $\frac{1}{4}$ mile of an urban class were included in the urban class. However, if these uses were not within $\frac{1}{4}$ mile of an urban class and were ≥ 40 ac, they were classified as low-density residential; if < 40 ac, they were not distinguished from the surrounding area.

Imagery and Image Interpretation

The imagery used for this study was based on aerial photography, which was either captured digitally or digitized and georeferenced afterward. The imagery for the first time period was based on Washington Department of Natural Resources aerial photographs from three different projects. The Olympic Peninsula and northwest Washington photos were natural color at a scale of 1:24,000. In southwest Washington, black and white photos at a scale of 1:40,000 were used. Photos for this time period were not available for the “nonforest zone” in eastern Washington. Almost all of the west side photos were taken in 1976, while the east side photos ranged from 1970 for the southeast corner of the state to 1978 with an overall east side mean of 1976. The photos were digitally scanned at a resolution of 1,200 pixels/in² and georegistered in a geographic information system (GIS) using recognizable points and existing registered imagery from later dates. The imagery for the second time period consisted of 1-m-resolution black and white imagery from the National Digital Ortho Program and acquired from the U.S. Department of Agriculture (USDA) Farm Service Agency, Aerial Photography Field Office (Salt Lake City, Utah). Most images dated from the early 1990s, but ranged from 1989 to 2001, with average dates by county ranging from 1990 to 1995 (except 1996 for Yakima, 1997 for Pend Oreille, and 1998 for Wahkiakum Counties), with an overall mean date of 1993.8 (nominal year of 1994 was used for results). The imagery for the last time period consisted of 1-m-resolution color digital imagery for the entire state from the National Agricultural Imagery Program taken in 2006, and also acquired from the Farm Service Agency.

Land use class polygons were delineated in GIS over displayed imagery for different dates. Multiple interpreters worked on the project and checked each other’s work. In addition, interpreters worked on different counties for different time periods, providing another check as areas were assessed through time. Land use calls were assigned to a systematic-random grid of 44,554 photointerpretation points on nonfederal lands, with a density of one point per 462 ac, except for the 12.2 million acre eastern Washington “nonforest zone,” where the grid density was one point per 6,000 ac. Points were used to assess change in classes over time, calculate distances to different contrasting land uses, and count structures.

Structures were counted in 80-ac circles around each nonurban grid point, in effect sampling 17 percent of the nonurban classes. However, structures in urban classes were counted when point centers were in a different class, and conversely structures in nonurban classes were not counted if the grid point was urban. Structures were individually identified in GIS, which simplified and reduced errors in assessing changes in structures over time. Structures could also be identified with

the land use polygon they fell in, as well as with the land use status of the grid point. Analyses of these two approaches are distinguished by referring to density of structures in the 80 ac “around” points in land use classes vs. density of structures “in” different land use classes.

For points in urban land use at any time period, tree cover was estimated from imagery for a 2.5-ac circle surrounding each point. As a calibration method, crown outlines were delineated in GIS on a portion of high-resolution digital images, and area calculated to estimate cover. Cover was estimated visually on the remainder of the points.

We compared our land use classifications with the national land cover classification created from satellite imagery referred to as the National Land Cover Database (NLCD) (Homer et al. 2004). Points were intersected with the 30 m pixels in the NLCD 2001 database for Washington. Land cover categories and estimated tree cover values from NLCD were associated with each point and summarized by our land use classes.

Statistical Analyses

Most analyses were based on the land use classification of individual grid points and their changes over time, with each point assigned an area weight based on the number of grid points on nonfederal land in each county. Estimates for nonfederal land area were based on U.S. Census Bureau area figures and federal land ownership figures maintained by each agency. For grid points in the eastern Washington nonforest zone where imagery for 1976 was not available, the land use for the first time period was assumed to be the same as for the second time period (i.e., no change). Standard errors for estimates of area in different zones were calculated as in Lund and Thomas (1989), using standard equations for proportions of sample points in different classes. Structure density calculations used the grid point area weights (i.e., acres per point) as weights to account for the lower density of points in the nonforest zone. Calculations of rates of change were based on the mean decimal years between dates for the grid points in each cell being analyzed. All rates presented are the compound annual rates of change.

**Washington's
population increased
by 66 percent from
1976 to 2006.**

Results

Between 1970 and 2006, human population almost doubled (a 93 percent increase) in western Washington and increased by 66 percent in eastern Washington (USDC CB 2008; table 1). To match the image dates, interpolation between census figures resulted in an estimated statewide population of 3.84 million in 1976 and 5.3 million in 1994, with a 66-percent increase between 1976 and 2006. The largest increases in population occurred in the already populous counties in the Puget

Table 1—Human population in Washington by census year and county, and overall percentage of change

Area	County	Population					Change from 1970 to 2006	
		1970	1980	1990	2000	2006		
		----- Number -----					Percent	
Western Washington:								
Puget Sound	Island	27,011	44,048	60,195	71,558	80,857	53,846	199.3
Puget Sound	King	1,159,369	1,269,898	1,507,319	1,737,034	1,834,194	674,825	58.2
Puget Sound	Kitsap	101,732	147,152	189,731	231,969	238,827	137,095	134.8
Puget Sound	Pierce	412,344	485,667	586,203	700,820	763,670	351,326	85.2
Puget Sound	San Juan	3,856	7,838	10,035	14,077	15,144	11,288	292.7
Puget Sound	Skagit	52,381	64,138	79,555	102,979	114,495	62,114	118.6
Puget Sound	Snohomish	265,236	337,720	465,642	606,024	664,581	399,345	150.6
Puget Sound	Whatcom	81,983	106,701	127,780	166,814	188,775	106,792	130.3
Olympic Peninsula	Clallam	34,770	51,648	56,464	64,525	69,716	34,946	100.5
Olympic Peninsula	Grays Harbor	59,553	66,314	64,175	67,194	70,836	11,283	18.9
Olympic Peninsula	Jefferson	10,661	15,965	20,146	25,953	29,029	18,368	172.3
Olympic Peninsula	Mason	20,918	31,184	38,341	49,405	54,915	33,997	162.5
Olympic Peninsula	Thurston	76,894	124,264	161,238	207,355	233,167	156,273	203.2
Southwest	Clark	128,454	192,227	238,053	345,238	409,230	280,776	218.6
Southwest	Cowlitz	68,616	79,548	82,119	92,948	98,831	30,215	44.0
Southwest	Lewis	45,467	56,025	59,358	68,600	72,759	27,292	60.0
Southwest	Pacific	15,796	17,237	18,882	20,984	21,401	5,605	35.5
Southwest	Skamania	5,845	7,919	8,289	9,872	10,524	4,679	80.1
Southwest	Wahkiakum	3,592	3,832	3,327	3,824	3,949	357	9.9
Total		2,574,478	3,109,325	3,776,852	4,587,173	4,974,900	2,400,422	93.2
Eastern Washington:								
Central	Chelan	41,103	45,061	52,250	66,616	70,023	28,920	70.4
Central	Douglas	16,787	22,144	26,205	32,603	35,266	18,479	110.1
Central	Kittitas	25,039	24,877	26,725	33,362	37,981	12,942	51.7
Central	Klickitat	12,138	15,822	16,616	19,161	19,815	7,677	63.2
Central	Okanogan	25,867	30,663	33,350	39,564	39,231	13,364	51.7
Central	Yakima	145,212	172,508	188,823	222,581	230,840	85,628	59.0
Inland Empire	Adams	12,014	13,267	13,603	16,428	16,614	4,600	38.3
Inland Empire	Asotin	13,799	16,823	17,605	20,551	21,049	7,250	52.5
Inland Empire	Benton	67,540	109,444	112,560	142,475	157,549	90,009	133.3
Inland Empire	Columbia	4,439	4,057	4,024	4,064	3,964	-475	-10.7
Inland Empire	Ferry	3,655	5,811	6,295	7,260	7,495	3,840	105.1
Inland Empire	Franklin	25,816	35,025	37,473	49,347	66,138	40,322	156.2
Inland Empire	Garfield	2,911	2,468	2,248	2,397	2,118	-793	-27.2
Inland Empire	Grant	41,881	48,522	54,758	74,698	81,348	39,467	94.2
Inland Eempire	Lincoln	9,572	9,604	8,864	10,184	10,217	645	6.7
Inland Empire	Pend Oreille	6,025	8,580	8,915	11,732	12,664	6,639	110.2
Inland Empire	Spokane	287,487	341,835	361,364	417,939	447,392	159,905	55.6
Inland Empire	Stevens	17,405	28,979	30,948	40,066	41,293	23,888	137.2
Inland Empire	Walla Walla	42,176	47,435	48,439	55,180	57,609	15,433	36.6
Inland Empire	Whitman	37,900	40,103	38,775	40,740	41,404	3,504	9.2
Total		838,766	1,023,028	1,089,840	1,306,948	1,400,010	561,244	66.9
Washington total		3,413,244	4,132,353	4,866,692	5,894,121	6,374,910	2,961,666	86.8

Source: U.S. Department of Commerce, Census Bureau (2008); 2006 figures estimated.

Sound area (King, Pierce, and Snohomish Counties), although increases of more than 150,000 people also occurred in Thurston, Clark, and Spokane Counties. The average annual increase in population over the period was 80,000, with the greatest increases occurring between 1990 and 2000 with an average increase of 103,000 people per year.

The land area of Washington was 42.6 million ac, of which 11.0 million ac (26 percent) were managed as national forests or national parks, referred to as “federal land” (table 2). The majority of the federal land (93 percent west side, 98 percent east side) was in the wildland forest land use class, with the remainder consisting of bare rock, sand, and ice in the “other” class. Because land use did not change on federal land, these areas were not included in subsequent analyses. Of the 24.2 million ac of wildland forest class in 1976, 56 percent (13.7 million ac) was in nonfederal ownership (illustrated in figure 4).

Table 2—Area of land use in Washington in 1976 by side of state and federal or nonfederal status

Land-use class	Eastern Washington				Western Washington				Total	
	Federal		Nonfederal		Federal		Nonfederal			
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Wildland forest	5,444	22	5,904	24	5,082	21	7,809	32	24,239	100
Wildland range	22	0	6,081	100					6,102	100
Mixed forest/agriculture	0	0	182	33	1	0	365	67	548	100
Mixed range/agriculture	1	1	64	99					65	100
Intensive agriculture	1	0	8,174	91			851	9	9,026	100
Low-density residential	2	0	389	30	1	0	913	70	1,305	100
Urban			226	37			386	63	612	100
Other	59	8	216	30	400	56	39	5	715	100
Total	5,531	13	21,238	50	5,483	13	10,363	24	42,614	100

Note: percentages are of state totals for each row.

Washington lost 650,000 acres of forest land use from 1976 to 2006.

In western Washington, the area in the nonfederal wildland forest land use class was 7.81 million ac in 1976 and declined by 493,000 ac (6.3 percent) between 1976 and 2006 (table 3), for an annual rate of decline of 0.22 percent per year. This rate is equivalent to losing an area of forest land use the size of a 1.32-ac football field every 42 minutes for the last 30 years. Although smaller declines in area were observed for the mixed forest/agriculture and intensive agriculture classes, the proportional declines were substantially greater, with annual rates of 1.0 and 0.7 percent per year, respectively (table 4). In eastern Washington, declines of nonfederal wildland forest were lower in magnitude and rate than in western Washington, with an overall loss of 157,000 ac at an annual rate of 0.09 percent per year. Overall declines in wildland range in eastern Washington were comparable to those of

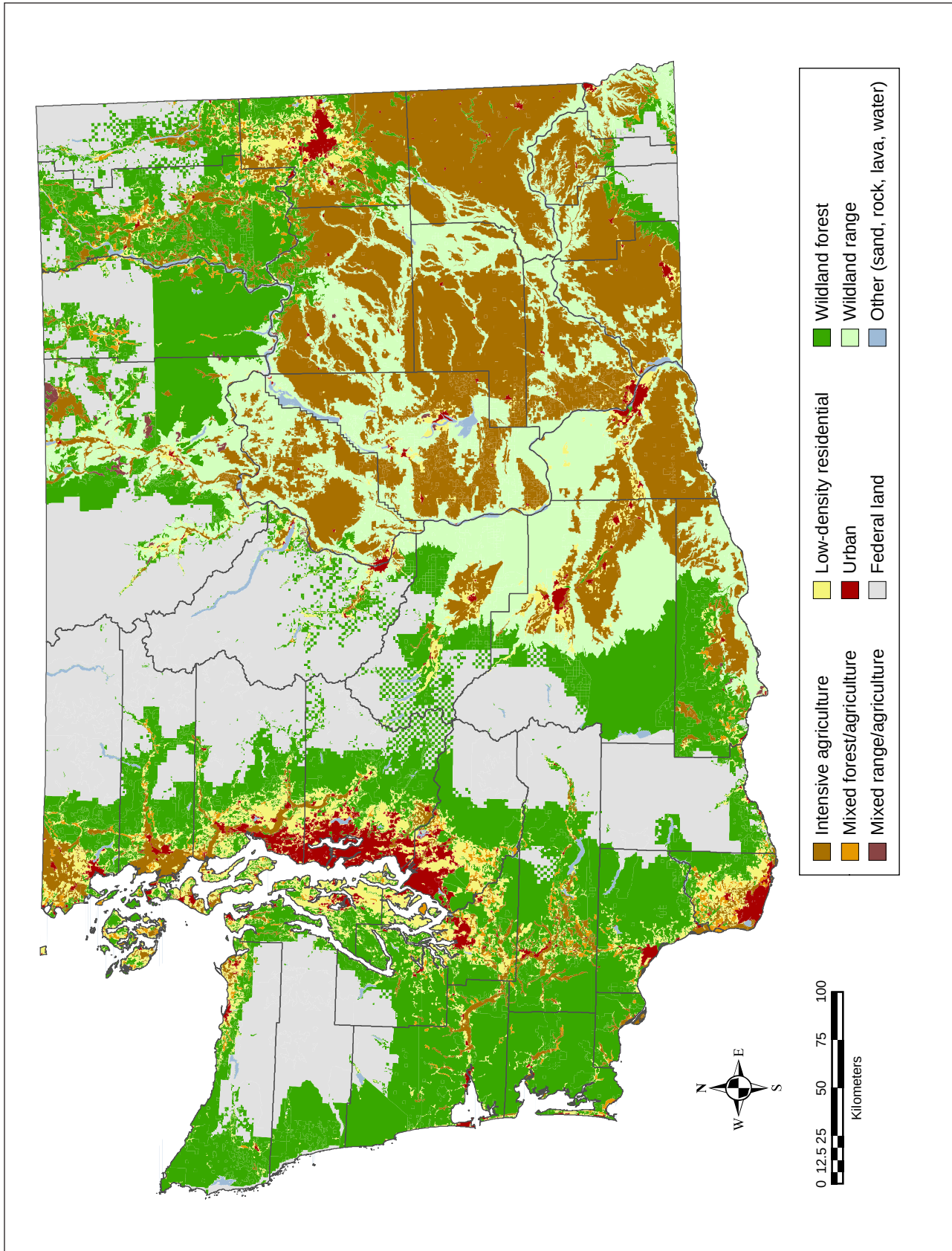


Figure 4—Delineated land use classes in Washington in 2006, and federal lands.

Table 3—Area of nonfederal land in Washington and percentages of total by side of state, land use class, and year

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Eastern Washington:						
Wildland forest	5,904	27.8	5,798	27.3	5,748	27.1
Wildland range	6,081	28.6	6,035	28.4	5,945	28.0
Mixed forest/agriculture	182	0.9	165	0.8	157	0.7
Mixed range/agriculture	64	0.3	64	0.3	64	0.3
Intensive agriculture	8,174	38.5	8,111	38.2	8,086	38.1
Low-density residential	389	1.8	589	2.8	723	3.4
Urban	226	1.1	259	1.2	299	1.4
Other	216	1.0	216	1.0	216	1.0
Total	21,238	100.0	21,238	100.0	21,238	100.0
Western Washington:						
Wildland forest	7,809	75.4	7,501	72.4	7,316	70.6
Mixed forest/agriculture	365	3.5	310	3.0	269	2.6
Intensive agriculture	851	8.2	748	7.2	683	6.6
Low-density residential	913	8.8	1,245	12.0	1,414	13.6
Urban	386	3.7	517	5.0	636	6.1
Other	39	0.4	43	0.4	45	0.4
Total	10,363	100.0	10,363	100.0	10,363	100.0

Table 4—Changes in area of nonfederal land in Washington and annual rates of change by side of state, land-use class, and period

Land use class	1976–1994		1994–2006		1976–2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Eastern Washington:						
Wildland forest	-106.3	-0.10	-50.3	-0.08	-156.6	-0.09
Wildland range	-46.0	-0.04	-89.8	-0.14	-135.7	-0.07
Mixed forest/agriculture	-17.2	-0.56	-7.9	-0.42	-25.1	-0.51
Mixed range/agriculture	0	0	0	0	0	0
Intensive agriculture	-63.5	-0.04	-24.6	-0.03	-88.1	-0.04
Low-density residential	200.1	2.32	133.2	1.92	333.3	2.17
Urban	32.8	0.77	39.5	1.28	72.3	0.96
Other	0	0	0	0	0	0
Western Washington:						
Wildland forest	-308.6	-0.24	-184.5	-0.18	-493.1	-0.22
Mixed forest/agriculture	-55.0	-0.99	-41.6	-1.05	-96.7	-1.02
Intensive agriculture	-102.9	-0.74	-64.4	-0.71	-167.3	-0.73
Low-density residential	332.1	1.97	169.9	0.91	502.0	1.47
Urban	130.7	1.87	118.9	1.46	249.6	1.68
Other	3.7	0.56	1.9	0.30	5.6	0.44

forest land, and declines in agriculture zones were lower in magnitude and rate (some calculated rates of change do not appear to align well with net change in acres for different time periods because the actual date of the midpoint varied from 1994). County-level changes are shown in the appendix.

Developed land classes covered 12.5 percent of nonfederal land in western Washington in 1976 and increased to 19.7 percent by 2006, representing annual rates of increase in area of 1.5 and 1.7 percent for low-density residential and urban classes, respectively. In eastern Washington, developed classes only covered 2.9 percent of nonfederal land in 1976, but increased to 4.8 percent by 2006, with annual rates of increase of 2.2 and 1.0 percent for low density and urban, respectively. The largest changes from resource lands (wildland forest or range, mixed forest/agriculture or mixed range/agriculture, and intensive agriculture classes) to developed lands occurred in the Puget Sound area (table 5). Most of the land surrounding the shores of Puget Sound was in the developed land classes in 2006. The increase in development between 1976 and 2006 exhibited a dispersed pattern in the lowlands of western Washington, and in Spokane and Stevens Counties in eastern Washington (fig. 5). The pattern of change from 1976 to 1994 was more evenly dispersed than development between 1994 and 2006 (fig. 6).

Although 51 percent of the wildland forest class in western Washington in 1976 was owned by forest industry, and 25 percent by other private owners, most of the loss of wildland forest (88 percent) occurred on other private land (table 6). In eastern Washington, a higher percentage of the wildland forest class was owned by other private (62 percent), where most of the loss of wildland forest occurred (91 percent).

In western Washington, most of the land that changed to low-density residential between 1976 and 2006 was from wildland forest, although the proportional changes from mixed-forest agriculture and intensive agriculture were much higher (tables 7 and 8). The proportional contribution from wildland forest to low-density residential was similar between periods: 67 percent for 1976 to 1994 and 63 percent for 1994 to 2006. Most of the urban area came from low-density residential although a substantial portion of the new urban area (24 percent) was forested in 1976 (fig. 7).

Twenty percent of nonfederal land was in developed land use by 2006.

Table 5—Area of different land use classes on nonfederal land in different regions of Washington and percentages of total by area, land-use class, and year

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Puget Sound:						
Wildland forest	2,517	61.5	2,306	56.3	2,207	53.9
Mixed forest/agriculture	167	4.1	129	3.1	110	2.7
Intensive agriculture	480	11.7	409	10.0	384	9.4
Low-density residential	605	14.8	822	20.1	891	21.8
Urban	307	7.5	411	10.0	484	11.8
Other	16	0.4	16	0.4	16	0.4
Total	4,092	100.0	4,092	100.0	4,092	100.0
Olympic Peninsula:						
Wildland forest	2,660	86.6	2,601	84.6	2,555	83.1
Mixed forest/agriculture	71	2.3	64	2.1	55	1.8
Intensive agriculture	140	4.5	122	4.0	104	3.4
Low-density residential	157	5.1	229	7.4	282	9.2
Urban	29	1.0	42	1.4	62	2.0
Other	15	0.5	15	0.5	15	0.5
Total	3,073	100.0	3,073	100.0	3,073	100.0
Southwest Washington:						
Wildland forest	2,631	82.3	2,594	81.1	2,554	79.9
Mixed forest/agriculture	127	4.0	118	3.7	103	3.2
Intensive agriculture	231	7.2	216	6.8	195	6.1
Low-density residential	150	4.7	194	6.1	241	7.5
Urban	50	1.6	64	2.0	90	2.8
Other	8	0.3	12	0.4	14	0.4
Total	3,198	100.0	3,198	100.0	3,198	100.0
Central Washington:						
Wildland forest	2,964	37.8	2,931	37.3	2,913	37.1
Wildland range	2,934	37.4	2,888	36.8	2,862	36.5
Mixed forest/agriculture	21	0.3	17	0.2	16	0.2
Mixed range/agriculture	54	0.7	54	0.7	54	0.7
Intensive agriculture	1,687	21.5	1,666	21.2	1,640	20.9
Low-density residential	106	1.4	199	2.5	263	3.4
Urban	52	0.7	62	0.8	69	0.9
Other	33	0.4	33	0.4	33	0.4
Total	7,850	100.0	7,850	100.0	7,850	100.0
Inland Empire:						
Wildland forest	2,941	22.0	2,867	21.4	2,834	21.2
Wildland range	3,147	23.5	3,147	23.5	3,083	23.0
Mixed forest/agriculture	161	1.2	148	1.1	141	1.1
Mixed range/agriculture	10	0.1	10	0.1	10	0.1
Intensive agriculture	6,487	48.5	6,445	48.1	6,446	48.1
Low-density residential	283	2.1	390	2.9	459	3.4
Urban	175	1.3	197	1.5	230	1.7
Other	184	1.4	184	1.4	184	1.4
Total	13,388	100.0	13,388	100.0	13,388	100.0

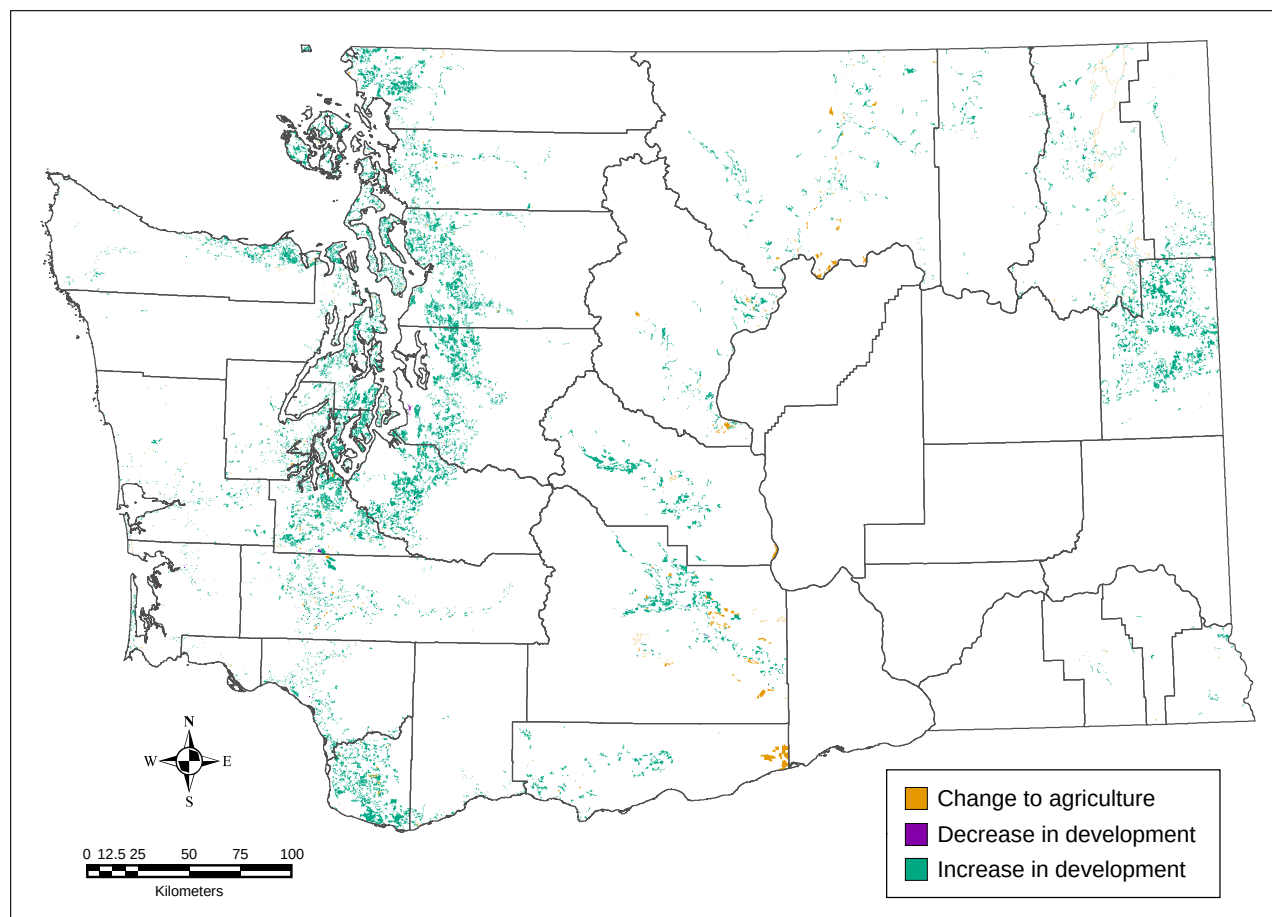


Figure 5—Change in development in Washington between 1976 and 2006. Change from forest land, range, agriculture, mixed forest/agriculture or mixed range/agriculture to low-density residential or urban was classified as an increase in development; change from any land use to agriculture was classified separately, and any other change from low-density or urban to other types was classified as a decrease in development.

Table 6—Changes in the area of wildland forest land use class in Washington by side of state, owner class, and year

Owner class	Area			Change from 1976 to 2006		
	1976	1994	2006	Area	Annual rate	Percentage of total
----- Thousand acres -----						
----- Percent -----						
Eastern Washington:						
Forest industry	1,095.1	1,091.8	1,089.4	-5.7	-0.02	3.6
Other private	3,640.2	3,543.3	3,497.2	-143.0	-0.14	91.3
State and local	1,006.4	1,001.3	1,000.8	-5.6	-0.02	3.6
Other federal	162.5	161.5	160.1	-2.3	-0.05	1.5
Total	5,904.2	5,797.9	5,747.6	-156.6	-0.09	100.0
Western Washington:						
Forest industry	4,026.7	4,011.0	3,984.3	-42.4	-0.04	8.6
Other private	1,910.8	1,629.3	1,479.3	-431.6	-0.85	87.5
State and local	1,756.9	1,746.9	1,740.0	-16.9	-0.03	3.4
Other federal	114.7	113.3	112.4	-2.3	-0.07	0.5
Total	7,809.1	7,500.5	7,316.0	-493.1	-0.22	100.0

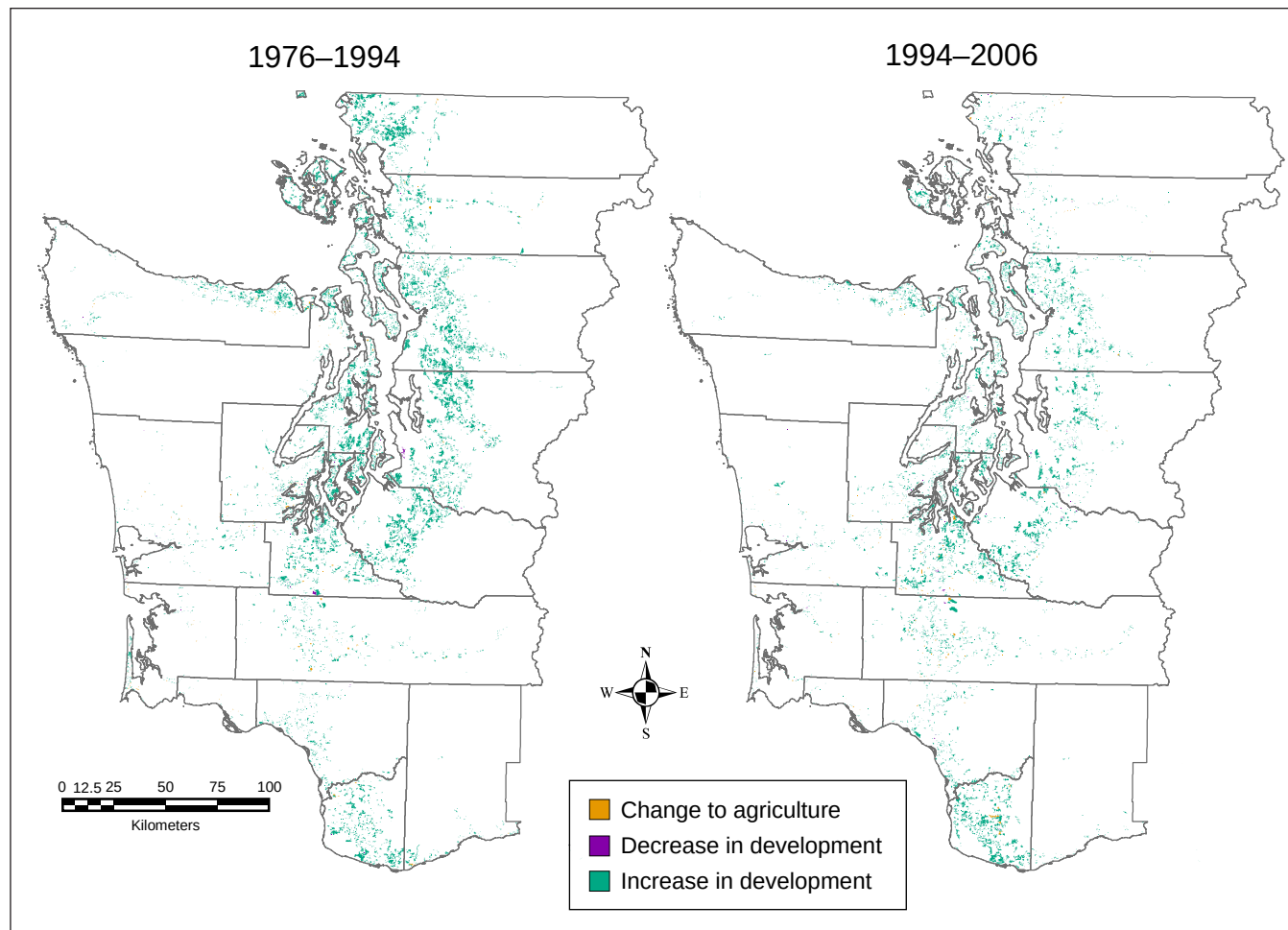


Figure 6—Change in development in western Washington between 1976 to 1994 and 1994 to 2006. Change from forest land, range, agriculture, mixed forest/agriculture or mixed range/agriculture to low-density residential or urban was classified as an increase in development; change from any land use to agriculture was classified separately, and any other change from low-density or urban to other types was classified as a decrease in development.

Table 7—Net change in area between land use classes on nonfederal land in western Washington, 1976–1994 and 1994–2006

Description of change	Wildland forest	Mixed forest/agriculture	Intensive agriculture	Low-density residential	Urban	Other
----- Acres -----						
Area by class in 1976	7,809,084	365,225	850,613	912,506	386,091	39,272
Net change from:						
Wildland forest	0	2,332	-1,456	279,944	24,047	3,690
Mixed forest/agriculture	-2,332	0	-932	53,716	4,572	
Intensive agriculture	1,456	932	0	80,190	20,311	
Low-density residential	-279,944	-53,716	-80,190	0	81,747	
Urban	-24,047	-4,572	-20,311	-81,747	0	
Other	-3,690					0
Total net change	-308,557	-55,025	-102,889	332,103	130,677	3,690
Area by class in 1994	7,500,527	310,201	747,724	1,244,609	516,768	42,962
Net change from:						
Wildland forest	0	5,066	3,217	152,176	22,694	1,384
Mixed forest/agriculture	-5,066	0	-917	39,862	7,767	
Intensive agriculture	-3,217	917	0	48,352	18,372	
Low-density residential	-152,176	-39,862	-48,352	0	70,043	482
Urban	-22,694	-7,767	-18,372	-70,043	0	
Other	-1,384			-482		0
Total net change	-184,537	-41,645	-64,424	169,864	118,877	1,866
Area by class in 2006	7,315,990	268,556	683,300	1,414,473	635,644	44,828

Table 8—Net change in area between land use classes on nonfederal land in western Washington, 1976–2006

Description of change	Wildland forest	Mixed forest/agriculture	Intensive agriculture	Low-density residential	Urban	Other
----- Acres -----						
Area by class in 1976	7,809,084	365,225	850,613	912,506	386,091	39,272
Net change from:						
Wildland forest	0	6,935	1,761	419,678	59,646	5,074
Mixed forest/agriculture	-6,935	0	-917	91,718	12,803	
Intensive agriculture	-1,761	917	0	122,126	46,030	
Low-density residential	-419,678	-91,718	-122,126	0	131,074	482
Urban	-59,646	-12,803	-46,030	-131,074	0	
Other	-5,074			-482		0
Total net change	-493,094	-96,670	-167,313	501,967	249,554	5,556
Area by class in 2006	7,315,990	268,556	683,300	1,414,473	635,644	44,828

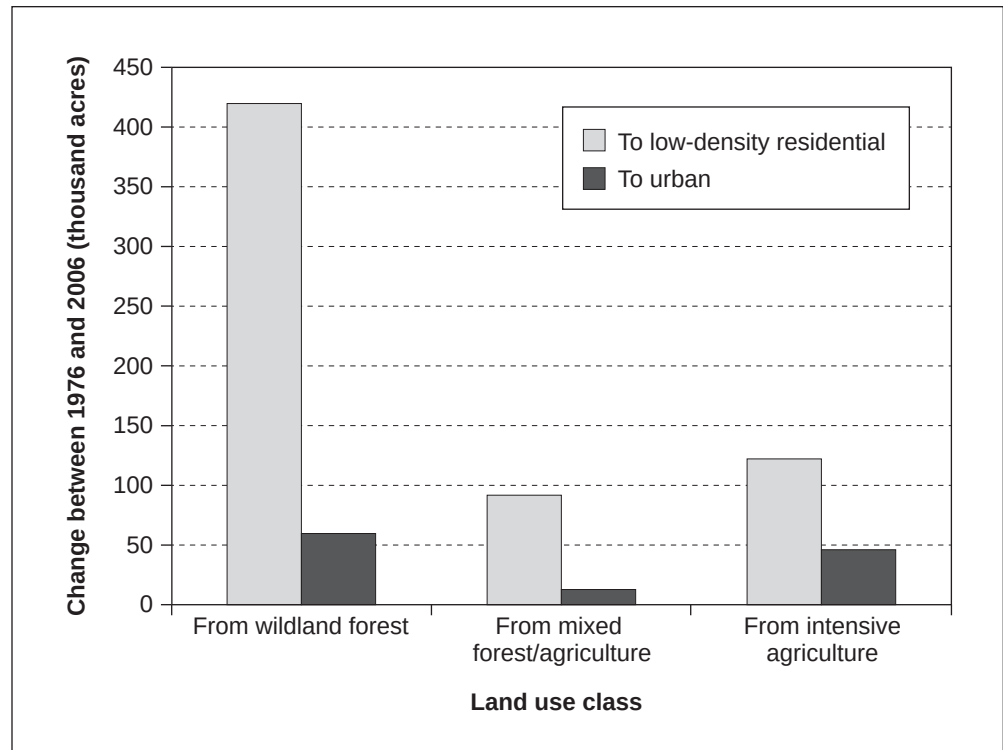


Figure 7—Western Washington net change in area from resource classes (forest land, mixed forest/agriculture, or intensive agriculture) to developed classes (low-density residential or urban) from 1976 to 2006.

In eastern Washington, the greatest change in area to low-density residential was from intensive agriculture, although the rate of conversion from wildland forest was similar (tables 9 and 10). The proportional contribution from wildland forest to low-density residential declined somewhat between periods: 41 percent for 1976 to 1994 and 32 percent for 1994 to 2006. Development of wildland range and mixed-agriculture classes was substantially lower than of forest or intensive agriculture classes. The increase in urban area in eastern Washington was substantially lower than in western Washington, but most of the new urban area (63 percent) was in resource land uses in 1976 (fig. 8).

Most new development was within ¼ mile of existing development.

Most of the land that changed from resource use to urban or low-density residential was in areas close to existing urban or residential classes, with the majority being less than ¼ mi away (figs. 9 and 10). A greater proportion of the development in western Washington occurred close to previously developed lands than in eastern Washington. For both sides of the state, however, more of the development was close to previous development from 1994 to 2006 than for 1976 to 1994. Most of the resource use areas that became closer to development in the study period were not near the major metropolitan areas, but were scattered around the region, suggesting that potential effects of development on resource use are widespread (fig. 11).

Table 9—Net change in area between land use classes on nonfederal land in eastern Washington, 1976–1994 and 1994–2006

Description of change	Wildland forest	Wildland range	Mixed forest/agriculture	Mixed range/agriculture	Intensive agriculture	Low-density residential	Urban
----- Acres -----							
Area by class in 1976	5,904,215	6,080,759	181,767	64,482	8,174,433	389,296	226,295
Net change from:							
Wildland forest	0	1,384	461		1,403	86,460	16,609
Wildland range	-1,384	0		922	28,147	18,285	
Mixed forest/agriculture	-461		0			16,743	927
Mixed range/agriculture		-922		0		940	
Intensive agriculture	-1,403	-28,147			0	90,205	2,794
Low-density residential	-86,460	-18,285	-16,743	-940	-90,205	0	12,508
Urban	-16,609		-927		-2,794	-12,508	0
Total net change	-106,316	-45,970	-17,209	-17	-63,450	200,125	32,838
Area by class in 1994	5,797,900	6,034,788	164,558	64,464	8,110,983	589,421	259,133
Net change from:							
Wildland forest	0				-510	48,950	1,869
Wildland range		0			49,729	28,177	11,867
Mixed forest/agriculture			0			7,425	464
Mixed range/agriculture				0			
Intensive agriculture	510	-49,729			0	66,251	7,605
Low-density residential	-48,950	-28,177	-7,425		-66,251	0	17,648
Urban	-1,869	-11,867	-464		-7,605	-17,648	0
Total net change	-50,309	-89,773	-7,888	0	-24,637	133,155	39,452
Area by class in 2006	5,747,590	5,945,015	156,670	64,464	8,086,346	722,576	298,585

Note: The “other” land use class had no change and is not shown.

Table 10—Net change in area between land use classes on nonfederal land in eastern Washington, 1976–2006

Description of change	Wildland forest	Wildland range	Mixed forest/agriculture	Mixed range/agriculture	Intensive agriculture	Low-density residential	Urban
----- Acres -----							
Area by class in 1976	5,904,215	6,080,759	181,767	64,482	8,174,433	389,296	226,295
Net change from:							
Wildland forest	0	1,384	461		431	134,944	19,405
Wildland range	-1,384	0		922	77,876	46,462	11,867
Mixed forest/agriculture	-461		0			23,705	1,854
Mixed range/agriculture		-922		0		940	
Intensive agriculture	-431	-77,876			0	154,146	12,249
Low-density residential	-134,944	-46,462	-23,705	-940	-154,146	0	26,916
Urban	-19,405	-11,867	-1,854		-12,249	-26,916	0
Total net change	-156,625	-135,743	-25,097	-17	-88,087	333,280	72,290
Area by class in 2006	5,747,590	5,945,015	156,670	64,464	8,086,346	722,576	298,585

Note: The “other” land use class had no change and is not shown.

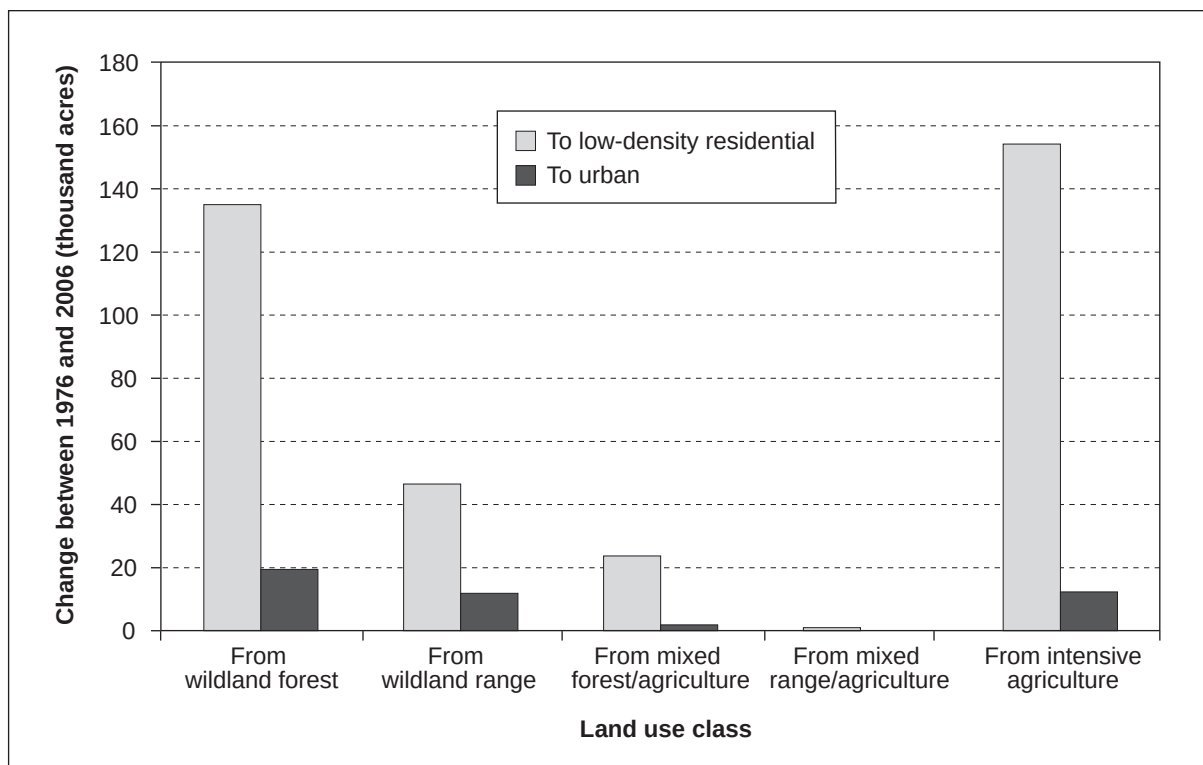
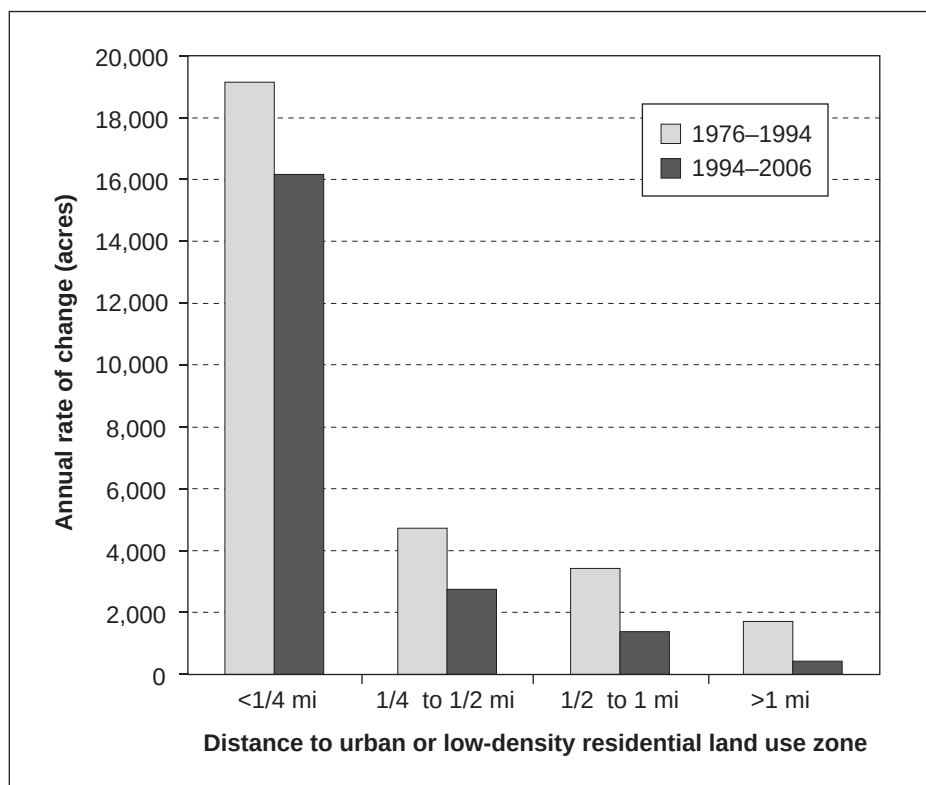


Figure 8—Eastern Washington net change in area from resource classes (forest land, range, mixed forest/agriculture or mixed range/agriculture, intensive agriculture) to developed classes (low-density residential or urban) from 1976 to 2006.

Figure 9—Western Washington net change in area from resource classes (forest land, agriculture, or mixed forest/agriculture) to developed classes (low-density residential or urban) for two periods (1976–1994 and 1994–2006) by initial distance to developed classes.



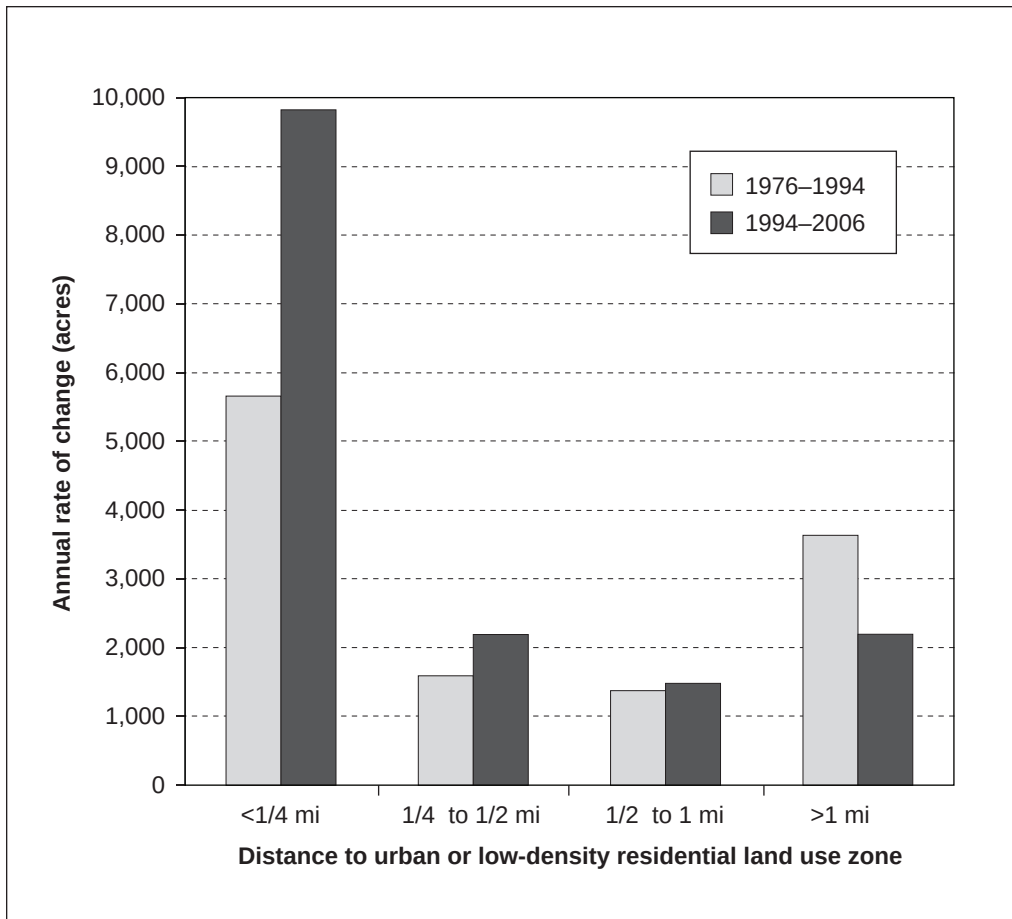


Figure 10—Eastern Washington net change in area from resource classes (forest land, agriculture, or mixed forest/agriculture) to developed classes (low-density residential or urban) for two periods (1976–1994 and 1994–2006) by initial distance to developed classes.

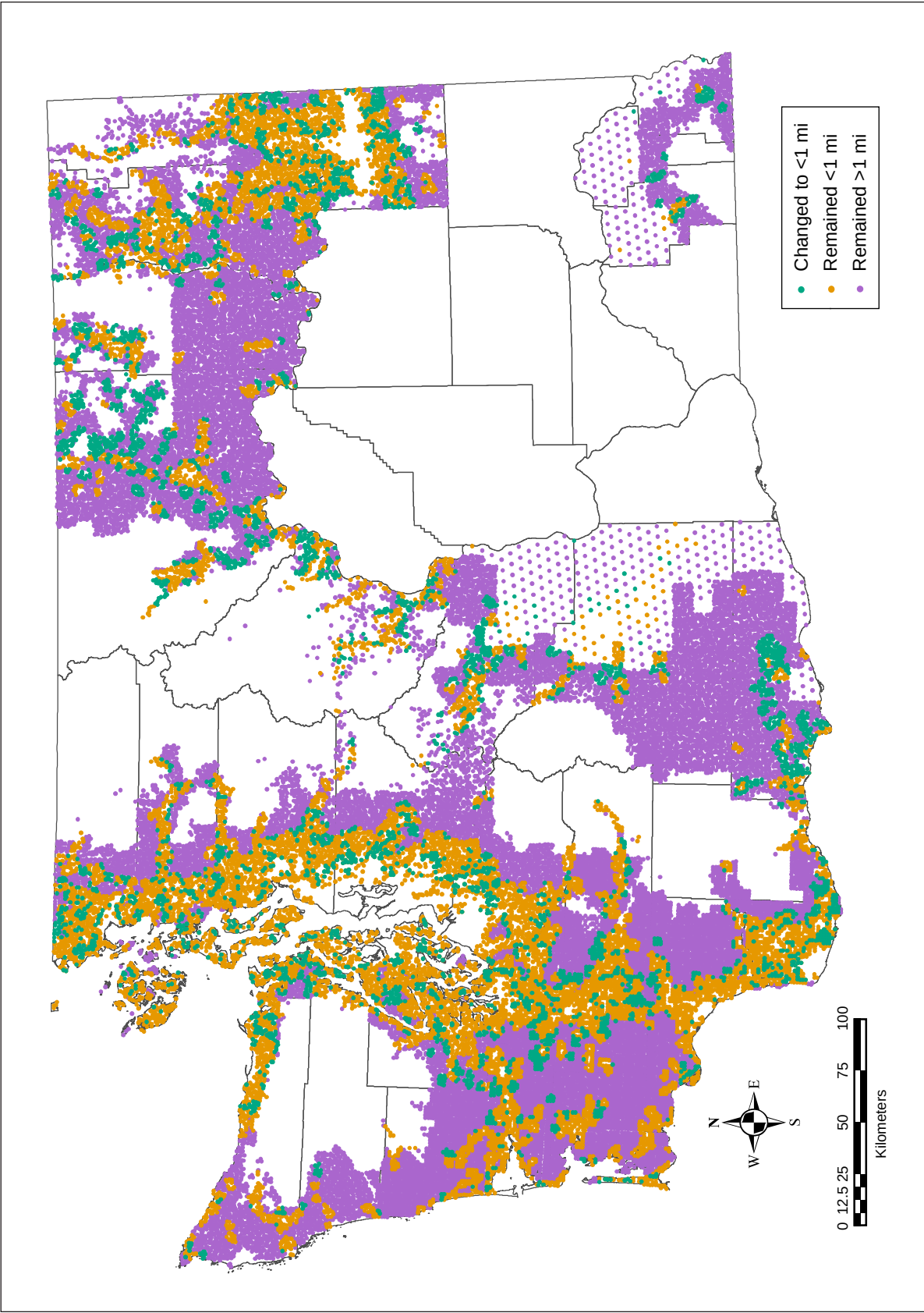


Figure 11—Map of change in distance from resource classes (forest land, agriculture, or mixed forest/agriculture) to the nearest developed classes (low-density residential or urban) from 1976 to 2006.

Across the state, the median elevation and slope for the forest and residential classes increased over time, while they decreased or remained stable for intensive agriculture. These results indicate that, on balance, development was moving into higher elevation, steeper forested areas instead of lower elevation agricultural areas (table 11). The lower elevation areas may also be more prone to flooding, which may be a factor affecting development patterns.

Table 11—Median of elevation and slope for land use classes on nonfederal lands in Washington by side of state and year

Land use class	Elevation			Slope		
	1976	1994	2006	1976	1994	2006
	----- Meters -----			----- Percent -----		
Eastern Washington:						
Wildland forest	889	895	898	18.1	18.4	18.4
Wildland range	533	534	536	7.9	7.9	8.0
Mixed forest/agriculture	697	699	698	7.3	7.7	7.7
Mixed range/agriculture	838	842	842	9.2	9.1	9.1
Intensive agriculture	541	539	539	3.8	3.8	3.8
Low-density residential	437	572	576	2.2	3.5	3.8
Urban	393	456	393	2.5	2.5	2.5
Other	195	195	195	0	0	0
Western Washington:						
Wildland forest	199	208	214	14.8	15.4	15.7
Mixed forest/agriculture	80	79	80	2.9	3.0	3.1
Intensive agriculture	36	34	31	1.0	0.9	0.9
Low-density residential	81	85	88	4.4	4.5	4.6
Urban	68	73	74	2.7	2.7	2.7
Other	1	1	1	0	0	0

The mean density of structures counted in 80-ac circles around each western Washington photointerpretation grid point for 1976 was 3.6, 28, and 33 structures per square mile for wildland forest, mixed forest/agriculture, and intensive agriculture land classes, respectively (table 12). Although structure densities around wildland forest were higher in the Puget Sound area than the rest of western Washington, structure densities around intensive agriculture were highest in southwest Washington, particularly in 2006. Mean structure densities increased around all land classes over time, with twice the density around the wildland forest and mixed forest/agriculture land classes in 2006 than in 1976. Structure densities for all land classes was highly skewed, but indicate that the median density also increased over time (fig. 12).

The number of structures around resource land uses doubled in western Washington.

Table 12—Density of structures in 80-ac circles around points in different land use classes, for nonfederal land in western Washington; means by area, land use class, and year

Land use class	Structures			Annual change in structures		Change in structures 1976–2006
	1976	1994	2006	1976–1994	1994–2006	
	<i>Number per square mile</i>			<i>----- Percent -----</i>		
Puget Sound:						
Wildland forest	5.5	8.0	11.3	2.20	2.84	208
Mixed forest/agriculture	27.6	45.6	55.5	2.93	1.57	201
Intensive agriculture	32.5	43.6	49.0	1.57	1.05	151
Low-density residential	126.8	151.5	191.1	1.11	1.69	151
Olympic Peninsula:						
Wildland forest	2.6	3.6	4.8	2.14	1.96	184
Mixed forest/agriculture	30.7	42.4	54.7	2.23	1.66	178
Intensive agriculture	28.3	43.7	42.0	3.00	-0.26	149
Low-density residential	98.9	115.9	143.6	1.07	1.43	145
Southwest Washington:						
Wildland forest	2.7	3.7	4.7	1.95	1.75	174
Mixed forest/agriculture	25.7	35.7	50.6	2.03	2.58	197
Intensive agriculture	35.0	44.6	59.1	1.53	2.03	169
Low-density residential	78.1	104.3	120.7	1.79	1.07	155
Western Washington totals:						
Wildland forest	3.5	5.0	6.7	2.10	2.21	189
Mixed forest/agriculture	27.6	41.2	53.5	2.48	1.93	194
Intensive agriculture	32.5	43.9	50.8	1.76	1.16	157
Low-density residential	114.0	137.6	169.7	1.19	1.50	149

Structure density was substantially lower in eastern Washington than in western Washington. The mean density of structures counted in 80-ac circles around each eastern Washington photointerpretation grid point for 1976 was 1.0 structures per square mile for wildland forest and wildland range land classes (table 13). Structure density was somewhat greater in mixed forest/agriculture than intensive agriculture land classes, and substantially greater than in mixed range/agriculture. Although structure densities around wildland forest were greater in the Inland Empire area than in central Washington, the reverse was true for all other land classes. Mean structure densities increased around most land classes over time, with about twice the density around the wildland forest and mixed forest/agriculture land classes in 2006 than in 1976. Structure densities for all land classes were highly skewed, but unlike in western Washington, the median density increased only slightly over time for the mixed forest/agriculture and residential land classes (fig. 13).

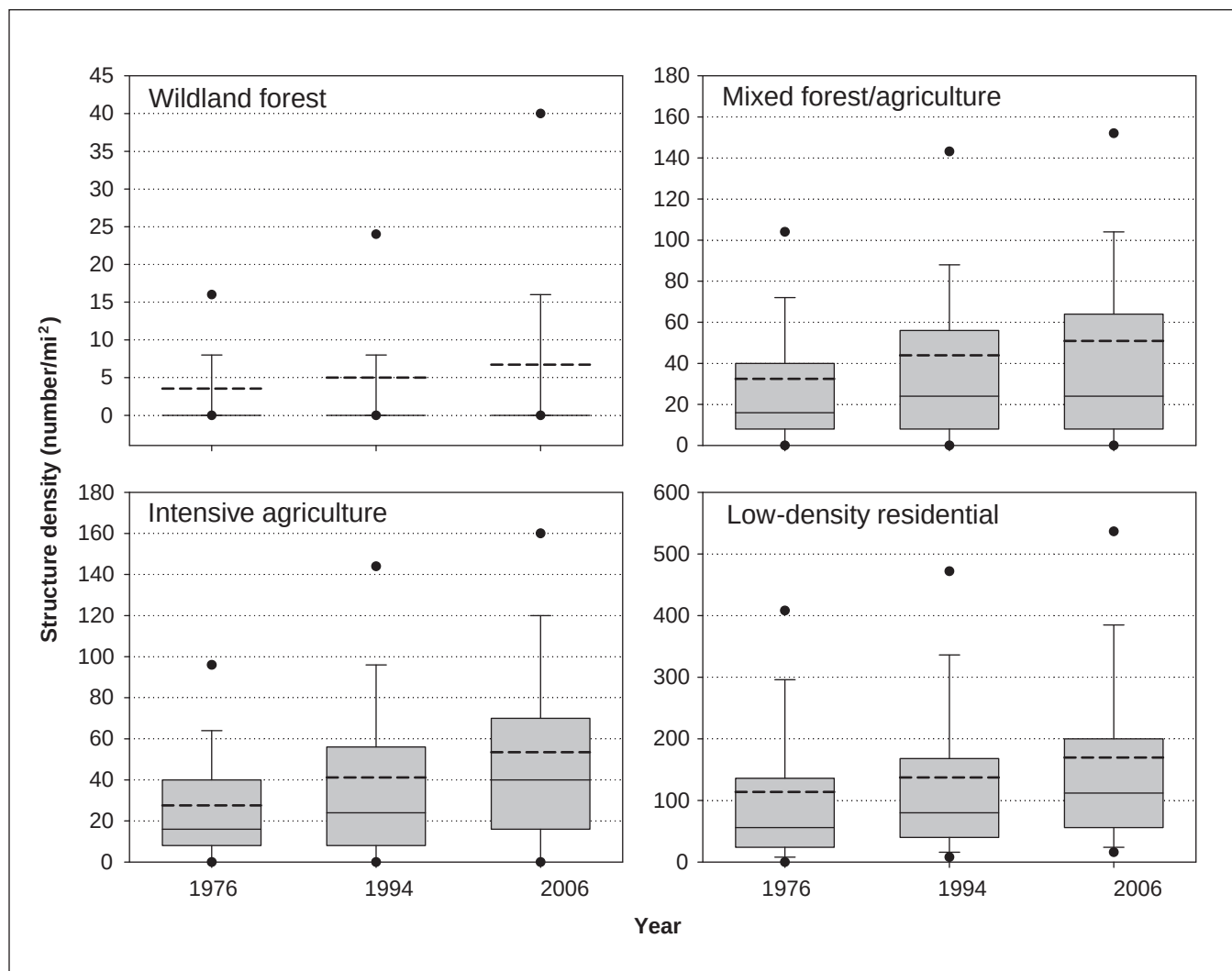


Figure 12—Distribution of structure densities in western Washington around points on different land use classes for three dates. The top and bottom of the shaded boxes are the 75th and 25th percentiles, the thin line within each box is the median, the heavy dashed line is the mean, the whiskers are the 10th and 90th percentiles, and the points are the 5th and 95th percentiles. Note: y-axis scale differs among graphs, and box values equal zero for wildland forest.

Table 13—Density of structures in 80-ac circles around points in different land use classes, for nonfederal land in eastern Washington; means by area, land use class, and year

Land use class	Structures			Annual change in structures		Change in structures 1976–2006
	1976	1994	2006	1976–1994	1994–2006	
	<i>Number per square mile</i>			<i>----- Percent -----</i>		
Central Washington:						
Wildland forest	0.5	1.0	1.3	3.22	2.70	247
Wildland range	0.5	1.0	1.3	3.40	2.33	245
Mixed forest/agriculture	8.4	11.7	15.5	1.66	2.73	186
Mixed range/agriculture	3.5	6.0	7.5	2.94	2.21	216
Intensive agriculture	9.2	10.5	11.0	0.70	0.44	120
Low-density residential	101.3	103.5	97.3	0.11	-0.62	96
Inland Empire:						
Wildland forest	1.5	2.3	3.0	2.18	2.52	195
Wildland range	2.1	2.1	1.8	0.17	-1.68	87
Mixed forest/agriculture	7.1	10.8	12.8	2.38	1.49	179
Mixed range/agriculture	5.9	6.2	6.6	0.32	0.52	112
Intensive agriculture	3.1	3.3	3.7	0.32	0.87	117
Low-density residential	67.5	68.9	81.6	0.11	1.57	121
Eastern Washington totals:						
Wildland forest	1.0	1.6	2.2	2.41	2.64	208
Wildland range	1.3	1.6	1.5	0.95	-0.29	117
Mixed forest/agriculture	7.3	10.9	13.1	2.28	1.62	180
Mixed range/agriculture	3.9	6.0	7.4	2.41	1.94	190
Intensive agriculture	4.4	4.8	5.2	0.46	0.65	118
Low-density residential	76.7	80.6	87.3	0.26	0.77	114

Points on resource land use classes with high structure counts within 80-ac circles were scattered around Washington (fig. 14). The highest structure densities around resource land use classes in western Washington, and the greatest increases in densities between 1976 and 2006, were within ¼ mi of developed classes (fig. 15). Although the highest densities in eastern Washington were also within ¼ mi of developed classes, changes in density were less dramatic and in some cases declined as land use of some resource land points changed to developed (fig. 16).

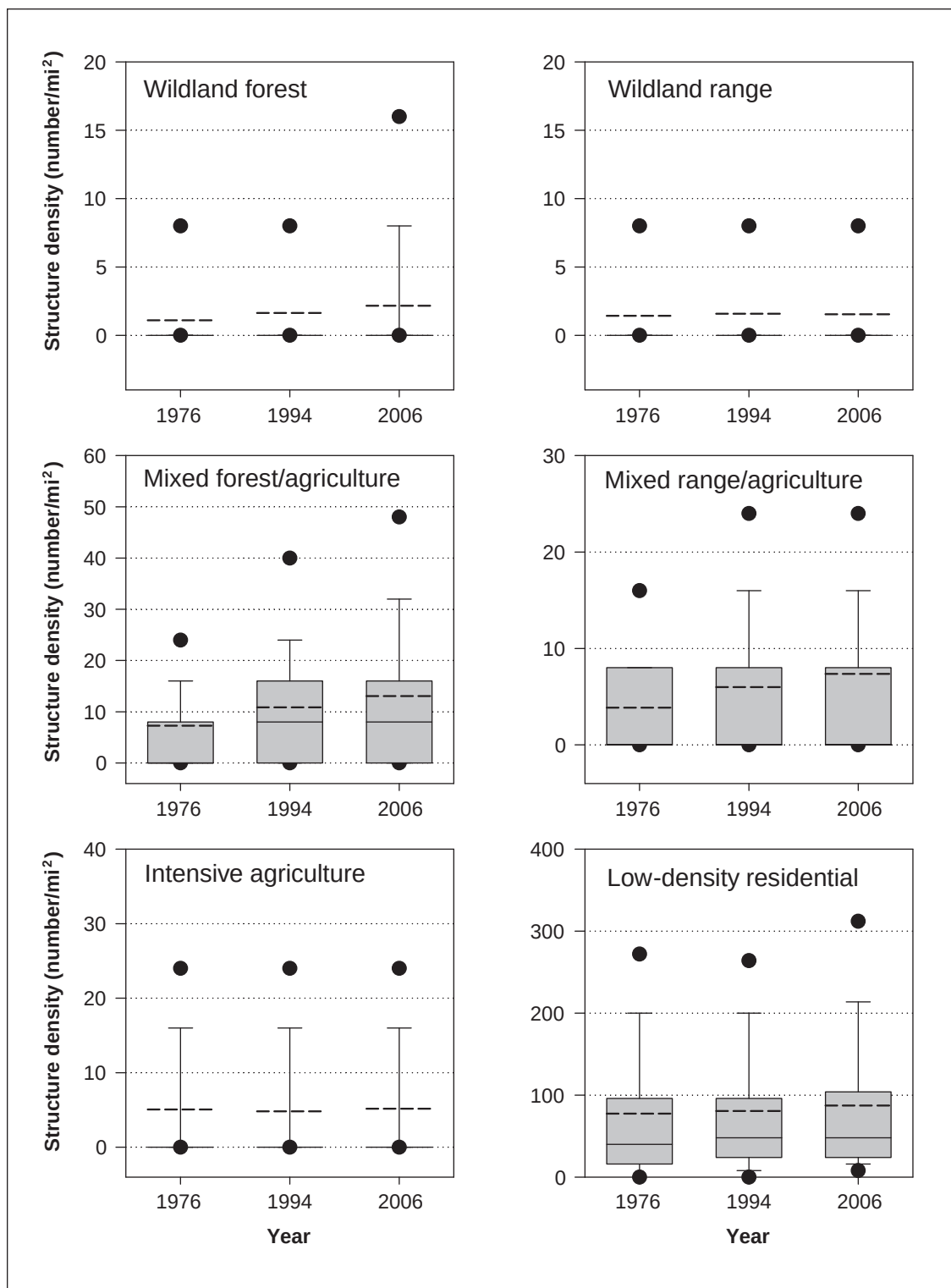


Figure 13—Distribution of structure densities in eastern Washington around points on different land use classes for three dates. The top and bottom of the shaded boxes are the 75th and 25th percentiles, the thin line within each box is the median, the heavy dashed line is the mean, the whiskers are the 10th and 90th percentiles, and the points are the 5th and 95th percentiles. Note: y-axis scale differs among graphs, and box values equal zero for three of the classes.

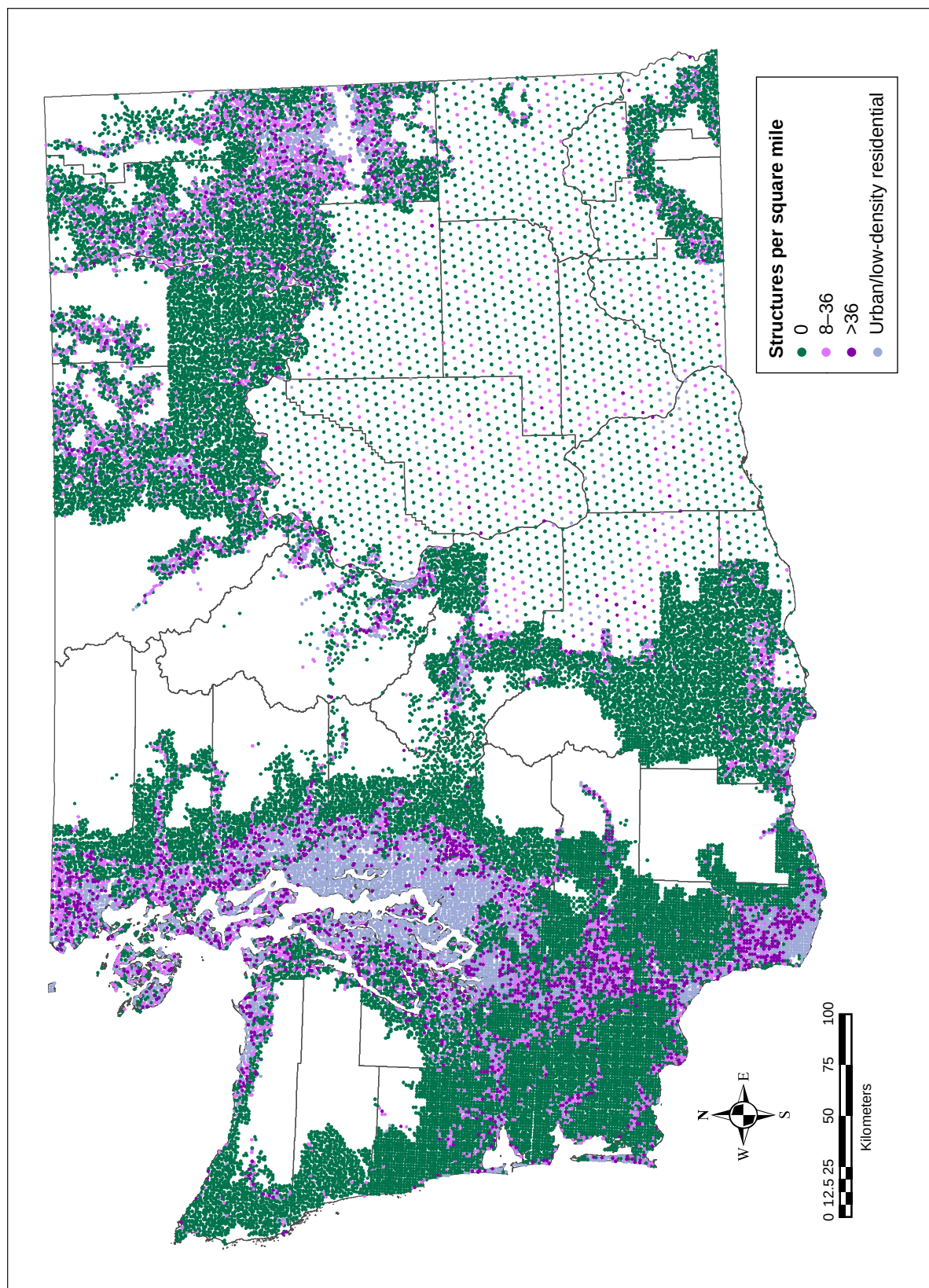


Figure 14—Map of structure density classes around points in resource lands (forest, range, and agricultural classes) in 2006.

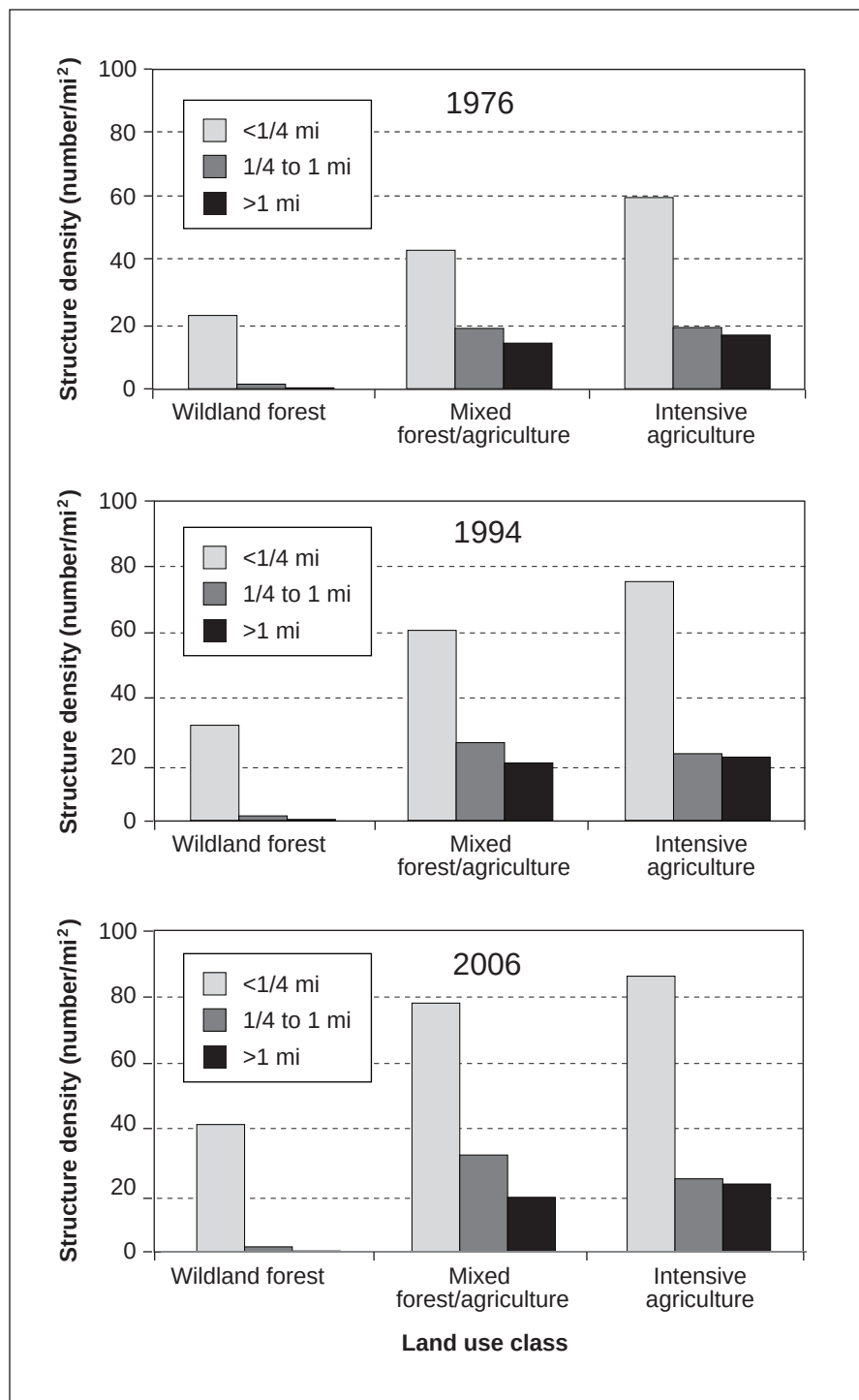


Figure 15—Structure density around points in western Washington resource land use classes (forest land, agriculture, or mixed forest/agriculture) by distance to developed land use classes (low-density residential or urban) for three dates.

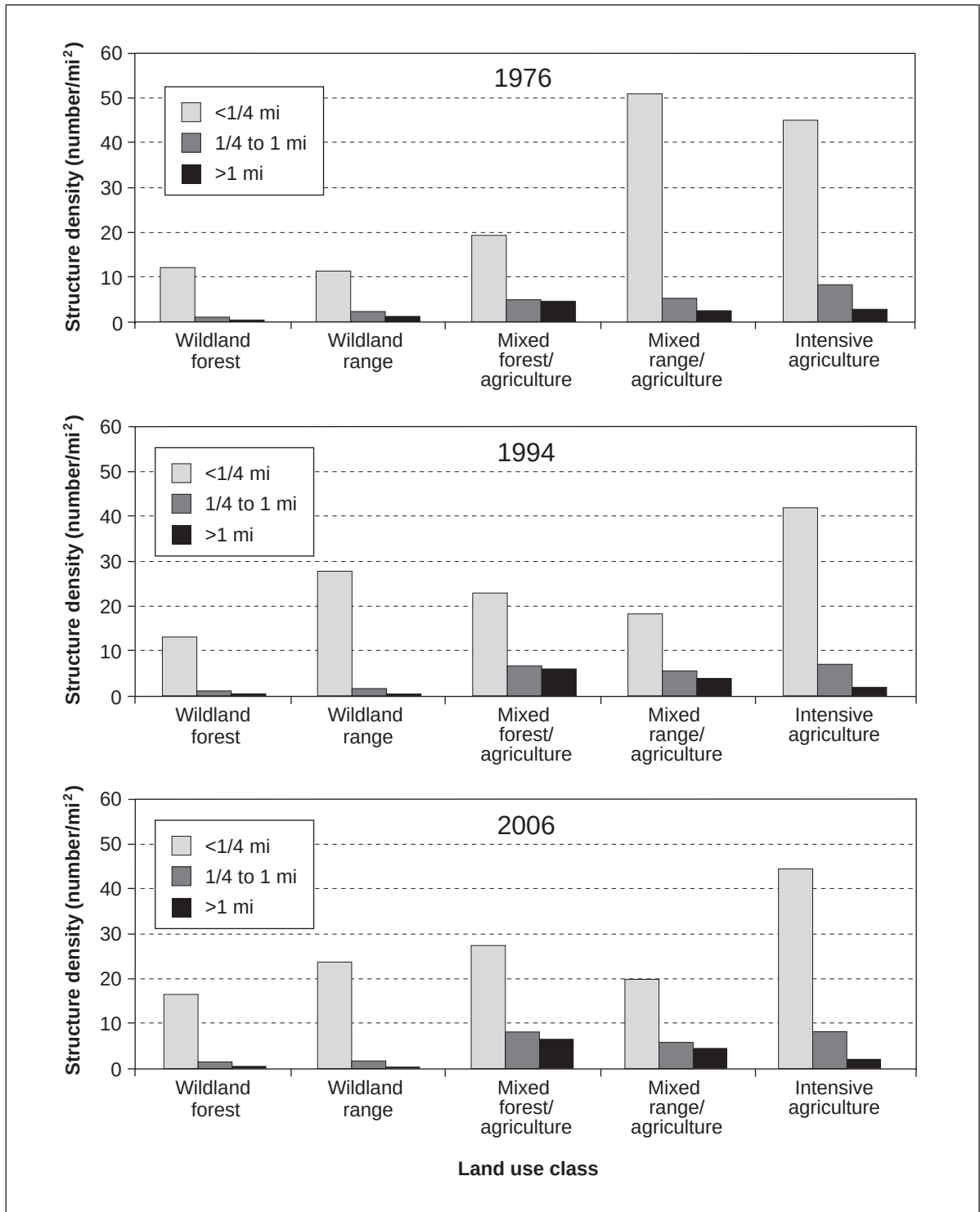


Figure 16—Structure density around points in eastern Washington resource land use classes (forest land, rangeland, agriculture, mixed forest/agriculture, or mixed range/agriculture) by distance to developed land use classes (low-density residential or urban) for three dates. Note: estimates for mixed range/agriculture are unreliable owing to low sample size.

In many cases, the structure densities around points in resource lands exceeded the expected values because many of the 80-ac circles included areas of developed land classes within them (table 14). Structure densities calculated for individual land use classes within those circles were lower than when all structures were assigned to the land use class at the center, particularly for wildland forest and range. For example, the density of structures in wildland forest in 2006 in eastern and western Washington was 0.5 and 0.4 per mi², respectively (table 15), while the density in 80-ac circles around wildland forest points was 2.2 and 6.7, respectively. Both estimates provide complementary perspectives on the impact of housing and development on forest land. Nevertheless, mean densities were still quite high (>20 structures per mi²) for intensive agriculture and mixed forest/agriculture in western Washington. Many of the high-housing-density agricultural resource lands in western Washington had visible evidence of open fields and tilling, but it is not clear whether crops or production differed from areas with low housing density. Density of structures within resource lands increased over time, although the rates were somewhat lower than when all lands classes in the 80 ac circles were included.

Increases in structures around forest points were primarily due to development in adjacent land uses.

Table 14—Percentages of 80-ac circles that were entirely in one land use class, by year

Land use class at center	1976	1994	2006
<i>Percent</i>			
Eastern Washington:			
Wildland forest	80.8	79.4	79.1
Wildland range	70.5	68.6	68.2
Mixed forest/agriculture	23.0	19.7	18.3
Mixed range/agriculture	43.8	43.8	39.8
Intensive agriculture	56.5	55.1	54.6
Low-density residential	11.6	14.7	15.5
Urban	22.6	21.9	26.7
Other	30.0	32.5	32.5
Western Washington:			
Wildland forest	82.2	81.7	81.7
Mixed forest/agriculture	26.5	19.7	16.6
Intensive agriculture	43.2	38.1	37.3
Low-density residential	16.1	20.7	24.3
Urban	49.0	50.3	51.3
Other	8.2	8.6	9.3

Table 15—Density of structures found in different land use classes for nonfederal land in Washington; means by side of state, land use class, and year

Land use class	Structures			Annual change in structures		Change in structures 1976–2006
	1976	1994	2006	1976–1994	1994–2006	
	<i>Number per square mile</i>			<i>----- Percent -----</i>		
Eastern Washington:						
Wildland forest	0.23	0.34	0.48	2.20	3.15	211
Wildland range	0.16	0.22	0.28	1.75	2.25	178
Mixed forest/agriculture	6.53	8.63	10.01	1.58	1.29	153
Mixed range/agriculture	2.32	4.77	5.23	4.06	0.85	226
Intensive agriculture	3.11	3.34	3.65	0.38	0.81	117
Low-density residential	104.30	104.68	114.34	0.02	0.82	110
Urban	592.91	606.74	634.07	0.13	0.39	107
Western Washington:						
Wildland forest	0.30	0.37	0.38	1.20	0.28	126
Mixed forest/agriculture	22.69	29.71	36.77	1.67	1.57	162
Intensive agriculture	23.74	28.63	31.81	1.11	0.81	134
Low-density residential	124.87	146.15	177.10	0.99	1.38	142
Urban	793.16	883.57	1107.20	0.68	1.61	140

Although federal forest lands managed by the Forest Service and National Park Service tend to be located in remote areas, the number of private structures around wildland forest points within 1 mi of their borders has increased over time. Structure densities doubled from 0.95 to 1.9 per mi² within 1 mi of these federal lands between 1976 and 2006 in western Washington, and density increases were even higher in eastern Washington, from 1.1 to 2.7 per mi² (fig. 17). This equates to an estimated 2,900 structures in western Washington and 5,000 in eastern Washington found on nonfederal forest land within 1 mi of federal land boundaries in 2006.

In 2006, most of the areas classified as urban land classes were contained in areas delineated by counties as Urban Growth Areas (UGA); the exceptions (45,000 and 20,000 ac in western and eastern Washington, respectively) appeared to consist of dense unincorporated suburban areas that met our land class density definitions (table 16). In western Washington, 98 percent of nonfederal lands in the wildland forest class was outside the UGAs, while the amounts for the mixed forest/agriculture and intensive agriculture classes were 91 and 93 percent, respectively. In eastern Washington, more than 99 percent of resource lands was outside the UGAs, except for mixed range/agriculture at 91 percent. The majority of lands classified as low-density residential was also outside of UGAs (82 percent and 88 percent for western and eastern Washington, respectively).

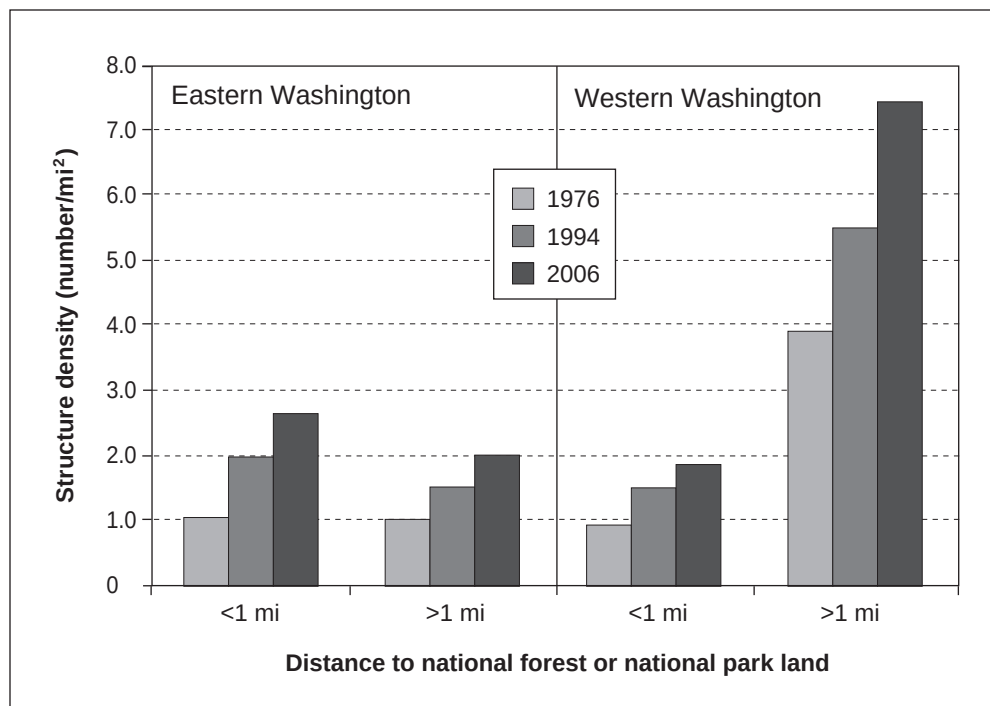


Figure 17—Structure density around points in wildland forest by distance to national forest or national park land for three dates.

Table 16—Area of nonfederal land in Washington in 2006 by land use class and Urban Growth Area (UGA) classification

Land use class	Incorporated		Not incorporated		Not in UGA		Total	
	Thousand acres	Percent	Thousand acres	Percent	Thousand acres	Percent	Thousand acres	Percent
Eastern Washington:								
Wildland forest	11.7	0.2	5.1	0.1	5,730.8	99.7	5,748	100
Wildland range	13.7	0.2	13.6	0.2	5,917.7	99.5	5,945	100
Mixed forest/agriculture	0.9	0.6	0.5	0.3	155.3	99.1	157	100
Mixed range/agriculture	0	0	5.8	8.9	58.7	91.1	64	100
Intensive agriculture	32.1	0.4	23.0	0.3	8,031.3	99.3	8,086	100
Low-density residential	53.3	7.4	29.9	4.1	639.4	88.5	723	100
Urban	243.7	81.6	34.9	11.7	20.0	6.7	299	100
Other	5.6	2.6	5.8	2.7	205.0	94.7	216	100
Total	361.1	1.7	118.4	0.6	20,758.1	97.7	21,238	100
Western Washington:								
Wildland forest	71.0	1.0	49.0	0.7	7,196.0	98.4	7,316	100
Mixed forest/agriculture	6.4	2.4	17.0	6.3	245.2	91.3	269	100
Intensive agriculture	26.7	3.9	23.5	3.4	633.0	92.6	683	100
Low-density residential	127.7	9.0	122.0	8.6	1,164.8	82.4	1,414	100
Urban	455.7	71.7	135.3	21.3	44.6	7.0	636	100
Other	5.1	11.3	1.8	4.1	37.9	84.6	45	100
Total	692.5	6.7	348.7	3.4	9,322	90.0	10,362.8	100

Tree cover in urban areas in 2006 was 10 percent in eastern Washington and 20 percent in western Washington. In eastern Washington, points that had been urban since 1976 had higher cover than points that were converted to urban since then, while the opposite was true for western Washington (fig. 18).

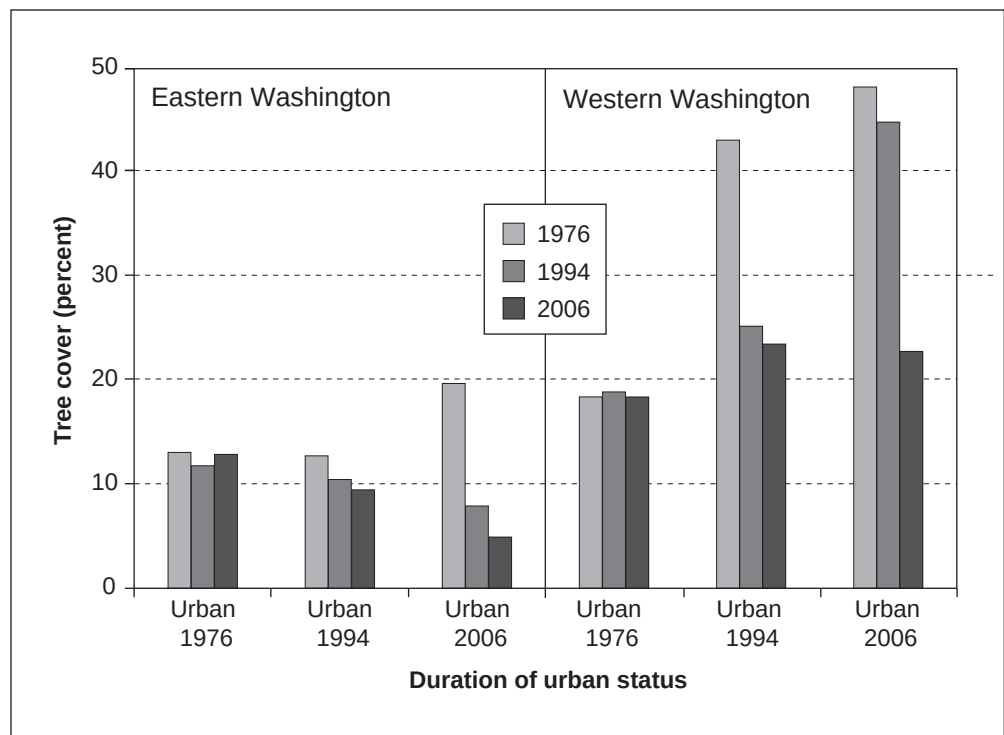


Figure 18—Tree cover in 2.5-ac circles surrounding urban land class points for three dates, by side of state and duration in urban land class: urban 1976 was urban at all three dates, urban 1994 for the last two dates, and urban 2006 was urban at only the last date.

**Land use classes
differed significantly
from land cover
classifications.**

As expected, there were important differences between the land use classes in this study and the NLCD-classified satellite image cover types. In the forest land use class, 26 and 15 percent of the area were classified as shrubland or grassland cover types in eastern and western Washington, respectively (tables 17 and 18). In many cases, these cover types probably reflect dominance by nontree vegetation in recently harvested or disturbed stands, open forests, and misclassified hardwood trees. In western Washington, 2.5 percent of the forest land use class is in “open space development” NLCD cover, while in eastern Washington the figure is 0.6 percent. Closer examination indicates that a GIS layer was used to convert a large number of forest logging roads to 30-m-wide developed strips, but only in western Washington, and regardless of whether the road was visible through the tree canopy.

Table 17—Percentage of the area of western Washington in each land use class in different satellite-derived National Land Cover Database (NLCD) land cover categories

NLCD land cover	Forest	Mixed agriculture/forest	Agriculture	Residential	Urban	Other
<i>Percent</i>						
Water	0.3	0.7	1.1	0.9	0.8	79.2
Ice/snow	0.1	0	0	0	0	3.7
Open space development	2.5	8.5	5.7	16.5	12.4	0
Low-density development	0.6	4.4	5.5	14.2	38.6	0
Medium-density development	0.1	0.4	1.1	1.7	25.9	0
High-intensity development	0	0.1	0.2	0.4	10.9	0
Barren	1.5	0.5	0.5	0.7	0.7	10.3
Deciduous forest	2.8	5.9	1.9	7.7	1.1	0
Conifer forest	69.0	14.0	2.2	19.5	3.1	1.0
Mixed forest	5.6	9.3	1.6	15.1	1.8	0
Shrubland	11.2	7.5	3.0	6.1	0.6	1.9
Grassland	3.5	8.1	3.0	4.9	1.1	1.3
Pasture/hay	0.2	24.5	47.2	6.5	1.4	0
Crops	0	1.5	13.5	0.3	0.2	0
Woody wetlands	2.2	9.2	5.9	4.0	0.6	0.1
Herbaceous wetlands	0.3	5.3	7.7	1.6	0.7	2.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 18—Percentage of the area of eastern Washington in each land use class in different satellite-derived National Land Cover Database (NLCD) land cover categories

NLCD land cover	Forest	Range	Mixed agriculture/ forest	Mixed agriculture/ range	Agriculture	Residential	Urban	Other
<i>Percent</i>								
Water	0.2	0.6	0.4	0.4	0.2	0.7	0.3	80.1
Ice/snow	0	1.5	0	0	0	0	0	2.9
Open space development	0.6	0	1.8	1.6	3.1	9.2	15.2	0.3
Low-density development	0.7	0.3	1.3	0.7	0.7	8.2	40.7	0.2
Medium-density development	0.1	0	0.1	0.2	0.1	2.1	26.6	0.1
High-intensity development	0	0	0	0	0	0.2	4.0	0
Barren	1.2	0.1	0	0	0	0.1	0	9.0
Deciduous forest	0.2	0.1	0.2	0.6	0.1	0.1	0	0
Conifer forest	69.7	0.9	31.7	4.4	1.0	22.9	1.6	0.9
Mixed forest	0.1	0	0	0	0	0.1	0	0
Shrubland	20.0	81.2	28.8	60.0	12.2	25.7	4.8	3.1
Grassland	6.0	10.6	25.2	21.3	3.8	10.3	1.4	2.4
Pasture/hay	0	0.5	2.4	2.4	3.9	5.8	1.5	0.1
Crops	0.3	3.1	5.1	6.7	73.9	12.5	3.5	0
Woody wetlands	0.5	0.3	1.2	0.6	0.3	0.9	0.1	0.4
Herbaceous wetlands	0.2	1.0	1.8	1.0	0.7	1.0	0.2	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The NLCD-estimated tree canopy cover varied with land use zone in western Washington, with more than 80 percent of the forest class having 30 m pixels with tree cover in >0 percent, while less than 20 percent of the intensive agriculture had tree cover >0 percent (fig. 19). Interestingly, more than 60 percent of the low-density residential class had tree cover, with 36 percent of the class having pixels with >80 percent tree cover. Thirty-eight percent of the urban class had pixels with tree cover. In eastern Washington, NLCD-estimated tree cover was much lower for nonforest land use points, with only 20 percent of the residential class points having >20 percent tree cover (fig. 20).

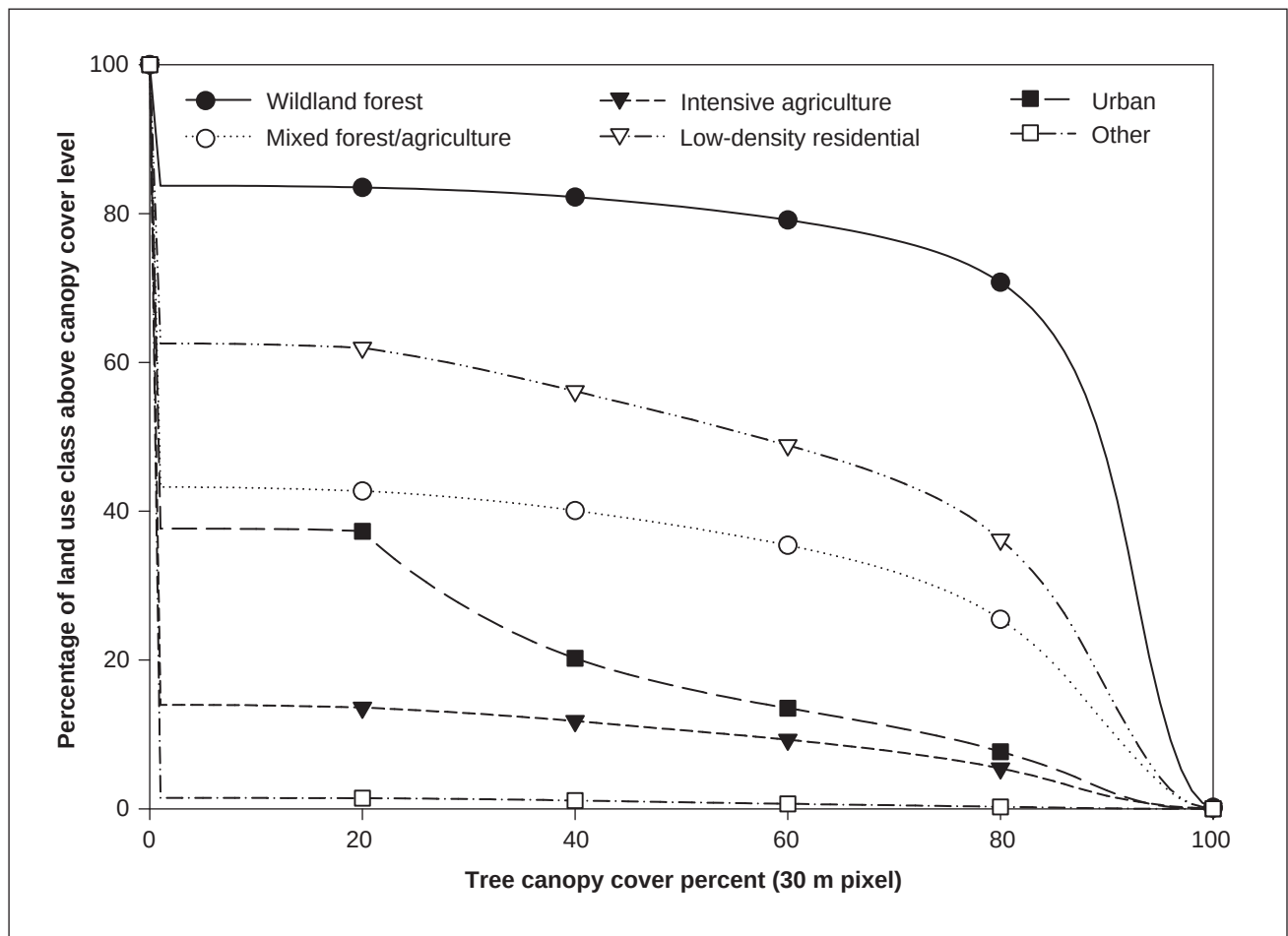


Figure 19—Reverse-cumulative distribution of National Land Classification Database-estimated tree cover by land use class for western Washington, showing the percentage of points with tree cover above the level shown on the x-axis. For example, 20 percent of urban class points had tree canopy cover of 40 percent or more in the surrounding 2.5-ac area.

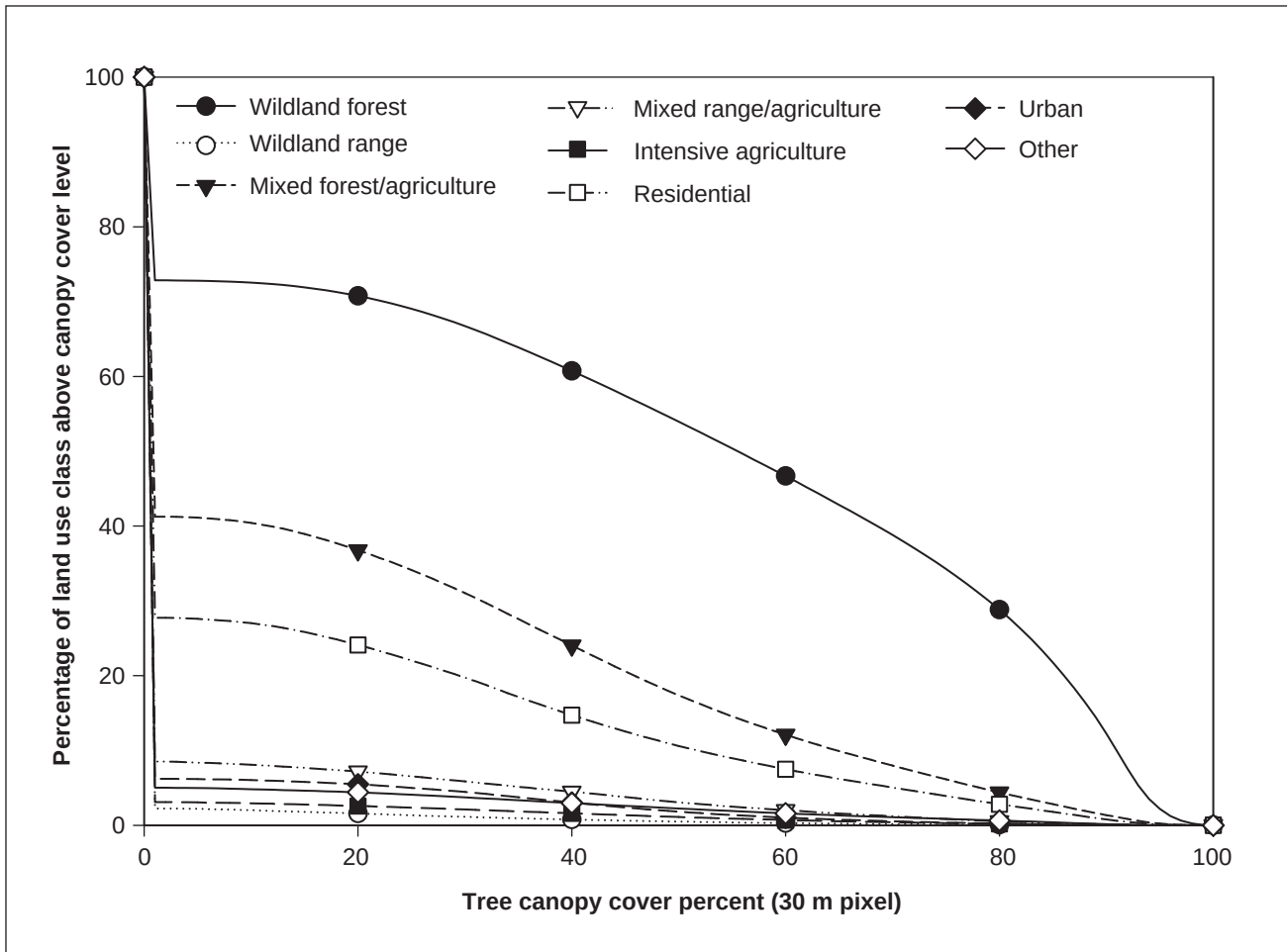


Figure 20—Reverse-cumulative distribution of National Land Classification Database-estimated tree cover by land use class for eastern Washington, showing the percentage of points with tree cover above the level shown on the x-axis. For example, 24 percent of mixed forest-agriculture class points had tree canopy cover of 40 percent or more in the surrounding 2.5-ac area.

Discussion

Substantial changes in land use and housing density occurred in Washington in the last 30 years. The state's population increased by an estimated 2.5 million people (66 percent) between 1976 and 2006, with most of the increase around Puget Sound. During this time, an estimated 1.16 million ac were converted from forestry, range, and agriculture land uses to low-density residential and urban land uses (equivalent to conversion of a football field every 18 minutes). Despite similar increases in population between 1976 to 1994 and 1994 to 2006, the rate of conversion of resource lands to developed lands was greater prior to 1994 than afterward. In addition to conversion, the density of housing structures on lands that remained in resource land uses increased as well. Increases in housing density on resource lands were greater in the 1994 to 2006 period than in the 1976 to 1994 period in eastern

The rate of conversion of resource lands to developed lands was greater prior to 1994 than afterward.

Washington, but lower in western Washington. These patterns of change in population, land use, and structures indicate housing densification on resource lands without wholesale change in land use, and higher rates of densification in existing urban and residential areas in western Washington than in eastern Washington.

Most of the land converted to residential and urban uses in Washington was forest land. The conversion of 650,000 ac of forest land over the 30-year period represented a loss of 2.7 percent of the total wildland forest in Washington, but a loss of 4.7 percent of the nonfederal wildland forest. This represents a potentially large impact on the ability to produce forest products, because very little timber volume has been produced from federal lands since 1990. For example, only 4 percent of the timber volume produced in Washington in 2010 came from federal lands (Washington State Department of Natural Resources 2012). Conversion of forest land to urban land uses also has an impact on wildlife and endangered species. Bilby and Mollot (2008) found that populations of Coho salmon in streams in the Puget Sound area declined by 75 percent in urbanizing areas while populations were stable elsewhere. Direct impacts to vegetation in riparian zones as well as pollution in runoff from impervious surfaces have been implicated in fishery declines (Morley and Karr 2002).

Changes in forest land ownership can be highly dynamic, and its transfer from public to private, or from industrial private to nonindustrial private owners, could set the stage for future development on those lands. This study did not address those issues, and looked only at ownership at one point in time. In localized geographic areas (e.g., the I-90 corridor through the Cascade Range), changes in ownership are likely to have a profound effect on development patterns. Although we found that most conversion of forest land happened on private nonindustrial ownerships, it is possible that those lands were previously in public or private industrial ownership. Although it would be good to investigate, it could be challenging to find the ownership information that aligns well with image dates (especially for the mid-90s images).

In addition to loss of land area, the increased proximity of developed land uses and housing structures to forest land may reduce timber production. For example, the likelihood of forest land being managed for timber production tends to decline as density of houses in the surrounding area increases (Kline et al. 2004, Wear et al. 1999). Although the overall population increase was lower in eastern Washington than in western Washington, increases in housing density on forest land were greater. This could be a cause of concern because wildfires are more common on the east side of the state, and changes in housing in the WUI can affect strategies and costs for controlling wildfires (Hammer et al. 2007).

Increased development also had substantial impacts on the area in agricultural land uses (i.e., mixed forest/agriculture, mixed range/agriculture, and intensive agriculture land classes). Statewide, agricultural land uses were a smaller portion of the land base than forest land, and experienced a comparable rate of conversion to developed uses (4 percent or 377,000 ac over the 30-year period). However, most of the loss of agricultural land occurred on the west side (264,000 ac), with an overall loss of 22 percent of the land area there. Other assessments estimate that more than 1.4 million acres of farmland were lost between 1950 and 2007 in the Puget Sound region alone (Canty et al. 2012). Housing structure density also increased within these agricultural zones and lot sizes declined. The impact of lot sizes on agricultural productivity is unclear, however; production is often higher from small farm lots than from traditional larger farms, as long as there are not too many “recreational” farmers in the mix (Heimlich et al. 2001).

Most of the urban land use classes we delineated appear to be contained in the state-designated UGAs. However, much of the low-density residential land use is outside of those areas, and housing density has continued to increase there. Additional examination of changes in development with reference to county or local land use plans could provide insight into recent and potential future patterns of development.

Different definitions and metrics of land use change result in different estimates of rates of forest conversion to nonforest land uses for western Washington. The estimate from FIA field plots is a loss of 207,000 ac of nonfederal forest land between 1990 and 2005 (Gray et al. 2005, unpublished data), and 239,000 ac between 1980 and 1990 (MacLean et al. 1992), for an overall loss of 446,000 ac and a rate of 0.22 percent per year. This study found a loss of 493,000 ac between 1976 and 2006 for an overall rate of 0.21 percent per year. In contrast, an effort to classify change with Landsat image classification suggested a loss of 1.2 million ac of forest land between 1988 and 2004, for an overall rate of 0.9 percent per year (Rural Technology Initiative 2006). Comparison of this image classification with inventory plots found substantial confusion between classifications of forest, agriculture, and developed land uses (Kline et al. 2009), with an apparent problem distinguishing recent clearcuts at lower elevations from land use change. For example, we found substantial areas classified by NLCD as shrubland and grassland in our forest land use class. However, when only the pixels classified as change from forest to developed use are considered, the estimate of forest loss in the Rural Technology Initiative report of 401,000 ac between 1988 and 2004 results in an estimated rate (0.30 percent per year) that is only 38 percent higher than the estimate for the 30-year period in this study (0.21 percent per year) (Rural Technology Initiative 2006).

This method is promising for providing consistent trend information on land use over time.

This method is promising for providing consistent trend information on land use over time. Human interpretation of landscape patterns in vegetation cover, roads, buildings, and landforms allows for much more nuanced interpretations of landscapes than is possible with computer algorithms. The structure counts provide more detail on location of people and houses than is possible otherwise (except perhaps with LiDAR). Most significantly, a consistent set of definitions and protocols was applied to the entire 30-year period, which has not been readily available in analyses of land use change to date. The scale at which polygons are mapped and the mix of classes that can occur in a polygon may be too coarse to estimate some site-specific impacts (e.g., on wildlife habitat). The delineation of the entire land area into land use polygons that can be updated as new imagery becomes available makes it possible to calculate change for relatively small areas. However, delineation of boundaries and polygon shapes is somewhat subjective, so the analyses based on grid points provides a more robust metric for change over time.

It may be desirable to update this study to a fourth time period with new state-wide imagery that is scheduled to be collected in 2014. In addition, imagery from the 1970s for the large nonforest zone in eastern Washington could be incorporated to provide a complete assessment of all land uses in the state over the last 30 years. Potential future applications of this study, in combination with inventory, environmental, or economic data, include (1) assessing changes in forest or agricultural management in areas close to residential areas or in proximity to housing structures; (2) analyzing fuels, fire risk, and housing density in fire-prone forests to aid in planning; (3) determining development patterns in relation to known or potential future flood zones; (4) examining the effectiveness of different land use planning approaches by comparing development patterns in areas with different policies; and (5) evaluating the effect of changes in parcel size on economic value, ecological value, and future development.

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Metric Equivalents

1 foot (ft) = 0.3048 meter (m)

1 acre (ac) = 0.4047 hectare (ha)

1 square mile (mi²) = 2.59 square kilometers (km²)

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Appendix

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Adams County:						
Wildland range	340	27.6	340	27.6	340	27.6
Intensive agriculture	874	71.0	874	71.0	874	71.0
Low-density residential	6	0.5	6	0.5	6	0.5
Urban	6	0.5	6	0.5	6	0.5
Other	6	0.5	6	0.5	6	0.5
Total	1,232	100	1,232	100	1,232	100
Asotin County:						
Wildland forest	65	28.2	65	28.2	64	27.8
Wildland range	161	46.9	161	46.9	161	46.9
Mixed forest/agriculture	7	3.0	7	3.0	7	3.0
Intensive agriculture	112	21.5	112	21.5	112	21.5
Low-density residential	10	0.4	10	0.4	1	0.6
Urban		0		0	9	0.2
Total	354	100	354	100	354	100
Benton County:						
Wildland forest	6	0.5	6	0.5	6	0.5
Wildland range	474	43.5	474	43.5	441	40.4
Intensive agriculture	491	45.1	491	45.1	520	47.7
Low-density residential	40	3.6	40	3.6	40	3.6
Urban	45	4.1	45	4.1	51	4.7
Other	34	3.1	34	3.1	34	3.1
Total	1,090	100	1,090	100	1,090	100
Chelan County:						
Wildland forest	205	53.8	200	52.4	197	51.7
Wildland range	105	27.5	100	26.2	98	25.7
Mixed forest/agriculture	1	0.4	0	0.1	0	0.1
Mixed range/agriculture	0	0.1	0	0		
Intensive agriculture	39	10.3	35	9.2	32	8.4
Low-density residential	25	6.5	39	10.2	41	10.8
Urban	6	1.5	7	1.9	13	3.4
Total	381	100	381	100	381	100
Clallam County:						
Wildland forest	536	87.7	523	85.5	517	84.7
Mixed forest/agriculture	11	1.8	10	1.6	8	1.3
Intensive agriculture	30	4.9	23	3.7	16	2.7
Low-density residential	28	4.6	48	7.9	60	9.8
Urban	5	0.8	6	1.0	8	1.2
Other	1	0.2	1	0.2	1	0.2
Total	611	100	611	100	611	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	Thousand acres	Percent	Thousand acres	Percent	Thousand acres	Percent
Clark County:						
Wildland forest	176	44.1	168	42.0	155	38.8
Mixed forest/agriculture	68	17.0	59	14.8	48	12.0
Intensive agriculture	81	20.2	70	17.4	51	12.9
Low-density residential	48	12.0	64	16.1	86	21.4
Urban	26	6.6	38	9.6	59	14.8
Other	0	0.1	0	0.1	0	0.1
Total	400	100	400	100	400	100
Columbia County:						
Wildland forest	87	55.1	86	54.5	86	54.5
Wildland range	59	6.0	59	6.0	59	6.0
Mixed forest/agriculture	3	2.1	3	2.1	3	2.1
Intensive agriculture	234	36.1	233	35.8	233	35.8
Low-density residential	0	0.3	2	1.2	2	1.2
Other	6	0.3	6	0.3	6	0.3
Total	390	100	390	100	390	100
Cowlitz County:						
Wildland forest	625	89.6	612	87.8	603	86.4
Mixed forest/agriculture	11	1.5	10	1.5	8	1.2
Intensive agriculture	15	2.2	15	2.2	13	1.9
Low-density residential	32	4.6	41	5.8	52	7.4
Urban	14	2.0	15	2.1	16	2.2
Other	1	0.1	5	0.7	6	0.9
Total	697	100	697	100	697	100
Douglas County:						
Wildland forest	14	12.2	14	12.2	14	12.2
Wildland range	538	47.2	538	47.2	531	46.9
Intensive agriculture	605	39.0	605	39.0	605	39.0
Low-density residential	1	1.2	1	1.2	8	1.6
Urban	7	0.4	7	0.4	7	0.4
Total	1,165	100	1,165	100	1,165	100
Ferry County:						
Wildland forest	828	88.2	823	87.7	819	87.3
Wildland range	28	3.0	28	3.0	28	3.0
Mixed forest/agriculture	38	4.0	37	4.0	37	3.9
Mixed range/agriculture	4	0.4	4	0.4	4	0.4
Intensive agriculture	26	2.8	26	2.7	25	2.7
Low-density residential	12	1.3	18	2.0	23	2.4
Urban	0	0	0	0	0	0
Other	2	0.2	2	0.2	2	0.2
Total	939	100	939	100	939	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Franklin County:						
Wildland range	271	33.8	271	33.8	265	33.1
Intensive agriculture	488	60.9	488	60.9	494	61.7
Low-density residential	18	2.3	18	2.3	18	2.3
Urban	6	0.8	6	0.8	6	0.8
Other	18	2.3	18	2.3	18	2.3
Total	801	100	801	100	801	100
Garfield County:						
Wildland forest	21	21.9	21	21.9	21	21.9
Wildland range	66	23.0	66	23.0	66	23.0
Mixed forest/agriculture	1	1.0	1	1.0	1	1.0
Intensive agriculture	261	53.6	261	53.6	260	52.6
Low-density residential	0	0	1	1.0		
Other	6	0.5	6	0.5	6	0.5
Total	355	100	355	100	355	100
Grant County:						
Wildland range	772	44.8	772	44.8	749	43.5
Mixed range/agriculture	6	0.3	6	0.3	6	0.3
Intensive agriculture	835	48.5	835	48.5	835	48.5
Low-density residential	40	2.3	40	2.3	52	3.0
Urban	6	0.3	6	0.3	17	1.0
Other	63	3.7	63	3.7	63	3.7
Total	1,722	100	1,722	100	1,722	100
Grays Harbor County:						
Wildland forest	985	91.2	983	90.9	981	90.8
Mixed forest/agriculture	8	0.8	9	0.8	7	0.7
Intensive agriculture	42	3.9	40	3.7	39	3.6
Low-density residential	32	3.0	33	3.1	36	3.4
Urban	9	0.8	12	1.1	13	1.2
Other	4	0.4	4	0.4	4	0.4
Total	1,081	100	1,081	100	1,081	100
Island County:						
Wildland forest	57	42.8	43	32.2	33	25.0
Mixed forest/agriculture	5	3.6	4	2.6	2	1.3
Intensive agriculture	26	19.7	24	18.1	24	17.8
Low-density residential	39	29.3	56	41.8	66	49.3
Urban	4	3.3	5	3.9	7	5.3
Other	2	1.3	2	1.3	2	1.3
Total	134	100	134	100	134	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	Thousand acres	Percent	Thousand acres	Percent	Thousand acres	Percent
Jefferson County:						
Wildland forest	432	94.0	419	91.2	414	90.1
Mixed forest/agriculture	6	1.4	6	1.3	5	1.0
Intensive agriculture	6	1.4	6	1.4	6	1.4
Low-density residential	11	2.3	23	4.9	26	5.6
Urban	2	0.4	3	0.7	6	1.4
Other	2	0.5	2	0.5	2	0.5
Total	460	100	460	100	460	100
King County:						
Wildland forest	631	62.4	588	58.2	567	56.1
Mixed forest/agriculture	8	0.8	6	0.6	5	0.5
Intensive agriculture	59	5.8	47	4.6	39	3.9
Low-density residential	156	15.4	169	16.7	169	16.7
Urban	156	15.4	199	19.7	229	22.6
Other	2	0.2	2	0.2	2	0.2
Total	1,011	100	1,011	100	1,011	100
Kitsap County:						
Wildland forest	147	57.8	118	46.6	105	41.3
Mixed forest/agriculture	10	3.9	8	3.0	6	2.3
Intensive agriculture	1	0.4	1	0.4	1	0.4
Low-density residential	85	33.3	110	43.4	123	48.6
Urban	10	4.1	15	6.0	18	6.9
Other	1	0.5	1	0.5	1	0.5
Total	254	100	254	100	254	100
Kittitas County:						
Wildland forest	412	67.2	407	66.3	401	65.4
Wildland range	450	23.9	441	23.2	438	22.9
Mixed forest/agriculture	1	0.2	1	0.2	1	0.2
Intensive agriculture	130	6.9	129	5.7	115	5.3
Low-density residential	9	1.5	25	4.1	46	5.7
Urban	7	0.2	8	0.4	8	0.5
Other	6	0.1	6	0.1	6	0.1
Total	1,017	100	1,017	100	1,017	100
Klickitat County:						
Wildland forest	586	61.2	577	60.3	571	59.7
Wildland range	284	17.0	283	16.9	276	16.8
Mixed forest/agriculture	18	1.9	15	1.6	14	1.5
Mixed range/agriculture	4	0.5	4	0.4	4	0.4
Intensive agriculture	274	18.3	272	18.0	275	17.8
Low-density residential	7	0.8	22	2.4	33	3.4
Urban	3	0.4	3	0.4	4	0.4
Other	12	0.2	12	0.2	12	0.2
Total	1,189	100	1,189	100	1,189	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Lewis County:						
Wildland forest	887	82.5	880	81.9	868	80.8
Mixed forest/agriculture	31	2.9	30	2.8	29	2.7
Intensive agriculture	109	10.1	106	9.9	105	9.8
Low-density residential	41	3.8	50	4.7	63	5.9
Urban	7	0.7	7	0.7	9	0.8
Other	0	0	0	0	0	0
Total	1,075	100	1,075	100	1,075	100
Lincoln County:						
Wildland forest	138	45.8	138	45.8	136	45.1
Wildland range	488	18.3	488	18.3	488	18.3
Mixed forest/agriculture	2	0.8	2	0.8	2	0.8
Mixed range/agriculture	1	0.3	1	0.3	1	0.3
Intensive agriculture	831	34.7	831	34.7	831	34.5
Low-density residential	0	0	2	0.8		
Urban	6	0.2	6	0.2	6	0.2
Total	1,467	100	1,467	100	1,467	100
Mason County:						
Wildland forest	415	90.9	402	87.9	393	86.0
Mixed forest/agriculture	6	1.2	6	1.3	6	1.2
Intensive agriculture	4	0.8	3	0.7	3	0.7
Low-density residential	28	6.1	41	9.0	50	11.0
Urban	2	0.4	2	0.4	2	0.5
Other	3	0.6	3	0.6	3	0.6
Total	457	100	457	100	457	100
Okanogan County:						
Wildland forest	943	50.1	930	49.4	926	49.3
Wildland range	654	34.8	639	34.0	632	33.6
Mixed range/agriculture	49	2.6	50	2.7	50	2.7
Intensive agriculture	206	11.0	209	11.1	209	11.1
Low-density residential	21	1.1	45	2.4	55	2.9
Urban	5	0.3	6	0.3	6	0.3
Other	1	0.1	1	0.1	1	0.1
Total	1,880	100	1,880	100	1,880	100
Pacific County:						
Wildland forest	580	93.0	576	92.5	574	92.0
Mixed forest/agriculture	11	1.7	12	1.9	12	1.9
Intensive agriculture	9	1.4	9	1.4	8	1.3
Low-density residential	17	2.8	20	3.2	19	3.1
Urban	2	0.3	2	0.3	5	0.9
Other	5	0.8	5	0.8	5	0.9
Total	623	100	623	100	623	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Pend Oreille County:						
Wildland forest	290	79.8	284	78.2	281	77.5
Mixed forest/agriculture	15	4.1	13	3.7	12	3.2
Intensive agriculture	41	11.4	41	11.2	40	10.9
Low-density residential	13	3.7	22	6.0	27	7.4
Urban	1	0.3	1	0.3	1	0.3
Other	3	0.8	3	0.8	3	0.8
Total	363	100	363	100	363	100
Pierce County:						
Wildland forest	467	61.8	424	56.1	400	53.0
Mixed forest/agriculture	55	7.3	41	5.4	34	4.5
Intensive agriculture	28	3.7	23	3.1	18	2.3
Low-density residential	136	18.0	174	23.0	188	24.9
Urban	69	9.1	92	12.2	114	15.1
Other	1	0.1	1	0.1	1	0.1
Total	756	100	756	100	756	100
San Juan County:						
Wildland forest	51	45.2	44	38.9	43	38.5
Mixed forest/agriculture	22	19.8	17	15.5	15	13.5
Intensive agriculture	16	14.7	13	11.9	12	10.7
Low-density residential	22	19.4	37	32.9	41	36.5
Other	1	0.8	1	0.8	1	0.8
Total	112	100	112	100	112	100
Skagit County:						
Wildland forest	446	72.0	435	70.1	432	69.6
Mixed forest/agriculture	24	3.9	19	3.1	17	2.8
Intensive agriculture	103	16.7	95	15.3	95	15.4
Low-density residential	32	5.2	50	8.0	54	8.7
Urban	10	1.6	17	2.8	17	2.8
Other	5	0.7	5	0.7	5	0.7
Total	620	100	620	100	620	100
Skamania County:						
Wildland forest	216	92.5	209	89.8	208	89.4
Mixed forest/agriculture	4	1.8	4	1.6	4	1.6
Intensive agriculture	3	1.2	2	1.0	2	1.0
Low-density residential	10	4.3	16	7.1	17	7.5
Urban	0	0.2	1	0.6	1	0.6
Total	233	100	233	100	233	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Snohomish County:						
Wildland forest	455	64.1	402	56.7	379	53.4
Mixed forest/agriculture	18	2.5	14	2.0	12	1.6
Intensive agriculture	89	12.5	75	10.6	68	9.5
Low-density residential	98	13.8	150	21.2	168	23.7
Urban	47	6.6	64	9.0	80	11.3
Other	3	0.5	3	0.5	3	0.5
Total	709	100	709	100	709	100
Spokane County:						
Wildland forest	381	41.5	332	37.5	317	35.8
Wildland range	64	4.2	64	4.2	63	4.1
Mixed range/agriculture	39	4.4	31	3.5	27	3.1
Intensive agriculture	481	40.7	444	36.6	427	34.6
Low-density residential	86	8.2	159	16.4	190	19.9
Urban	75	0.9	96	1.7	101	2.4
Other	1	0.1	1	0.1	1	0.1
Total	1,126	100	1,126	100	1,126	100
Stevens County:						
Wildland forest	1,053	77.4	1,040	76.4	1,032	75.8
Wildland range	4	0.3	4	0.3	4	0.3
Mixed range/agriculture	56	4.1	53	3.9	52	3.8
Intensive agriculture	196	14.4	192	14.1	186	13.6
Low-density residential	47	3.5	65	4.8	81	6.0
Urban	4	0.3	6	0.4	6	0.4
Other	1	0.1	1	0.1	1	0.1
Total	1,361	100	1,361	100	1,361	100
Thurston County:						
Wildland forest	292	62.9	275	59.2	249	53.6
Mixed forest/agriculture	40	8.6	33	7.1	30	6.4
Intensive agriculture	57	12.3	50	10.7	39	8.5
Low-density residential	59	12.6	83	17.8	110	23.6
Urban	12	2.7	19	4.1	32	6.9
Other	5	1.0	5	1.0	5	1.0
Total	465	100	465	100	465	100
Wahkiakum County:						
Wildland forest	148	87.6	148	87.3	146	86.5
Mixed forest/agriculture	3	1.6	3	1.6	3	1.6
Intensive agriculture	15	8.6	15	8.6	15	8.6
Low-density residential	2	1.1	2	1.3	4	2.2
Other	2	1.1	2	1.1	2	1.1
Total	169	100	169	100	169	100

Table 19—Area of nonfederal land in Washington by county and percentages of total by area, land use class, and year (continued)

Land use class	1976		1994		2006	
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Percent</i>
Walla Walla County:						
Wildland forest	44	24.9	44	24.9	44	24.9
Wildland range	150	6.7	150	6.7	150	6.7
Intensive agriculture	570	63.5	570	63.5	564	63.0
Low-density residential	11	2.9	11	2.9	17	3.5
Urban	12	0.8	12	0.8	12	0.8
Other	24	1.1	24	1.1	24	1.1
Total	811	100	811	100	811	100
Whatcom County:						
Wildland forest	264	53.2	251	50.6	248	50.0
Mixed forest/agriculture	25	5.1	20	4.1	19	3.9
Intensive agriculture	158	31.8	130	26.2	128	25.8
Low-density residential	38	7.6	76	15.4	81	16.4
Urban	10	2.1	18	3.5	18	3.7
Other	1	0.2	1	0.2	1	0.2
Total	496	100	496	100	496	100
Whitman County:						
Wildland forest	29	10.5	29	10.5	29	10.5
Wildland range	269	15.3	269	15.3	269	15.3
Intensive agriculture	1,047	72.3	1,047	72.3	1,047	72.3
Urban	13	0.8	13	0.8	13	0.8
Other	19	1.1	19	1.1	19	1.1
Total	1,377	100	1,377	100	1,377	100
Yakima County:						
Wildland forest	803	60.7	803	60.7	803	60.7
Wildland range	902	32.7	887	32.4	886	32.3
Intensive agriculture	433	4.8	417	4.4	405	4.3
Low-density residential	42	0.7	67	1.3	80	1.5
Urban	24	0.1	30	0.2	30	0.2
Other	13	1.0	13	1.0	13	1.0
Total	2,218	100	2,218	100	2,218	100

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