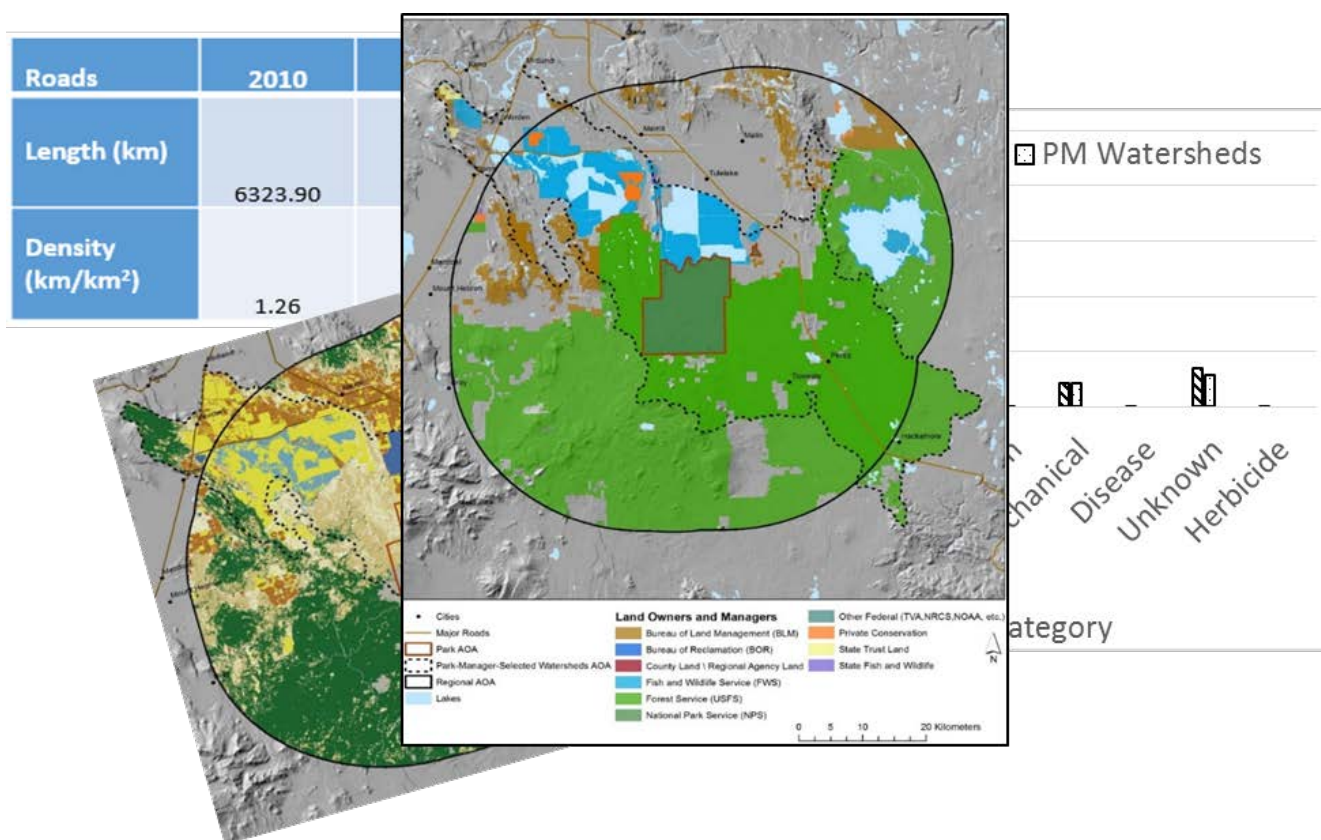




Land Cover and Land Use Monitoring

2016 Results for Lava Beds National Monument

Natural Resource Data Series NPS/KLMN/NRDS—2017/1107



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

Land Cover and Land Use Monitoring

2016 Results for Lava Beds National Monument

Natural Resource Data Series NPS/KLMN/NRDS—2017/1107

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on well-established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

This report summarizes landscape conditions in Lava Beds National Monument. Landscape spatial structure resulting from natural processes, and its variation through time, underlies the diversity and integrity of ecosystems. 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 flow 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. 2016a). 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 and land use to each of the NPS units in the Klamath Network.

The Klamath Network protocol uses methods associated with the NPS NPScene project, which provides information on the status and trends of park natural resources at ecosystem-level and regional scales. We used Geographic Information System (GIS) tools 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. The three spatial scales are the park boundary (Park), watersheds adjacent to the park boundary (Park-Manager-Selected), and a 30 km buffer around the park boundary (Regional). The number of years available for each dataset varies and is therefore not consistent across all landscape metrics. For some metrics, we present results for multiple years but do not analyze for or discuss change over time; trend analysis will be the subject of future reports.

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

Conservation Status

Public land around Lava Beds National Monument (hereafter, Lava Beds) was primarily owned by the US Forest Service with some owned by the US Fish and Wildlife Service and the Bureau of Land Management. Very little of this area was permanently protected from conversion to an unnatural state. However, more than half of the area had a moderate level of conservation protection that still allows broad, low intensity or localized, high intensity extractive uses. Data are not available for a portion of the area.

Land Cover

In the areas surrounding the Park, there was a mixture of evergreen forest, shrub/scrub, herbaceous, and some agricultural land. The Park itself was dominated by shrub/scrub, barren land, and herbaceous, and within the Park, the area inside the Jack Fire perimeter was dominated by shrub/scrub and herbaceous. Most cover was categorized as natural, with converted areas primarily being crops and pasture. The total amount of impervious surface (e.g., asphalt) was minimal in and around the Park.

Landscape Pattern

In all cover types, small patches were the most abundant. Largest forest patches occurred primarily south of the Park; these patches were large and intact, with some of the forest in thin sections and on the edge of non-forest types. There were some large patches of grassland to the northwest of the Park. However, much of the grassland was small patches or thin sections connecting patches. Largest patches of intact shrubland were in the southeast section of the Park and extending out of the Park boundary. Similar to grassland, much of the area was small patches or thin sections connecting patches.

Housing and Population

The study area contained few housing developments, with most categorized as “rural”, for their low density. The relative proportion of rural housing decreased slightly between 1970 and 2010, coinciding with a slight increase in exurban, or medium density, housing. Between 1990 and 2010, there was a large percent increase in population outside, the Park although the total population remained relatively low in 2010.

Roads

Excluding the Park, which had very low road density, there were numerous roads throughout the study area. Areas within the Park were furthest from roads and correspondingly had the largest sections of land without roads. Outside of the Park, areas furthest from roads were distributed across the study area and not in any particular location. There was little change in the amount of roads between 2010 and 2015.

Disturbance

Wildfire was the dominant disturbance between 1999 and 2012 in and around the Park, although thinning also occurred.

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

List of Abbreviations

Abbreviation	Description
AOA	Area of Analysis
BLM	Bureau of Land Management
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	Spatially Explicit Regional Growth Model
SOP	Standard Operating Procedure
USGS	United States Geological Survey

Introduction

The purpose of natural resource monitoring in national park units is to develop scientifically sound information about the current status and long-term trends in the composition, structure, and function of park ecosystems. Managers can use monitoring information to increase confidence in their decisions and improve 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 (KLMN) vital signs selection process identified 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 Klamath 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's (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 follows methods and guidance in the *Land Cover and Land Use Monitoring Protocol for the Klamath Network* (Mohren et al. 2016a). We summarize the purpose and methods of the protocol in this report; complete details are in the protocol (<https://irma.nps.gov/DataStore/Reference/Profile/2237050>).

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

Lava Beds is located in northeastern California, approximately 249 kilometers (155 miles) northeast of Redding, California, and 72 kilometers (45 miles) southeast of Klamath Falls, Oregon. Other

federal agency lands border Lava Beds on all sides. The Modoc National Forest and the Klamath National Forest border the east, west, and south sides. The north side of the Park is bordered by the Klamath Basin National Wildlife Refuge Complex, which lease agricultural land on the adjoining boundary land.

Lava Beds ranges in elevation from 1,200 meters (4,040 feet) to 1685 meters (5,529 feet). The high elevation semi-arid desert environment of Lava Beds receives an average of 381 mm (15 inches) of precipitation annually at Park headquarters. The climate is characterized by warm to hot, dry summers, with occasional summer thunderstorms, and cold winters. The average annual high temperature is 15.6°C (60°F), and average annual low temperature is 1.7° C (35° F). Average annual snowfall is 1,118 mm (44 inches).

Lava Beds was established by presidential proclamation No. 1755 on November 21, 1925 (44 Stat. 2591). This proclamation recognized the significance of the area's cultural and natural resources. Park lands were home to the Modoc Indians and their ancestors for thousands of years and were the scene of the Modoc War, which took place during 1872 and 1873. Lava Beds contains more than 700 lava tube caves and features and a representative variety of high elevation desert vegetation and wildlife, including threatened and endangered species. These communities have high biotic integrity compared to surrounding areas, which are more affected by exotic species invasions, livestock grazing, and other stressors. In addition, the cave entrance and interior communities are associated with many unique biotic resources.

The majority of visitation at Lava Beds is concentrated in the small fraction of caves that are open and accessible to the general public. Lava Beds has a variety of exotic plants to contend with and is taking aggressive measures to inventory and eradicate these species. A total fire exclusion policy from 1925 through 1976, grazing by a variety of domestic animals, and a western pine beetle infestation in the 1920's have combined to drastically alter the distribution and abundance of fuels, vegetation, and wildlife.

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. After implementation of the national protocol, the national program will stop supporting the NPScape toolboxes used to calculate metrics in this report. Instead, the national program will calculate and provide the metrics in this report as part of the national I&M landscape dynamics protocol, provide this information through the NPS Statistics Summary database, and facilitate visualization of results via the Landscape Dynamics Metric Viewer (<https://nps.maps.arcgis.com/apps/webappviewer/index.html?id=2ec2585fa978404fbe316ec280645518>).

Areas of Analysis

The choice of 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 types of spatial scales based on park needs and recommendations from the scientific literature. These three types of spatial scales or Areas of Analysis (AOAs) include: 1) Park, 2) Park-Manager-Selected, and 3) Regional (Figure 1).

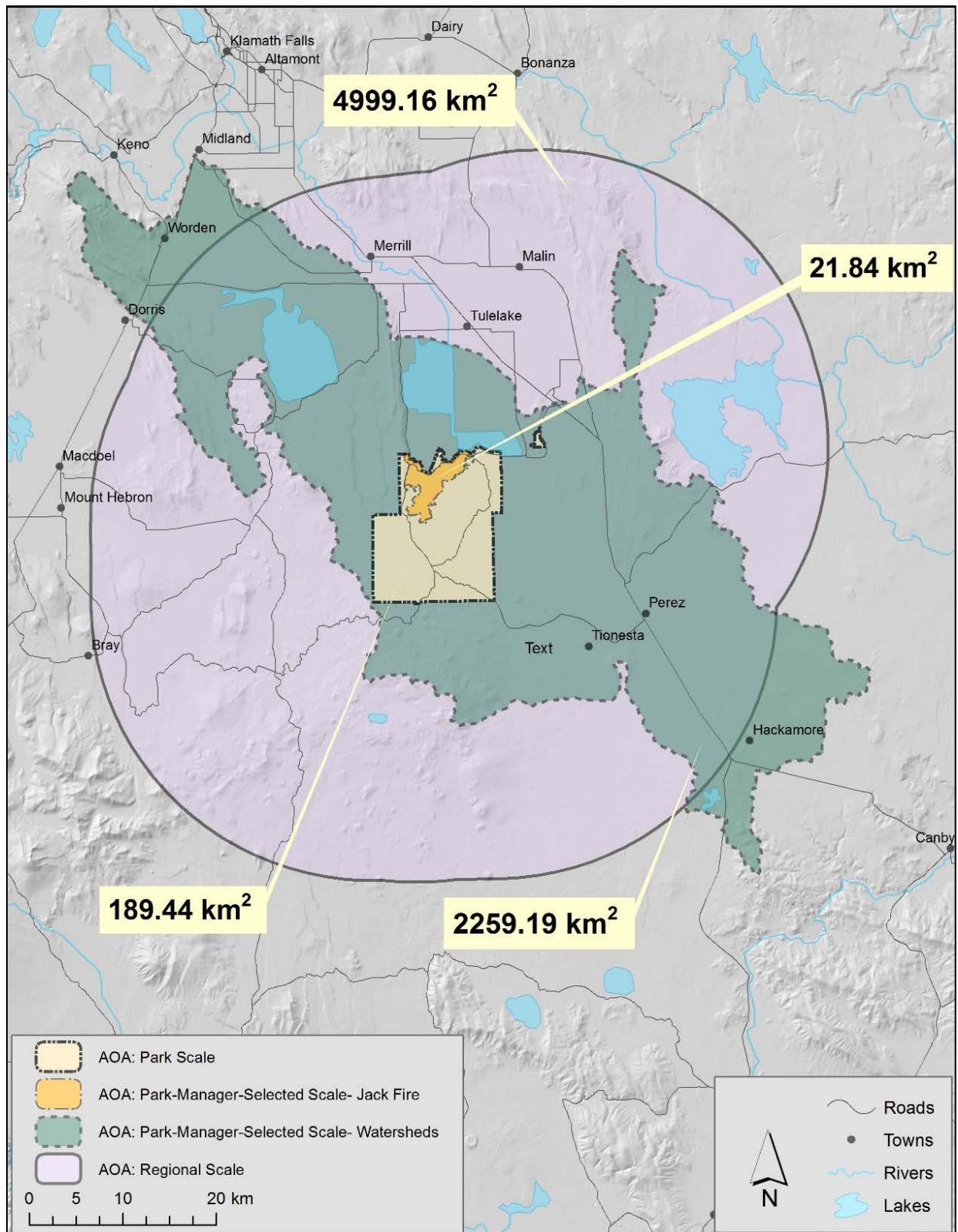


Figure 1. Reference map of all Lava Beds National Monument Areas of Analysis (AOA).

Park Scale

The Park AOA uses the park boundary (Nelson and Kinseth 2016). This AOA encompasses the area that NPS park managers have the most influence over and 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.

Park-Manager-Selected Scale

Lava Beds staff chose two additional AOAs. Because natural resources, ecological processes, and anthropogenic influences cross jurisdictional boundaries, the first “Park-Manager-Selected Watersheds” AOA includes lands adjacent to the park. Specifically, this AOA is at the watershed level. The US Geological Survey (USGS) assigns watersheds a Hydrologic Unit Code (HUC) of 10 (<https://water.usgs.gov/GIS/huc.html>), and we follow the HUC10 boundaries of watersheds that are fully or partially inside the Park. For Lava Beds, the Park-Manager-Selected Watersheds AOA covers 2,259.19 km² and comprises the following watersheds: Copic Bay, Lower Klamath Lake, and Tule Lake. A second “Park-Manager-Selected Jack Fire” AOA was selected, which is the boundary for the Jack Fire that occurred in 2008 in the northern section of the Park; it covers 21.84 km².

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 boundary.

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 Lava Beds National Monument land cover/land use results.

Dataset	Year	Indicator
Protected Areas Database of the United States (PAD-US)	2012	Conservation Status
National Land Cover Data (NLCD)	2006 and 2011	Land Cover and Pattern
US Census Bureau Block Group data	1970-2010	Housing and Population
US Census Bureau roads data (TIGER) and Lava Beds road data	2010 and 2016	Roads
USGS Landscape Fire and Resource Management Planning Tools (LANDFIRE)	1999-2012	Disturbance

Timeframe

Different years are reported for different landscape variables, depending on dataset availability. We present results for multiple years for some landscape variables, but this is not intended to show change over time. Future reports will examine trends.

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 the standard operating procedures associated with the land cover and land use monitoring protocol for the network (Mohren et al. 2016b). Not all indicators are relevant to all AOAs; thus Table 2 outlines which indicators are reported for each.

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

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

Indicator	Measure	AOA Scale
Conservation Status	Percentage & Total Protected	PM ¹ & R
	Percentage & Total Ownership	
Land Cover	Area/ Percentage 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 ¹ & 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	

¹ Jack Fire AOA not included

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 areas that are categorized in PAD-US version 1.3 as “unavailable data.” *SOP #2 (Conservation Status Metrics)* of the land cover/land use protocol for the network provides detailed methods for this indicator.

Within the Regional and Park-Manager-Selected Watersheds AOAs, we used the ownership and status categories (Table 3) to summarize the percentage of area and total area that were considered protected, as well as the percentage of area and total area by ownership.

Table 3. Protection status categories from the Protected Areas Database of the United States, produced by the USGS Gap Analysis Program.

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.

Land Cover: We analyzed land cover for all AOAs using National Land Cover Data (NLCD). We calculated the proportion of the landscape at each Level 2 class (Table 4) within each AOA using data from 2006 and 2011. In addition, we calculated the total area for each land cover type. Also, using 2011 data, we calculated impervious surface cover and summarized total area and percentage of area within surface class categories. In this analysis, each pixel value denotes how much of that pixel has an impervious surface. Natural lands vs. converted lands (Table 4) were also summarized by total area and percentage of area, and the percentage change in area, using data from 2011. Detailed methods for this indicator are provided in the protocol (*SOP #3: Land Cover Metrics*).

Table 4. National Land Cover Data (NLCD) land cover classes, modified from the Anderson land use and land cover classification system.

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

Landscape Pattern: These analyses were performed for the Park-Manager-Selected Watersheds, Park-Manager-Selected Jack Fire, 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 Level 1 classes (Table 4): Forest, Shrubland, and Grassland. As with Landscape Cover metrics, NLCD classes are modified from the Anderson land use and land cover classification system. The morphology of each land cover type was classified into morphological pattern types (e.g., edge, core, bridge), as defined in Table 5 and Figure 2.

Descriptions in Table 5 are provided by the USDA Forest Service

(<https://forestthreats.org/research/tools/landcover-maps/mspa>). We provided a summary of total area

and percentage of area for each pattern type. We also provided the count and total area of patches in different size classes.

Table 5. Pattern types describing area morphology for National Land Cover Data cover. Simplified descriptions were provided by the US Forest Service's Morphological Spatial Pattern Analysis (MSPA) of forest cover map.

Pattern Type	Technical Definition	Description
Branch	A cluster of non-core pixels connected to one edge.	Connected at one end to edge, perforation, bridge, or loop
Edge	Pixels within a defined distance ('edge') to the background. We used an edge of 150 m (5 pixels).	Outside perimeter
Islet	Island of pixels that is not core habitat.	Disconnected and too small to contain core
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.	Interior area of patch excluding perimeter
Bridge	A cluster of non-core pixels connected at two or more locations to edge.	Connected at both ends to different core patches
Perforated	Inner boundary of a core area that is adjacent to a hole in the core area.	Inside perimeter
Loop	A cluster of pixels that connects to two or more locations of the same edge	Connected at both ends to the same core patch

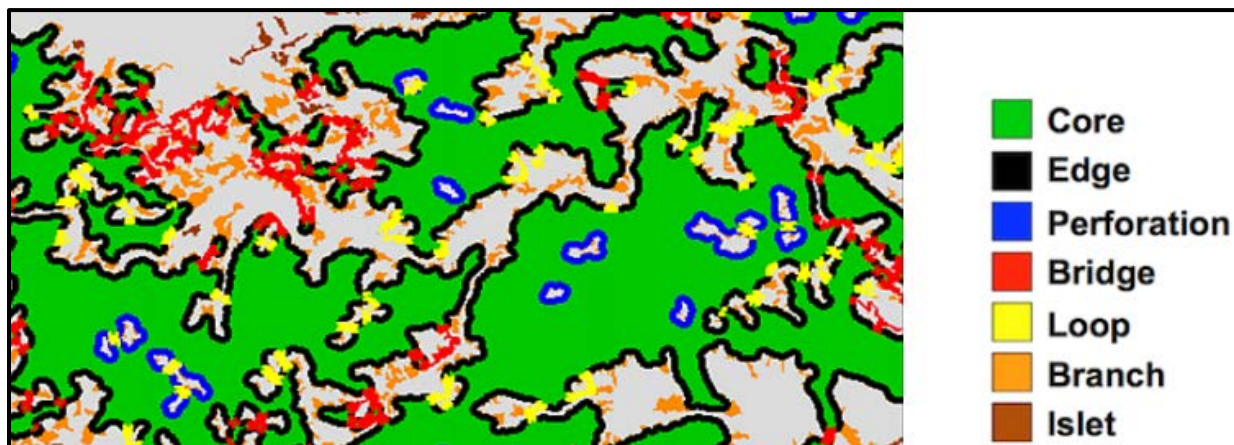


Figure 2. Illustration of morphological pattern types on a landscape. Image provided by Peter Vogt of the European Commission Joint Research Centre.

The density of each class is summarized in seven categories (Riitters 2011) and shown in Table 6. A land cover type is considered highly dense if no other land cover type or open space is detected in its vicinity. For forest, grassland, and shrubland cover types, we calculated the total and relative area in

each density class observed, as well as the percent of each density class in the AOA. Detailed methods for this indicator are provided in the protocol (*SOP #04: Pattern Metrics*).

Table 6. 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. Higher values of p (area density) mean a higher percentage of forest, grassland, or shrubland cover in a set area. For example, in the forest cover type, higher density means that the area surrounding the pixel is also mostly forested.

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	$p = 0.0$

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

Housing density metrics use the Spatially Explicit Regional Growth Model (SERGoM v3) (Theobald 2005) which uses US Census Bureau source data. To simplify reporting, we grouped housing densities into density classes (Table 7). We summarized data by these grouped classes for Park-Manager-Selected Watersheds and Regional AOAs using data from 1970 to 2010. By class, we provided total area, percent of total AOA, and percent of census area (area where the census occurred, generally omitting the Park, national forests, etc.).

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—areas that maintained primarily in a natural state). At the Park-Manager-Selected Watersheds 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.

Table 7. Grouped housing density classes represent one or more housing density classes. Data are from the US Census Bureau.

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

Roads: Detailed methods for this indicator are provided in the protocol (*SOP #7: Road Metrics*). We completed this analysis for Park-Manager-Selected Watersheds and Regional AOAs with 2010 and 2015 TIGER data using the four road codes described in Table 8: primary road; secondary road; local neighborhood road, rural road, city street; and vehicular trail (4WD). TIGER data may not always represent current conditions. For example, TIGER data may not immediately reflect when a road is decommissioned and used as a trail instead. Nonetheless, TIGER provides a consistent data source across time and space.

We summarized total road length and road density. Additionally, we provided the same summaries within the Park and Park-Manager-Selected Jack Fire AOAs using 2016 data from the Park.

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, we counted roadless areas and summed their total area within size categories. Water bodies (using the USGS National Hydrography Dataset 2015, <https://nhd.usgs.gov/data.html>) were erased and then polygons smaller than 0.0144 km² were removed.

Table 8. US Census Bureau TIGER road codes 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.

Disturbance: Detailed methods for this indicator are provided in the protocol (*SOP #8: Disturbance Metrics*). We used the USGS Landscape Fire and Resource Management Planning Tools (LANDFIRE) data for 1999 to 2012. LANDFIRE includes disturbance data (e.g., harvest, development) in addition to fire data. For all AOAs, we provided total area and percentage of AOA by disturbance types, defined in Table 9.

Table 9. USGS Landscape Fire and Resource Management Planning Tools (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.

Table 9 (continued). USGS Landscape Fire and Resource Management Planning Tools (LANDFIRE) disturbance categories.

Category	Description
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.
Biological	The use of living organisms, such as predators, parasites, and pathogens, to control weeds, pest insects, or diseases.

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 with an “A” prefix, but are presented in full in Appendix A to avoid lengthy diversion from the text.

As a reminder, results for each of the levels of spatial analysis (except the Park-Manager-Selected Jack Fire AOA) include the area of the Park at each level’s core. Also, different years are reported for different landscape variables, depending on dataset availability. We did not perform any statistical analyses in this report. Any mention of change among years is purely descriptive and does not imply trend.

Conservation Status

Ownership

In 2012, most of the land for which data were available within the Regional AOA was owned by the US Forest Service (51.4%), followed by the Fish and Wildlife Service (9.1%). Within the Park-Manager-Selected AOA, 49.1% of the land was US Forest Service and 16.4% was Fish and Wildlife Service (Figures 3 and 4; Table A1 in Appendix A, *Data Tables*). Note that data for 28.7% of the Regional AOA and 21.9% 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.

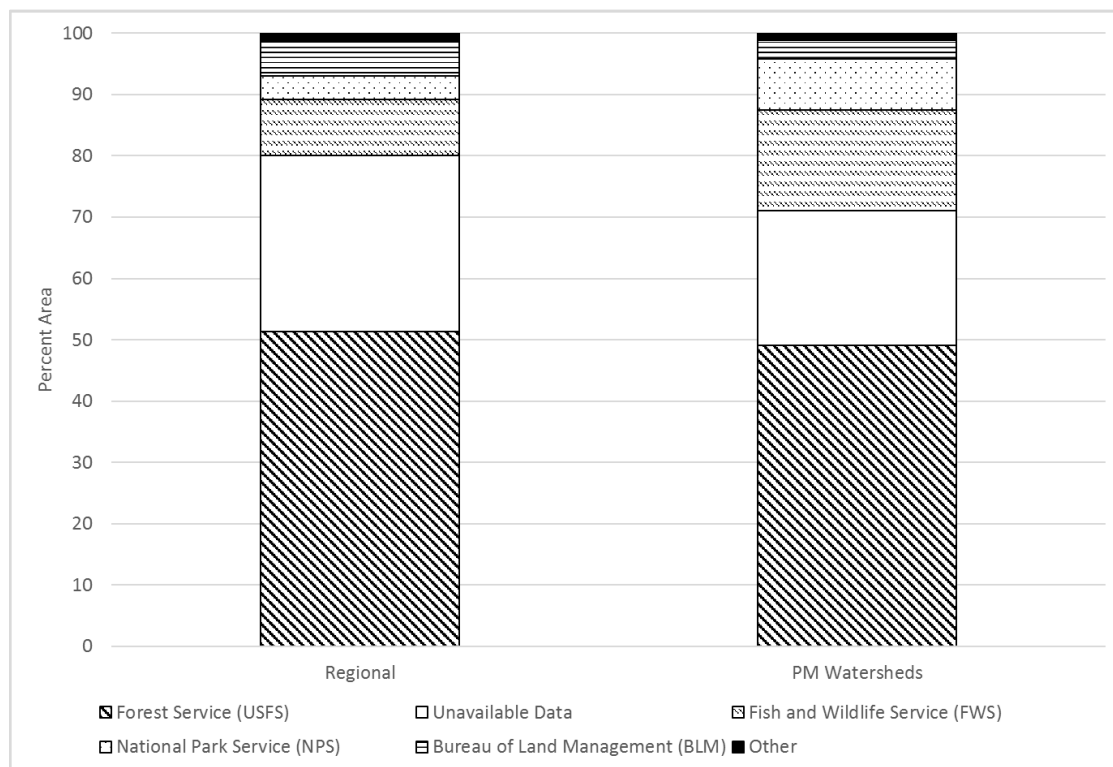


Figure 3. Percentage of land ownership within the Regional and Park-Manager-Selected Watersheds (PM Watersheds) Areas of Analysis (AOA) in 2012.

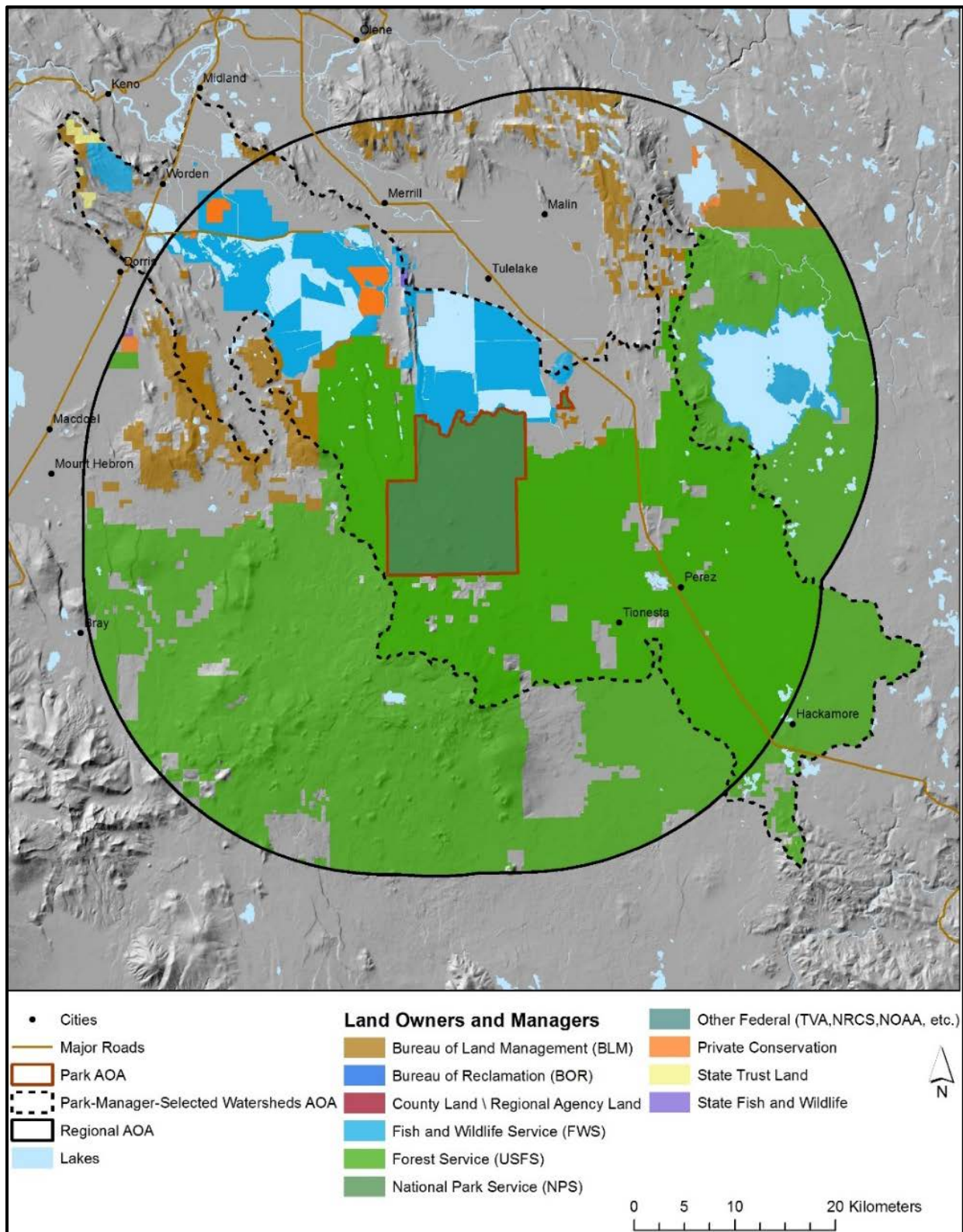


Figure 4. Land owners in the Regional and Park-Manager-Selected Watersheds Areas of Analysis (AOA), using 2012 data from the USGS Gap Analysis Program, Protected Areas Database for the US. Areas without colors identified in the legend are those for which ownership is unknown.

Protected Areas

The USGS Gap Analysis Program (GAP) Conservation Status 1 is the most protected status, representing permanent protection from conversion of natural land cover and a mandated management plan (see Methods, Table 3, for status definitions). In 2012, Status 1 constituted less than 0.01% of the Regional and Park-Manager-Selected Watershed AOAs (Table A2, Figures 5 and 6). The Park falls entirely within category 2 which makes up 13.1% of the Regional AOA and 25.0% of the Park-Manager-Selected Watershed AOAs, respectively. Within the Regional and Park-Manager-Selected Watersheds AOAs, the largest single category of land was in Status 3 (57.7% and 52.3%, 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). Federally listed endangered and threatened species are also protected throughout the area. Data for 28.7% of the Regional AOA and 21.9% of the Park-Manager-Selected Watershed AOA were not available; therefore the percentage of land managed within each status category may have been greater, depending on the composition of the unavailable data.

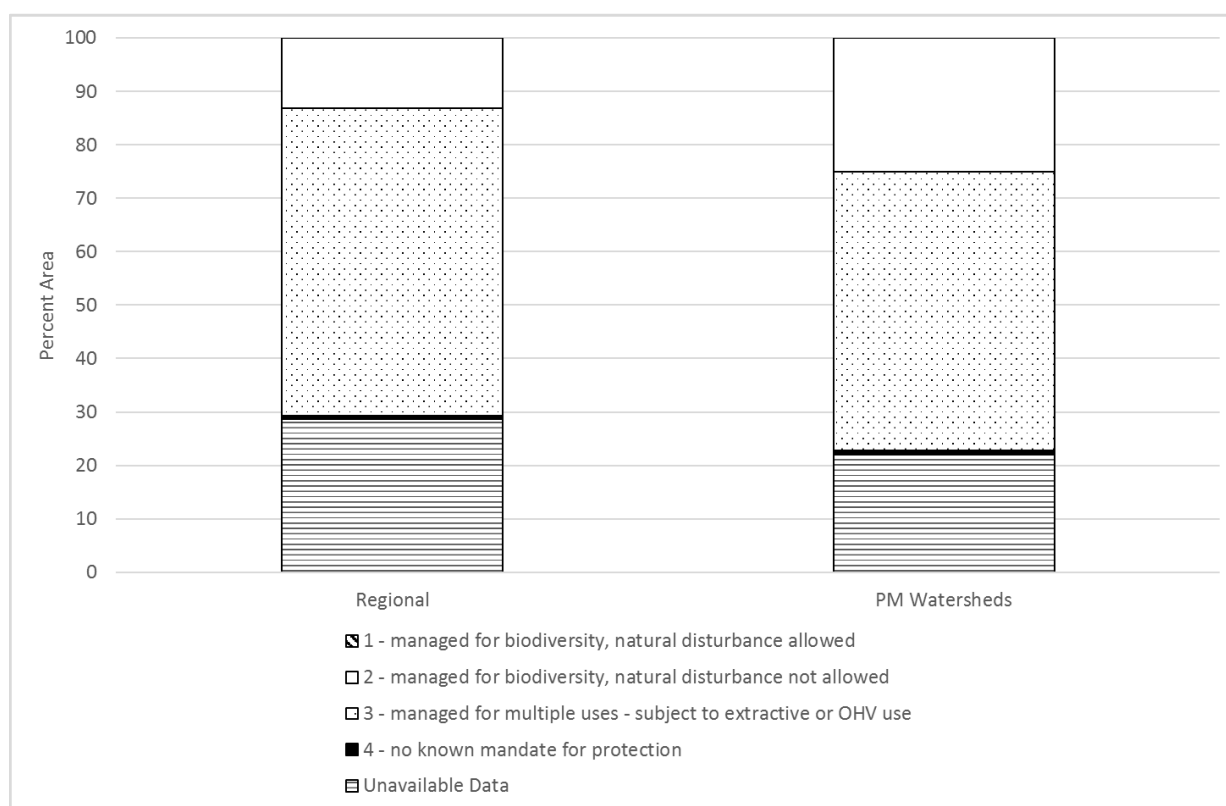


Figure 5. Percentage in each USGS Gap Analysis Program (GAP) Conservation Status category within the Regional and Park-Manager-Selected Watersheds (PM Watersheds) Areas of Analysis (AOA) in 2012.

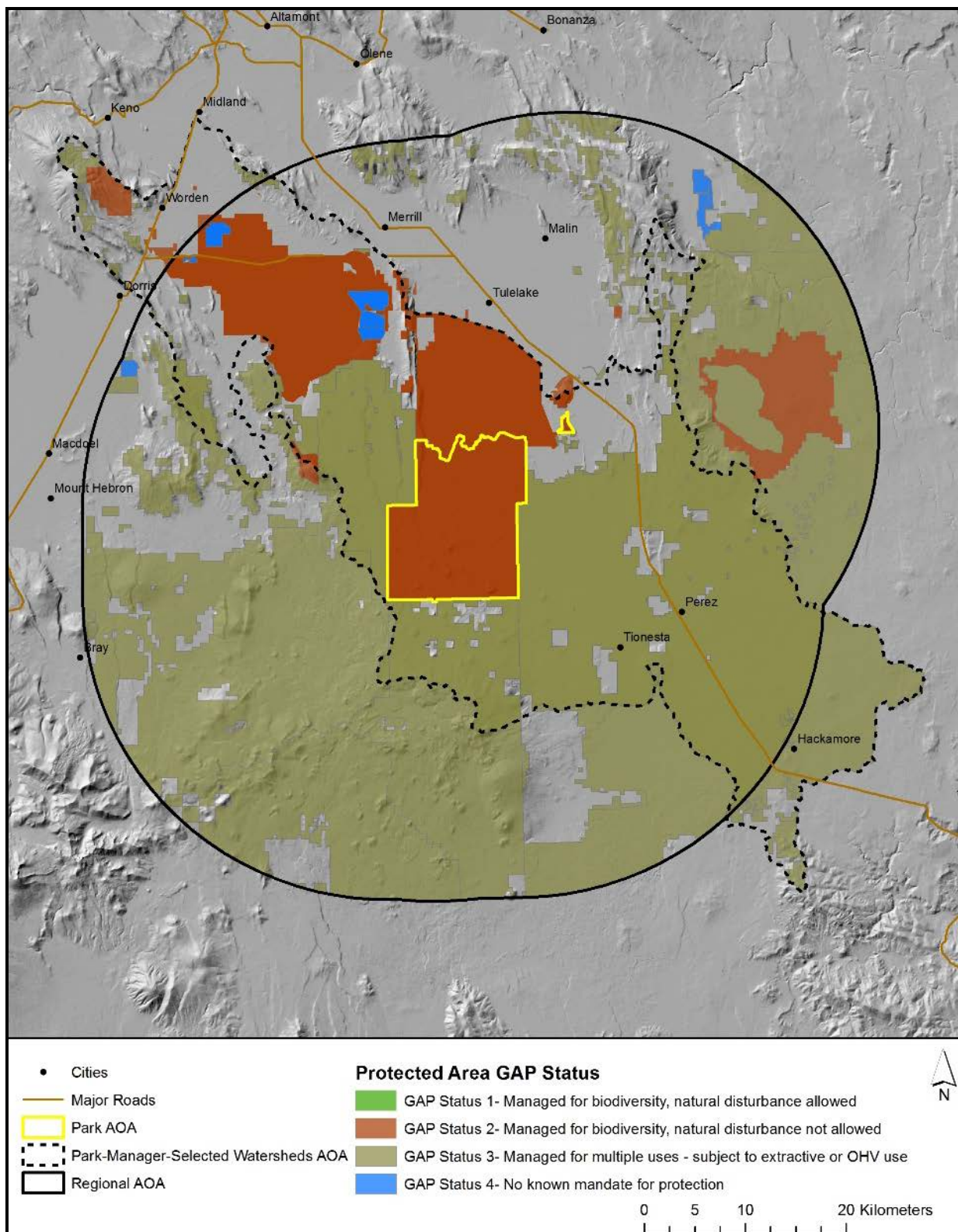


Figure 6. Protection status category in the Regional and Park-Manager-Selected Watersheds Areas of Analysis (AOA), using 2012 data from the USGS Gap Analysis Program (GAP) Protected Areas Database for the US (PAD-US).

Land Cover

Land Cover Classes

We summarized land cover using the National Land Cover Data (NLCD) Level 2 classes (see Methods, Table 4, for class definitions) (Figures 7 and 8).

In the Regional AOA, *Evergreen Forest* comprised 31.6% (2006) and 30.6% (2011), *Shrub/Scrub* comprised 26.6% (2006) and 27.4% (2011), and *Herbaceous* comprised 16.9% (2006) and 17.1% (2011) (Table A3).

In the Park-Manager-Selected Watersheds AOA, *Shrub/Scrub* was 31.4% (2006) and 32.0% (2011), *Herbaceous* was 21.2% (2006) and 21.5% (2011), and *Evergreen* was 17.6% (2006) and 16.7% (2011) (Table A4).

In the Park-Manager-Selected Jack Fire AOA, there was no difference between 2006 and 2011. *Shrub/Scrub* was 51.2% and *Herbaceous* was 44.6% (Table A5).

In the Park AOA, *Shrub/Scrub* covered 55.5% (2006) and 55.7% (2011), and *Barren Land* covered 18.0% in both 2006 and 2011. *Herbaceous* covered 16.0% in both 2006 and 2011 (Table 6).

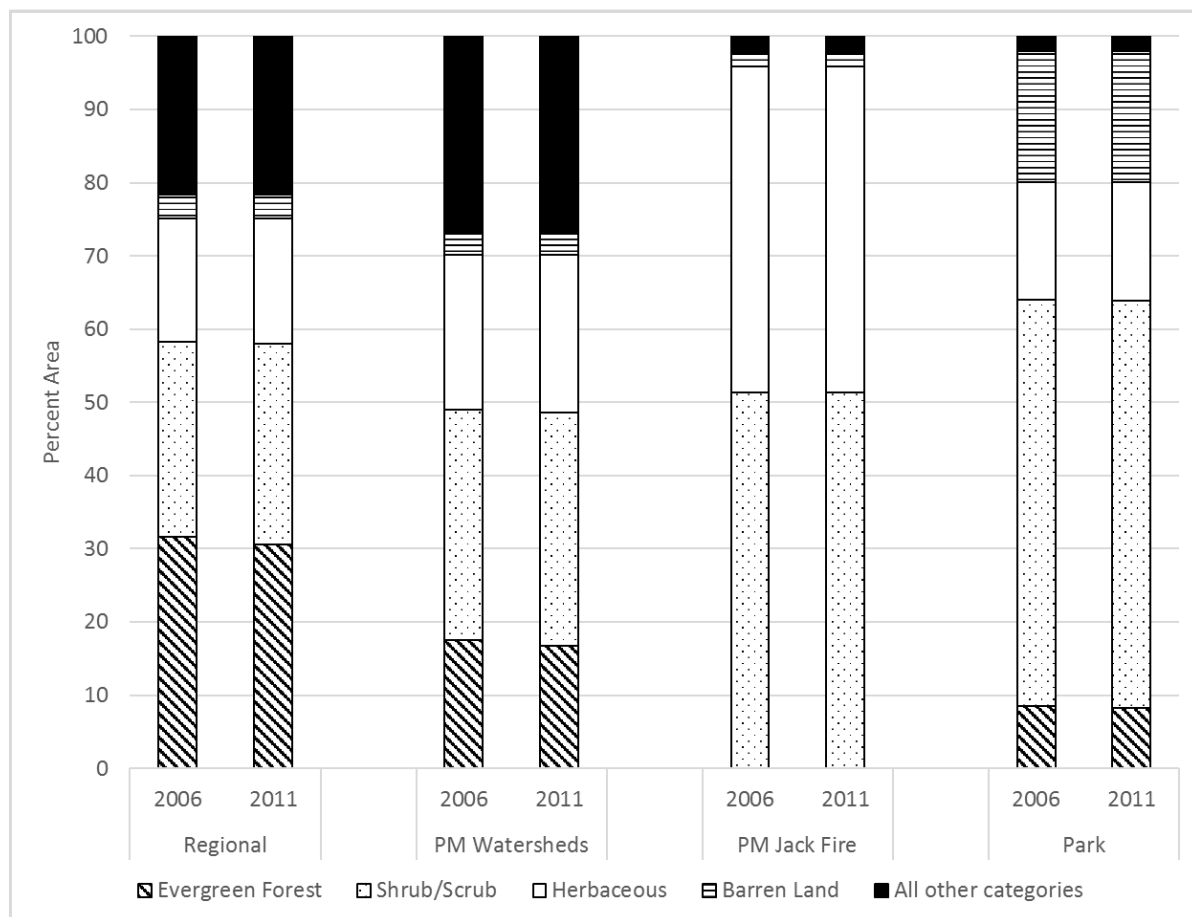


Figure 7. Percentage of National Land Cover Data Level 2 classes in all Areas of Analysis (AOA) for 2006 and 2011.

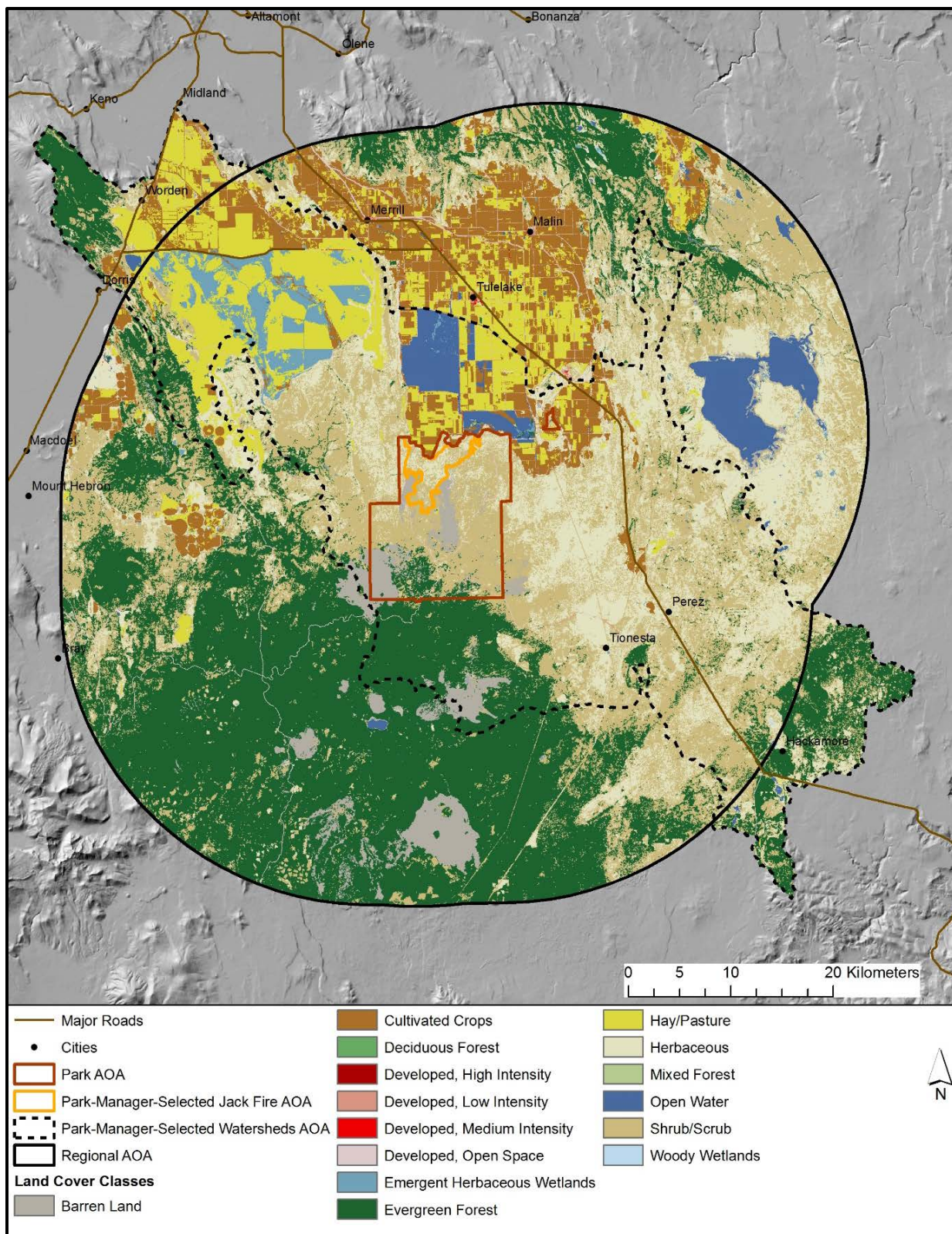


Figure 8. Land cover by National Land Cover Data Level 2 classes at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

Impervious Surface Cover

In 2006 and 2011, the majority of each AOA lacked impervious surface (i.e., 0%–2% impervious surface class) (Figure 9; Tables A7-A10). This lowest impervious surface class occurred in greater than 96% of the Regional AOA and Park-Manager-Selected Watersheds AOA and in greater than 97% of the Park-Manager-Selected Jack Fire AOA and the Park AOA. Likewise, in all AOAs, less than 0.1% of the area had a high amount of impervious surface (50%–100% impervious surface class).

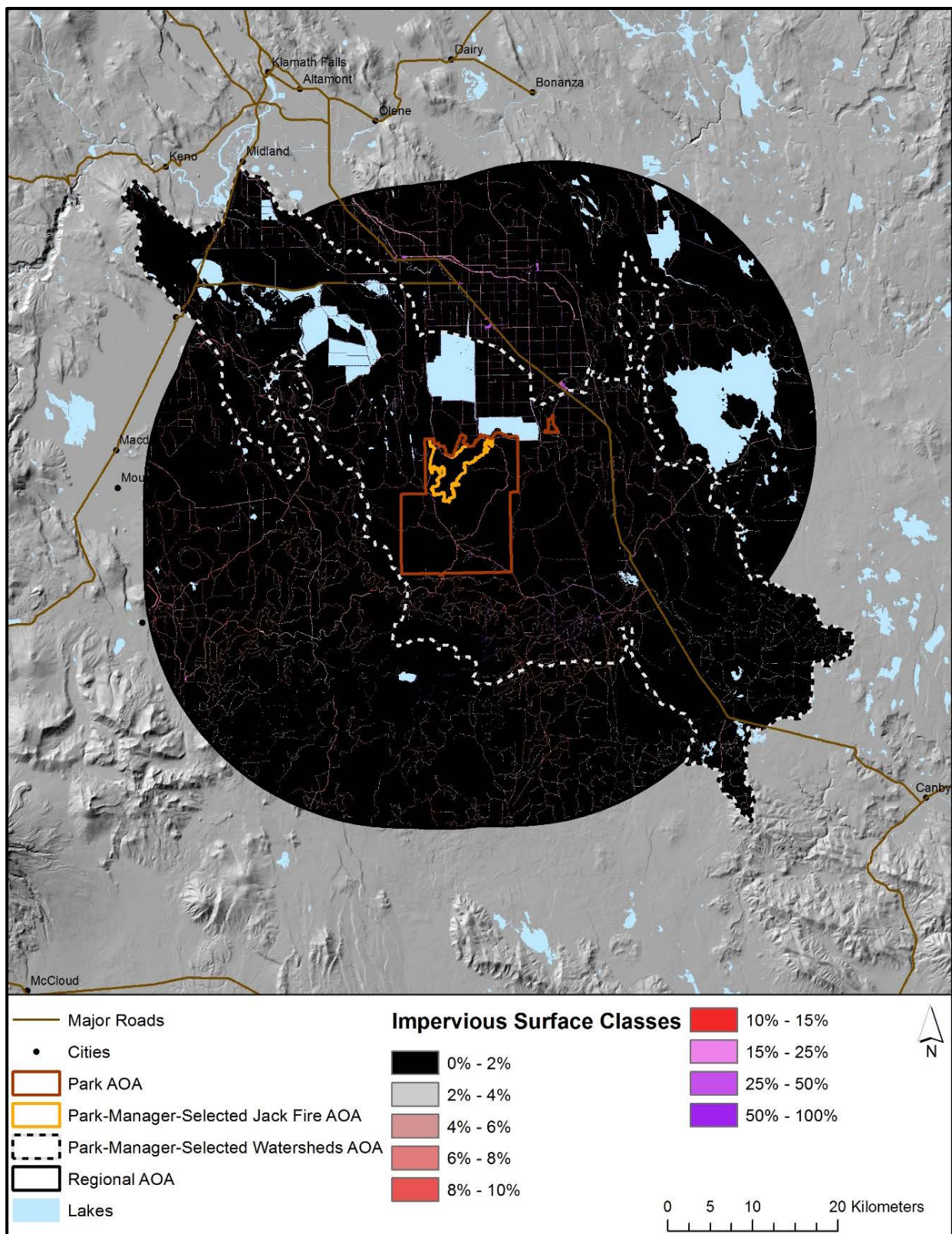


Figure 9. Impervious surface area at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

Natural vs. Converted

For all three AOAs, the majority of the land cover was categorized as *Natural* in 2006 and 2011 (see Methods, Table 4, for cover classes). *Natural* land cover in both 2006 and 2011 comprised 83% of the Regional AOA, 79% of the Park-Manager-Selected Watersheds AOA, 98% of the Park-Manager-Selected Jack Fire AOA, and 98% of the Park AOA (Figure 10; Tables A11–A14). At all three AOAs, little change in area (km²) occurred since 2006. Most of the *Converted* areas were agricultural lands and towns to the north of the Park. Outside of towns, *Converted* areas throughout the AOAs were roads.

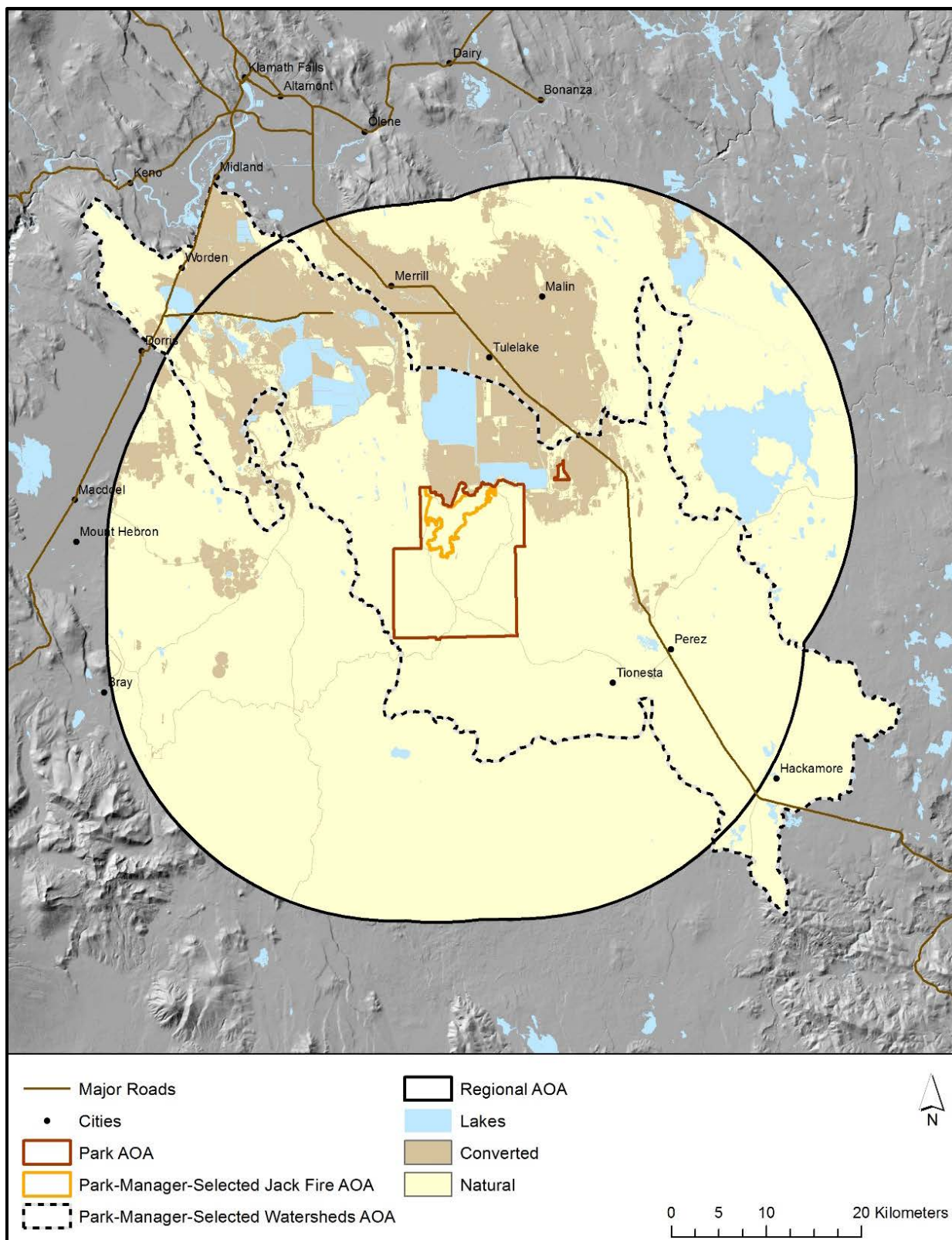


Figure 10. Natural and converted lands at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

Landscape Pattern

Morphology

Forest

In the Regional AOA, 30.6% was forested (Figure 11). Forest was categorized as *Core* (44.8%), followed by *Edge* (20.1%) (Table A15) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected Watersheds AOA, forest covered 16.7% of the area and was characterized as *Core* (33.5%), followed by *Bridge* (24.8%) and *Edge* (21.0%) (Table A15). The Park-Manager-Selected Jack Fire AOA was only 0.5% forested, which was all *Islet* (Table A15).

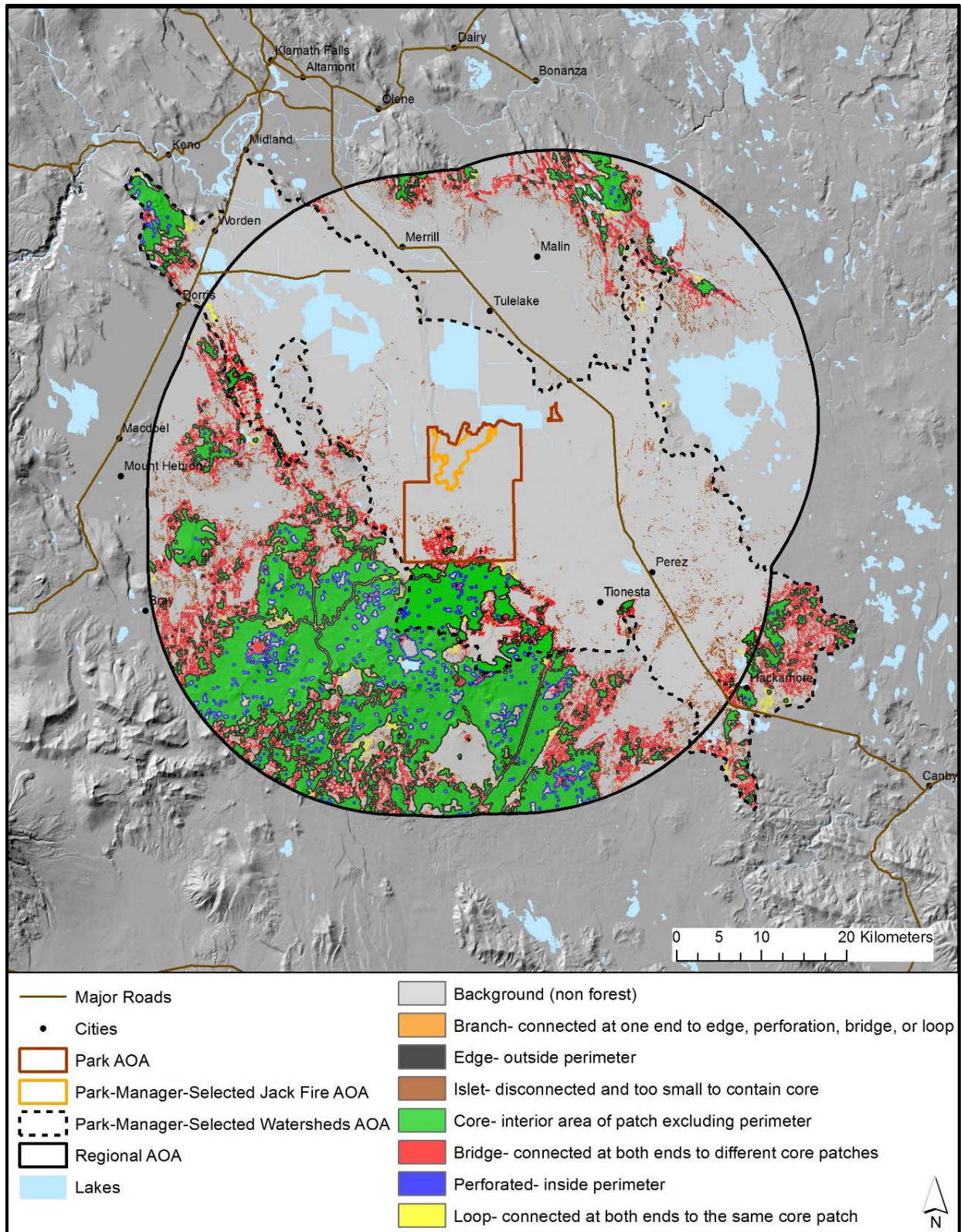


Figure 11. National Land Cover Data forest morphology classification for the Regional and Park-Manager-Selection Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>).

Grassland

In 2011, grassland occurred in approximately 25.3% of the Regional AOA, approximately 35.1% of the Park-Manager-Selected AOA, and approximately 44.6 of the Park-Manager-Selected Jack Fire AOA.

In the Regional AOA, grassland was categorized primarily as *Bridge* (31.7%), followed by *Edge* (21.7%) and *Islet* (20.0%) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected Watersheds AOA, grassland was categorized primarily as *Bridge* (31.6%), followed by *Core* (22.2%) and *Edge* (21.9%). In the Park-Manager-Selected Jack Fire AOA, grassland was categorized primarily as *Bridge* (64.0%), followed by *Islet* (19.6%) (Figure 12; Table A16).

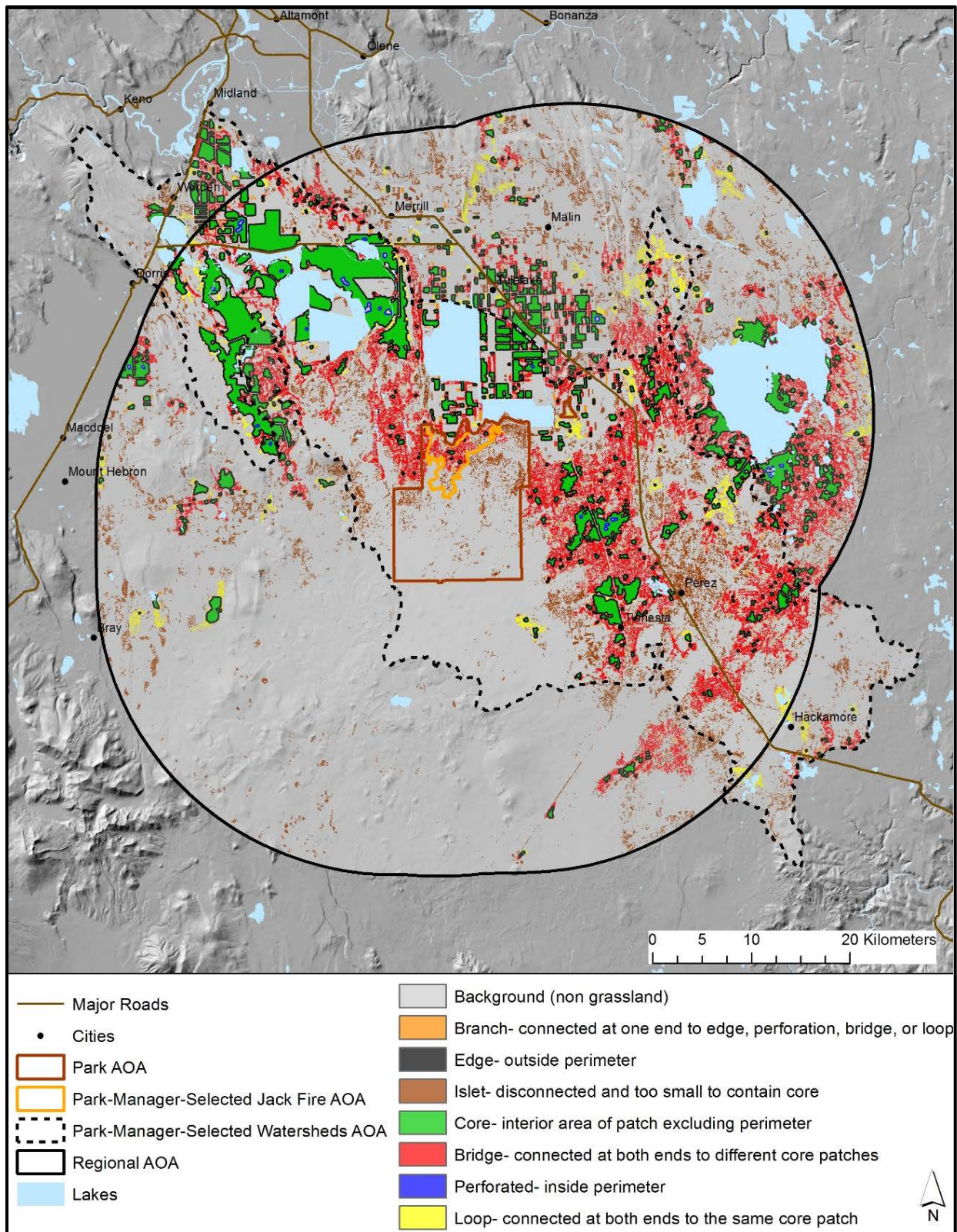


Figure 12. National Land Cover Data grassland morphology classification for the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>)

Shrubland

Shrubland comprised 27.4% of the Regional AOA, 32.0% of the Park-Manager-Selected Watersheds AOA, and 51.2% of the Park-Manager-Selected Jack Fire AOA. In the Regional AOA, shrubland was categorized primarily as *Bridge* (48.0%), followed by *Islet* (21.9%) and *Edge* (16.4%) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected Watersheds AOA, shrubland was categorized primarily as *Bridge* (50.0%), followed by *Islet* (18.9%) and *Edge* (17.5%). In the Park-Manager-Selected Jack Fire AOA, shrubland was categorized primarily as *Bridge* (45.6%), followed by *Islet* (31.4%) and *Edge* (15.5%) (Figure 13; Table A17).

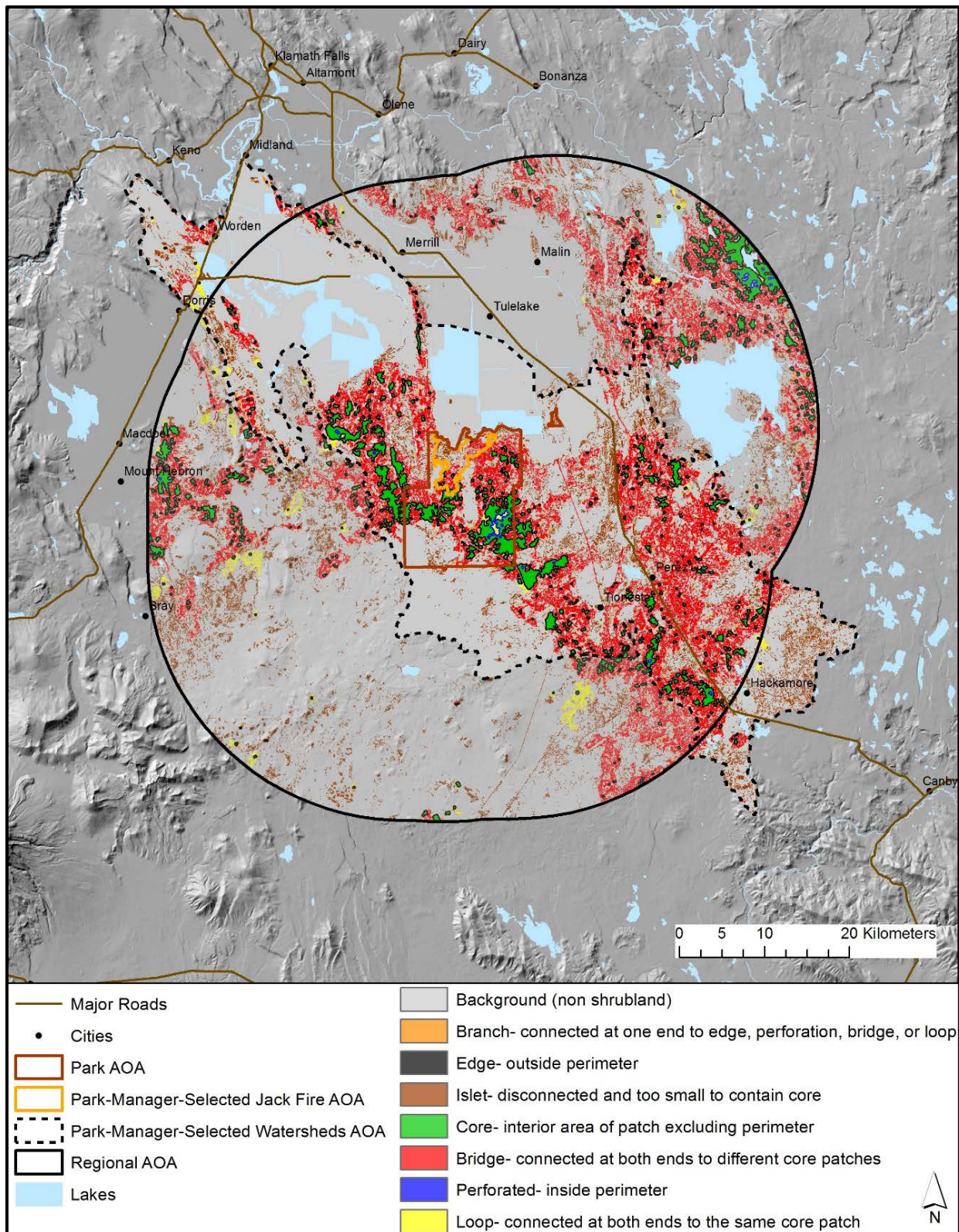


Figure 13. National Land Cover Data shrubland morphology classification for the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>)

Patch Size

Forest patch size

In the Regional AOA and Park-Manager-Selected Watersheds AOA, almost all of the patches were less than 1 km², but the total combined area of these small patches was relatively low in 2011. For the Regional AOA, most area was in the 500-1,000 km² patch size category (Figure 14; Table A18). In the Park-Manager Selected Watersheds AOA, total area was distributed across the patch categories. In the Park-Manager Selected Jack Fire AOA, there was only one patch, and it was in the <1 km² category.

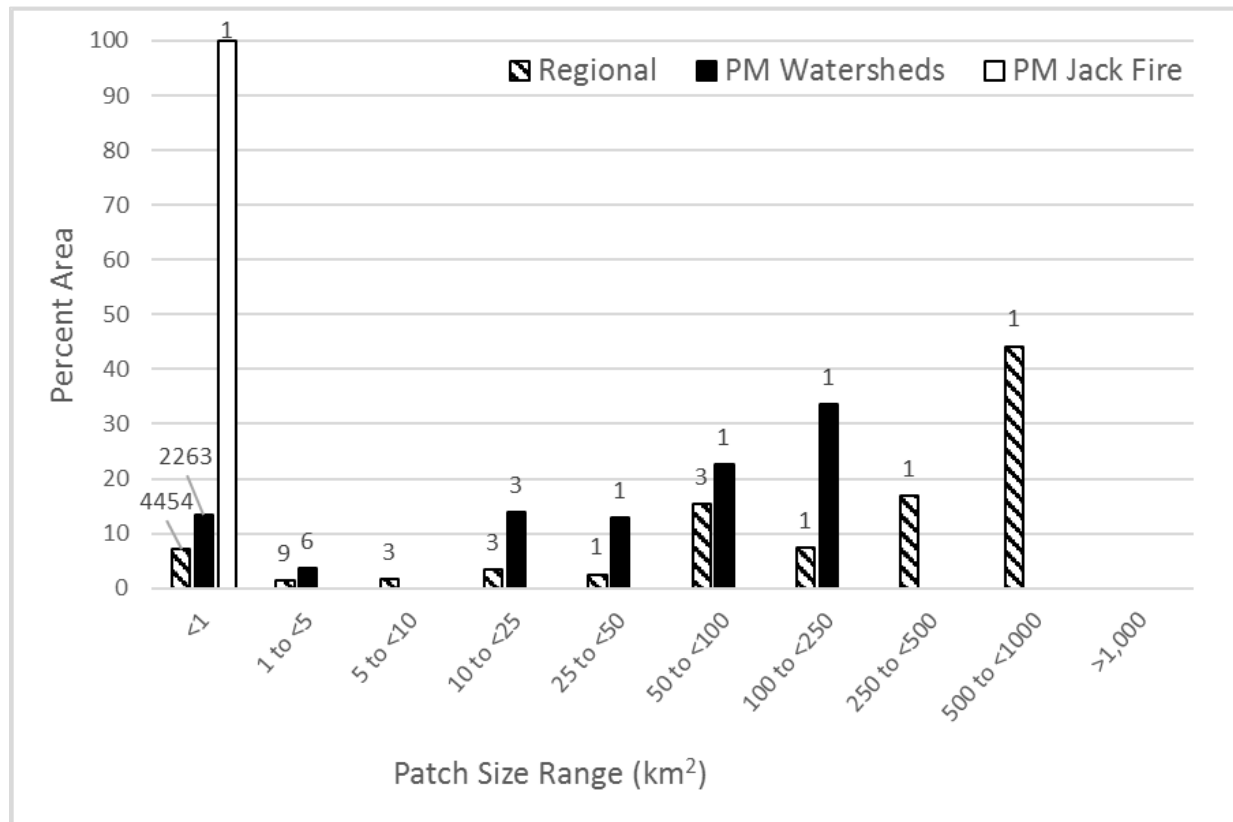


Figure 14. Percentage of area within each patch size category for forestlands in the Regional and Park-Manager-Selected (PM Watersheds and PM Jack Fire) Areas of Analysis. The number at the top of each bar is the number of patches comprising the area.

Grassland patch size

In the Regional AOA and Park-Manager-Selected Watersheds AOAs in 2011, most patches were in the <1 km² category, although the total area was distributed across patch categories. In the Park-Manager-Selected Jack Fire AOA, most patches were within the <1 km² range, but most area was in one patch in the 5-10 km² category (Table A19, Figure 15).

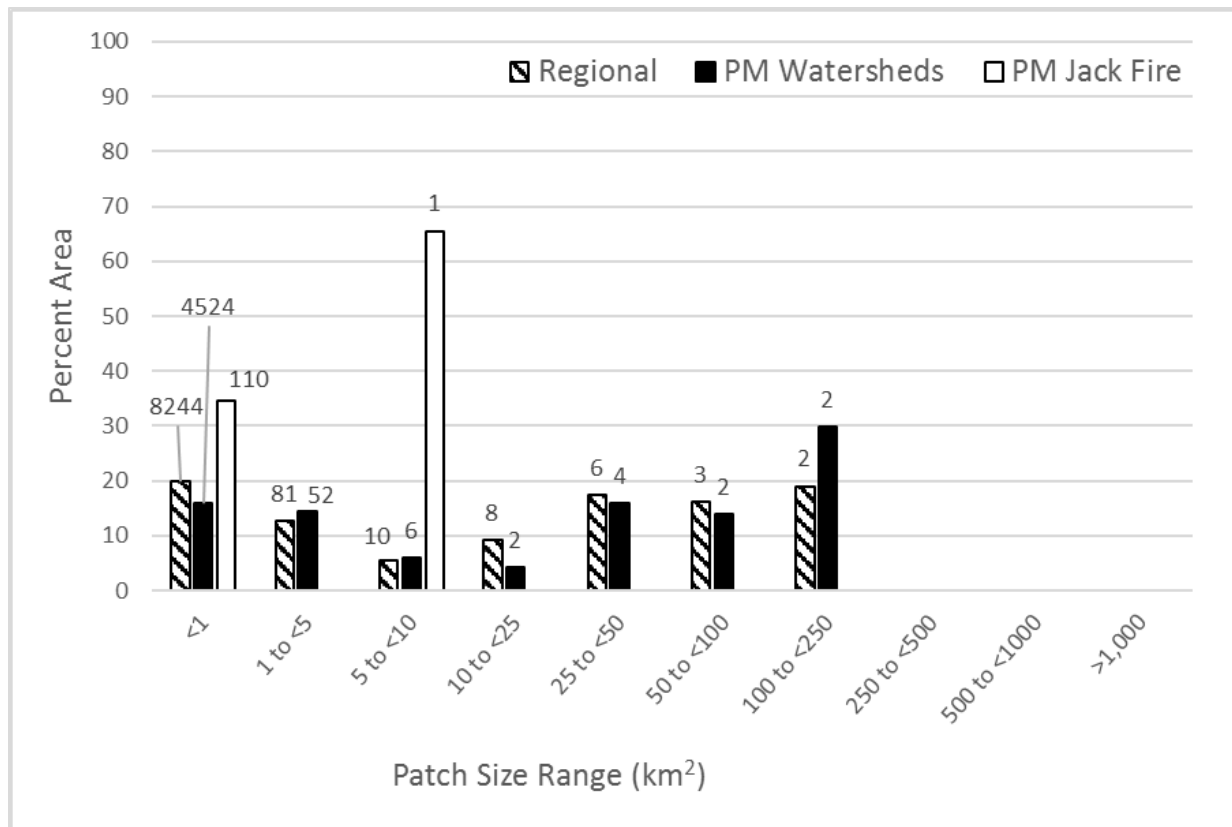


Figure 15. Percentage area within each patch size category for grasslands in the Regional and Park-Manager-Selected (PM Watersheds and PM Jack Fire) Areas of Analysis. The number at the top of each bar is the number of patches comprising the area.

Shrubland patch size

In the Regional and Park-Manager-Selected Watersheds AOA, most patches were within the <1 km² range; total area varied across patch categories with the greatest area in the 100-250 km² category (Table A20; Figure 16). In the Park-Manager-Selected Jack Fire AOA, most patches were within the <1 km² range, but most area occurred in two patches in the 1-5 km² category.

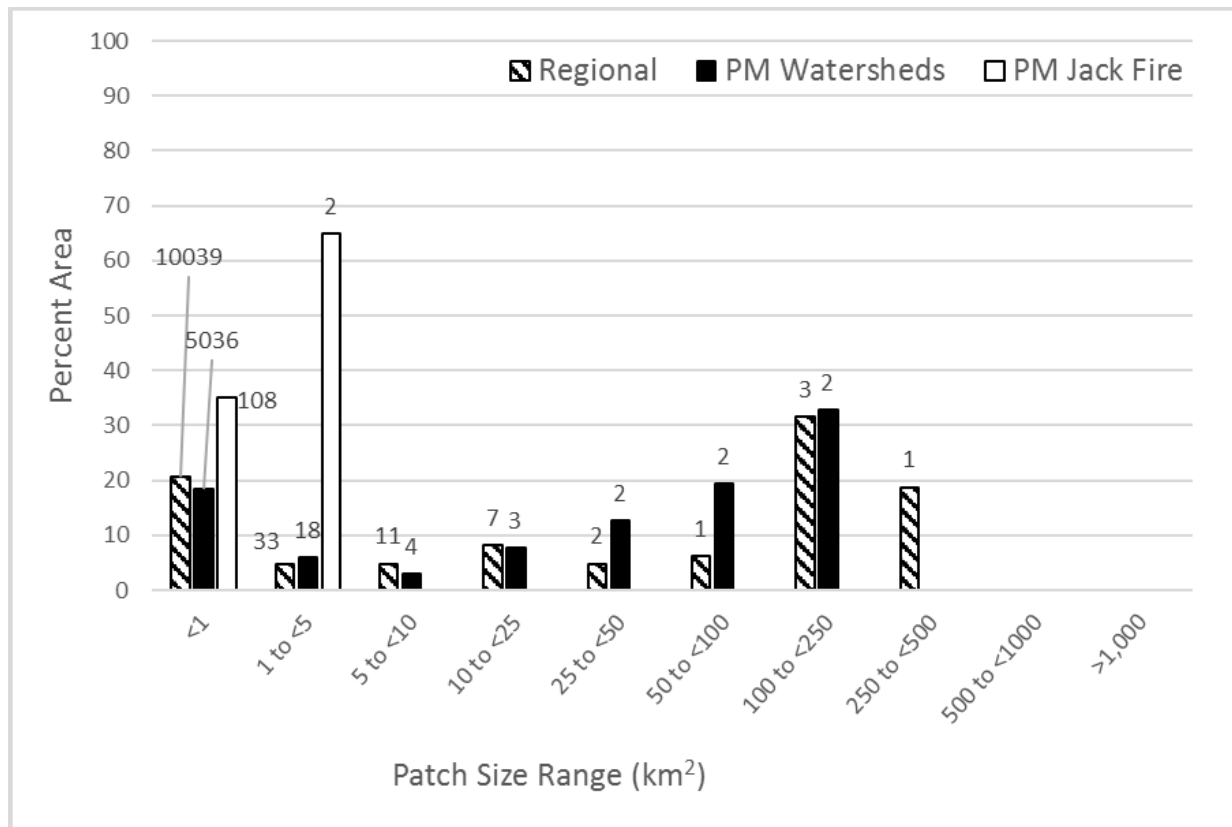


Figure 16. Percentage area within each patch size category for shrublands in the Regional and Park-Manager-Selected (PM Watersheds and PM Jack Fire) Areas of Analysis. The number at the top of each bar is the number of patches comprising the area.

Area Density

The majority of forest cover within the Regional AOA occurred in the *Intact* density class (38.1%), followed by the *Patchy* density class (18.6%) and the *Dominant* density class (16.7%) (Figure 17; Table A21) in 2011. See the Methods, Table 6, for density class definitions. In the Park-Manager-Selected Watersheds AOA, 26.0% of the forest cover was in the *Patchy* density class, 25.0% was in the *Intact* density class, and 17.0% was in the *Dominant* density class. In the Park-Manager-Selected Jack Fire AOA, half the forested area was *Rare* (50.9%) and half was *Patchy* (49.1%) (Table A21).

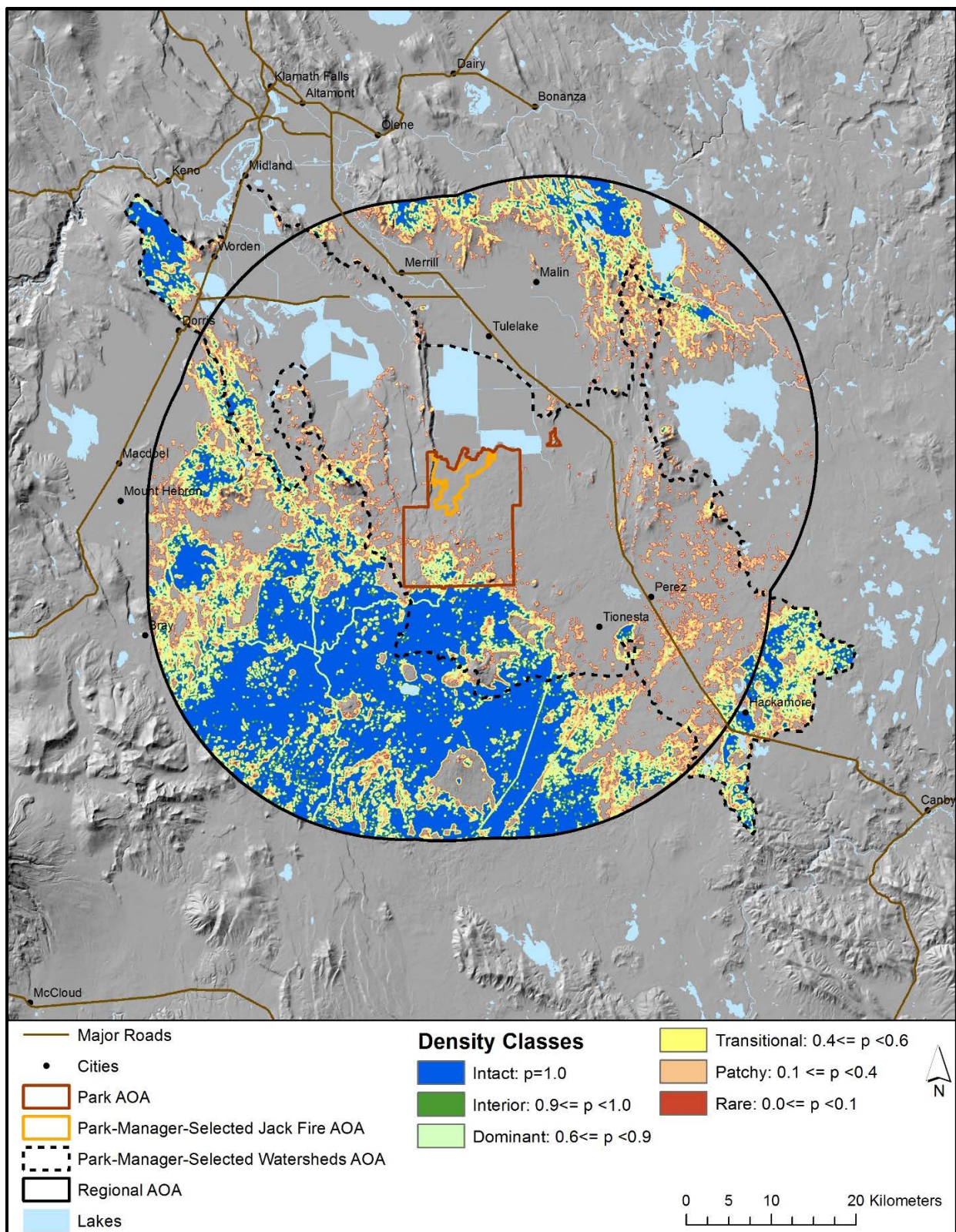


Figure 17. National Land Cover Data forest density classes for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.

Most grasslands within the Regional AOA occurred in the *Patchy* density class (31.2%), followed by the *Dominant* density class (20.4%) and the *Transitional* density class (16.9%) (Figure 18; Table A22) in 2011. See the Methods, Table 6, for density class definitions. In the Park-Manager-Selected Watersheds AOA, 28.5% of grassland was in the *Patchy* density class, 21.3% was in the *Dominant* density class, and 17.0% was in the *Transitional* density class. In the Park-Manager-Selected Jack Fire AOA, 32.2% of grassland was in the *Patchy* density class, 27.4% was in the *Dominant* density class, and 25.1% was in the *Transitional* density class.

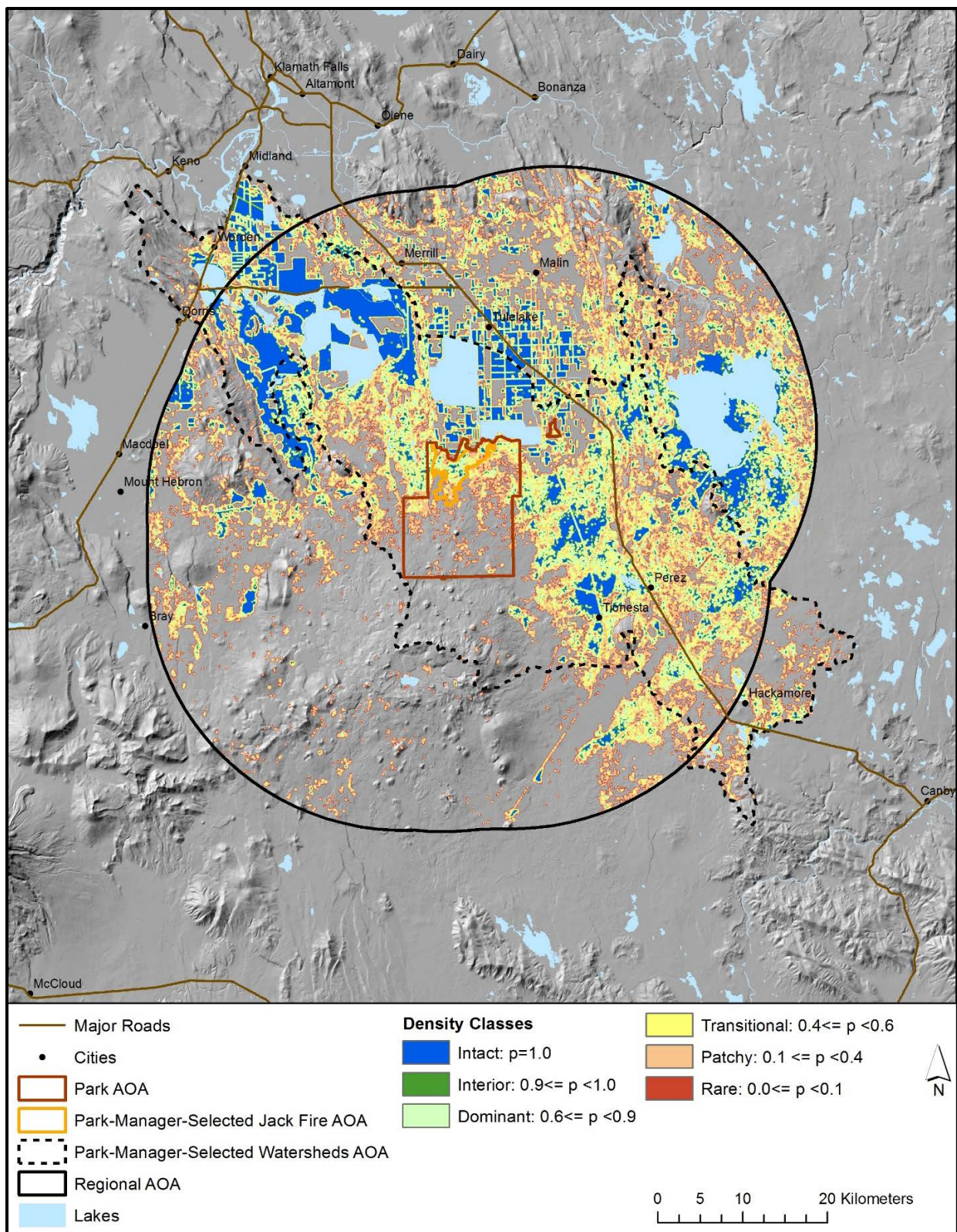


Figure 18. National Land Cover Data grassland density for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.

Shrubland within the Regional AOA occurred in the *Patchy* density class (32.7%), followed by the *Dominant* density class (23.3%) and the *Transitional* density class (19.5%) (Figure 19; Table A23) in 2011. See the Methods, Table 6, for density class definitions. In the Park-Manager-Selected Watersheds AOA, 31.2% was in the *Patchy* density class, 24.2% was in the *Dominant* density class, and 20.2% was in the *Transitional* density class. In the Park-Manager-Selected Jack Fire AOA, 32.7% of the shrublands area was in the *Patchy* density class, 24.9% was in the *Dominant* density class, and 24.6% was in the *Transitional* density class.

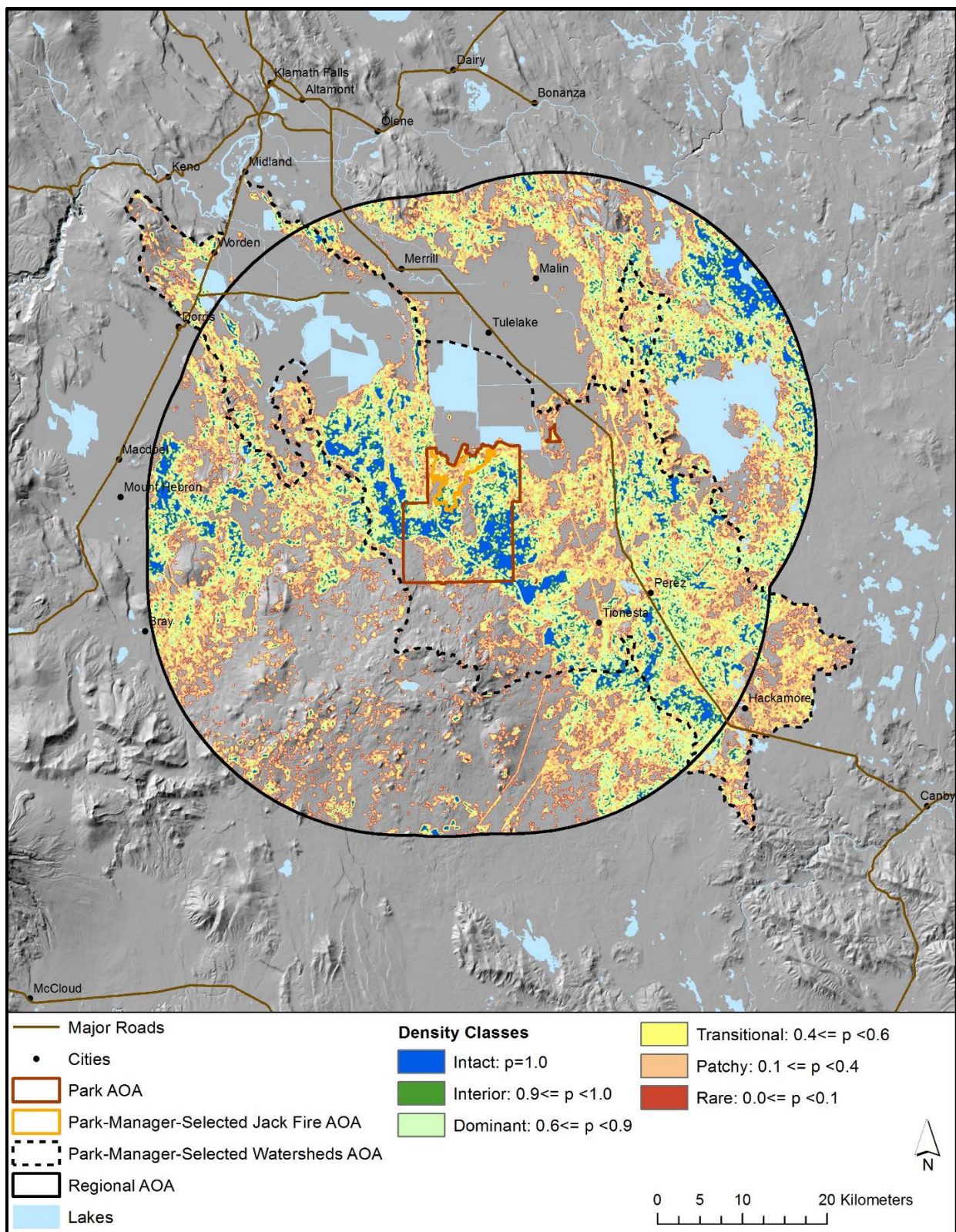


Figure 19. National Land Cover Data shrubland density for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.

Housing and Population

Housing Density

Lava Beds is surrounded by a limited amount of housing development (Figure 20), mostly categorized as *Rural* (<7 units/km²) (see Methods, Table 7, for housing density categories). The area encompasses several towns including Tulelake, Malin, Merrill, Perez, Tionesta, and Hackamore.

Since 1970, the area considered *Rural* decreased slightly. In 1970, this area comprised 95.5% of the Census areas within the Regional AOA and 97.4% in the Park-Manager-Selected Watersheds AOA (Tables A24 and A25; Figures 21 and 22). By 2010, *Rural* area decreased to 91.6% of the Regional AOA and 94.1% of the Park-Manager-Selected Watersheds AOA.

During the same time frame, the *Exurban* class (7–145 units/ km²) increased from 4.3% to 8.1% in the Regional AOA and from 2.6% to 5.8% in the Park-Manager-Selected Watersheds AOA.

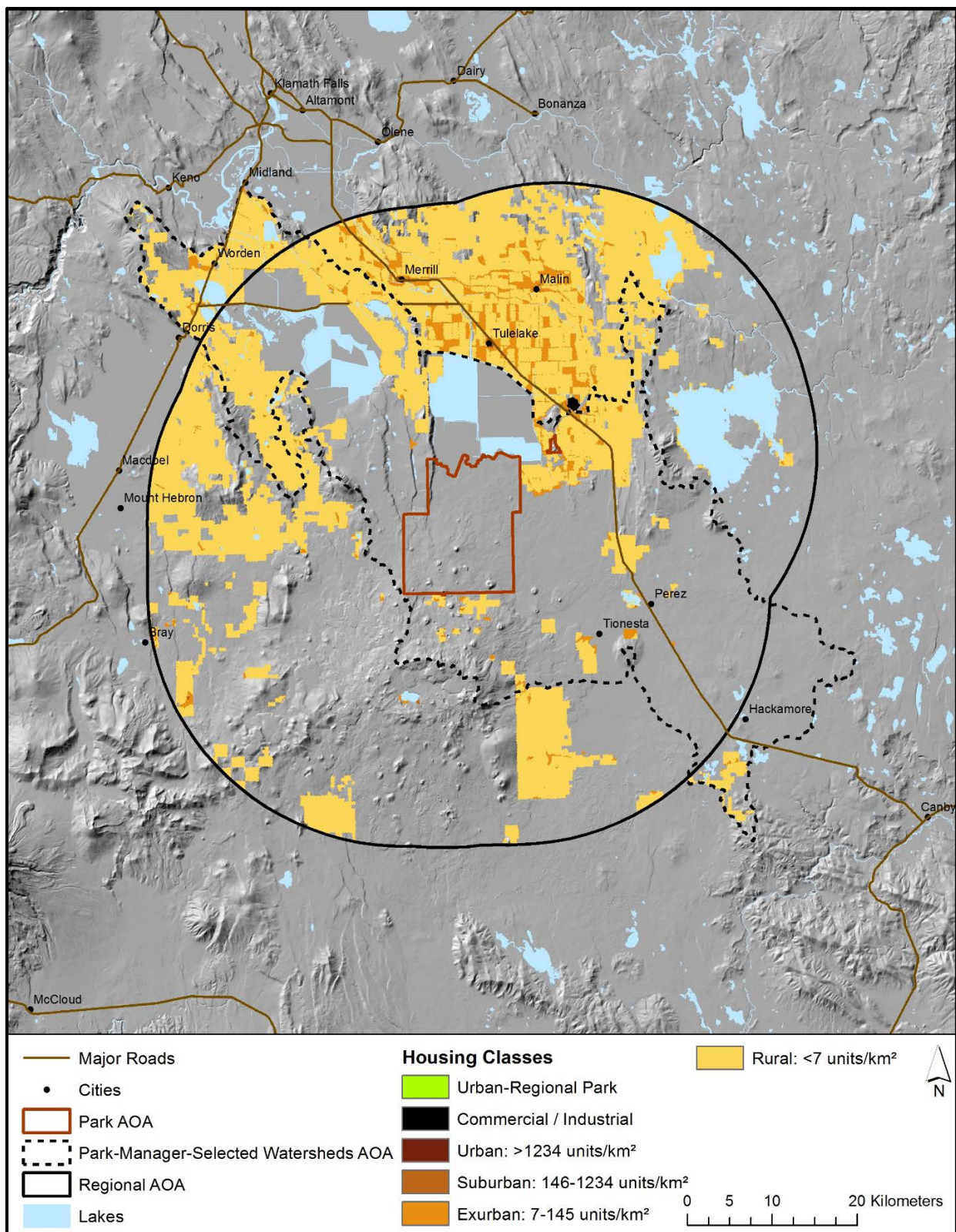


Figure 20. Housing classes in the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2010. No data exist for gray areas.

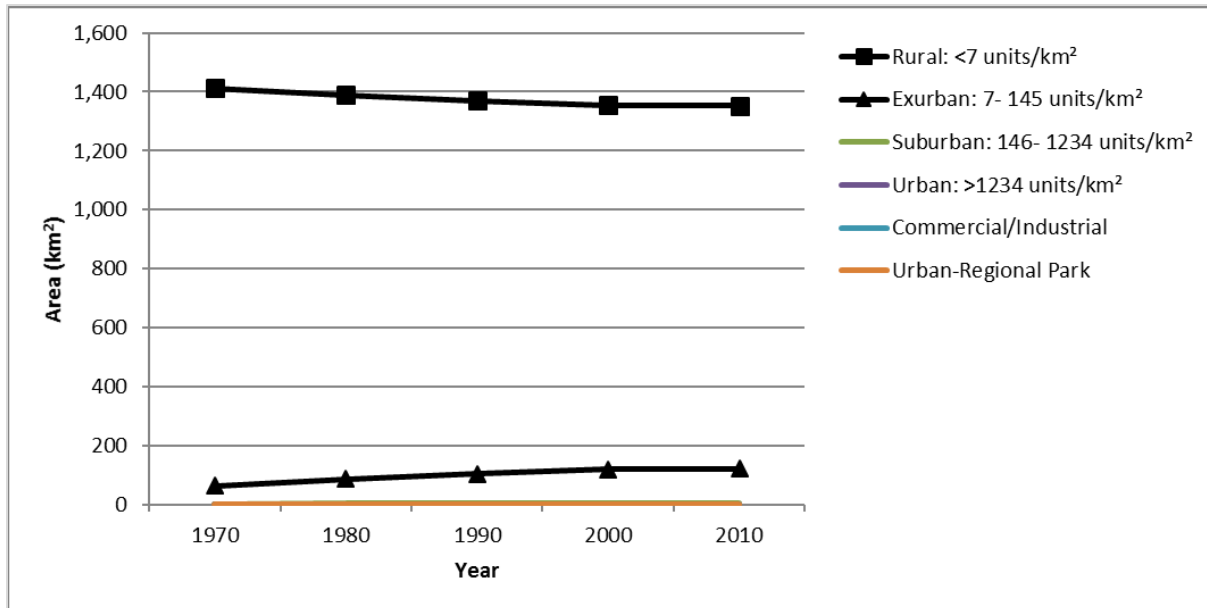


Figure 21. Area (km²) in each housing class from 1970 to 2010 in the Regional Area of Analysis.

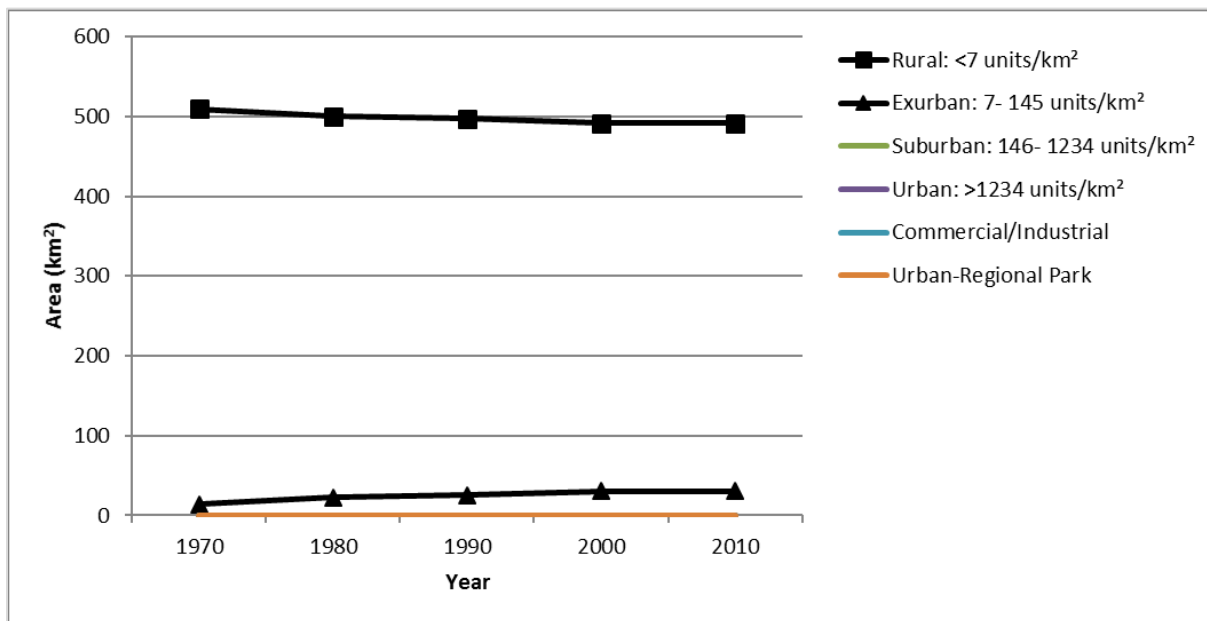


Figure 22. Area (km²) in each housing class from 1970 to 2010 in the Park-Manager-Selected Watersheds Area of Analysis.

Total Population

Between 1990 and 2010, the population increased by 18% in the Regional AOA and by 47% in the Park-Manager-Selected Watersheds AOAs.

The population within the Regional AOA was approximately 5,880 in 1990, 6,722 in 2000, and 6,961 in 2010 (Figure 23; Table A26). The population within the Park-Manager-Selected Watersheds AOA was 1,811 in 1990, 2,225 in 2000, and 2,657 in 2010 (Table A27).

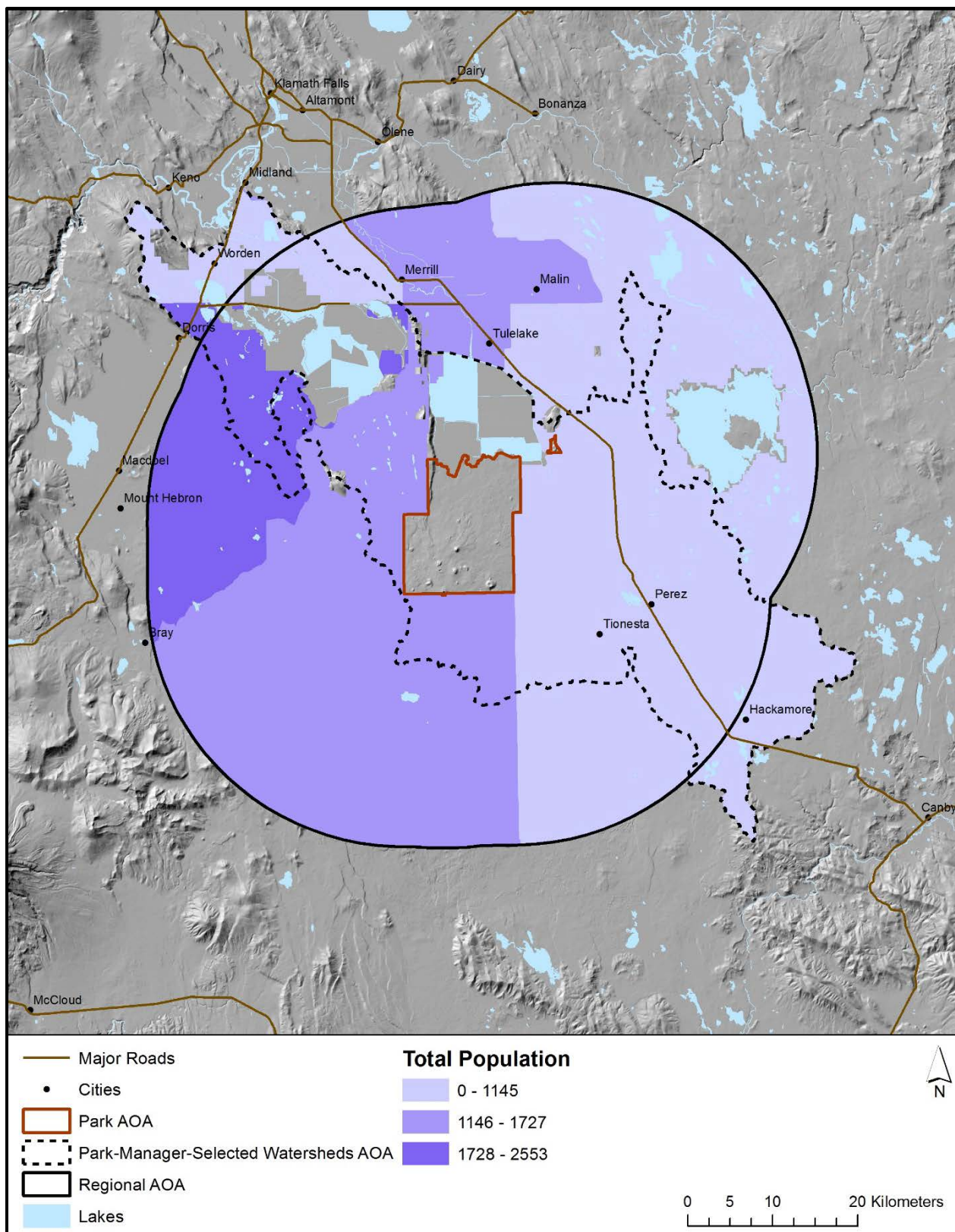


Figure 23. Total population in the Regional and Park-Manager-Selected Watersheds Areas of Analysis (AOA) in 2010. Areas where people are assumed to be absent were masked out; this included water and PAD-US protected areas (status 1 and 2—areas that maintained primarily in a natural state)

Population Density

The population density (individuals per square kilometer) was relatively low throughout the study area (Figure 24). Population density within the Regional AOA increased from 1.41 in 1990, to 1.59 in 2000, to 1.66 in 2010 (Figure 25, Table A26). The population density for the Park-Manager-Selected Watersheds AOA increased from 1.13 in 1990, to 1.37 in 2000, and to 1.64 in 2010 (Figure 25; Table A27).

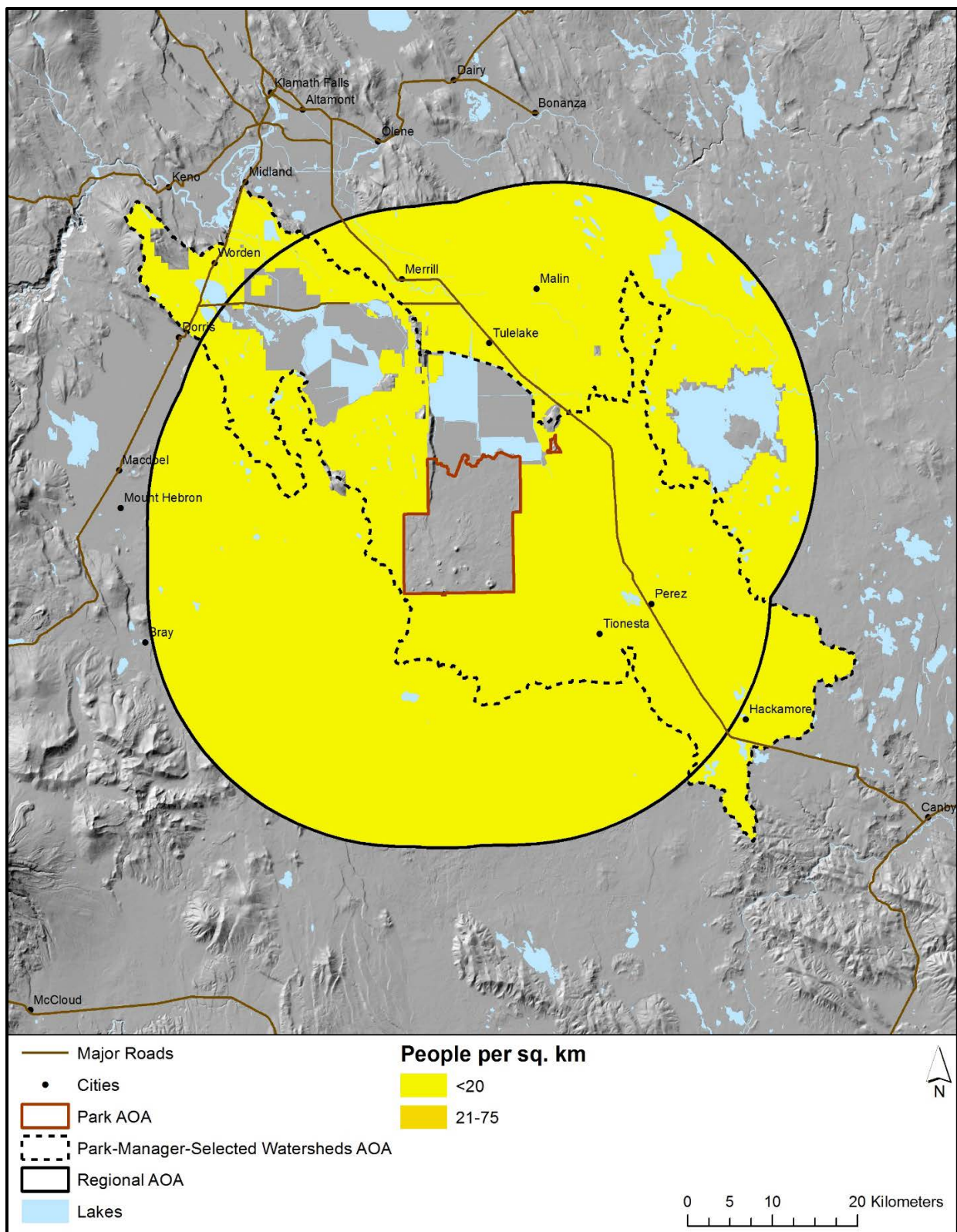


Figure 24. Population density from Census Block-Groups that intersect the Regional and Park-Manager-Selected Watersheds Areas of Analysis (AOAs). Areas where people are assumed to be absent were

masked out; this included water and PAD-US protected areas (status 1 and 2—areas that maintained primarily in a natural state)

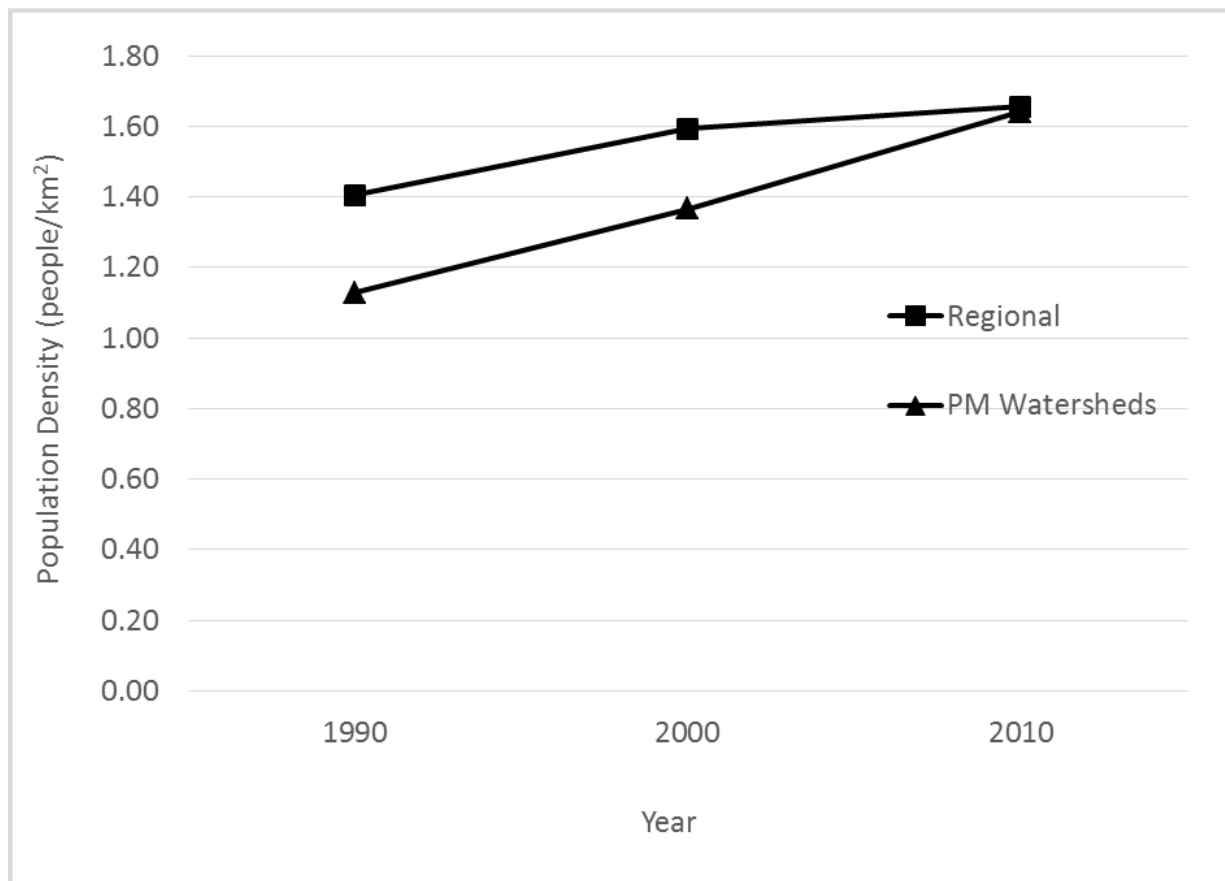


Figure 25. Population density (people/km²) from 1990 to 2010 at Regional and Park-Manager-Selected Watersheds (PM Watersheds) Areas of Analysis.

Roads

As noted in the Methods, the TIGER data we use for road metrics were not always up to date, but they did provide a consistent data source across time and space.

Road Density

The vast majority of roads surrounding the Park were category S1400 (Local Neighborhood Road, Rural Road, City Street; see Methods, Table 8, for road code definitions). The S1400 category included US Forest Service roads.

Between 2010 and 2015, road density decreased slightly in both the Regional and Park-Manager-Selected Watersheds AOAs. Regional AOA road density was 1.26 in 2010 and 1.24 in 2015 (Figures 26 and 27; Tables A28 and A29). Park-Manager-Selected Watersheds AOA road density was 1.26 in 2010 and 1.25 in 2015. Note that this slight decrease in road density over time was surprising and may reflect a problem with the source data. Park AOA road density was 0.33 in 2016, and Park-Manager-Selected Jack Fire road density was 0.59 (Figures 26 and 28; Table A30).

In 2015, total road length in the Regional AOA was 6,210.5 km and 2,815.9 km in the Park-Manager-Selected Watersheds AOA (Tables A28 and A29). In 2016, total road length was 61.7 km in the Park AOA and 13.0 km in the Park-Manager-Selected Jack Fire AOA (Table A30).

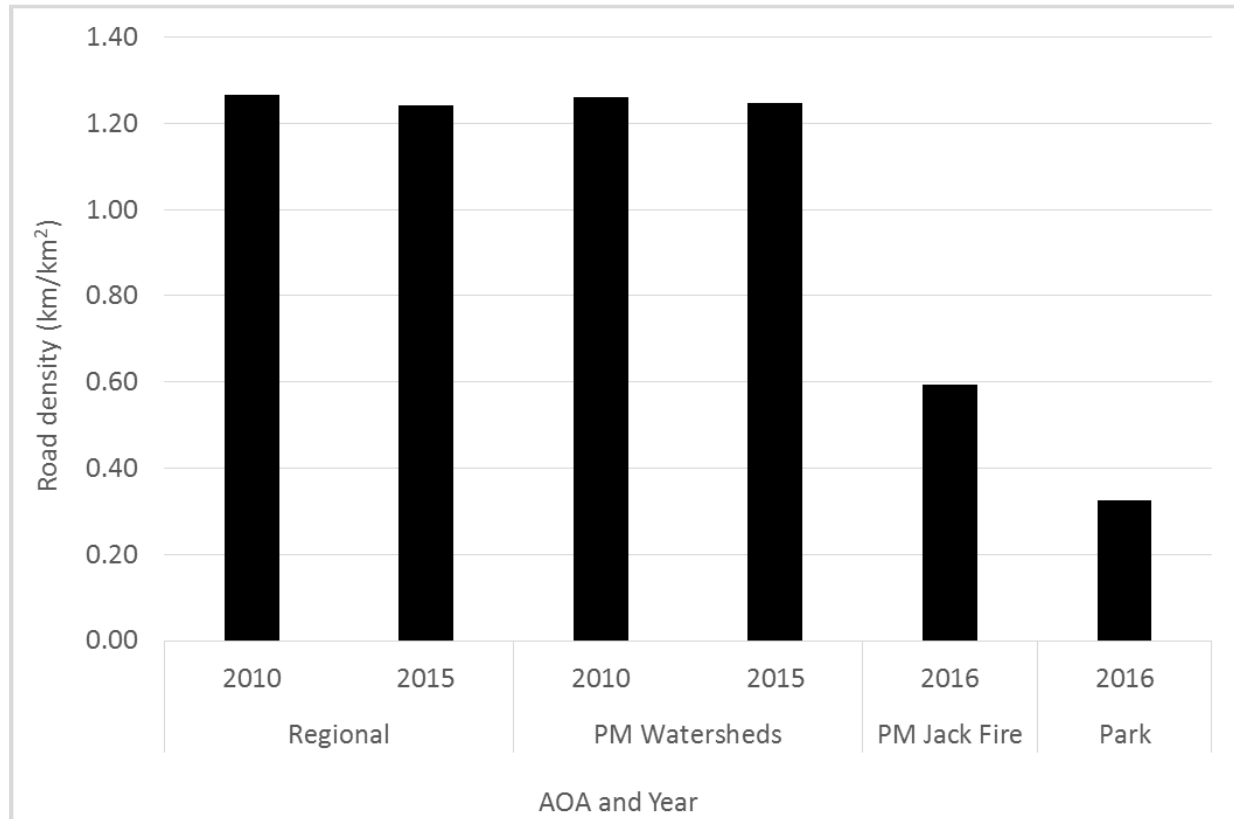


Figure 26. Road density (km/km²) in 2010 and 2015 at the Regional and Park-Manager-Selected Watersheds (PM Watersheds) Areas of Analysis (AOA), and in 2016 at the Park and Park-Manager-Selected Jack Fire (PM Jack Fire) AOA. Note that the 2016 Park and Park-Manager-Selected Jack Fire analyses were done with Lava Beds-supplied data, whereas the Regional and Park-Manager-Selected Watersheds analyses were done with US Census Bureau TIGER data.

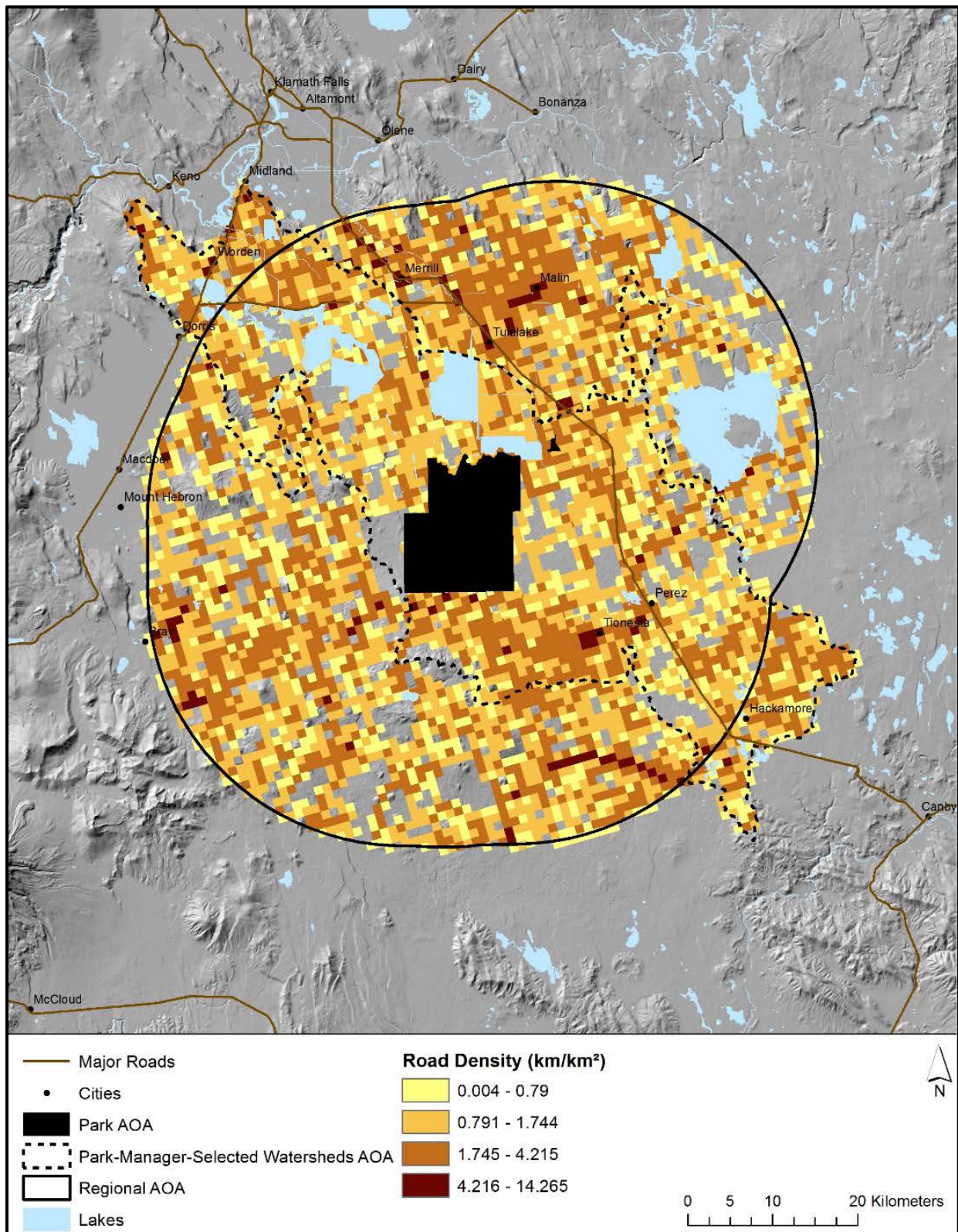


Figure 27. Road density (km/km²) using 2015 US Census Bureau TIGER data at the Regional and Park-Manager-Selected Watersheds (PM Watersheds) Areas of Analysis (AOA). See Figure 28 for Park and Park-Manager-Selected Jack Fire AOAs.

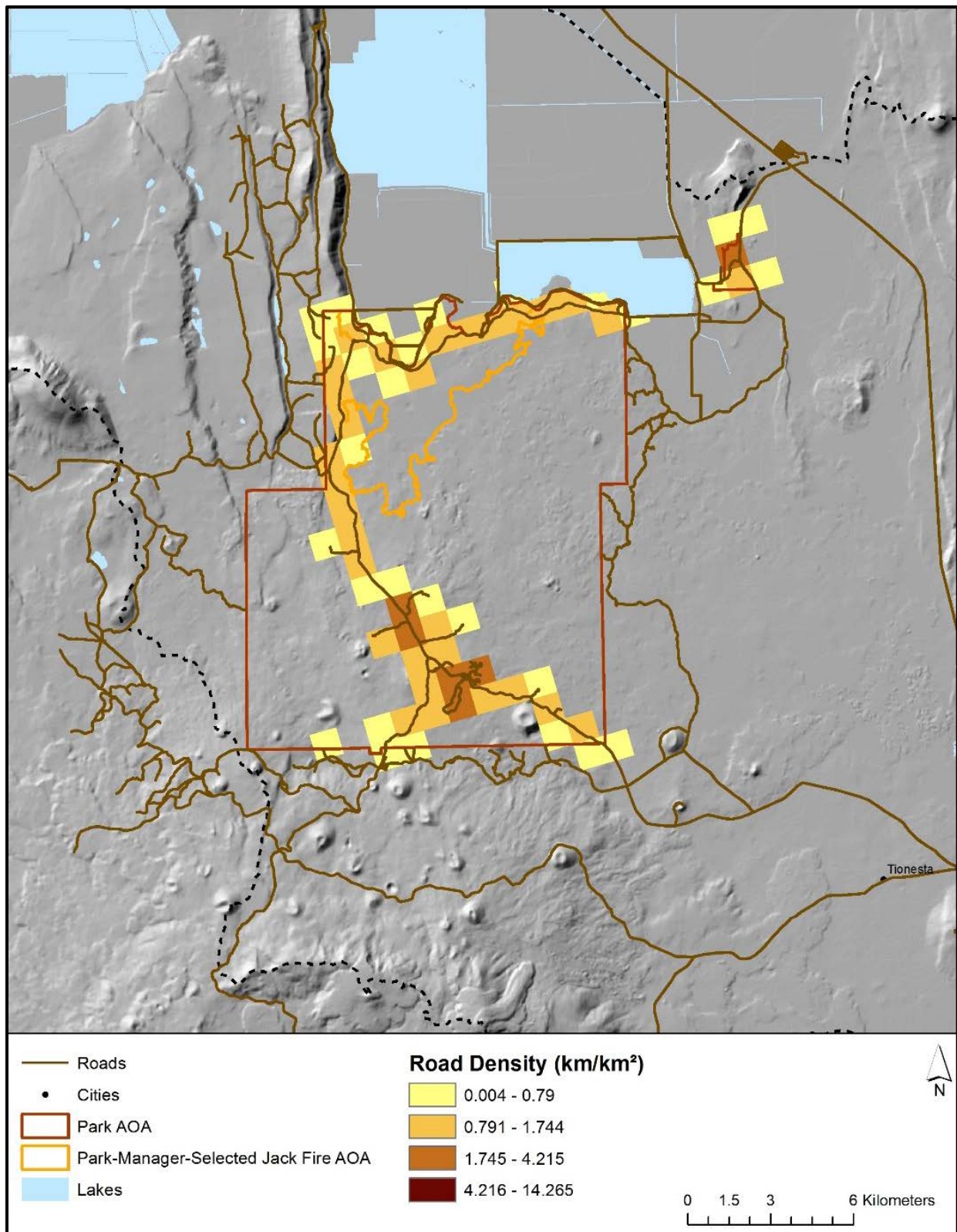


Figure 28. Road density (km/km²) using 2016 Lava Beds National Monument data within the Park and Park-Manager-Selected Jack Fire Area of Analyses (AOAs).

Distance from Roads

Most of the areas that were far from roads were within Lava Beds (Figures 29 and 30). Those areas outside the Park were mostly within US Forest Service and US Fish and Wildlife Service lands.

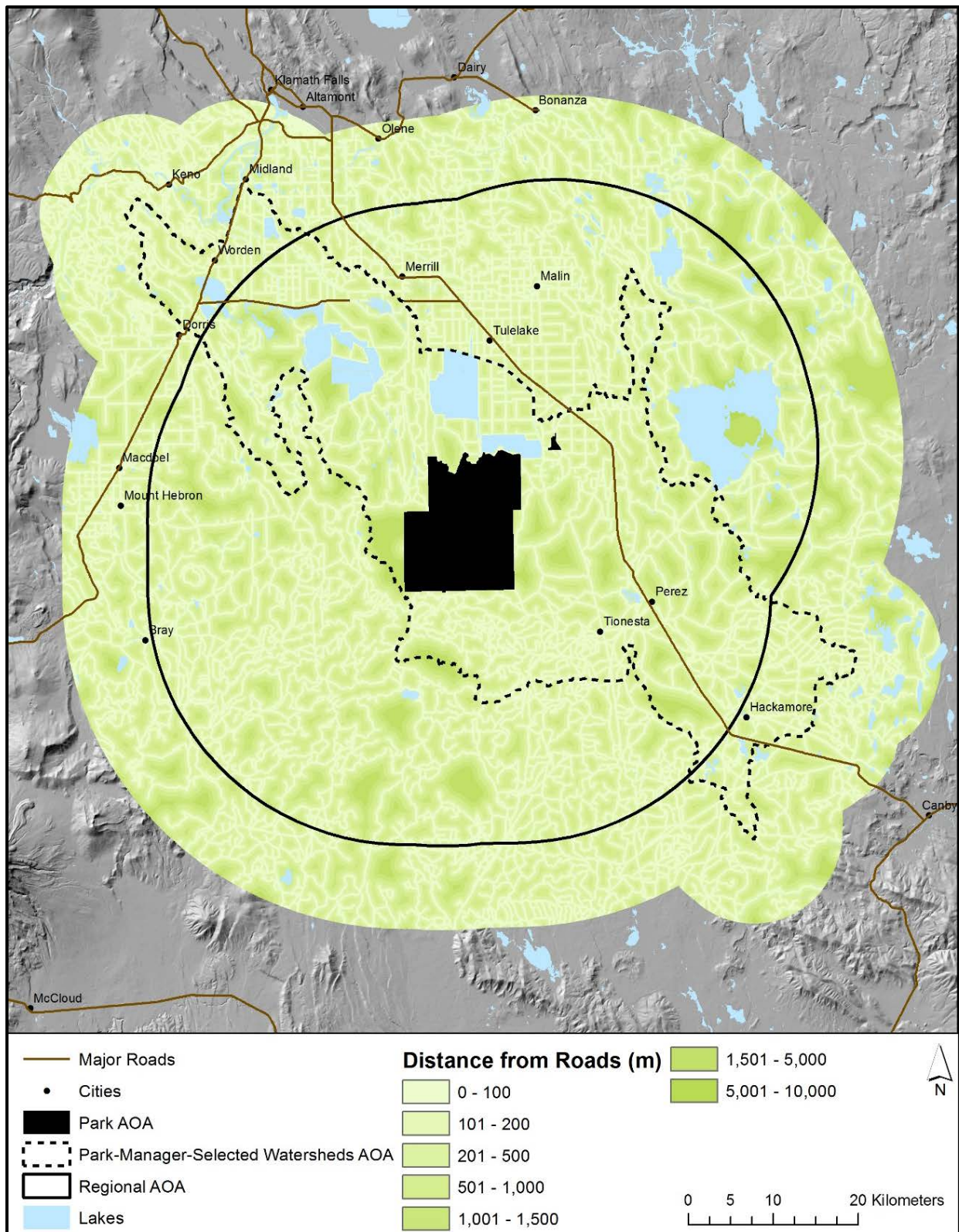


Figure 29. Distance from roads using 2015 US Census Bureau TIGER data in the Regional and Park-Manager-Selected Watersheds (PM Watersheds) Areas of Analysis (AOA). See Figure 30 for Park and Park-Manager-Selected Jack Fire AOAs.

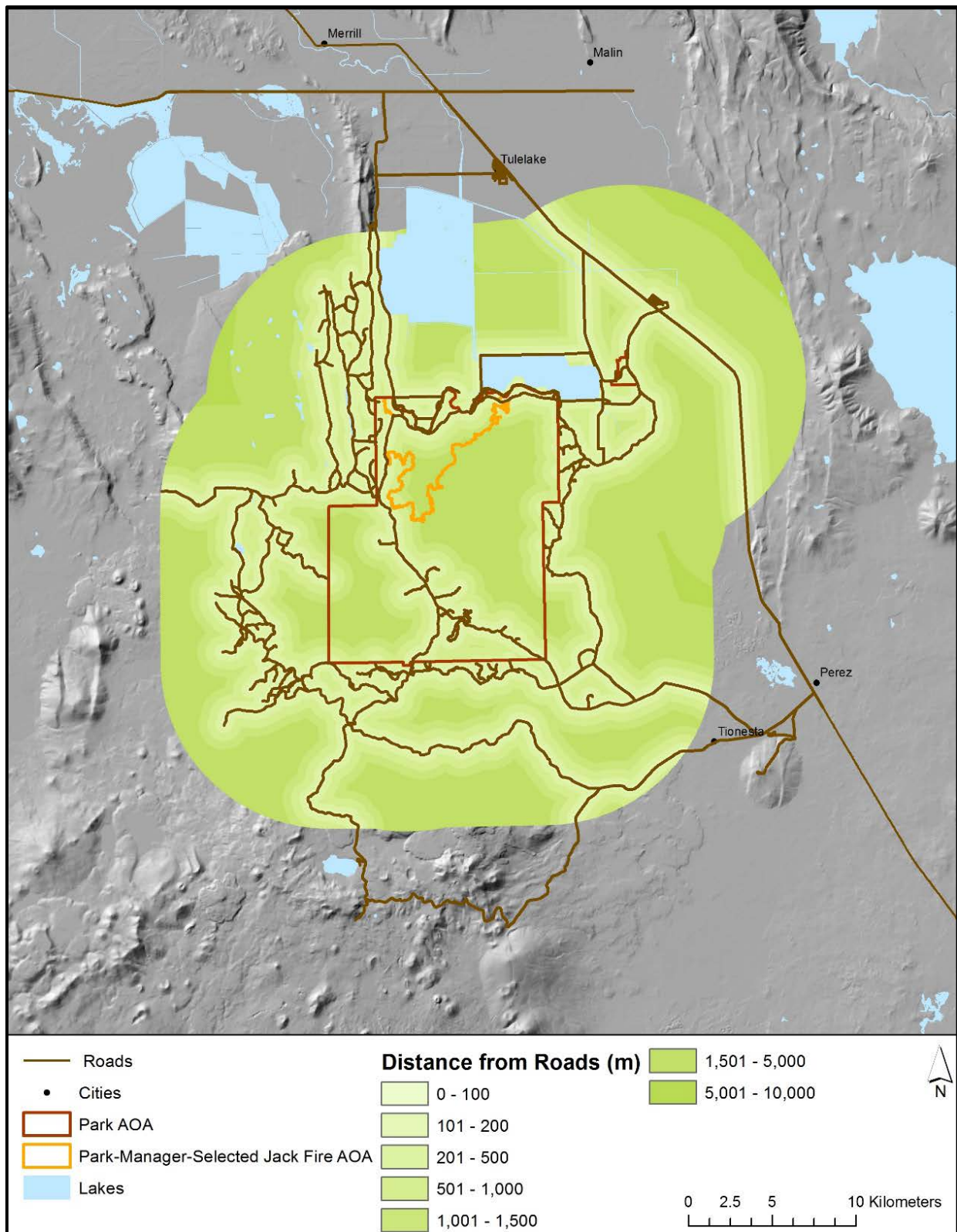


Figure 30. Distance from roads using 2016 Lava Beds National Monument data within the Park and the Park-Manager-Selected Jack Fire Area of Analysis (AOA).

Roadless Areas

The largest areas without roads (patches) were within Lava Beds and to the east of the Park in US Forest Service lands and private land (Figure 31). There was little change in roadless areas between 2010 and 2015. In both 2010 and 2015, the Regional and Park-Manager-Selected Watershed AOAs each contained one patch greater than 100 km², totaling approximately 101 km² (Tables A31 and A32). Because of its small size, the Park-Manager-Selected Jack Fire AOA (2016 data) had only six patches, with five in the 1–10 km² category (Table A33). Within the Park AOA (2016 data), there was one continuously roadless area covering 112 km² (Figure 32; Table A33); most fell within the 1–10 km² category.

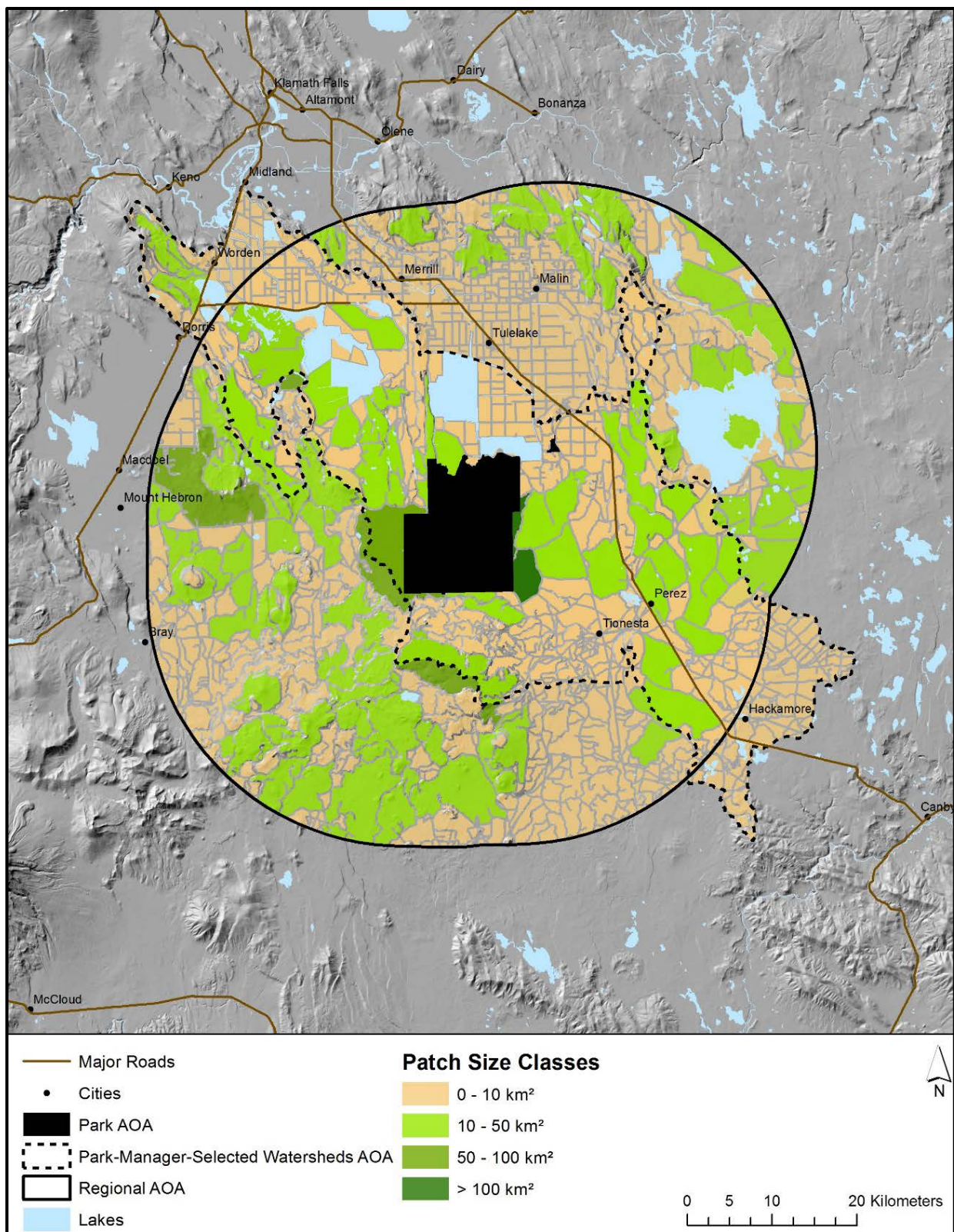


Figure 31. Roadless areas using 2015 US Census Bureau TIGER data, for the Regional and Park-Manager-Selected Watersheds Areas of Analysis (AOA). See Figure 32 for Park and Park-Manager-Selected Jack Fire AOAs.

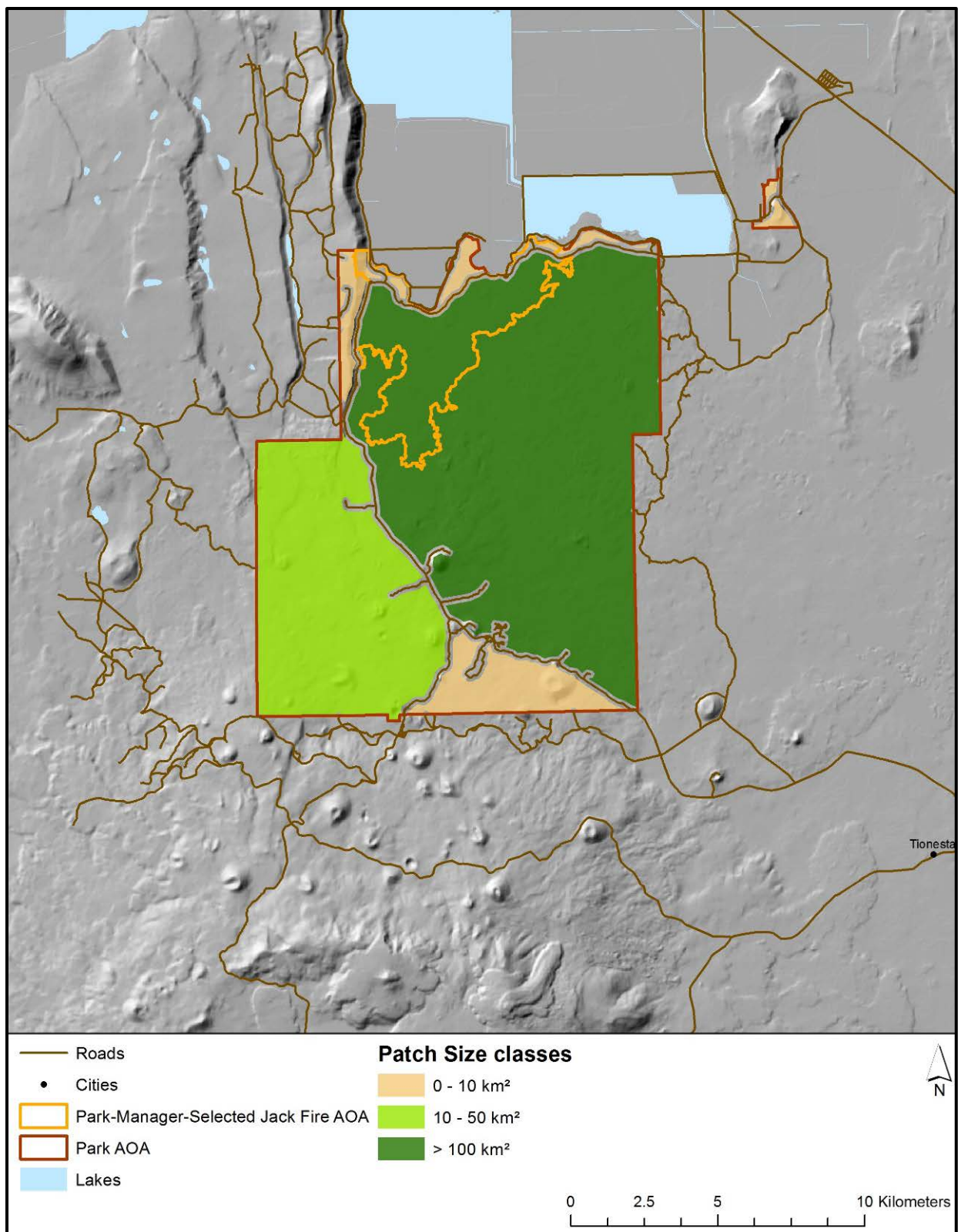


Figure 32. Roadless areas, using 2016 Lava Beds National Monument data within the Park and the Park-Manager-Selected Jack Fire Area of Analysis (AOA).

Disturbance

In the Regional AOA, a cumulative total area of 723.24 km² was disturbed from 1999 to 2012 (Tables A34–A36). Figure 33 shows disturbed area by year within each of the AOAs.

Wildfire affected the most area (299.19 km²), followed by *Thinning* (165.62 km²), and then *Unknown* (99.95 km²) (see Methods, Table 9, for disturbance category definitions). These accounted for 41.4%, 22.9%, and 13.8%, respectively, of the total disturbed areas within the Regional AOA. Figure 34 presents percentage in each disturbance category for each AOA, and Figure 35 illustrates areas affected by each disturbance type.

In the Park-Manager-Selected Watersheds AOA, from 1999 to 2012, the total disturbed area was 331.83 km² (Tables A37–A38). *Wildfire* affected the most area (160.07 km²), followed by *Prescribed Fire* (53.19 km²), and then *Thinning* (50.72 km²). These accounted for 48.2%, 16.0%, and 15.3%, respectively, of the disturbed areas within the Park-Manager-Selected Watersheds AOA.

In the Park-Manager-Selected Jack Fire AOA, from 1999 to 2012, the total disturbed area was 24.51 km² (Table A39), and the only disturbance types were *Wildfire* (100% as extent was created due to Jack Fire) and some *Prescribed Fire* (2.67 km²), which occurred prior to the Jack Fire.

For the Park AOA, from 1999 to 2012, the total disturbed area was 92.79 km² (Table A40). *Wildfire* affected the most area (63.89 km²), followed by *Prescribed Fire* (18.95 km²). These disturbance types accounted for 68.9% and 20.4%, respectively, of all disturbed areas within the Park AOA.

Figures 36 and 37 plot the area affected by each of the largest disturbance types over time within the Regional and Park-Manager-Selected Watersheds AOAs, respectively.

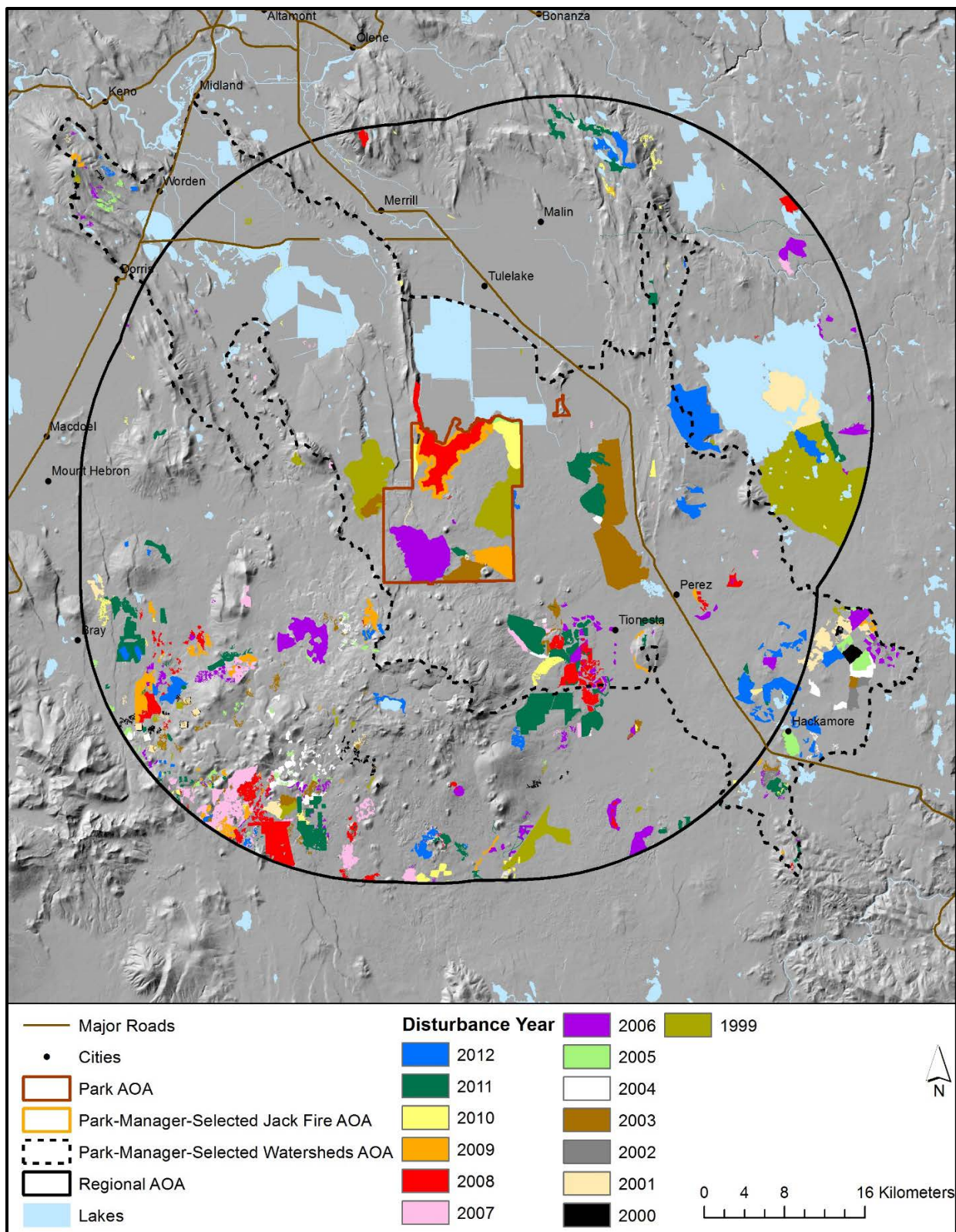


Figure 33. Locations of disturbances by year (1999–2012) at Regional, Park-Manager-Selected Watersheds, Park-Manager-Selected Jack Fire, and Park Areas of Analysis (AOA).

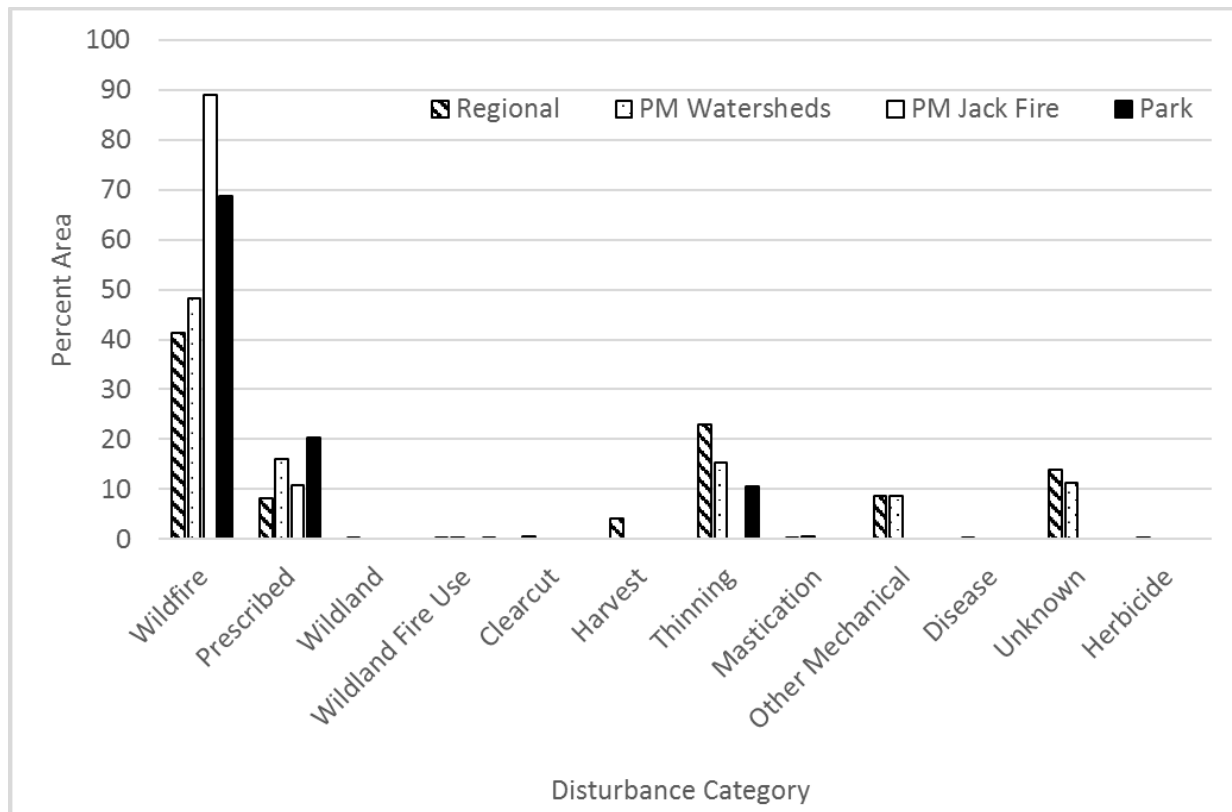


Figure 34. Percentage area (area disturbed/total disturbed area for that Area of Analysis (AOA)) affected by each disturbance type from 1999 to 2012, at the Regional, Park-Manager-Selected Watersheds (PM Watersheds), Park-Manager-Selected Jack Fire (PM Jack Fire), and Park Areas of Analysis.

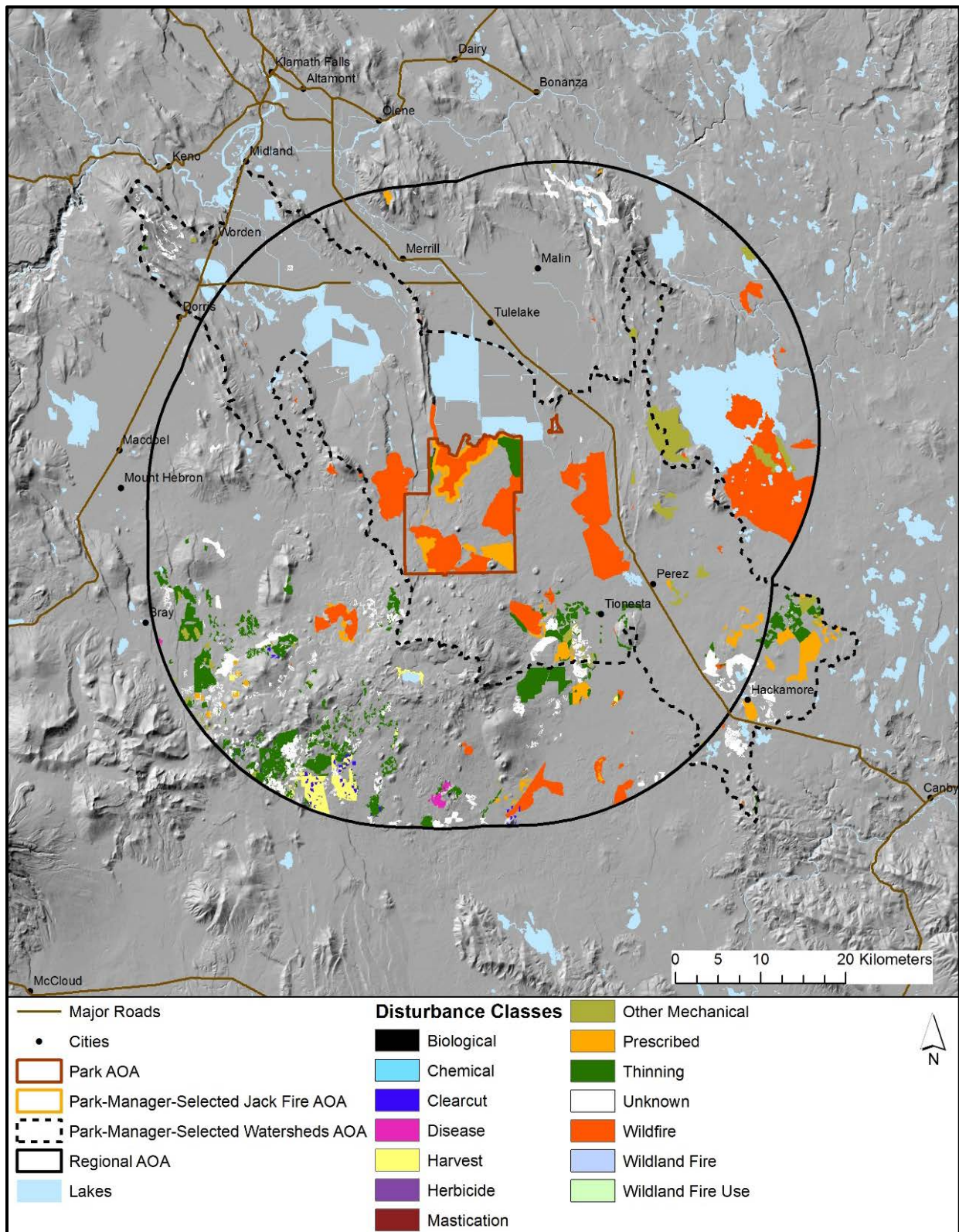


Figure 35. Areas affected by different disturbance types from 1999–2012, for Regional, Park-Manager-Selected Watersheds, Park-Manager-Selected Jack Fire, and Park Areas of Analysis (AOA).

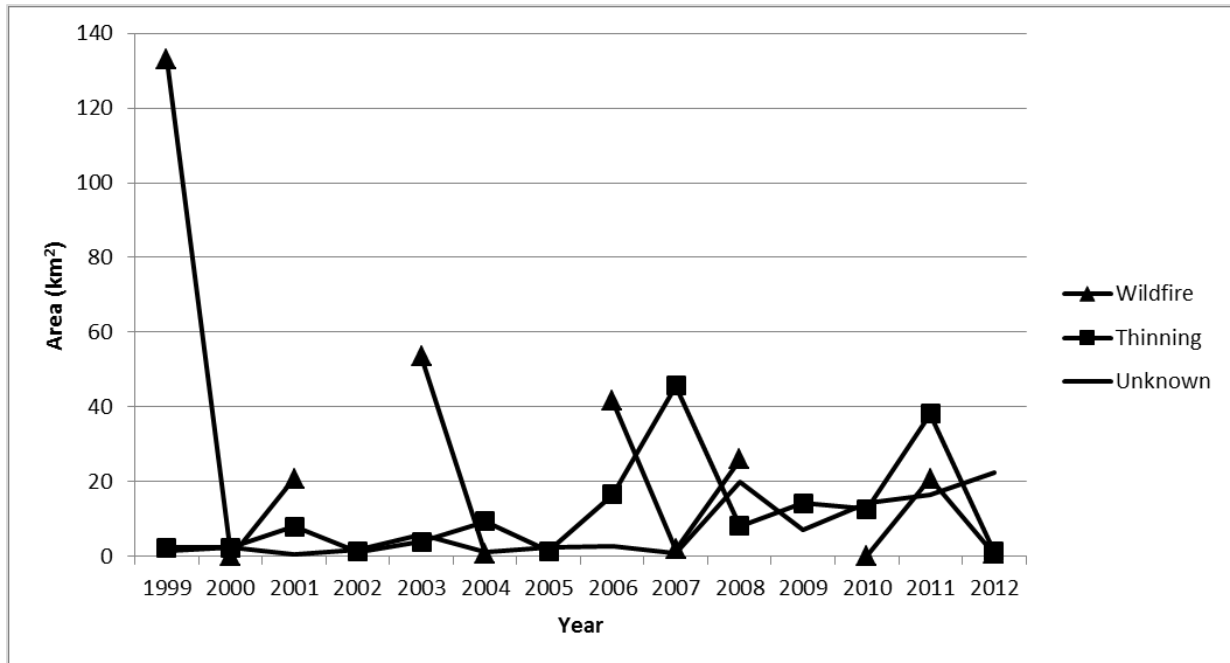


Figure 36. Total area (km²) affected by the three largest disturbance types, by year, for the Regional Area of Analysis. Complete disturbance type values are in Tables A34–A36.

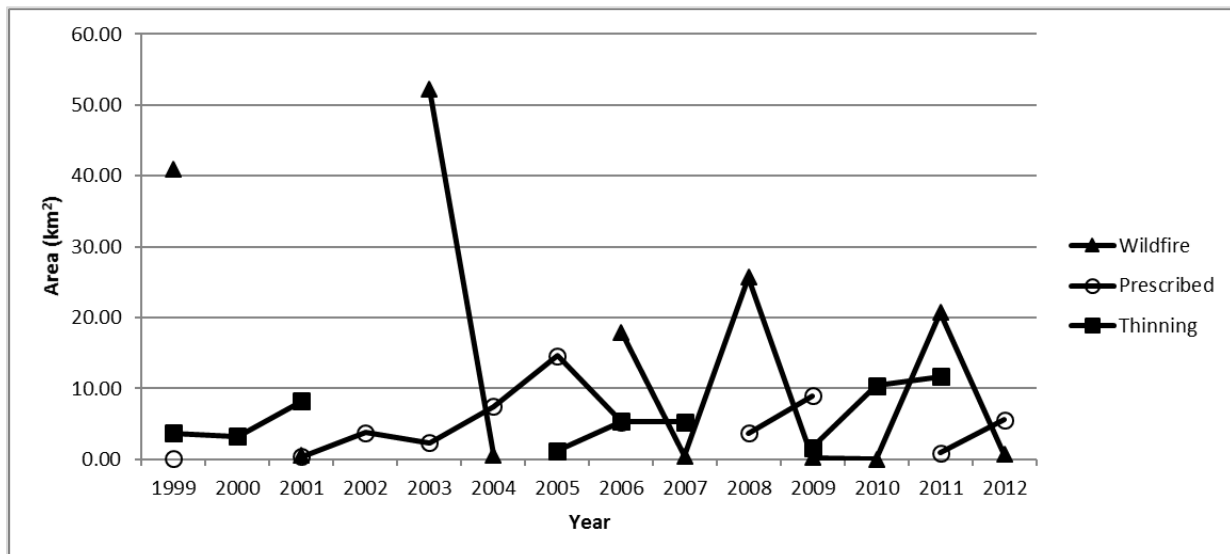


Figure 37. Total area (km²) affected by the three largest disturbance types, by year, for the Park-Manager-Selected Watersheds Area of Analysis. Complete disturbance type values are in Tables A37–A38.

Discussion

This report summarizes landscape level information about Lava Beds and its surrounding areas from largely regional- and national-level datasets. In the Regional AOA, the vegetation was primarily evergreen forest and shrub/scrub. Within both Park-Manager-Selected AOAs, the vegetation was primarily shrub/scrub, followed by herbaceous. The Park AOA was dominated by shrub/scrub, followed by barren land and herbaceous.

While use or management of the Park may degrade the existing areas, the Park itself and nearby US Fish and Wildlife Service lands are protected from conversion of natural land (GAP Conservation Status 2). The US Forest Service and Bureau of Land Management lands outside the Park were mostly GAP Conservation Status 3, which means that even though the area has protection from conversion of natural land, extractive use is allowed.

Small patches of forest, grassland, and shrubland cover were abundant. Forest patches were large and intact. Grassland and shrubland occurred in smaller patches.

Most of the study area was considered to be in natural condition, with few impervious surfaces. There were few roads within the Park; more roads existed outside the Park boundary. While the population and housing increased in the areas surrounding the Park, they were still relatively low in 2010. A variety of disturbances occurred, including harvest, thinning, and prescribed burns, in the areas outside the Park. The biggest disturbance, however, was fire.

As mentioned in the Methods, TIGER data are not always kept up to date and may therefore be inaccurate. For future analyses, it would be highly beneficial for parks to update the US Census Bureau TIGER dataset with current park data.

Looking at individual indicators and how they change over time can provide useful information to land managers. While the individual statistics are important, there is also power in taking an integrated approach. A land manager could look for correlation and causation by examining individual landscape 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 land bird monitoring surveys, detailed vegetation maps, and park-specific projects (such as prescribed burning and invasive plant management actions), can help provide an integrated look at ecosystem dynamics.

Managers can also compare what is occurring inside park boundaries with conditions 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 Lava Beds summarizes data from 2006 to 2016 (varies by indicator) and was developed as a “proof of concept” for the Klamath Network 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 Inventory and Monitoring Landscape Dynamics protocol, as implemented for Klamath Network parks in 2021. Monitoring land

cover and land use will continue to be a team effort between specialists in the Park, Inventory and Monitoring staff (Central Office, Klamath Network), and the national landscape dynamics protocol staff.

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Appendix A: Data Tables

Table A1. Area and percentage of AOA attributed to different landowners for the Regional and Park-Manager-Selected Watersheds AOAs, using USGS Gap Analysis Program (GAP), Protected Areas Database for US (PAD-US) 2012 data. *Note that the percentage could be larger depending on the composition of the unavailable data.

Owner Name	Regional		Park-Manager-Selected- Watersheds	
	Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
Forest Service (USFS)	2568.54	51.38	1108.31	49.06
Fish and Wildlife Service (FWS)	455.49	9.11	370.98	16.42
Bureau of Land Management (BLM)	283.03	5.66	68.10	3.01
National Park Service (NPS)	190.25	3.81	190.25	8.42
Bureau of Reclamation (BOR)	36.94	0.74	0.00	0.00
Private Landowner	29.36	0.59	17.79	0.79
State Fish and Wildlife	1.80	0.04	0.70	0.03
Other Federal Land	0.62	0.01	0.54	0.02
State Department of Land	0.49	0.01	—	—
State Department of Natural Resources	0.15	<0.01	6.86	0.30
Unknown	0.13	<0.01	0.08	<0.01
County Land	0.01	<0.01	—	—
Unavailable Data	1432.35	28.65	495.60	21.94

Table A2. Area (km²) and minimum percentage of AOA attributed to USGS Gap Analysis Program (GAP) Protected Areas Database for the US (PAD-US) conservation status rankings for the Regional and Park-Manager-Selected Watersheds AOAs. *Note that the percentage could be larger depending on the composition of the unavailable data.

Status	Description	Regional		Park-Manager-Selected- Watersheds	
		Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
1	Managed for biodiversity, natural disturbance allowed	<0.01	<0.01	<0.01	<0.01
2	Managed for biodiversity, natural disturbance NOT allowed	654.54	13.09	564.81	25.00

Table A2 (continued). Area (km²) and minimum percentage of AOA attributed to USGS Gap Analysis Program (GAP) Protected Areas Database for the US (PAD-US) conservation status rankings for the Regional and Park-Manager-Selected Watersheds AOA. *Note that the percentage could be larger depending on the composition of the unavailable data.

Status	Description	Regional		Park-Manager-Selected-Watersheds	
		Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
3	Managed for multiple use	2882.84	57.67	1180.92	52.27
4	No known mandate	29.43	0.59	17.86	0.79
N/A	Unavailable	1432.35	28.65	495.60	21.94

Table A3. Area and percentage of AOA by National Land Cover Data land cover classes in the Regional AOA for 2006 and 2011.

Level 2	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
Open Water	175.46	3.51	132.58	2.65
Developed, Open Space	56.51	1.13	55.94	1.12
Developed, Low Intensity	13.17	0.26	13.14	0.26
Developed, Medium Intensity	1.57	0.03	2.04	0.04
Developed, High Intensity	0.30	0.01	0.43	0.01
Barren Land	164.77	3.30	164.36	3.29
Deciduous Forest	0.39	0.01	0.19	<0.01
Evergreen Forest	1579.76	31.60	1528.05	30.57
Mixed Forest	0.02	<0.01	0.02	<0.01
Shrub/Scrub	1330.48	26.61	1370.81	27.42
Herbaceous	844.44	16.89	855.20	17.11
Hay/Pasture	408.08	8.16	410.49	8.21
Cultivated Crops	380.03	7.60	386.73	7.74
Woody Wetlands	0.94	0.02	0.81	0.02
Herbaceous Wetlands	43.26	0.87	78.39	1.57

Table A4. Area and percentage of AOA by National Land Cover Data land cover classes in the Park-Manager-Selected Watersheds AOA for 2006 and 2011.

Level 2	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
Open Water	98.64	4.37	56.88	2.52
Developed, Open Space	26.15	1.16	25.93	1.15
Developed, Low Intensity	6.05	0.27	6.04	0.27
Developed, Medium Intensity	0.41	0.02	0.59	0.03
Developed, High Intensity	0.04	<0.01	0.10	<0.01
Barren Land	65.66	2.91	65.60	2.90
Deciduous Forest	0.07	<0.01	0.04	<0.01
Evergreen Forest	396.56	17.55	376.58	16.67
Mixed Forest	0.01	0.00	0.01	0.00
Shrub/Scrub	710.05	31.43	722.06	31.96
Herbaceous	478.18	21.17	485.24	21.48
Hay/Pasture	306.65	13.57	307.86	13.63
Cultivated Crops	132.55	5.87	139.73	6.18
Woody Wetlands	0.25	0.01	0.25	0.01
Herbaceous Wetlands	37.91	1.68	72.28	3.20

Table A5. Area and percentage of Areas of Analysis by National Land Cover Data classes in the Park-Manager-Selected Jack Fire AOA for 2006 and 2011.

Level 2	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
Developed, Open Space	0.43	1.99	0.43	1.99
Developed, Low Intensity	0.08	0.37	0.08	0.37
Barren Land	0.37	1.69	0.37	1.69
Evergreen Forest	0.01	0.05	0.01	0.05
Shrub/Scrub	11.19	51.24	11.19	51.24
Herbaceous	9.74	44.58	9.74	44.58
Hay/Pasture	0.01	0.06	0.01	0.06
Cultivated Crops	<0.01	0.02	<0.01	0.02

Table A6. Area and percentage of Areas of Analysis by National Land Cover Data classes in the Park AOA for 2006 and 2011.

Level 2	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
Open Water	<0.01	<0.01	<0.01	<0.01
Developed, Open Space	3.07	1.62	3.07	1.62
Developed, Low Intensity	0.42	0.22	0.42	0.22
Developed, Medium Intensity	0.01	<0.01	0.01	<0.01
Barren Land	34.04	17.97	34.03	17.96
Evergreen Forest	16.13	8.52	15.55	8.21
Shrub/Scrub	105.12	55.49	105.59	55.74
Herbaceous	30.36	16.03	30.48	16.09
Hay/Pasture	0.25	0.13	0.25	0.13
Cultivated Crops	0.04	0.02	0.04	0.02

Table A7. Area and percentage of AOA by Impervious Surface class in the Regional AOA, for 2006 and 2011.

Impervious Surface	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
0% - 2%	4840.06	96.82	4839.98	96.82
2% - 4%	35.21	0.70	35.05	0.70
4% - 6%	24.02	0.48	23.91	0.48
6% - 8%	19.42	0.39	19.31	0.39
8% - 10%	16.32	0.33	16.21	0.32
10% - 15%	25.62	0.51	25.43	0.51
15% - 25%	21.26	0.43	21.09	0.42
25% - 50%	13.60	0.27	13.56	0.27
50% - 100%	3.65	0.07	4.62	0.09

Table A8. Area and percentage of AOA by Impervious Surface class in the Park-Manager-Selected Watersheds AOA, for 2006 and 2011.

Impervious Surface	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
0% - 2%	2188.80	96.89	2188.76	96.88
2% - 4%	16.53	0.73	16.49	0.73
4% - 6%	8.60	0.38	8.55	0.38
6% - 8%	6.48	0.29	6.43	0.28
8% - 10%	6.10	0.27	6.05	0.27
10% - 15%	12.20	0.54	12.12	0.54
15% - 25%	11.97	0.53	11.89	0.53
25% - 50%	7.18	0.32	7.15	0.32
50% - 100%	1.31	0.06	1.73	0.08

Table A9. Area and percentage of AOA by Impervious Surface group in the Park-Manager-Selected Jack Fire AOA, for 2006 and 2011.

Impervious Surface	2006		2011	
	Area (km2)	Percentage of AOA	Area (km2)	Percentage of AOA
0% - 2%	21.35	97.64	21.35	97.64
2% - 4%	0.03	0.13	0.03	0.13
4% - 6%	0.02	0.07	0.02	0.07
6% - 8%	0.01	0.03	0.01	0.03
8% - 10%	0.02	0.07	0.02	0.07
10% - 15%	0.12	0.55	0.12	0.55
15% - 25%	0.26	1.19	0.26	1.19
25% - 50%	0.06	0.29	0.06	0.29
50% - 100%	0.01	0.02	0.01	0.02

Table A10. Area and percentage of AOA by Impervious Surface class in the Park AOA, for 2006 and 2011.

Impervious Surface	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
0% - 2%	184.80	97.55	184.80	97.55
2% - 4%	0.39	0.21	0.39	0.21
4% - 6%	0.33	0.18	0.33	0.18
6% - 8%	0.40	0.21	0.40	0.21
8% - 10%	0.53	0.28	0.52	0.28
10% - 15%	1.18	0.62	1.18	0.62
15% - 25%	1.34	0.71	1.34	0.71
25% - 50%	0.44	0.23	0.44	0.23
50% - 100%	0.04	0.02	0.05	0.03

Table A11. Area and percentage of AOA in *Natural* or *Converted* land in the Regional AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percentage Area	Area (km ²)	Percentage Area	
Natural	4139.50	82.80	4130.41	82.62	-0.22
Converted	859.66	17.20	868.76	17.38	1.05

Table A12. Area and percentage of AOA in *Natural* or *Converted* land in the Park-Manager-Selected Watersheds AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percentage Area	Area (km ²)	Percentage Area	
Natural	1787.31	79.11	1778.92	78.74	-0.47
Converted	471.85	20.89	480.24	21.26	1.75

Table A13. Area and percentage of AOA in *Natural* or *Converted* land in the Park-Manager-Selected Jack Fire AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percentage Area	Area (km ²)	Percentage Area	
Natural	21.31	97.57	21.31	97.57	0.00
Converted	0.53	2.43	0.53	2.43	0.00

Table A14. Area and percentage of AOA in *Natural* or *Converted* land in the Park AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percentage Area	Area (km ²)	Percentage Area	
Natural	185.66	98.00	185.66	98.00	0.00
Converted	3.79	2.00	3.79	2.00	0.00

Table A15. Area, percentage of AOA, and percentage of forest area by forest morphology classification in the Regional and Park-Manager-Selected AOA for 2011.

Forest Morphology Classification	2011			2011			2011		
	Regional			Park-Manager-Selected - Watersheds			Park-Manager-Selected - Jack Fire		
	Area (km ²)	Percentage of AOA	Percentage of Forested Area	Area (km ²)	Percentage of AOA	Percentage of Forested area	Area (km ²)	Percentage of AOA	Percentage of Forested area
Background (non- forested)	3470.20	69.42	NA	1882.37	83.32	NA	21.83	99.95	NA
Branch	32.34	0.65	2.12	9.58	0.42	2.54	–	–	–
Edge	307.88	6.16	20.14	79.18	3.51	21.01	–	–	–
Islet	104.44	2.09	6.83	46.41	2.05	12.32	0.01	0.05	100.00
Core	685.47	13.71	44.83	126.34	5.59	33.53	–	–	–
Bridge	280.60	5.61	18.35	93.45	4.14	24.80	–	–	–
Perforated	94.04	1.88	6.15	14.03	0.62	3.72	–	–	–
Loop	24.18	0.48	1.58	7.83	0.35	2.08	–	–	–

Table A16. Area, percentage of AOA, and percentage of grassland area by pattern morphology classification in the Regional and Park-Manager-Selected AOA, for 2011.

Grassland Pattern Morphology Classification	2011			2011			2011		
	Regional			Park-Manager-Selected - Watersheds			Park-Manager-Selected - Jack Fire		
	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland
Background (non- grassland)	3733.48	74.68	NA	1466.06	64.89	NA	12.09	55.36	NA
Branch	55.05	1.10	4.35	32.38	1.43	4.08	0.48	2.20	4.94

Table A16 (continued). Area, percentage of AOA, and percentage of grassland area by pattern morphology classification in the Regional and Park-Manager-Selected AOA's, for 2011.

Grassland Pattern Morphology Classification	2011			2011			2011		
	Regional			Park-Manager-Selected - Watersheds			Park-Manager-Selected - Jack Fire		
	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland
Edge	274.95	5.50	21.72	173.43	7.68	21.87	0.95	4.36	9.76
Islet	253.63	5.07	20.04	127.93	5.66	16.13	1.91	8.75	19.59
Core	223.86	4.48	17.69	175.65	7.78	22.15	0.09	0.42	0.94
Bridge	400.75	8.02	31.66	250.77	11.10	31.62	6.24	28.56	63.97
Perforated	5.44	0.11	0.43	4.00	0.18	0.50	0	0	0
Loop	52.01	1.04	4.11	28.94	1.28	3.65	0.08	0.35	0.79

Table A17. Area, percentage of AOA, and percentage of shrubland area by pattern morphology classification in the Regional and Park-Manager-Selected AOA's for 2011.

Shrubland Pattern Morphology Classification	2011			2011			2011		
	Regional			Park-Manager-Selected- Watersheds			Park-Manager-Selected- Jack Fire		
	Area (km ²)	Percentage of AOA	Percentage of Shrubland	Area (km ²)	Percentage of AOA	Percentage of Shrubland	Area (km ²)	Percentage of AOA	Percentage of Shrubland
Background (non- shrubland)	3628.36	72.58	NA	1537.14	68.04	NA	10.66	48.82	NA
Branch	62.11	1.24	4.53	28.65	1.27	3.97	0.52	2.38	4.65
Edge	224.37	4.49	16.37	126.30	5.59	17.49	1.73	7.92	15.48
Islet	299.91	6.00	21.88	136.26	6.03	18.87	3.51	16.06	31.38
Core	95.13	1.90	6.94	58.52	2.59	8.10	0.32	1.47	2.87

Table A17 (continued). Area, percentage of AOA, and percentage of shrubland area by pattern morphology classification in the Regional and Park-Manager-Selected AOAs for 2011.

Shrubland Pattern Morphology Classification	2011			2011			2011		
	Regional			Park-Manager-Selected- Watersheds			Park-Manager-Selected- Jack Fire		
	Area (km ²)	Percentage of AOA	Percentage of Shrubland	Area (km ²)	Percentage of AOA	Percentage of Shrubland	Area (km ²)	Percentage of AOA	Percentage of Shrubland
Bridge	658.37	13.17	48.03	361.33	15.99	50.04	5.10	23.35	45.62
Perforated	5.48	0.11	0.40	3.44	0.15	0.48	0	0	0
Loop	25.44	0.51	1.86	7.54	0.33	1.04	0	0	0

Table A18. Count and total area by patch size range, for forest in the Regional and Park-Manager-Selected AOAs, for 2011.

Patch Size Range, in km ²	2011		2011		2011	
	Regional		Park-Manager-Selected Watersheds		Park-Manager-Selected Jack Fire	
	Count	Total Area (km ²)	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	4454	109.76	2263	50.53	1	0.01
1 to <5	9	21.26	6	13.67	0	0
5 to <10	3	25.51	0	0	0	0
10 to <25	3	53.11	3	52.30	0	0
25 to <50	1	38.62	1	48.22	0	0
50 to <100	3	233.96	1	85.46	0	0
100 to <250	1	112.47	1	126.63	0	0
250 to <500	1	258.98	0	0	0	0
500 to <1000	1	675.30	0	0	0	0
>1,000	0	0	0	0	0	0
Total	4476	1528.96	2275	376.82	1	0.01

Table A19. Count and total area by patch size range, for grassland in the Regional and Park-Manager-Selected AOAs, for 2011.

Patch Size Range, in km ²	2011		2011		2011	
	Regional		Park-Manager-Selected Watersheds		Park-Manager-Selected Jack Fire	
	Count	Total Area (km ²)	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	8244	252.47	4524	125.97	110	3.36
1 to <5	81	161.42	52	115.25	0	0
5 to <10	10	69.51	6	46.76	1	6.39
10 to <25	8	116.10	2	33.66	0	0
25 to <50	6	220.48	4	125.72	0	0
50 to <100	3	204.89	2	109.51	0	0
100 to <250	2	240.84	2	236.24	0	0

Table A19 (continued). Count and total area by patch size range, for grassland in the Regional and Park-Manager-Selected AOAs, for 2011.

Patch Size Range, in km ²	2011		2011		2011	
	Regional		Park-Manager-Selected Watersheds		Park-Manager-Selected Jack Fire	
	Count	Total Area (km ²)	Count	Total Area (km ²)	Count	Total Area (km ²)
250 to <500	0	0	0	0	0	0
500 to <1000	0	0	0	0	0	0
>1,000	0	0	0	0	0	0
Total	8354	1265.69	4592	793.10	111	9.75

Table A20. Count and total area by patch size range, for shrubland in the Regional and Park-Manager-Selected AOAs, for 2011.

Patch Size Range, in km ²	2011		2011		2011	
	Regional		Park-Manager-Selected Watersheds		Park-Manager-Selected Jack Fire	
	Count	Total Area (km ²)	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	10039	283.74	5036	132.78	108	3.92
1 to <5	33	66.33	18	43.23	2	7.25
5 to <10	11	66.03	4	21.79	0	0
10 to <25	7	111.83	3	55.42	0	0
25 to <50	2	66.66	2	90.99	0	0
50 to <100	1	85.40	2	140.70	0	0
100 to <250	3	433.59	2	237.13	0	0
250 to <500	1	257.22	0	0	0	0
500 to <1000	0	0	0	0	0	0
>1,000	0	0	0	0	0	0
Total	10097	1370.80	5067	722.05	110	11.18

Table A21. Area, percentage of AOA, and percentage of forest area by pattern density classification in the Regional and Park-Manager-Selected AOAs, for 2011.

Forest Pattern Density Classification	2011			2011			2011		
	Regional		Percentage of AOA	Park-Manager-Selected Watersheds		Percentage of AOA	Park-Manager-Selected Jack Fire		Percentage of AOA
	Area (km ²)	Percentage of Forested area		Area (km ²)	Percentage of Forested area		Area (km ²)	Percentage of Forested area	
Rare	180.59	8.10	3.61	84.60	12.83	3.74	0.05	50.91	0.23
Patchy	415.32	18.63	8.31	171.14	25.96	7.58	0.05	49.09	0.22
Transitional	207.79	9.32	4.16	73.91	11.21	3.27	–	–	–
Dominant	372.52	16.71	7.45	112.26	17.03	4.97	–	–	–
Interior	203.30	9.12	4.07	52.46	7.96	2.32	–	–	–
Intact	849.40	38.11	16.99	164.88	25.01	7.30	–	–	–
Total	2228.93	100.00	44.59	659.25	100.00	29.18	0.10	100.00	0.45

Table A22. Area, percentage of AOA, and percentage of grassland area by pattern density classification in the Regional AOA and Park-Manager-Selected AOAs, for 2011.

Grassland Pattern Density Classification	2011			2011			2011		
	Regional		Percentage of AOA	Park-Manager-Selected Watersheds		Percentage of AOA	Park-Manager-Selected Jack Fire		Percentage of AOA
	Area (km ²)	Percentage of grassland area		Area (km ²)	Percentage of grassland area		Area (km ²)	Percentage of grassland area	
Rare	295.68	11.84	5.91	146.98	10.05	6.51	1.29	6.57	5.92
Patchy	777.73	31.15	15.56	417.03	28.52	18.46	6.35	32.24	29.07
Transitional	421.25	16.87	8.43	248.81	17.02	11.01	4.95	25.14	22.67
Dominant	510.14	20.44	10.20	310.74	21.25	13.75	5.40	27.41	24.72

Table A22 (continued). Area, percentage of AOA, and percentage of grassland area by pattern density classification in the Regional AOA and Park-Manager-Selected AOAs, for 2011.

Grassland Pattern Density Classification	2011			2011			2011		
	Regional			Park-Manager-Selected Watersheds			Park-Manager-Selected Jack Fire		
	Area (km ²)	Percentage of grassland area	Percentage of AOA	Area (km ²)	Percentage of grassland area	Percentage of AOA	Area (km ²)	Percentage of grassland area	Percentage of AOA
Interior	157.30	6.30	3.15	94.33	6.45	4.18	1.17	5.93	5.35
Intact	334.24	13.39	6.69	244.20	16.70	10.81	0.53	2.71	2.44
Total	2496.34	100.00	49.94	1462.09	100.00	64.72	19.70	100.00	90.17

Table A23. Area, percentage of AOA, and percentage of shrubland area by pattern density classification in the Regional and Park-Manager-Selected AOAs for 2011.

Shrubland Pattern Density Classification	2011			2011			2011		
	Regional			Park-Manager-Selected Watersheds			Park-Manager-Selected Jack Fire		
	Area (km ²)	Percentage of shrubland area	Percentage of AOA	Area (km ²)	Percentage of shrubland area	Percentage of AOA	Area (km ²)	Percentage of shrubland area	Percentage of AOA
Rare	293.97	10.49	5.88	117.58	8.40	5.20	1.03	4.84	4.72
Patchy	915.82	32.67	18.32	436.98	31.21	19.34	6.95	32.67	31.84
Transitional	546.59	19.50	10.93	282.20	20.16	12.49	5.24	24.60	23.97
Dominant	651.81	23.25	13.04	339.12	24.22	15.01	5.30	24.88	24.25
Interior	197.56	7.05	3.95	108.77	7.77	4.81	1.72	8.08	7.88
Intact	197.35	7.04	3.95	115.46	8.25	5.11	1.05	4.91	4.79
Total	2803.10	100.00	56.07	1400.10	100.00	61.97	21.28	100.00	97.44

Table A24. Area, percentage of total area, and percentage 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/ km2)	1412.33	1389.61	1370.77	1355.37	1353.53
Percentage of Total Area	28.25	27.80	27.42	27.11	27.08
Percentage of Census Area	95.48	93.95	92.67	91.63	91.57
Exurban (7–146 units/ km2)	63.37	85.48	104.14	119.10	119.84
Percentage of Total Area	1.27	1.71	2.08	2.38	2.40
Percentage of Census Area	4.28	5.78	7.04	8.05	8.11
Suburban (146–1235 units/ km2)	1.66	2.25	2.35	2.81	2.90
Percentage of Total Area	0.03	0.05	0.05	0.06	0.06
Percentage of Census Area	0.11	0.15	0.16	0.19	0.20
Urban (>1235 units/ km2)	0.05	0.07	0.15	0.12	0.14
Percentage of Total Area	<0.01	<0.01	<0.01	<0.01	<0.01
Percentage of Census Area	<0.01	<0.01	0.01	0.01	0.01
Commercial/Industrial	1.76	1.76	1.76	1.76	1.76
Percentage of Total Area	0.04	0.04	0.04	0.04	0.04
Percentage of Census Area	0.12	0.12	0.12	0.12	0.12
Urban-Regional Park	0	0	0	0	0
Percentage of Total Area	0	0	0	0	0
Percentage of Census Area	0	0	0	0	0
Total Area	4999.158	4999.16	4999.16	4999.16	4999.16
Total Census Area	1479.17	1479.17	1479.17	1479.16	1478.17

Table A25. Area, percentage of total area, and percentage of census area by housing density category in the Park-Manager-Selected Watersheds AOA for 1970–2010.

Park-Manager-Selected Watersheds Housing Density Categories	1970	1980	1990	2000	2010
Rural (<6 units/ km2)	509.66	500.50	497.56	491.46	491.89
Percentage of Total Area	22.56	22.15	22.02	21.75	21.77
Percentage of Census Area	97.38	95.63	95.07	94.15	94.11

Table A25 (continued). Area, percentage of total area, and percentage of census area by housing density category in the Park-Manager-Selected Watersheds AOA for 1970–2010.

Park-Manager-Selected Watersheds Housing Density Categories	1970	1980	1990	2000	2010
Exurban (7-146 units/ km2)	13.64	22.63	25.51	30.09	30.40
Percentage of Total Area	0.60	1.00	1.13	1.33	1.35
Percentage of Census Area	2.61	4.32	4.87	5.76	5.82
Suburban (146- 1235 units/ km2)	0.03	0.20	0.26	0.40	0.37
Percentage of Total Area	<0.01	0.01	0.01	0.02	0.02
Percentage of Census Area	0.01	0.04	0.05	0.08	0.07
Urban (>1235 units/ km2)	0	0	0	0	0
Percentage of Total Area	0	0	0	0	0
Percentage of Census Area	0	0	0	0	0
Commercial/Industrial	0.03	0.03	0.03	0.03	0.03
Percentage of Total Area	<0.01	<0.01	<0.01	<0.01	<0.01
Percentage of Census Area	0.01	0.01	0.01	0.01	0.01
Urban-Regional Park	0	0	0	0	0
Percentage of Total Area	0	0	0	0	0
Percentage of Census Area	0	0	0	0	0
Total Area	2259.19	2259.19	2259.19	2259.19	2259.19
Total Census Area	523.36	523.36	523.36	521.98	522.69

Table A26. Census blocks, area, total population, and population density in the Regional AOA for 1990, 2000, and 2010.

	1990	2000	2010	1990–2000 Percentage Change	2000–2010 Percentage Change
Number of Census Blocks	14	14	13	–	–
Corrected Area (km2)	4181.70	4217.72	4204.56	–	–
Population	5878	6722	6961	14.32	3.56
Population Density (population/km2)	1.41	1.59	1.66	13.35	3.88

Table A27. Census blocks, area, total population, and population density in the Park-Manager-Selected Watersheds AOA for 1990, 2000, and 2010.

Parameter	1990	2000	2010	1990–2000 Percentage Change	2000–2010 Percentage Change
Number of Census Blocks	10	10	11	–	–
Corrected Area (km ²)	1605.51	1626.88	1618.13	–	–
Population	1811	2225	2657	22.82	19.45
Population Density (population/km ²)	1.13	1.37	1.64	21.21	20.10

Table A28. Road length and density in the Regional AOA for 2010 and 2015. Summaries were calculated from US Census Bureau TIGER data.

Parameter	2010	2015
Length (km)	6323.90	6210.53
Density (km/km ²)	1.26	1.24

Table A29. Road length and density in the Park-Manager-Selected Watersheds AOA for 2010 and 2015. Summaries were calculated from US Census Bureau TIGER data.

Parameter	2010	2015
Length (km)	2846.65	2815.89
Density (km/km ²)	1.26	1.25

Table A30. Road length and density in the Park and Park-Manager-Selected Jack Fire AOAs for 2016. Summaries were calculated from Lava Beds National Monument data.

	Park	PM Jack Fire
Parameter	2016	2016
Length (km)	61.70	12.95
Density (km/km ²)	0.33	0.59

Table A31. Count and total area by roadless area size category in the Regional AOA, using 2010 and 2015 US Census Bureau TIGER data.

Roadless Area Categories	2010		2015	
	Count	Total km ²	Count	Total km ²
0-10 km2	1192	1619.37	1203	1618.27
10-50 km2	70	1470.81	71	1470.93
50-100 km2	4	266.65	4	266.70
> 100 km2	1	100.49	1	100.49

Table A32. Count and total area by roadless area size category in the Park-Manager-Selected Watersheds AOA, using 2010 and 2015 US Census Bureau TIGER data.

Roadless Area Categories	2010		2015	
	Count	Total km ²	Count	Total km ²
0-10 km2	603	777.96	612	787.48
10-50 km2	29	595.70	28	584.98
50-100 km2	1	74.01	1	74.01
> 100 km2	1	100.50	1	100.50

Table A33. Count and total area by roadless area size category in the Park and Park-Manager-Selected Jack Fire AOA, using 2016 Lava Beds National Monument road data.

Roadless Area Categories	Park		PM Jack Fire	
	Count	Total km ²	Count	Total km ²
0-10 km2	9	14.80	5	0.77
10-50 km2	1	47.23	1	18.51
50-100 km2	0	0	0	0
> 100 km2	1	112.38	0	0

Table A34. Area and percentage of AOA affected by fire related disturbances in the Regional AOA, for 1999–2012.

Year	Wildfire		Prescribed		Wildland		Wildland Fire Use	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	132.92	2.66	0.14	0.00	–	–	–	–
2001	0.09	0.00	–	–	–	–	–	–
2000	20.75	0.42	2.43	0.05	–	–	–	–
2002	–	–	0.17	0.00	–	–	–	–
2003	53.54	1.07	3.94	0.08	–	–	–	–
2004	0.71	0.01	7.60	0.15	–	–	–	–
2005	–	–	12.66	0.25	–	–	–	–
2006	41.66	0.83	8.87	0.18	0.51	0.01	0.11	<0.01
2007	1.89	0.04	–	–	–	–	–	–
2008	25.98	0.52	5.42	0.11	–	–	–	–
2009	–	–	9.00	0.18	–	–	–	–
2010	0.24	0.00			–	–	–	–
2011	20.74	0.41	5.06	0.10	–	–	–	–
2012	0.67	0.01	3.10	0.06	–	–	–	–
Total	299.19	5.98	58.40	1.17	0.51	0.01	0.11	<0.01

Table A35. Area and percentage of AOA affected by logging related disturbances in the Regional AOA for 1999–2012.

Year	Clearcut		Harvest		Thinning		Mastication		Other Mechanical	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	–	–	1.17	0.02	2.44	0.05	–	–	–	–
2000	–	–	0.75	0.01	2.35	0.05	–	–	–	–
2001	–	–	3.83	0.08	8.00	0.16	–	–	–	–
2002	–	–	–	–	1.34	0.03	–	–	–	–
2003	–	–	–	–	3.90	0.08	–	–	–	–
2004	–	–	–	–	9.33	0.19	–	–	0.01	<0.01
2005	0.10	<0.01	0.31	0.01	1.45	0.03	–	–	3.00	0.06
2006	0.58	0.01	1.67	0.03	16.60	0.33	0.79	0.02	13.10	0.26
2007	0.87	0.02	1.14	0.02	45.66	0.91	–	–	1.85	0.04
2008	1.02	0.02	9.89	0.20	8.22	0.16	–	–	4.29	0.09
2009					14.20	0.28	–	–	0.97	0.02
2010	0.60	0.01			12.63	0.25	–	–	0.84	0.02
2011	1.59	0.03	8.80	0.18	38.22	0.76	0.21	<0.01	5.58	0.11
2012			1.44	0.03	1.28	0.03	–	–	32.10	0.64
Total	4.75	0.09	29.00	0.58	165.62	3.31	1.00	0.02	61.73	1.23

Table A36. Area and percentage of AOA affected by disturbances other than fire and logging in the Regional AOA for 1999–2012.

Year	Disease		Herbicide		Unknown	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	—	—	—	—	1.54	0.03
2000	—	—	—	—	2.29	0.05
2001	—	—	—	—	0.48	0.01
2002	—	—	—	—	1.89	0.04
2003	—	—	—	—	5.83	0.12
2004	—	—	—	—	1.33	0.03
2005	0.34	0.01	—	—	2.48	0.05
2006	—	—	—	—	2.74	0.05
2007	—	—	—	—	0.73	0.01
2008	—	—	—	—	19.80	0.40
2009	—	—	<0.01	<0.01	7.28	0.15
2010	—	—	—	—	14.47	0.29
2011	—	—	—	—	16.60	0.33
2012	2.64	0.05	—	—	22.48	0.45
Total	2.98	0.06	<0.01	<0.01	99.95	2.00

Table A37. Area and percentage of AOA affected by fire related disturbances in the Park-Manager-Selected Watersheds AOA for 1999–2012.

Year	Wildfire		Prescribed		Wildland Fire Use	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	40.87	1.81	0.14	0.01	—	—
2000	—	—	—	—	—	—
2001	0.62	0.03	0.41	0.02	—	—
2002	—	—	3.80	0.17	—	—
2003	52.19	2.31	2.32	0.10	—	—
2004	0.63	0.03	7.50	0.33	—	—
2005	—	—	14.59	0.65	—	—
2006	17.95	0.79	5.31	0.24	0.11	<0.01
2007	0.48	0.02	—	—	—	—
2008	25.69	1.14	3.72	0.16	—	—
2009	0.23	0.01	8.96	0.40	—	—

Table A37 (continued). Area and percentage of AOA affected by fire related disturbances in the Park-Manager-Selected Watersheds AOA for 1999–2012.

Year	Wildfire		Prescribed		Wildland Fire Use	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
2010	0.01	0.00	–	–	–	–
2011	20.74	0.92	0.88	0.04	–	–
2012	0.67	0.03	5.56	0.25	–	–
Total	160.07	7.09	53.19	2.35	0.11	<0.01

Table A38. Area and percentage of AOA affected by logging related and unknown disturbances in the Park-Manager-Selected Watersheds AOA for 1999–2012.

Year	Thinning		Mastication		Other Mechanical		Unknown	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	3.67	0.16	–	–	–	–	0.95	0.04
2000	3.21	0.14	–	–	–	–	0.23	0.01
2001	8.23	0.36	–	–	–	–	0.13	0.01
2002	–	–	–	–	–	–	2.67	0.12
2003	–	–	–	–	–	–	0.78	0.03
2004	–	–	–	–	–	–	0.57	0.03
2005	1.22	0.05	–	–	–	–	1.93	0.09
2006	5.38	0.24	1.75	0.08	13.76	0.61	1.68	0.07
2007	5.28	0.23	–	–	–	–	0.53	0.02
2008	–	–	–	–	2.35	0.10	6.02	0.27
2009	1.68	0.07	–	–	0.99	0.04	1.02	0.04
2010	10.37	0.46	–	–	0.94	0.04	3.93	0.17
2011	11.67	0.52	–	–	0.78	0.03	2.48	0.11
2012	–	–	–	–	9.62	0.43	14.64	0.65
Total	50.72	2.24	1.75	0.08	28.44	1.25	37.55	1.66

Table A39. Area and percentage of AOA affected by fire related disturbances in the Park-Manager-Selected Jack Fire AOA for 1999–2012.

Year	Wildfire		Prescribed	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	—	—	—	—
2000	—	—	—	—
2001	—	—	—	—
2002	—	—	—	—
2003	—	—	—	—
2004	—	—	2.37	10.86
2005	—	—	0.30	1.36
2006	—	—	—	—
2007	—	—	—	—
2008	21.84	100.00	—	—
2009	—	—	—	—
2010	—	—	—	—
2011	—	—	—	—
2012	—	—	—	—
Total	21.84	100.00	2.67	12.22

Table A40. Area and percentage of AOA age disturbances in the Park AOA for 1999–2012.

Year	Wildfire		Prescribed Fire		Wildland Fire Use		Thinning	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	17.38	9.17	0.14	0.08	—	—	—	—
2000	—	—	—	—	—	—	—	—
2001	—	—	0.41	0.21	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	5.86	3.09	0.20	0.11	—	—	—	—
2004	—	—	2.38	1.26	—	—	—	—
2005	—	—	2.36	1.25	—	—	—	—
2006	17.89	9.44	4.02	2.12	0.11	0.06	—	—
2007	—	—	—	—	—	—	—	—
2008	22.75	12.01	—	—	—	—	—	—
2009	—	—	8.53	4.50	—	—	—	—
2010	—	—	—	—	—	—	9.84	5.19
2011	—	—	0.88	0.47	—	—	—	—
2012	0.01	0.00	0.03	0.02	—	—	—	—
Total	63.89	33.72	18.95	10.00	0.11	0.06	—	—

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