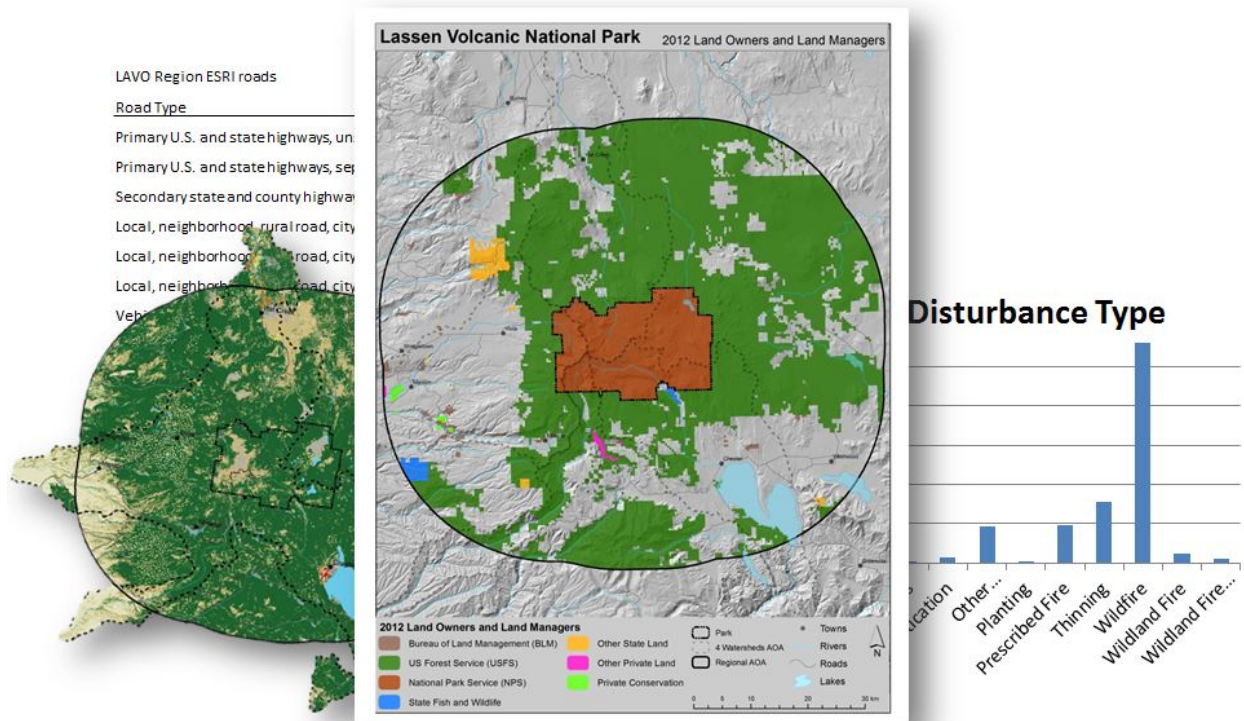




Land Cover and Land Use Monitoring in the Klamath Network

2016 Summary for Lassen Volcanic National Park

Natural Resource Report NPS/KLMN/NRR—2016/1308



ON THE COVER

Samples of maps and statistics shown in this report: 2012 land owners and managers, 2011 land cover, LANDFIRE disturbance chart, and road type table. Images by: Jace Ives, Southern Oregon University

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Natural Resource Report NPS/KLMN/NRR—2016/1308

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Abstract

Landscape spatial structure resulting from natural processes, and its variation through time, underlies the diversity and integrity of ecosystems. The composition (types and amounts of different land cover), configuration (spatial arrangement of land cover types), and connectivity determine habitat availability, the movements of organisms, and energy and material flows on a landscape. In 2016 the Klamath Network, in partnership with Southern Oregon University, completed and implemented our land cover and land use monitoring protocol (Mohren et al., in review). The goal of this monitoring effort is to support National Park Service (NPS) management of natural resources by providing relevant landscape-scale information about ecosystem composition and structure to each of the NPS units in the Klamath Network.

As part of this effort, we implemented methods developed as part of the National Park Service's NPScape project, which was designed to provide information on the status and trends of park natural resources at broad regional and ecosystem scales. Geographic Information System (GIS) tools were used to analyze largely regional- and national- level datasets at three spatial scales for the following landscape indicators: Conservation Status, Land Cover, Landscape Pattern, Housing and Population, Roads, and Disturbance.

In Lassen Volcanic National Park, the landscape vegetation was primarily evergreen forest, and the land outside the park was mostly national forest. Due to several designated wilderness areas surrounding the park, this area is characterized by low populations, low housing density, and low road density. A variety of disturbances have occurred, including logging and fire. Integrating these data with finer scale projects will help provide an integrated look at ecosystem dynamics. Managers can also compare what is occurring inside the park boundaries versus outside of the park.

To improve flow and readability of the report, data tables are included in the appendix.

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This project was supported by many people. Much of the material was developed by the NPScape team. We would especially like to thank Bill Monahan, Lisa Nelson, and Michelle Kinseth.

We are immensely grateful to the park staff who contributed to this report, with special thanks to Elizabeth Hale (LAVO) and Jason Mateljak (LAVO). Monika Tantare, a Southern Oregon University student, did extensive practical work using ArcGIS tools to make maps and calculate statistics.

The data used to develop the summaries in these reports came from a variety of sources and without their data this project would not be possible. We especially want to thank the staff at the US Census Bureau, USGS Land Cover Institute, and GAP Analysis Program.

List of Abbreviations

Abbreviation	Description
AOA	Area of Analysis
BLM	Bureau of Land Management
CRI	Conservation Risk Index
DOI	US Department of Interior
GAP	Gap Analysis Program
GIS	Geographic Information System
HUC	Hydrologic Unit Code
I&M	Inventory and Monitoring
IRMA	Integrated Resource Management Applications
NLCD	National Land Cover Data (or Database, Dataset)
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
PAD-US	Protected Areas Database of the United States
SERGoM	Spacially Explicit Regional Growth Model
SOP	Standard Operating Procedure

Introduction

The overall purpose of natural resource monitoring in national park units is to develop scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems. Use of monitoring information will increase confidence in managers' decisions, improving their ability to manage park resources. This increased knowledge will allow managers to confront and mitigate threats to the parks and operate more effectively in legal and political arenas (Stephens et al. 2010).

The Klamath Inventory and Monitoring Network vital signs selection process defined important questions to answer in relation to potential trends in ecosystem structure, function, and composition in the parks. Using the process described in the *Vital signs monitoring plan for the Klamath Network: Phase II report* (Odion et al. 2005), land cover and land use ranked ninth out of the ten vital signs that were selected. The land cover/land use vital sign was selected in an effort to address the following objectives:

1. Determine the status and trends in the composition and configuration of land-cover classes within all the Network parks and directly adjacent land.
2. Determine the status and trends in the connectivity of the land cover classifications.
3. Determine the status and trends in human populations near the parks.
4. Determine trends in disturbances.

The goal of this monitoring effort is to support National Park Service (NPS) management of natural resources by providing relevant landscape-scale information to each of the NPS units that make up the Klamath Network. The composition (types and amounts of different land cover), configuration (spatial arrangement of land cover types), and connectivity of land cover determine habitat availability, the movements of organisms, and energy and material flows on a landscape (Turner et al. 2001).

This report was developed following the methods and guidance in the *Land Cover and Land Use Monitoring Protocol for the Klamath Network* (Mohren et al., in review). While a summary of the purpose and methods of the protocol are provided in this report, complete details can be found in the protocol (<http://science.nature.nps.gov/im/units/klmn/monitor/landcover.cfm>).

The overall objective of this report is to determine for Lassen Volcanic National Park (LAVO) the status of the metrics described in the KLMN land cover / land use monitoring protocol: Conservation Status, Land Cover, Landscape Pattern, Housing, Population, Roads, and Disturbance. Trend measurements and modeling efforts will be addressed in future reports, as stated in the protocol.

Lassen Volcanic National Park is located in northeastern California, about 65 kilometers (40 miles) east of the cities of Red Bluff and Redding. To the east, the largest nearby town is Susanville. Several small towns exist near the park including Mineral, Viola, Chester, and Westwood. The park is surrounded by Lassen National Forest. The route for California State Highway 89 runs through the park's western side. Other nearby highways are 44 and 36.

Three biogeographic regions come together in Lassen Volcanic National Park: the southern Cascades, the northern Sierra Nevada Mountains, and the Basin and Range Province. The park encompasses 43,078 hectares (106,448 acres) and is almost completely surrounded by national forest land (Lassen National Forest). Several small sections of private land adjoin the park boundary in Mill Creek, Willow Creek, Warner Valley, and Lost Creek. The park's area includes 31,962 hectares (78,982 acres) of designated wilderness. Elevations range from 1,585 meters (5,200 feet) in the southeast near Warner Valley to 3,189 meters (10,463 feet) at the summit of Lassen Peak. Topography within the park varies greatly, with rugged, volcanic mountain peaks in the western section, a lava plateau in the east, deep glaciated valleys in the south, and peaks and ridges of lava modified by erosion in the north.

The park was established by an Act of Congress on August 9, 1916. Incorporated into the park were Cinder Cone and Lassen Peak National Monuments, which were originally established by Presidential Proclamations (No. 753 and 754) on May 6, 1907, as part of the Lassen Peak Forest Reserve (established on June 5, 1905, by Presidential Proclamation). In 1972, Congress designated 75% of the park (31,964 ha) as the Lassen Volcanic Wilderness.

Lassen Volcanic National Park contains a variety of outstanding biotic systems. An overlap of plant species commonly associated with each province combined with the variety of geologic formations and textural compositions of lava contribute to a high diversity of native plant and animal communities. The majority of park land still contains native vegetation complexes; however, most communities have been altered directly or indirectly to some degree by human-caused alterations in natural disturbance regimes. Lassen Volcanic National Park contains several rare and important habitats. In particular, whitebark pine and upland quaking aspen woodlands are found in much higher proportions within the park than the surrounding region. Some of the resource management concerns in the park are nonnative species, disturbed land restoration, air pollution, and boundary management issues (e.g., cattle grazing, poaching).

Methods

The Klamath Network is using data and tools from the NPScape project, which was designed to provide information on the status and trends of park natural resources at broad regional and ecosystem scales. Details on the NPScape project can be found at <http://science.nature.nps.gov/im/monitor/npscape/>. This report is a snapshot in time based on the project's available data and tools.

The Inventory and Monitoring Central Office is currently developing a national landscape dynamics protocol with a target completion date of 2017. With implementation of the national protocol, the NPScape program will stop supporting the toolboxes that were used to conduct the analyses in this report. Alternatively, metrics in this report will be calculated as part of the national landscape dynamics protocol, provided through the NPS Statistics Summary database, and visualized via the Landscape Dynamics Metric Viewer (<http://science.nature.nps.gov/im/monitor/npscape/viewer/>).

Areas of Analysis

The spatial scale of a landscape-level analysis has a significant impact on natural resource metrics and anthropogenic influences. The scale of analysis should be considered thoughtfully as no single scale or set of scales can meet all needs (Gross and Svancara 2009). For this protocol, we identified three spatial scales based on park needs and recommendations from the scientific literature. These three spatial scales or Areas of Analysis (AOA's) include: Park, Park-Manager-Selected, and Regional (Figure 1).

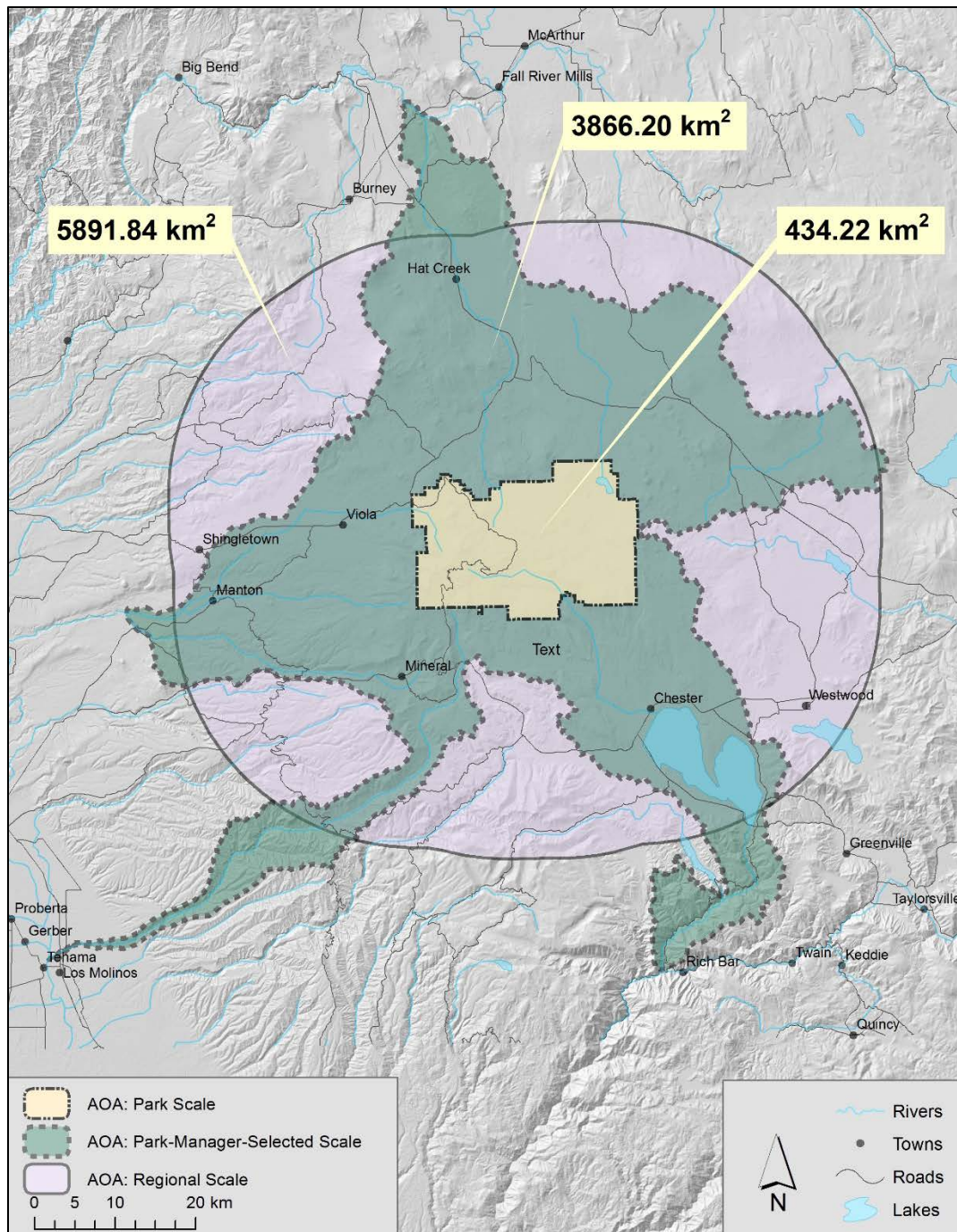


Figure 1. Reference map of all Lassen Volcanic NP Areas of Analysis (AOA).

Park Scale

The Park AOA uses the park boundary (Nelson and Kinseth 2015). This AOA encompasses the area that NPS park managers have the most influence over and which they can directly alter through management actions. Analysis at this scale will give park managers the best possible picture of changes that are occurring in the park. The LAVO Park AOA omits a small administrative area (0.85 km²) in the town of Mineral, California.

Park-Manager-Selected Scale

Because natural resources, ecological processes, and anthropogenic influences cross jurisdictional boundaries, the “Park-Manager-Selected” AOA includes lands adjacent to the park. Specifically this AOA encompasses boundaries of HUC10 watersheds that are fully or partially inside the park. For LAVO, the Park-Manager-Selected AOA covers 3866.2 km² and comprises the following HUC10 watersheds: Hat Creek, Butte Creek-Lost Creek, Upper Pine Creek, Upper North Fork Feather River, Headwaters North Fork Feather River, Mill Creek, South Fork Battle Creek, and North Fork Battle Creek.

Regional Scale

The third AOA addresses landscape metrics at a regional level. The effective domain of many local ecological processes is thought to be on the order of 15 to 40 km, but few studies have demonstrated effects at distances greater than 25 km. Therefore, we define the Regional AOA as including all adjacent areas within 30 km of the park boundaries. The LAVO Regional AOA also omits the administrative area in Mineral, so the buffer is 30 km around the main park polygon.

Data Sources

This protocol uses data developed by other entities as a cost-effective approach to landscape monitoring. An additional benefit of using regional and national-level data is the ability to use the same datasets and maintain consistency across the different areas of analysis. In Table 1, we list the data sources used. Additional details on these data sources can be found in the protocol.

Table 1. Data sources for this Land Cover Land Use report.

Dataset	Indicator
Protected Areas Database of the United States (PAD-US)	Conservation Status
National Land Cover Data (NLCD)	Land Cover and Pattern
US Census Bureau BlockData	Housing and Population
US Census Bureau Roads Data (TIGER) and Park Road Data	Roads
LANDFIRE (USGS)	Disturbance

Indicator Analysis

This section briefly describes the GIS analyses used for landscape indicators in this report. Detailed information on each indicator can be found in standard operating procedures of the *Land Cover and Land Use Monitoring Protocol for the Klamath Network* (Mohren et al., in review). Not all indicators are relevant to all AOAs; thus Table 2 outlines which indicators are reported for each. Below we refer to indicator categories and definitions which are fully described in tables within Appendix A (e.g., Table A4).

We did not perform any statistical analyses in this report and any mention of change among years is purely descriptive and not implying trend.

Table 2. Indicators that will be evaluated in the listed Areas of Analyses (AOA): P = Park, PM = Park-Manager-Selected, and R = Regional.

Indicator	Measure	AOA Scale
Conservation Status	Percent & Total Protected	PM & R
	Percent & Total Ownership	
Land Cover	Area/Percent in Land Cover Types	P, PM, & R
	Natural vs. Converted	
	Impervious Surface	
Landscape Pattern	Morphological Pattern Analysis	PM & R
	Patch Size by Cover Type	
	Distribution of Patch Sizes for Cover Types	
	Density Analysis of Cover Types	
Housing and Population	Housing Density	PM & R
	Recent Change in Housing Density	
	Total Population	
	Population Density	
	Recent Population Change	
Roads	Road Density	P, PM, & R
	Road Length	
	Distance to Roads	
	Area without Roads	
Disturbance	Disturbance Occurrence	P, PM, & R
	Total Area by Disturbance Type	

Landscape Dynamics Indicators

The NPScape program used ArcToolbox and Python scripting to create utilities in ESRI ArcGIS that run automatically. We used these utilities to analyze the seven indicators below.

Conservation Status and Ownership: We analyzed data from the Protected Areas Database of the United States (PAD-US) to summarize ownership and conservation status. The PAD-US is produced by the USGS Gap Analysis Program (GAP), the primary developer of land stewardship and protected areas information in the United States. Ownership and conservation status is unknown for some areas, which are categorized in PAD-US version 1.3 as “unavailable data”. Detailed methods for this indicator are provided in SOP #02: *Conservation Status Metrics*.

Within the Regional and Park-Manager-Selected AOAs, we used the ownership and status categories to summarize the percent of area and total area that were considered protected (see Table A1 in Appendix A, *Indicator Definitions and Categories*, for status definitions), as well as the percent of area and total area by ownership.

Land Cover: We completed this analysis for the three AOAs using National Land Cover Data (NLCD). We calculated the proportion of the landscape at each Anderson Level 2 class (see Table A2) within each AOA using data from 2006 and 2011. In addition, the total area for each land cover

type is provided. Also, using 2011 data, we calculated impervious surface cover and summarized total area and percent area by range category. In this analysis, each pixel value denotes how much of that pixel has an impervious surface. Natural lands vs. converted lands (see Table A2) were also summarized by total area and percent area, and the percent change in area, using data from 2011. Detailed methods for this indicator are provided in *SOP #3: Land Cover Metrics*.

Landscape Pattern: These analyses were performed for the Park-Manager-Selected and Regional AOAs. Morphology data were generated from 2011 NLCD for forest, grassland, and shrubland. We used morphology data with an edge width of 5 (EW5), which is 5 pixels at 30m resolution. Density data were also generated with a 7×7 pixel window size (size in m^2 and acres: $210m^2$, 10.9 acres).

We examined both the morphology and density of three Anderson level 1 classes (see Table A2): Forest, Shrubland, and Grassland. The morphology of each land cover type was classified into morphological pattern types (e.g., edge, core, bridge), as defined in Table A3. A summary of total area and percent of area for each of the pattern types is provided. We also provided the count and total area by patch size range.

The density of each class is summarized in seven categories (Riitters 2011) and shown in Table A4. A land cover type is considered highly dense if no other land cover type or open space is detected in its vicinity. By density class, we provided total area, percent of area of that Anderson level 1 class, and percent of the AOA. Detailed methods for this indicator are provided in *SOP #04: Pattern Metrics*.

Housing and Population: Detailed methods for this indicator are provided in *SOP #5: Housing Metrics* and *SOP #6: Population Metrics*.

Housing density metrics are based on US Census Bureau data, location-specific growth rates, and the Spatially Explicit Regional Growth Model (SERGoM, v3; Theobald 2005). To simplify reporting, we combined housing densities into grouped housing density classes and summarized data by these grouped classes (see Table A5) for Park-Manager-Selected and Regional AOAs using data from 1970 to 2010. By class, we provided total area, percent of total AOA, and percent of census area.

Population metrics are also based on US Census Bureau data. Census Block-Groups can cover large areas and may include areas with higher population; however, the Block-Groups are smaller than counties and better display population data near rural or protected areas. We used all the Census Block-Groups that intersect the AOAs and resulting blocks were clipped to AOAs. Areas where people are assumed to be absent were subtracted or masked out; this included water (from Census water data) and PAD-US protected areas (status 1 and 2). At the Park-Manager-Selected and Regional AOAs, we provided summaries for the total population and population density as well as changes in population size and density for 1990, 2000, and 2010 data.

Roads: Detailed methods for this indicator are provided in *SOP #7: Road Metrics*. We completed this analysis for Park-Manager-Selected and Regional AOAs with 2010 and 2015 TIGER data using the four road codes described in Table A6. We summarized total road length and road density.

Additionally, we provided the same summaries within the Park AOA using 2016 data from the park (parking areas were removed).

Additionally, we looked at the distance to the nearest road (each pixel was assigned the value of how far it was from the nearest road). This could be used to compare areas that are virtually roadless to areas where road densities have the ability to affect ecological integrity. Finally, for roadless areas, we summarized the count and total area by size range categories. Water bodies (using USGS National Hydrography Dataset 2015) were erased and then polygons smaller than 0.0144 km² were removed.

Disturbance

Detailed methods for this indicator are provided in *SOP #8: Disturbance Metrics*. We used LANDFIRE 1999-2012 as a data source. For the three AOAs, total area and percent of AOA were provided by disturbance types defined in Table A7.

Results

Results are presented using text, maps, and figures in the following sections. Tables containing the detailed values associated with these results are referenced here but presented in full as appendix material to avoid lengthy diversion from the text. No statistical analyses were performed.

Conservation Status

Ownership

Based on 2012 data, much of the land within the Regional AOA was under public stewardship, with the greatest amount owned by the US Forest Service (48.1%), followed by the National Park Service (7.4%). The pattern is the same within the Park-Manager-Selected AOA, where 52.3% of the land was US Forest Service land and 11.2% was National Park Service (Table B1 in Appendix B, *Data Tables*; Figures 2 and 3). Note that data for 42.9% of the Regional AOA and 34.8% of the Park-Manager-Selected AOA were not available and therefore the percentage of land managed by each of these groups may have been greater, depending on the composition of the unavailable data.

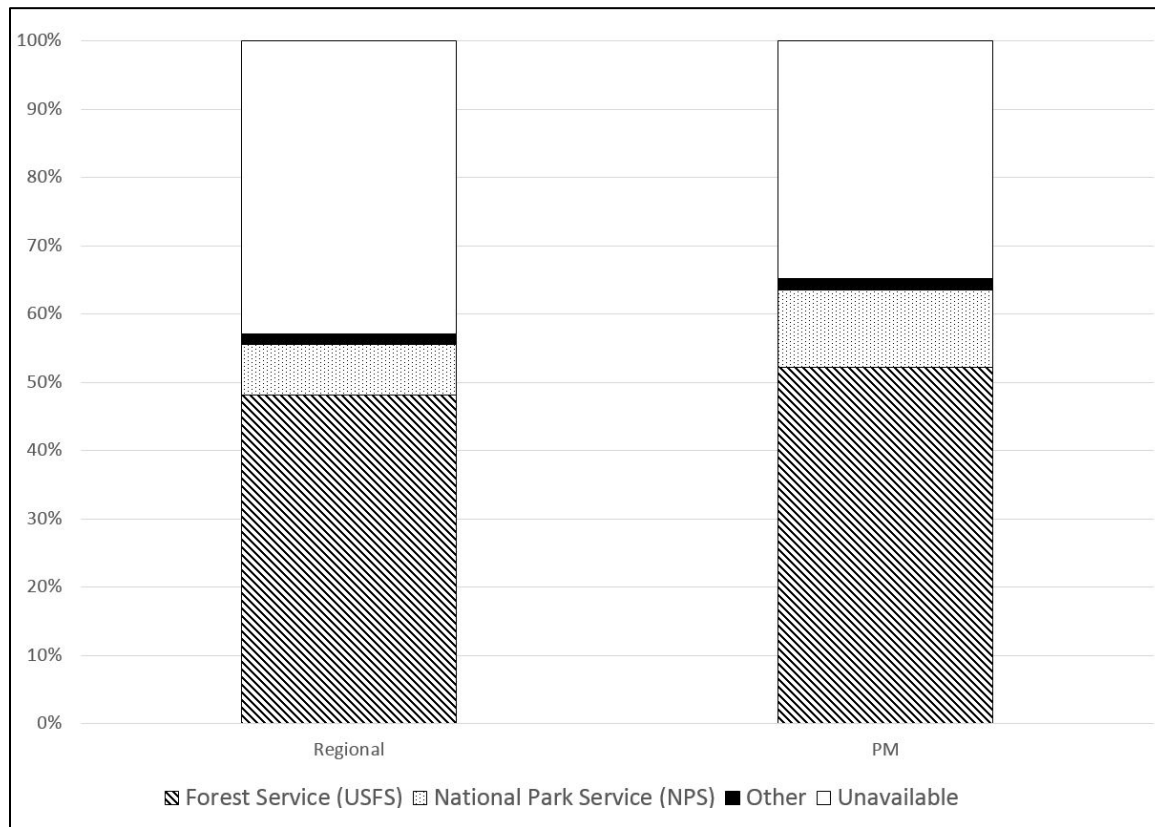


Figure 2. Percent land ownership within the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA).

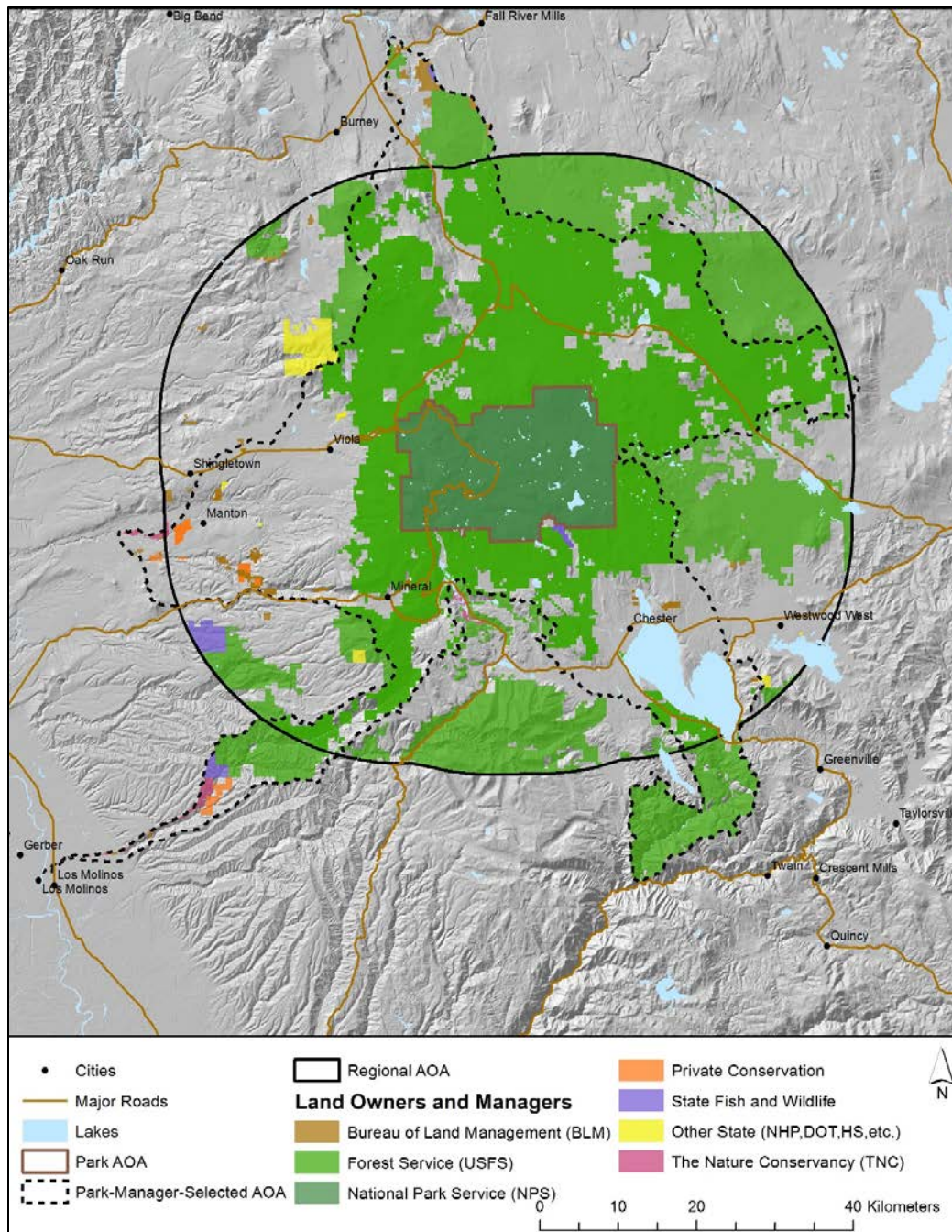


Figure 3. Land owners in the Regional and Park-Manager-Selected Areas of Analysis (AOA), using GAP PAD-US 2012 data. Areas without colors identified in the legend are those for which ownership is unknown.

Protected Areas

GAP Conservation Status category 1 is the most protected status, representing permanent protection from conversion of natural land cover and a mandated management plan (Table A1). Within the

Park-Manager-Selected and Regional AOAs, this category is represented primarily by US Forest Service wilderness areas and Lassen Volcanic National Park. Status category 1 constituted 16% and 10% of these AOAs, respectively (Table B2, Figures 4 and 5). Within the Park-Manager-Selected and Regional AOAs, the largest single category of land was category 3 (48% and 46%, respectively). These areas have permanent protection from conversion of natural land cover for the majority of the area, but are subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area. Data for 42.9% of the Regional AOA and 34.8% of the Park-Manager-Selected AOA were not available and therefore the percentage of land managed within each status category may have been greater, depending on the composition of the unavailable data.

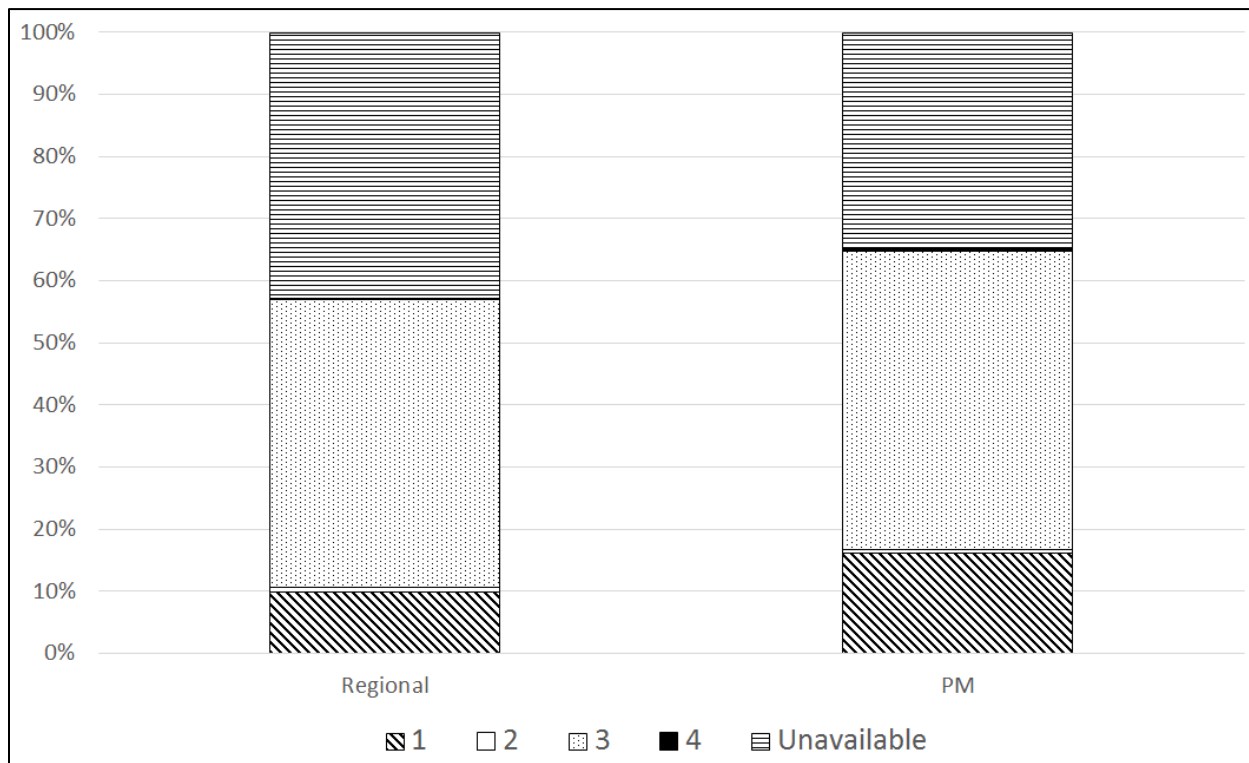


Figure 4. Percent in each GAP Conservation Status category (Table A1) within the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA).

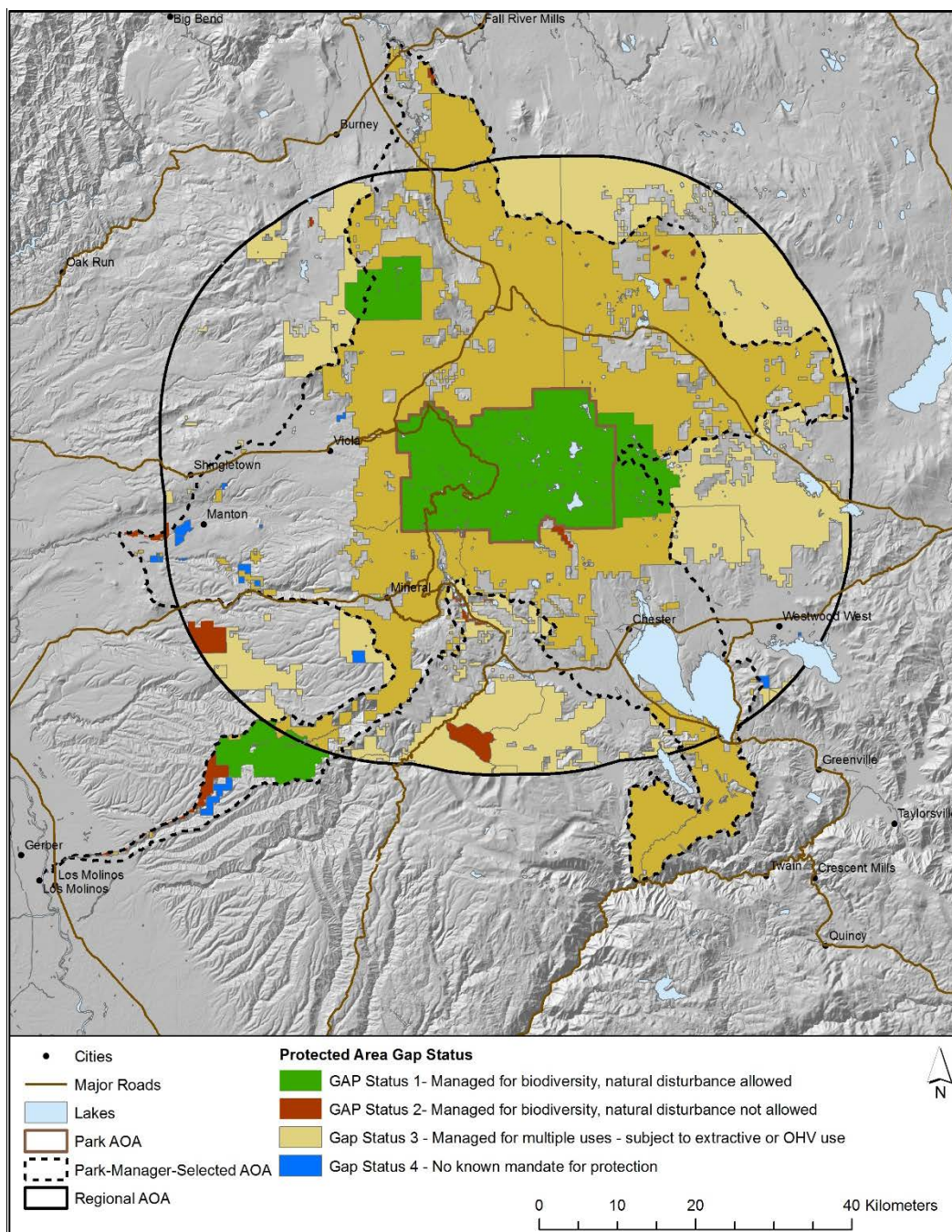


Figure 5. Conservation status (Table A1) in the Regional and Park-Manager-Selected Areas of Analysis (AOA), using GAP PAD-US 2012 data.

Land Cover

Anderson Level 2

Summarizing by Anderson Level 2 land cover categories (Table A2), evergreen forest was the dominant cover type in both 2006 and 2011, and in all three AOAs; this was followed by shrub/scrub (Figures 6 and 7). In 2006 and 2011, within the Regional AOA, evergreen forest was 73% and 72%, respectively, and shrub/scrub was 18% to 19%, respectively (Table B3). Other classes each covered less than 4% of the AOA. Similarly, in 2006 and 2011 within the Park-Manager-Selected AOA, evergreen forest was 68% and 67%, respectively, and shrub/scrub was 19% and 20%, respectively (Table B4). In 2006 and 2011, within the Park AOA, evergreen forest covered 72% and 71%, respectively, and shrub/scrub covered 20% (Table B5).

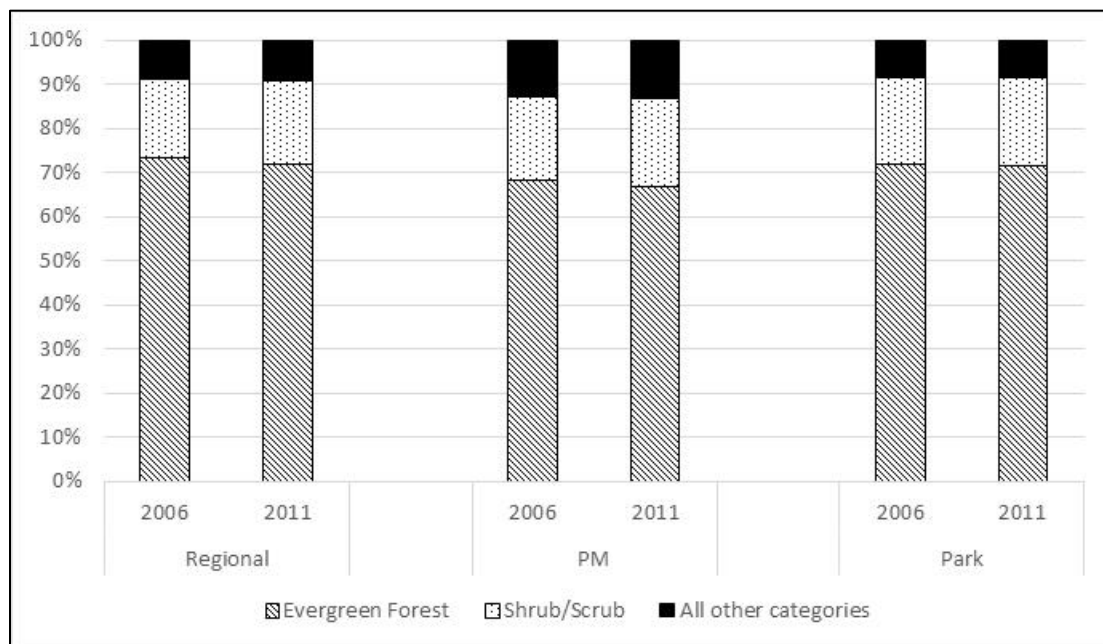


Figure 6. Percent of Anderson Level 2 (Table A2) classes in Regional, Park-Manager-Selected (PM), and Park Areas of Analysis (AOA) for 2006 and 2011.

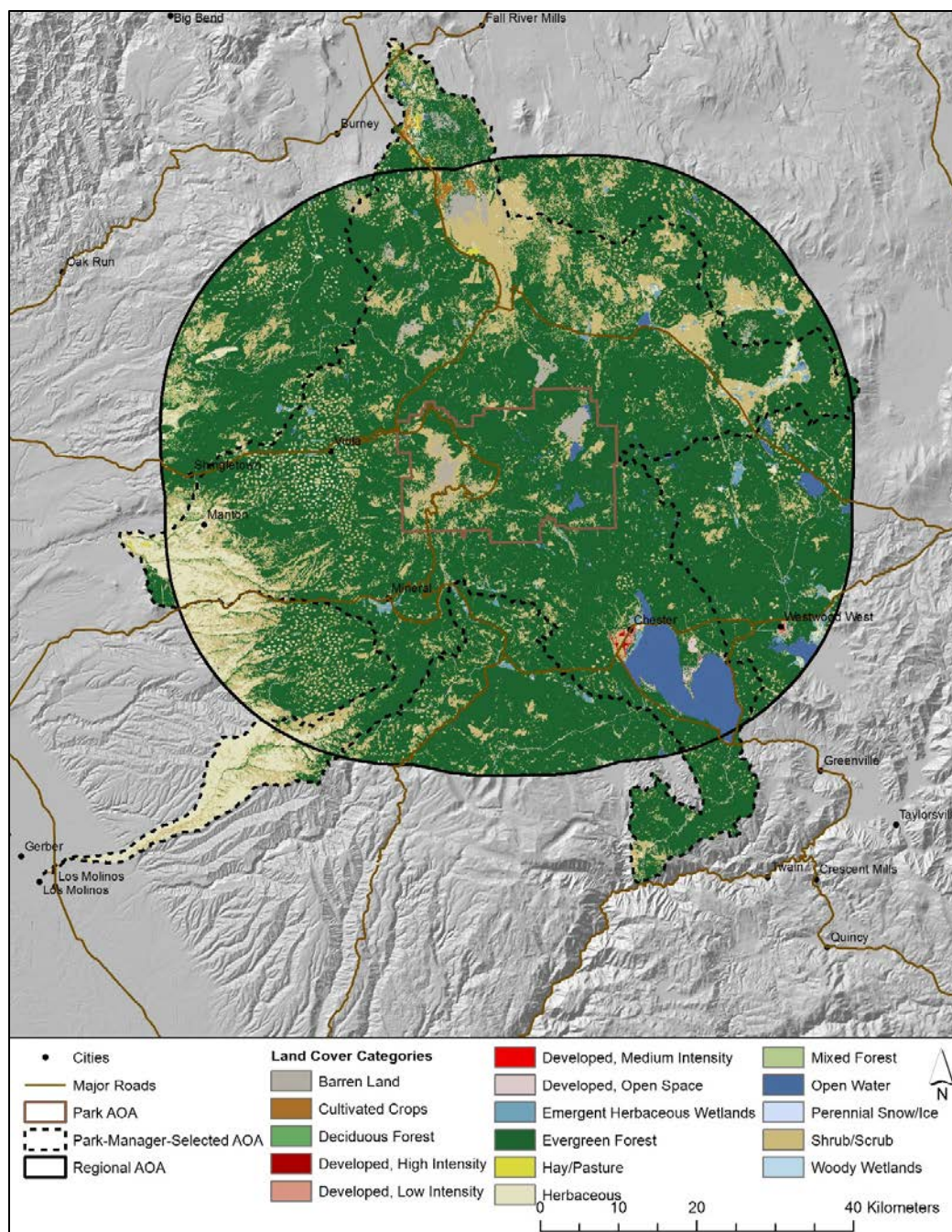


Figure 7. 2011 Anderson Level 2 land cover categories (Table A2) at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

Impervious Surface Cover

In 2006 and 2011, more than 96% of each AOA was in the no impervious surface category (i.e., 0%–2% impervious surface). Likewise, there was little area (<0.3%) that had a high amount of impervious surface (50%–100% impervious surface; Tables B6–B8, Figure 8). Most impervious surfaces are the roads within the AOAs and the towns of Chester and Mineral and around Lake Almanor.

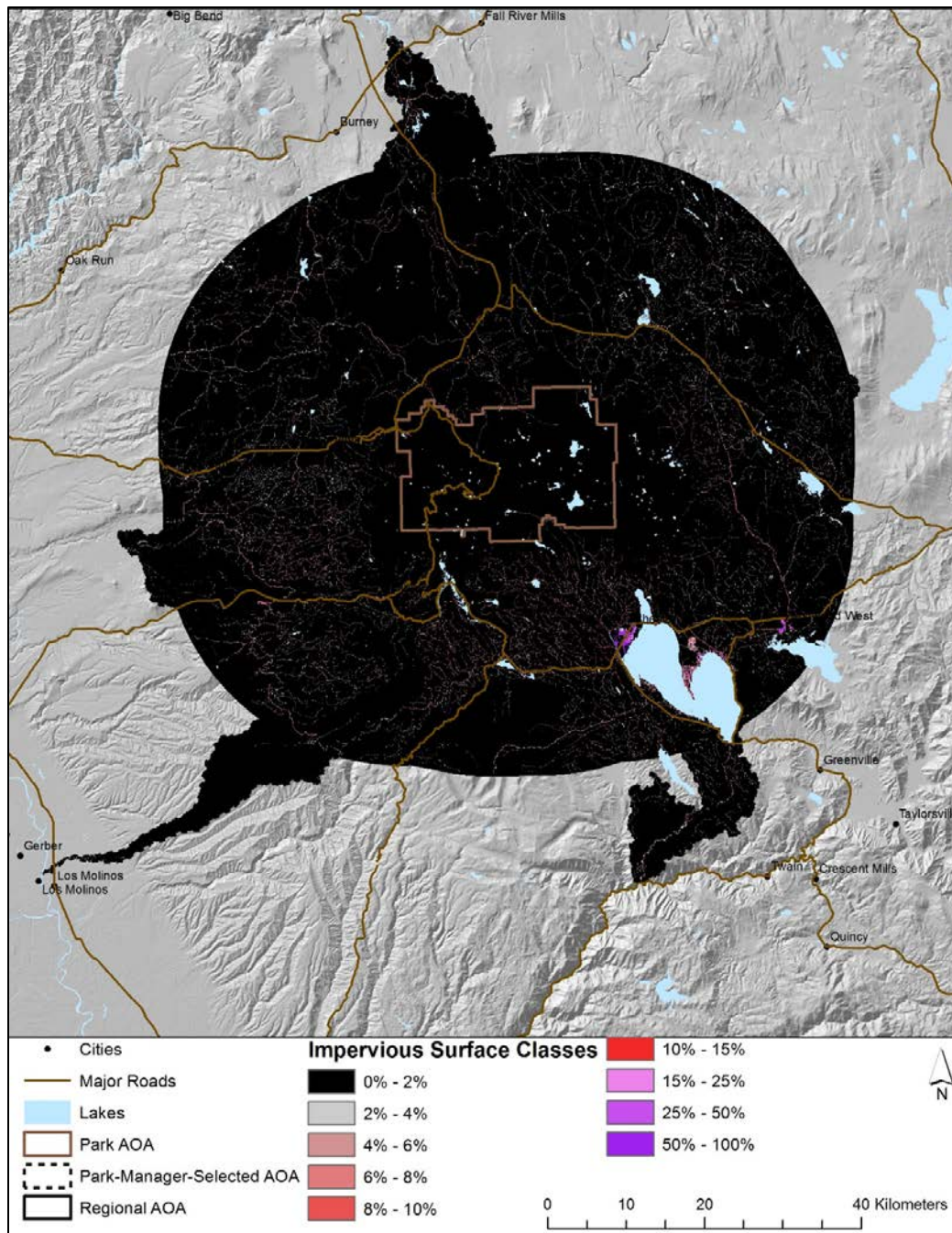


Figure 8. 2011 Impervious Surface Area at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

Natural vs. Converted

For all three AOAs, the majority of the land cover is categorized as *Natural* (Table A2). *Natural* land cover in both 2006 and 2011 composed 98.6% of the Regional AOA, 98.3% of the Park-Manager-Selected AOA, and 99% of the Park AOA (Tables B9–B11, Figure 9). At all three AOAs, the change in area (km²) since 2006 was less than 0.6%. Most of the *Converted* areas in the south were

development around Lake Almanor. *Converted* areas in the north are agricultural and those areas throughout the AOAs are roads.

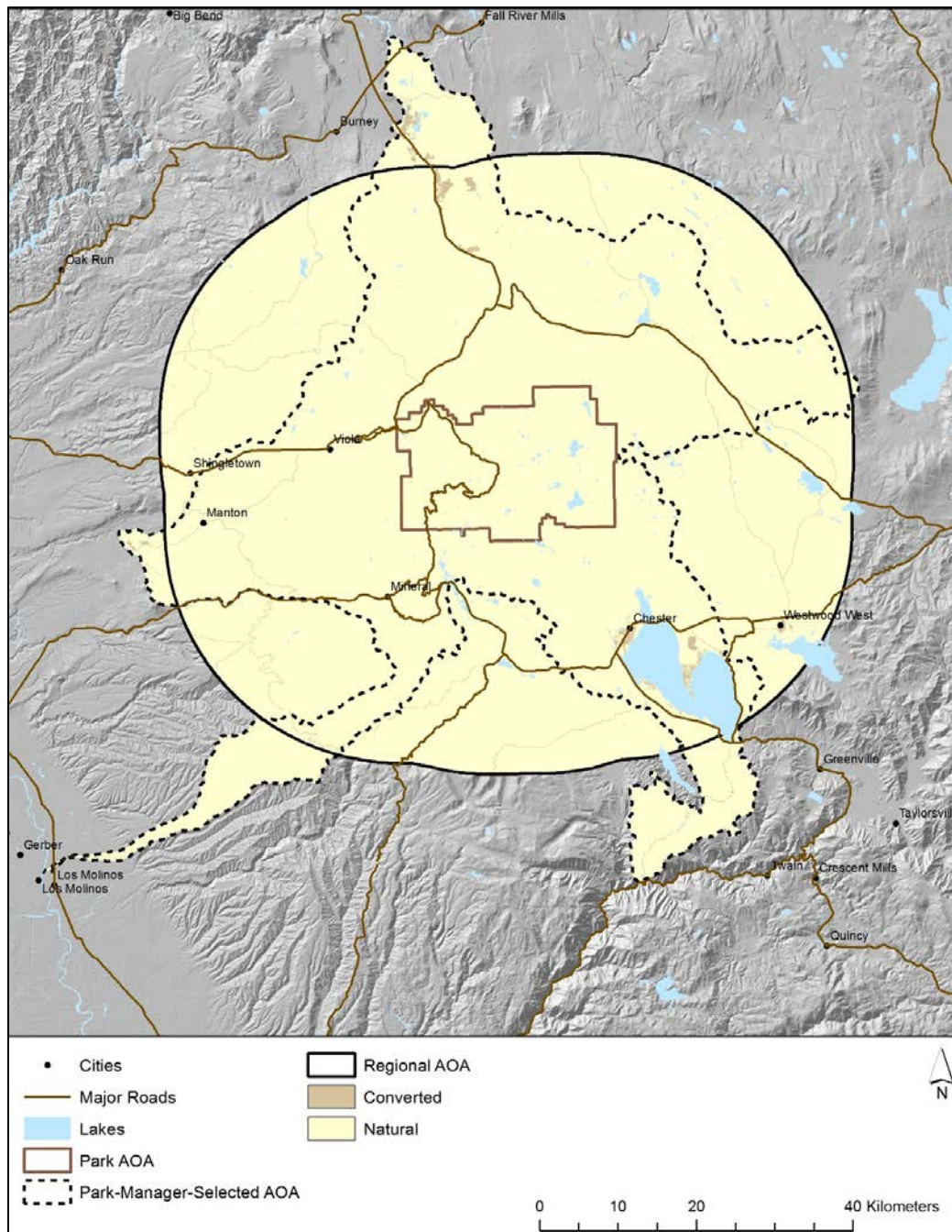


Figure 9. 2011 Natural and converted lands (Table A2) at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

Landscape Pattern

Morphology

Forest

Much of the landscape is covered with forest arranged in large contiguous areas. In the Regional AOA, 73.7% was forested (Figure 10). Almost half (45.3%) of the forest area was classified as *Core* (Tables A3 and B12). There is a similar pattern in the Park-Manager-Selected AOA with 67.2% forested and *Core* areas of 43.2% (Table B12). Following *Core*, *Edge* is the next largest category. *Edge* is the pixel area that separates the *Core* from other types (e.g., *Bridge*, Non-forest).

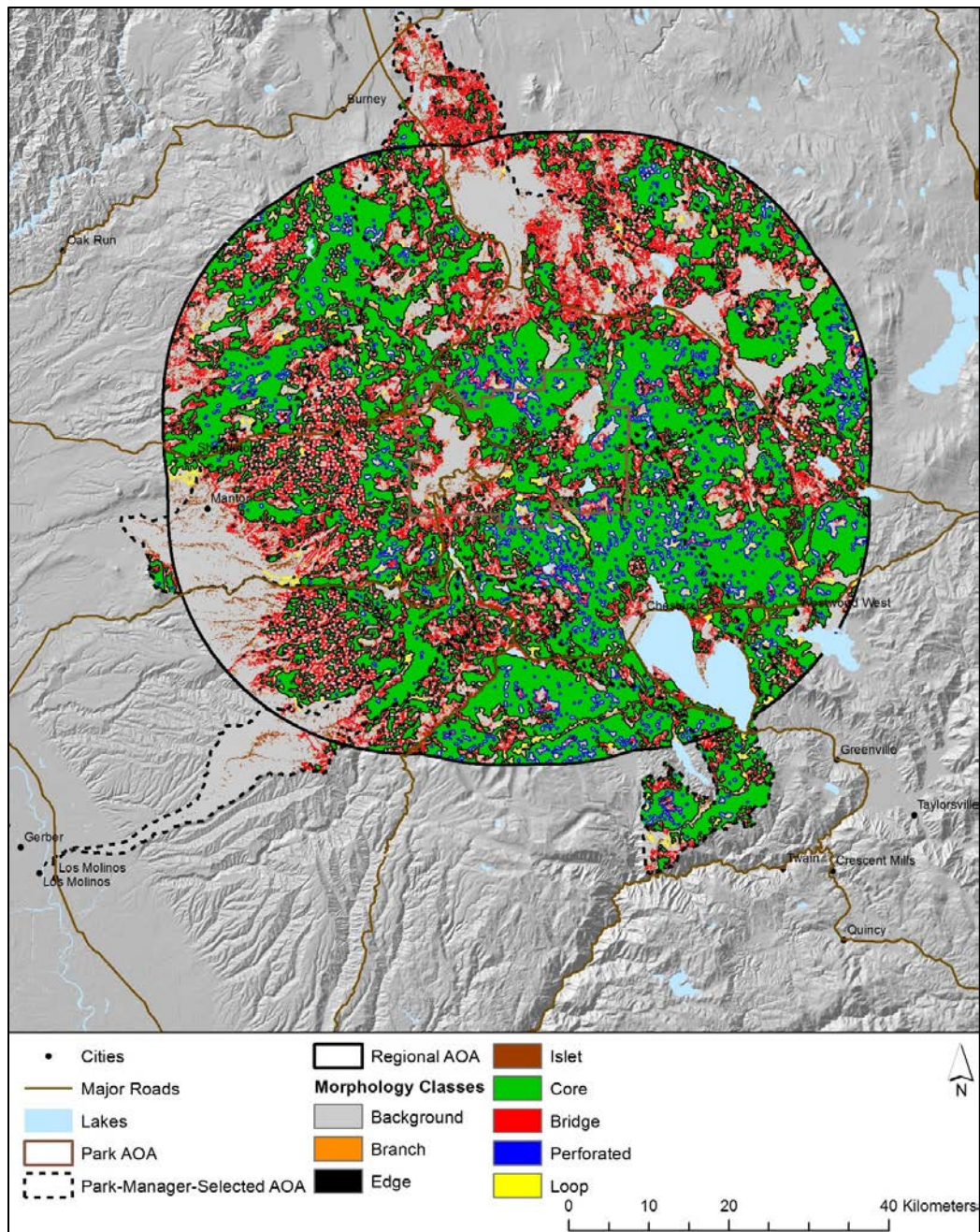


Figure 10. 2011 NLCD land cover forest morphology classification (Table A3) for the Regional and Park-Manager-Selection Areas of Analysis (AOA).

Grassland

Within both Regional and Park-Manager-Selected AOAs, there was a small presence of grassland in the southwest: approximately 3% of the Regional AOA and approximately 5.7% of the Park-Manager-Selected AOA (Table B13). In the Regional AOA, grassland was categorized primarily as *Islets* or *Bridges* (Figure 11). The Park-Manager-Selected AOA was categorized primarily as *Edge*, *Islets*, and *Bridge*.

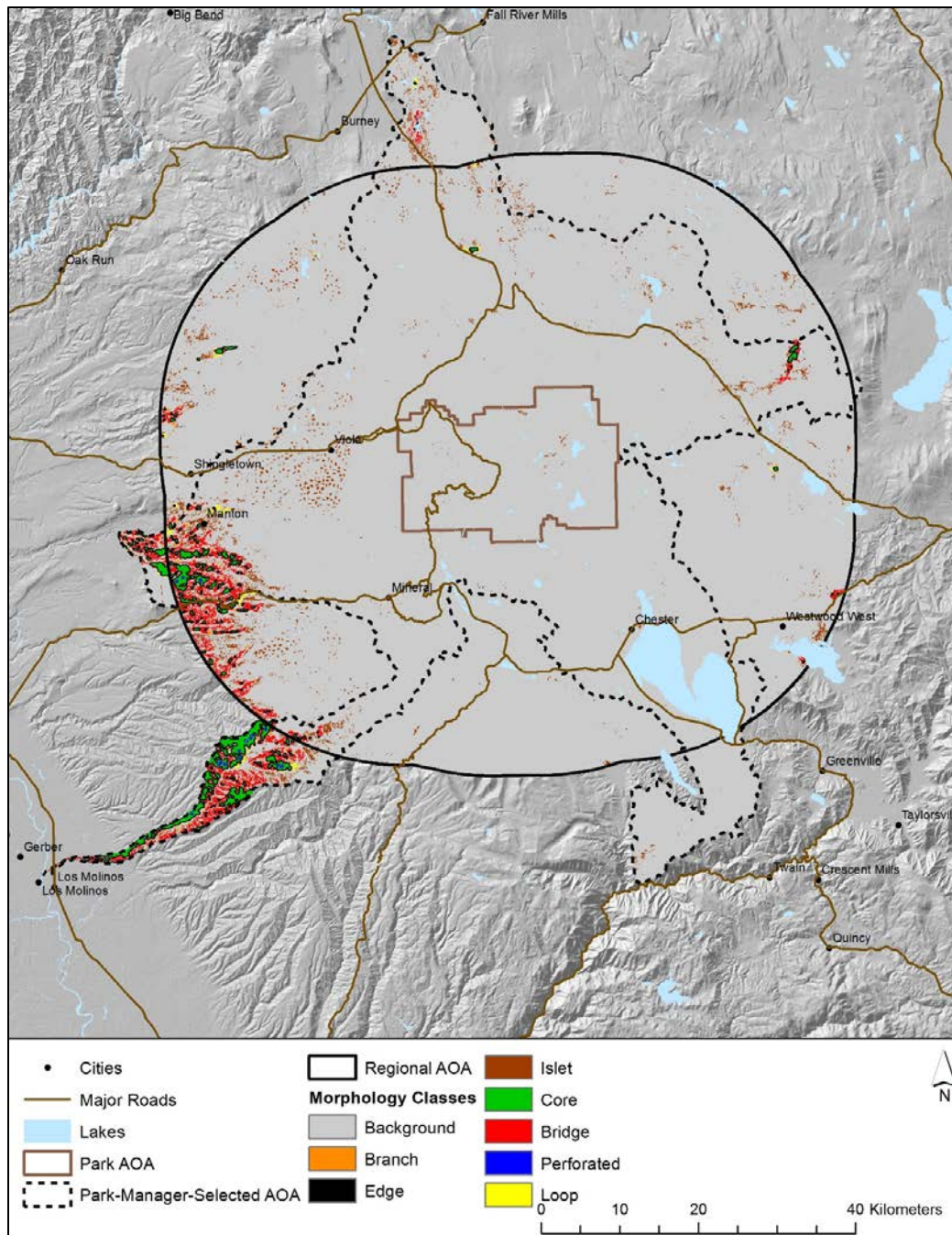


Figure 11. 2011 NLCD land cover grassland morphology classification (Table A3) for the Regional and Park-Manager-Selected Areas of Analysis (AOA).

Shrubland

Shrubland comprised 19% of the Regional AOA, and 20% of the Park-Manager-Selected AOA. Most area was categorized as *Islets*, followed by *Bridges* (Table B14, Figure 12).

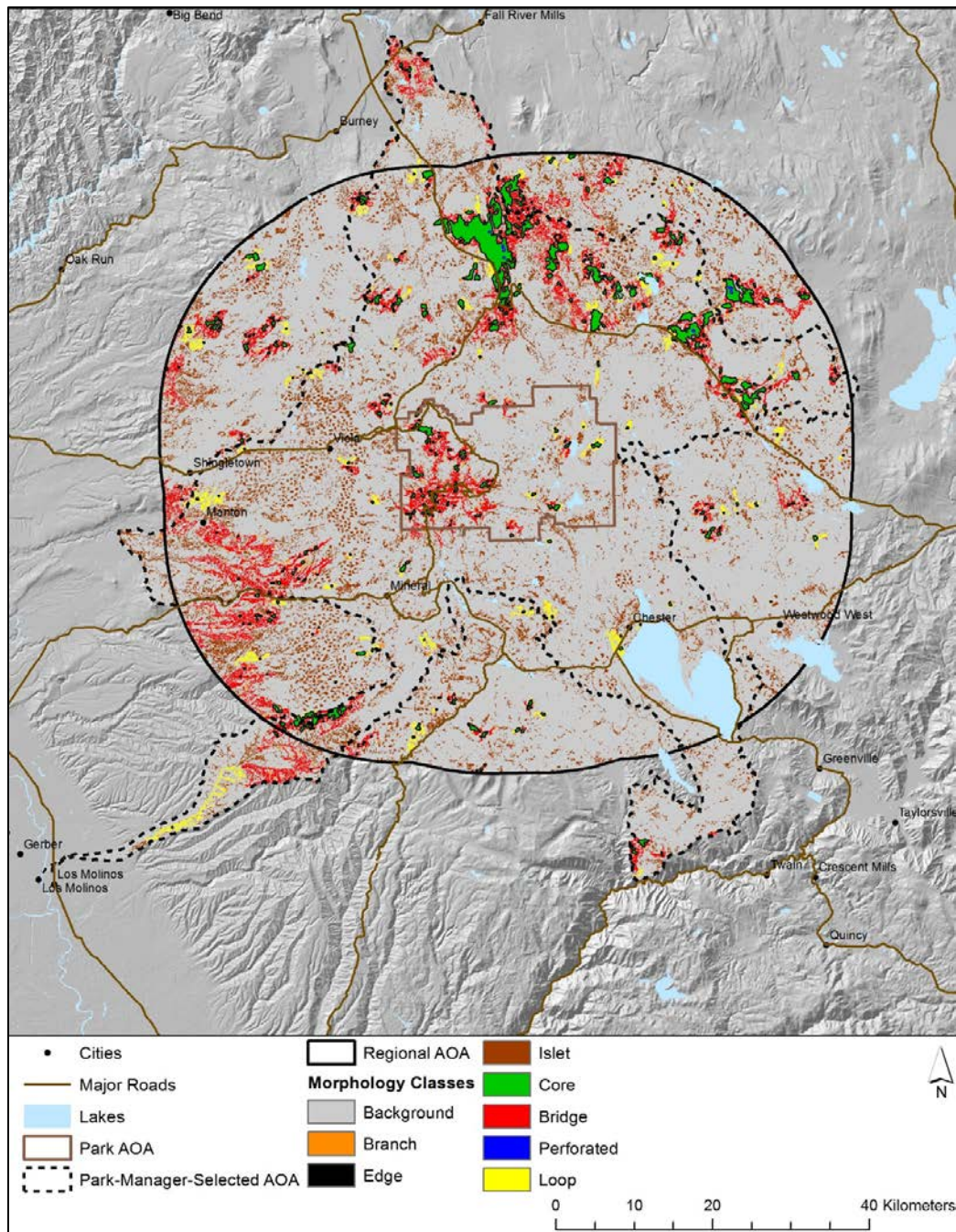


Figure 12. 2011 NLCD land cover shrubland morphology classification (Table A3) for the Regional and Park-Manager-Selected Areas of Analysis (AOA).

Patch Size

Forest patch size

For forest patch size categories and years, the majority of the patches were less than 1 km², but the total area of these combined small patches was low. The majority of the area was in the largest patch sizes (Table B15, Figure 13).

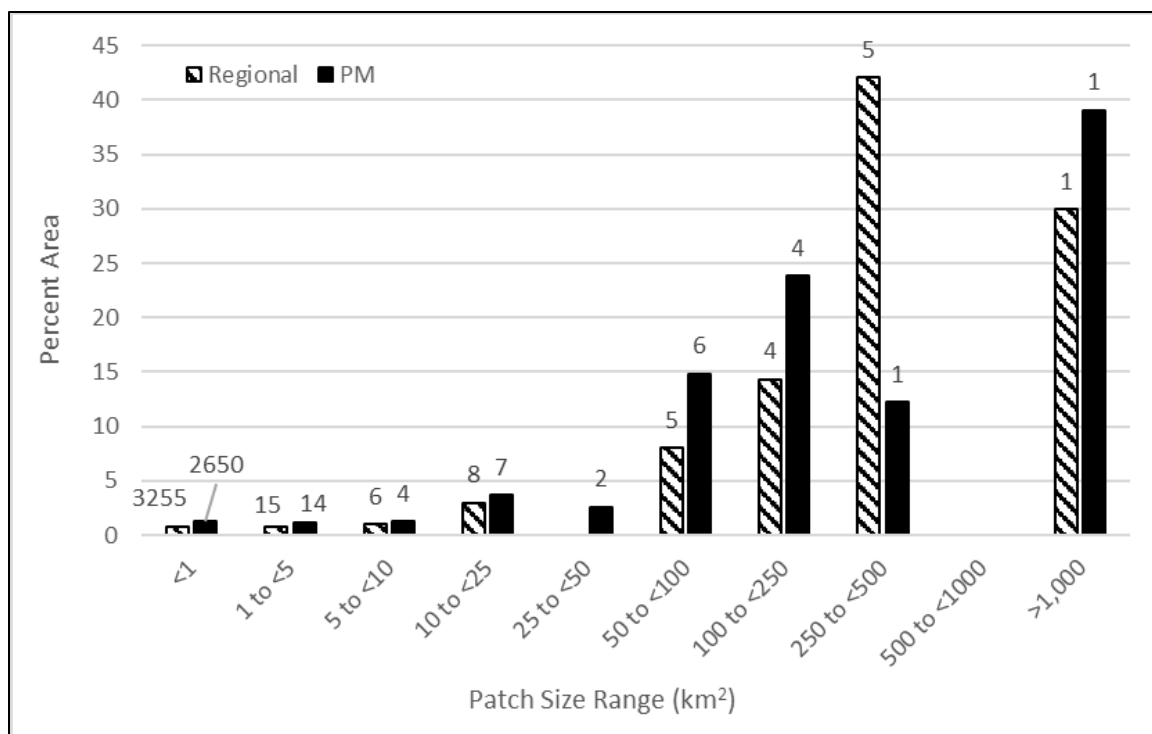


Figure 13. Percent area within each patch size category for forestlands in the Regional and Park-Manager-Selected Areas of Analysis. The number at the top of each bar is the number of patches comprising the area.

Grassland and shrubland patch size

Total land area was much lower in grasslands and shrublands than forest. In both Regional and Park-Manager-Selected AOAs, total grassland areas were distributed among the smallest patch range classes. The vast majority of patches were within the <1 km² category (Table B16). Similarly, total shrubland areas were distributed among the smaller patch range classes with the majority of patches within the <1 km² category (Table B17).

Area Density

Lassen Volcanic NP contains large forested areas that were predominantly *Intact* (47.1%) (Table A4) for the Regional AOA (Table B18, Figure 14). Similarly, for the Park-Manager-Selected AOA, 44.4% was *Intact* (Table B18). These areas will benefit species that depend on large contiguous forest.

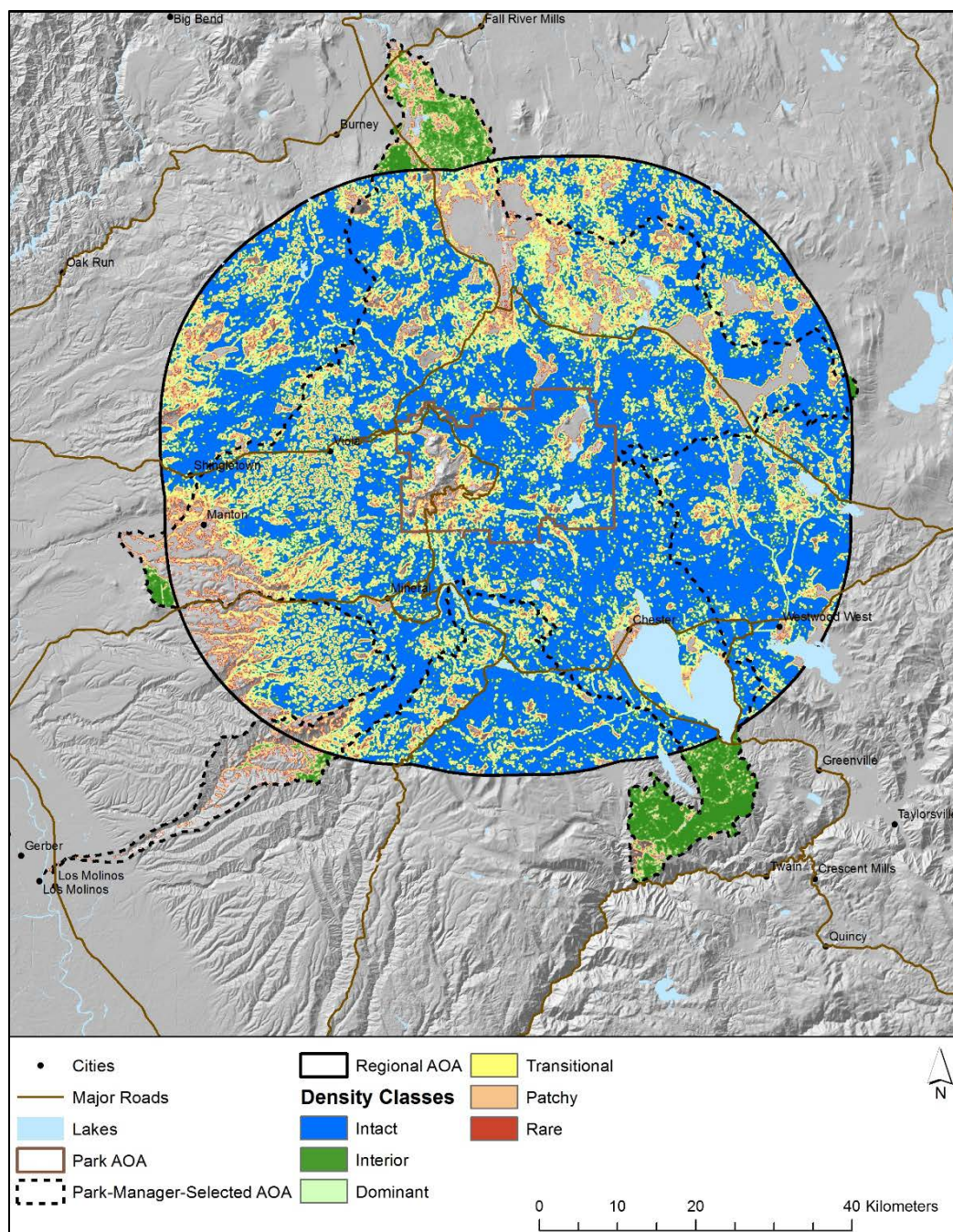


Figure 14. 2011 NLCD land cover forest density (Table A4) for Regional and Park-Manager-Selected Areas of Analysis (AOA).

Grasslands and shrublands were predominantly *Patchy* (Figures 15 and 16, Tables B19 and B20).

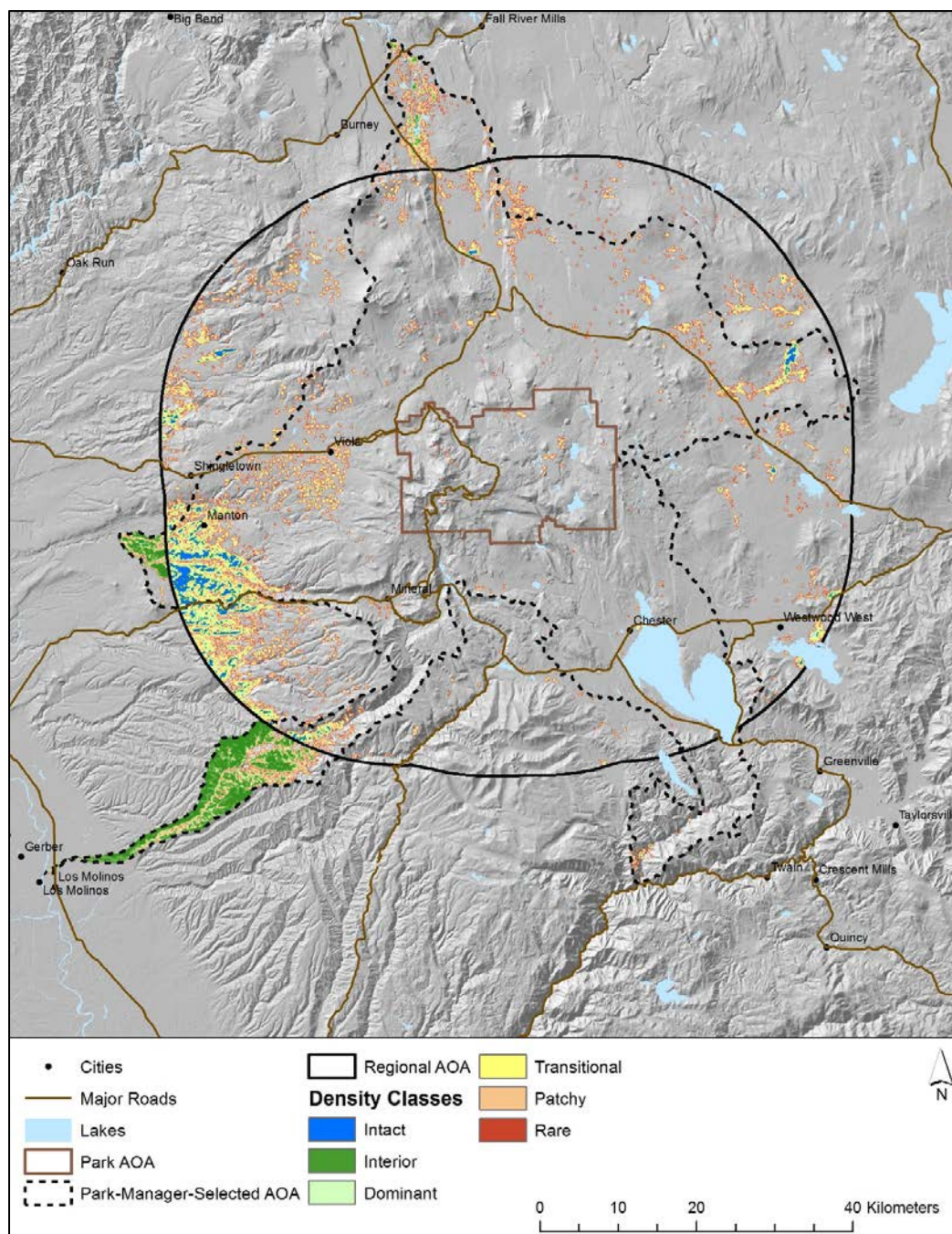


Figure 15. 2011 NLCD land cover grassland density (Table A4) for Regional and Park-Manager-Selected Areas of Analysis (AOA).

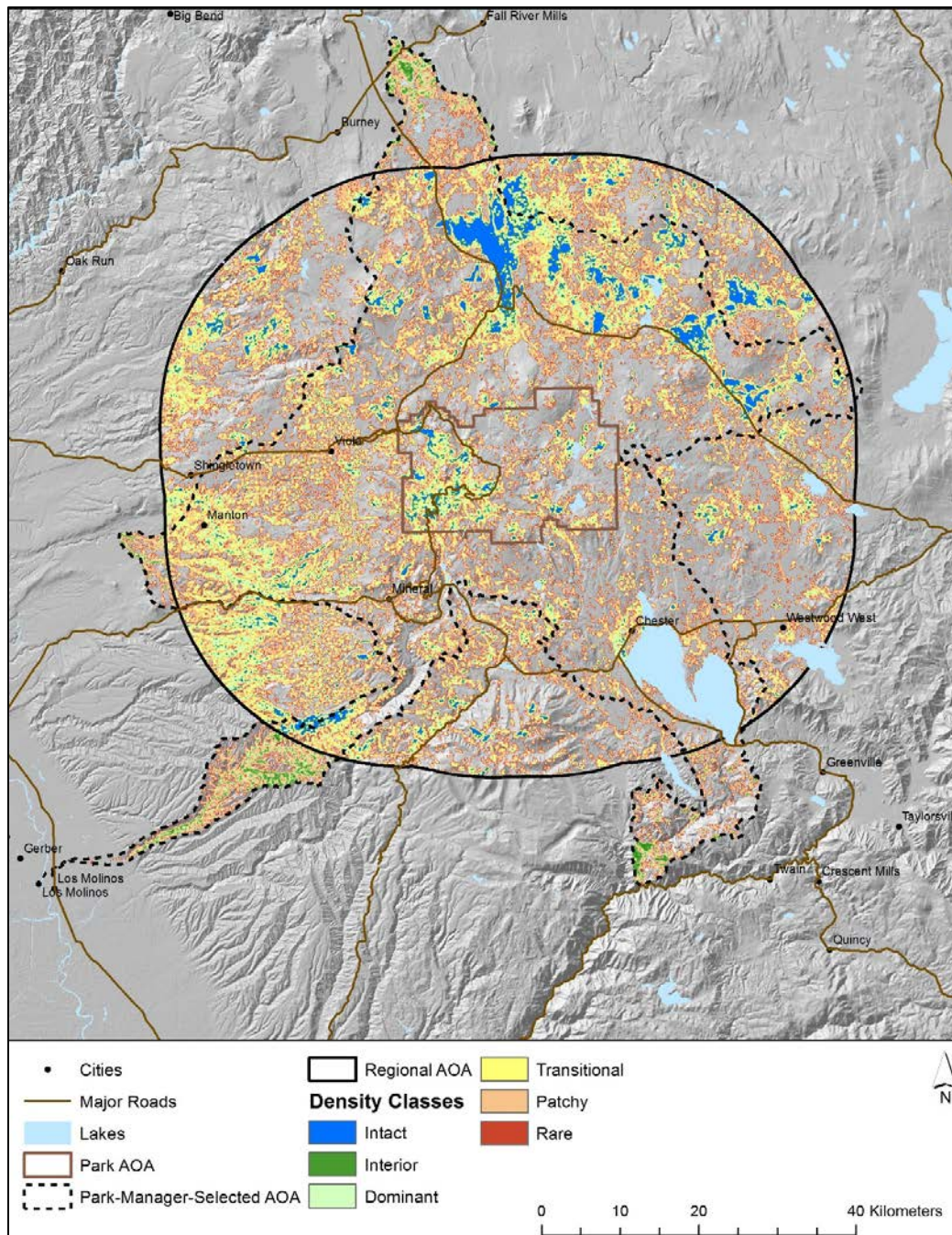


Figure 16. 2011 NLCD land cover shrubland density (Table A4) for Regional and Park-Manager-Selected Areas of Analysis (AOA).

Housing and Population

Housing Density

Lassen Volcanic NP is surrounded by a limited amount of housing development (Figure 17); the region encompasses several small towns including Shingletown, Manton, Viola, Hat Creek, Mineral, Chester, and Westwood. Since 1970, the area considered *Rural* (Table A5) has decreased. In 1970, this area comprised over 95% of the Census areas within each AOA (Tables B21 and B22, Figures

18 and 19). By 2010, these decreased to 86.1% in the Park-Manager-Selected AOA and 89.1% in the Regional AOA. There was a slight change in *Exurban* areas: from 3.3% to 10.3% in the Regional AOA and from 5.3% to 13.2% in the Park-Manager-Selected AOA.

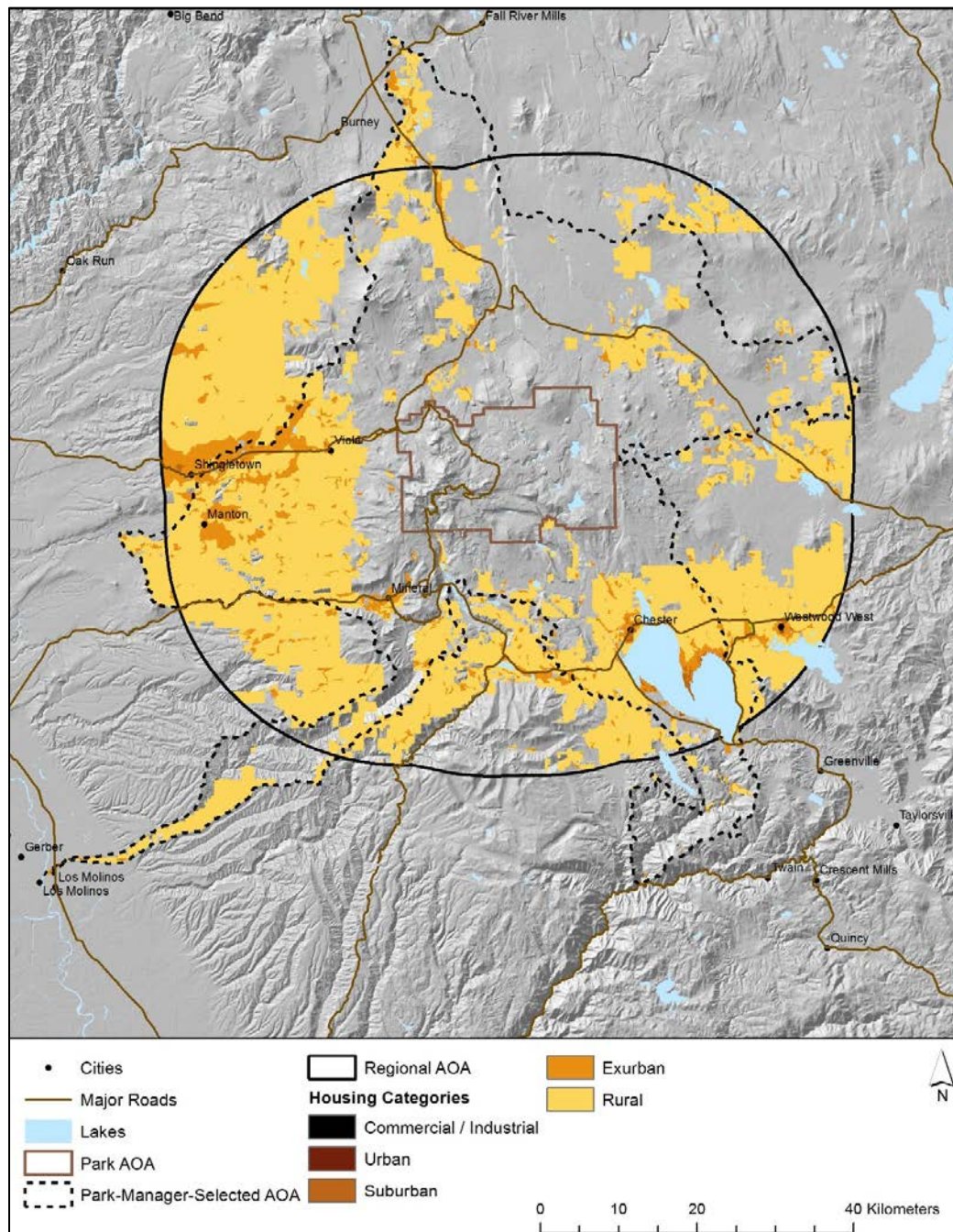


Figure 17. 2010 housing category groups (Table A5) in the Regional and Park-Manager-Selected Areas of Analysis (AOA).

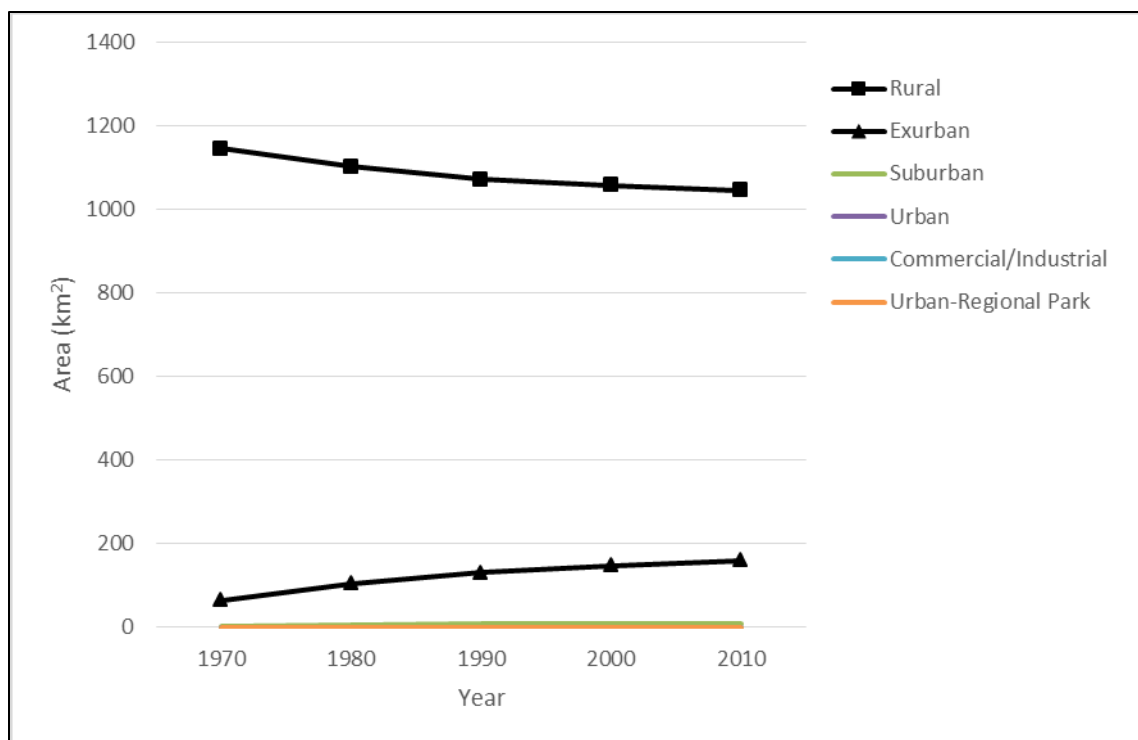


Figure 18. Area (km²) in each housing category group (Table A5) from 1970 to 2010 in the Regional Area of Analysis.

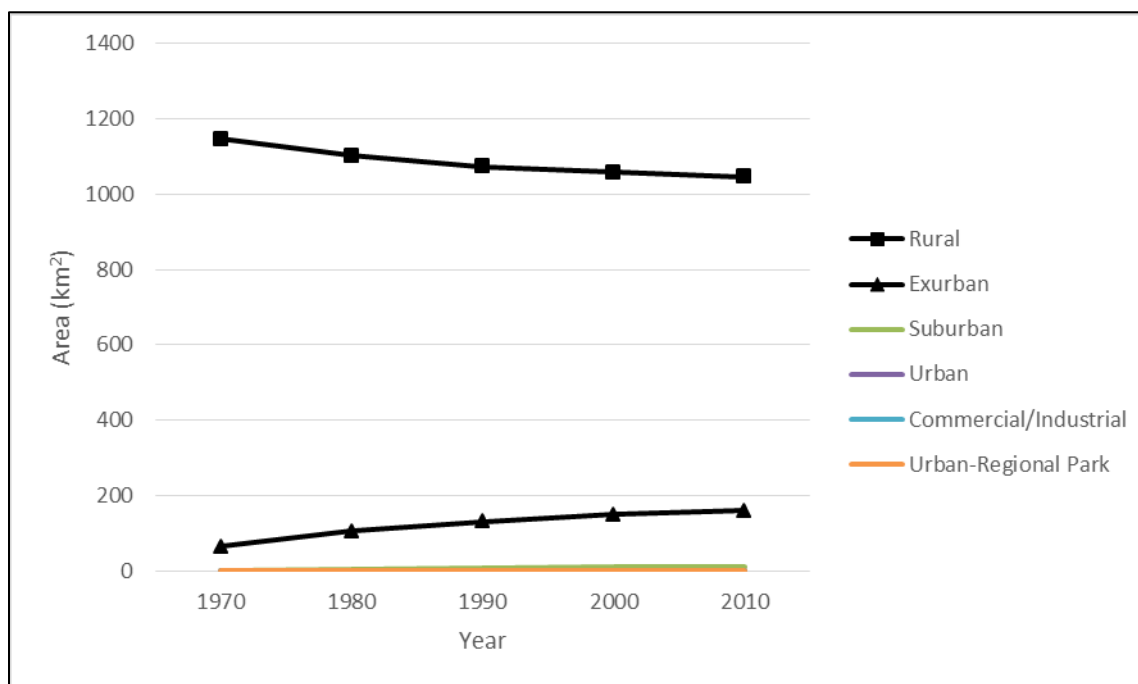


Figure 19. Area (km²) in each housing category group (Table A5) from 1970–2010 in the Park-Manager-Selected Area of Analysis.

Total Population

The population is relatively low around Lassen Volcanic NP (Figure 20). The population within the Regional AOA was 11,532 in 1990, 12,991 in 2000, and 12,565 in 2010 (Table B23). The population within the Park-Manager-Selected AOA was 7000 in 1990, 8028 in 2000, and 7465 in 2010 (Table B24).

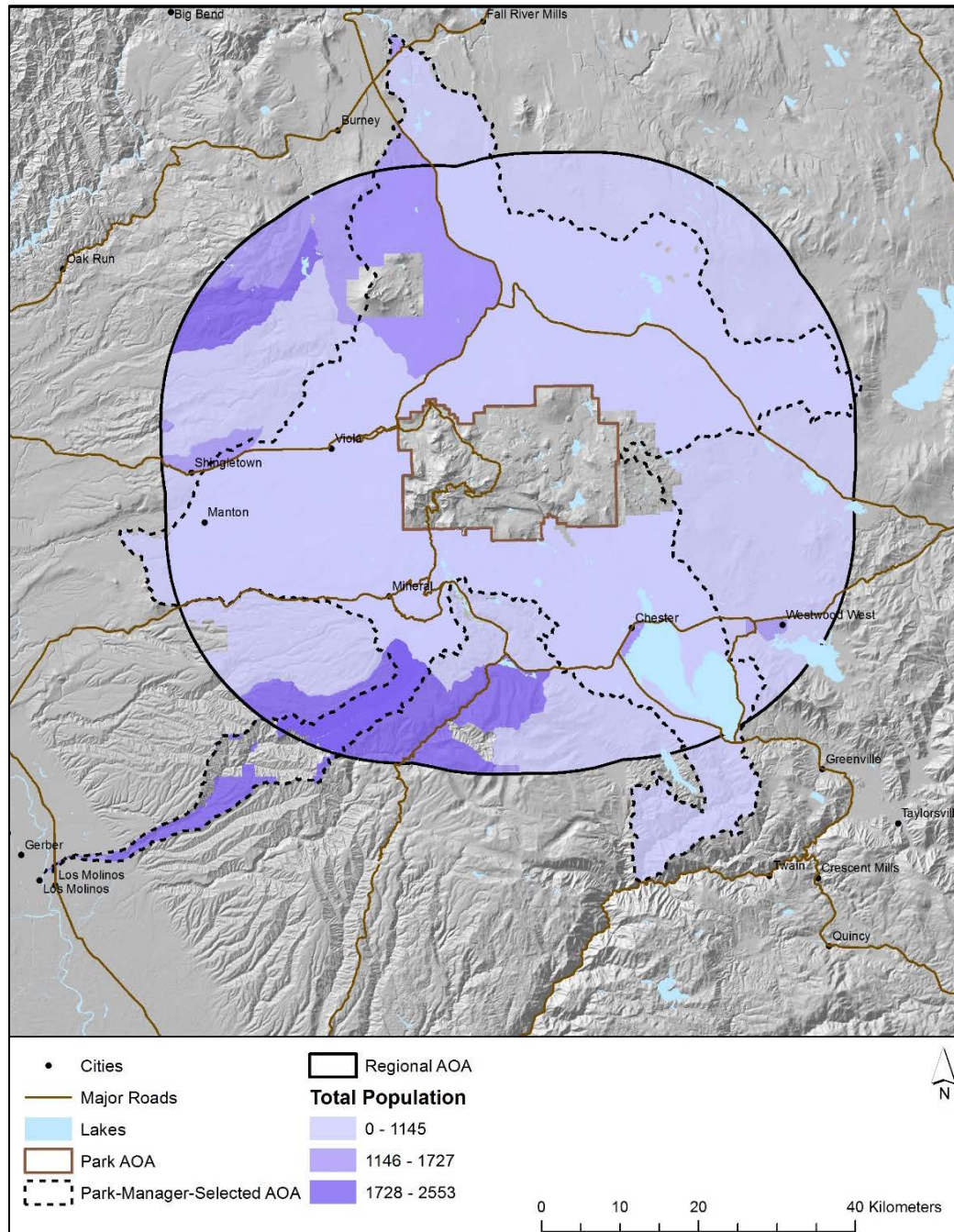


Figure 20. 2010 total population in the Regional and Park-Manager-Selected Areas of Analysis (AOA).

Population Density

The population density (individuals per square kilometer) for the Regional AOA was 2.24 in 1990, 2.55 in 2000, and 2.46 in 2010 (Table B23, Figures 21 and 22). The population density for the Park-Manager-Selected AOA was 2.23 in 1990, 2.58 in 2000, and 2.39 in 2010 (Table B24, Figures 21 and 22).

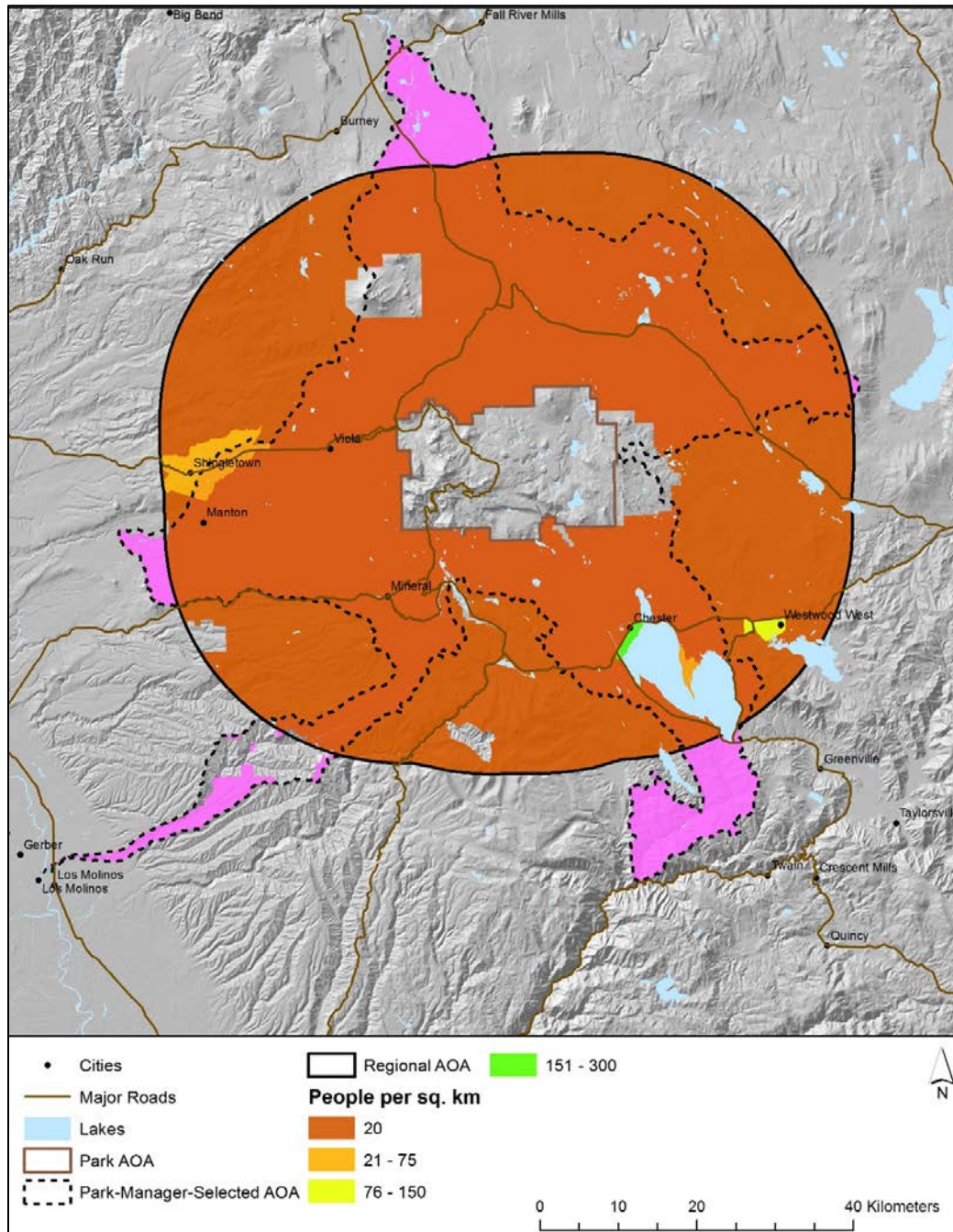


Figure 21. 2010 population density from Census Block-groups that intersect the Regional and Park-Manager-Selected Areas of Analysis (AOAs).

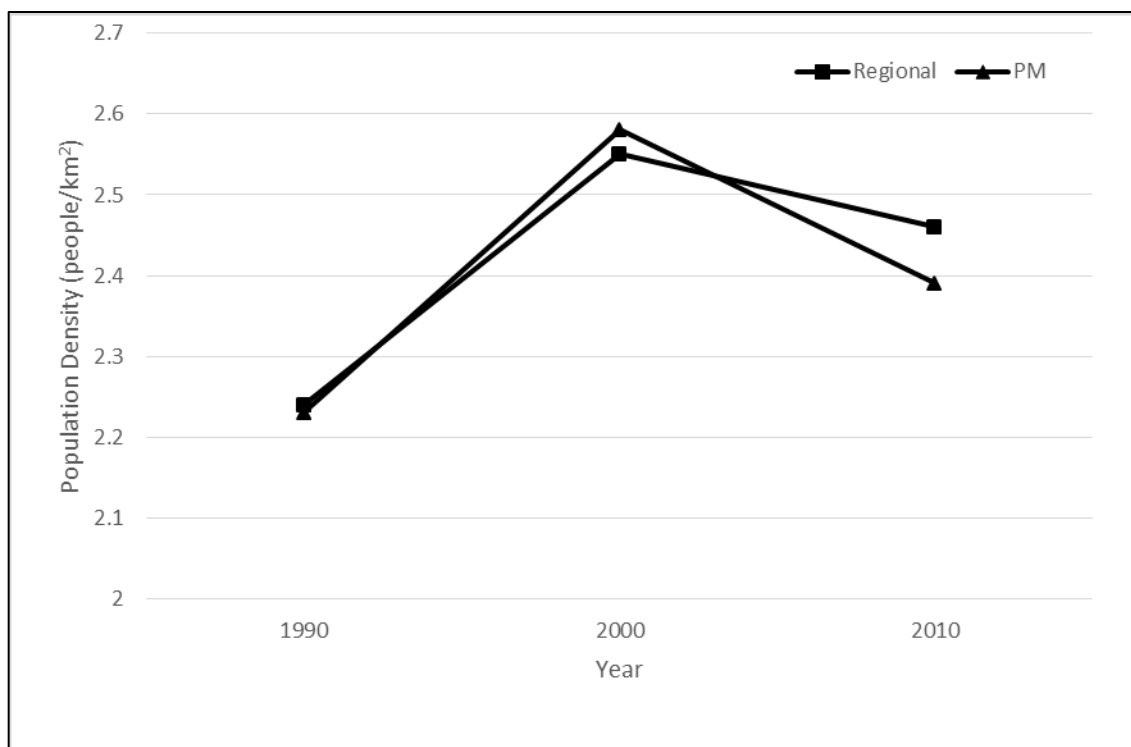


Figure 22. Population density (people/km²) from 1990 to 2010 at Regional and Park-Manager-Selected Areas of Analysis.

Roads

Road Density

Road density is much lower in Lassen Volcanic NP than in the surrounding areas. The vast majority of the roads surrounding the park are category S1400 (Local Neighborhood Road, Rural Road, City Street; see Table A6 for road code definitions). For both 2010 and 2015, the Regional AOA had a road density of 1.55 km/km², the Park-Manager-Selected AOA had a density of 1.44 km/km², and the Park AOA had a density of 0.21 km/km² (Figures 23 and 24). In 2015, total road length in the Regional AOA was 9146 km and 5579 km in the Park-Manager-Selected AOA; total road length in 2016 was 91 km in the Park AOA (Tables B25–B27).

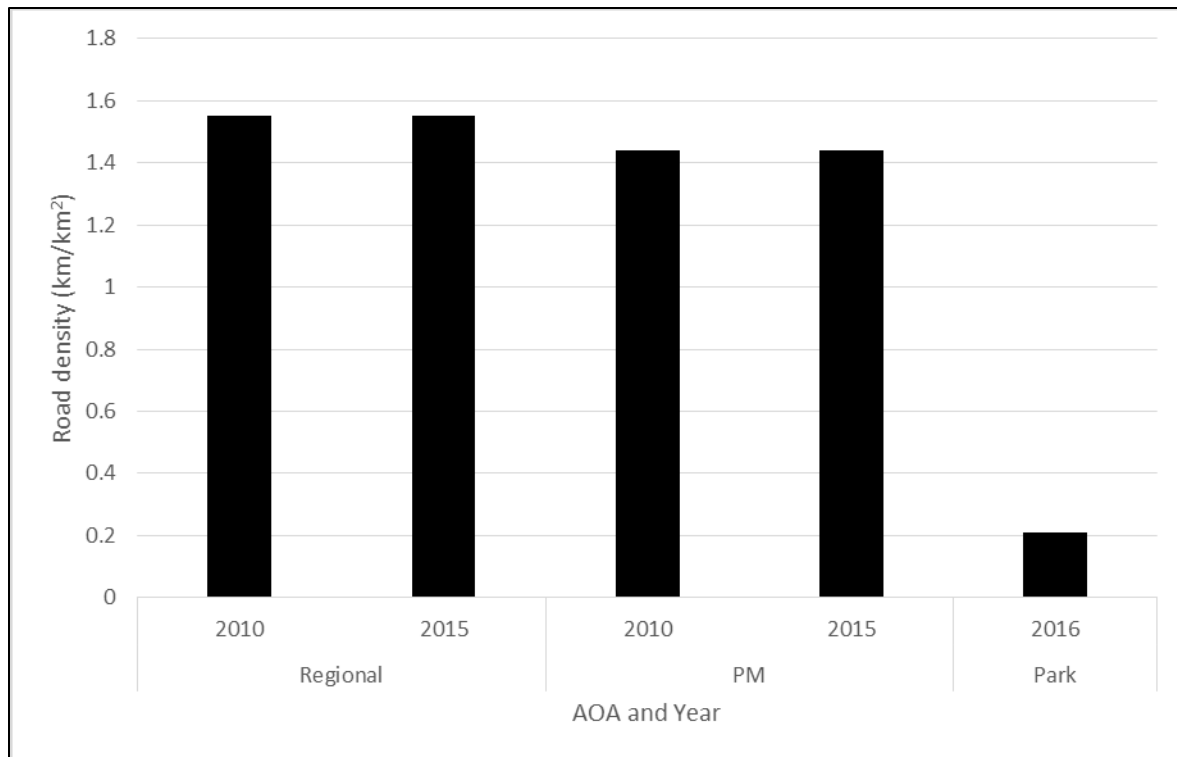


Figure 23. Road density (km/km²) in 2010 and 2015 at the Regional and Park-Manager-Selected Areas of Analysis (AOA), and for 2016 at the Park AOA. Note that the 2016 Park analysis was done with park-supplied data, whereas the Regional and Park-Manager-Selected analyses were done with TIGER data.

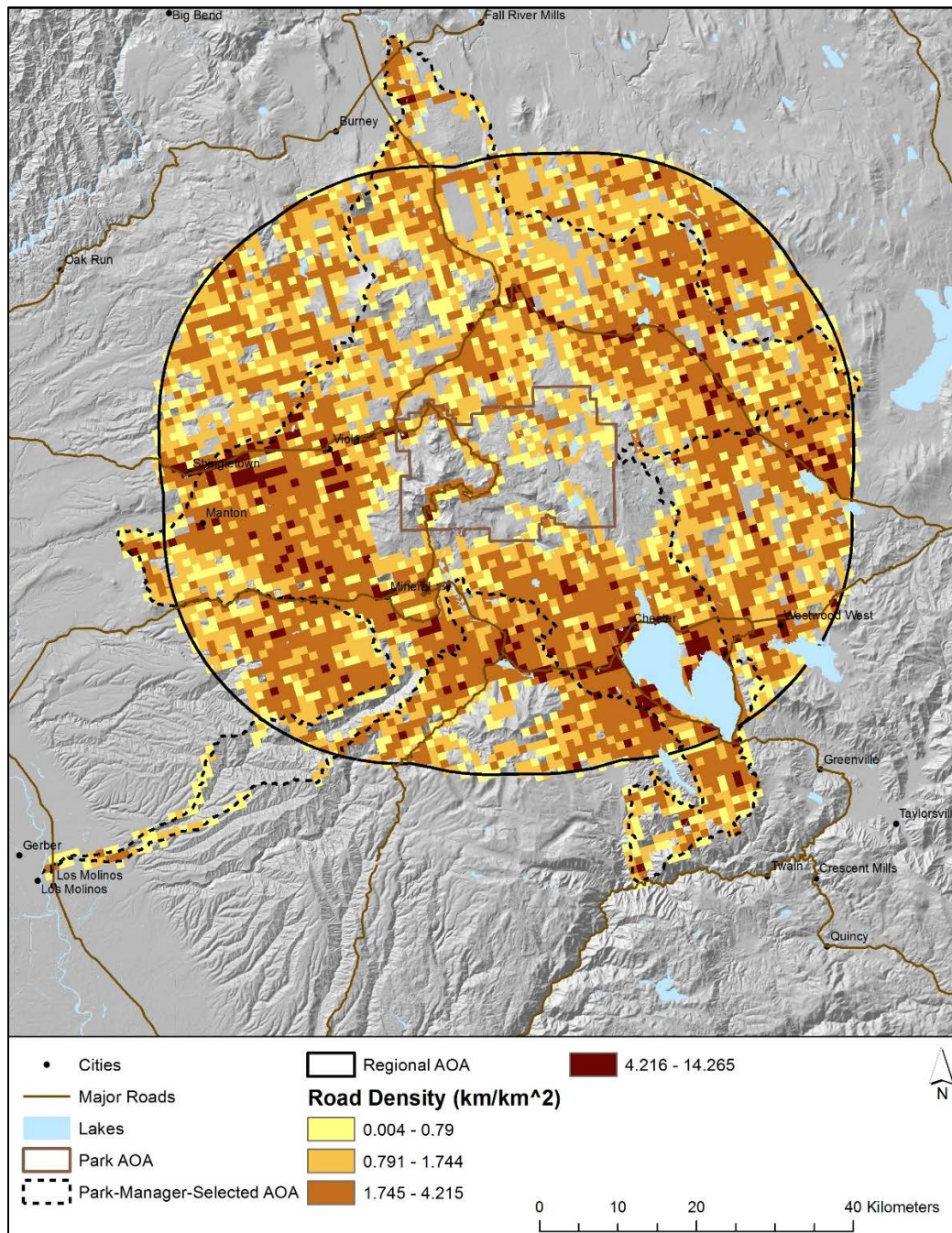


Figure 24. Road density (km/km^2) in 2015 at the Regional and Park-Manager-Selected Areas of Analysis (AOA). Note that TIGER derived data are displayed for the Park AOA, not the park road data which are used in the Park AOA analyses.

Distance from Roads

Compared to the Regional and Park-Manager-Selected AOAs, the Park AOA includes a higher proportion of area with a greater distance from roads (Figures 25 and 26). Outside of Lassen Volcanic NP, areas that are the greatest distance from roads are generally national forest lands, including some wilderness areas and mountainous areas (e.g., Butte Mountain).

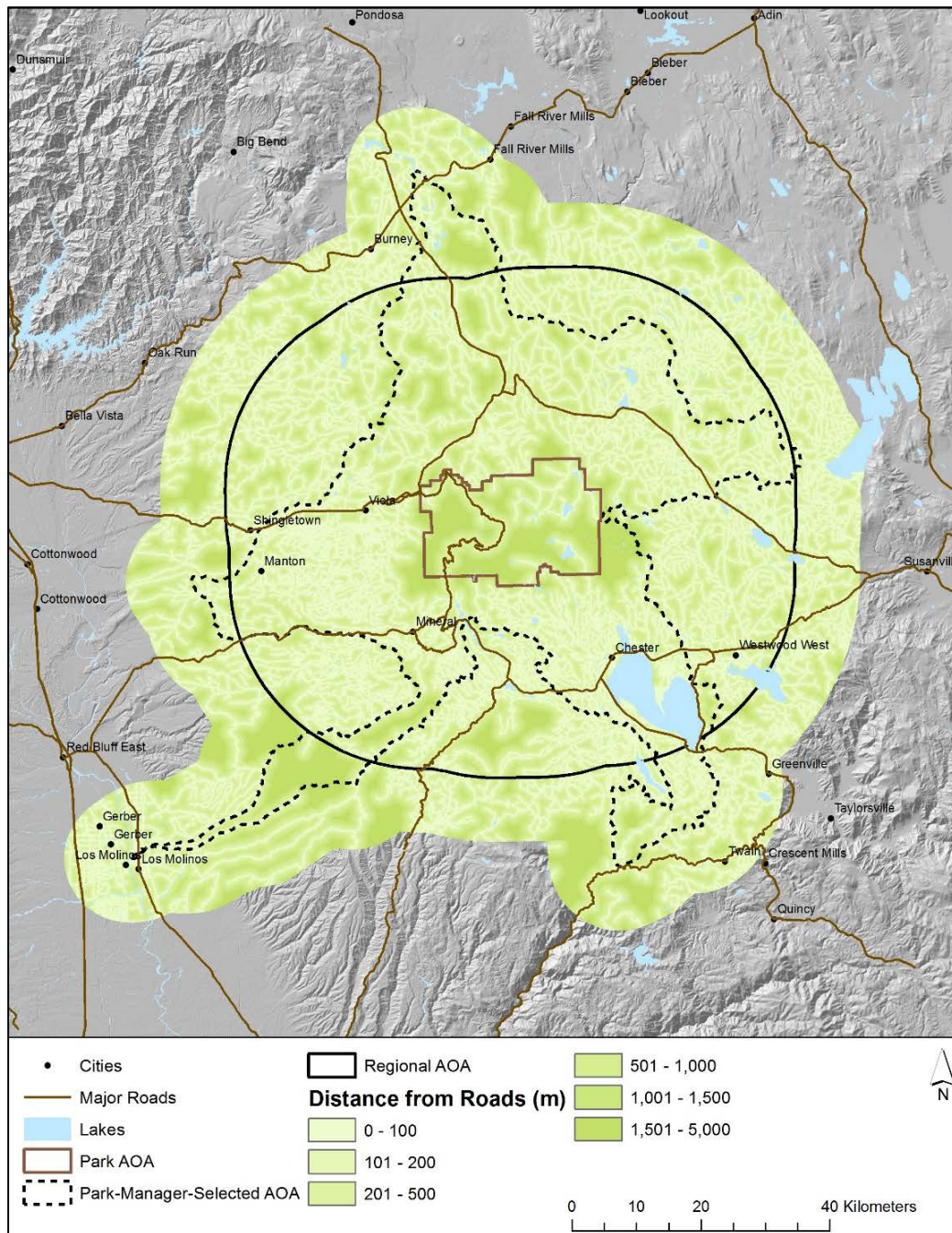


Figure 25. Distance from roads using 2015 TIGER data in the Regional and Park-Manager-Selected Areas of Analysis (AOA). Note that TIGER-derived data are displayed for the Park AOA, not the park road data that are used in the Park AOA analyses.

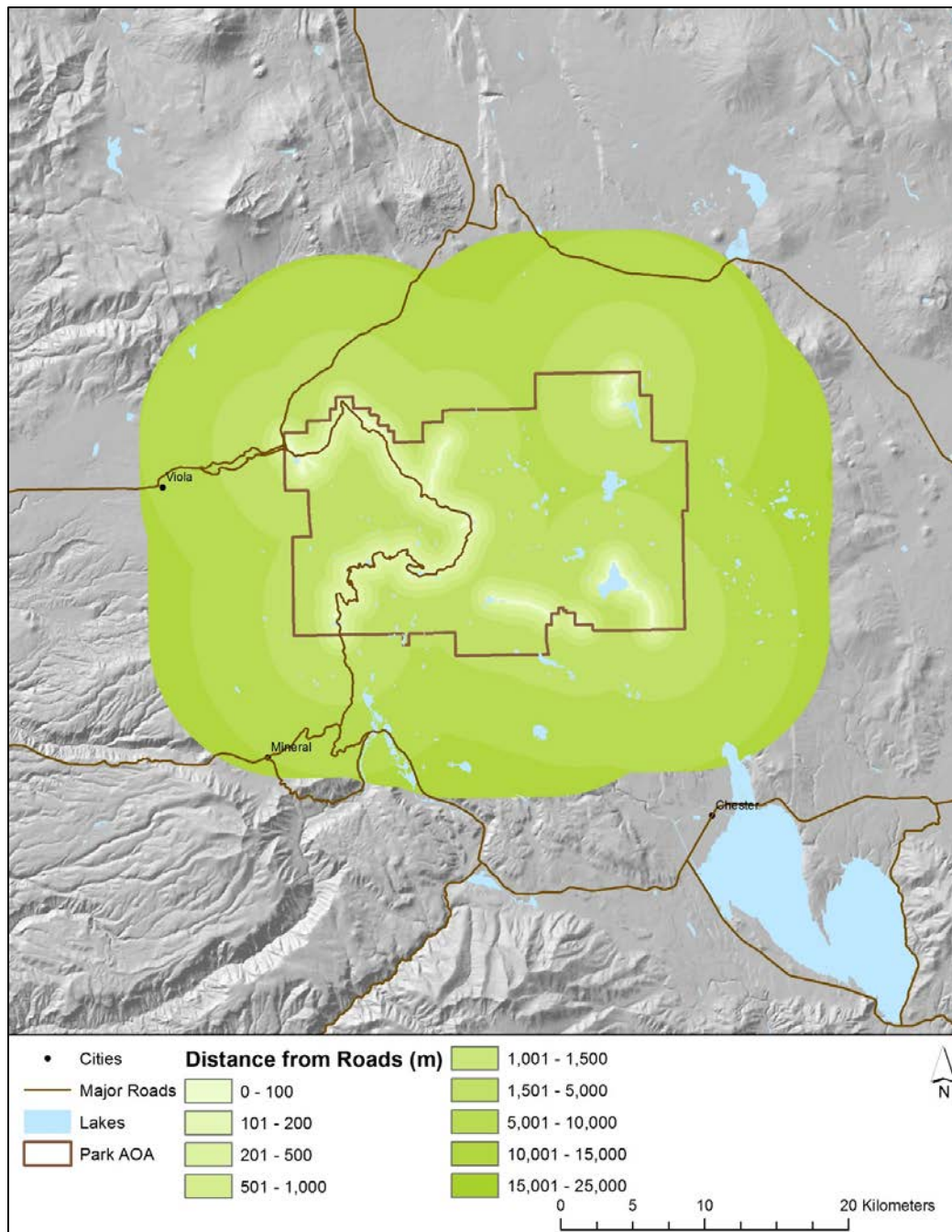


Figure 26. Distance from roads using 2016 park data within the Park Area of Analysis (AOA).

Roadless Areas

The bulk of the roadless areas are in Lassen Volcanic NP and areas directly adjacent to the park. The adjacent park lands are primarily US Forest Service lands, some as wilderness areas and others as GAP Status 3 lands. Roadless areas not adjacent to the park are largely composed of national forest.

There has been little change between 2010 and 2015. In 2015, the Regional AOA contained four areas with more than 100 km², totaling 956 km² (Figure 27, Table B28). The Park-Manager-Selected

AOA also contained large roadless areas. The three areas with more than 100 km² without roads had a total area of 803 km² in 2015 (Figure 27, Table B29). Within the Park AOA (2016 data), there are few roads, and one continuously roadless area covering 304 km² (Figure 28, Table B30).

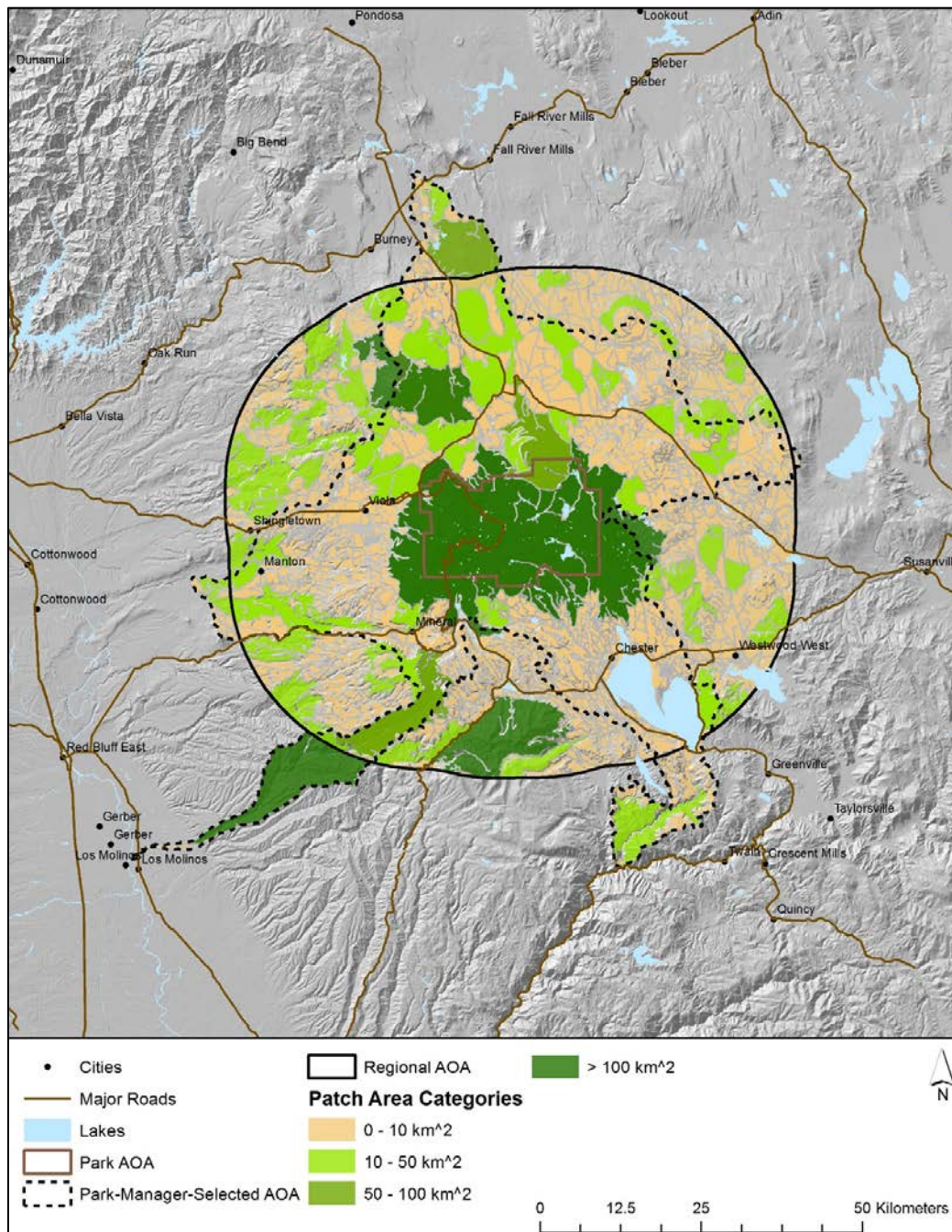


Figure 27. Roadless areas using 2015 TIGER, for the Regional and Park-Manager-Selected Areas of Analysis (AOA). Note that TIGER derived data are displayed for the Park Area of Analysis (AOA), not the park road data which are used in the Park AOA analyses.

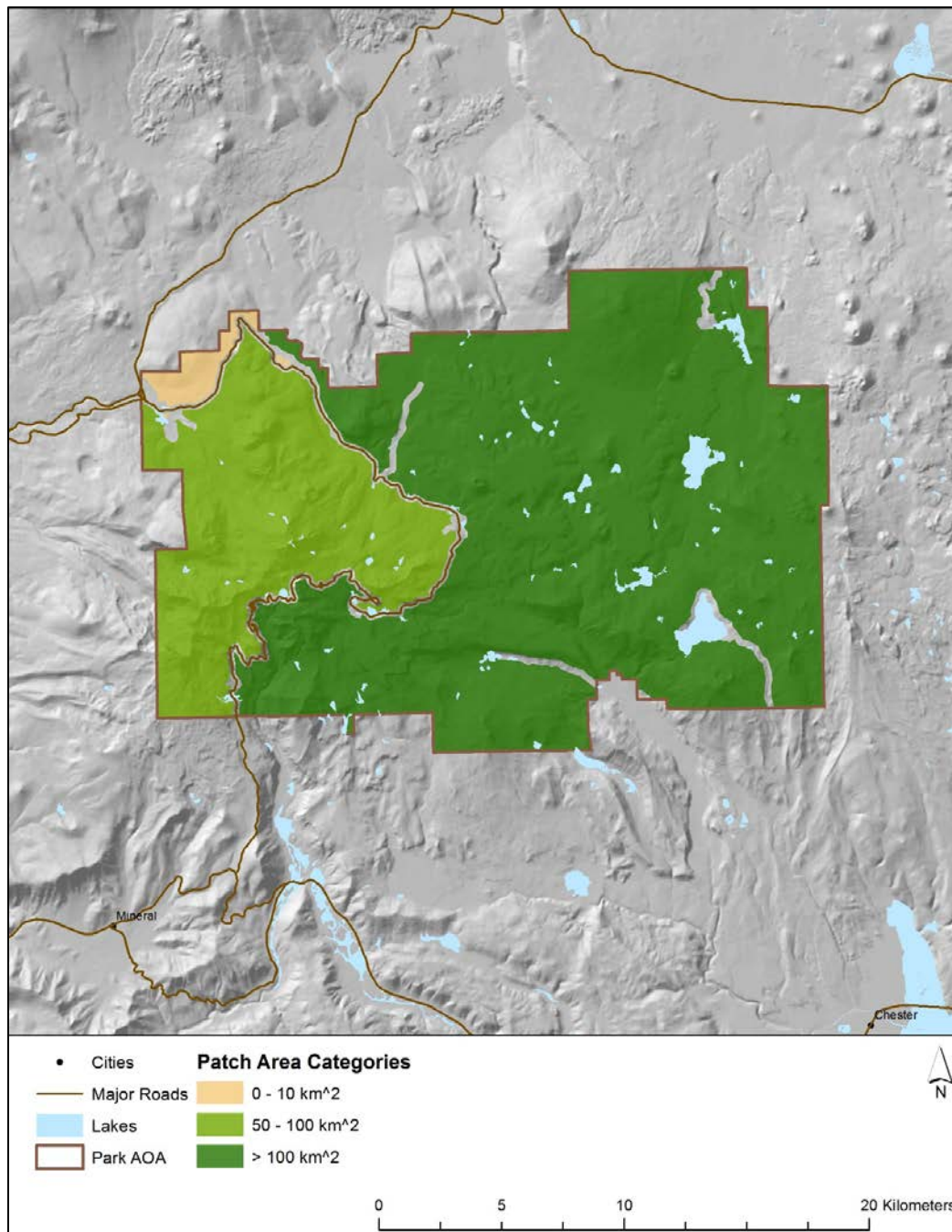


Figure 28. Roadless areas, using 2016 park data within the Park Area of Analysis (AOA).

Disturbance

In the Regional AOA, a cumulative total area of 2354.1 km² was disturbed from 1999 to 2012 (Tables B31–B33). Figure 29 presents the total quantity of disturbed area by year within each of the three AOAs. The most area was affected by *Thinning* (655.8 km²), followed by *Wildfire* (585.0 km²), and then *Harvest* (391.3 km²) (Table A7). These account for 27.9%, 24.8%, and 16.6%, respectively, of the total disturbed areas within the Regional AOA. Figure 30 presents percentage in each disturbance category for each AOA, and Figure 31 illustrates areas affected by each disturbance type.

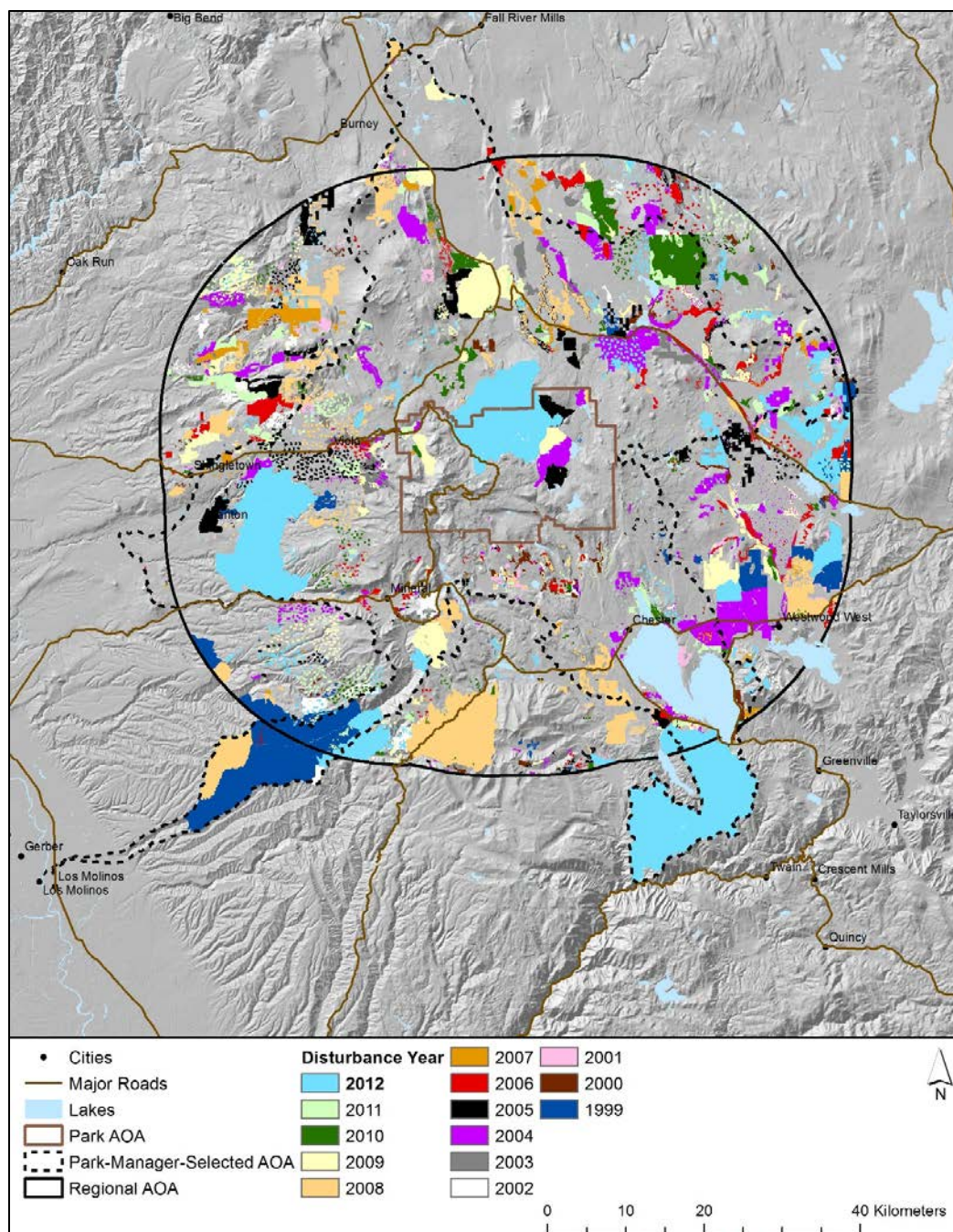


Figure 29. Locations of disturbances by year (1999–2012) at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

In the Park-Manager-Selected AOA, from 1999 to 2012, the total disturbed area was 1646.2 km². (Figure 29, Tables B34–B36). The most area was affected by *Wildfire* (748.9 km²), followed by *Thinning* (264.5 km²), and then *Harvest* (229.8 km²). These account for 45.5%, 16.1%, and 14.0%, respectively, of the disturbed areas within the Park-Manager-Selected AOA (Figures 30 and 31).

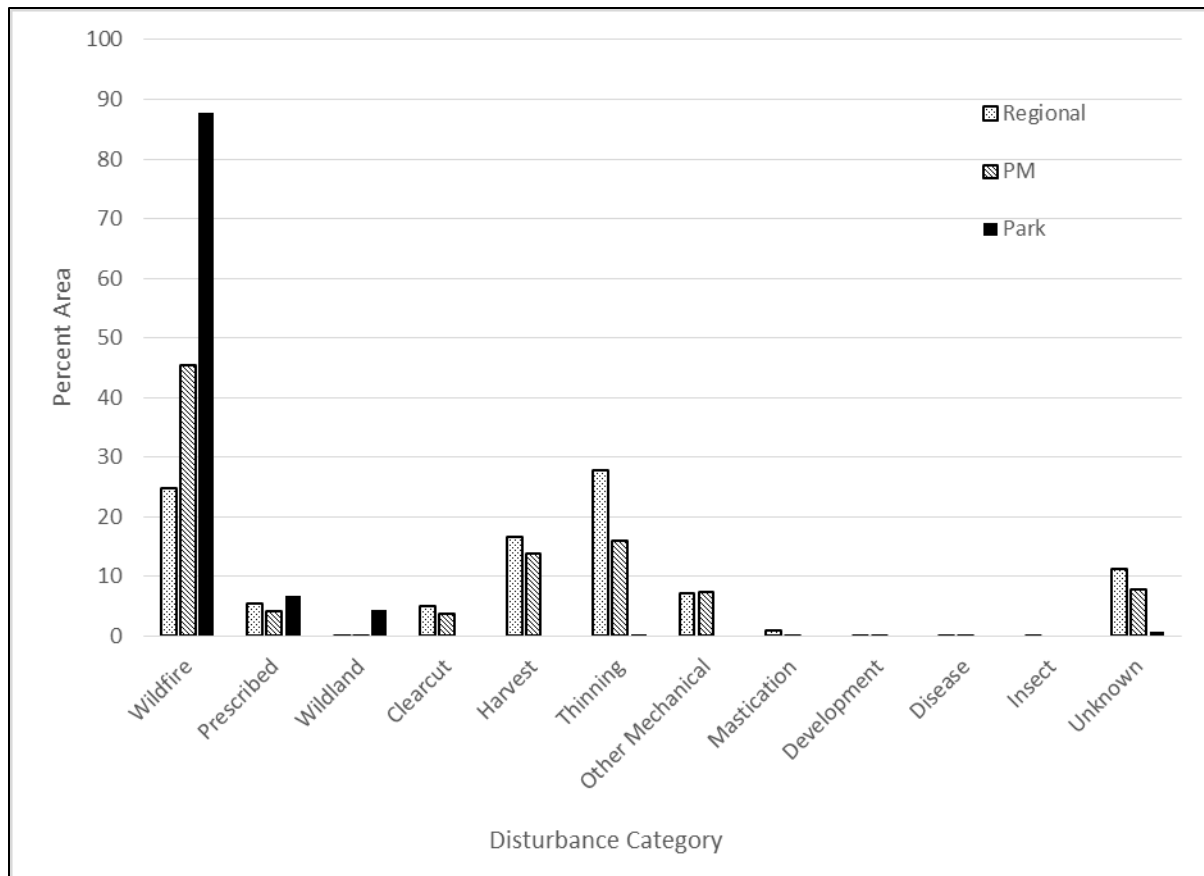


Figure 30. Percent area (area disturbed/total disturbed area for that Area of Analysis (AOA)) affected by each disturbance type (Table A7) from 1999 to 2012, at all three AOAs.

For the Park AOA, from 1999 to 2012, the total disturbed area was 142.4 km² (Figure 29, Tables B37–B38). The most area was affected by *Wildfire* (125.1 km²). This disturbance type accounts for 87.8% of all disturbed areas within the Park AOA (Figures 30 and 31).

Figures 32 through 34 plot the area affected by each of the largest disturbance types over time within the Regional, Park-Manager-Selected, and Park AOAs, respectively.

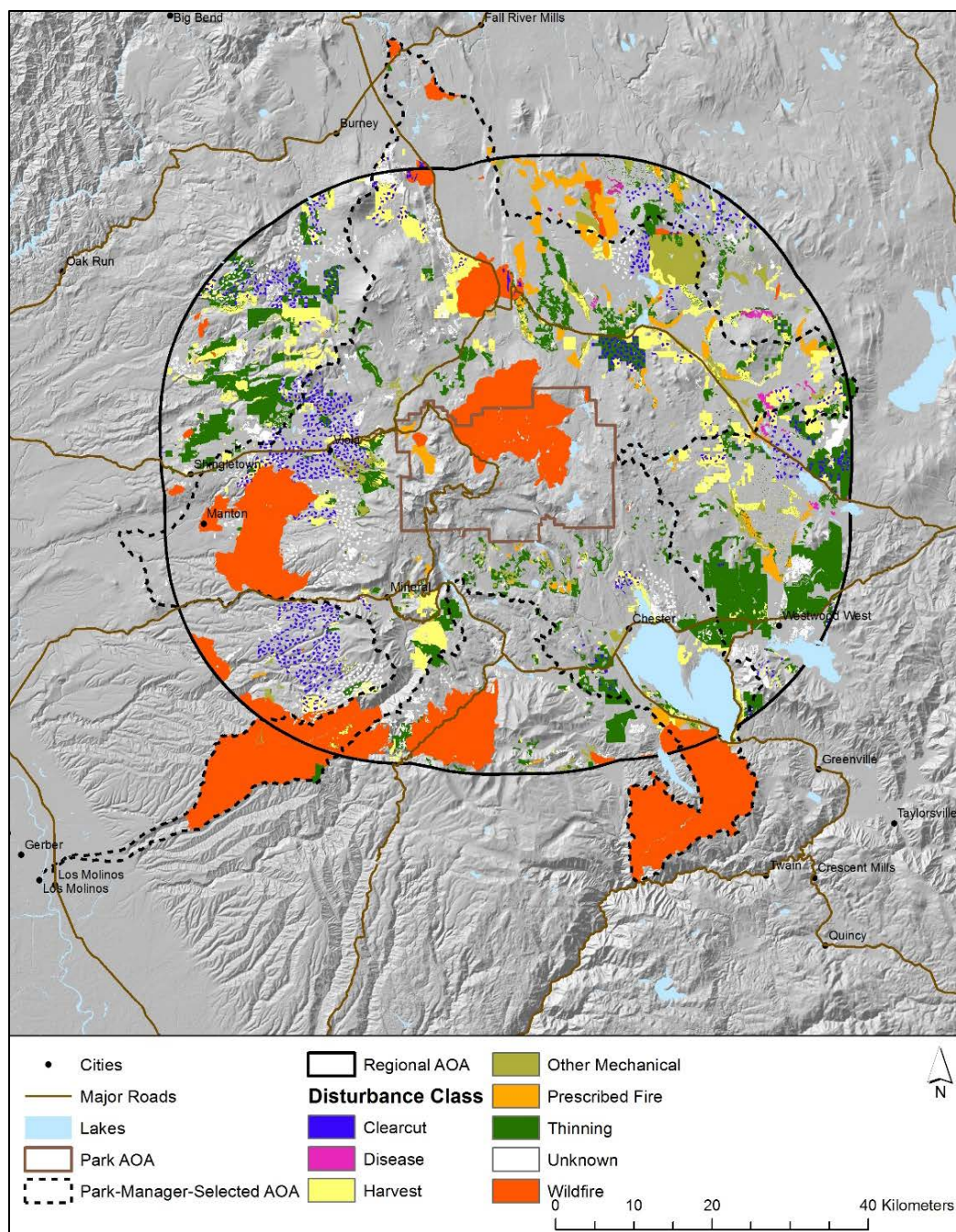


Figure 31. Areas affected by different disturbance types (Table A7) from 1999–2012, for Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA). Years with large areas disturbed by fire were 1999, 2004–2005, 2008–2009, and 2012.

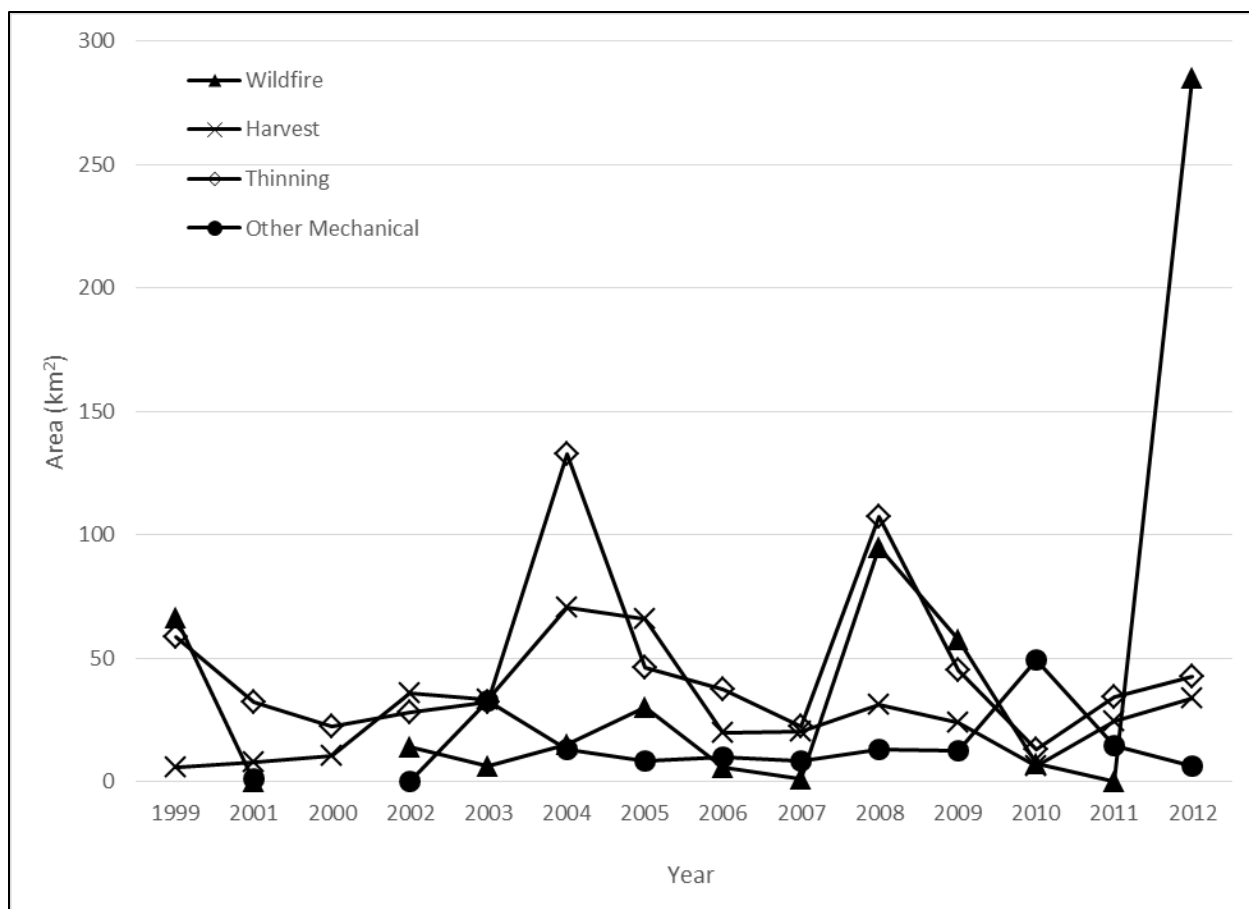


Figure 32. Total area (km²) of the four largest disturbance types (Table A7), by year, for the Regional Area of Analysis. Complete disturbance type values are in Tables B31–B33.

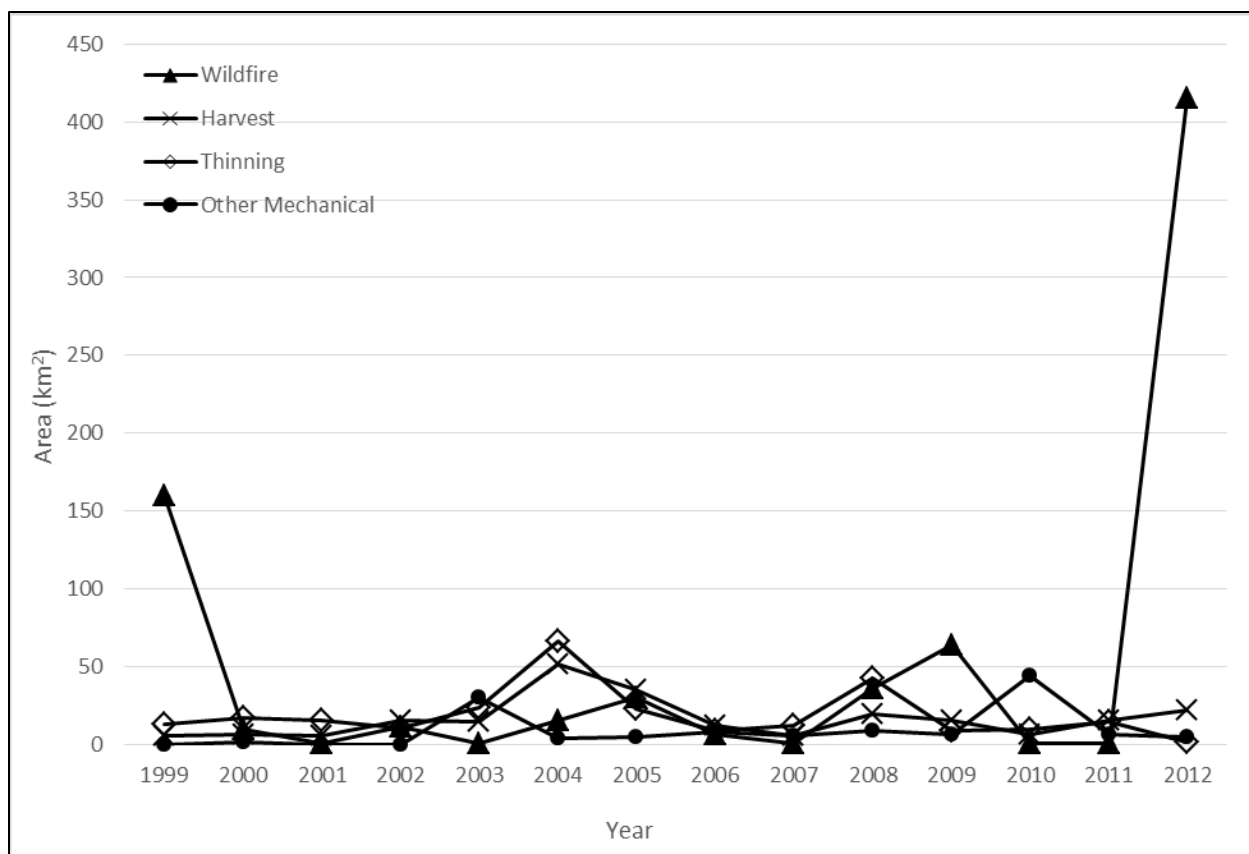


Figure 33. Total area (km²) of the four largest disturbance types (Table A7), by year, for the Park-Manager-Selected Area of Analysis. Complete disturbance type values are in Tables B34–B36.

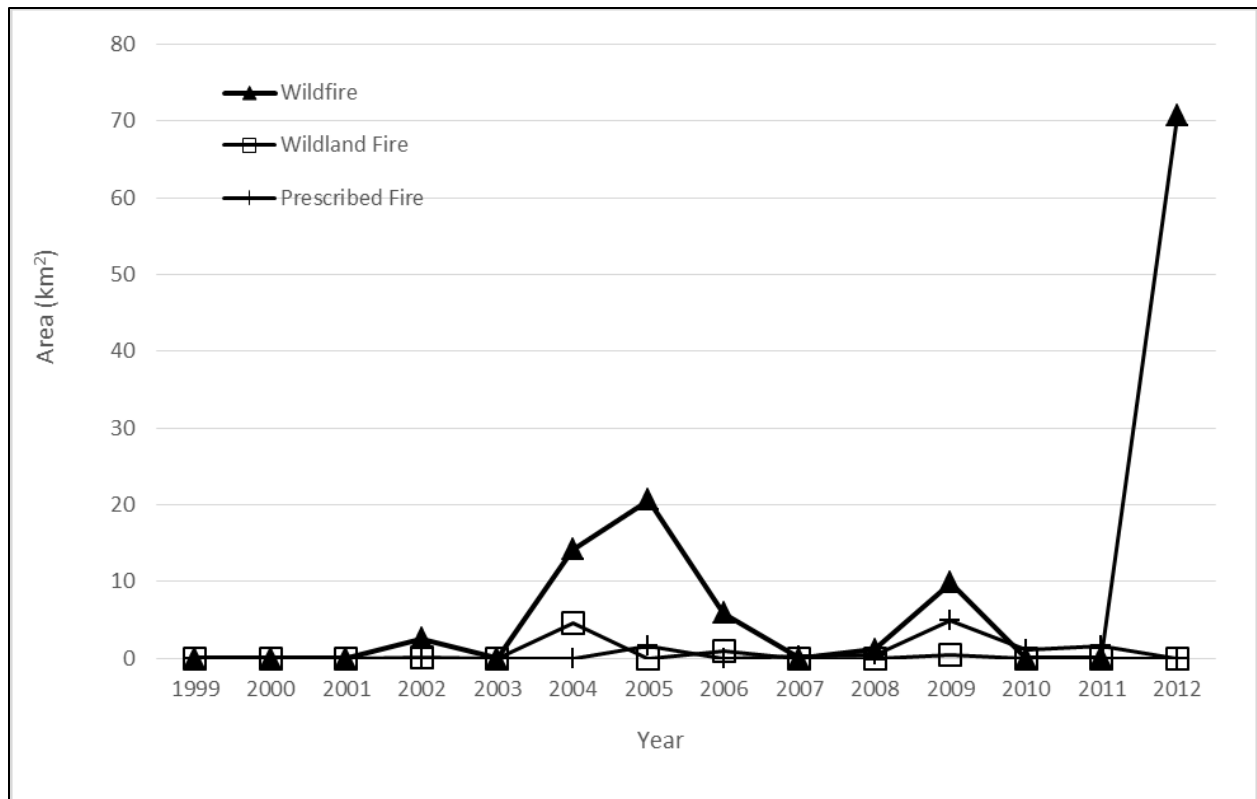


Figure 34. Total area (km²) of the three largest disturbance types (Table A7), by year, for the Park Area of Analysis. Complete disturbance type values are in Tables B37–B38.

Discussion

This report summarizes landscape level information about Lassen Volcanic NP and its surrounding areas from largely regional- and national-level datasets. The vegetation within the Park, Regional, and Park-Manager-Selected AOAs is primarily evergreen forest, and the land outside the park is mostly national forest with a GAP Conservation Status of 3. Within the forested areas, almost half of the land is classified as Core. Similarly, most of the forest land is made up of large patches. Most of the AOAs are considered to be in natural condition, with few impervious surfaces. The areas around the park are characterized by low populations, low housing density, and low road density. A variety of disturbances have occurred, including logging in the areas outside the park. The biggest disturbance, however, was fire.

Looking at individual indicators and how they change over time can provide useful information to land managers. While the individual statistics are important in themselves, there is also power in taking an integrated approach. For example, in the Regional AOA, from 2006 to 2011, there was a decrease of about 80 km² of evergreen forest and a 62 km² increase in shrub/scrub area. A land manager could look for correlation and causation by examining these changes along with data from other indicators such as disturbances, protection status and ownership, housing, and landscape patterns. In addition, integrating these data with finer scale projects, including vegetation and landbird monitoring surveys, detailed vegetation maps, and park specific projects such as prescribed burning and invasive plant management actions, will help provide an integrated look at ecosystem dynamics.

Managers can also compare what is occurring inside the park boundaries versus outside of the park. This provides park staff with information that can potentially be used to work with neighboring land managers to protect areas that may be important for the preservation of resources.

This report for LAVO summarizes data from 2006 to 2016 (varies by indicator) and was developed as a “proof of concept” for the KLMN Land Cover Land Use protocol, which strives to provide the best data and a detailed analysis to the park in a time and cost-efficient manner. The next report will summarize results from the forthcoming national I&M landscape dynamics protocol, as implemented for KLMN parks in 2021. Monitoring land cover and land use will continue to be a team effort between specialists in the park, I&M staff (Central Office, Klamath Network), and the national landscape dynamics protocol staff.

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Appendix A: Indicator Definitions and Categories

Table A1. GAP PAD-US protection status categories.

Status	Description
1	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
2	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
3	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area, as is required by law.
4	There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

Table A2. Anderson level 1 and 2 classifications.

Anderson Level 1	Anderson Level 2	Natural/Converted
1 Open Water	11 Open Water 12 Perennial Ice/Snow	Natural
2 Developed	21 Developed Open Space 22 Developed Low Intensity 23 Developed Medium Intensity 24 Developed High Intensity	Converted
3 Barren/Quarries/Transitional	31 Barren Land	Natural
4 Forest	41 Deciduous Forest 42 Evergreen Forest 43 Mixed Forest	Natural
5 Shrub/Scrub	51 Dwarf Scrub 52 Shrub/Scrub	Natural
7 Grassland/Herbaceous	71 Grassland/Herbaceous 72 Sedge/Herbaceous 73 Lichens 74 Moss	Natural
8 Agriculture	81 Pasture/Hay 82 Cultivated Agriculture	Converted
9 Wetlands	90 Woody Wetlands 95 Emergent Herbaceous Wetlands	Natural

Table A3. Area morphology pattern types for NLCD cover within the moving window.

Pattern Type	Description
Branch	A cluster of non-core pixels connected to one edge.
Edge	Pixels within a defined distance ('edge') to the background. We used an edge of 150 m (5 pixels).
Islet	Island of pixels that is not core habitat.
Core	Pixels that are within a patch, and more than 10 m from non-patch types. In other words, core areas are areas that are not near the transition zones of classification types.
Bridge	A cluster of non-core pixels connected at two or more locations to edge.
Perforated	Inner boundary of a core area that is adjacent to a hole in the core area.
Loop	A cluster of pixels that connects to two or more locations of the same edge

Table A4. Area density class definitions for forest, grassland, and shrubland cover within a moving window GIS analysis (window size can vary depending on pixel size and image detail). These classes follow Riitters (2011). As a window moves across the landscape, the density is the percentage of pixels of a cover type in the window calculated for the pixel at the center of the window.

Area Density Class	Area Density (p)
Intact	$p = 1.0$
Interior	$0.9 \leq p < 1.0$
Dominant	$0.6 \leq p < 0.9$
Transitional	$0.4 \leq p < 0.6$
Patchy	$0.1 \leq p < 0.4$
Rare	$0.0 \leq p < 0.1$
None	$p = 0.0$

Table A5. Grouped housing density classes represent one or more housing density classes. Data from the US Census Bureau Data.

Grouped Housing Density Class	Housing Density Class
Urban-Regional Park	Urban-Regional Park
Commercial / Industrial	Commercial / Industrial
Urban	>2,470 units / km ² 1,235–2,470 units / km ²
Suburban	495–1,234 units / km ² 146–495 units / km ²
Exurban	50–145 units / km ² 25–49 units / km ² 13–24 units / km ² 7–12 units / km ²
Rural	4–6 units / km ² 1.5–3 units / km ² < 1.5 units / km ² Private undeveloped

Table A6. TIGER data road codes (MTFCC) used in this report.

Code	Type	Description
S1100	Primary Road	Primary roads are generally divided, limited-access highways within the interstate highway system or under state management, and are distinguished by the presence of interchanges. These highways are accessible by ramps and may include some toll highways.
S1200	Secondary Road	Secondary roads are main arteries, usually in the U.S. Highway, State Highway or County Highway system. These roads have one or more lanes of traffic in each direction, may or may not be divided, and usually have at-grade intersections with many other roads and driveways. They often have both a local name and a route number.
S1400	Local Neighborhood Road, Rural Road, City Street	Generally a paved non-arterial street, road, or byway that usually has a single lane of traffic in each direction. Roads in this feature class may be privately or publicly maintained. Scenic park roads would be included in this feature class, as would (depending on the region of the country) some unpaved roads.
S1500	Vehicular Trail (4WD)	An unpaved dirt trail where a four-wheel drive vehicle is required. These vehicular trails are found almost exclusively in very rural areas. Minor, unpaved roads usable by ordinary cars and trucks belong in the S1400 category.

Table A7. LANDFIRE disturbance categories.

Category	Description
Development	Conversion of natural lands into housing, commercial, or industrial building sites. Involves permanent land clearing.
Clearcut	The cutting of essentially all trees, producing a fully exposed microclimate for the development of a new age class.
Harvest	A general term for the cutting, felling, and gathering of forest timber. The term harvest was assigned to events where there was not enough information available to call them one of the 2 distinct types, clearcut or thinning.
Thinning	A tree removal practice that reduces tree density and competition between trees in a stand. Thinning concentrates growth on fewer, high-quality trees, provides periodic income, and generally enhances tree vigor.
Mastication	Means by which vegetation is mechanically "mowed" or "chipped" into small pieces and changed from a vertical to horizontal arrangement.
Other Mechanical	Catch all term for a variety of forest and rangeland mechanical activities related to fuels reduction and site preparation including; piling of fuels, chaining, lop and scatter, thinning of fuels, Dixie harrow, etc.
Wildfire	An unplanned, unwanted wildland fire including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to suppress or put out the fire.
Wildland Fire Use	The application of the appropriate management response to naturally-ignited wildland fires to accomplish specific resource management objectives in pre-defined designated areas outlined in Fire Management Plans.
Prescribed Fire	Any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and NEPA requirements (where applicable) must be met, prior to ignition.
Wildland Fire	A catch all term used to describe any non-structure fire that occurs in the wildland. Three distinct types of wildland fire have been defined: wildfire, wildland fire use, and prescribed fire. The term wildland fire was assigned to events where there was not enough information available to call them one of the 3 distinct types.
Insects	Infestations of unwanted insects that can affect vegetative health such as bark beetle.
Disease	Infestations of disease that can affect vegetative health such as root rot.

Appendix B: Data Tables

Table B1. Area and percent of AOA attributed to different land owners for the Regional and Park-Manager-Selected AOAs, using GAP PAD-US 2012 data. *Note that the percent could be larger depending on the composition of the unavailable data.

Owner Name	Regional		Park-Manager-Selected	
	Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
Forest Service (USFS)	2835.43	48.12	2020.13	52.25
National Park Service (NPS)	434.51	7.37	434.51	11.24
Other State	42.00	0.71	2.33	0.06
Bureau of Land Management (BLM)	21.86	0.37	28.82	0.75
State Fish and Wildlife (SFW)	18.91	0.32	10.34	0.27
Private Landowner (PL)	7.62	0.13	15.76	0.41
Nature Conservancy (TNC)	6.78	0.12	10.14	0.26
Unavailable Data	2524.73	42.86	1344.17	34.76

Table B2. Area (km²) and minimum percentage of AOA attributed to 2012 PAD-US GAP conservation status rankings for the Regional and Park-Manager-Selected AOAs. *Note that the percent could be larger depending on the composition of the unavailable data.

Status	Description	Regional		Park-Manager-Selected	
		Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
1	Managed for biodiversity, natural disturbance allowed	589.08	10.00	622.84	16.11
2	Managed for biodiversity, natural disturbance NOT allowed	44.66	0.76	22.94	0.59
3	Managed for multiple use	2719.64	46.16	1858.79	48.08
4	No known mandate	13.73	0.23	17.45	0.45
N/A	Unavailable	2524.73	42.85	1344.18	34.77

Table B3. Area and percent of AOA by NLCD Anderson Level 2 land cover types in the Regional AOA for 2006 and 2011.

Anderson Level 2	2006		2011	
	Area (km ²)	Percent of AOA	Area (km ²)	Percent of AOA
Open Water	141.73	2.41	141.35	2.40
Perennial Snow/Ice	0	0	0.02	<0.01
Developed, Open Space	62.71	1.06	62.64	1.06
Developed, Low Intensity	6.29	0.11	6.24	0.11
Developed, Medium Intensity	2.33	0.04	2.45	0.04
Developed, High Intensity	1.69	0.03	1.70	0.03
Barren Land	66.35	1.13	66.58	1.13
Deciduous Forest	20.17	0.34	19.93	0.34
Evergreen Forest	4316.83	73.27	4,236.38	71.90
Mixed Forest	2.39	0.04	2.34	0.04
Shrub/Scrub	1044.80	17.73	1,106.47	18.78
Herbaceous	166.16	2.82	184.12	3.13
Hay/Pasture	2.24	0.04	2.27	0.04
Cultivated Crops	5.57	0.09	5.49	0.09
Woody Wetlands	0.01	<0.01	0.02	<0.01
Herbaceous Wetlands	52.65	0.89	53.90	0.91

Table B4. Area and percent of AOA by NLCD Anderson Level 2 land cover types in the Park-Manager-Selected AOA for 2006 and 2011.

Anderson Level 2	2006		2011	
	Area (km ²)	Percent of AOA	Area (km ²)	Percent of AOA
Open Water	121.83	3.15	121.64	3.15
Perennial Snow/Ice	0	0	0.02	<0.01
Developed, Open Space	42.86	1.11	42.80	1.11
Developed, Low Intensity	4.9	0.13	4.83	0.13
Developed, Medium Intensity	2.09	0.05	2.20	0.06
Developed, High Intensity	1.68	0.04	1.69	0.04
Barren Land	69.95	1.81	70.20	1.82
Deciduous Forest	10.53	0.27	10.41	0.27
Evergreen Forest	2629.66	68.02	2585.65	66.88
Mixed Forest	1.33	0.03	1.31	0.03
Shrub/Scrub	735.54	19.02	767.78	19.86
Herbaceous	204.26	5.28	215.85	5.58
Hay/Pasture	6.15	0.16	6.05	0.16
Cultivated Crops	9.7	0.25	9.42	0.24
Woody Wetlands	0.30	0.01	0.32	0.01
Herbaceous Wetlands	25.41	0.66	26.02	0.67

Table B5. Area and percent of AOA by NLCD Anderson Level 2 land cover types in the Park AOA for 2006 and 2011.

Anderson Level 2	2006		2011	
	Area (km ²)	Percent of AOA	Area (km ²)	Percent of AOA
Open Water	7.80	1.80	7.79	1.79
Perennial Snow/Ice	0	0	0	0
Developed, Open Space	3.34	0.77	3.34	0.77
Developed, Low Intensity	0.38	0.09	0.37	0.09
Developed, Medium Intensity	0.40	0.09	0.41	0.10
Developed, High Intensity	0.80	0.18	0.80	0.18
Barren Land	22.23	5.12	22.22	5.12
Deciduous Forest	0	0	0	0
Evergreen Forest	311.35	71.70	310.13	71.42
Mixed Forest	0	0	0	0
Shrub/Scrub	86.21	19.86	87.37	20.12
Herbaceous	0.92	0.21	0.90	0.21
Hay/Pasture	0	0	0	0
Cultivated Crops	0	0	0	0
Woody Wetlands	0	0	0	0
Herbaceous Wetlands	0.78	0.18	0.88	0.20

Table B6. Area and percent of AOA by Impervious Surface group in the Regional AOA, for 2006 and 2011.

Impervious Surface	2006		2011	
	Area (km ²)	Percent of AOA	Area (km ²)	Percent of AOA
0% - 2%	5674.19	96.31	5674.18	96.30
2% - 4%	93.51	1.59	93.48	1.59
4% - 6%	41.55	0.71	41.53	0.70
6% - 8%	23.34	0.40	23.32	0.40
8% - 10%	15.01	0.25	14.99	0.25
10% - 15%	20.38	0.35	20.33	0.35
15% - 25%	13.27	0.23	13.21	0.22
25% - 50%	6.41	0.11	6.40	0.11
50% - 100%	4.24	0.07	4.45	0.08

Table B7. Area and percent of AOA by Impervious Surface group in the Park-Manager-Selected AOA, for 2006 and 2011.

	2006		2011	
Impervious Surface	Area (km ²)	Percent of AOA	Area (km ²)	Percent of AOA
0% - 2%	3729.65	96.47	3729.64	96.47
2% - 4%	52.84	1.37	52.81	1.37
4% - 6%	25.27	0.65	25.26	0.65
6% - 8%	15.29	0.40	15.27	0.39
8% - 10%	10.17	0.26	10.15	0.26
10% - 15%	14.24	0.37	14.20	0.37
15% - 25%	9.83	0.25	9.78	0.25
25% - 50%	4.97	0.13	4.96	0.13
50% - 100%	3.93	0.10	4.1229	0.10664

Table B8. Area and percent of AOA by Impervious Surface group in the Park AOA, for 2006 and 2011.

	2006		2011	
Impervious Surface	Area (km ²)	Percent of AOA	Area (km ²)	Percent of AOA
0% - 2%	429.51	98.92	429.51	98.92
2% - 4%	1.01	0.23	1.01	0.23
4% - 6%	0.47	0.11	0.47	0.11
6% - 8%	0.33	0.08	0.33	0.08
8% - 10%	0.30	0.07	0.30	0.07
10% - 15%	0.57	0.13	0.57	0.13
15% - 25%	0.51	0.12	0.51	0.12
25% - 50%	0.35	0.08	0.35	0.08
50% - 100%	1.16	0.27	1.17	0.27

Table B9. Area and percent of AOA for *Natural* and *Converted* land in the Regional AOA, for 2006 and 2011.

	2006		2011		
Land Type	Area (km ²)	Percent Area	Area (km ²)	Percent Area	% Change in Area
Natural	5811.07	98.63	5811.11	98.63	<0.01
Converted	80.83	1.37	80.78	1.37	-<0.01

Table B10. Area and percent of AOA for *Natural* and *Converted* land in the Park-Manager-Selected AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percent Area	Area (km ²)	Percent Area	
Natural	3798.81	98.26	3799.18	98.27	0.01
Converted	67.38	1.74	67.00	1.73	-0.56

Table B11. Area and percent of AOA for *Natural* and *Converted* land in the Park AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percent Area	Area (km ²)	Percent Area	
Natural	429.29	98.86	429.29	98.86	0
Converted	4.93	1.14	4.93	1.14	0

Table B12. Area, percent of AOA, and percent of forest area by forest morphology classification in the Park-Manager-Selected and Regional AOAs for 2011.

Classification	2011 Park-Manager-Selected			2011 Regional		
	Area (km ²)	Percent of AOA	Percent of Forested Area	Area (km ²)	Percent of AOA	Percent of forested area
Background (non-forested)	1268.57	32.81	NA	1633.21	27.72	NA
Branch	51.57	1.33	1.99	81.92	1.39	1.92
Edge	674.66	17.45	25.97	1133.12	19.23	26.61
Islet	61.79	1.60	2.38	71.27	1.21	1.67
Core	1122.20	29.03	43.20	1927.96	32.72	45.27
Bridge	462.79	11.97	17.82	678.69	11.52	15.94
Perforated	181.213	4.69	6.98	292.46	4.96	6.87
Loop	43.44	1.12	1.67	73.21	1.24	1.72

Table B13. Area, percent of AOA, and percent of grassland area by pattern morphology classification in the Park-Manager-Selected and Regional AOA, for 2011.

Classification	2011 Park-Manager-Selected			2011 Regional		
	Area (km ²)	Percent of AOA	Percent of Grassland	Area (km ²)	Percent	Percent of Grassland
Background (non-grassland)	3644.28	94.26	NA	5705.50	96.84	NA
Branch	8.34	0.22	3.76	8.21	0.14	4.40
Edge	57.45	1.49	25.89	32.99	0.56	17.70
Islet	55.43	1.43	24.98	80.21	1.36	43.03
Core	34.14	0.88	15.39	10.87	0.18	5.83
Bridge	59.28	1.53	26.71	48.93	0.83	26.25
Perforated	2.19	0.06	0.99	0.43	0.01	0.23
Loop	5.07	0.13	2.28	4.76	0.08	2.55

Table B14. Area, percent of AOA, and percent of shrubland area by pattern morphology classification in the Park-Manager-Selected and Regional AOA, for 2011.

Classification	2011 Park-Manager-Selected			2011 Regional		
	Area (km ²)	Percent of AOA	Percent of Shrubland	Area (km ²)	Percent of AOA	Percent of Shrubland
Background (non Shrubland)	3098.40	80.14	NA	4785.36	81.22	NA
Branch	34.37	0.89	4.48	47.79	0.81	4.32
Edge	101.67	2.63	13.24	141.77	2.41	12.81
Islet	343.44	8.88	44.73	532.87	9.04	48.16
Core	60.37	1.56	7.86	74.70	1.27	6.75
Bridge	187.87	4.86	24.47	256.57	4.35	23.19
Perforated	0.77	0.02	0.1	1.21	0.02	0.11
Loop	39.35	1.02	5.12	51.57	0.88	4.66

Table B15. Count and total area by patch size range, for forest in the Park-Manager-Selected and Regional AOAs, for 2011.

Patch Size Range, in km ²	2011 Park-Manager-Selected		2011 Regional	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	2650	68.35	3255	77.24
1 to <5	14	30.03	15	32.80
5 to <10	4	33.15	6	42.40
10 to <25	7	93.70	8	125.45
25 to <50	2	67.01	-	-
50 to <100	6	380.28	5	339.09
100 to <250	4	609.96	4	604.87
250 to <500	1	313.19	5	1772.18
500 to <1000	-	-	-	-
>1,000	1	1002.00	1	1264.60
Total	2689	2597.68	3299	4258.63

Table B16. Count and total area by patch size range, for grassland in the Park-Manager-Selected and Regional AOAs, for 2011.

Patch Size Range, in km ²	2011 Park-Manager-Selected		2011 Regional	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	2114	60.79	3070	85.24
1 to <5	9	19.60	18	38.49
5 to <10	1	9.95	1	6.04
10 to <25	1	23.48	2	27.40
25 to <50	1	32.80	1	29.21
50 to <100	1	75.27	-	-
100 to <250	-	-	-	-
250 to <500	-	-	-	-
500 to <1000	-	-	-	-
>1,000	-	-	-	-
Total	2127	221.90	3092	186.39

Table B17. Count and total area by patch size range, for shrubland in the Park-Manager-Selected AOA and Regional AOA, for 2011.

Patch Size Range, in km ²	2011 Park-Manager-Selected		2011 Regional	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	11022	340.68	16021	531.68
1 to <5	61	121.68	91	183.11
5 to <10	5	37.93	10	75.53
10 to <25	7	105.99	8	134.57
25 to <50	2	64.32	2	64.39
50 to <100	1	97.24	-	-
100 to <250	-	-	1	117.19
250 to <500	-	-	-	-
500 to <1000	-	-	-	-
>1,000	-	-	-	-
Total	11098	767.85	16133	1106.481

Table B18. Area, percent of AOA, and percent of forest area by pattern density classification in the Regional AOA, for 2011.

Classification	2011 Park-Manager-Selected			2011 Regional		
	Area (km ²)	Percent of Forested area	Percent of AOA	Area (km ²)	Percent of Forested area	Percent of AOA
Rare	110.63	3.34	2.86	153.01	2.88	2.60
Patchy	363.71	10.99	9.41	528.97	9.96	8.98
Transitional	303.15	9.16	7.84	456.70	8.60	7.75
Dominant	661.05	19.98	17.1	1029.00	19.37	17.46
Interior	400.90	12.12	10.37	642.04	12.09	10.9
Intact	1469.40	44.41	38.01	2501.51	47.10	42.46
Total	3308.84	100	85.59	5311.23	100	90.15

Table B19. Area, percent of AOA, and percent of grassland area by pattern density classification in the Regional AOA for 2011.

Classification	2011 Park-Manager-Selected			2011 Regional		
	Area (km ²)	Percent of Grassland Area	Percent of AOA	Area (km ²)	Percent of Grassland Area	Percent of AOA
Rare	82.96	17.34	2.15	126.11	23.70	2.14
Patchy	158.02	33.04	4.09	216.23	40.64	3.67
Transitional	62.28	13.02	1.61	69.80	13.12	1.18
Dominant	81.47	17.03	2.11	71.58	13.45	1.21
Interior	35.05	7.33	0.91	23.44	4.41	0.4
Intact	58.52	12.23	1.51	24.92	4.68	0.42
Total	478.30	100	12.38	532.08	100	9.02

Table B20. Area, percent of AOA, and percent of shrubland area by pattern density classification in the Regional and Park-Manager-Selected AOAs for 2011.

	2011 Park-Manager-Selected			2011 Regional		
	Area (km ²)	Percent of Shrubland Area	Percent of AOA	Area (km ²)	Percent of Shrubland Area	Percent of AOA
Rare	383.50	18.68	9.92	584.41	19.35	9.92
Patchy	862.17	41.99	22.3	1277.63	42.31	21.68
Transitional	331.63	16.15	8.58	478.03	15.83	8.11
Dominant	292.15	14.23	7.56	427.73	14.16	7.26
Interior	78.84	3.84	2.04	114.55	3.79	1.94
Intact	105.02	5.11	2.72	137.54	4.55	2.33
Total	2053.31	100	53.12	3019.89	100	51.24

Table B21. Area, percent of total area, and percent of census area by housing density category in the Regional AOA, for 1970–2010.

Regional Housing Density Categories	1970	1980	1990	2000	2010
Rural (<6 units/ km ²)	2278.87	2226.54	2158.51	2120.75	2103.72
Percent of Total Area	38.68	37.79	36.64	35.99	35.71
Percent of Census Area	96.58	94.36	91.48	89.82	89.13
Exurban (7–146 units/ km ²)	76.87	125.26	189.28	226.64	242.98
Percent of Total Area	1.30	2.13	3.21	3.85	4.12
Percent of Census Area	3.26	5.31	8.02	9.60	10.29
Suburban (146–1235 units/ km ²)	2.84	6.69	10.63	12.46	12.45
Percent of Total Area	0.05	0.11	0.18	0.21	0.21
Percent of Census Area	0.12	0.28	0.45	0.53	0.53
Urban (>1235 units/ km ²)	0.15	0.24	0.31	0.48	0.41
Percent of Total Area	<0.01	<0.01	0.01	0.01	0.01
Percent of Census Area	0.07	0.01	0.01	0.02	0.02
Commercial/Industrial	0.23	0.23	0.23	0.23	0.23
Percent of Total Area	<0.01	<0.01	<0.01	<0.01	<0.01
Percent of Census Area	0.01	0.01	0.01	0.01	0.001
Urban-Regional Park	0.54	0.54	0.54	0.54	0.54
Percent of Total Area	0.01	0.01	0.01	0.01	0.01
Percent of Census Area	0.02	0.02	0.02	0.02	0.02
Total Area	5891.84	5891.84	5891.84	5891.84	5891.84
Total Census Area	2359.50	2359.50	2359.50	2361.10	2360.33

Table B22. Area, percent of total area, and percent of census area by housing density category in the Park-Manager-Selected AOA for 1970–2010.

Park-Manager-Selected Housing Density Categories	1970	1980	1990	2000	2010
Rural (<6 units/ km ²)	1146.16	1103.01	1073.2	1058.36	1045.84
Percent of Total Area	29.65	28.53	27.76	27.37	27.05
Percent of Census Area	94.53	90.97	88.51	86.96	86.05
Exurban (7-146 units/ km ²)	64.48	104.53	131	148.65	159.45
Percent of Total Area	1.67	2.70	3.39	3.84	4.12
Percent of Census Area	5.32	8.62	10.80	12.21	13.12
Suburban (146- 1235 units/ km ²)	1.67	4.68	7.98	9.67	9.71
Percent of Total Area	0.04	0.12	0.21	0.25	0.25
Percent of Census Area	0.14	0.39	0.66	0.79	0.80
Urban (>1235 units/ km ²)	-	0.09	0.13	0.24	0.2
Percent of Total Area	-	<0.01	<0.01	0.01	0.01
Percent of Census Area	-	0.01	0.011	0.02	0.02
Commercial/Industrial	0.18	0.18	0.18	0.18	0.18
Percent of Total Area	<0.01	<0.01	<0.01	<0.01	<0.01
Percent of Census Area	0.01	0.01	0.01	0.01	0.01
Urban-Regional Park	-	-	-	-	-
Percent of Total Area	-	-	-	-	-
Percent of Census Area	-	-	-	-	-
Total Area	3866.20	3866.20	3866.20	3866.20	3866.20
Total Census Area	1212.49	1212.49	1212.49	1217.10	1215.38

Table B23. Census blocks, area, total population, and population density in the Regional AOA for 1990, 2000, and 2010.

Measures	1990	2000	2010	1990–2000 Percent Change	2000–2010 Percent Change
Number of Census Blocks	26	20	23	-	-
Corrected Area (km ²)	5141.05	5092.25	5111.29	-	-
Population	11532.21	12991.37	12565.31	12.65	-3.28
Population Density (population/km ²)	2.24	2.55	2.46	13.84	-3.53

Table B24. Census blocks, area, total population, and population density in the Park-Manager-Selected AOA for 1990, 2000, and 2010.

Measures	1990	2000	2010	1990–2000 Percent Change	2000–2010 Percent Change
Number of Census Blocks	25	18	21	-	-
Corrected Area (km ²)	3141.38	3115.29	3128.34	-	-
Population	6999.94	8028.02	7464.68	14.69	-7.02
Population Density (population/km ²)	2.23	2.58	2.39	15.70	-7.36

Table B25. Road length and density in the Regional AOA for 2010 and 2015. Summaries were calculated from TIGER data.

Measures	2010	2015
Length (km)	9141.78	9145.56
Density (km/km ²)	1.55	1.55

Table B26. Road length and density in the Park-Manager-Selected AOA for 2010 and 2015. Summaries were calculated from TIGER data.

Measures	2010	2015
Length (km)	5579.31	5579.46
Density (km/km ²)	1.44	1.44

Table B27. Road length and density in the Park AOA for 2016. Summaries were calculated from park data.

Measures	2016
Length (km)	90.92
Density (km/km ²)	0.21

Table B28. Count and total area by roadless area size category in the Regional AOA, using 2010 and 2015 TIGER data.

Area Categories	2010		2015	
	Count	Total km ²	Count	Total km ²
0-10 km ²	1719	1663.96	1720	1665.10
10-50 km ²	60	1080.78	60	1080.56
50-100 km ²	2	151.98	2	151.98
> 100 km ²	4	959.02	4	956.11

Table B29. Count and total area by roadless area size category in the Park-Manager-Selected AOA, using 2010 and 2015 TIGER data.

Area Categories	2010		2015	
	Count	Total km ²	Count	Total km ²
0-10 km ²	1106	935.48	1107	936.53
10-50 km ²	31	565.63	31	565.61
50-100 km ²	4	304.58	4	304.58
> 100 km ²	3	806.02	3	803.10

Table B30. Count and total area by roadless area size category in the Park AOA, using 2016 park road data.

Area Categories	2016	
	Count	Total km ²
0-10 km ²	4	5.95
10-50 km ²	0	-
50-100 km ²	1	94.69
> 100 km ²	1	304.30

Table B31. Area and percent of AOA for fire related disturbances in the Regional AOA, for 1999–2012.

Year	Wildfire		Prescribed		Wildland	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	66.41	1.13	-	-	-	-
2001	0.12	<0.01	-	-	-	-
2000	-	-	-	-	-	-
2002	13.93	0.24	0.85	0.01	0.14	<0.01
2003	6.45	0.11	10.70	0.18		
2004	15.31	0.26	11.13	0.19	4.57	0.08
2005	30.25	0.51	12.97	0.22	<0.01	<0.01
2006	6.12	0.10	33.75	0.57	1.12	0.02
2007	1.17	0.02	9.65	0.16	-	-
2008	95.01	1.61	8.93	0.15	-	-
2009	57.65	0.98	17.61	0.30	0.48	0.01
2010	7.48	0.13	15.03	0.26	-	-
2011	0.08	<0.01	6.17	0.10	-	-
2012	285.00	4.84	1.31	0.02	-	-

Table B32. Area and percent of AOA for logging related disturbances in the Regional AOA for 1999–2012.

Year	Clearcut Area (km ²)	% of AOA	Harvest Area (km ²)	% of AOA	Thinning Area (km ²)	% of AOA	Other Mechanical Area (km ²)	% of AOA	Mastication Area (km ²)	% of AOA
1999	2.32	0.04	5.79	0.1	58.88	1	-	-	-	-
2000	0.12	<0.01	8.18	0.14	32.25	0.55	1.07	0.02		
2001	0.17	<0.01	10.39	0.18	22.48	0.38	-	-	-	-
2002	3.21	0.05	36.03	0.61	27.99	0.48	0.02	<0.01	-	-
2003	2.52	0.04	33.49	0.57	32.16	0.55	32.94	0.56	-	-
2004	10.42	0.18	70.6	1.2	132.64	2.25	13.02	0.22	2.81	0.05
2005	23.67	0.4	66.25	1.12	46.15	0.78	8.44	0.14	1.64	0.03
2006	8.36	0.14	19.86	0.34	37.38	0.63	10.14	0.17	0.42	0.01
2007	0.35	0.01	20.23	0.34	22.44	0.38	8.6	0.15	9.26	0.16
2008	19.66	0.33	31.2	0.53	107.68	1.83	13.39	0.23	7.04	0.12
2009	13.68	0.23	24.08	0.41	45.44	0.77	12.56	0.21	-	-
2010	0.43	0.01	6.61	0.11	13.31	0.23	49.39	0.84	-	-
2011	13.35	0.23	24.79	0.42	34.6	0.59	14.83	0.25	-	-
2012	20.46	0.35	33.8	0.57	42.43	0.72	6.33	0.11	-	-

Table B33. Area and percent of AOA for disturbances other than fire and logging in the Regional AOA for 1999–2012.

Year	Development Area (km ²)	% of AOA	Disease Area (km ²)	% of AOA	Insect Area (km ²)	% of AOA	Unknown Area (km ²)	% of AOA
1999	-	-	-	-	-	-	7.00	0.12
2000	-	-	-	-	-	-	10.52	0.18
2001	-	-	-	-	-	-	8.44	0.14
2002	-	-	1.84	0.03	-	-	14.54	0.25
2003	-	-	-	-	-	-	32.55	0.55
2004	0.43	0.01	-	-	-	-	10.38	0.18
2005	-	-	-	-	-	-	9.32	0.16
2006	-	-	-	-	-	-	14.13	0.24
2007	0.01	<0.01	0.22	<0.01	-	-	22.21	0.38
2008	0.15	<0.01	1.53	0.03	-	-	31.78	0.54
2009	0.01	<0.01	0.20	<0.01	-	-	13.43	0.23
2010	0.16	<0.01	0.85	0.01	0.30	0.01	30.23	0.51
2011	0.05	<0.01	0.04	<0.01	-	-	25.26	0.43
2012	-	-	7.13	0.12	-	-	34.26	0.58

Table B34. Area and percent of AOA for fire related disturbances in the Park-Manager-Selected AOA for 1999–2012.

Year	Wildfire Area (km ²)	% of AOA	Prescribed Area (km ²)	% of AOA	Wildland Area (km ²)	% of AOA
1999	160.28	4.15	0	0	0	0
2000	9.88	0.26	0	0	0	0
2001	0.12	<0.01	0	0	0	0
2002	11.23	0.29	0.85	0.02	0.14	<0.01
2003	0.32	0.01	8.12	0.21	0	0
2004	15.41	0.4	9.05	0.23	4.57	0.12
2005	30.25	0.78	9.49	0.25	0.01	<0.01
2006	6.12	0.16	16.37	0.42	0.99	0.03
2007	0.06	<0.01	3.53	0.09	0	0
2008	35.98	0.93	5.29	0.14	0	0
2009	63.72	1.65	8.01	0.21	0.48	0.01
2010	0.07	<0.01	1.58	0.04	0	0
2011	0.08	<0.01	5.22	0.14	0	0
2012	415.39	10.74	1.68	0.04	0	0

Table B35. Area and percent of AOA for logging related disturbances in the Park-Manager-Selected AOA for 1999–2012.

Year	Clearcut Area (km ²)	% of AOA	Harvest Area (km ²)	% of AOA	Thinning Area (km ²)	% of AOA	Mastication Area (km ²)	% of AOA	Other Mechanical Area (km ²)	% of AOA
1999	0.09	<0.01	5.44	0.14	13.16	0.34	0	0	0	0
2000	0	0	6.12	0.16	17.18	0.44	0	0	1.52	0.04
2001	0.09	<0.01	4.99	0.13	15.38	0.4	0	0	0	0
2002	0.5	0.01	15.39	0.4	10.22	0.26	0	0	0.02	0
2003	1.37	0.04	14.64	0.38	23.46	0.61	0	0	30.31	0.78
2004	5.66	0.15	51.36	1.33	66.39	1.72	0.83	0.02	3.53	0.09
2005	14.51	0.38	35.31	0.91	22.33	0.58	0	0	4.62	0.12
2006	3.33	0.09	12.2	0.32	8.54	0.22	0.01	<0.01	7.58	0.2
2007	0.11	<0.01	5.47	0.14	11.97	0.31	3.89	0.10	5.57	0.14
2008	12.86	0.33	19.2	0.5	42.41	1.1	3.3	0.09	8.83	0.23
2009	4.91	0.13	15.59	0.4	8.82	0.23	0	0	6.42	0.17
2010	0.43	0.01	6.25	0.16	9.19	0.24	0	0	44.15	1.14
2011	6.72	0.17	15.64	0.4	14.35	0.37	0	0	6.13	0.16
2012	11.59	0.3	22.22	0.57	1.09	0.03	0	0	4.33	0.11

Table B36. Area and percent of AOA for disturbances other than fire and logging in the Park-Manager-Selected AOA for 1999–2012.

Year	Development Area (km ²)	% of AOA	Disease Area (km ²)	% of AOA	Unknown Area (km ²)	% of AOA
1999	0	0	0	0	3.47	0.09
2000	0	0	0	0	5.23	0.14
2001	0	0	0	0	3.91	0.1
2002	0	0	0	0	6.87	0.18
2003	0	0	0	0	18.47	0.48
2004	0.43	0.01	0	0	3.8	0.1
2005	0	0	0	0	5.66	0.15
2006	0	0	0	0	8.08	0.21
2007	0.01	<0.01	0.13	<0.01	7.96	0.21
2008	0.15	<0.01	0.64	0.02	17.21	0.45
2009	0.01	<0.01	0	0	5.76	0.15
2010	0.16	<0.01	0	0	15.82	0.41
2011	0.05	<0.01	0	0	14.2	0.37
2012	0	0	3.33	0.09	13.08	0.34

Table B37. Area and percent of AOA for fire related disturbances in the Park AOA for 1999–2012.

Year	Wildfire Area (km ²)	% of AOA	Prescribed Fire Area (km ²)	% of AOA	Wildland Fire Area (km ²)	% of AOA
1999	0	0	0	0	0	0
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	2.57	0.59	0	0	0.14	0.03
2003	0	0	0	0	0	0
2004	14.14	3.26	0	0	4.56	1.05
2005	20.64	4.75	1.65	0.38	0.01	<0.01
2006	5.87	1.35	0	0	0.99	0.23
2007	0	0	0.2	0.05	0	0
2008	1.12	0.26	0.39	0.09	0	0
2009	9.85	2.27	4.95	1.14	0.48	0.11
2010	0	0	1.03	0.24	0	0
2011	0.08	0.02	1.55	0.36	0	0
2012	70.79	16.3	0	0	0	0

Table B38. Area and percent of AOA for disturbances other than fire in the Park AOA for 1999–2012.

Year	Unknown Area (km ²)	% of AOA	Thinning Area (km ²)	% of AOA
1999	0.22	0.05	0	0
2000	0.2	0.05	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0.38	0.09	0	0
2004	0.34	0.08	0	0
2005	0.01	<0.01	0	0
2006	0.02	0.01	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0.2	0.05
2011	0	0	0	0
2012	0.05	0.01	0	0

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