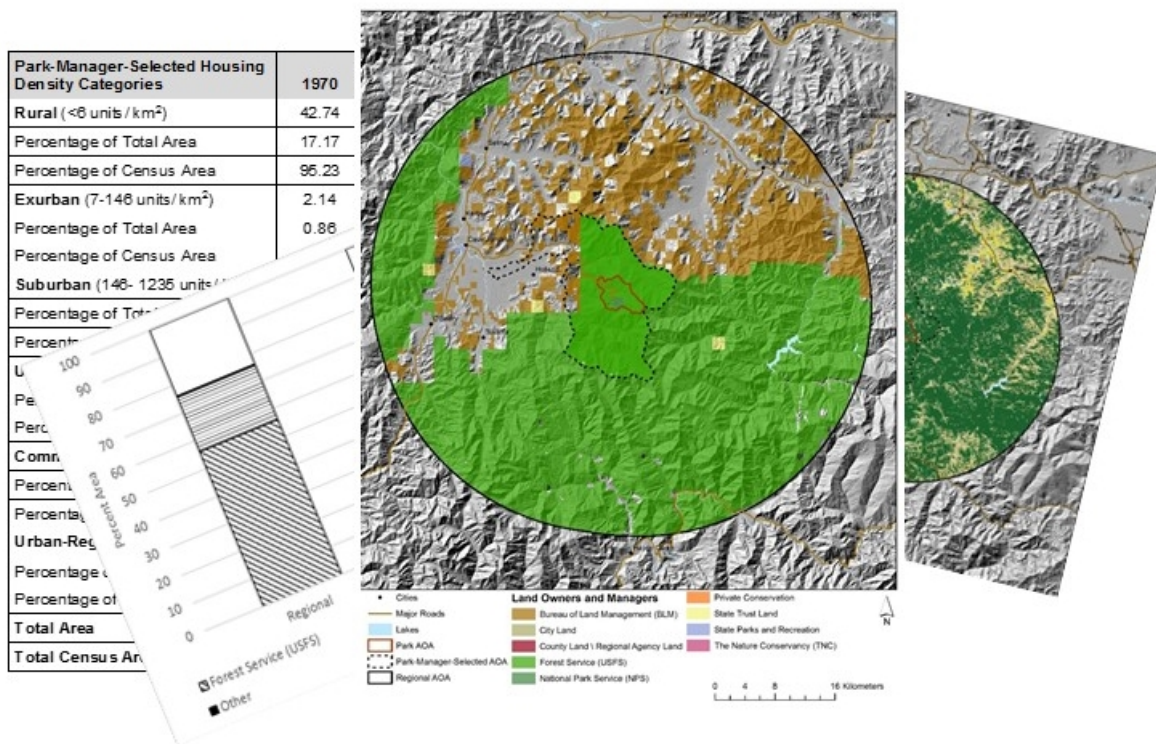




Land Cover and Land Use Monitoring

2016 Results for Oregon Caves National Monument and Preserve

Natural Resource Data Series NPS/KLMN/NRDS—2017/1108



ON THE COVER

Samples of maps and statistics shown in this report: 2012 Conservation Status, 2011 Land Cover, Owner/Manager Chart, and Housing category table.

Images by: Jace Ives, Southern Oregon University

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2016 Results for Oregon Caves National Monument and Preserve

Natural Resource Data Series NPS/KLMN/NRDS—2017/1108

Jace Ives¹, Allison Snyder², Elizabeth Edson³, Jacob King¹, Lorin Groshong¹, Sean Mohren⁴

¹Southern Oregon University
1250 Siskiyou Blvd.
Ashland, Oregon 97520

²National Park Service
Klamath Inventory and Monitoring Network
1250 Siskiyou Blvd.
Ashland, Oregon 97520

³Golden Gate Parks Conservancy
Building 201
Fort Mason San Francisco, CA 94129

⁴National Park Service
Crater Lake National Park
PO Box 7
Crater Lake, OR 97604

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Fort Collins, Colorado

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 Oregon Caves National Monument and Preserve. 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 NPScape 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

Land around the Oregon Caves National Monument and Preserve (hereafter, Oregon Caves) was primarily owned by the US Forest Service and Bureau of Land Management. Little of this area was permanently protected from conversion to an unnatural state. However, the majority 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

Within the study area, the most abundant cover type was evergreen forest, followed by shrub/scrubs. Most cover was categorized as natural, with converted areas primarily being in towns and agricultural areas. The total amount of impervious surface (e.g., asphalt) was minimal in and around the Park.

Landscape Pattern

Landscape cover was mostly forest, followed by shrubland, and then grassland. While some forest patches were large and intact, much was in thin sections that connected patches, resulting in much of the forest being on the edge of non-forest types. Very little grassland occurred in the study area, and most was in small patches or thin sections connecting patches. Largest patches of intact shrubland

were west of the Park, and similar to grassland, much of the area was small patches or thin sections connecting patches. In all cover types, small patches were the most abundant; however, within forest cover, most of the land area was in larger size patches.

Housing and Population

Oregon Caves was surrounded by housing developments categorized as “rural,” for their low density. The relative proportion of rural housing decreased between 1970 and 2010, coinciding with an increase in exurban, or medium density, housing. Population growth also increased outside the Park between 1990 and 2010.

Roads

Road densities were the highest along the Highway 199 corridor. Roads existed throughout the Park (likely old logging roads). Due to the small size of the Park, not much of the land was far from a road. Areas within Rogue River-Siskiyou National Forest and Klamath National Forest were furthest from any roads. Correspondingly, the largest section of land without roads was south of the Park, mostly within the Klamath National Forest. Other large roadless areas were in the Rogue River-Siskiyou National Forest and within some Bureau of Land Management land to the north of the Park. These areas also tended to be mountainous. There was little change in the amount of roads between 2010 and 2015.

Disturbance

In the overall study area, wildfire was the dominant disturbance between 1999 and 2012, although mechanical disturbance also occurred. Within the Park and the watershed surrounding the Park, mechanical disturbance was dominant.

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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 the Oregon Caves National Monument and Preserve (hereafter, Oregon Caves). The overall objective of this report is to determine for Oregon Caves 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.

Oregon Caves lies near the top of a steep drainage in the Klamath-Siskiyou Mountains of southwest Oregon just north of the California border. The main part of the Monument is 1844 hectares (4,554

acres) and is located approximately 32 km (20 miles) east of Cave Junction via Oregon Highway 46. The 1.6 hectare (4 acre) visitor center site is located in the town of Cave Junction. Elevation is 549 meters (1,800 feet) for the visitor center. The rest of the Park ranges from approximately 747 meters (2,450 feet) to 2012 meters (6,600 feet). Oregon Caves is small in size, but plant and animal communities are generally of high biotic integrity and diversity. Above ground, the Park encompasses a remnant old-growth coniferous forest and several hundred acres of subalpine habitat. Below ground is an active marble cave that began forming over a million and a half years ago in one of the world's most diverse geologic realms.

Oregon Caves National Monument was created by Presidential proclamation in 1909 to protect a three-mile cave “of unusual scientific interest and importance.” The proclamation states that “...the public interests will be promoted by reserving these caves with as much land as necessary for the proper protection thereof.” In December 2014, approximately 1647 ha (4,070 acres) of adjacent late-successional USFS lands were added to the Park which was renamed Oregon Caves National Monument and Preserve.

The climate of the region around Oregon Caves is strongly influenced by the ocean, which contributes to relatively mild summers and winters. Temperatures typically range from -6.6° C (20° F) to 4.4° C (40° F) during the winter and from 10° C (50° F) to 32° C (90° F) during the summer. The cave temperature is 5.6 °C (43° F) year round away from cave entrances. Approximately 1397 mm (55 inches) of precipitation falls per year, mostly as wet snow.

Park resources are impacted by fire suppression, logging, roads, non-native species, and dramatically reduced snowpack compared to previous twenty year averages. Fire suppression and/or increased drought intensity and duration have increased white- and silver fir, as well as shrub density, and have decreased the abundance of Douglas-fir saplings and the extent of meadows. Much of the area in the expansion and outside the Park has been logged. Based on studies completed elsewhere, high road density likely affects the distribution of large- to medium-sized mammals and may affect the distribution of certain arthropods.

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 scales for a landscape-level analysis has a significant impact on natural resource metrics and anthropogenic influences. The scale of analysis should be considered thoughtfully as no single scale or set of scales can meet all needs (Gross and Svancara 2009). For this protocol, we identified three spatial scales based on park needs and recommendations from the scientific literature. These three spatial scales, which we call Areas of Analysis (AOAs), include 1) Park, 2) Park-Manager-Selected, and 3) Regional (Figure 1).

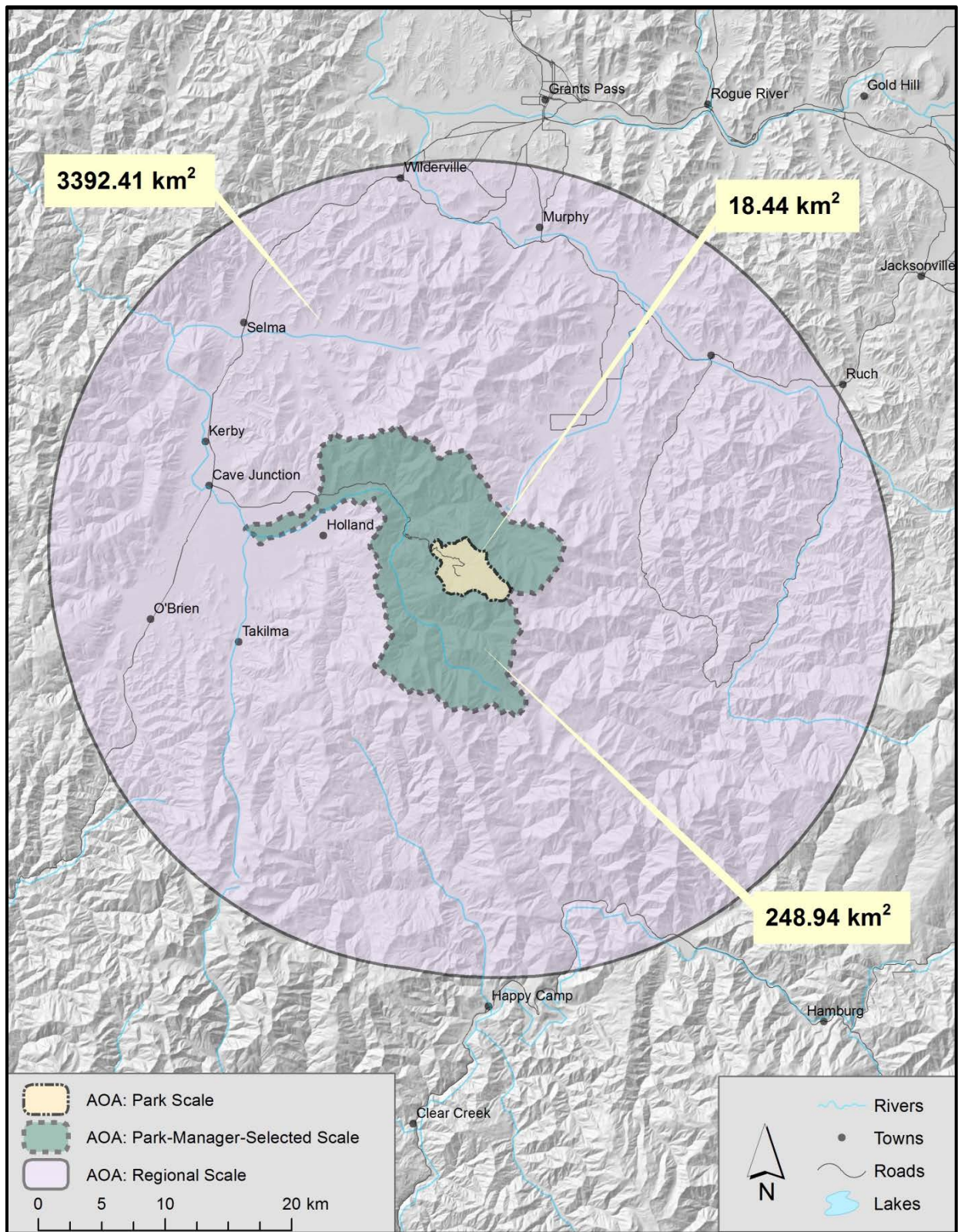


Figure 1. Reference map of all three Oregon Caves National Monument and Preserve Areas of Analysis (AOA).

Park Scale

The Park AOA uses the Park boundary (Nelson and Kinseth 2015). This AOA encompasses the area that NPS park managers have the most influence over and can directly alter through management actions. Analysis at this scale will give park managers the best possible picture of changes that are occurring in the Park. The Oregon Caves Park AOA omits a small administrative area (0.016 km²) in the town of Cave Junction, Oregon.

Park-Manager-Selected Scale

Because natural resources, ecological processes, and anthropogenic influences cross jurisdictional boundaries, the “Park-Manager-Selected” AOA includes the Park and 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. Because Oregon Caves is completely contained within one HUC 10 watershed, the Park-Manager-Selected AOA includes just the Sucker Creek watershed which covers 248.94 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, our Regional AOA include the Park and all adjacent areas within 30 km of the Park boundary. The Oregon Caves Regional AOA also omits the administrative area in Cave Junction, so the buffer is 30 km around the main Park polygon.

Data Sources

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

Table 1. Data sources for Oregon Caves Monument and Preserve 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 Crater Lake NP 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 Oregon Caves National Monument and Preserve: P = Park, PM = Park-Manager-Selected, and R = Regional.

Indicator	Measure	AOA Scale
Conservation Status	Percentage & Total Protected	PM & 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 & R
	Recent Change in Housing Density	
	Total Population	
	Population Density	
	Recent Population Change	
Roads	Road Density	P, PM, & R
	Road Length	
	Distance to Roads	
	Area without Roads	
Disturbance	Disturbance Occurrence	P, PM, & R
	Total Area by Disturbance Type	

Landscape Dynamics Indicators

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

Conservation Status and Ownership: We analyzed data from the Protected Areas Database of the United States (PAD-US) to summarize ownership and conservation status. The PAD-US is produced by the USGS Gap Analysis Program (GAP), the primary developer of land stewardship and protected areas information in the United States. Ownership and conservation status is unknown for 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 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 the three 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. NLCD classes are modified from the Anderson land use and land cover classification system (Anderson et al. 1976). 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 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 30 m resolution. Density data were also generated with a 7×7 pixel window size (size in m² and acres: 210 m², 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

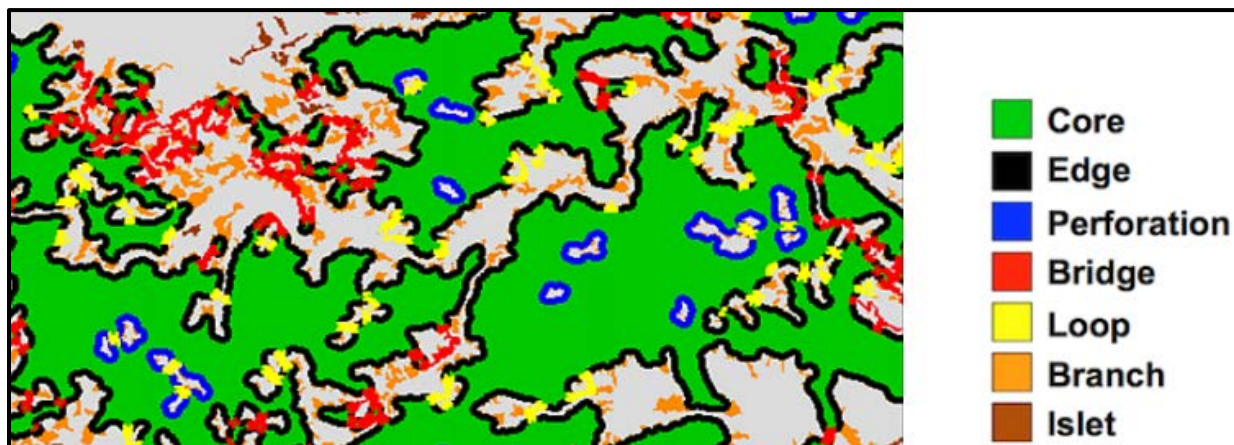


Figure 2. Illustration of morphological pattern types on a landscape. Image provided by Peter Vogt of the European Commission Joint Research Centre.

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 and Regional AOAs using data from 1970 to 2010. By class, we provided total area, percentage of total AOA, and percentage 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 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 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 AOA 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 three 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 three levels of spatial analysis 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 was within the Regional AOA was under public stewardship, with the greatest amount owned by the US Forest Service (56.1%), followed by the Bureau of Land Management (19.5%). The pattern is the same within the Park-Manager-Selected AOA, where 76.6% of the land was US Forest Service land and 9.4% was Bureau of Land Management (Figures 3 and 4; Table A1 in Appendix A, *Data Tables*). Note that data for 23.8% of the Regional AOA and 13.2% 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. Also, the PAD data are from 2012, and since then, the Park boundary has expanded.

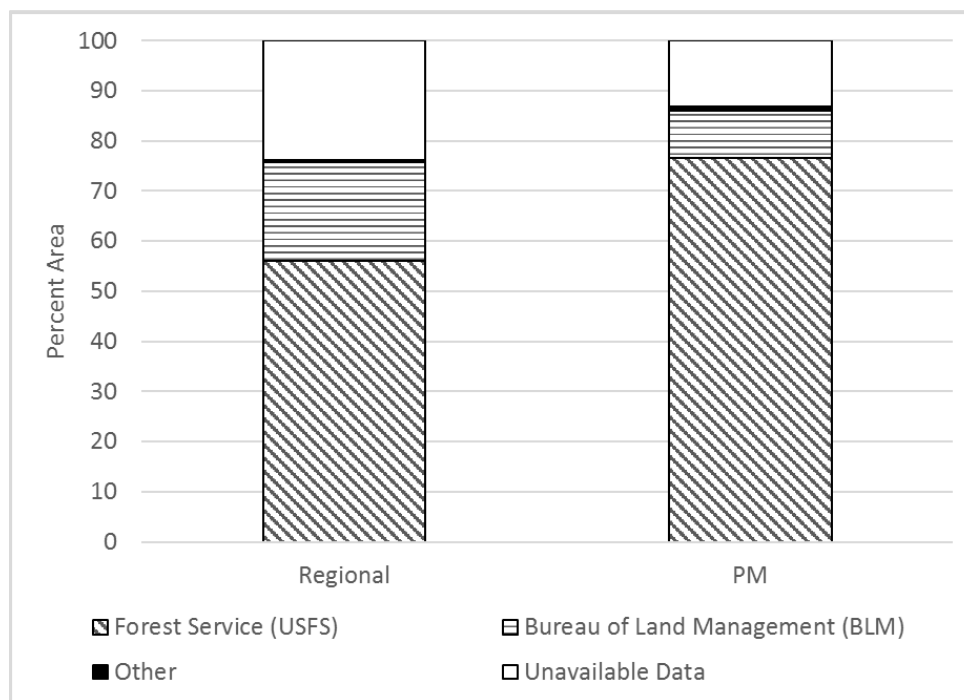


Figure 3. Percentage of land ownership within the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA) in 2012.

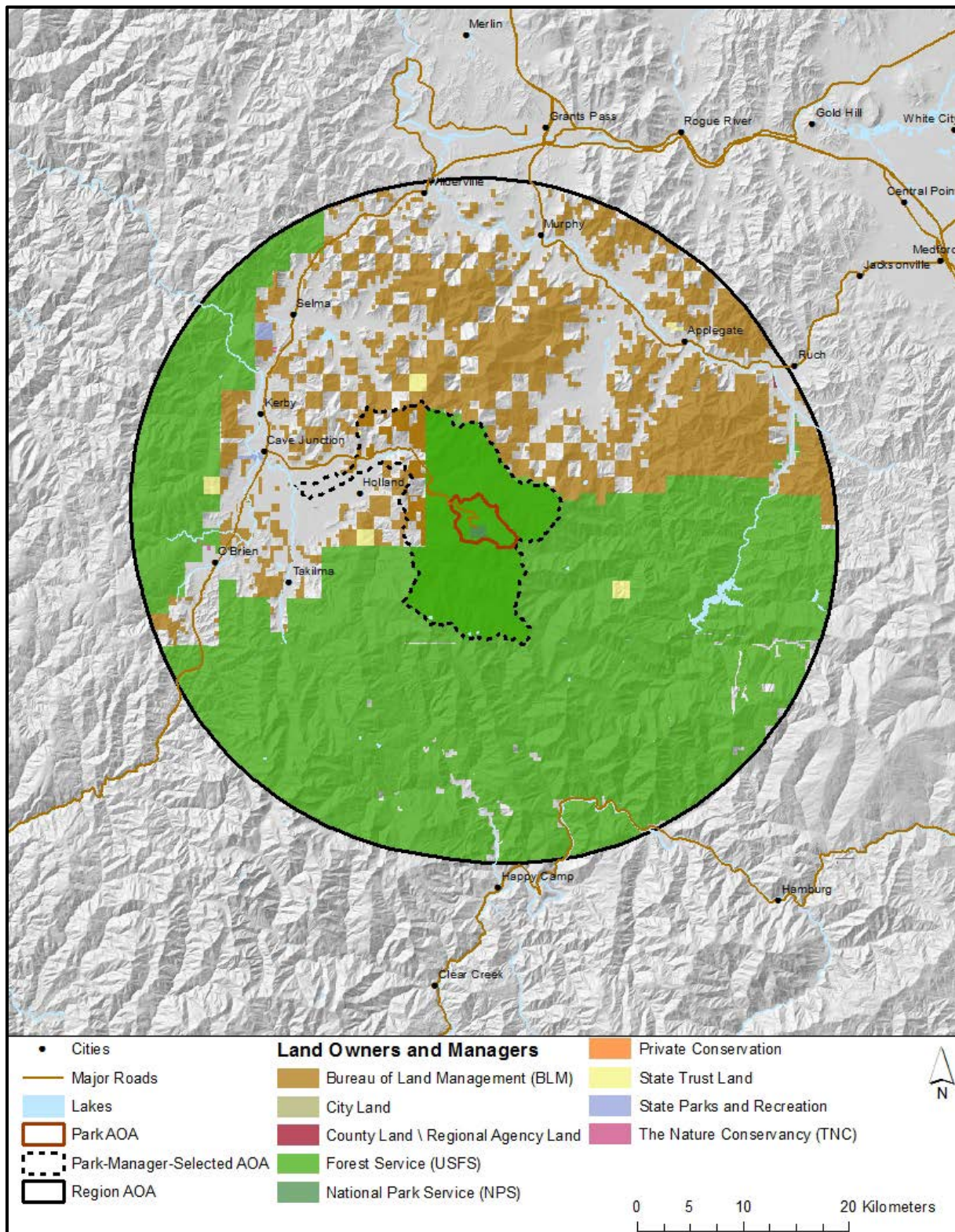


Figure 4. Land ownership in the Regional and Park-Manager-Selected Areas of Analysis (AOA), using 2012 data from the USGS Gap Analysis Program, Protected Areas Database for the US. Areas without colors identified in the legend are those for which ownership is unknown. PAD data are from 2012 and the Park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

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). Within the Park-Manager-Selected and Regional AOAs, this category is represented primarily by US Forest Service wilderness areas. In 2012, Status 1 constituted 4.4% and 4.6% of the Regional and Park-Manager-Selected AOAs, respectively (Figures 5 and 6; Table A2). Within the Regional and Park-Manager-Selected AOAs, the largest single category of land was in Status 3 (70.4% and 81.1%, 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. Most of Oregon Caves is in category 3 although the area within the Park boundary prior to the 2014 expansion is category 2. Data for 23.8% of the Regional AOA and 13.2% of the Park-Manager-Selected 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.

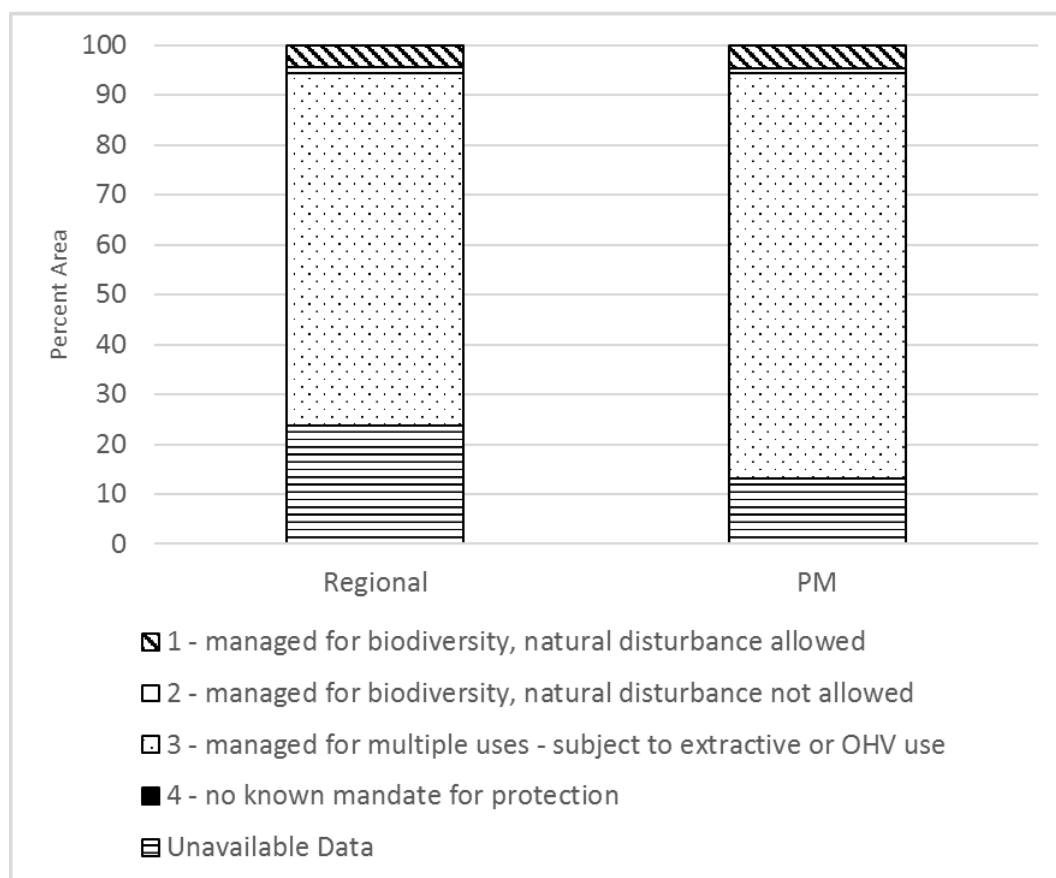


Figure 5. Percentage in each USGS Gap Analysis Program (GAP) Conservation Status category within the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA) in 2012.

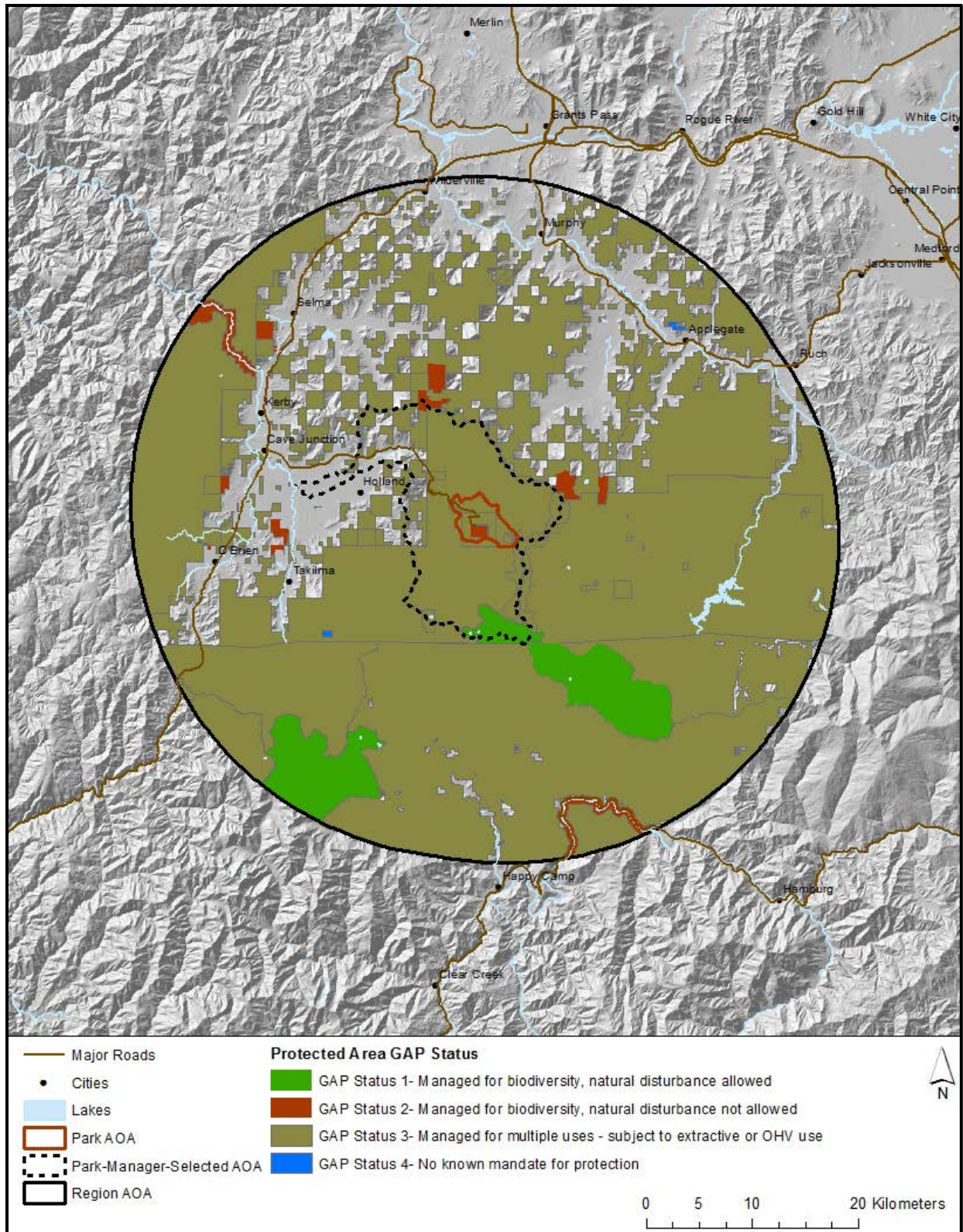


Figure 6. Protection status category in the Regional and Park-Manager-Selected Areas of Analysis (AOA), using 2012 data from the USGS Gap Analysis Program (GAP) Protected Areas Database for the US (PAD-US). PAD data are from 2012 and the Park boundary has expanded since then.

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). *Evergreen Forest* was the dominant cover type in both 2006 and 2011 and in all three AOAs; *Shrub/Scrub* was the next most abundant cover type (Figures 7 and 8).

In the Regional AOA, *Evergreen Forest* comprised 65.9% (2006) and 65.7% (2011) of the land cover, and *Shrub/Scrub* comprised 19.7% (2006) and 20.0% (2011). Other classes each covered less than 4% of the AOA (Table A3).

Similarly, in the Park-Manager-Selected AOA, *Evergreen Forest* was 82.8% (2006) and 82.6% (2011) and *Shrub/Scrub* was 6.5% (2006) and 6.7% (2011) of the land cover (Table A4).

In the Park AOA, *Evergreen Forest* represented 83.5% (2006) and 83.6% (2011) and *Shrub/Scrub* represented 7.2% (2006) and 6.9% (2011) of the land cover (Table A5).

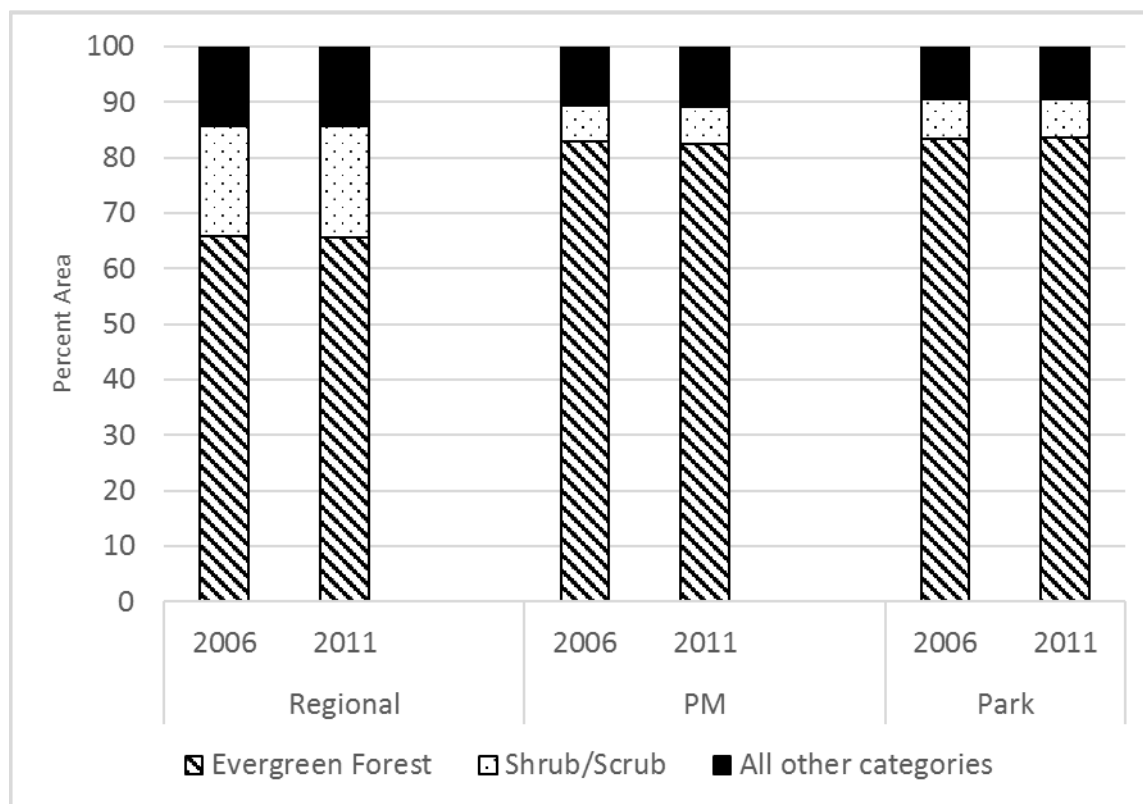


Figure 7. Percentage of National Land Cover Data Level 2 classes in Regional, Park-Manager-Selected (PM), and Park Areas of Analysis (AOA) for 2006 and 2011.

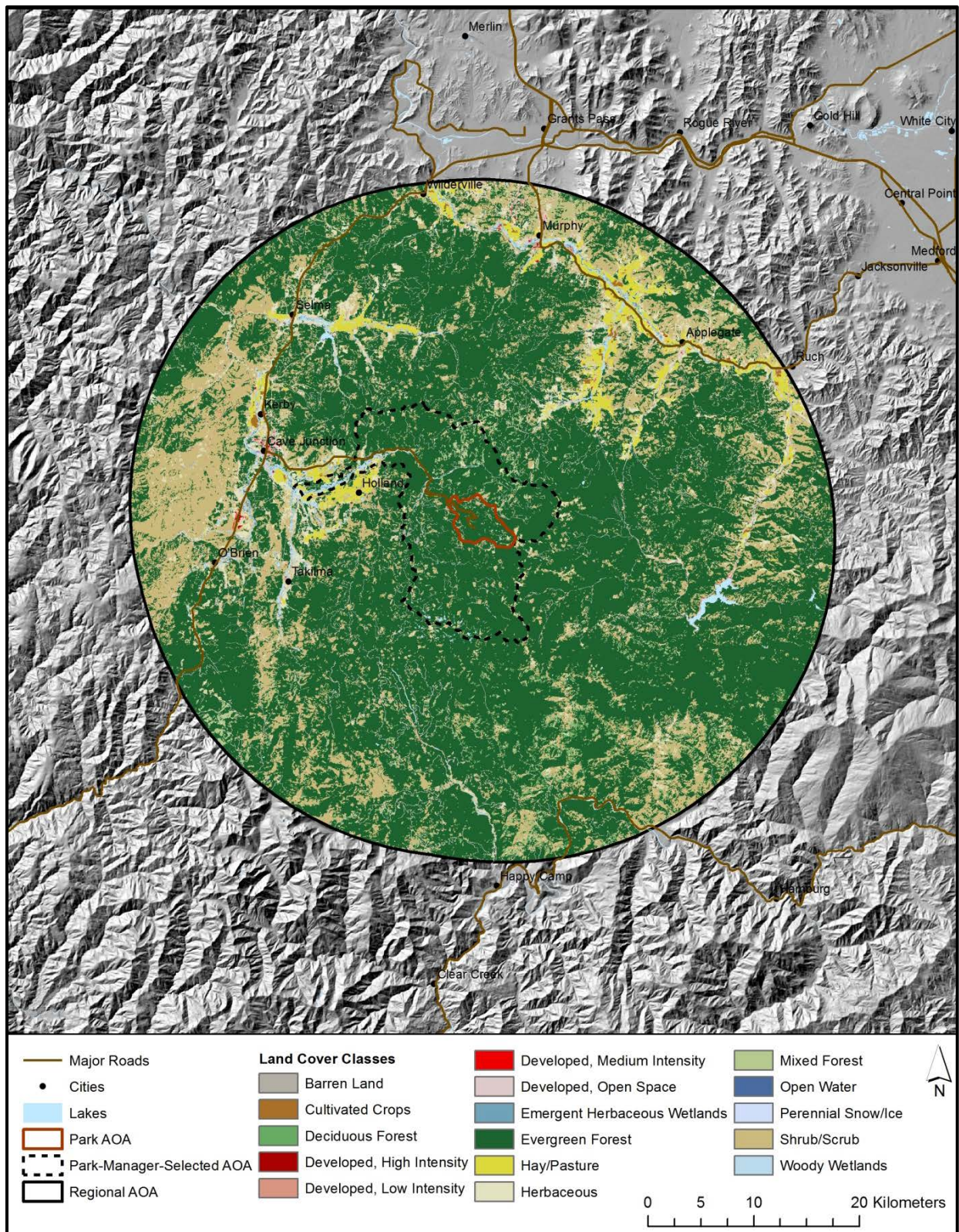


Figure 8. Land cover by National Land Cover Data Level 2 classes in Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

Impervious Surface Cover

In 2006 and 2011, more than 95% of each AOA lacked impervious surface (i.e., 0%–2% impervious surface class) (Figure 9; Tables A6–A8). This lowest impervious surface class occurred in greater than 96% of the Regional and Park-Manager-Selected AOAs, and greater than 95% of the Park AOA. Likewise, less than 2% of the area had a high amount of impervious surface (50%–100% impervious surface class). Most impervious surfaces are the roads within the AOAs and the towns of Cave Junction, Murphy, and O’Brien.

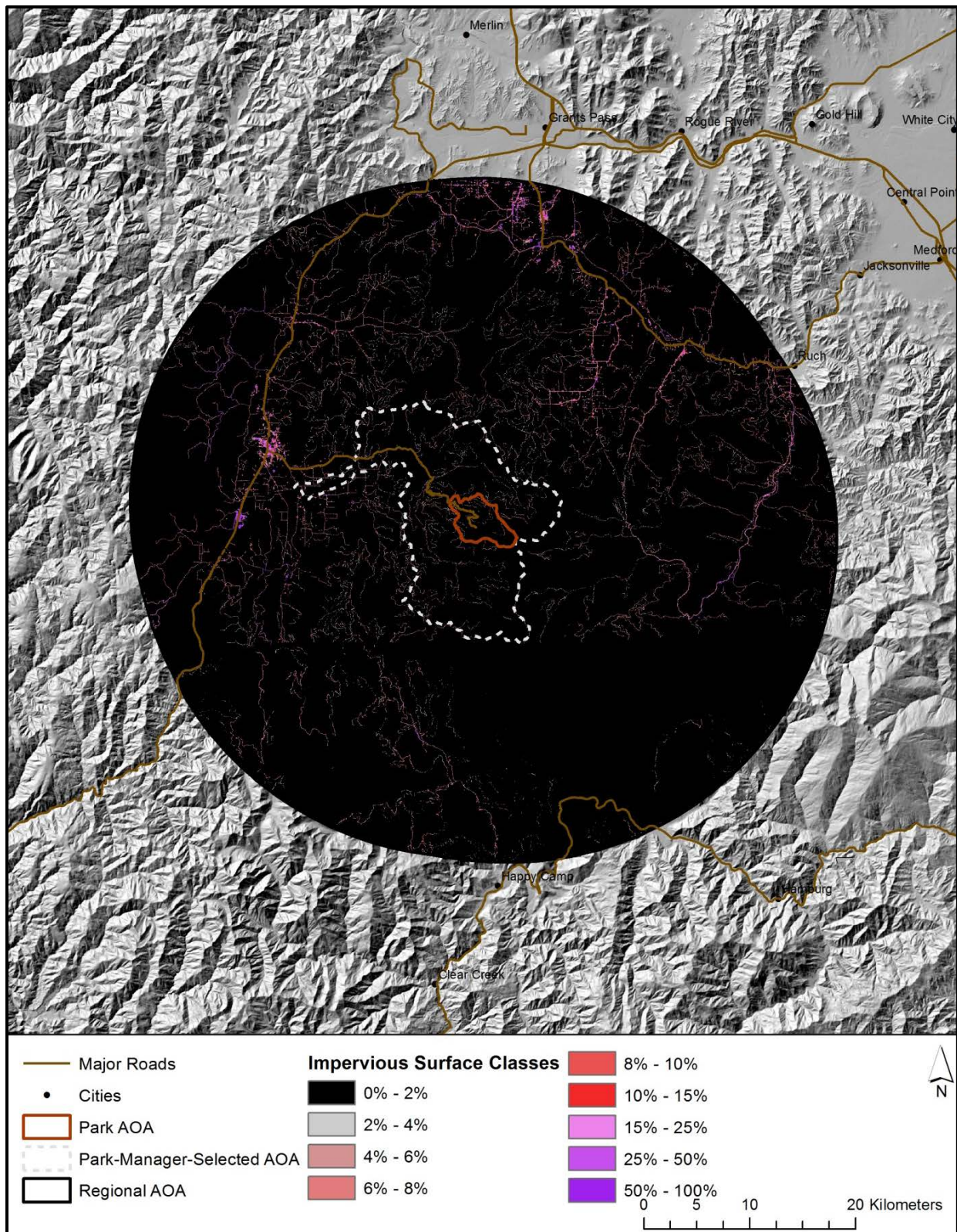


Figure 9. Impervious surface area at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

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 94% of the Regional AOA, 96% of the Park-Manager-Selected AOA, and 95% of the Park AOA (Figure 10, Tables A9–A11). In the Regional AOA, the change in area (km²) since 2006 was less than 0.08%, whereas the Park-Manager-Selected and Park AOAs had no change. Apart from roads and towns, most *Converted* areas were agricultural.

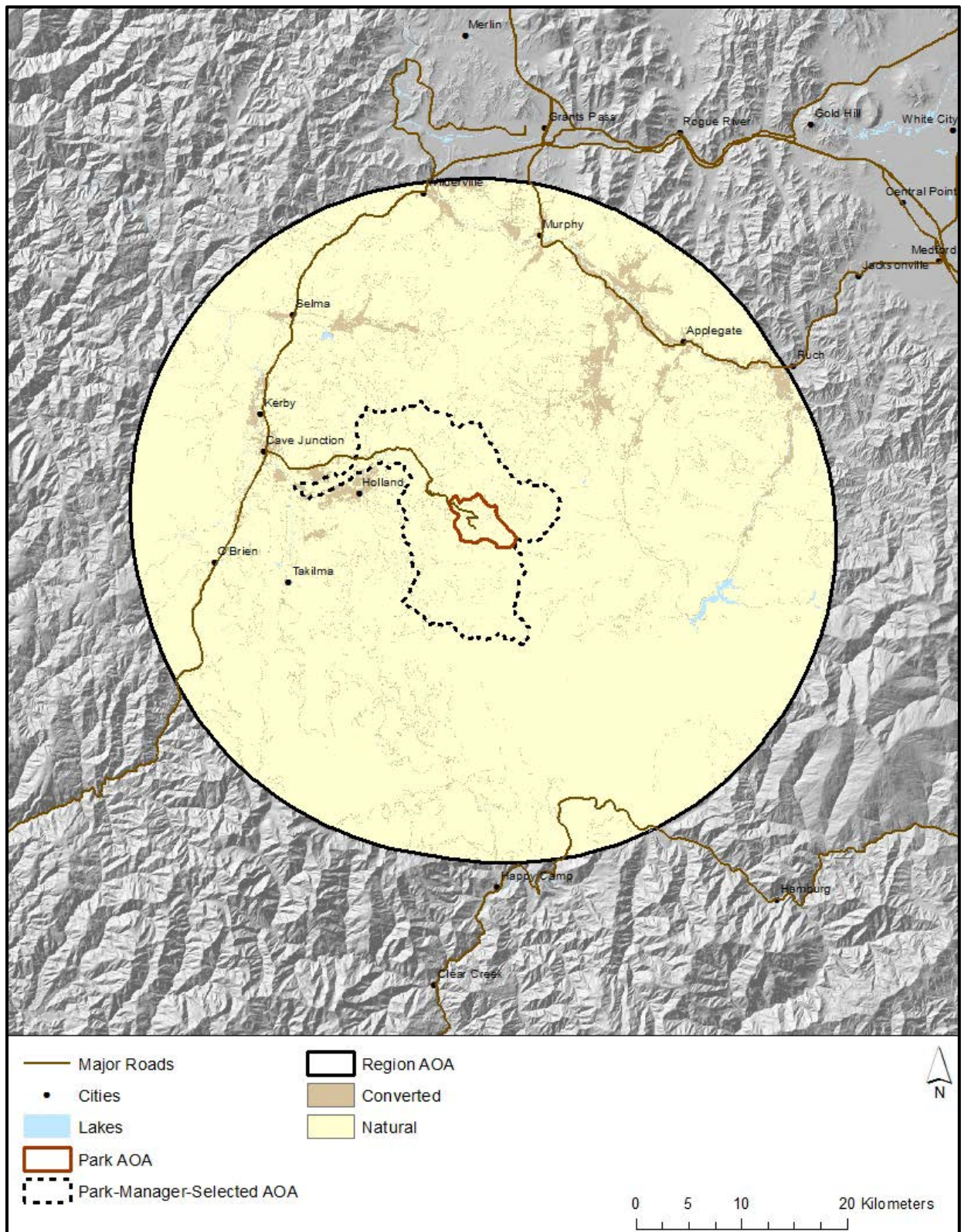


Figure 10. Natural and converted lands at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

Landscape Pattern

Morphology

Forest

Forest covered the greatest portion of the landscape and was generally arranged in contiguous areas. In the Regional AOA, 70% was forested (Figure 11). The forested areas was categorized as *Core* (32.9%), *Edge* (32.5%), and *Bridge* (25.1%) (Table A12) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected AOA, 87% was forested and was categorized as *Core* (40.8%), *Edge* (36.2%), and *Bridge* (20.0%) (Table A12).

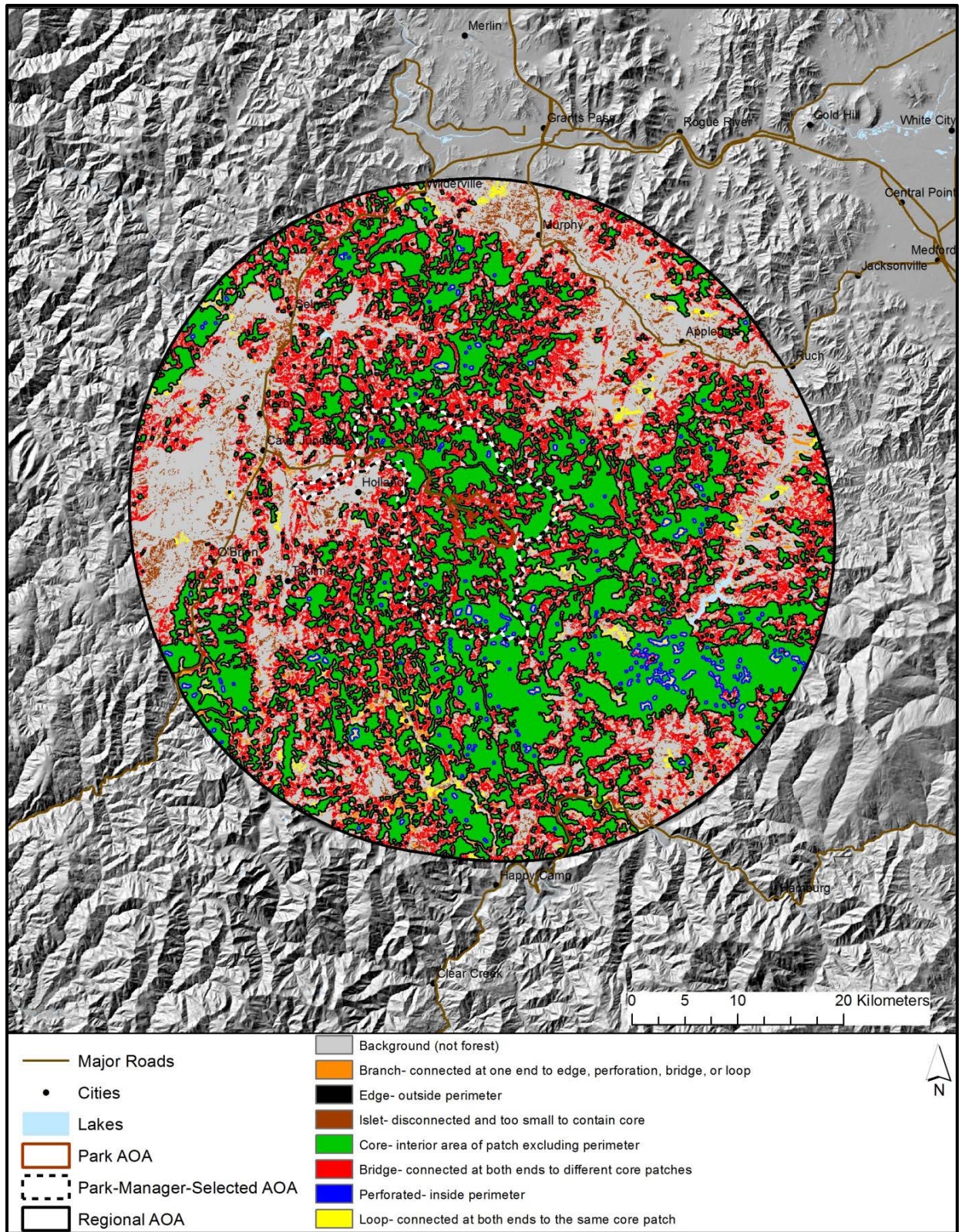


Figure 11. National Land Cover Data forest morphology classification for the Regional and Park-Manager-Selection Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>).

Grassland

In 2011, grassland occurred in approximately 5% of the Regional and approximately 2% of the Park-Manager-Selected AOAs (Table A13).

In the Regional AOA, grassland was categorized primarily as *Islet* (53.0%), *Bridge* (17.0 %), and *Edge* (14.1%) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected AOA, grassland was categorized primarily as *Islet* (63.4%), followed by *Bridge* (15.0%) (Figure 12).

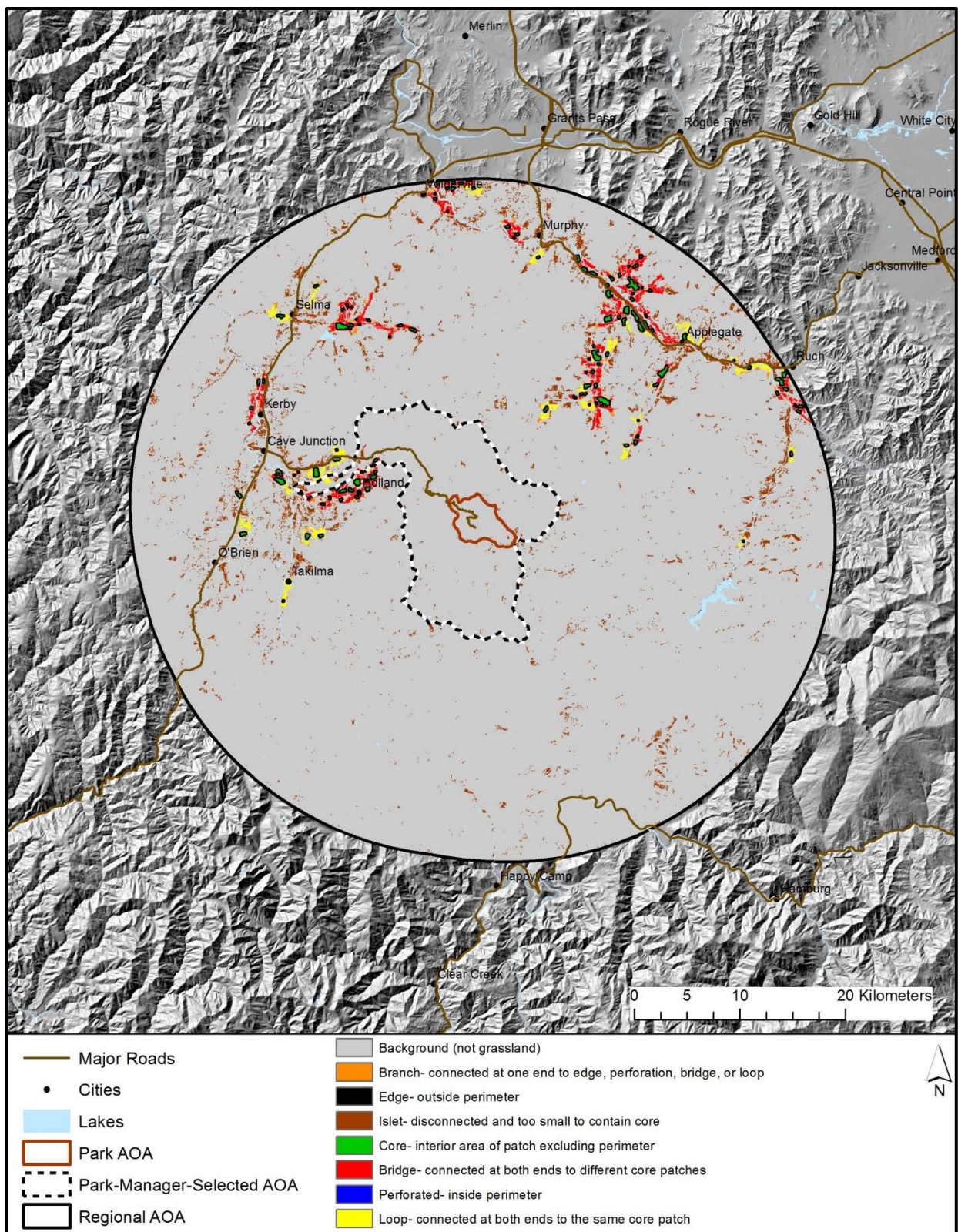


Figure 12. National Land Cover Data grassland morphology classification for the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>)

Shrubland

Shrubland comprised 20% of the Regional AOA and 7% of the Park-Manager-Selected AOA. In the Regional AOA, shrubland was categorized primarily as *Islet* (48.9%), followed by *Bridge* (26.1%) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected AOA, shrubland was categorized completely as *Islet* (100.0 (Figure 13; Table A14).

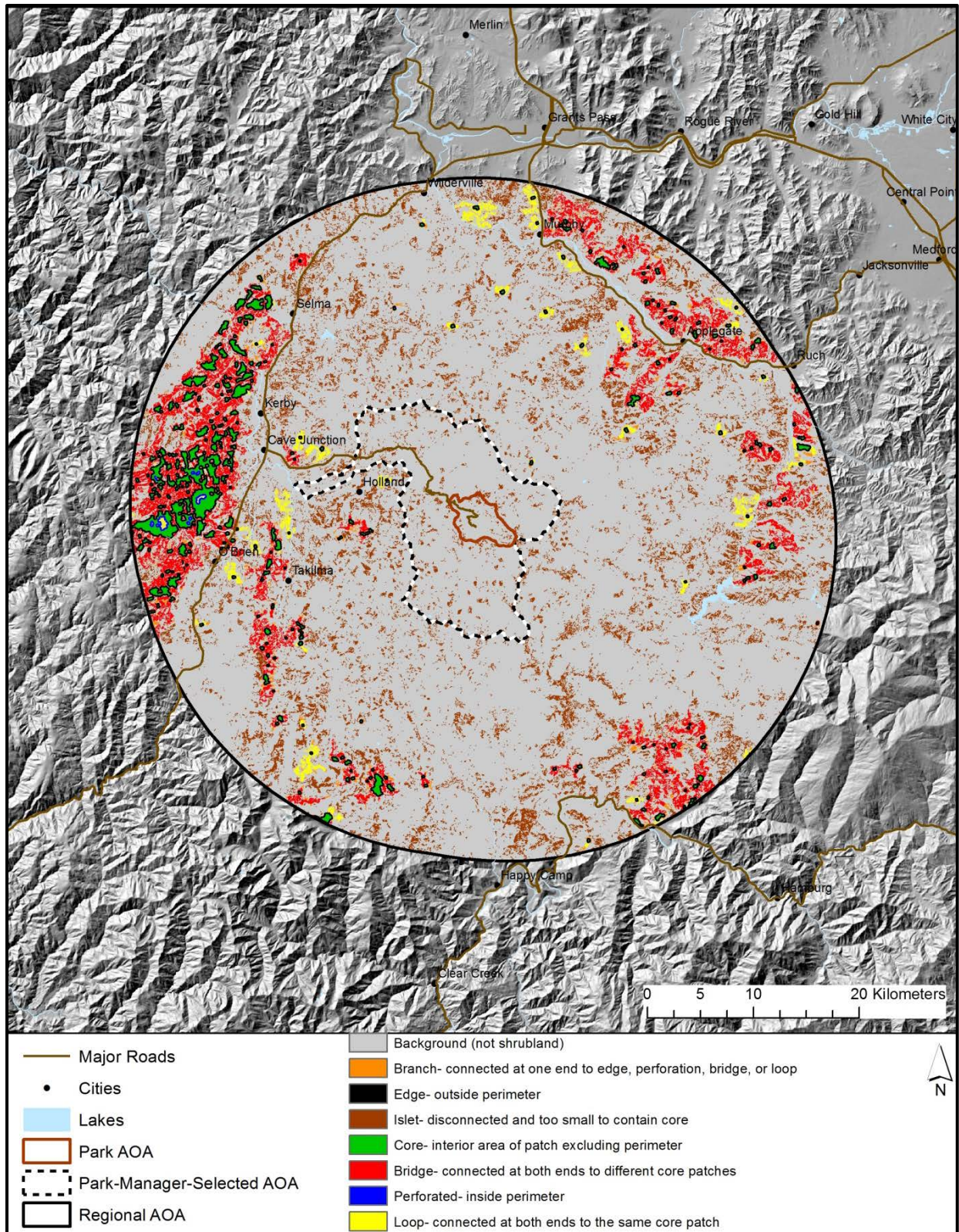


Figure 13. National Land Cover Data shrubland morphology classification for the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>)

Patch Size

Forest patch size

The majority of forest patches were less than 1 km², but the total combined area of these small patches was low in 2011. For the Regional AOA, most area was in the >1,000 km² patch size category (Figure 14, Table A15). In the Park-Manager-Selected AOA, most area was in the 100- <250 km² patch size category.

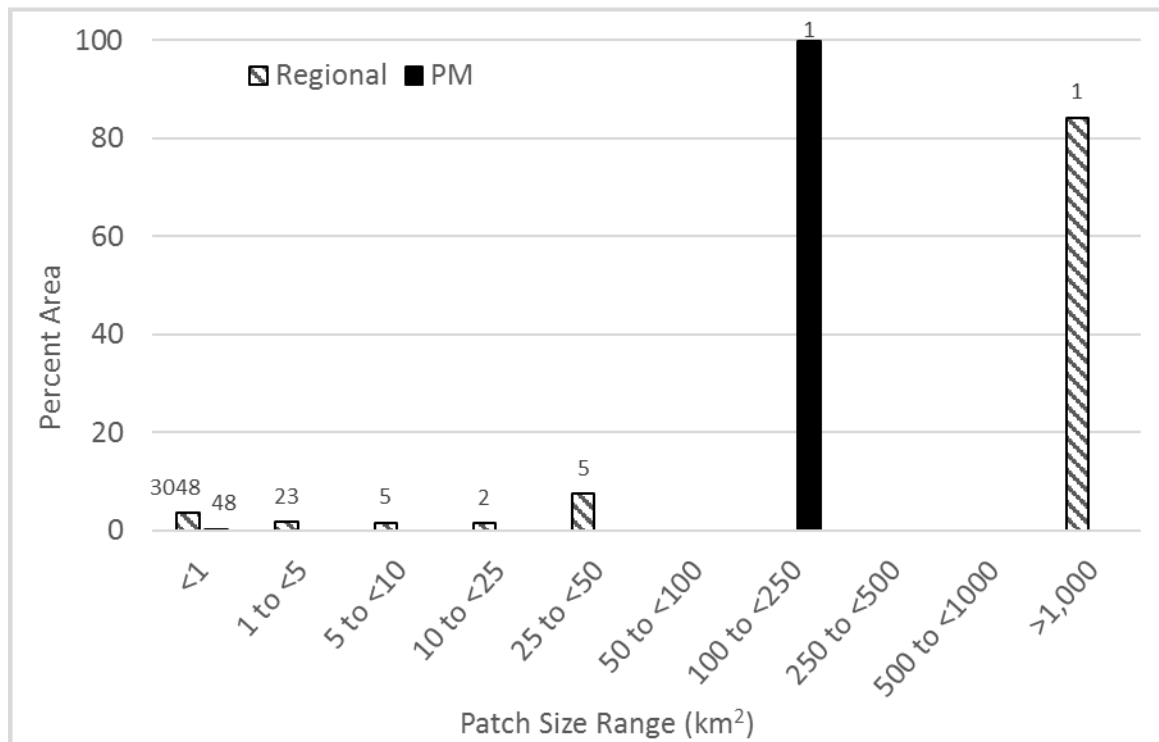


Figure 14. Percentage of area within each patch size category for forestlands in the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA) in 2011. The number at the top of each bar is the number of patches comprising the area.

Grassland Patch Size

In the Regional and Park-Manager-Selected AOA in 2011, most patches were <1 km², and this category also had the most area (Figure 15; Table A16).

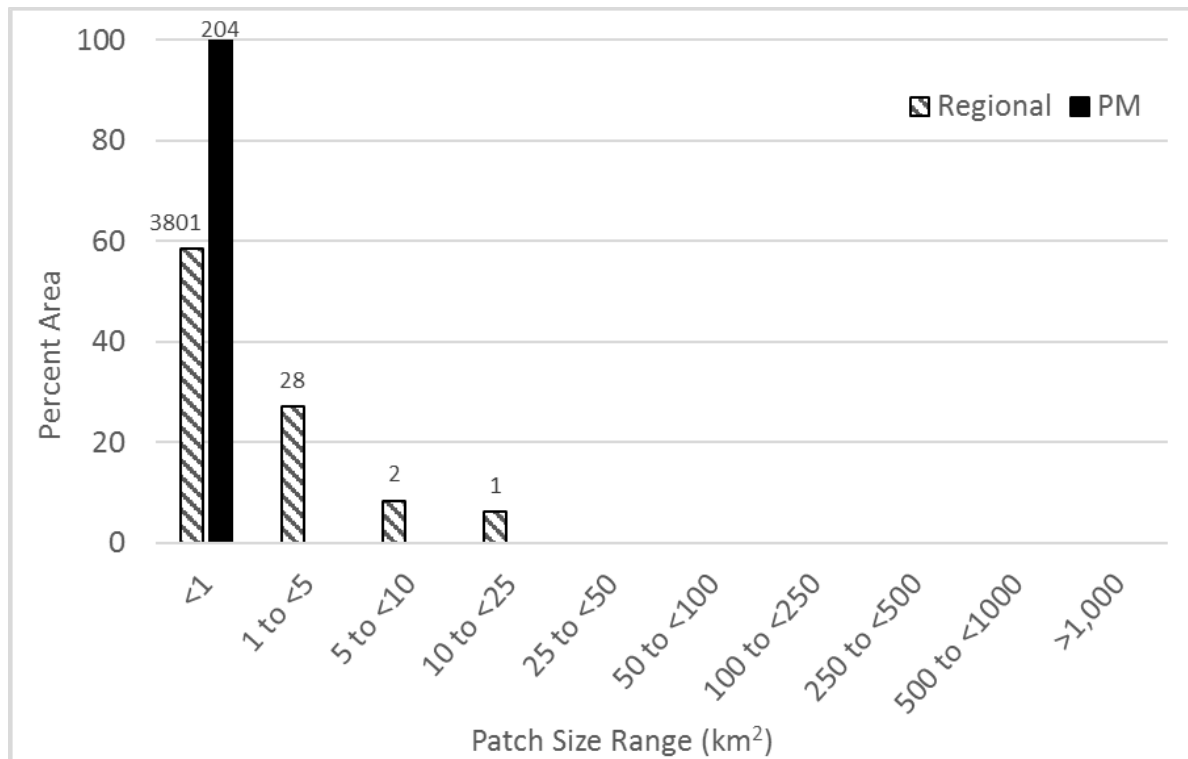


Figure 15. Percentage area within each patch size category for grasslands in the Regional and Park-Manager-Selected (PM) Areas of Analysis in 2011. The number at the top of each bar is the number of patches comprising the area.

Shrubland Patch Size

In the Regional and Park-Manager-Selected AOAs, most patches were within the <1 km² range, and these categories also had the most area (Figure 16; Table A17).

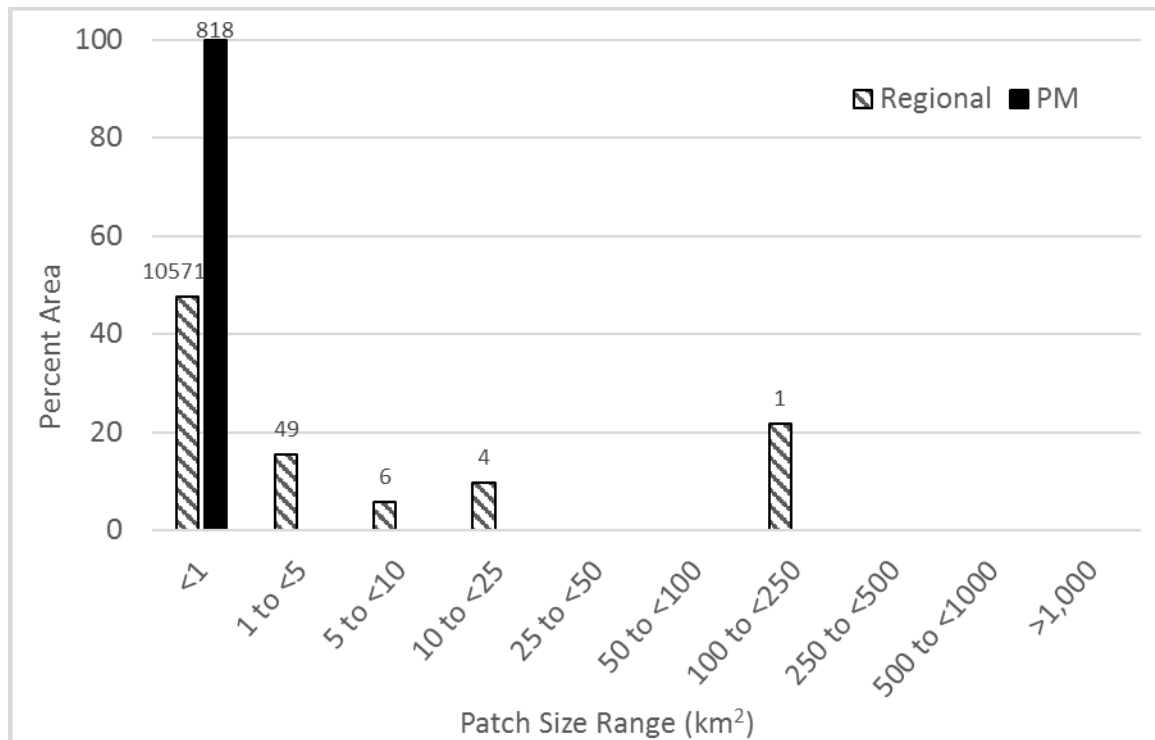


Figure 16. Percentage of area within each patch size category for shrublands in the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA) in 2011. The number at the top of each bar is the number of patches comprising the area.

Area Density

The majority of forest cover within the Regional AOA occurred in the *Intact* density class (35%), followed by the *Dominant* density class (25%) (Figure 17; Table A18). See the Methods, Table 6, for density class definitions.

Similarly, for the Park-Manager-Selected AOA, 49% was in the *Intact* density class, and 25% was in the *Dominant* density class (Table A18).

Grasslands and shrublands were predominantly in the *Patchy* density class (Figures 18 and 19; Tables A19 and A20).

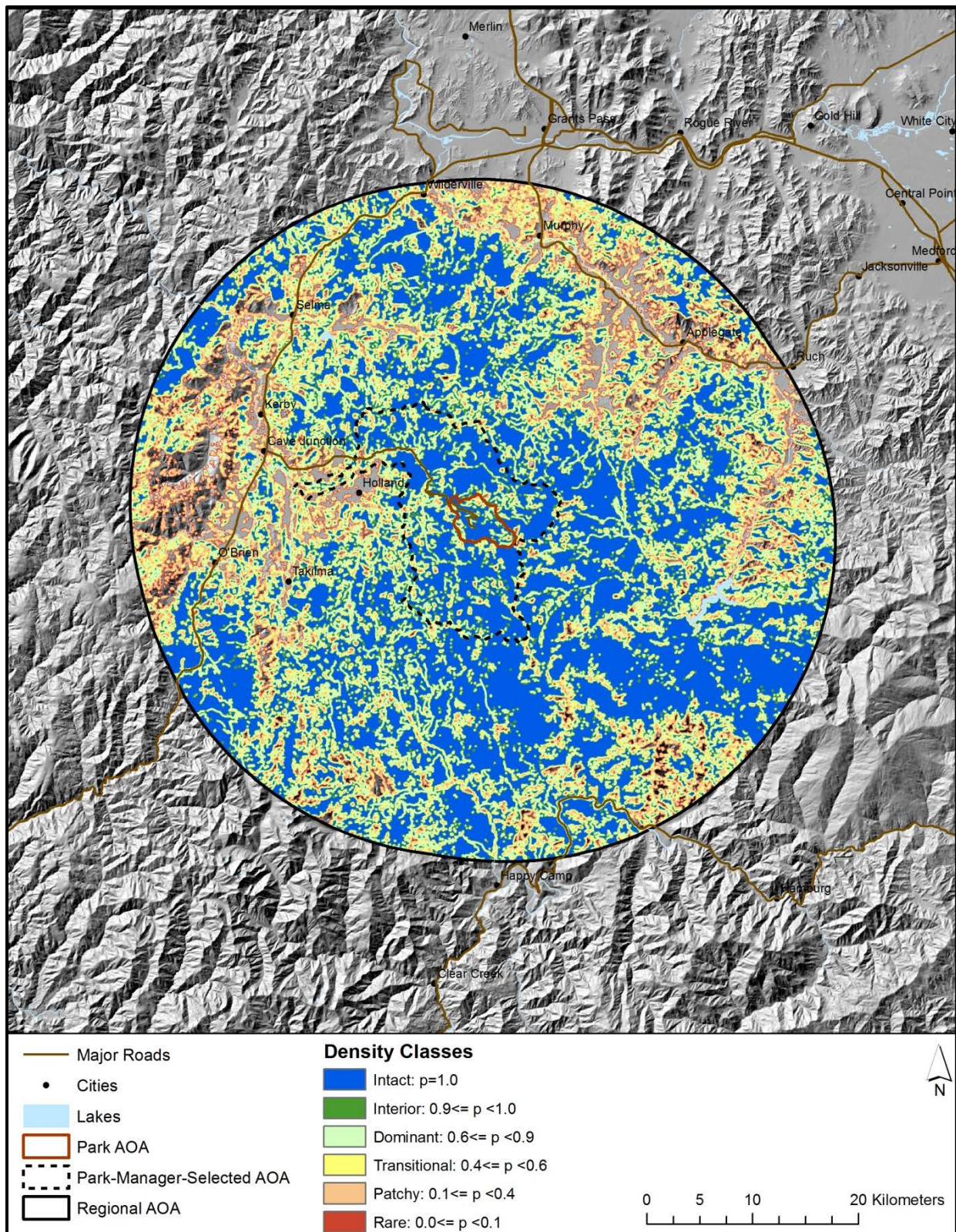


Figure 17. National Land Cover Data forest density classes for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.

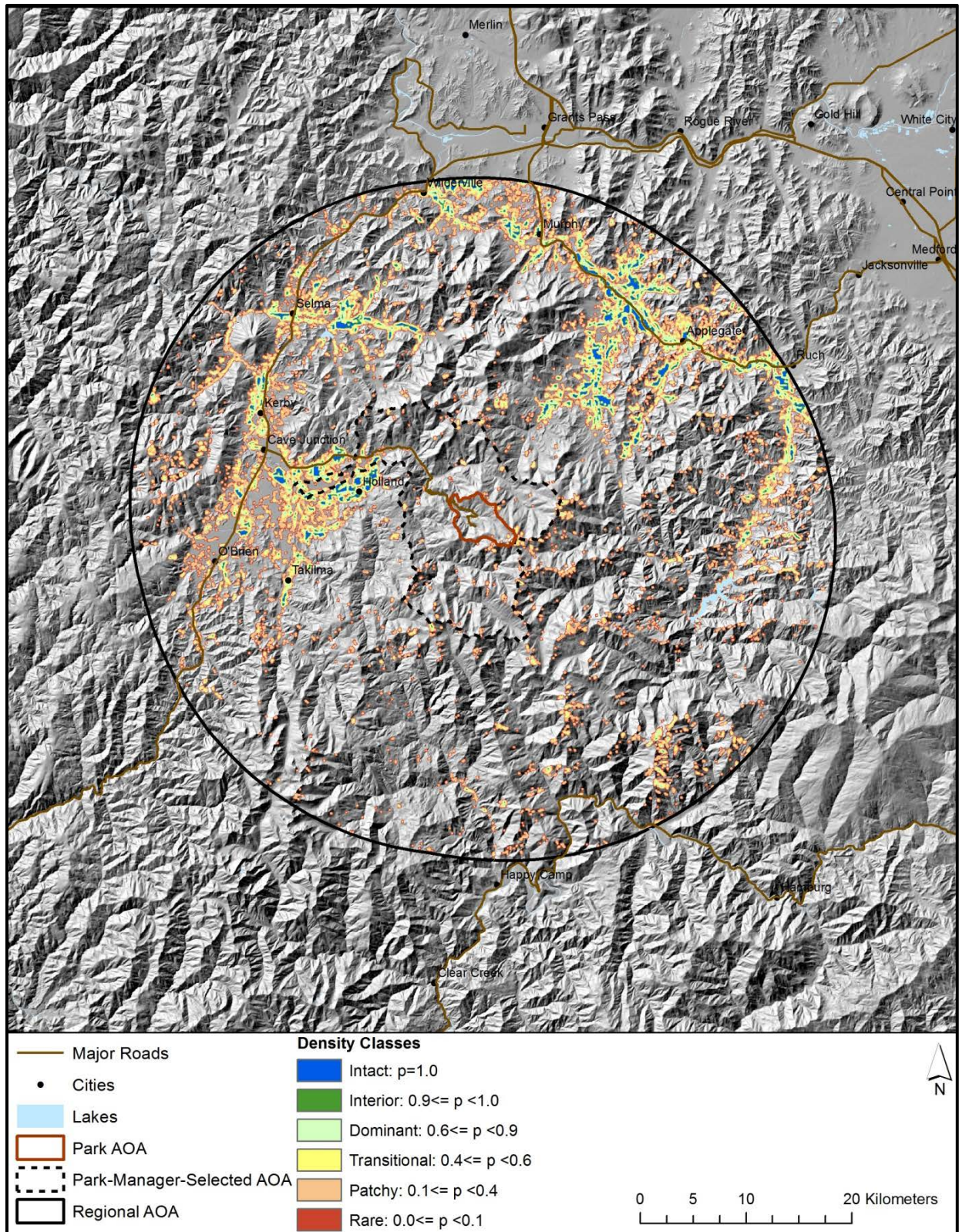


Figure 18. National Land Cover Data grassland density for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.

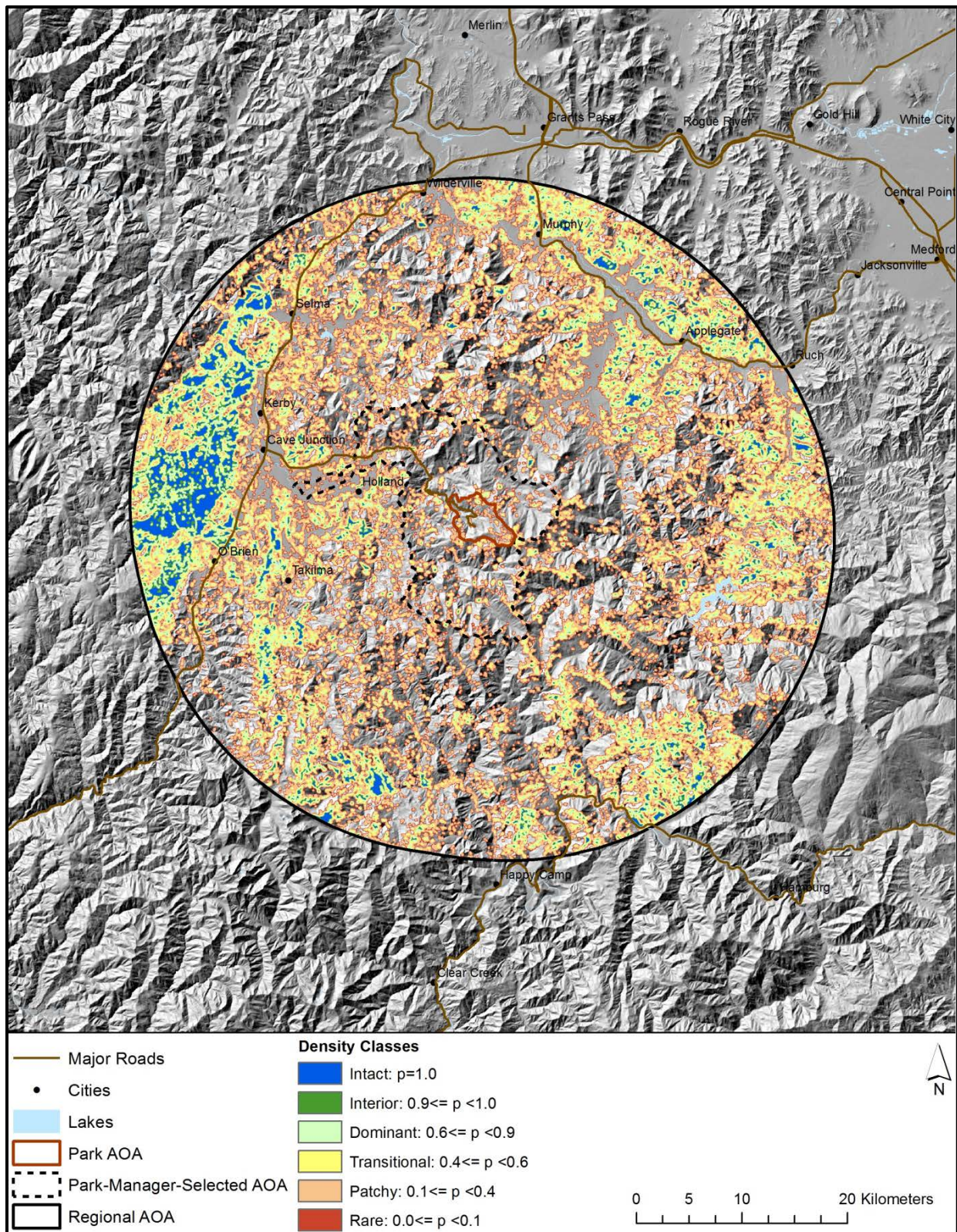


Figure 19. National Land Cover Data shrubland density for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.

Housing and Population

Housing Density

Oregon Caves is surrounded by a limited amount of housing development (Figure 20); the region encompasses several small towns including Cave Junction, Kerby, Selma, O'Brien, Wilderville, Takilma, Holland, Murphey, and Applegate.

Since 1970, the area categorized as *Rural* (<7 units/km²) (see Methods, Table 7, for housing density categories) decreased. In 1970, this area comprised 87% of the Census areas of the Regional AOA and 95% of the Park-Manager-Selected AOA. By 2010, *Rural* area decreased to 59% of the Regional AOA and 81% of the Park-Manager-Selected AOA. The *Exurban* (7–145 units/ km²) class increased from 12% to 40% in the Regional AOA and from 5% to 19% in the Park-Manager-Selected AOA (Tables A21 and Table A22, Figures 21 and 22).

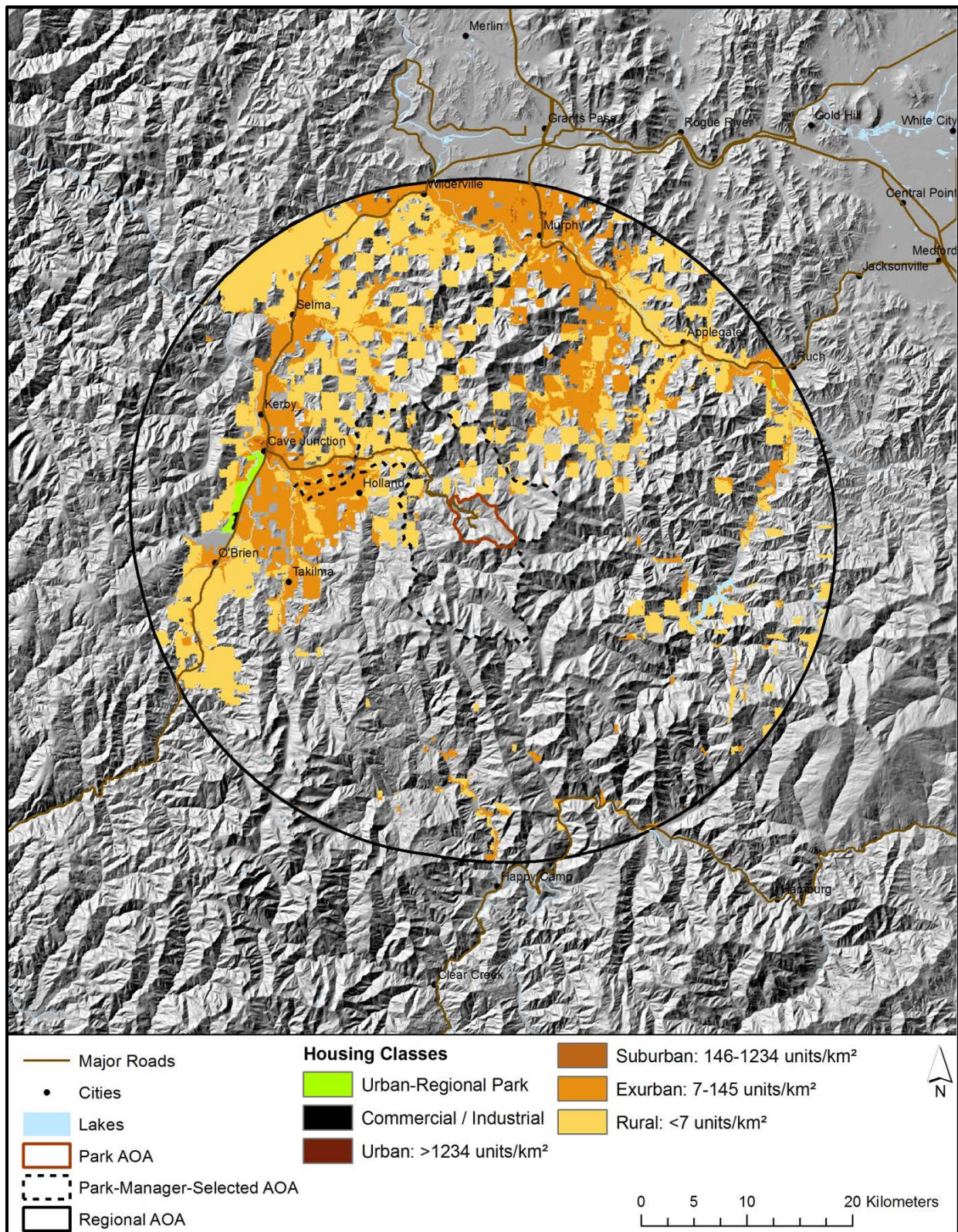


Figure 20. Housing classes in the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2010. No data exist for gray areas.

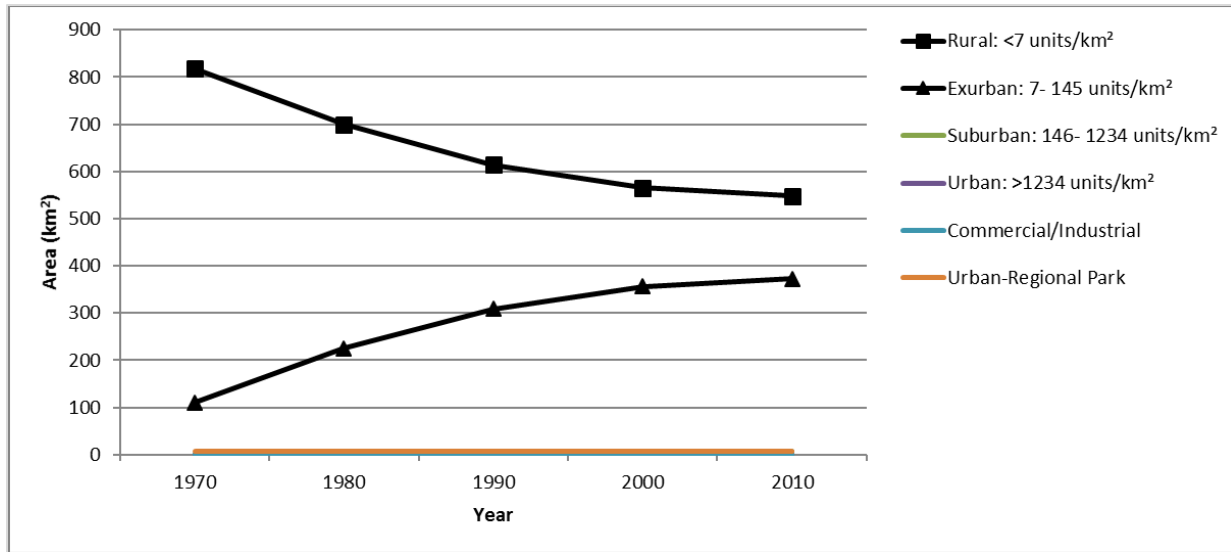


Figure 21. Area (km²) in each housing class from 1970 to 2010 in the Regional Area of Analysis.

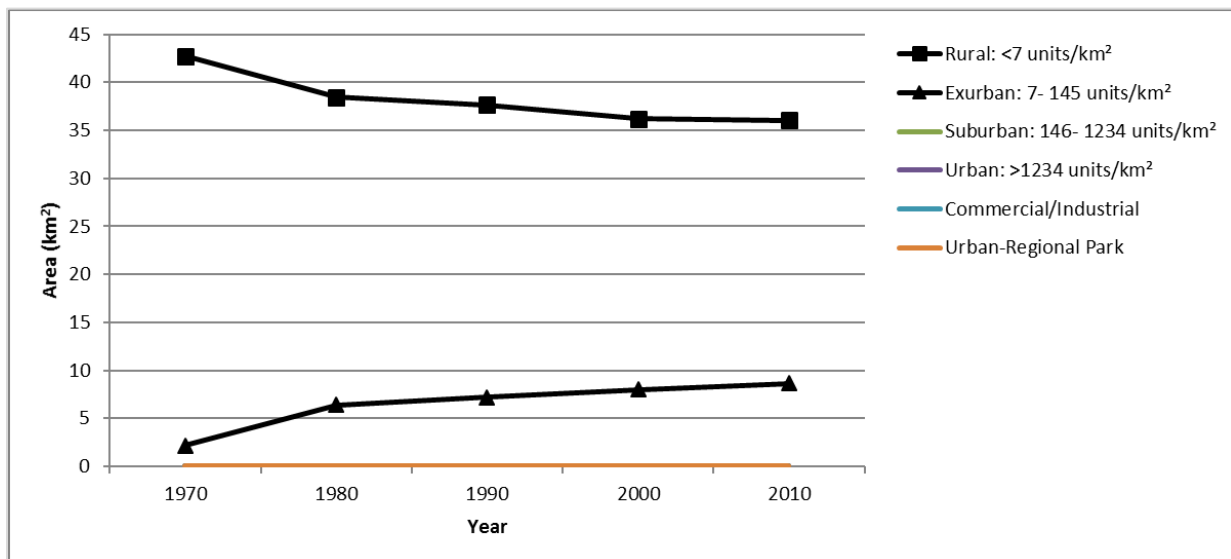


Figure 22. Area (km²) in each housing class from 1970 to 2010 in the Park-Manager-Selected Area of Analysis.

Total Population

The population was relatively low around Oregon Caves (Figure 23). Between 1990 and 2010, the population increased by 15% in the Regional AOA and 0.5% in the Park-Manager-Selected AOA.

The population within the Regional AOA was approximately 20,739 in 1990, 23,146 in 2000, and 23,774 in 2010 (Table A23). The population within the Park-Manager-Selected AOA was approximately 952 in 1990, 939 in 2000, and 956 in 2010 (Table A24).

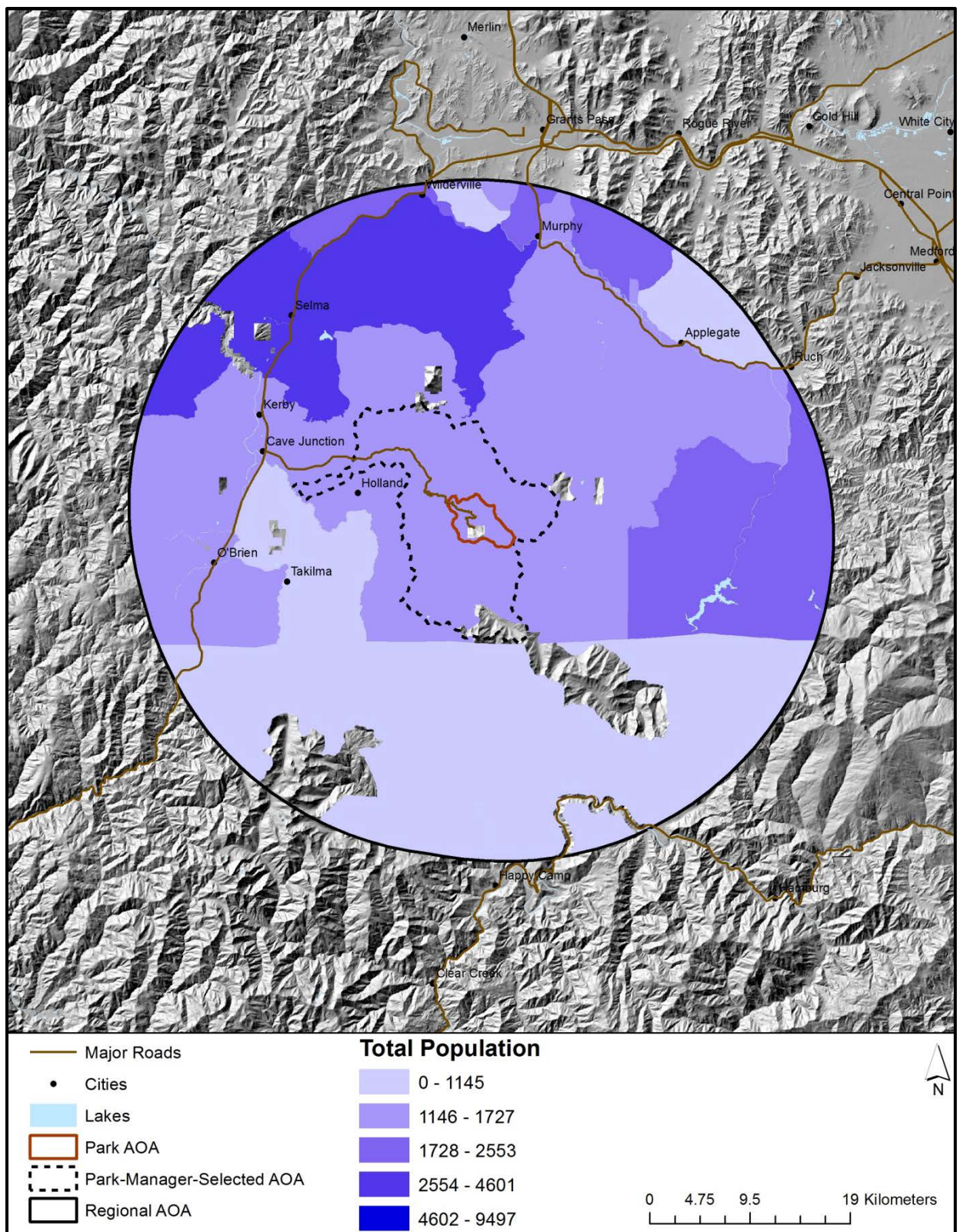


Figure 23. Total population in the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2010. Areas where people are assumed to be absent were masked out; this included water and PAD-US protected areas (status 1 and 2—areas that maintained primarily in a natural state).

Population Density

The population density (individuals per square kilometer) for the Regional AOA increased from 6.49 in 1990, to 7.25 in 2000, to 7.45 in 2010 (Table A23, Figures 24 and 25). The population density for the Park-Manager-Selected AOA decreased from 4.05 in 1990, to 4.00 in 2000, and then increased to 4.07 in 2010 (Table A24, Figures 24 and 25).

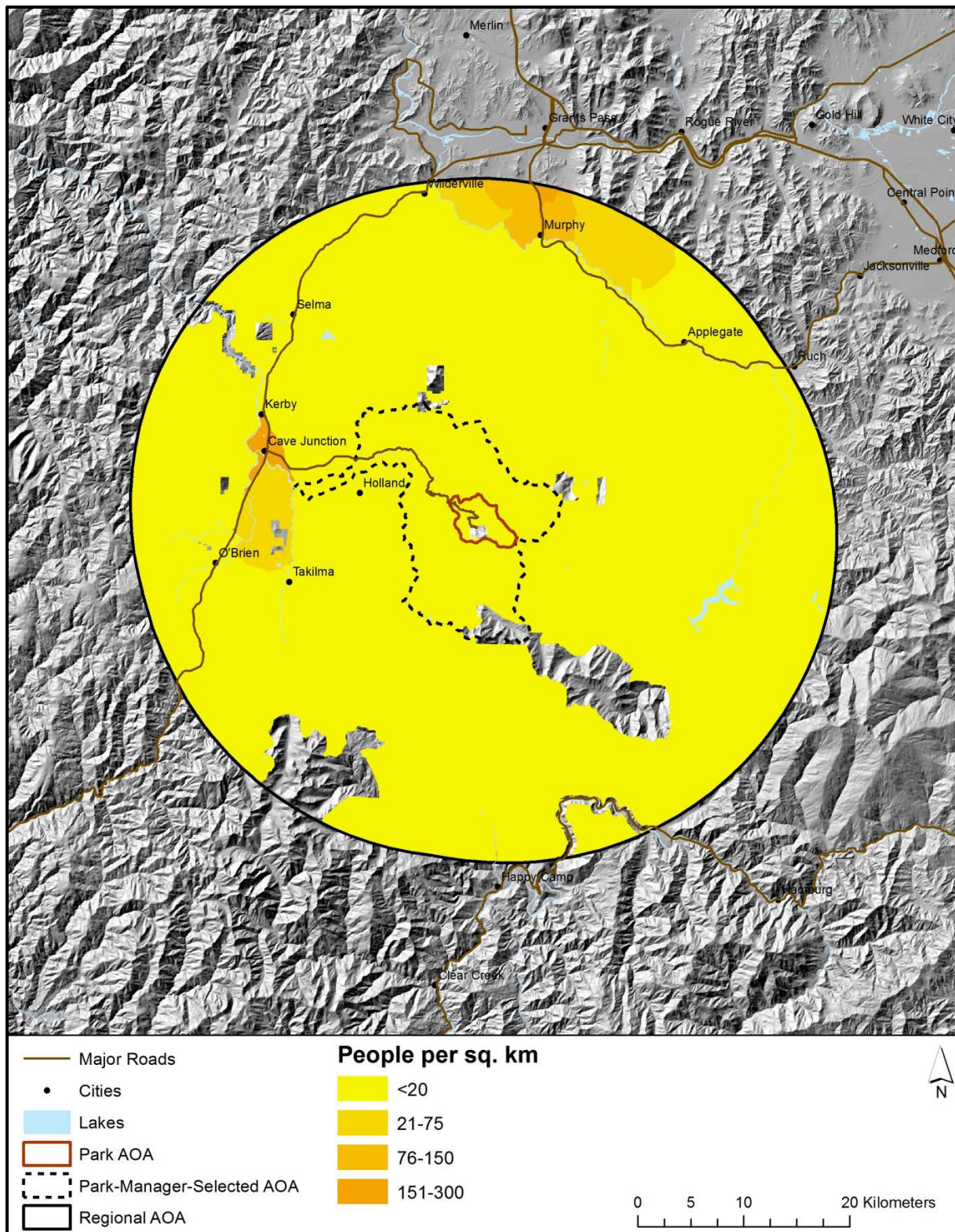


Figure 24. Population density from Census Block-Groups that intersect the Regional and Park-Manager-Selected Areas of Analysis (AOAs) in 2010. Areas where people are assumed to be absent were masked out; this included water and PAD-US protected areas (status 1 and 2—areas that maintained primarily in a natural state).

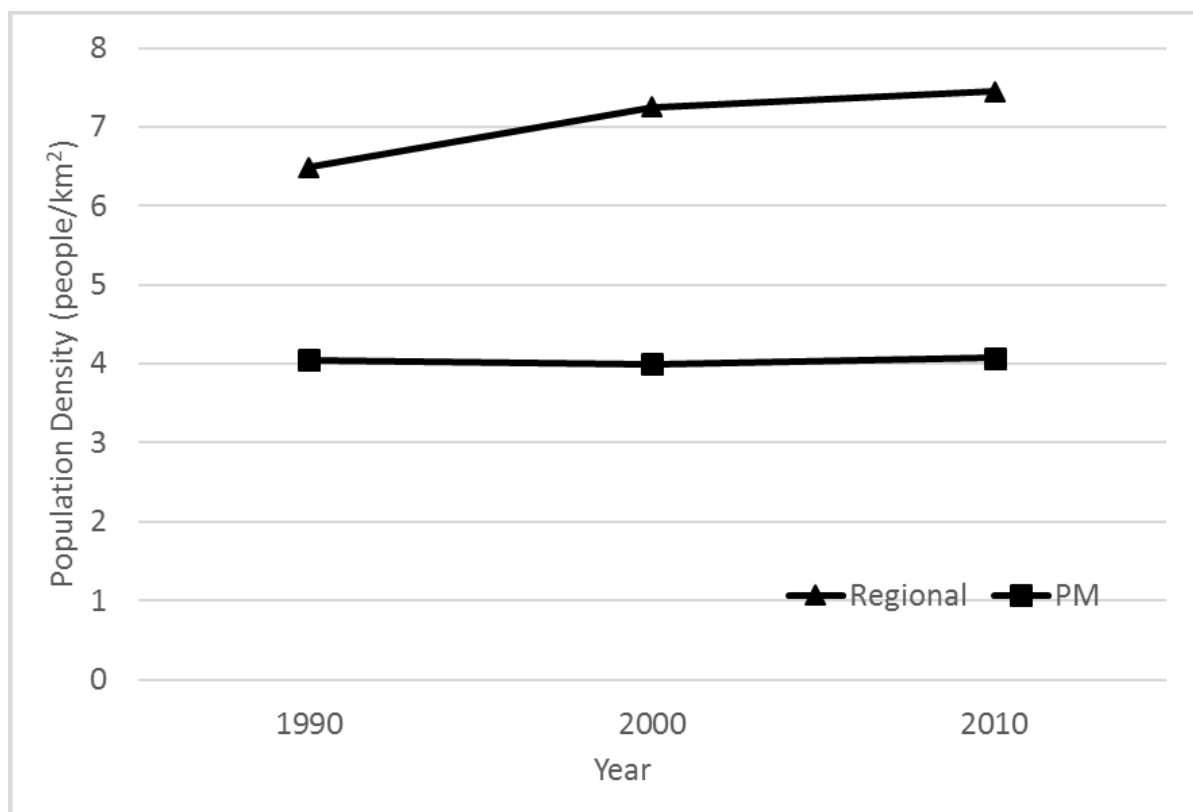


Figure 25. Population density (people/km²) from 1990 to 2010 at Regional and Park-Manager-Selected Areas of Analysis.

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 majority of roads surrounding the Park were category S1400 (Local Neighborhood Road, Rural Road, and 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 the Regional AOA and increased slightly in the Park-Manager-Selected AOA. Regional AOA road density was 1.31 in 2010 and 1.29 in 2015 (Figures 26 and 27; Table A25). Note that this slight decrease in road density over time was surprising and may reflect a problem with the source data. Park-Manager-Selected AOA road density was 1.57 in 2010 and 1.58 in 2015 (Figures 26 and 27; Table A26). Park AOA road density was 1.24 in 2016 (Figure 28 and Table A27).

In 2015, total road length in the Regional AOA was 4,449 km and 392 km in the Park-Manager-Selected AOA. In 2016, total road length was 43 km in the Park AOA (Tables A25–A27).

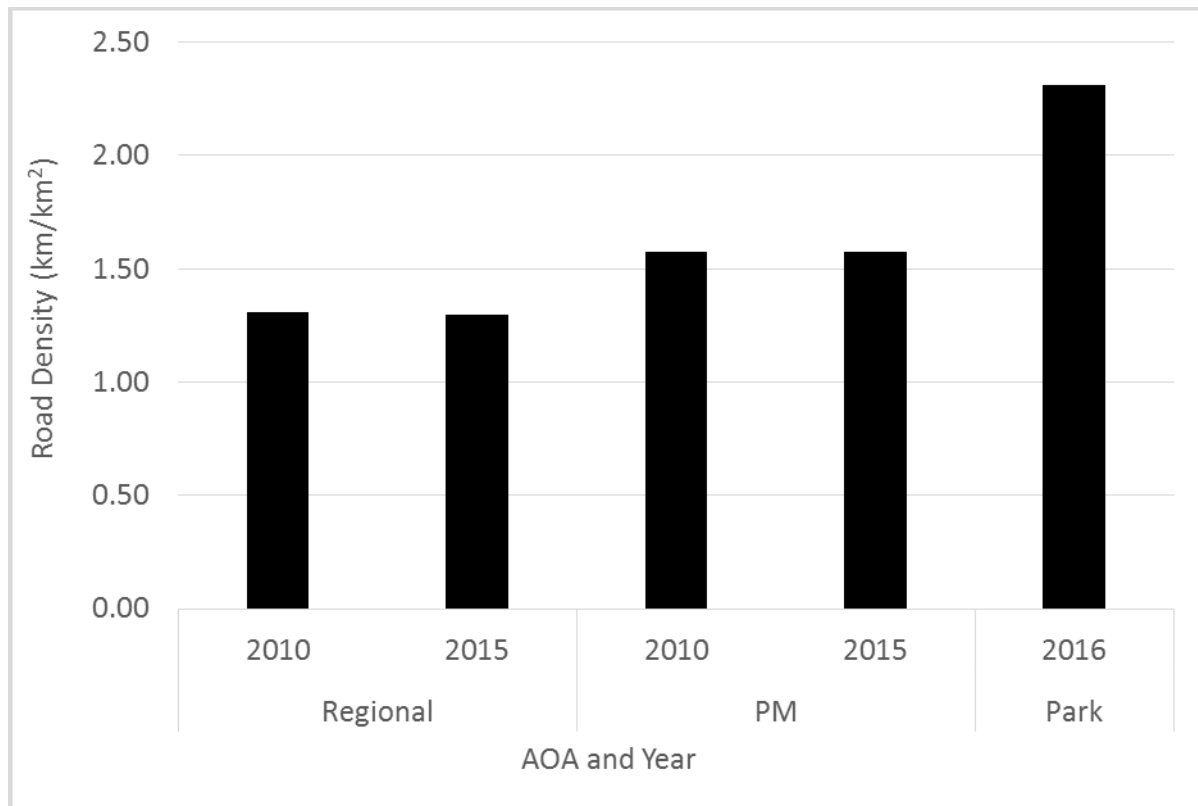


Figure 26. Road density (km/km²) in 2010 and 2015 at the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA), and in 2016 at the Park AOA. Note that the 2016 Park analysis was done with Oregon Caves National Monument and Preserve-supplied data, whereas the Regional and Park-Manager-Selected analyses were done with US Census Bureau TIGER data.

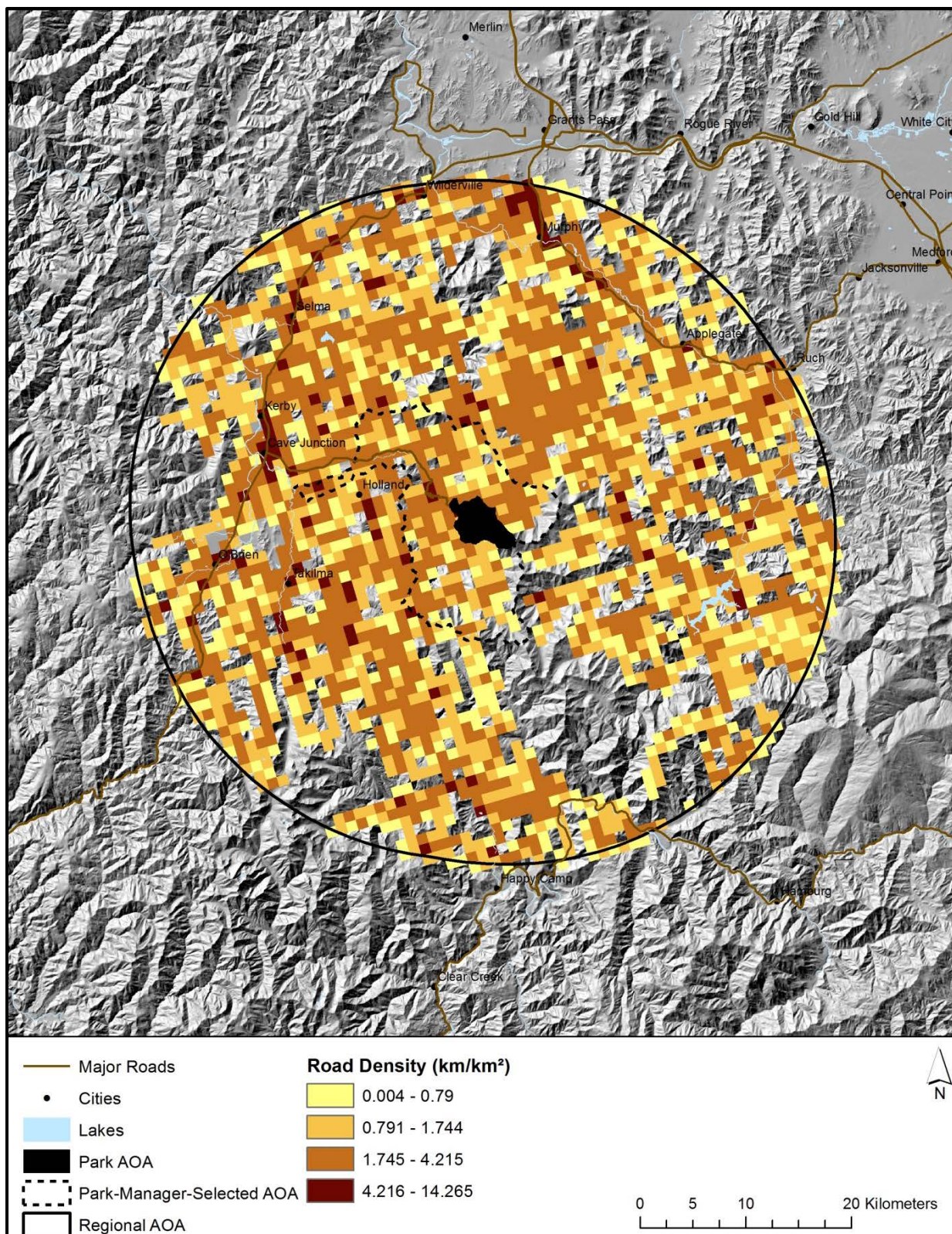


Figure 27. Road density (km/km²) using 2015 US Census Bureau TIGER data at the Regional and Park-Manager-Selected Areas of Analysis (AOA). See Figure 28 for Park AOA.

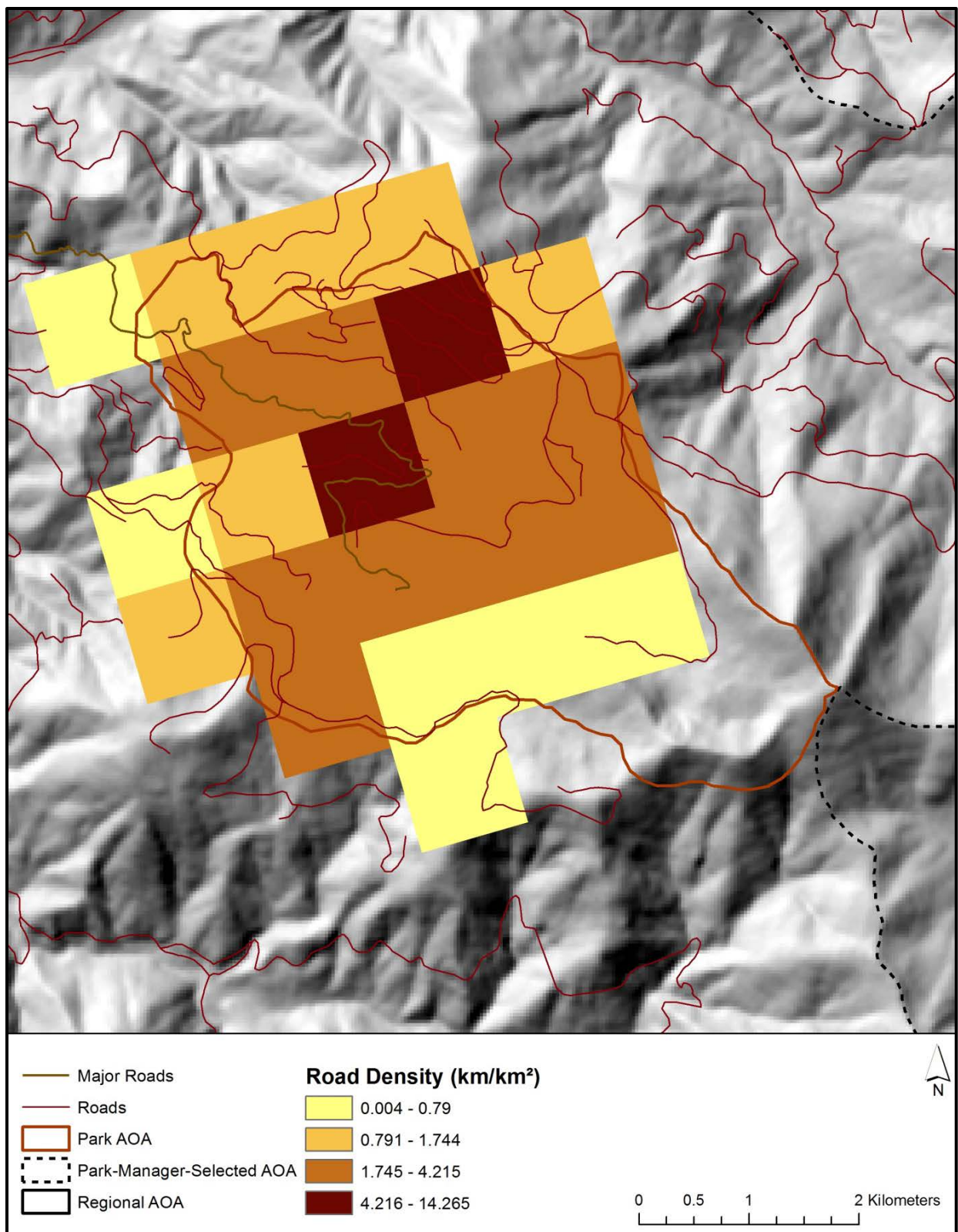


Figure 28. Road density (km/km²) using 2016 Oregon Caves National Monument and Preserve data within the Park Area of Analysis (AOA).

Distance from Roads

Most of the areas that are far from roads were outside Oregon Caves, and were generally wilderness areas and mountainous areas (Figure 29). Most area within the Park boundary was relatively close to a road.

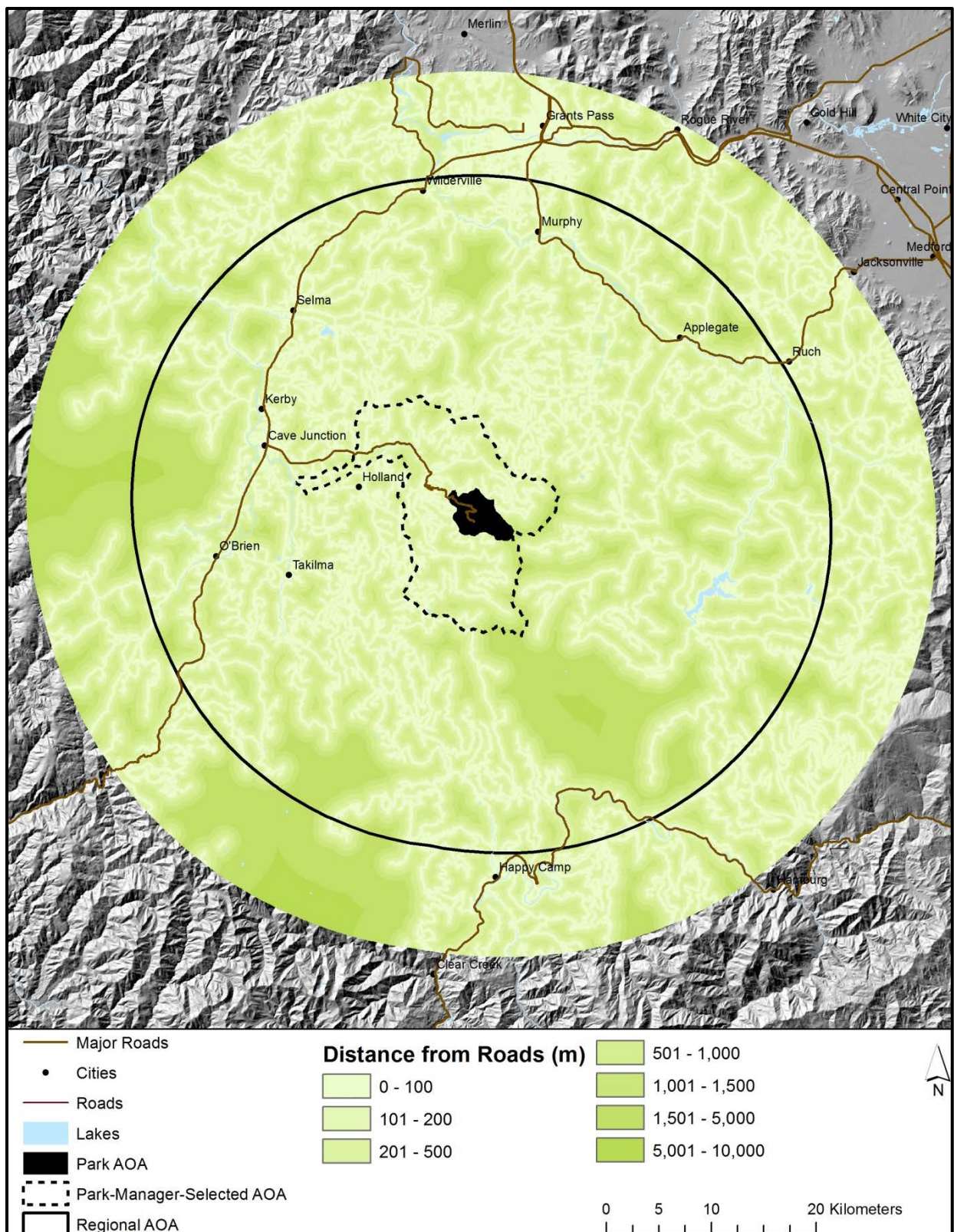


Figure 29. Distance from roads using 2015 US Census Bureau TIGER data in the Regional and Park-Manager-Selected Areas of Analysis (AOA). See Figure 30 for Park AOA.

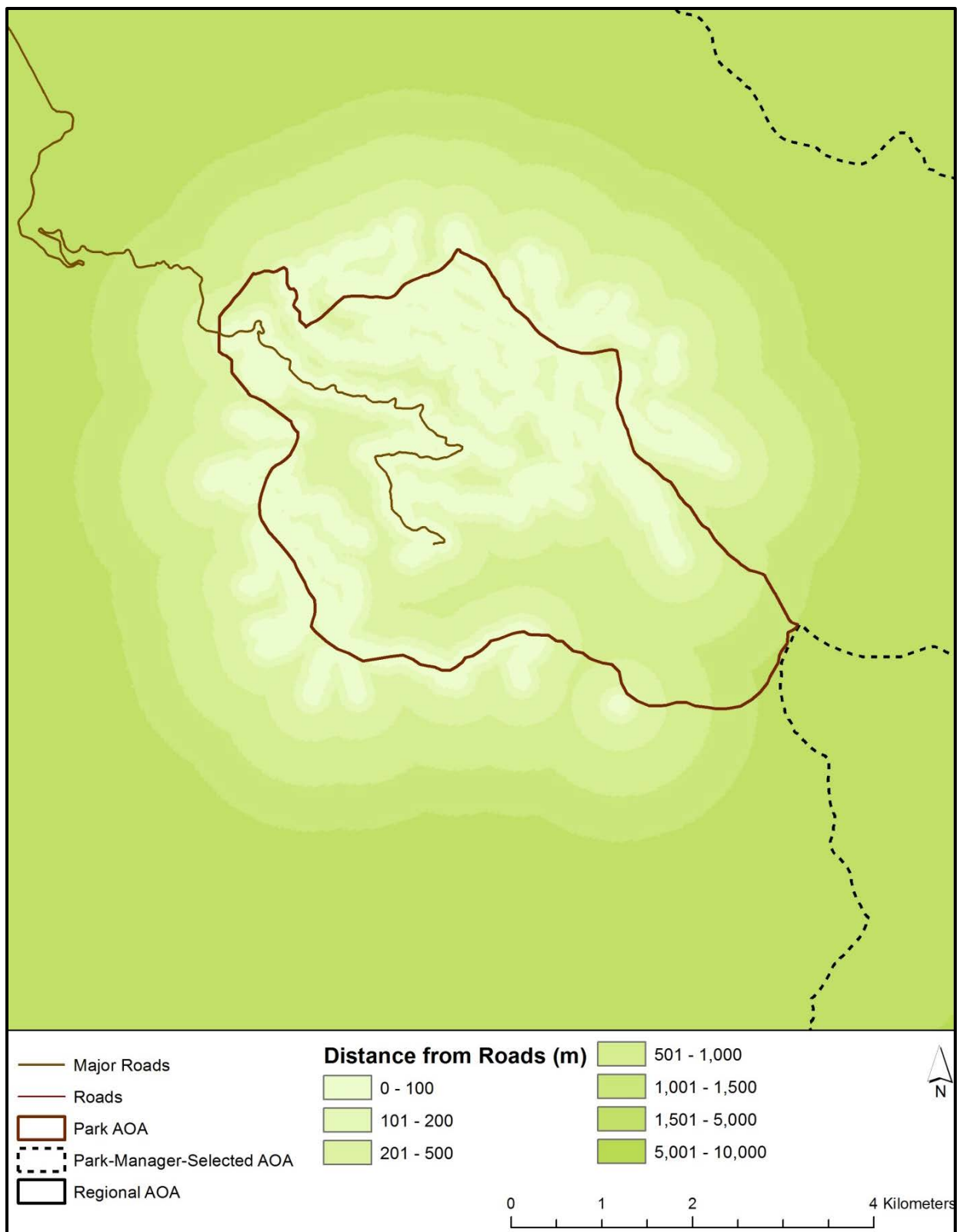


Figure 30. Distance from roads using 2016 Oregon Caves National Monument and Preserve data within the Park Area of Analysis (AOA).

Roadless Areas

Roadless areas (patches) were primarily US Forest Service lands, some as wilderness areas and others as GAP Status 3 lands.

There was little change in roadless areas between 2010 and 2015. In both 2010 and 2015, the Regional AOA contained four patches greater than 100 km², totaling 930 km² (Table A28, Figure 31). In both 2010 and 2015, the Park-Manager-Selected AOA contained no patches greater than 100 km², although one patch was between 50 and 100 km². Both Regional and Park-Manager-Selected AOAs contained numerous roads dividing land into areas less than 10 km² (Tables A28 and A29, Figure 31). Within the Park AOA (2016 data), there were several roads; all areas broken apart by roads were less than 10 km² (Table A30, Figure 32).

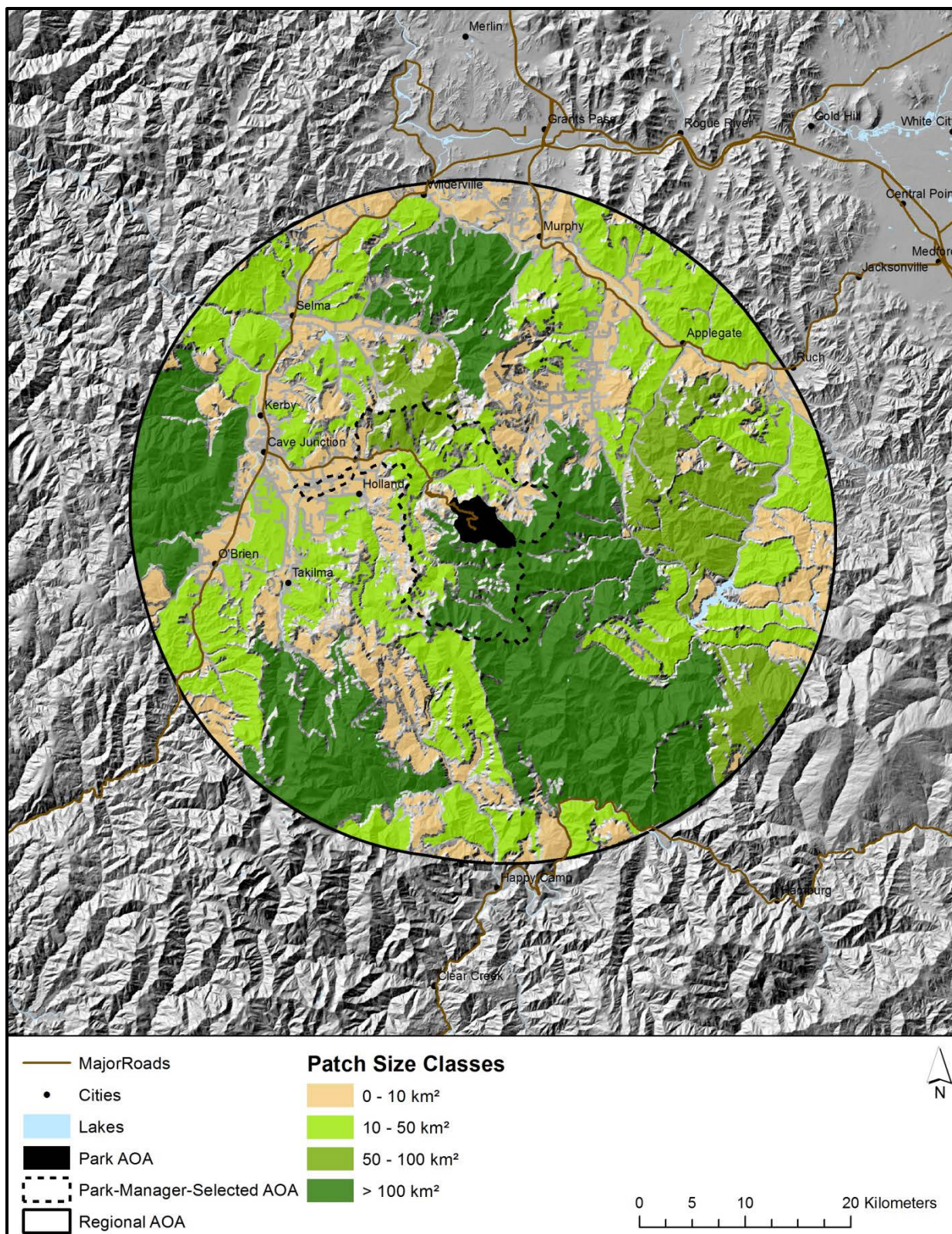


Figure 31. Roadless areas using 2015 US Census Bureau TIGER data for the Regional and Park-Manager-Selected Areas of Analysis (AOA). See Figure 32 for Park AOA.

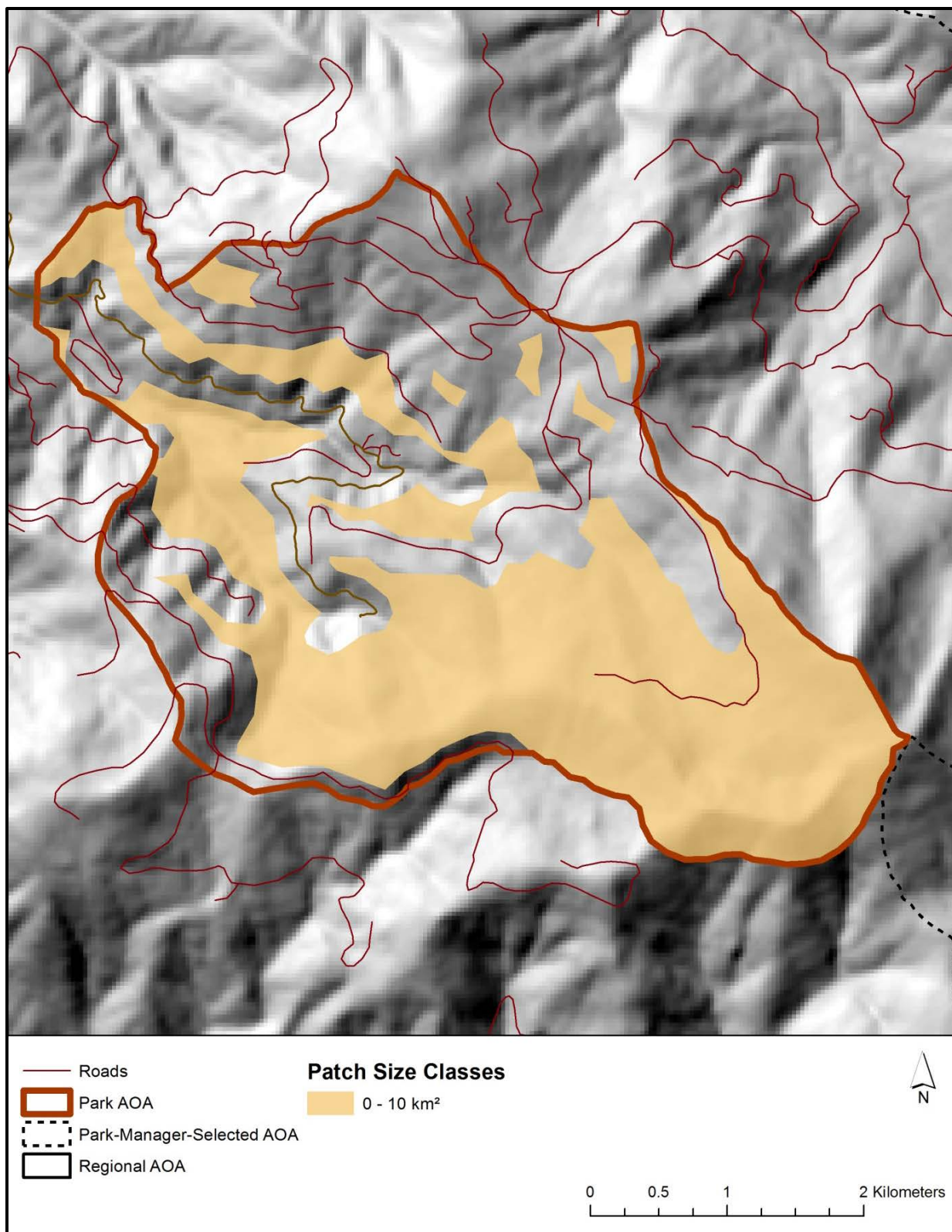


Figure 32. Roadless areas, using 2016 Oregon Caves National Monument and Preserve data within the Park Area of Analysis (AOA).

Disturbance

In the Regional AOA, a cumulative total area of 708 km² was disturbed from 1999 to 2012 (Tables A31–A33). Figure 33 shows disturbed area by year within each of the three AOAs. *Wildfire* affected the most area (280.0 km²), followed by *Other Mechanical* (225.4 km²) (see Methods, Table 9, for disturbance category definitions). These accounted for 40% and 32%, 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 AOA, from 1999 to 2012, the total disturbed area was 39.5 km² (Tables A34 and A35). *Other Mechanical* (32.0 km²) affected the most area, accounting for 81% of the disturbed areas within the Park-Manager-Selected AOA.

For the Park AOA, from 1999 to 2012, the total disturbed area was 4.4 km² (Table A36). *Other Mechanical* affected the most area (3.8 km²). This disturbance type accounted for 86% of all disturbed areas within the Park AOA.

Figures 36 through 38 plot the area affected by each of the largest disturbance types over time within the Regional, Park-Manager-Selected, and Park AOAs, respectively.

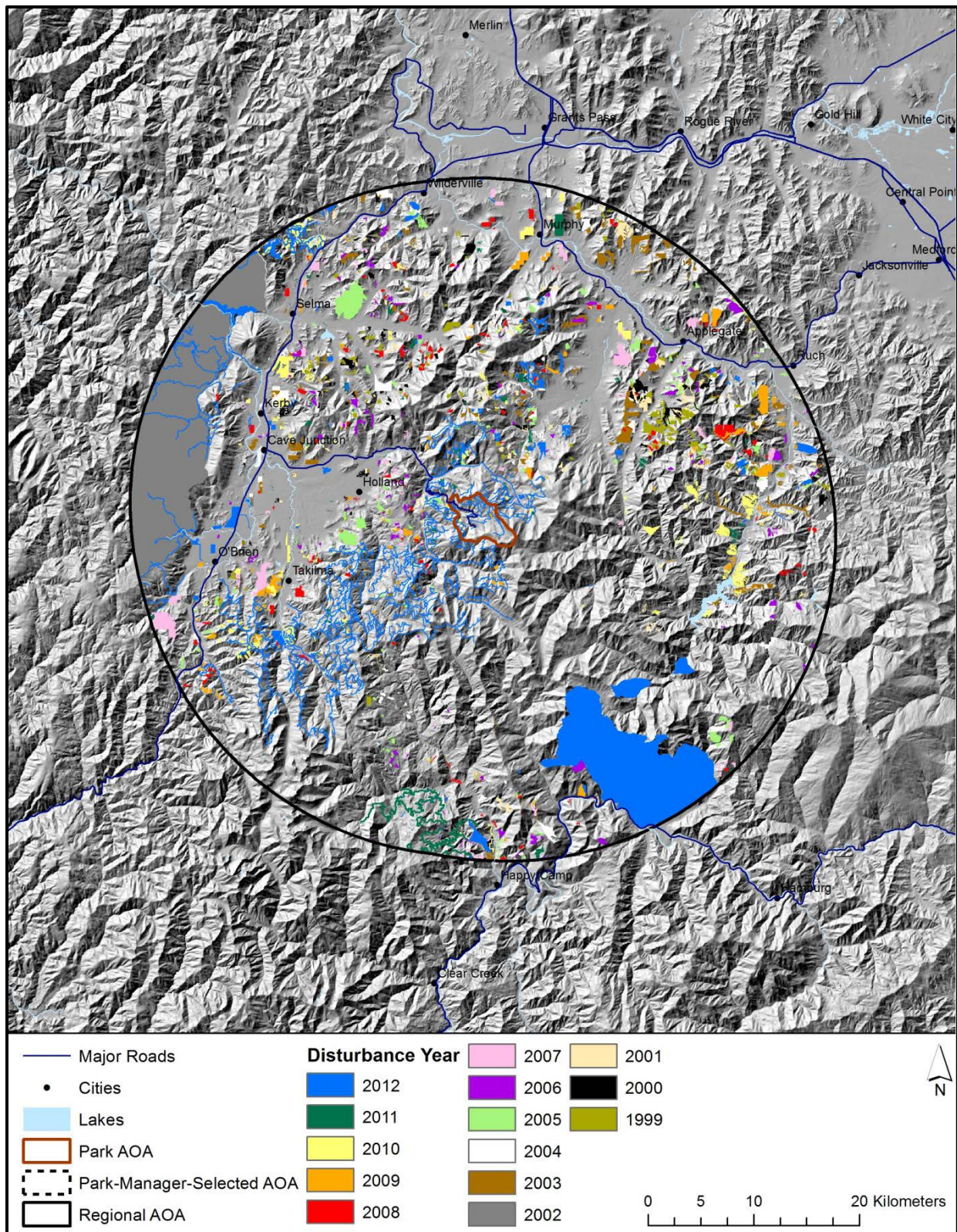


Figure 33. Locations of disturbances by year (1999–2012) at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

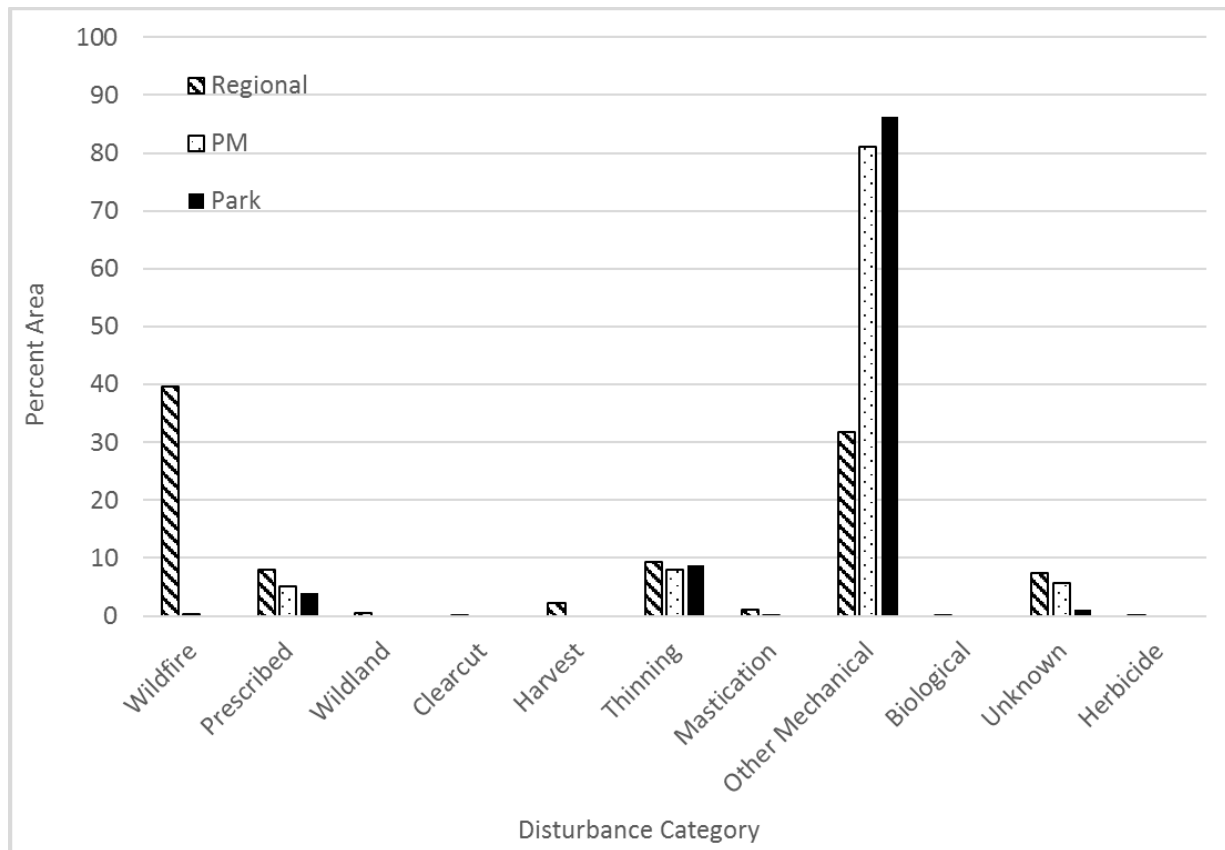


Figure 34. Percentage area (area disturbed/total disturbed area for that Area of Analysis (AOA)) affected by each disturbance type from 1999 to 2012, at the Regional, Park-Manager-Selected (PM), and Park Areas of Analysis.

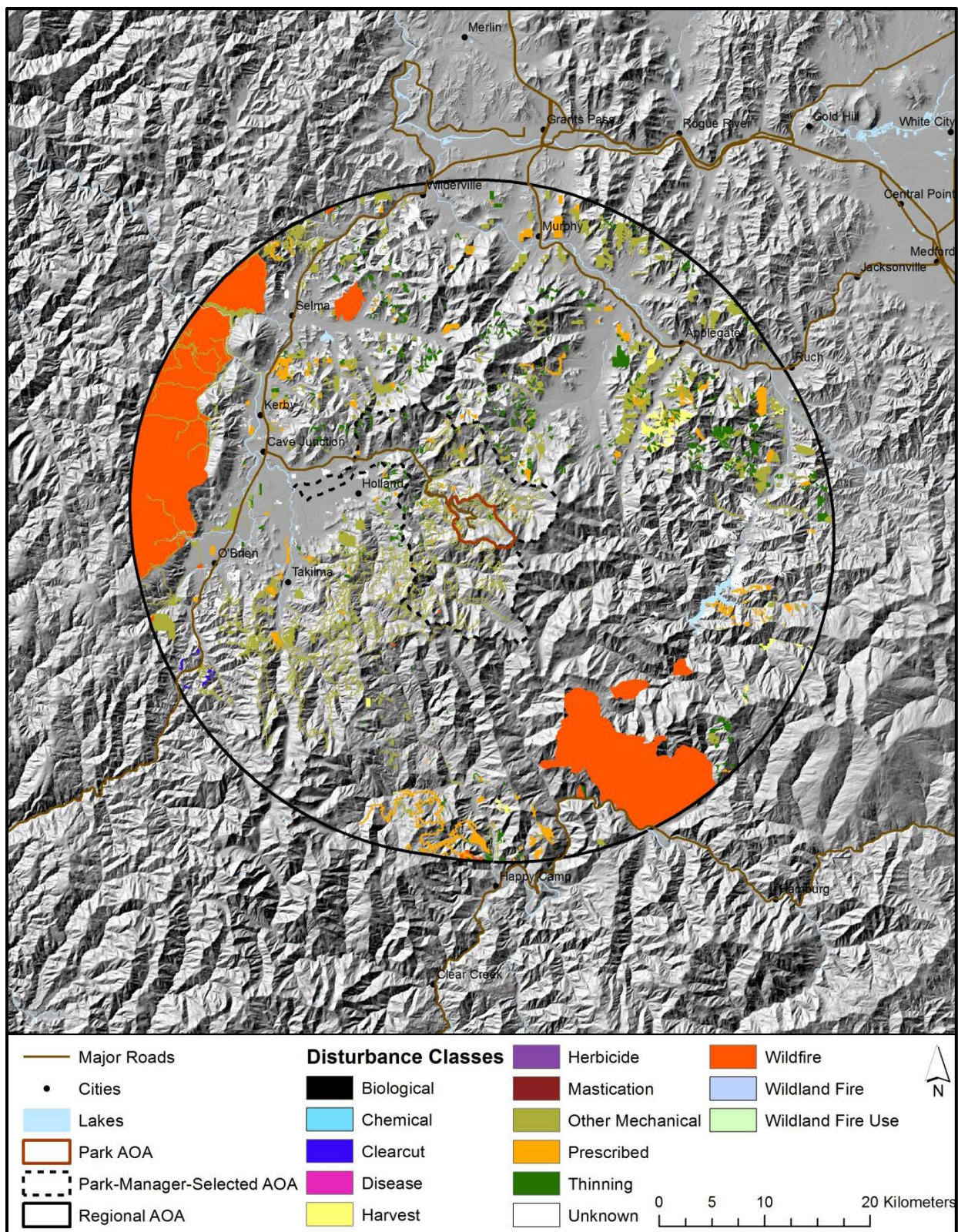


Figure 35. Areas affected by different disturbance types from 1999 to 2012, for Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

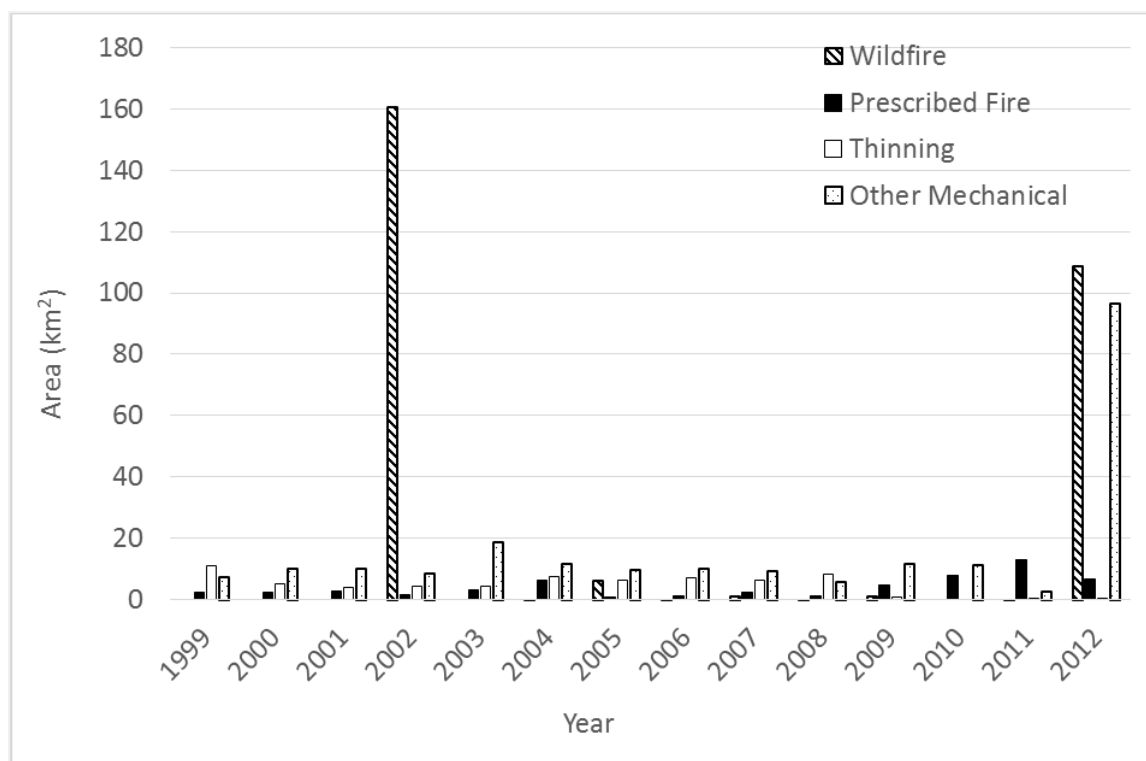


Figure 36. Total area (km²) affected by the four largest disturbance types, by year, for the Regional Area of Analysis. Complete disturbance type values are in Tables A31–A33.

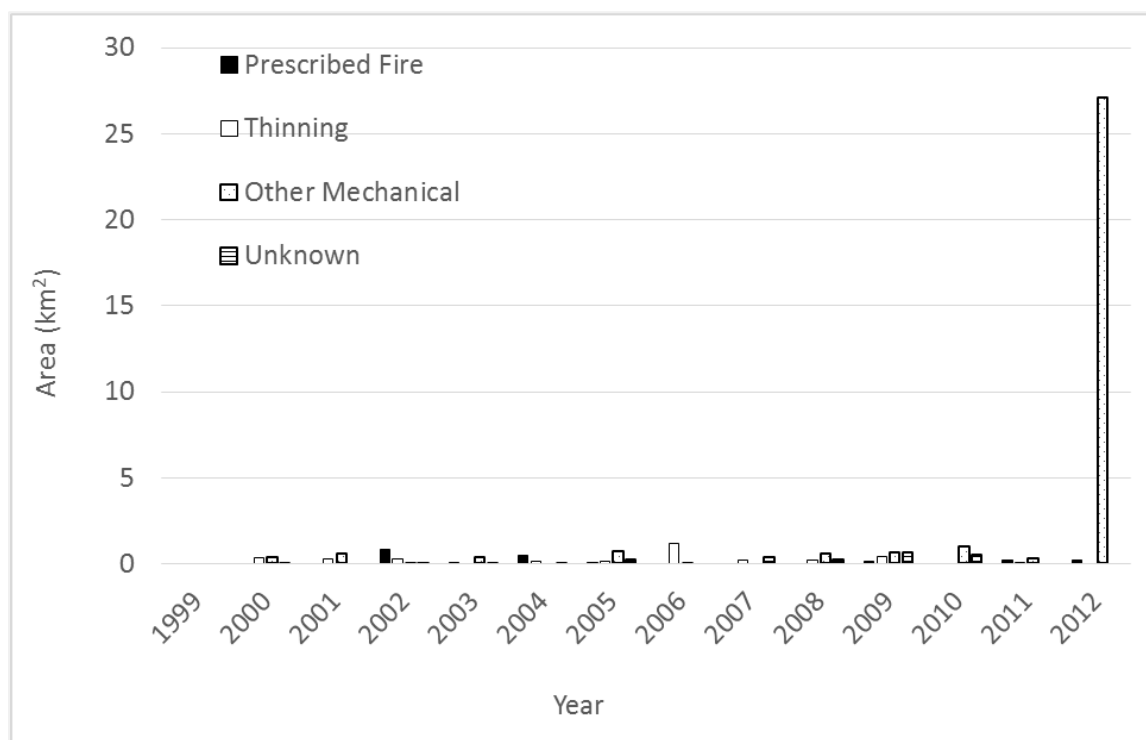


Figure 37. Total area (km²) affected by the four largest disturbance types, by year, for the Park-Manager-Selected Area of Analysis. Complete disturbance type values are in Tables A34–A35.

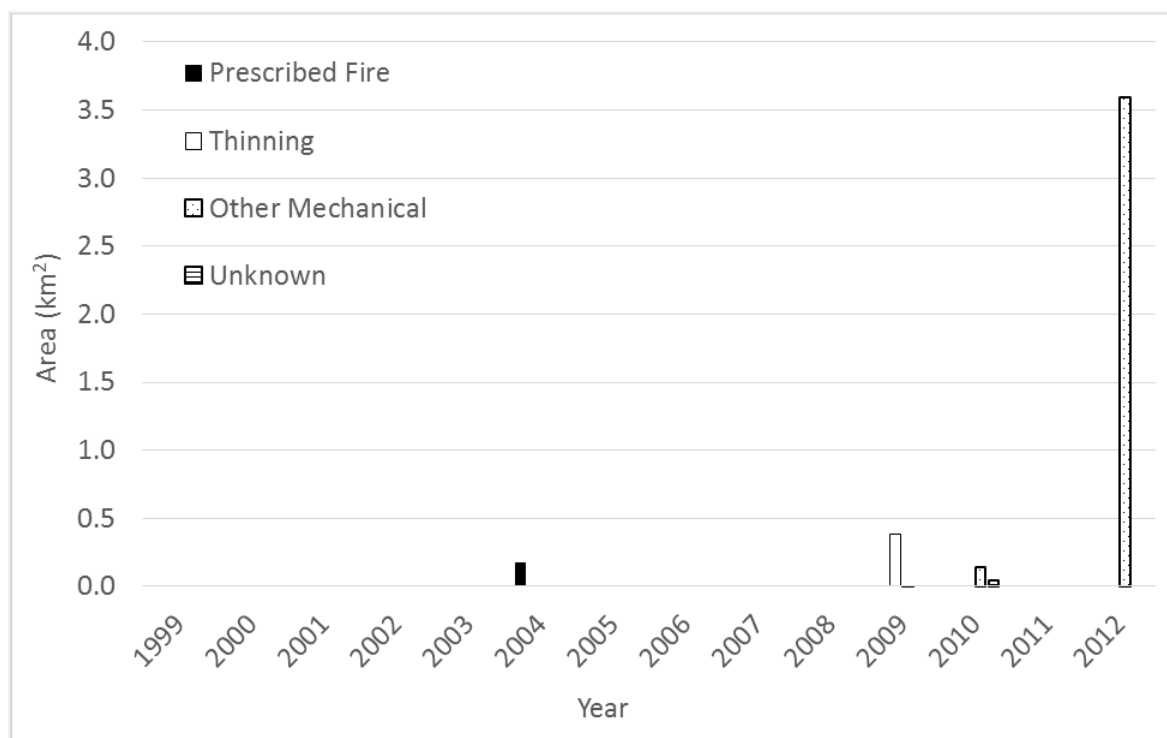


Figure 38. Total area (km²) of the three largest disturbance types, by year, for the Park Area of Analysis. Complete disturbance type values are in Table A36.

Discussion

This report summarizes landscape level information about Oregon Caves and its surrounding areas from largely regional- and national-level datasets. The vegetation within the Park, Regional, and Park-Manager-Selected AOAs is primarily evergreen forest, and the land outside the Park is predominately national forest with a GAP Conservation Status of 3, which means that even though the area has protection from conversion of natural land, extractive use is allowed. Within the forested areas, almost half of the land is in large intact patches. Most grassland and shrubland in the study area are in small patches. Most of the AOAs are considered to be in natural condition, with few impervious surfaces. The areas around the Park are characterized by low populations, low housing density, and low road density. A variety of disturbances have occurred, with the most area affected by mechanical disturbance, thinning, and wildfire.

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 Oregon Caves 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.

Literature Cited

- Anderson, J. R., E. E. Hardy, J. T. Roach, and R. E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964, USGS, Reston, Virginia.
- Gross, J. E., and L. Svancara. 2009. Measure description summary: landscape pattern. Unpublished National Park Service report, Inventory and Monitoring Division, National Park Service, Fort Collins, Colorado.
- Mohren, S. R., L. C. Groshong, D. A. Sarr, A. Snyder, and A. Chung-MacCoubrey. 2016a. Land cover and land use monitoring protocol for the Klamath Network: Narrative. Natural Resource Report NPS/KLMN/NRR—2016/1342. National Park Service, Fort Collins, Colorado.
- Mohren, S. R., L. C. Groshong, D. A. Sarr, A. Snyder, and A. Chung-MacCoubrey. 2016b. Land cover and land use monitoring protocol for the Klamath Network: Standard operating procedures, version 1.0. National Park Service, Klamath Inventory and Monitoring Network, Ashland, Oregon.
- Nelson, L., and M. Kinseth. 2016. NPS Boundary-Derived Areas of Analysis for use with Landscape Dynamics. NPS/NRSS/IMD/SOP-1.5.
<https://irma.nps.gov/DataStore/Reference/Profile/2235933>
- Odion, D. D. Sarr, B. Truitt, A. Duff, S. Smith, W. Bunn, E. Beever, S. Shafer, S. Smith, J. Rocchio, R. Hoffman, C. Currens, and M. Madej. 2005. Vital signs monitoring plan for the Klamath Network: Phase II report. Klamath Network-National Park Service, Ashland, Oregon.
- Riitters, K. H. 2011. Spatial patterns of land cover in the United States: A technical document supporting the forest service 2010 RPA Assessment. Gen. Tech. Rep. SRS-136. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, North Carolina.
- Stephens, J. L., S. R. Mohren, J. D. Alexander, D. A. Sarr, and K. M. Irvine. 2010. Klamath Network landbird monitoring protocol. Natural Resource Report NPS/KLMN/NRR—2010/187. National Park Service, Fort Collins, Colorado.
- Theobald, D. M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. *Ecology and Society* 10:32.
- Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York.

Appendix A: Data Tables

Table A1. Area and percentage of AOA attributed to different landowners for the Regional and Park-Manager-Selected 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	
	Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
Bureau of Land Management (BLM)	662.36	19.52	23.31	9.36
Forest Service (USFS)	1903.99	56.12	190.64	76.58
National Park Service (NPS)	1.89	0.06	1.89	0.76
State Park & Recreation	4.25	0.13	0	0
State Department of Natural Resources	10.69	0.32	0.16	0.06
State Department of Land	0.83	0.02	0	0
City Land	0.01	<0.01	0	0
County Land	0.24	0.01	0	0
The Nature Conservancy (TNC)	0.43	0.01	0	0
Private Landowner	0.01	<0.01	0	0
Unavailable Data	807.71	23.81	32.94	13.23

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 AOAs in 2012. *Note that the percentage could be larger depending on the composition of the unavailable data.

Status	Description	Regional		Park-Manager-Selected	
		Area (km ²)	Minimum percentage of AOA*	Area (km ²)	Minimum percentage of AOA*
1	Managed for biodiversity, natural disturbance allowed	149.91	4.42	11.39	4.57
2	Managed for biodiversity, natural disturbance NOT allowed	45.12	1.33	2.66	1.07
3	Managed for multiple use	2388.42	70.40	201.96	81.13
4	No known mandate	1.25	0.04	0	0
N/A	Unavailable	807.71	23.81	32.94	13.23

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	3.95	0.12	3.97	0.12
Developed, Open Space	118.44	3.49	118.36	3.49
Developed, Low Intensity	13.43	0.40	13.45	0.40
Developed, Medium Intensity	2.03	0.06	2.08	0.06
Developed, High Intensity	0.78	0.02	0.78	0.02
Barren Land	14.24	0.42	8.03	0.24
Deciduous Forest	17.73	0.52	17.72	0.52
Evergreen Forest	2236.16	65.92	2228.33	65.69
Mixed Forest	90.10	2.66	89.51	2.64
Shrub/Scrub	669.75	19.74	679.33	20.03
Herbaceous	104.30	3.07	109.20	3.22
Hay/Pasture	75.85	2.24	76.00	2.24
Cultivated Crops	4.76	0.14	4.76	0.14
Woody Wetlands	33.08	0.98	33.08	0.98
Herbaceous Wetlands	7.79	0.23	7.78	0.23

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

Level 2	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
Open Water	0.07	0.03	0.07	0.03
Developed, Open Space	9.49	3.81	9.48	3.81
Developed, Low Intensity	0.14	0.06	0.15	0.06
Developed, Medium Intensity	0.03	0.01	0.03	0.01
Developed, High Intensity	—	—	—	—
Barren Land	0.30	0.12	0.61	0.24
Deciduous Forest	0.12	0.05	0.12	0.05

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

Level 2	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
Evergreen Forest	206.22	82.84	205.49	82.55
Mixed Forest	6.51	2.61	6.47	2.60
Shrub/Scrub	16.18	6.50	16.57	6.66
Herbaceous	3.23	1.30	3.30	1.33
Hay/Pasture	1.52	0.61	1.52	0.61
Cultivated Crops	0.02	0.01	0.02	0.01
Woody Wetlands	4.51	1.81	4.51	1.81
Herbaceous Wetlands	0.58	0.23	0.57	0.23

Table A5. 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	—	—	—	—
Developed, Open Space	1.06	5.74	1.06	5.74
Developed, Low Intensity	0.01	0.03	0.01	0.03
Developed, Medium Intensity	0.01	0.03	0.01	0.03
Developed, High Intensity	—	—	—	—
Barren Land	—	—	—	—
Deciduous Forest	0.01	0.05	0.01	0.05
Evergreen Forest	15.40	83.46	15.43	83.64
Mixed Forest	0.26	1.42	0.26	1.41
Shrub/Scrub	1.33	7.19	1.27	6.91
Herbaceous	0.14	0.79	0.16	0.89
Hay/Pasture	—	—	—	—
Cultivated Crops	—	—	—	—
Woody Wetlands	0.21	1.13	0.21	1.13
Herbaceous Wetlands	0.03	0.17	0.03	0.17

Table A6. Area and percentage of AOA by Impervious Surface group 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%	3280.11	96.69	3280.08	96.69
2% - 4%	28.17	0.83	28.16	0.83
4% - 6%	16.92	0.50	16.90	0.50
6% - 8%	11.72	0.35	11.70	0.34
8% - 10%	9.22	0.27	9.21	0.27
10% - 15%	16.51	0.49	16.49	0.49
15% - 25%	16.26	0.48	16.23	0.48
25% - 50%	10.25	0.30	10.28	0.30
50% - 100%	3.21	0.09	3.34	0.10

Table A7. Area and percentage of AOA by Impervious Surface group in the Park-Manager-Selected AOA, for 2006 and 2011.

Impervious Surface	2006		2011	
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA
0% - 2%	241.17	96.88	241.17	96.88
2% - 4%	3.26	1.31	3.26	1.31
4% - 6%	1.62	0.65	1.62	0.65
6% - 8%	0.89	0.36	0.89	0.36
8% - 10%	0.55	0.22	0.55	0.22
10% - 15%	0.78	0.31	0.78	0.31
15% - 25%	0.47	0.19	0.47	0.19
25% - 50%	0.15	0.06	0.15	0.06
50% - 100%	0.04	0.02	0.04	0.02

Table A8. Area and percentage of AOA by Impervious Surface group 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%	17.62	95.53	17.62	95.53
2% - 4%	0.34	1.82	0.34	1.82
4% - 6%	0.19	1.03	0.19	1.03
6% - 8%	0.10	0.52	0.10	0.52
8% - 10%	0.06	0.31	0.06	0.31
10% - 15%	0.08	0.46	0.08	0.46
15% - 25%	0.04	0.21	0.04	0.21
25% - 50%	0.01	0.07	0.01	0.07
50% - 100%	0.01	0.04	0.01	0.04

Table A9. Area and percentage of AOA for *Natural* and *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	3177.1	93.65	3176.94	93.65	-0.01
Converted	215.28	6.35	215.44	6.35	0.08

Table A10. Area and percentage of AOA for *Natural* and *Converted* land in the Park-Manager-Selected AOA, for 2006 and 2011.

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percentage Area	Area (km ²)	Percentage Area	
Natural	237.72	95.5	237.72	95.5	0
Converted	11.20	4.50	11.20	4.50	0

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

Land Type	2006		2011		% Change in Area
	Area (km ²)	Percentage Area	Area (km ²)	Percentage Area	
Natural	17.38	94.2	17.38	94.2	0
Converted	1.07	5.8	1.07	5.8	0

Table A12. Area, percentage of AOA, and percentage of forest area by forest morphology classification in the Regional and Park-Manager-Selected AOAs for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of AOA	Percentage of Forested Area	Area (km ²)	Percentage of AOA	Percentage of forested area
Background (non-forested)	1023.77	30.18	NA	32.33	12.99	NA
Branch	68.07	2.01	2.87	1.81	0.73	0.84
Edge	770.42	22.71	32.53	78.44	31.51	36.21
Islet	87.34	2.57	3.69	0.25	0.10	0.11
Core	778.07	22.94	32.85	88.39	35.51	40.81
Bridge	594.58	17.53	25.10	43.31	17.40	19.99
Perforated	45.18	1.33	1.91	3.96	1.59	1.83
Loop	24.97	0.74	1.05	0.45	0.18	0.21

Table A13. Area, percentage of AOA, and percentage of grassland area by pattern morphology classification in the Regional and Park-Manager-Selected AOAs, for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland
Background (non-grassland)	3207.18	94.54	NA	244.10	98.06	NA
Branch	9.79	0.29	5.29	0.14	0.06	2.89
Edge	26.15	0.77	14.12	0.39	0.16	8.04
Islet	98.21	2.89	53.03	3.15	1.27	65.36
Core	5.00	0.15	2.70	0.04	0.01	0.75

Table A13 (continued). Area, percentage of AOA, and percentage of grassland area by pattern morphology classification in the Regional and Park-Manager-Selected AOAs, for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland
Bridge	31.42	0.93	16.96	0.72	0.29	15.00
Perforated	—	—	—	—	—	—
Loop	14.64	0.43	7.90	0.38	0.15	7.96

Table A14. Area, percentage of AOA, and percentage of shrubland area by pattern morphology classification in the Regional and Park-Manager-Selected AOAs for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Shrubland
Background (non Shrubland)	2713.07	79.97	NA	232.35	93.34	NA
Branch	27.49	0.81	4.05	—	—	—
Edge	80.94	2.39	11.91	—	—	—
Islet	331.99	9.79	48.87	16.58	6.66	100.00
Core	30.22	0.89	4.45	—	—	—
Bridge	177.24	5.22	26.09	—	—	—
Perforated	2.12	0.06	0.31	—	—	—
Loop	29.33	0.86	4.32	—	—	—

Table A15. 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	Regional		Park-Manager-Selected	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	3048	82.91	48	0.54
1 to <5	23	39.78	0	0
5 to <10	5	37.24	0	0
10 to <25	2	35.98	0	0
25 to <50	5	178.67	0	0

Table A15 (continued). 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	Regional		Park-Manager-Selected	
	Count	Total Area (km ²)	Count	Total Area (km ²)
50 to <100	0	0	0	0
100 to <250	0	0	1	216.06
250 to <500	0	0	0	0
500 to <1000	0	0	0	0
>1,000	1	1994.05	0	0
Total	3084	2368.63	49	216.60

Table A16. 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	Regional		Park-Manager-Selected	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	3801	108.30	204	4.82
1 to <5	28	50.03	0	0
5 to <10	2	15.50	0	0
10 to <25	1	11.38	0	0
25 to <50	0	0	0	0
50 to <100	0	0	0	0
100 to <250	0	0	0	0
250 to <500	0	0	0	0
500 to <1000	0	0	0	0
>1,000	0	0	0	0
Total	3832	185.20	204	4.82

Table A17. Count and total area by patch size range, for shrubland in the Regional and Park-Manager-Selected AOA, for 2011.

Patch Size Range, in km ²	Regional		Park-Manager-Selected	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	10571	322.90	818	16.58
1 to <5	49	104.23	0	0
5 to <10	6	38.77	0	0
10 to <25	4	65.95	0	0
25 to <50	0	0	0	0
50 to <100	0	0	0	0
100 to <250	1	147.47	0	0
250 to <500	0	0	0	0
500 to <1000	0	0	0	0
>1,000	0	0	0	0
Total	10631	679.33	818	16.58

Table A18. Area, percentage of AOA, and percentage of forest area by pattern density classification in the Regional and Park-Manager-Selected AOAs, for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of Forested area	Percentage of AOA	Area (km ²)	Percentage of Forested area	Percentage of AOA
Rare	120.53	3.81	3.55	1.66	0.67	0.67
Patchy	417.53	13.19	12.31	9.66	3.90	3.88
Transitional	321.74	10.16	9.48	13.59	5.49	5.46
Dominant	789.21	24.92	23.26	61.58	24.87	24.74
Interior	417.63	13.19	12.31	40.62	16.40	16.32
Intact	1099.98	34.74	32.42	120.53	48.67	48.42
Total	3166.61	100.00	93.34	247.64	100.00	99.48

Table A19. Area, percentage of AOA, and percentage of grassland area by pattern density classification in the Regional and Park-Manager-Selected AOAs for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of Grassland Area	Percentage of AOA	Area (km ²)	Percentage of Grassland Area	Percentage of AOA
Rare	155.75	26.25	4.59	7.16	34.87	2.87
Patchy	256.65	43.25	7.57	9.26	45.11	3.72
Transitional	71.68	12.08	2.11	1.83	8.91	0.73
Dominant	74.16	12.50	2.19	1.75	8.53	0.70
Interior	18.87	3.18	0.56	0.33	1.59	0.13
Intact	16.27	2.74	0.48	0.21	1.00	0.08
Total	593.38	100.00	17.49	20.52	100.00	8.24

Table A20. Area, percentage of AOA, and percentage of shrubland area by pattern density classification in the Regional and Park-Manager-Selected AOAs for 2011.

Classification	Regional			Park-Manager-Selected		
	Area (km ²)	Percentage of Shrubland Area	Percentage of AOA	Area (km ²)	Percentage of Shrubland Area	Percentage of AOA
Rare	366.03	19.57	10.79	26.95	33.38	10.83
Patchy	793.87	42.44	23.40	41.79	51.77	16.79
Transitional	289.01	15.45	8.52	7.97	9.88	3.20
Dominant	280.48	14.99	8.27	3.69	4.57	1.48
Interior	73.93	3.95	2.18	0.29	0.35	0.11
Intact	67.32	3.60	1.98	0.03	0.04	0.01
Total	1870.64	100.00	55.14	80.73	100.00	32.43

Table A21. 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)	817.03	699.88	614.39	564.79	548.41
Percentage of Total Area	24.08	20.63	18.11	16.65	16.17
Percentage of Census Area	87.21	74.70	65.58	60.31	58.57
Exurban (7–146 units/ km2)	110.77	225.41	308.84	356.84	372.93

Table A21 (continued). 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
Percentage of Total Area	3.27	6.64	9.10	10.52	10.99
Percentage of Census Area	11.82	24.06	32.97	38.11	39.83
Suburban (146–1235 units/ km2)	1.14	3.65	5.66	6.83	7.06
Percentage of Total Area	0.03	0.11	0.17	0.20	0.21
Percentage of Census Area	0.12	0.39	0.60	0.73	0.75
Urban (>1235 units/ km2)	0.01	0.01	0.06	0.07	0.06
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	0.85	0.85	0.85	0.85	0.85
Percentage of Total Area	0.03	0.03	0.03	0.03	0.03
Percentage of Census Area	0.09	0.09	0.09	0.09	0.09
Urban-Regional Park	7.07	7.07	7.07	7.07	7.07
Percentage of Total Area	0.21	0.21	0.21	0.21	0.21
Percentage of Census Area	0.75	0.75	0.75	0.75	0.76
Total Area	3392.41	3392.41	3392.41	3392.41	3392.41
Total Census Area	936.87	936.87	936.87	936.45	936.38

Table A22. Area, percentage of total area, and percentage of census area by housing density category in the Park-Manager-Selected AOA for 1970–2010.

Park-Manager-Selected Housing Density Categories	1970	1980	1990	2000	2010
Rural (<6 units/ km2)	42.74	38.47	37.66	36.22	36.02
Percentage of Total Area	17.17	15.45	15.13	14.55	14.47
Percentage of Census Area	95.23	85.72	83.91	81.80	80.56
Exurban (7-146 units/ km2)	2.14	6.41	7.18	8.00	8.63
Percentage of Total Area	0.86	2.57	2.88	3.21	3.47
Percentage of Census Area	4.77	14.28	16.00	18.07	19.30
Suburban (146- 1235 units/ km2)	0	0	0.04	0.06	0.06
Percentage of Total Area	0	0	0.02	0.02	0.02
Percentage of Census Area	0	0	0.09	0.14	0.13

Table A22 (continued). Area, percentage of total area, and percentage of census area by housing density category in the Park-Manager-Selected AOA for 1970–2010.

Park-Manager-Selected Housing Density Categories	1970	1980	1990	2000	2010
Urban (>1235 units/ km ²)	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	0	0	0	0
Percentage of Total Area	0	0	0	0	0
Percentage of Census Area	0	0	0	0	0
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	248.941	248.94	248.94	248.94	248.94
Total Census Area	44.88	44.88	44.88	44.28	44.71

Table A23. Census blocks, area, total population, and population density in the Regional AOA for 1990, 2000, and 2010.

Measures	1990	2000	2010	1990–2000 Percent Change	2000–2010 Percent Change
Number of Census Blocks	31	26	26	–	–
Corrected Area (km ²)	3340.62	3340.39	3337.46	–	–
Population	20720.71	23133.85	23762.22	11.65	2.72
Population Density (population/km ²)	6.20	6.93	7.12	11.77	2.74

Table A24. Census blocks, area, total population, and population density in the Park-Manager-Selected AOA for 1990, 2000, and 2010.

Measures	1990	2000	2010	1990–2000 Percent Change	2000–2010 Percent Change
Number of Census Blocks	5	3	2	–	–
Corrected Area (km ²)	234.84	234.84	234.84	–	–
Population	951.63	938.93	956.00	-1.33	1.82
Population Density (population/km ²)	4.05	4.00	4.07	-1.34	1.82

Table A25. Road length and density in the Regional AOA for 2010 and 2015. Summaries were calculated from US Census Bureau TIGER data.

Measures	2010	2015
Length (km)	4448.64	4392.30
Density (km/km ²)	1.31	1.29

Table A26. Road length and density in the Park-Manager-Selected AOA for 2010 and 2015. Summaries were calculated from US Census Bureau TIGER data.

Measures	2010	2015
Length (km)	392.05	392.53
Density (km/km ²)	1.57	1.58

Table A27. Road length and density in the Park AOA for 2016. Summaries were calculated from Oregon Caves data.

Measures	2016
Length (km)	42.64
Density (km/km ²)	2.31

Table A28. 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 km ²	515	447.99	506	449.60
10-50 km ²	42	874.66	42	875.78
50-100 km ²	4	248.31	4	247.55
> 100 km ²	4	929.58	4	929.86

Table A29. Count and total area by roadless area size category in the Park-Manager-Selected 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 km ²	51	36.28	51	36.28
10-50 km ²	4	54.02	4	54.02
50-100 km ²	1	75.79	1	75.79
> 100 km ²	0	0	0	0

Table A30. Count and total area by roadless area size category in the Park AOA, using 2016 Oregon Caves road data.

Roadless Area Categories	Count	Total km ²
0-10 km ²	7	9.84
10-50 km ²	0	0
50-100 km ²	0	0
> 100 km ²	0	0

Table A31. Area and percentage of AOA by fire related disturbances in the Regional AOA, for 1999–2012.

Year	Wildfire		Prescribed		Wildland	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	–	–	2.52	0.07	1.19	0.03
2001	–	–	2.31	0.07	–	–
2000	–	–	2.82	0.08	0.13	<0.01
2002	160.84	4.74	1.65	0.05	–	–
2003	–	–	3.05	0.09	0.09	0.06
2004	0.01	<0.01	6.16	0.18	0.86	0.03
2005	6.44	0.19	0.67	0.02	0.15	<0.01
2006	0.96	0.03	1.28	0.04	0.13	<0.01
2007	1.35	0.04	2.25	0.07	0.90	0.03
2008	0.39	0.01	1.25	0.04	–	–
2009	1.03	0.03	4.70	0.14	–	–

Table A31 (continued). Area and percentage of AOA by fire related disturbances in the Regional AOA, for 1999–2012.

Year	Wildfire		Prescribed		Wildland	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
2010			7.88	0.23	–	–
2011	0.18	0.01	13.10	0.39	–	–
2012	108.82	3.21	6.59	0.19	<0.01	<0.01
Total	280.02	8.25	56.23	1.66	3.44	0.15

Table A32. Area and percentage of AOA 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	0.02	<0.01	9.92	0.29	11.22	0.33	–	–	7.37	0.22
2000	0.01	<0.01	0.08	<0.01	5.24	0.15	–	–	10.10	0.30
2001	0.01	<0.01	1.44	0.04	3.80	0.11	<0.01	<0.01	10.39	0.31
2002	–	–	1.07	0.03	4.37	0.13	0.09	<0.01	8.85	0.26
2003	<0.01	<0.01	0.51	0.02	4.37	0.13	2.28	0.07	18.69	0.55
2004	–	–	0.82	0.02	7.41	0.22	2.61	0.08	11.94	0.35
2005	0.39	0.01			6.29	0.19	0.39	0.01	9.87	0.29
2006	–	–	1.40	0.04	7.27	0.21	–	–	10.30	0.30
2007	–	–	0.11	<0.01	6.25	0.18	2.26	0.07	9.27	0.27
2008	0.63	0.02	–	–	8.43	0.25	–	–	5.92	0.17
2009	–	–	–	–	0.68	0.02	–	–	11.91	0.35
2010	–	–	–	–	–	–	0.03	<0.01	11.40	0.34
2011	–	–	–	–	0.05	<0.01	0.33	0.01	2.70	0.08
2012	–	–	–	–	0.57	0.02	0.23	0.01	96.64	2.85
Total	1.05	0.03	15.36	0.45	65.95	1.94	8.21	0.24	225.36	6.64

Table A33. Area and percentage of AOA by disturbances other than fire and logging in the Regional AOA for 1999–2012.

Year	Biological		Herbicide		Unknown	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	—	—	—	—	1.42	0.04
2000	—	—	—	—	3.02	0.09
2001	—	—	—	—	1.32	0.04
2002	—	—	—	—	2.91	0.09
2003	—	—	—	—	1.20	0.04
2004	—	—	—	—	3.06	0.09
2005	—	—	—	—	2.83	0.08
2006	—	—	—	—	1.59	0.05
2007	—	—	—	—	1.63	0.05
2008	—	—	—	—	3.55	0.10
2009	0.10	<0.01	—	—	4.27	0.13
2010	—	—	—	—	14.86	0.44
2011	—	—	—	—	5.19	0.15
2012	—	—	0.12	<0.01	5.03	0.15
Total	0.10	<0.01	0.12	<0.01	51.85	1.53

Table A34. Area and percentage of AOA by fire related disturbances in the Park-Manager-Selected AOA for 1999–2012.

Year	Wildfire		Prescribed	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	—	—	—	—
2000	—	—	—	—
2001	—	—	—	—
2002	—	—	0.82	0.33
2003	—	—	0.05	0.02
2004	—	—	0.50	0.20
2005	—	—	0.05	0.02

Table A34 (continued). Area and percentage of AOA by fire related disturbances in the Park-Manager-Selected AOA for 1999–2012.

Year	Wildfire		Prescribed	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA
2006	–	–	–	–
2007	–	–	–	–
2008	0.09	0.04	–	–
2009	–	–	0.13	0.05
2010	–	–	–	–
2011	–	–	0.23	0.09
2012	–	–	0.22	0.09
Total	0.09	0.04	2.00	0.81

Table A35. Area and percentage of AOA by logging related and unknown disturbances in the Park-Manager-Selected 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	–	–	–	–	–	–	–	–
2000	0.33	0.13	–	–	0.36	0.14	0.08	0.03
2001	0.29	0.12	–	–	0.61	0.25	–	–
2002	0.28	0.11	–	–	0.16	0.07	0.12	0.05
2003	–	–	–	–	0.39	0.16	0.00	0.00
2004	0.12	0.05	–	–	–	–	0.02	0.01
2005	0.11	0.04	–	–	0.74	0.30	0.26	0.26
2006	1.15	0.46	–	–	0.05	0.02	–	–
2007	0.20	0.08	–	–	–	–	0.37	0.15
2008	0.17	0.07	–	–	0.60	0.24	0.21	0.08
2009	0.43	0.17	–	–	0.68	0.27	0.65	0.26
2010	–	–	–	–	1.01	0.40	0.52	0.21
2011	0.05	0.02	0.02	0.01	0.30	0.12	–	–
2012	–	–	–	–	27.12	10.89	–	–
Total	3.13	1.26	0.02	0.01	32.01	12.86	2.22	1.05

Table A36. Area and percentage of AOA by disturbances in the Park AOA for 1999–2012.

Year	Prescribed Fire		Other Mechanical		Thinning		Unknown	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	—	—	—	—	—	—	—	—
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	0.17	0.92	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	—	—	—	—	—	—	—	—
2008	—	—	—	—	—	—	—	—
2009	—	—	0.02	0.11	0.38	2.07	—	—
2010	—	—	0.14	0.79	—	—	0.04	0.24
2011	—	—	—	—	—	—	—	—
2012	—	—	3.59	19.46	—	—	—	—
Total	0.17	0.92	3.76	20.36	0.38	2.07	0.04	0.24

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