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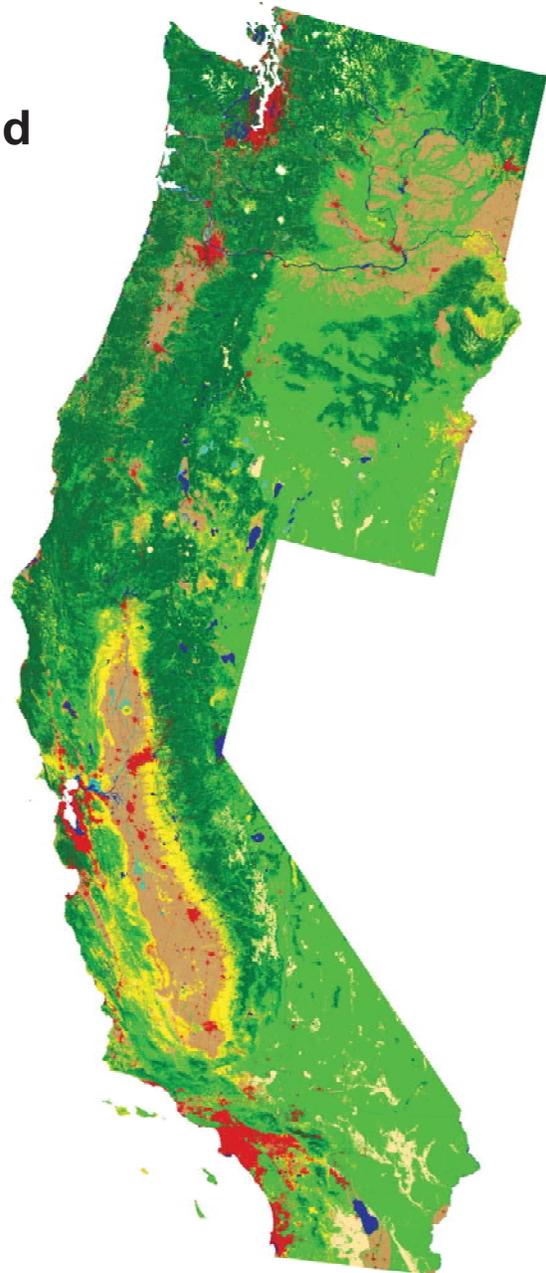
General Technical
Report NRS-65



Urban and Community Forests of the Pacific Region

California Oregon Washington

David J. Nowak
Eric J. Greenfield



Abstract

This report details how land cover and urbanization vary within the states of California, Oregon, and Washington by community (incorporated and census designated places), county subdivision, and county. Specifically this report provides critical urban and community forestry information for each state including human population characteristics and trends, changes in urban and community lands, tree canopy and impervious surface cover characteristics, distribution of land-cover classes, a relative comparison of urban and community forests among local government types, determination of priority areas for tree planting, and a summary of urban tree benefits. Report information can improve the understanding, management, and planning of urban and community forests. The data from this report is reported for each state on the CD provided in the back of this book, and it may be accessed by state at: <http://www.nrs.fs.fed.us/data/urban>.

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INTRODUCTION

As part of the Forest and Rangeland Renewable Resources Planning Act of 1974, the first national assessment of urban forests was completed in 2000 (Dwyer et al. 2000, Nowak et al. 2001b). This assessment used 1-km resolution Advanced Very-High Resolution Radiometer (AVHRR) data (Zhu 1994) and 1990 U.S. Census Bureau (2007) population and geographic data to assess urban tree cover. The assessment concluded that urban areas in the conterminous United States doubled in size between 1969 and 1994 and covered 3.5 percent of the total land area. Urban areas were estimated to contain approximately 3.8 billion trees with an average tree canopy cover of 27 percent.

To update this first report, higher resolution (30 m) tree canopy and impervious surface cover maps were used (from 2001 Landsat satellite imagery and published in 2007) (Homer et al. 2007, U.S. Geol. Surv. 2007) in conjunction with 1990 and 2000 census and geographic data (1:5,000,000 scale cartographic boundary files) (U.S. Census Bureau 2007) to assess current urban and community forest attributes. These results are being published for each of the lower 48 United States to provide information on urban change and state-specific urban and community forestry data.

This report includes information for the following states: California, Oregon, and Washington.

Data are reported for the state, county, county subdivision, and community jurisdictions. The jurisdictional units used in this report are derived from U.S. Census (2007) geographic data and defined legal or statistical divisions. “County”¹ refers to the primary subdivision within states. “County subdivisions” are primary divisions of a county and are statistically equivalent entities for the reporting of census data. They include census county divisions (CCD), census sub areas, minor civil divisions (MCD), and unorganized territories. “Communities” are incorporated and census designated places, and consolidated cities (U.S. Census Bureau 2007). For detailed definitions, see http://www.census.gov/geo/www/cob/cs_metadata.html (2007).

¹The primary legal divisions of most states are termed “counties.” In Louisiana, these divisions are known as “parishes.” In four states (Maryland, Missouri, Nevada, and Virginia), there are one or more incorporated places that are independent of any county organization and thus constitute primary divisions of their states; these incorporated places are known as “independent cities” and are treated as equivalent to counties for statistical purposes. (For some statistical purposes they may be treated as county subdivisions and places.) The District of Columbia has no primary divisions, and the entire area is considered equivalent to a county for statistical purposes. (http://www.census.gov/geo/www/cob/co_metadata.html, 2007)

REPORT OVERVIEW

The information in this report can aid local and regional managers and planners of urban and community forest resources. This report provides urban and community forest reference information and data from the state to local level on the following attributes related to the urban and community forest resource:

- Human population characteristics and trends
- Urban and community land
- Tree canopy cover characteristics
- Impervious surface cover characteristics
- Classified land-cover characteristics
- Relative comparisons of urban and community forests
- Priority areas for tree planting
- Urban tree benefits

Information in this report can be used by urban and community forestry professionals to:

- Understand general land-cover characteristics and urbanization trends at several geographic scales
- Compare tree canopy cover among similar communities
- Determine areas of greatest growth and areas of highest tree planting priority
- Relate urban and community forests to pollution removal and carbon storage
- Promote more detailed and/or locally appropriate urban and community forest inventories, censuses, or field surveys (e.g., i-Tree – www.itreetools.org)
- Establish local to statewide standards related to urban and community forestry
- Support urban and community forestry programs
- Improve urban and community forest management and planning

The remainder of this section details how information was derived for each attribute reported for the urban and community areas. The subsequent state summaries

detail the findings for each state in this region. Most tables for each state are not given in this report, rather they can be found on the CD provided with this report or accessed at: <http://www.nrs.fs.fed.us/data/urban>.

URBAN FOREST ATTRIBUTES

Human Population Characteristics and Trends

Human population and population density changes over time, and geographic distribution are important measurements of the urban environment because human populations are an integral part of community and urban forest dynamics. Within divisions of state, county, county subdivision, and community, total population, population changes from 1990 to 2000 and population density are detailed based on U.S. Census data (U.S. Census Bureau 2007).

Urban and Community Land

Two geographic definitions overlap: “community” and “urban”. The definition of community is based on jurisdictional or political boundaries delimited by U.S. Census definitions of places (U.S. Census Bureau 2007). Community lands are places of established human settlement that may include all, some, or no urban land within their boundaries.

The definition of urban is based on population density as delimited using the U.S. Census Bureau’s (2007) definition: all territory, population, and housing units located within urbanized areas or urban clusters. Urbanized area and urban cluster boundaries encompass densely settled territories, which are described by one of the following:

- One or more block groups or census blocks with a population density of at least 386.1 people/km² (1,000 people/mile²)
- Surrounding block groups and census blocks with a population density of 193.1 people/km² (500 people/mile²)
- Less densely settled blocks that form enclaves or indentations, or are used to connect discontinuous areas

More specifically, urbanized areas consist of territory with 50,000 or more people. Urban clusters, a concept new to the 2000 Census, consist of territory with at least 2,500 people but fewer than 50,000 people. This new definition tends to be more restrictive than the 1990 U.S. Census urban definition and encompasses many areas typically considered suburban. The 2000 Census definition of urban was applied to 1990 Census geographic data to analyze change in urban land between 1990 and 2000 (Nowak et al. 2005).

As urban land reveals the more heavily populated areas (population density-based definition) and community land indicates both urban and rural (i.e., non-urban) communities that are recognized by their geopolitical boundaries (political definition), both definitions provide information related to human settlements and the forest resources within those settlements. As some urban land exists beyond community boundaries and not all community land is urban (i.e., communities are often a mix of urban and rural land), the category of “urban or community” was created to understand forest attributes accumulated by the union of these two definitions. The “urban or community” term used throughout this report encompasses both urban land and land in communities.

Percent urban land is a ratio of urban land over total land within a census geographic division, and percent community land is a ratio of community land over total land within the geopolitical unit. In addition, changes in urban land and changes in community land are reported between 1990 and 2000.

For each state, Tables 1 through 4 summarize the population, and urban and community land attributes for the state, communities, county subdivisions, and counties respectively (CD and <http://www.nrs.fs.fed.us/data/urban>).

Tree Canopy Cover Characteristics

Tree canopy cover is a critical measure of the urban and community forest resource. Tree canopy cover gives a broad indication of the overall forest resource and its associated benefits. To assess urban and

community land cover characteristics, the multi-resolution land characteristics consortium’s National Land Cover Database (NLCD) was used (Homer et al. 2004, U.S. Geol. Surv. 2007, Yang et al. 2003). The NLCD, released in early 2007, was processed from 2001 Landsat satellite imagery and provides estimates of percentage tree canopy and impervious surface cover within 30-m pixels or cells across the state. The tree canopy percentages in this report are calculated using the land area (not including water) of the geopolitical units derived from the U.S. Census cartographic boundary data and NLCD. In addition to percentage tree cover, four other canopy cover attributes, derived from the same data, were assessed:

- Tree canopy cover per capita—Tree canopy cover (m²) divided by the number of people within the area of analysis.
- Total green space—Total area minus impervious and water cover (ha). This attribute estimates pervious cover (i.e., grass, soil, or tree-covered areas).
- Canopy green space—Tree cover divided by total green space (percent). This value is the proportion of the total green space that is filled by tree canopies.
- Available green space—Total green space minus tree canopy cover (ha). This value is the amount of grass and soil area not covered with tree canopies and potentially available for planting.

Impervious Surface Cover Characteristics

Similar to tree cover, impervious surface cover provides another piece of valuable information related to the urban environment. Impervious surface cover gives an indication of an area’s developed hardscape, which has important influences on urban air temperatures and water flows and also yields information on limitations to urban tree cover. Impervious surface cover also was derived from the NLCD database (U.S. Geol. Surv. 2007). The impervious surface cover percentages in this report are calculated using the land area (not including water) of the geopolitical units derived from the U.S. Census

cartographic boundary data and NLCD. Impervious surface per capita is calculated from NLCD 2001 and U.S. Census data.

For each state, Tables 1, and 5 through 7 summarize the tree canopy and impervious surface cover attributes for the state, communities, county subdivisions, and counties respectively (CD and <http://www.nrs.fs.fed.us/data/urban>).

Classified Land-cover Characteristics

Land-cover types also are summarized using 2001 Landsat satellite data that were classified with the U.S. Geological Survey land cover categorization scheme based on a modified Anderson land-cover classification (U.S. Geol. Surv. 2007). Land area, tree canopy cover, and available green space within generalized land cover categories vary among communities, county subdivisions, counties, and state. The percentages are calculated from the NLCD 2001 and U.S. Census cartographic boundary data. The land-cover categories defined here are derived from established NLCD 2001 land-cover classes. These generalized land-cover categories or types may not be present in some states.

- Developed—NLCD classes 21 (developed-open space), 22 (developed-low intensity), 23 (developed-medium intensity), and 24 (developed-high intensity)
- Barren—NLCD class 31 (barren land [rock/sand/clay])
- Forested—NLCD classes 41 (deciduous forest), 42 (evergreen forest), and 43 (mixed forest)
- Shrub/Scrub—NLCD class 52 (shrub/scrub)
- Grassland—NLCD class 71 (grassland/herbaceous)
- Agriculture—NLCD classes 81 (pasture/hay) and 82 (cultivated crops)
- Wetland—NLCD classes 90 (woody wetlands) and 95 (emergent herbaceous wetlands)

For each state, Tables 8 through 10 summarize the classified land-cover characteristics for communities, county subdivisions, and counties and state respectively (CD and <http://www.nrs.fs.fed.us/data/urban>).

Relative Comparisons of Tree Cover

A question commonly asked in evaluating the urban and community forest resource is, “How does my community compare with other communities?”

To help answer this question, tree canopy cover was compared among the counties, county subdivisions, and communities relative to other areas with comparable population density and within the same NLCD mapping unit (ecoregion). For this comparison, seven population density classes were established:

- Density class 1 — 0 to 38.6 people/km² (0 to 99.9 people/mile²)
- Density class 2 — 38.7 to 96.5 people/km² (100 to 249.9 people/mile²)
- Density class 3 — 96.6 to 193.1 people/km² (250 to 499.9 people/mile²)
- Density class 4 — 193.2 to 289.6 people/km² (500 to 749.9 people/mile²)
- Density class 5 — 289.7 to 386.2 people/km² (750 to 999.9 people/mile²)
- Density class 6 — 386.3 to 1931.2 people/km² (1000 to 4999.9 people/mile²) and
- Density class 7 — 1931.3 or greater people/km² (5000 or greater people/mile²)

Mapping zones were delimited within the NLCD to increase classification accuracy and efficiency (Fig. A). The mapping units represent relatively homogeneous ecological conditions (Homer and Gallant 2001). To locate geopolitical units within a mapping zone, centroid (geometric center) points of the local governments were used.

For three or more geographic units in the same mapping zone and population density class, a standardized tree canopy score based on the range of values within that zone and class was assigned to each unit. The standardized score is calculated as:

Standardized score = (tree canopy percent of unit – minimum tree canopy percentage in class)/range of tree canopy percent in class.

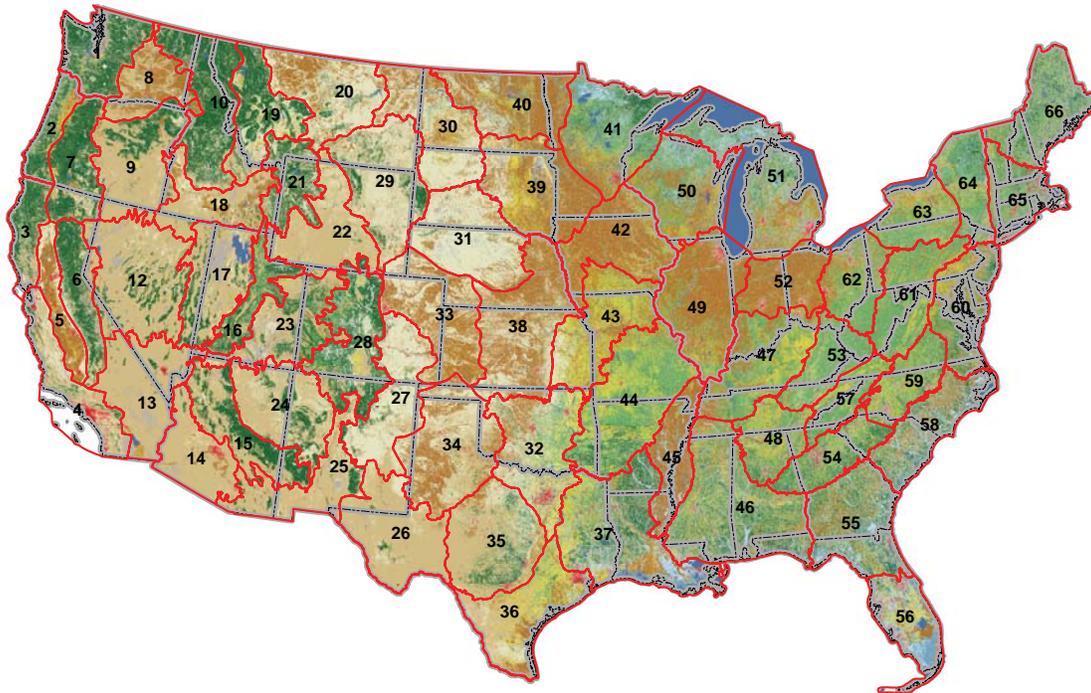


Figure A.—The mapping zones of the continental United States relative to states and land cover (NLCD 2001).

Communities, county subdivisions, and counties were assigned to one of the following categories based on their standardized score:

- Excellent—Standardized score of 0.9 to 1.0
- Very Good—0.7 to 0.89
- Good—0.5 to 0.69
- Fair—0.3 to 0.49
- Poor—0 to 0.29

To help understand the variability of tree cover, minimum, median, maximum, and weighted mean values for percent tree canopy cover in each population density class of each political subdivision are reported in Table 11 for each mapping zone (CD and <http://www.nrs.fs.fed.us/data/urban>). This information can be used to understand the actual range and values used for the assessment.

For each state, Tables 12 through 14 summarize the urban and community forest ratings for communities, county subdivisions, and counties respectively (CD and <http://www.nrs.fs.fed.us/data/urban>).

Priority Areas for Tree Planting

NLCD (U.S. Geol. Survey 2007) and 2000 U.S. Census data (2007) were used to produce an index that prioritizes tree planting areas for communities, county subdivisions, and counties. An index was developed to help identify areas with relatively low tree canopy cover and high population density (high priority tree-planting areas). This index provides one form of prioritization. States and local governments may design their own prioritization method incorporating individual and diverse value systems. The index used in this report combines three criteria.

- Population density—The greater the population density, the greater the priority for tree planting
- Canopy green space—The lower the value, the greater the priority for tree planting
- Tree canopy cover per capita—The lower the amount of tree canopy cover per person, the greater the priority for tree planting

Each criterion above was standardized² on a scale of 0 to 1, with 1 representing the maximum population density and minimum canopy green space and tree cover per capita. The standardized values were weighted to produce a combined score:

$$I = (PD * 40) + (CG * 30) + (TPC * 30)$$

Where I is the combined index score

PD is the standardized population density value

CG is the standardized canopy green space value, and

TPC is the standardized tree cover per capita value.

The combined score was standardized again and multiplied by 100 to produce the planting priority index. The tree planting priority index (PPI) ranks each state's communities, county subdivisions, and counties with values from 100 (highest priority) to 0 (lowest priority). This index is a type of "environmental equity" index with areas of higher human population density and lower canopy green space and tree cover per capita tending to get the higher index value.

For each state, Tables 15 through 17 summarize the tree planting priority index for communities, county subdivisions, and counties respectively (CD and <http://www.nrs.fs.fed.us/data/urban>).

Urban Tree Benefits

Urban and community forests are important for human and ecological health (Nowak and Dwyer 2007). The benefits ascribed to urban and community trees include:

- Carbon storage and sequestration
- Air pollution removal
- Surface air temperature reduction
- Reduced building energy use
- Absorption of ultraviolet radiation
- Improved water quality
- Reduced noise pollution
- Improved human comfort
- Increased property value
- Improved human physiological and psychological well-being
- Improved aesthetics
- Improved community cohesion

To understand the contribution and magnitude of the forest resource in urban or community areas, the total number of trees, carbon storage and annual carbon uptake (sequestration), air pollution removal, and the associated dollar values for carbon and air pollution benefits are estimated.

Carbon sequestration and storage values were estimated from tree cover (m²) multiplied by average carbon storage (9.1 kg C/m²), and sequestration (0.3 kg C/m²) density values derived from several U.S. communities (e.g., Nowak and Crane 2002). Monetary values associated with urban tree carbon storage and sequestration were based on the 2001-2010 projected marginal social cost of carbon dioxide emissions, \$22.8/t C (Fankhauser 1994). The number of urban and community trees was estimated in a similar manner multiplying tree canopy cover (m²) by average tree density per hectare of canopy cover from several U.S. cities (Table A).

Air pollution removal estimates are derived from the Urban Forest Effects (UFORE) model (Nowak and Crane 2000) and 2000 weather and pollution data (National Climatic Data Center 2000, U.S. EPA 2008). The UFORE model was used to integrate hourly pollution and weather data with urban or community tree cover data to estimate annual pollution removal in each state (Nowak and Crane 2000, Nowak et al. 2006d).

²Standardized value for population density (PD) was calculated as $PD = (n - \min) / r$, where PD is the value 0-1, n is the value for the geopolitical unit (population/km²), min is the minimum value for all units, and r is the range of values among all units (maximum value – minimum value). Standardized value for canopy green space (CG) was calculated as $CG = (\max - n) / r$, where CG is the value 0-1, max is the maximum value for all geopolitical units, n is the value for the unit (tree canopy cover m²/total green space m²), and r is the range of values. Standardized value for tree cover per capita (TPC) was calculated as $TPC = (\max - n) / r$, where TPC is the value (0-1), max is the maximum value for all geographic units, n is the value for the geopolitical unit (m²/capita), and r is the range of values among all units.

Table A.—Average number of trees, carbon storage, and carbon sequestration rates per unit of canopy cover for several U.S. cities

City	Trees (no./ha cover)	Carbon	
		Storage (kg C/m ² cover)	Sequestration (kg C/m ² cover)
Atlanta, GA ^a	751.5	9.7	0.3
Baltimore, MD ^a	598.1	12.3	0.3
Boston, MA ^a	371.7	9.1	0.3
Chicago, IL ^b	618.0	12.9	n/a
Casper, WY ^c	252.8	7.0	0.2
Freehold, NJ ^a	275.0	10.4	0.3
Jersey City, NJ ^a	308.7	4.4	0.2
Minneapolis, MN ^d	245.5	5.7	0.2
Moorestown, NJ ^a	547.9	9.9	0.3
Morgantown, WV ^a	829.6	10.6	0.3
New York, NY ^e	312.0	7.3	0.2
Philadelphia, PA ^f	394.3	9.0	0.3
San Francisco, CA ^g	468.1	12.3	0.3
Syracuse, NY ^h	583.1	10.5	0.3
Oakland, CA ⁱ	570.0	5.2	n/a
Washington, DC ^j	423.4	10.4	0.3
Woodbridge, NJ ^a	557.3	8.2	0.3
Mean	476.9	9.1	0.3

^a Unpublished data analyzed using UFORE model

^b Nowak 1994a,b

^c Nowak et al. 2006a

^d Nowak et al. 2006b

^e Nowak et al. 2007a

^f Nowak et al. 2007b

^g Nowak et al. 2007c

^h Nowak et al. 2001a

ⁱ Nowak 1993; Nowak and Crane 2002

^j Nowak et al. 2006c

To estimate pollution by urban trees in each state, state pollutant flux rates (grams of pollution removal per square meter of canopy per year) were derived from a study of national pollution removal by urban trees for the year 1994 (Nowak et al. 2006d). As pollution concentrations vary through time, the 1994 flux rates were adjusted to 2000 values based on average regional pollution concentration changes between 1994 and 2000 (U.S. EPA 2003). As

flux rate = deposition velocity * pollution concentration,

the ratio of the pollution concentration between years was used to update the flux rate. Arithmetic mean concentration values were used for nitrogen dioxide, particulate matter less than 10 microns, and sulfur dioxide, 2nd Max. 8-hr average for carbon dioxide, and 4th Max. 8-hr average for ozone, to determine

the ratio of change between 1994 and 2000 (U.S. EPA 2003). The new 2000 flux rates were multiplied by urban or community tree cover in the state to estimate total pollution removal by trees.

Pollution removal dollar value estimates were calculated using 1994 national median externality values used in energy decision making (Murray et al. 1994, Ottinger et al. 1990). The 1994 values were adjusted to 2007 dollars based on the producer price index (U.S. Dept. of Labor 2008). These values, in dollars/metric ton (t) are:

- Nitrogen dioxide (NO₂) = \$9,906/t
- Particulate matter less than 10 microns (PM₁₀) = \$6,614/t
- Sulfur dioxide (SO₂) = \$2,425/t
- Carbon monoxide (CO) = \$1,407/t

Externality values for ozone (O₃) were set to equal the value for NO₂. Externality values can be considered the estimated cost of pollution to society that is not accounted for in the market price of the goods or services that produced the pollution.

For each state, Table 1 summarizes carbon storage and air pollution removal estimates for urban, community, and urban or community trees statewide.

Data Accuracy and Application

The data presented in this report yield the most comprehensive and up-to-date assessment of continental U.S. urban and community forests. The data allows for relative comparisons among geographies and provides baseline information for assessing relative changes in urban and community forest cover in the future. As stated previously, tree cover information was based on finer resolution data than used in the original urban forest assessment (Dwyer et al. 2000). As the methodologies for quantifying tree cover have changed between the original and current assessment, evaluating changes is not possible since the detected changes could be caused by either actual landscape changes or differences in methodology.

The U.S. Census generalized cartographic boundary data are a simplified and smoothed extracts of the Topologically Integrated Geographic Encoding and Referencing (TIGER) database, with a target scale range of 1:5,000,000 (U.S. Census Bureau 2007). Because of this scale and generalization, border simplification impacts attribute measurements that are derived from the boundary data, especially for small areas and at the local scale. In particular, percentages (unitless ratios) generated from attribute measurements made for the smallest communities or county subdivisions may be under- or overstated depending upon the relative location of the smoothed border of the geopolitical unit.

While the 2001 NLCD is a substantial improvement over the 1991 AVHRR data (30-m versus 1-km resolution), it also has local-scale data and application

limitations. Initial tree canopy cover results revealed mean absolute errors (mean of the absolute difference between predicted and actual values) from 8.4 percent to 14.1 percent, with correlation coefficients between predicted and actual values ranging from 0.78 to 0.93. Impervious surface cover results revealed mean absolute errors from 4.6 percent to 7 percent, with *r*-values from 0.83 to 0.91 (Homer et al. 2004).

A more recent analysis of 127 community and 20 county geographies sampled throughout the continental United States compared NLCD tree canopy and impervious surface cover estimates with high resolution (1-m or less resolution) aerial photo-interpreted estimates. This analysis revealed that NLCD underestimates both tree canopy and impervious surface cover compared to photo-interpreted values. NLCD underestimates of tree cover vary by mapping zone, while underestimates of impervious surface cover, which are relatively minor, varies by population density (Greenfield et al. 2009). These findings are consistent with Walton (2008), who found a consistent under-prediction bias for the 2001 NLCD derived tree canopy cover values in census places (communities) of western New York.

The tree cover and impervious cover data given in this report are directly from the NLCD database. To help understand the potential underestimate in the cover values, each U.S. mapping zone was photo-interpreted using Google Earth images³. Table B provides a comparison of results from NLCD versus photo-interpreted data for mapping zones applicable to this collection of states.

Comparisons between NLCD impervious surface cover estimates and photo-interpreted values were not reported because differences were related to population density, which can vary significantly among geographic units. Despite the potential underestimates in tree canopy cover values, relative comparisons

³Nowak, D.J.; Greenfield, E.J. Tree and impervious cover in the conterminous United States: Testing of NLCD cover estimates by mapping zone. In review.

Table B.—Comparison of NLCD versus photo-interpretation (PI) derived values of percent tree canopy cover by NLCD mapping zones

Mapping zone ^a	n ^b	Percent tree canopy cover		Difference ^e	Margin of error ^f	Significant difference ^g
		NLCD ^c	PI ^d			
1	488	57.7%	65.4%	7.7%	3.9%	Yes
2	998	53.0%	69.7%	16.8%	2.2%	Yes
3	998	43.9%	72.4%	28.5%	2.4%	Yes
4	1000	11.5%	37.4%	25.9%	2.6%	Yes
5	1000	5.5%	11.0%	5.5%	1.9%	Yes
6	996	35.6%	58.9%	23.3%	2.8%	Yes
7	995	40.7%	61.9%	21.2%	2.8%	Yes
8	639	1.3%	3.2%	1.8%	1.3%	Yes
9	903	12.6%	18.9%	6.3%	2.6%	Yes
10	965	47.8%	72.1%	24.3%	2.6%	Yes
12	998	5.9%	11.2%	5.3%	2.0%	Yes
13	983	0.7%	8.4%	7.7%	1.8%	Yes
14	671	1.0%	20.3%	19.3%	3.1%	Yes
18	983	2.2%	9.1%	7.0%	1.9%	Yes

^a NLCD mapping zones

^b Number of photo-interpreted sample points

^c Percent tree canopy value derived from NLCD data

^d Percent tree canopy derived from photo-interpreted data

^e PI value minus NLCD value

^f 95% confidence interval of PI value

^g Significant difference between NLCD and PI values if NLCD value is outside of 95% confidence interval of PI value

of tree cover among geographies in this report (e.g., planting priority index and the ratings of excellent to poor for local government tree cover) are reasonable as the under-prediction of tree cover is fairly consistent within each mapping zone. However, it is important to note that the tree canopy and impervious surface cover could be underestimated, as well as their associated ecosystem services and values. A forthcoming analysis will better assess the accuracy of the NLCD cover maps (Homer et al. 2007), but these maps and data provide comprehensive, consistent, and comparable estimates (with an inherent degree of error and uncertainty) of tree canopy and impervious surface cover to help urban and community forest management, planning and policy making. Higher resolution cover data may provide more accurate results at the local scale, but the NLCD cover maps provide a cost-effective means to consistently assess and compare the relative differences of urban cover types regionally. For more refined and locally appropriate data, local field or high resolution (1 m or less) image analyses are recommended (e.g., i-Tree – www.itreetools.org; UTC – www.nrs.fs.fed.us/urban/utc).

Because of limited urban and community forest field data, data from several urban and community forests were used to estimate the number of trees and carbon storage by trees. These coarse estimates reveal that urban and community forests contain a large number of trees and provide significant environmental benefits. Field data are needed from all states to help improve these estimates as well as to estimate other forest effects (e.g., building energy conservation and changes in stream flow and water quality). Data from long-term monitoring of urban and community forests used in conjunction with satellite-based cover maps will provide essential information to assess forest health and change, and to improve urban and community forest management.

Practical Applications for Managers

The data from this report can be used to aid urban forest management at both the state and local levels. Data can be used to:

- Determine the extent, magnitude, and variation in the urban and community forestry resource

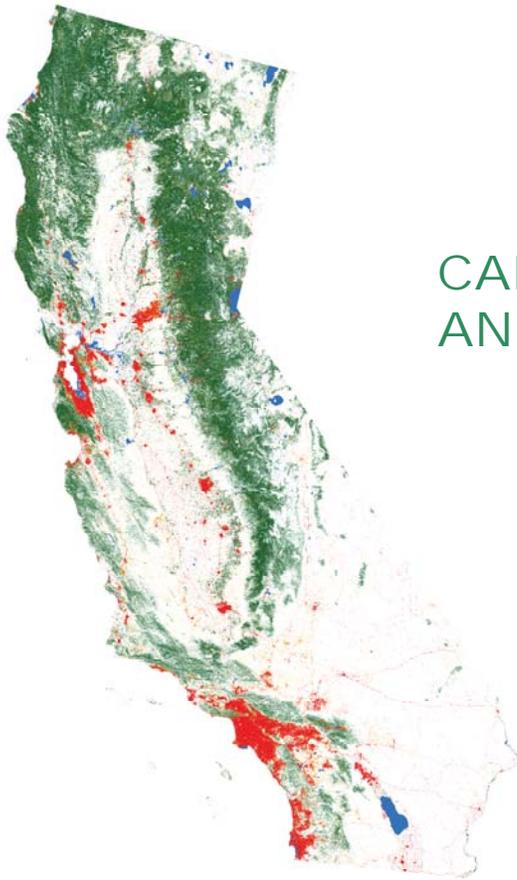
- Determine areas of greatest population growth, urbanization, and development (sprawl) to direct urban and community forestry to minimize negative impacts and maximize environmental benefits
- Evaluate existing tree canopy, impervious surface cover, and available planting space (available green space) to direct current and future urban and community forestry efforts such as planting programs
- Compare tree canopy cover for similar geopolitical units and set tree canopy goals
- Prioritize tree planting based on population density, tree canopy green space, and tree canopy cover per person
- Understand the pollution removal and carbon storage benefits of urban and community forests
- Promote more detailed and/or locally appropriate urban and community forest inventories, censuses, or field surveys (e.g. i-Tree – www.itreetools.org)
- Establish statewide to local standards related to urban and community forestry (e.g., establishing minimum goals of percent canopy green space or tree cover per capita and directing resources so that communities can reach the minimum standards)
- Improve urban and community forest management and cost estimation by providing an estimate of the number of trees in each geopolitical unit (i.e., urban area size (ha) * percent tree cover * 477 trees/ha, or local tree density information from local data)
- Guide policy decisions related to urban sprawl and urban and community forest management

SUMMARY

The data presented in this report provide a better understanding of urban and community forests. This information can be used to advance urban and community forest policy and management that could improve environmental quality and human health throughout the state. The following sections detail specific urban and community forestry data for the states in this regional report.

ACKNOWLEDGMENTS

This research was funded, in part, by the U.S. Forest Service’s RPA Assessment Staff, State and Private Forestry’s Urban and Community Forestry Program, and Northeastern Area State and Private Forestry. Thanks also goes to Chris Sorrentino for assistance with report compilation, Nana Efua Imbeah for assistance with data processing, and Mike Boarman for assistance with image processing.



CALIFORNIA'S URBAN AND COMMUNITY FORESTS

Statewide Summary

Urban or community land in California comprises about 8.6 percent of the state land area in 2000, an increase from 7.5 percent in 1990. Statewide tree canopy cover averages 18.0 percent and tree cover in urban or community areas is about 11.4 percent, with 20.1 percent impervious surface cover and 14.3 percent of the total green space covered by tree canopy cover. Statewide, urban or community land in California has an estimated 188.5 million trees, which store about 36.0 million metric tons of carbon (\$820.8 million), and annually remove about 1.2 million metric tons of carbon (\$27.0 million) and 48,280 metric tons of air pollution (\$392.3 million) (Table CA-1).

Tables CA-2 through CA-17 are not printed in this report but are available on the CD located on the inside back cover and at <http://nrs.fs.fed.us/data/urban>.

Table CA-1.—Statewide summary of population, area, population density, tree canopy and impervious surface land cover, and urban tree benefits in urban, community, and urban or community areas.

California		Statewide	Urban ^a	Community ^b	Urban or Community ^c
Population	2000	33,871,648	31,989,663	31,171,082	n/a
	1990	29,760,021	27,571,321	26,688,792	n/a
	% Change (1990-2000)	13.8	16.0	16.8	n/a
	% Total population (2000)	100.0	94.4	92.0	n/a
Total area	km ² (2000)	423,969.6	20,695.7	30,929.8	35,168.9
	km ² (1990)	423,969.6	20,514.7	24,903.9	30,790.4
	% Change (1990-2000)	0.0	0.9	24.2	14.2
Land area	km ² (2000)	404,362.1	20,512.8	30,402.5	34,596.8
	% Land area (2000)	100.0	5.1	7.5	8.6
	km ² (1990)	404,362.1	20,431.8	24,455.2	30,328.2
	% Land area (1990)	100.0	5.1	6.0	7.5
	% Change (1990-2000)	0.0	0.4	24.3	14.1
Population density (people/land area km ²)	2000	83.8	1,559.5	1,025.3	n/a
	1990	73.6	1,349.4	1,091.3	n/a
	% Change (1990-2000)	13.8	15.6	-6.1	n/a
Tree canopy cover (2000)	km ²	72,872.4	1,378.5	3,564.6	3,952.5
	% Land area	18.0	6.7	11.7	11.4
	Per capita (m ² /person)	2,151.4	43.1	114.4	n/a
	% Canopy green space ^d	18.4	9.7	15.0	14.3
Total green space (2000) ^e	km ²	395,949.0	14,148.4	23,822.7	27,633.9
	% Land area	97.9	69.0	78.4	79.9
Available green space (2000) ^f	km ²	323,081.0	12,772.4	20,260.9	23,684.5
	% Land area	79.9	62.3	66.6	68.5
Impervious surface cover (2000)	km ²	8,413.1	6,364.4	6,579.8	6,962.9
	% Land area	2.1	31.0	21.6	20.1
	Per capita (m ² /person)	248.4	199.0	211.1	n/a
	Estimated number of trees	n/a	65,700,000	170,000,000	188,500,000
		Carbon			
	Carbon stored (metric tons)	n/a	12,500,000	32,400,000	36,000,000
	Carbon stored (\$)	n/a	\$285,000,000	\$738,700,000	\$820,800,000
	Carbon sequestered (metric tons/year)	n/a	414,000	1,069,000	1,186,000
	Carbon sequestered (\$/year)	n/a	\$9,439,000	\$24,373,000	\$27,041,000
		Pollution			
Urban tree benefits (2000)	CO removed (metric tons/year)	n/a	482	1,245	1,381
	CO removed (\$/year)	n/a	\$677,500	\$1,752,000	\$1,942,600
	NO ₂ removed (metric tons/year)	n/a	2,666	6,892	7,642
	NO ₂ removed (\$/year)	n/a	\$26,404,600	\$68,276,200	\$75,705,300
	O ₃ removed (metric tons/year)	n/a	6,973	18,031	19,993
	O ₃ removed (\$/year)	n/a	\$69,075,000	\$178,613,000	\$198,048,000
	SO ₂ removed (metric tons/year)	n/a	896	2,317	2,569
	SO ₂ removed (\$/year)	n/a	\$2,173,000	\$5,618,900	\$6,230,300
	PM ₁₀ removed (metric tons/year)	n/a	5,822	15,056	16,694
	PM ₁₀ removed (\$/year)	n/a	\$38,509,800	\$99,577,600	\$110,412,600
	Total pollution removal (metric tons/year)	n/a	16,840	43,540	48,280
	Total pollution removal (\$/year)	n/a	\$136,800,000	\$353,800,000	\$392,300,000

^a Urban land is based on population density and was delimited using the United States Census definitions of urbanized areas and urban clusters. ^b Community land is based on jurisdictional or political boundaries of communities based on United States Census definitions of incorporated or census designated places. ^c Urban or communities is land that is urban, community, or both. Communities may include all, some, or no urban land within their boundaries. ^d Canopy green space is the tree canopy cover divided by total green space. ^e Total green space (TGS) is total area – impervious surface cover – water. ^f Available green space (AGS) is total green space – tree canopy cover (if the calculated value is less than 0, then value set at 0).

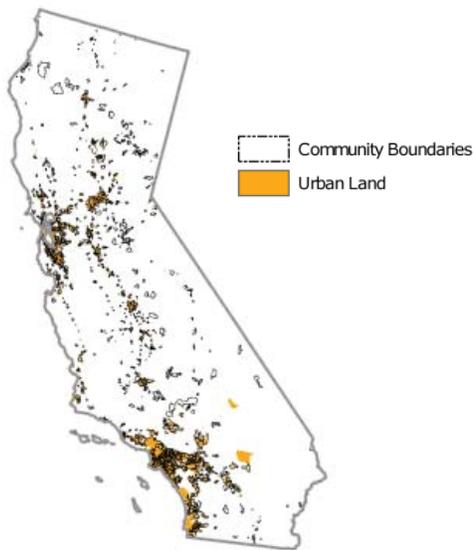


Figure CA-1.—Urban or community land in 2000; urban area relative to community boundaries.

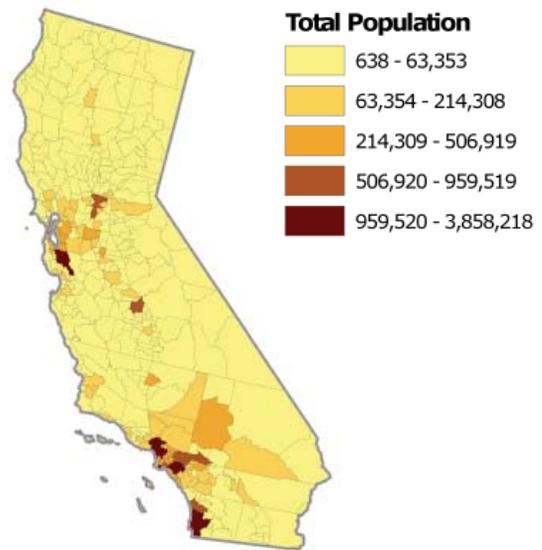


Figure CA-2.—2000 population within county subdivision boundaries.

Human Population Characteristics and Trends

The population in California increased 13.8 percent, from 29,760,021 in 1990 to 33,871,648 in 2000 (Table CA-1). In California, 94.4 percent of the State's population is in urban areas (Fig. CA-1), and 92.0 percent of the population is within communities (Fig. CA-2).

Urban and Community Land

Urban land comprises 5.1 percent of the land area of California, while lands within communities make up 7.5 percent of the State (Fig. CA-1). Between 1990 and 2000, urban area increased 0.4 percent, while community land increased from 6.0 to 7.5 percent (Table CA-1). Urban area in California is projected to increase to 15.0 percent by 2050, based on average urban growth pattern of the 1990s (Nowak and Walton 2005). Both urban land (attaining minimum population density) and community land (political boundaries) increased from 1990 to 2000. The percentages are calculated using the total (water and land) area of the geopolitical units derived from U.S. Census cartographic boundary data. Percent urban land varied across the State (Fig. CA-3; Tables CA-2 through 4).

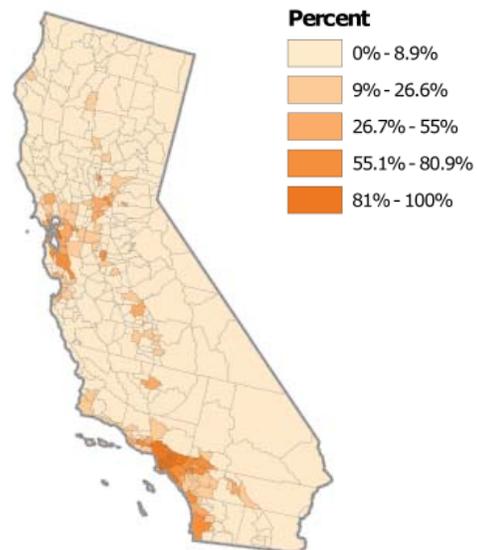


Figure CA-3.—Percent of county subdivision area classified as urban land in 2000.

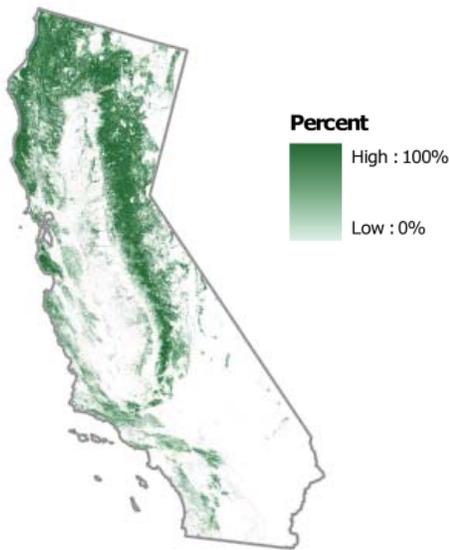


Figure CA-4.—Percentage tree canopy cover.

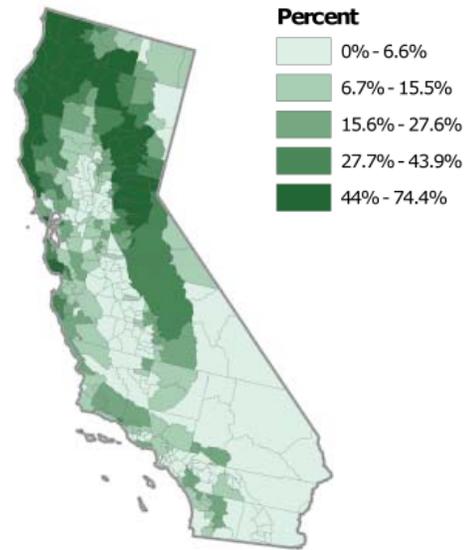


Figure CA-5.—Percentage tree canopy cover within county subdivisions.

Tree Canopy Cover Characteristics

Tree canopy cover in California averages 18.0 percent (Fig. CA-4), with 97.9 percent total green space, 18.4 percent canopy green space, and 2,151.4 m² of canopy cover per capita. Average tree cover in urban areas in California was 6.7 percent, with 69.0 percent total green space, 9.7 percent canopy green space, and 43.1 m² of canopy cover per capita. Within community lands in California, average tree cover was 11.7 percent, with 78.4 percent total green space, 15.0 percent canopy green space, and 114.4 m² of canopy cover per capita (Table CA-1). Tree canopy cover, canopy green space, and tree cover per capita varied among communities, county subdivisions, and counties (Fig. CA-5 through 6; Tables CA-5 through 7).

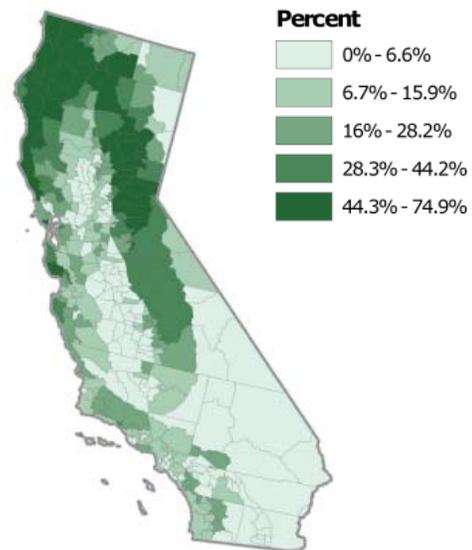


Figure CA-6.—Percentage tree canopy green space in county subdivisions.

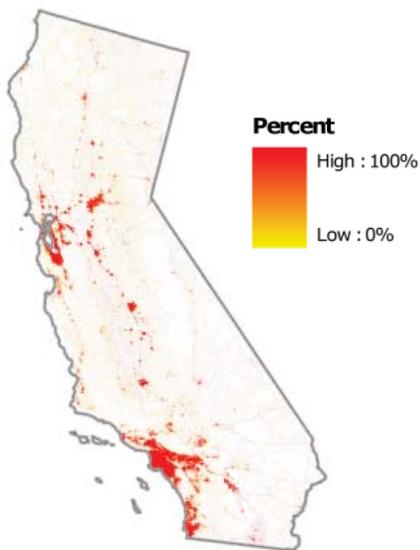


Figure CA-7.—Percentage impervious surface cover.

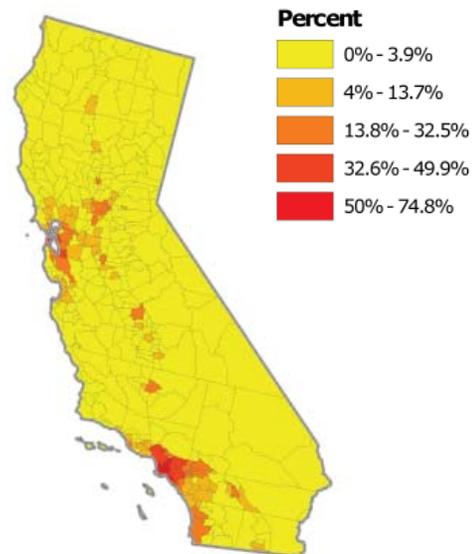


Figure CA-8.—Percentage impervious surface cover within county subdivisions.

Impervious Surface Cover Characteristics

Average impervious surface cover in California is 2.1 percent of the land area (Fig. CA-7), with 248.4 m² of impervious surface cover per capita. Average impervious surface cover in urban areas was 31.0 percent, with 199.0 m² of impervious surface cover per capita. Within community lands in California, average impervious surface cover was 21.6 percent with 211.1 m² of impervious surface cover per capita (Table CA-1). Impervious surface cover varied across the State (Fig. CA-8; Tables CA-5 through 7).

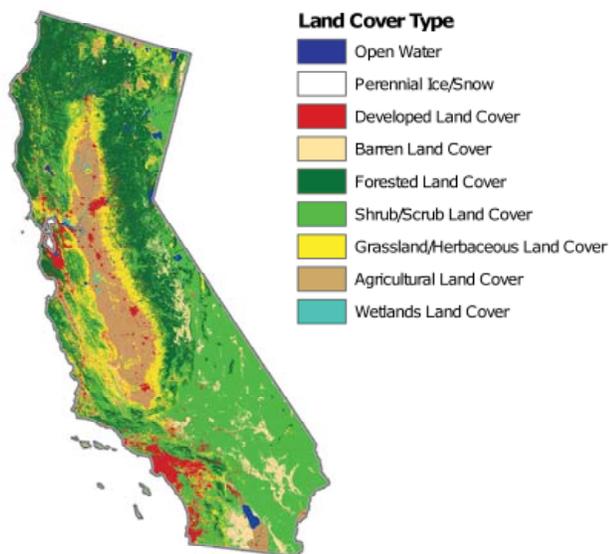


Figure CA-9.—Classified land cover.

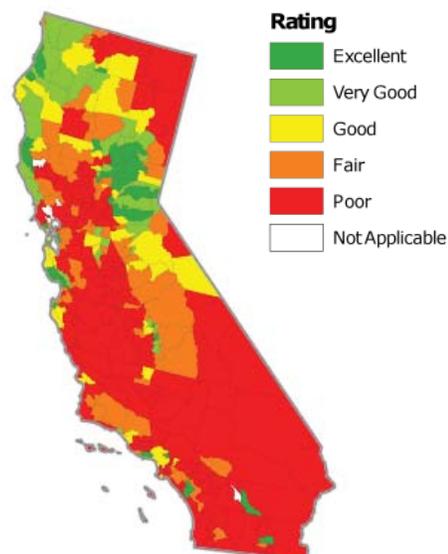


Figure CA-10.—Relative comparisons of tree cover for county subdivisions.

Classified Land-cover Characteristics

California’s land cover is dominated by scrub/shrub land (Fig. CA-9). The characteristics as a percent of the total land area in California are (Tables CA-8 through 10):

- Scrub/Shrub – 40.3 percent
- Forested – 24.1 percent
- Grassland – 13.2 percent
- Agricultural – 10.4 percent
- Developed – 6.5 percent
- Barren – 5.0 percent
- Wetland – 0.5 percent

Relative Comparisons of Tree Cover

Out of the 1,081 California communities, 50 received a rating of excellent and 758 received a rating of poor (Table CA-12). Of the 387 county subdivisions, 35 had a rating of excellent and 196 were rated poor (Fig. CA-10, Table CA-13); and out of 58 counties, 10 were given a rating of excellent and 14 were given a rating of poor (Table CA-14). Variability of assessment scores is a product of the difference in land-cover distributions and the percentage of canopy cover within the population density classes and mapping zones (Fig. CA-10; Tables CA-11 through 14).

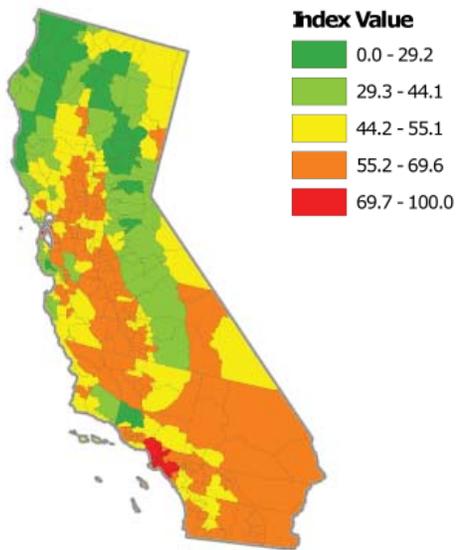


Figure CA-11.—Planting priority index for county subdivisions. The higher the index value, the greater priority for planting.

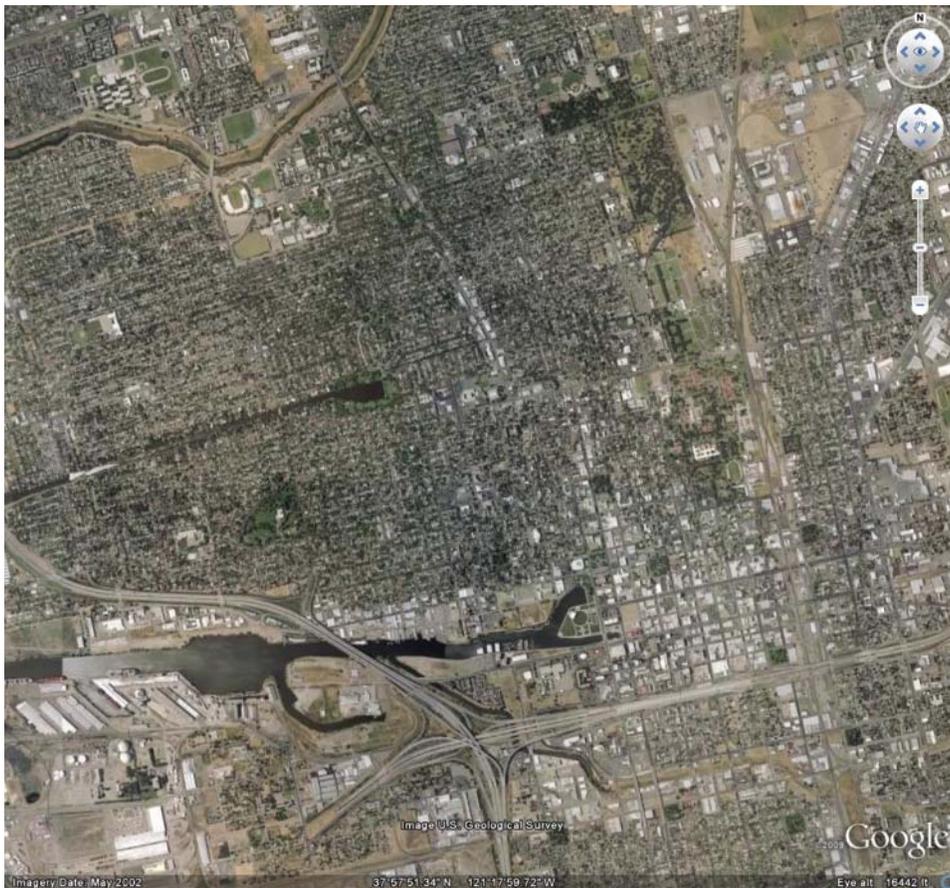
Priority Areas for Tree Planting

Priority areas for planting tend to be highest in more urbanized areas due to higher population density (Fig. CA-11; Tables CA-15 through 17). These index values can also be produced using high resolution cover data to determine local planting priority areas (e.g., neighborhoods).

Urban Tree Benefits

The following forest attributes are estimated for the urban or community land in California (Table CA-1). These are rough estimates of values. More localized data are needed for more precise estimates, but these values reveal first-order approximations.

- 188.5 million trees
- 36.0 million metric tons of C stored (\$820.8 million value)
- 1.2 million metric tons/year of C sequestered (\$27.0 million value)
- 48,280 metric tons/year total pollution removal (\$392.3 million value)
 - 1,381 metric tons/year of CO removed (\$1.9 million value)
 - 7,642 metric tons/year NO₂ removed (\$75.7 million value)
 - 19,993 metric tons/year of O₃ removed (\$198.0 million value)
 - 2,569 metric tons/year of SO₂ removed (\$6.2 million value)
 - 16,694 metric tons/year of PM₁₀ removed (\$110.4 million value)



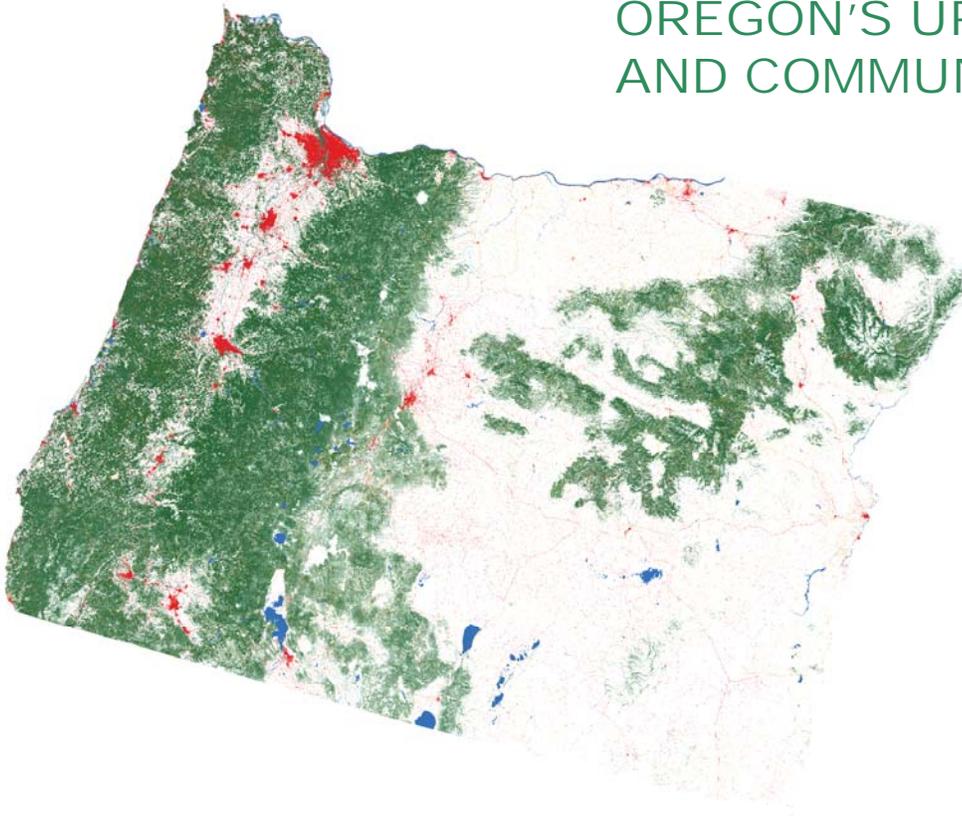
Summary

The data presented in this report provide a better understanding of California's urban and community forests. This information can be used to advance urban and community forest policy and management that could improve environmental quality and human health throughout the State.

These data establish a baseline to assess future change and can be used to understand:

- Extent of the urban and community forest resource
- Variations in the resource across the State
- Magnitude and value of the urban and community forest resource
- Urban growth in California
- Implications of policy decisions related to urban sprawl and urban and community forest management

OREGON'S URBAN AND COMMUNITY FORESTS



Statewide Summary

Urban or community land in Oregon comprises about 1.5 percent of the state land area in 2000, an increase from 1.3 percent in 1990. Statewide tree canopy cover averages 28.5 percent and tree cover in urban or community areas is about 15.0 percent, with 23.6 percent impervious surface cover and 19.7 percent of the total green space covered by tree canopy cover. Statewide, urban or community land in Oregon has an estimated 27.6 million trees, which store about 5.3 million metric tons of carbon (\$120.8 million), and annually remove about 173,000 metric tons of carbon (\$3.9 million) and 4,090 metric tons of air pollution (\$31.4 million) (Table OR-1).

Tables OR-2 through OR-17 are not printed in this report but are available on the CD located on the inside back cover and at <http://nrs.fs.fed.us/data/urban>.

Table OR-1.—Statewide summary of population, area, population density, tree canopy and impervious surface land cover, and urban tree benefits in urban, community, and urban or community areas.

Oregon		Statewide	Urban ^a	Community ^b	Urban or Community ^c
Population	2000	3,421,399	2,694,144	2,565,695	n/a
	1990	2,842,321	2,003,271	1,983,683	n/a
	% Change (1990-2000)	20.4	34.5	29.3	n/a
	% Total population (2000)	100.0	78.7	75.0	n/a
Total area	km ² (2000)	254,804.7	2,663.7	3,177.2	3,948.4
	km ² (1990)	254,804.7	2,283.4	2,665.3	3,319.0
	% Change (1990-2000)	0.0	16.7	19.2	19.0
Land area	km ² (2000)	249,013.1	2,636.5	3,081.8	3,843.0
	% Land area (2000)	100.0	1.1	1.2	1.5
	km ² (1990)	249,013.1	2,262.1	2,585.0	3,229.3
	% Land area (1990)	100.0	0.9	1.0	1.3
	% Change (1990-2000)	0.0	16.6	19.2	19.0
Population density (people/land area km ²)	2000	13.7	1,021.9	832.5	n/a
	1990	11.4	885.6	767.4	n/a
	% Change (1990-2000)	20.4	15.4	8.5	n/a
Tree canopy cover (2000)	km ²	71,046.7	364.7	462.7	577.8
	% Land area	28.5	13.8	15.0	15.0
	Per capita (m ² /person)	20,765.4	135.4	180.3	n/a
	% Canopy green space ^d	28.7	19.9	20.4	19.7
Total green space (2000) ^e	km ²	247,322.0	1,835.7	2,272.6	2,934.6
	% Land area	99.3	69.6	73.7	76.4
Available green space (2000) ^f	km ²	176,286.0	1,471.4	1,810.4	2,357.4
	% Land area	70.8	55.8	58.7	61.3
Impervious surface cover (2000)	km ²	1,691.5	800.9	809.2	908.4
	% Land area	0.7	30.4	26.3	23.6
	Per capita (m ² /person)	494.4	297.3	315.4	n/a
Urban tree benefits (2000)	Estimated number of trees	n/a	17,400,000	22,100,000	27,600,000
			Carbon		
	Carbon stored (metric tons)	n/a	3,300,000	4,200,000	5,300,000
	Carbon stored (\$)	n/a	\$75,200,000	\$95,800,000	\$120,800,000
	Carbon sequestered (metric tons/year)	n/a	109,000	139,000	173,000
	Carbon sequestered (\$/year)	n/a	\$2,485,000	\$3,169,000	\$3,944,000
			Pollution		
	CO removed (metric tons/year)	n/a	162	205	256
	CO removed (\$/year)	n/a	\$227,400	\$288,400	\$360,200
	NO ₂ removed (metric tons/year)	n/a	464	588	734
	NO ₂ removed (\$/year)	n/a	\$4,592,200	\$5,825,500	\$7,274,900
	O ₃ removed (metric tons/year)	n/a	993	1,260	1,574
	O ₃ removed (\$/year)	n/a	\$9,842,000	\$12,485,000	\$15,591,000
	SO ₂ removed (metric tons/year)	n/a	298	373	472
	SO ₂ removed (\$/year)	n/a	\$722,100	\$916,000	\$1,143,900
PM ₁₀ removed (metric tons/year)	n/a	666	845	1,056	
PM ₁₀ removed (\$/year)	n/a	\$4,407,700	\$5,591,600	\$6,982,700	
Total pollution removal (metric tons/year)	n/a	2,580	3,280	4,090	
Total pollution removal (\$/year)	n/a	\$19,800,000	\$25,100,000	\$31,400,000	

^a Urban land is based on population density and was delimited using the United States Census definitions of urbanized areas and urban clusters. ^b Community land is based on jurisdictional or political boundaries of communities based on United States Census definitions of incorporated or census designated places. ^c Urban or communities is land that is urban, community, or both. Communities may include all, some, or no urban land within their boundaries. ^d Canopy green space is the tree canopy cover divided by total green space. ^e Total green space (TGS) is total area – impervious surface cover – water. ^f Available green space (AGS) is total green space – tree canopy cover (if the calculated value is less than 0, then value set at 0).

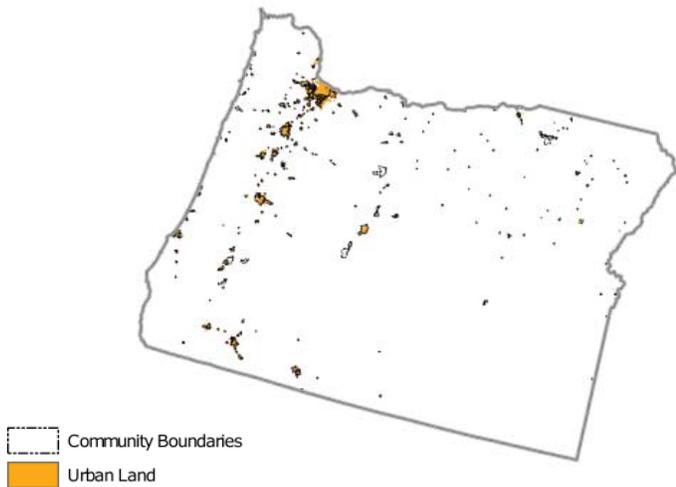


Figure OR-1.—Urban or community land in 2000; urban area relative to community boundaries.

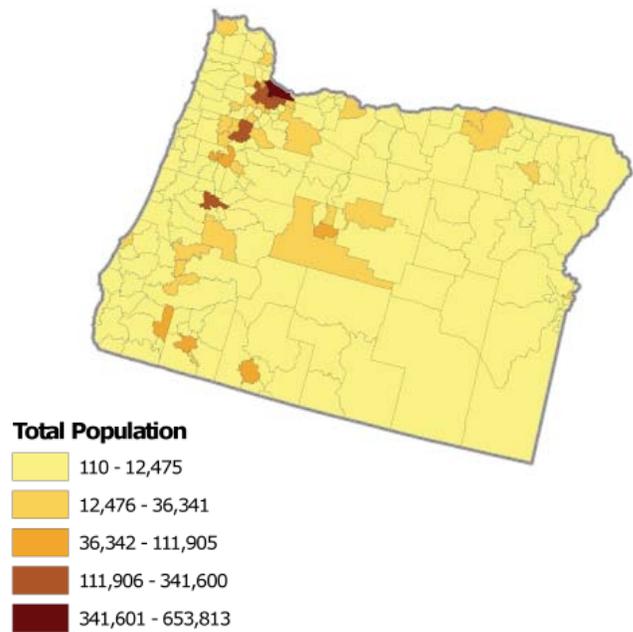


Figure OR-2.—2000 population within county subdivision boundaries.

Human Population Characteristics and Trends

The population in Oregon increased 20.4 percent, from 2,842,321 in 1990 to 3,421,399 in 2000 (Table OR-1). In Oregon, 78.7 percent of the State’s population is in urban areas (Fig. OR-1), and 75.0 percent of the population is within communities (Fig. OR-2).

Urban and Community Land

Urban land comprises 1.1 percent of the land area of Oregon, while lands within communities make up 1.2 percent of the State (Fig. OR-1). Between 1990 and 2000, urban area increased 16.6 percent, while community land increased from 1.0 to 1.2 percent (Table OR-1). Urban area in Oregon is projected to increase to 3.5 percent by 2050, based on average urban growth pattern of the 1990s (Nowak and Walton 2005). Both urban land (attaining minimum population density) and community land (political boundaries) increased from 1990 to 2000. The percentages are calculated using the total (water and land) area of the geopolitical units derived from U.S. Census cartographic boundary data. Percent urban land varied across the State (Fig. OR-3; Tables OR-2 through 4).

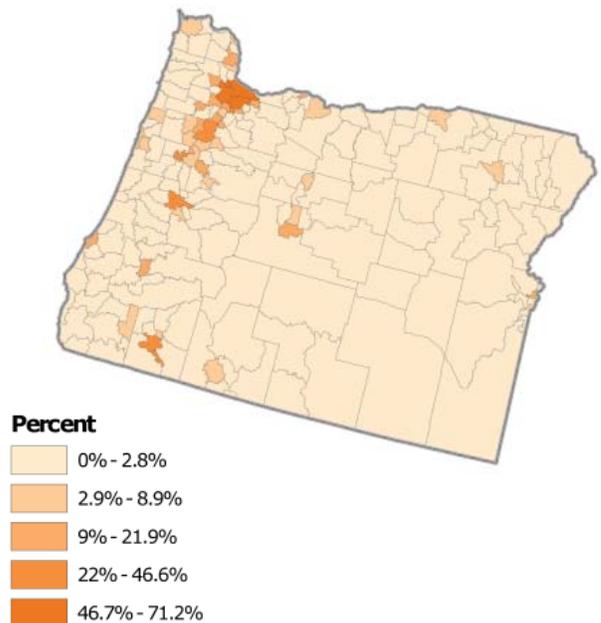


Figure OR-3.—Percent of county subdivision area classified as urban land in 2000.

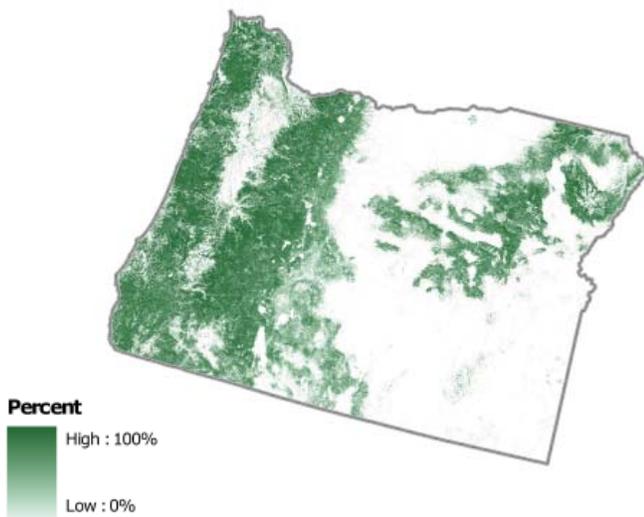


Figure OR-4.—Percentage tree canopy cover.

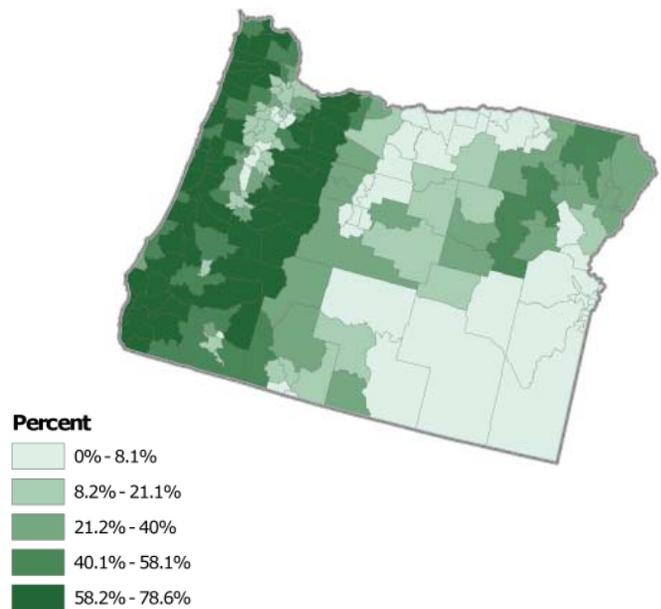


Figure OR-5.—Percentage tree canopy cover within county subdivisions.

Tree Canopy Cover Characteristics

Tree canopy cover in Oregon averages 28.5 percent (Fig. OR-4), with 99.3 percent total green space, 28.7 percent canopy green space, and 20,765.4 m² of canopy cover per capita. Average tree cover in urban areas in Oregon was 13.8 percent, with 69.6 percent total green space, 19.9 percent canopy green space, and 135.4 m² of canopy cover per capita. Within community lands in Oregon, average tree cover was 15.0 percent, with 73.7 percent total green space, 20.4 percent canopy green space, and 180.3 m² of canopy cover per capita (Table OR-1). Tree canopy cover, canopy green space, and tree cover per capita varied among communities, county subdivisions, and counties (Fig. OR-5 through 6; Tables OR-5 through 7).

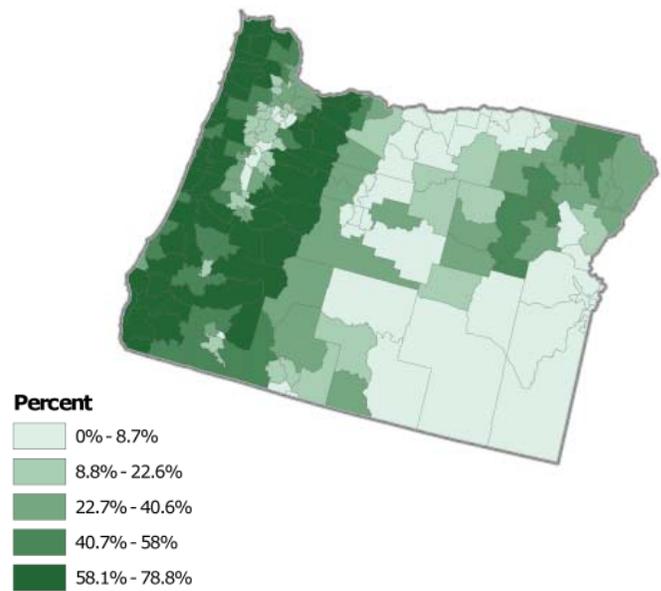


Figure OR-6.—Percentage tree canopy green space in county subdivisions.

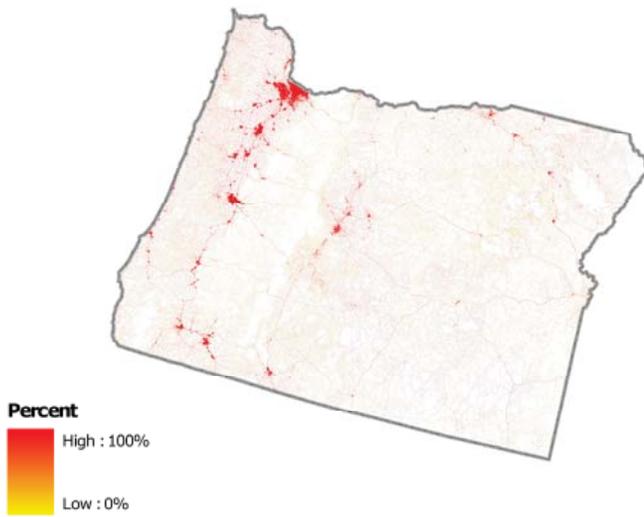


Figure OR-7.—Percentage impervious surface cover.

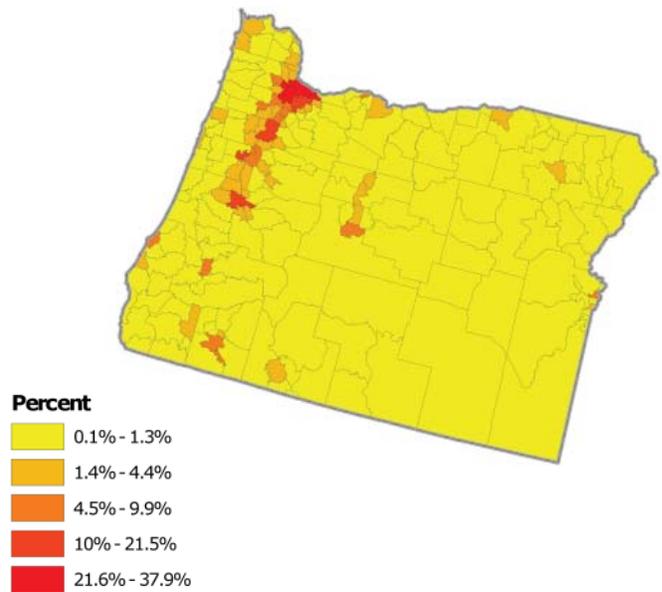


Figure OR-8.—Percentage impervious surface cover within county subdivisions.

Impervious Surface Cover Characteristics

Average impervious surface cover in Oregon is 0.7 percent of the land area (Fig. OR-7), with 494.4 m² of impervious surface cover per capita. Average impervious surface cover in urban areas was 30.4 percent, with 297.3 m² of impervious surface cover per capita. Within community lands in Oregon, average impervious surface cover was 26.3 percent with 315.4 m² of impervious surface cover per capita (Table OR-1). Impervious surface cover varied across the State (Fig. OR-8; Tables OR-5 through 7).

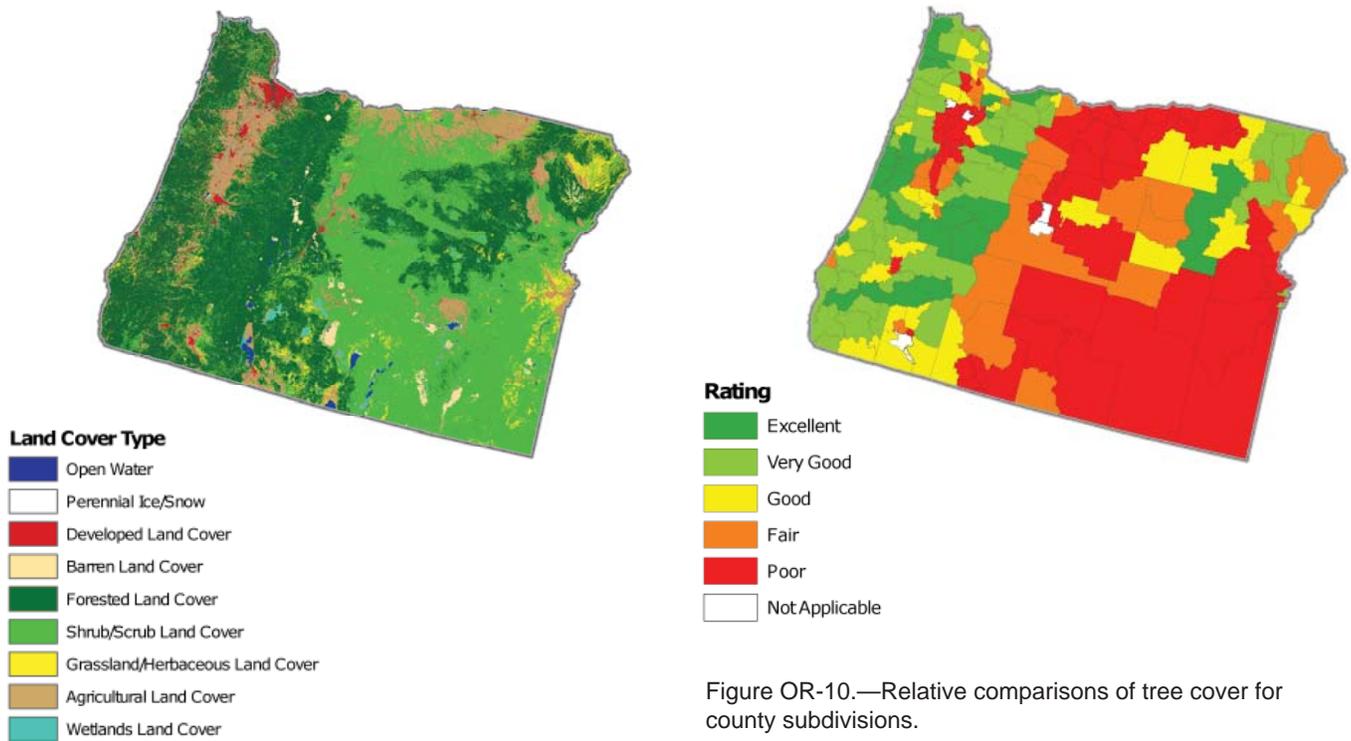


Figure OR-9.—Classified land cover.

Figure OR-10.—Relative comparisons of tree cover for county subdivisions.

Classified Land-cover Characteristics

Oregon’s land cover is dominated by scrub/shrub land (Fig. OR-9). The characteristics as a percent of the total land area in Oregon are (Tables OR-8 through 10):

- Scrub/Shrub – 43.7 percent
- Forested – 37.8 percent
- Agricultural – 8.4 percent
- Grassland – 5.1 percent
- Developed – 2.6 percent
- Barren – 1.4 percent
- Wetland – 0.8 percent

Relative Comparisons of Tree Cover

Out of the 309 Oregon communities, 19 received a rating of excellent and 192 received a rating of poor (Table OR-12). Of the 211 county subdivisions, 28 had a rating of excellent and 64 were rated poor (Fig. OR-10, Table OR-13); and out of 36 counties, four were given a rating of excellent and eight were given a rating of poor (Table OR-14). Variability of assessment scores is a product of the difference in land-cover distributions and the percentage of canopy cover within the population density classes and mapping zones (Fig. OR-10; Tables OR-11 through 14).

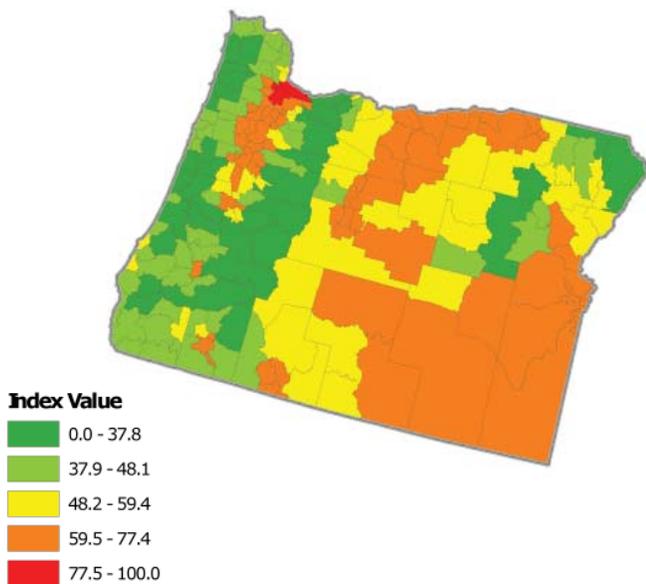


Figure OR-11.—Planting priority index for county subdivisions. The higher the index value, the greater priority for planting.

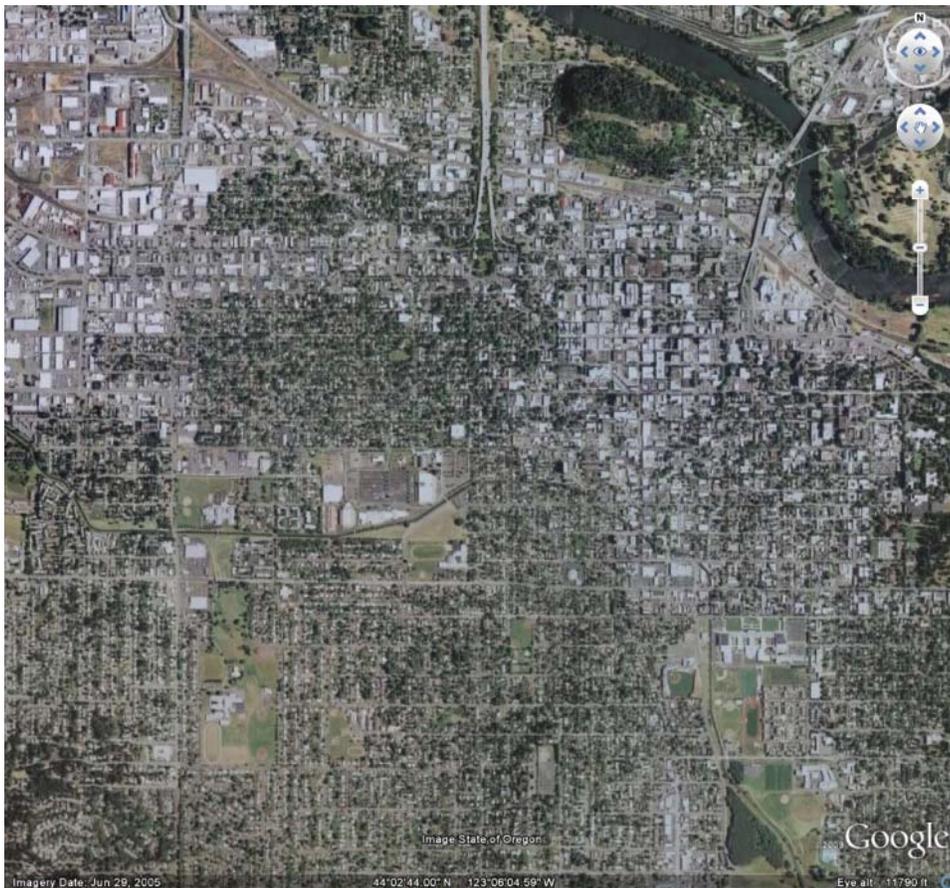
Priority Areas for Tree Planting

Priority areas for planting tend to be highest in more urbanized areas due to higher population density (Fig. OR-11; Tables OR-15 through 17). These index values can also be produced using high resolution cover data to determine local planting priority areas (e.g., neighborhoods).

Urban Tree Benefits

The following forest attributes are estimated for the urban or community land in Oregon (Table OR-1). These are rough estimates of values. More localized data are needed for more precise estimates, but these values reveal first-order approximations.

- 27.6 million trees
- 5.3 million metric tons of C stored (\$120.8 million value)
- 173,000 metric tons/year of C sequestered (\$3.9 million value)
- 4,090 metric tons/year total pollution removal (\$31.4 million value)
 - 256 metric tons/year of CO removed (\$360,200 value)
 - 734 metric tons/year NO₂ removed (\$7.3 million value)
 - 1,574 metric tons/year of O₃ removed (\$15.6 million value)
 - 472 metric tons/year of SO₂ removed (\$1.1 million value)
 - 1,056 metric tons/year of PM₁₀ removed (\$7.0 million value)



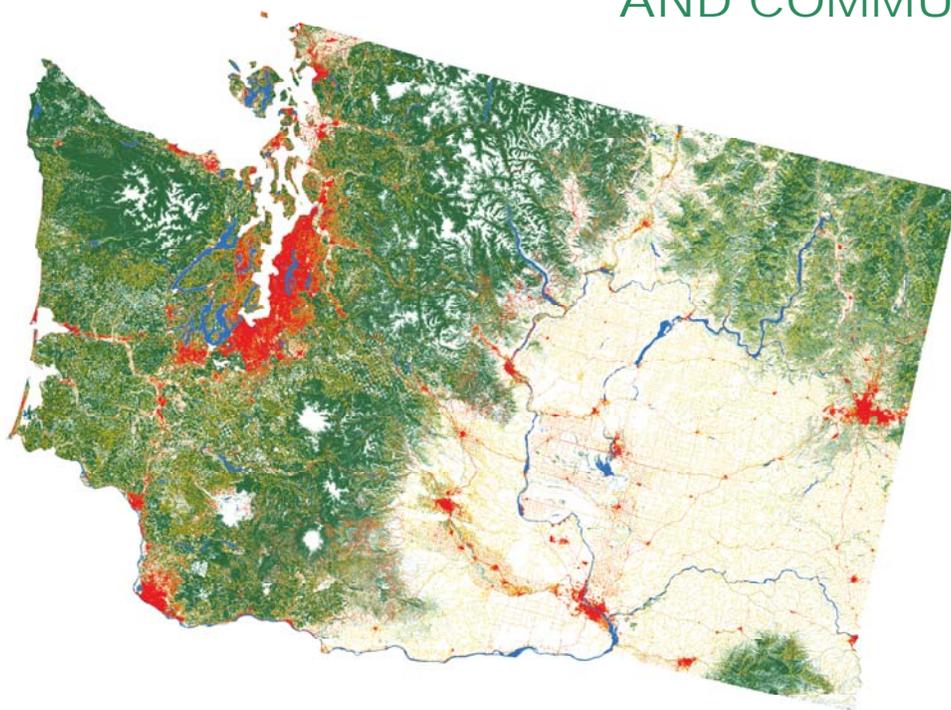
Summary

The data presented in this report provide a better understanding of Oregon’s urban and community forests. This information can be used to advance urban and community forest policy and management that could improve environmental quality and human health throughout the State.

These data establish a baseline to assess future change and can be used to understand:

- Extent of the urban and community forest resource
- Variations in the resource across the State
- Magnitude and value of the urban and community forest resource
- Urban growth in Oregon
- Implications of policy decisions related to urban sprawl and urban and community forest management

WASHINGTON'S URBAN AND COMMUNITY FORESTS



Statewide Summary

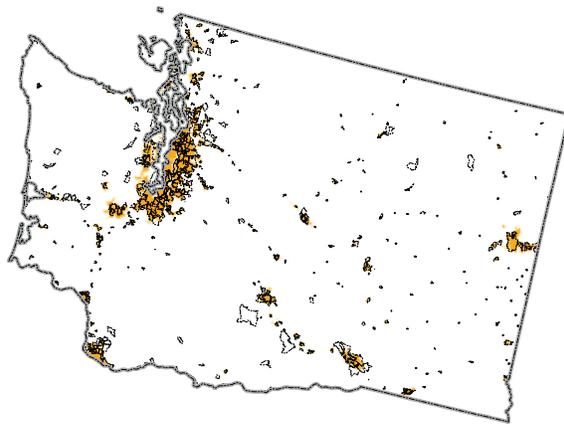
Urban or community land in Washington comprises about 5.2 percent of the state land area in 2000, an increase from 3.8 percent in 1990. Statewide tree canopy cover averages 36.6 percent and tree cover in urban or community areas is about 27.7 percent, with 18.7 percent impervious surface cover and 34.1 percent of the total green space covered by tree canopy cover. Statewide, urban or community land in Washington has an estimated 118.4 million trees, which store about 22.6 million metric tons of carbon (\$515.3 million), and annually remove about 745,000 metric tons of carbon (\$17.0 million) and 20,370 metric tons of air pollution (\$156.1 million) (Table WA-1).

Tables WA-2 through WA-17 are not printed in this report but are available on the CD located on the inside back cover and at <http://nrs.fs.fed.us/data/urban>.

Table WA-1.—Statewide summary of population, area, population density, tree canopy and impervious surface land cover, and urban tree benefits in urban, community, and urban or community areas.

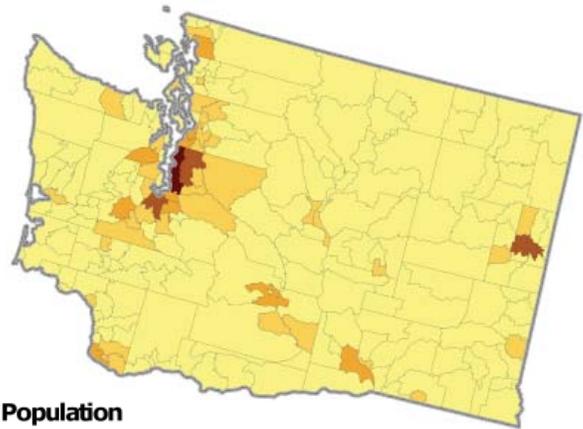
Washington		Statewide	Urban ^a	Community ^b	Urban or Community ^c	
Population	2000	5,894,121	4,831,106	4,667,234	n/a	
	1990	4,866,692	3,717,948	3,360,668	n/a	
	% Change (1990-2000)	21.1	29.9	38.9	n/a	
	% Total population (2000)	100.0	82.0	79.2	n/a	
Total area	km ² (2000)	184,665.2	5,556.6	8,010.8	9,318.3	
	km ² (1990)	184,665.2	4,564.0	5,718.0	6,912.8	
	% Change (1990-2000)	0.0	21.7	40.1	34.8	
Land area	km ² (2000)	172,506.3	5,466.1	7,676.2	8,955.6	
	% Land area (2000)	100.0	3.2	4.4	5.2	
	km ² (1990)	172,506.3	4,522.0	5,444.8	6,629.9	
	% Land area (1990)	100.0	2.6	3.2	3.8	
	% Change (1990-2000)	0.0	20.9	41.0	35.1	
Population density (people/land area km ²)	2000	34.2	883.8	608.0	n/a	
	1990	28.2	822.2	617.2	n/a	
	% Change (1990-2000)	21.1	7.5	-1.5	n/a	
Tree canopy cover (2000)	km ²	63,140.5	1,415.3	2,085.4	2,483.4	
	% Land area	36.6	25.9	27.2	27.7	
	Per capita (m ² /person)	10,712.5	292.9	446.8	n/a	
	% Canopy green space ^d	37.2	35.2	33.8	34.1	
Total green space (2000) ^e	km ²	169,716.0	4,026.0	6,170.3	7,277.4	
	% Land area	98.4	73.7	80.4	81.3	
Available green space (2000) ^f	km ²	106,655.0	2,623.6	4,098.2	4,809.5	
	% Land area	61.8	48.0	53.4	53.7	
Impervious surface cover (2000)	km ²	2,790.1	1,440.2	1,505.9	1,678.2	
	% Land area	1.6	26.3	19.6	18.7	
	Per capita (m ² /person)	473.4	298.1	322.7	n/a	
Urban tree benefits (2000)	Estimated number of trees	n/a	67,500,000	99,500,000	118,400,000	
	Carbon					
	Carbon stored (metric tons)	n/a	12,900,000	19,000,000	22,600,000	
	Carbon stored (\$)	n/a	\$294,100,000	\$433,200,000	\$515,300,000	
	Carbon sequestered (metric tons/year)	n/a	425,000	626,000	745,000	
	Carbon sequestered (\$/year)	n/a	\$9,690,000	\$14,273,000	\$16,986,000	
	Pollution					
	CO removed (metric tons/year)	n/a	616	908	1,081	
	CO removed (\$/year)	n/a	\$867,000	\$1,277,500	\$1,521,400	
	NO ₂ removed (metric tons/year)	n/a	1,799	2,651	3,157	
	NO ₂ removed (\$/year)	n/a	\$17,819,700	\$26,256,800	\$31,268,400	
	O ₃ removed (metric tons/year)	n/a	4,822	7,105	8,461	
	O ₃ removed (\$/year)	n/a	\$47,765,000	\$70,380,000	\$83,813,000	
	SO ₂ removed (metric tons/year)	n/a	1,533	2,259	2,690	
SO ₂ removed (\$/year)	n/a	\$3,718,200	\$5,478,600	\$6,524,300		
PM ₁₀ removed (metric tons/year)	n/a	2,841	4,186	4,985		
PM ₁₀ removed (\$/year)	n/a	\$18,790,400	\$27,687,200	\$32,971,900		
Total pollution removal (metric tons/year)	n/a	11,610	17,110	20,370		
Total pollution removal (\$/year)	n/a	\$89,000,000	\$131,100,000	\$156,100,000		

^a Urban land is based on population density and was delimited using the United States Census definitions of urbanized areas and urban clusters. ^b Community land is based on jurisdictional or political boundaries of communities based on United States Census definitions of incorporated or census designated places. ^c Urban or communities is land that is urban, community, or both. Communities may include all, some, or no urban land within their boundaries. ^d Canopy green space is the tree canopy cover divided by total green space. ^e Total green space (TGS) is total area – impervious surface cover – water. ^f Available green space (AGS) is total green space – tree canopy cover (if the calculated value is less than 0, then value set at 0).



 Community Boundaries
 Urban Land

Figure WA-1.—Urban or community land in 2000; urban area relative to community boundaries.



Total Population
 36 - 20,308
 20,309 - 60,717
 60,718 - 207,188
 207,189 - 480,100
 480,101 - 896,887

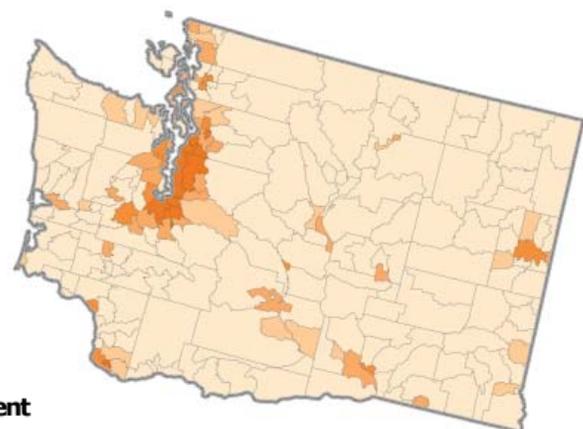
Figure WA-2.—2000 population within county subdivision boundaries.

Human Population Characteristics and Trends

The population in Washington increased 21.1 percent, from 4,866,692 in 1990 to 5,894,121 in 2000 (Table WA-1). In Washington, 82.0 percent of the State's population is in urban areas (Fig. WA-1), and 79.2 percent of the population is within communities (Fig. WA-2).

Urban and Community Land

Urban land comprises 3.2 percent of the land area of Washington, while lands within communities make up 4.4 percent of the State (Fig. WA-1). Between 1990 and 2000, urban area increased 20.9 percent, while community land increased from 3.2 to 4.4 percent (Table WA-1). Urban area in Washington is projected to increase to 9.2 percent by 2050, based on average urban growth pattern of the 1990s (Nowak and Walton 2005). Both urban land (attaining minimum population density) and community land (political boundaries) increased from 1990 to 2000. The percentages are calculated using the total (water and land) area of the geopolitical units derived from U.S. Census cartographic boundary data. Percent urban land varied across the State (Fig. WA-3; Tables WA-2 through 4).



Percent
 0% - 3.7%
 3.8% - 12.6%
 12.7% - 32.9%
 33% - 63.3%
 63.4% - 100%

Figure WA-3.—Percent of county subdivision area classified as urban land in 2000.

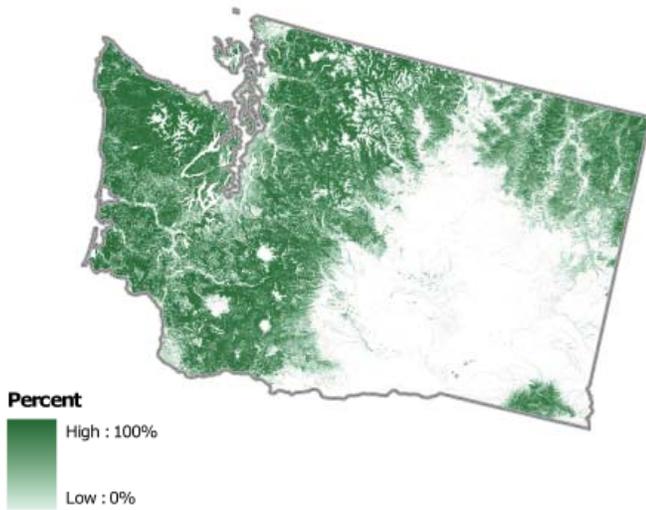


Figure WA-4.—Percentage tree canopy cover.

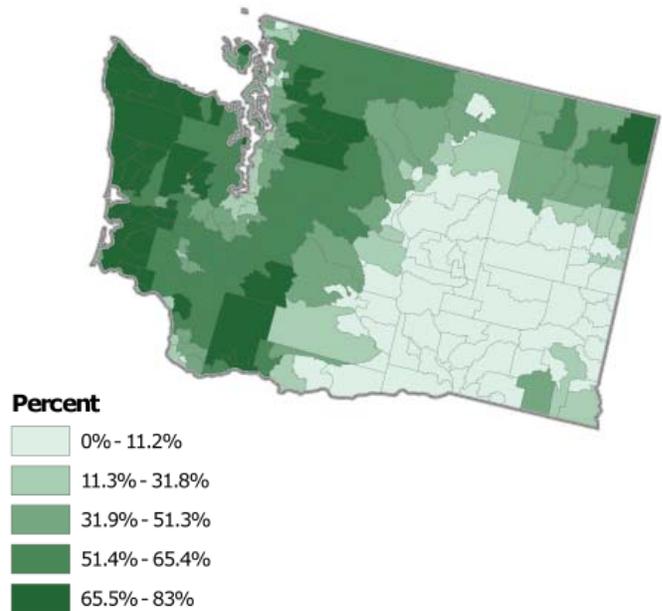


Figure WA-5.—Percentage tree canopy cover within county subdivisions.

Tree Canopy Cover Characteristics

Tree canopy cover in Washington averages 36.6 percent (Fig. WA-4), with 98.4 percent total green space, 37.2 percent canopy green space, and 10,712.5 m² of canopy cover per capita. Average tree cover in urban areas in Washington was 25.9 percent, with 73.7 percent total green space, 35.2 percent canopy green space, and 292.9 m² of canopy cover per capita. Within community lands in Washington, average tree cover was 27.2 percent, with 80.4 percent total green space, 33.8 percent canopy green space, and 446.8 m² of canopy cover per capita (Table WA-1). Tree canopy cover, canopy green space, and tree cover per capita varied among communities, county subdivisions, and counties (Fig. WA-5 through 6; Tables WA-5 through 7).

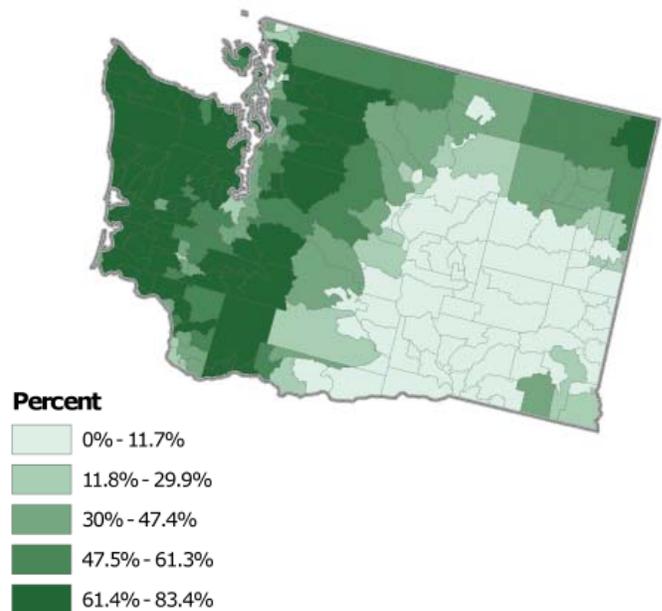


Figure WA-6.—Percentage tree canopy green space in county subdivisions.

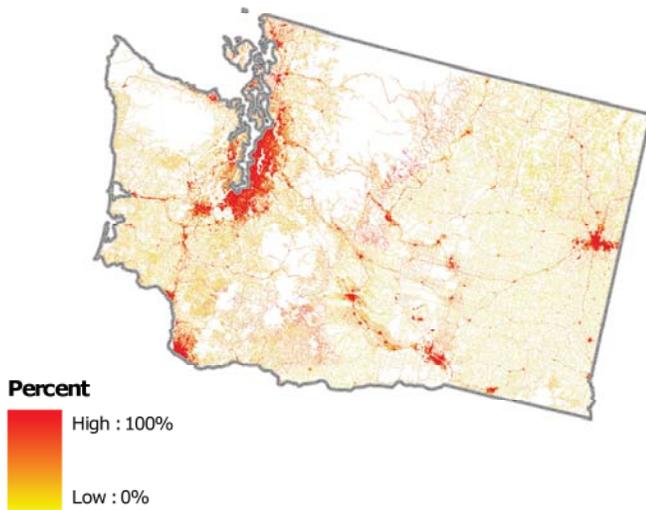


Figure WA-7.—Percentage impervious surface cover.

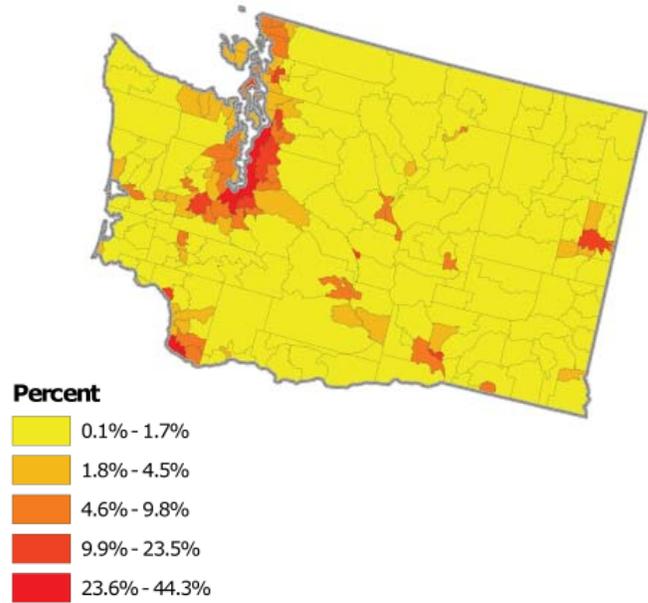


Figure WA-8.—Percentage impervious surface cover within county subdivisions.

Impervious Surface Cover Characteristics

Average impervious surface cover in Washington is 1.6 percent of the land area (Fig. WA-7), with 473.4 m² of impervious surface cover per capita. Average impervious surface cover in urban areas was 26.3 percent, with 298.1 m² of impervious surface cover per capita. Within community lands in Washington, average impervious surface cover was 19.6 percent with 322.7 m² of impervious surface cover per capita (Table WA-1). Impervious surface cover varied across the State (Fig. WA-8; Tables WA-5 through 7).

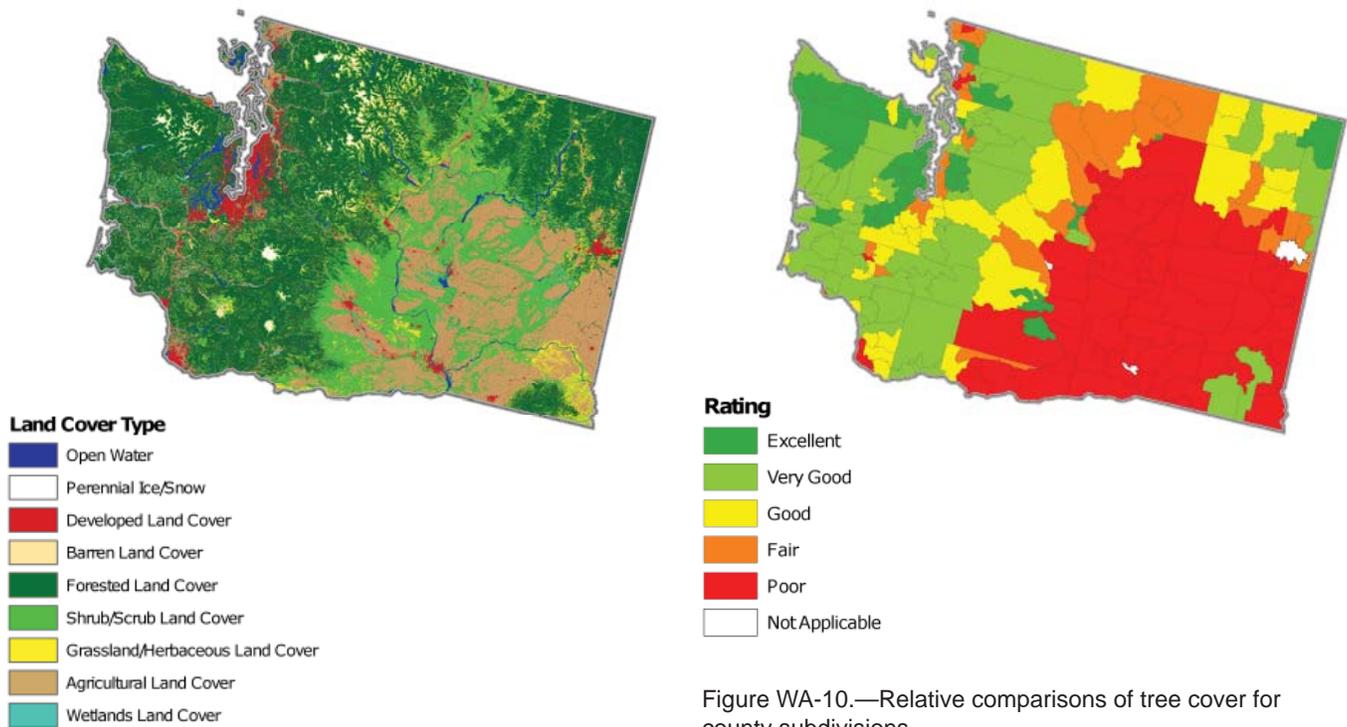


Figure WA-9.—Classified land cover.

Figure WA-10.—Relative comparisons of tree cover for county subdivisions.

Classified Land-cover Characteristics

Washington’s land cover is dominated by forest land (Fig. WA-9). The characteristics as a percent of the total land area in Washington are (Tables WA-8 through 10):

- Forested – 43.5 percent
- Scrub/Shrub – 24.0 percent
- Agricultural – 18.5 percent
- Developed – 5.8 percent
- Grassland – 5.6 percent
- Barren – 1.5 percent
- Wetland – 0.8 percent

Relative Comparisons of Tree Cover

Out of the 522 Washington communities, 27 received a rating of excellent and 268 received a rating of poor (Table WA-12). Of the 242 county subdivisions, 31 had a rating of excellent and 71 were rated poor (Fig. WA-10, Table WA-13); and out of 39 counties, six were given a rating of excellent and 14 were given a rating of poor (Table WA-14). Variability of assessment scores is a product of the difference in land-cover distributions and the percentage of canopy cover within the population density classes and mapping zones (Fig. WA-10; Tables WA-11 through 14).

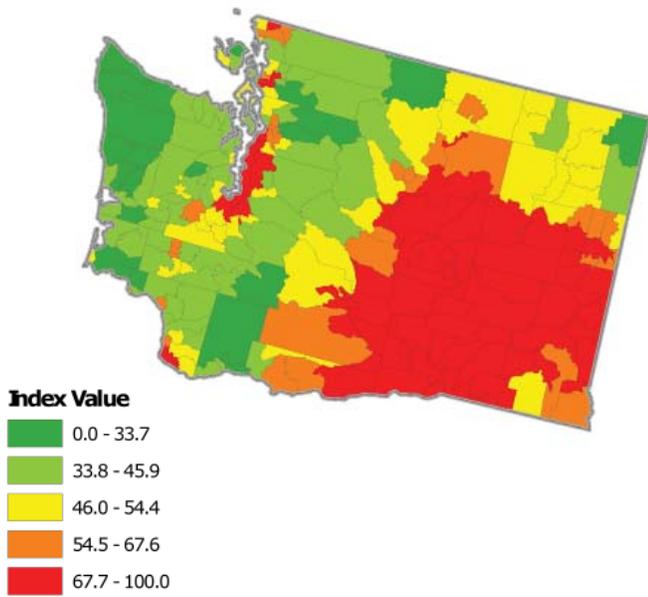


Figure WA-11.—Planting priority index for county subdivisions. The higher the index value, the greater priority for planting.

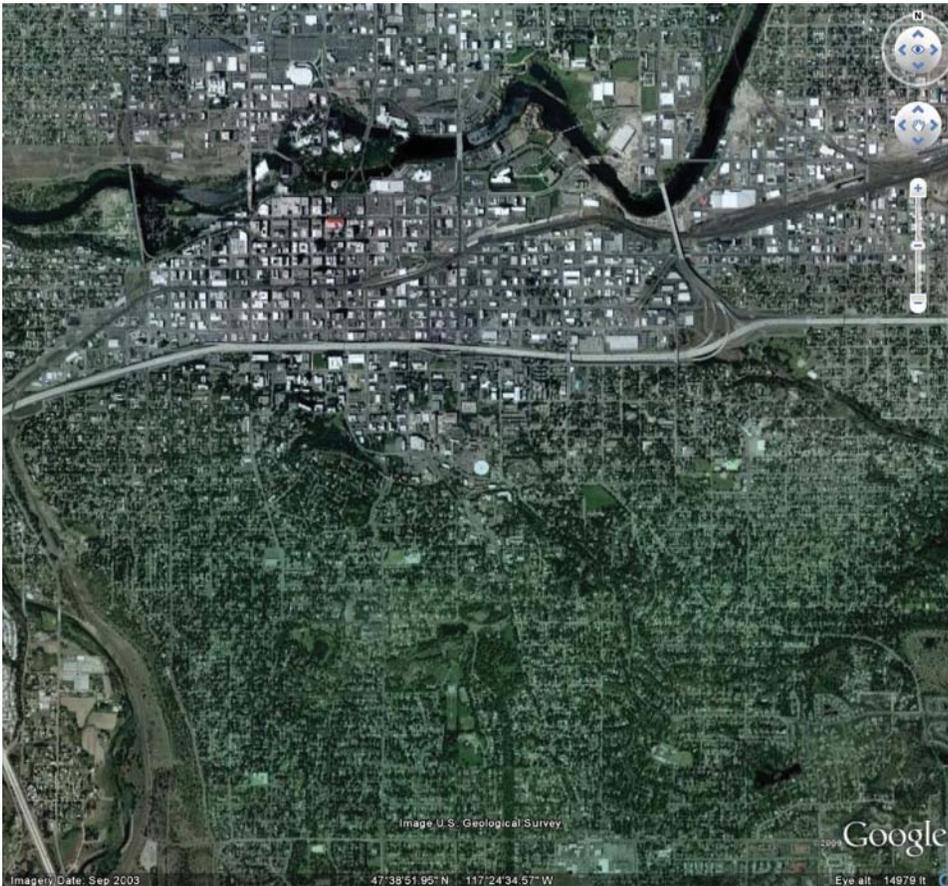
Priority Areas for Tree Planting

Priority areas for planting tend to be highest in more urbanized areas due to higher population density (Fig. WA-11; Tables WA-15 through 17). These index values can also be produced using high resolution cover data to determine local planting priority areas (e.g., neighborhoods).

Urban Tree Benefits

The following forest attributes are estimated for the urban or community land in Washington (Table WA-1). These are rough estimates of values. More localized data are needed for more precise estimates, but these values reveal first-order approximations.

- 118.4 million trees
- 22.6 million metric tons of C stored (\$515.3 million value)
- 745,000 metric tons/year of C sequestered (\$17.0 million value)
- 20,370 metric tons/year total pollution removal (\$156.1 million value)
 - 1,081 metric tons/year of CO removed (\$1.5 million value)
 - 3,157 metric tons/year NO₂ removed (\$31.3 million value)
 - 8,461 metric tons/year of O₃ removed (\$83.8 million value)
 - 2,690 metric tons/year of SO₂ removed (\$6.5 million value)
 - 4,985 metric tons/year of PM₁₀ removed (\$33.0 million value)



Summary

The data presented in this report provide a better understanding of Washington's urban and community forests. This information can be used to advance urban and community forest policy and management that could improve environmental quality and human health throughout the State.

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APPENDIX

Urban Forest Data: States of the Pacific Region

The following tables are generated to support state reports on urban and community forests of the Pacific states of California, Oregon, and Washington. For specific state data tables use the CD accompanying this publication and search within the regional or state folder, or go to: <http://www.nrs.fs.fed.us/data/urban>.

State Specific Tables:

Table 1.—Statewide summary of population, area, population density, tree canopy and impervious surface land cover, and urban tree benefits in urban, community, and urban or community areas.

Table 2.—2000 population characteristics, population change (1990-2000), and percent of land classified as urban within communities.

Table 3.—2000 population characteristics, population change (1990-2000), percent of land classified as urban or as communities within county subdivisions.

Table 4.—2000 population characteristics, population change (1990-2000), percent of land classified as urban or as communities within counties.

Table 5.—Tree canopy and impervious surface cover characteristics by community.

Table 6.—Tree canopy and impervious surface cover characteristics by county subdivision.

Table 7.—Tree canopy and impervious surface cover characteristics by county.

Table 8.—Land area, tree canopy cover, and available green space distributed within generalized land cover categories for communities.

Table 9.—Land area, tree canopy cover, and available green space distributed within generalized land cover categories for county subdivisions.

Table 10.—Land area, tree canopy cover, and available green space distributed within generalized land cover categories for counties.

Table 11.—Statistical summary of mapping zone values used to calculate urban and community forestry assessment.

Table 12.—Urban and community forestry assessment by community.

Table 13.—Urban and community forestry assessment by county subdivisions.

Table 14.—Urban and community forestry assessment by counties.

Table 15.—Planting priority index for communities.

Table 16.—Planting priority index for county subdivisions.

Table 17.—Planting priority index for counties.

Nowak, David J.; Greenfield, Eric J. 2010. **Urban and community forests of the Pacific region: California, Oregon, Washington.** Gen. Tech. Rep. NRS-65. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 38 p. [Includes CD-ROM].

This report details how land cover and urbanization vary within the states of California, Oregon, and Washington by community (incorporated and census designated places), county subdivision, and county. Specifically this report provides critical urban and community forestry information for each state including human population characteristics and trends, changes in urban and community lands, tree canopy and impervious surface cover characteristics, distribution of land-cover classes, a relative comparison of urban and community forests among local government types, determination of priority areas for tree planting, and a summary of urban tree benefits. Report information can improve the understanding, management, and planning of urban and community forests. This data is reported for each state on the CD provided in the back of this book and may be accessed by state at: <http://www.nrs.fs.fed.us/data/urban>.

KEY WORDS: urban forestry, tree cover, impervious cover, classified land cover, ecosystem services, urbanization

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