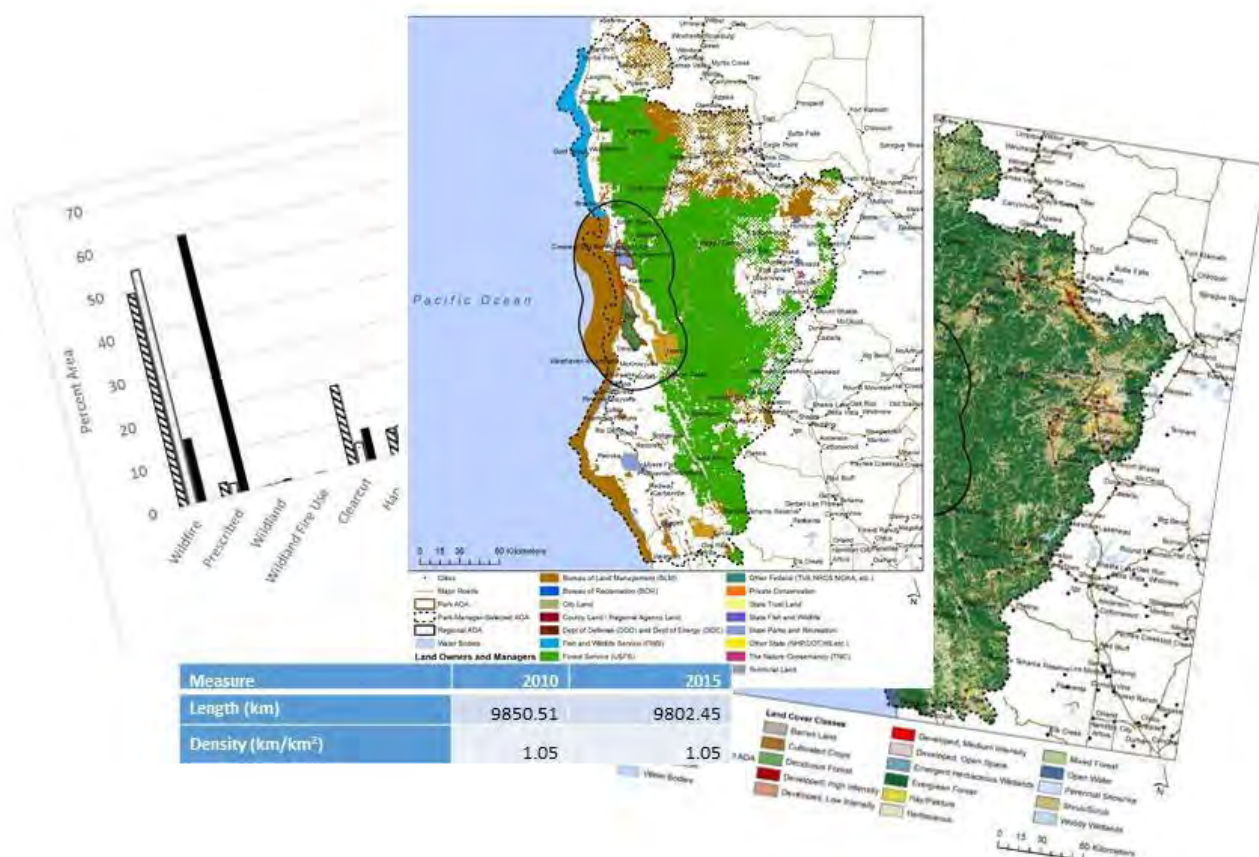




Land Cover and Land Use Monitoring

2016 Results for Redwood National and State Parks

Natural Resource Data Series NPS/KLMN/NRDS—2018/1158



ON THE COVER

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

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Natural Resource Data Series NPS/KLMN/NRDS—2018/1158

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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 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 Redwood National and State Parks. 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), a 100-mile park buffer with watershed and subbasin boundaries (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 area around the Redwood National and State Parks (hereafter, Redwood or the Park) was primarily owned by the Bureau of Land Management and US Forest Service. While some of this area was permanently protected from conversion to an unnatural state, most of the area for which data were available had a moderate level of conservation protection that still allowed broad, low intensity or localized, high intensity extractive uses. Data were not available for a large portion of the area.

Land Cover

In the park and areas surrounding the park, the most abundant cover type was evergreen forest. Most cover was categorized as natural, with converted areas primarily in cities and towns, followed by 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 many forest patches were large and intact, some were thin sections that connected patches, resulting in some of the forest being on the edge of non-forest types.

Little grassland occurred in the study area. While there were some large patches in the study area, much of the grassland was small patches. Little shrubland occurred in the study area, 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

Redwood 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 higher in the park than in surrounding areas. Areas furthest from roads were primarily in the Kalmiopsis, Siskiyou, Marble Mountain, and Trinity Alps Wilderness Areas within the Rogue River-Siskiyou, Six Rivers, Klamath, and Shasta-Trinity National Forests, respectively. Similarly, the largest sections of land without roads were in these same areas. There was little change in roads between 2010 and 2015.

Disturbance

Outside of the park boundary, wildfire was the dominant disturbance between 1999 and 2012. In these areas, tree harvesting also occurred. Within the park, prescribed fire was the largest disturbance type.

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NPS Resource Managers, Biologists, Ecologists, and GIS Specialists who contributed to this protocol throughout its development, with special thanks to Leonel Arguello, David Best, and Judy Wartella. Monika Tantare, a Southern Oregon University student, did extensive practical work using ArcGIS tools to make maps and calculate statistics.

The data used to develop the summaries in these reports came from a variety of sources, 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 USGS GAP Analysis Program.

List of Abbreviations

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 and 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 and land use in the Redwood National and State Parks. The overall objective of this report is to determine for Redwood the status of the metrics described in the KLMN land cover and 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.

The Redwood National and State Parks consist of four administrative units in Del Norte and Humboldt Counties, California: Redwood National Park, which is a federal park under the

jurisdiction of the NPS, and three state parks, under the jurisdiction of the California Department of Parks and Recreation (CDPR). The legislated National Park boundary includes the three State Parks (Prairie Creek Redwoods State Park, Del Norte Coast Redwoods State Park, and Jedediah Smith Redwoods State Park). Together, these four Parks encompass about 534 km² (131,983 ac), are about 80 km (50 mi) in length, and have 56 km (35 mi) of coastline. On its western side, the National Park boundary extends 400 m (0.25 mi) beyond the Pacific Ocean's mean high tide line, and the NPS exercises jurisdiction over the waters, intertidal lands, and submerged lands. The coastal jurisdiction of state parklands extends 305 m (1,000 ft) west of the ordinary high-water mark. Elevations within the Park range from sea level to 996 m (3,267 ft).

Redwood National Park was established in 1968 and expanded in 1978. Prairie Creek Redwoods State Park was established in 1923, Del Norte Coast Redwoods State Park in 1925, and Jedediah Smith Redwoods State Park in 1929. These Parks were established to preserve significant examples of the primeval coastal redwood forests and the prairies, streams, seashore, and woodlands with which they are associated for purposes of public inspiration, enjoyment, and scientific study, and to preserve all related scenic, historical, and recreational values.

The climate of near-coastal northwestern California and southwestern Oregon is temperate, with rainy winters, dry summers, and frequent coastal fog and stratus. Mean annual precipitation at Crescent City is 1,778 mm (70 in); at Klamath, 2,210 mm (87 in); and at Orick, 1,753 mm (69 in). Winter storms are usually intense with heavy rainfall and high winds interspersed with intervals of generally fair weather. At Crescent City, the mean annual temperature is 11.4° C (52.6° F) and the mean daily maximum and minimum temperatures are 15.8° C (60.4° F) and 7.1° C (44.8° F), respectively.

Redwood contains a wide variety of plant and animal communities, ranging from kelp forest, intertidal, and estuarine marine communities, to emergent wetlands, to terrestrial communities on the immediate coast as well as more inland areas. Forests include some trees among the tallest in the world. There are also extensive forests recovering from clear cut logging.

Resource management concerns include erosion and sedimentation, non-native species, and recovery of second growth forests. Roughly 275 km² (68,000 ac) of the National and State Park's vegetation has been disturbed by past logging, grazing, and farming, and is now in various stages of succession. The nature and extent of the effect of vegetative succession on all wildlife species inhabiting the Park is largely unknown. Two threatened species, the northern spotted owl (*Strix occidentalis caurina*) and Marbled Murrelet (*Brachyramphus marmoratus*), as well as one endangered plant, beach layia (*Layia carnosa*), are known to reside in the Park.

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 national 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 2018. After implementation of the national protocol, the NPScape program will stop supporting the toolboxes that were used to conduct the analyses in this report. Alternatively, the national program will continue calculating the same metrics in this report as part of the national landscape dynamics protocol, provided through the NPS Statistics Summary database, and visualized 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 Redwood National and State Parks Areas of Analysis (AOA).

Park Scale

The Park AOA uses the National (Nelson and Kinseth 2016) and State Park boundaries. This AOA encompasses the area that 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

Because natural resources, ecological processes, and anthropogenic influences cross jurisdictional boundaries, the “Park-Manager-Selected” AOA includes lands adjacent to the parks. Redwood staff determined that the AOA that best meets their needs includes a 100-mile condor range and watershed/subbasin divides, where possible. The US Geological Survey (USGS) assigns watersheds a Hydrologic Unit Code (HUC) of 10 and assigns subbasins a HUC of 8. The Park-Manager-Selected area included a 100-mile Park buffer and HUC 8 subbasins that drain to the west to the Pacific Ocean. Some HUC 10 headwater watersheds were eliminated where they extended significantly beyond the 100-mile buffer (e.g. upper reaches of Upper and Upper Middle Fork of the Eel River). The area covered approximately 52,971 km² (20,452 mi²). Note that this AOA was revised in 2016 and therefore differs from what was specified in the protocol (Mohren et al. 2016a).

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 (9 to 25 mi), but few studies have demonstrated effects at distances greater than 25 km (16 mi). Therefore, our Regional AOA includes the Park and all adjacent areas within 30 km of the Park boundary. The Redwood Regional AOA buffer is 30 km (19 mi) around the National and State Parks polygon. Note that because Redwood is adjacent to the ocean, the 30 km buffer extends into the water; this area is roughly 3,250 km² (1,255 mi²) or approximately 35 % of the AOA.

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 Redwood land cover and 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 Redwood 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; Table 2 outlines which indicators are reported for each.

We did not perform any statistical analyses for 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 Redwood: P = Park, PM = Park-Manager-Selected, and R = Regional.

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

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. Processed geospatial datasets for each indicator are available for download (National Park Service 2018).

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 and 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) from 2006 and 2011. We calculated the proportion of the landscape at each Level 2 class (Table 4) within each AOA. 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. We also 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. Detailed methods for this indicator are provided in the protocol (*SOP #3: Land Cover Metrics*).

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

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, or 150 m. Density data were also generated with a 7×7 pixel window size (size in m^2 and acres: $210 m^2$, 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 present a summary of total area and percentage of area for each pattern type. We also present 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 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

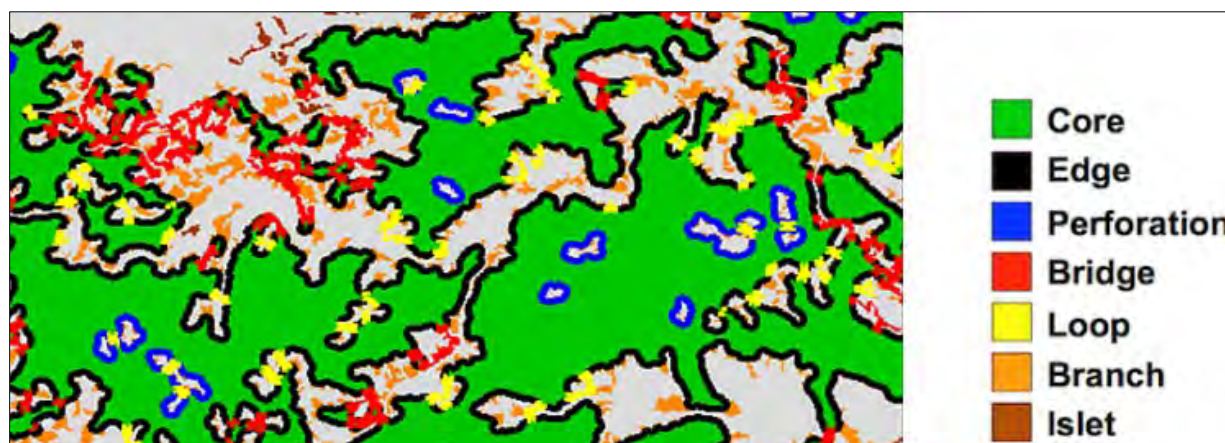


Figure 2. Illustration of morphological pattern types on a landscape. Image provided by Peter Vogt of the European Commission Joint Research Centre.

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

Housing density metrics use the Spatially Explicit Regional Growth Model (SERGoM v3) (Theobald 2005), which is based on 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 present total area, percentage of total AOA, and percentage of census area (area where the census occurred, generally omitting the Park, national forests, etc.).

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

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 were 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 are maintained primarily in a natural state). Note that this does exclude the six in-holdings that exist within the Park boundary. At the Park-Manager-Selected and Regional AOAs, we present 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

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 provided a consistent data source across time and space. Detailed methods for this indicator are provided in the protocol (*SOP #7: Road Metrics*).

We summarized total road length and road density. We also summarized these two metrics 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 summarized 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

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 summarized total area and percentage of AOA by disturbance types, defined in Table 9. Detailed methods for this indicator are provided in the protocol (*SOP #8: Disturbance Metrics*).

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 presented in full in Appendix A: Data Tables 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 for this report. Any mention of change among years is purely descriptive and does not imply trend.

Conservation Status

Ownership

In 2012, the Bureau of Land Management (30%) and the US Forest Service (28%) owned most of the area for which data were available within the Regional AOA. Within the Park-Manager-Selected AOA, 40.2% of the area was US Forest Service and 13% was Bureau of Land Management (Figures 3 and 4; Table A1 in Appendix A). Note that data for 29% of the Regional AOA and 41% of the Park-Manager-Selected AOA were not available, and therefore the percentage of area managed by each of these groups may have been greater, depending on the composition of the unavailable data.

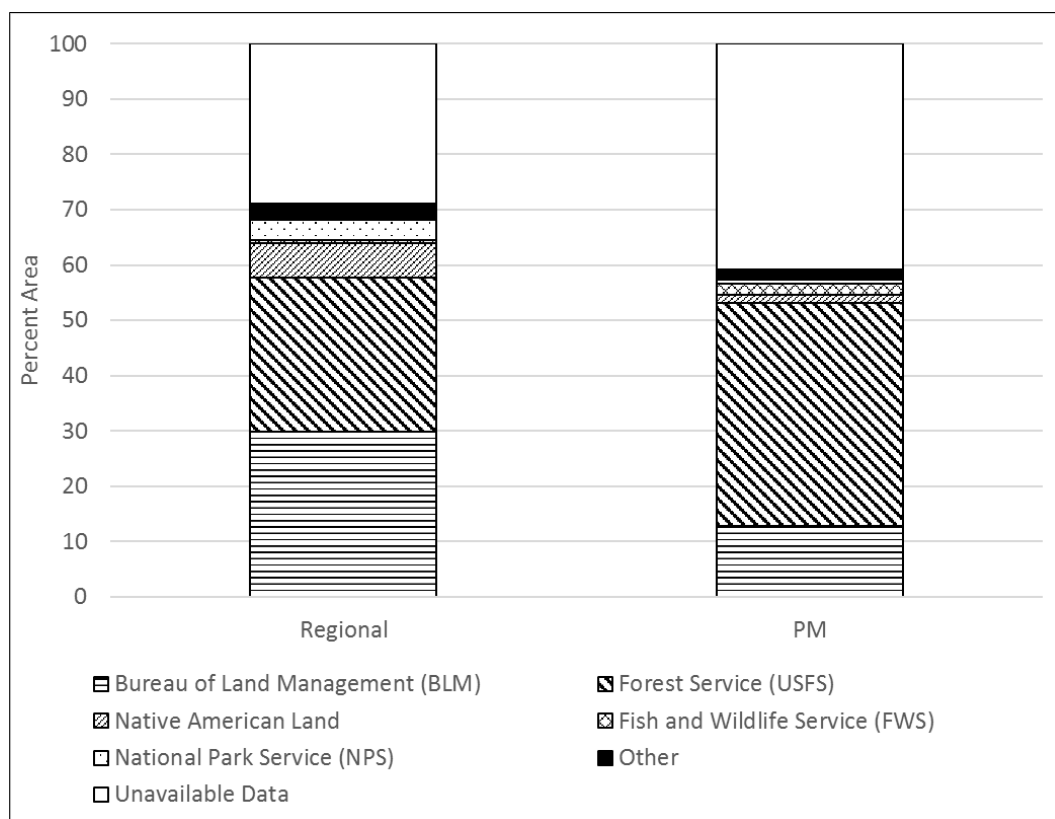


Figure 3. Percentage of land ownership within the Regional and Park-Manager-Selected (PM) Areas of Analysis in 2012.

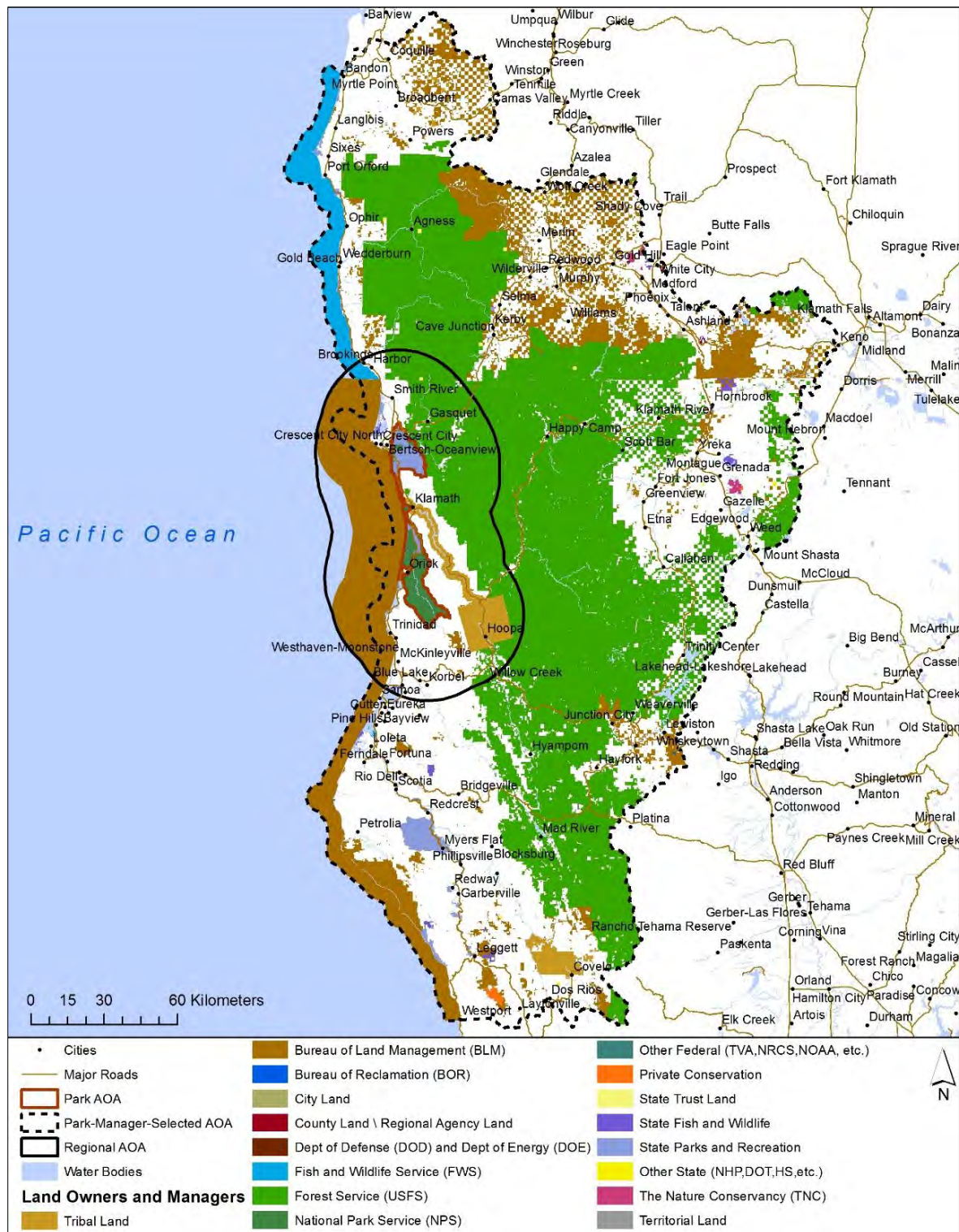


Figure 4. Land ownership in the Regional and Park-Manager-Selected Areas of Analysis (AOA), using 2012 data from the USGS Gap Analysis Program, Protected Areas Database for the US. Areas without colors identified in the legend are those for which ownership is unknown. Due to errors in the source data, this map shows less State Parks and Recreation area than actually occurs on the ground, particularly within Prairie Creek Redwoods State Park.

Protected Areas

The USGS GAP Conservation Status category 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 Regional and Park-Manager-Selected AOAs, this category is represented primarily by US Forest Service wilderness areas and Redwood National and State Parks. In 2012, Status 1 constituted 10% of the Regional and Park-Manager-Selected AOAs (Figures 5 and 6; Table A2). Within the Regional and Park-Manager-Selected AOAs, the largest single category was in Status 3 (51% and 39%, 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 29% of the Regional AOA and 41% of the Park-Manager-Selected AOA were not available, and therefore the percentage of area 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 Conservation Status category within the Regional and Park-Manager-Selected (PM) Areas of Analysis in 2012.

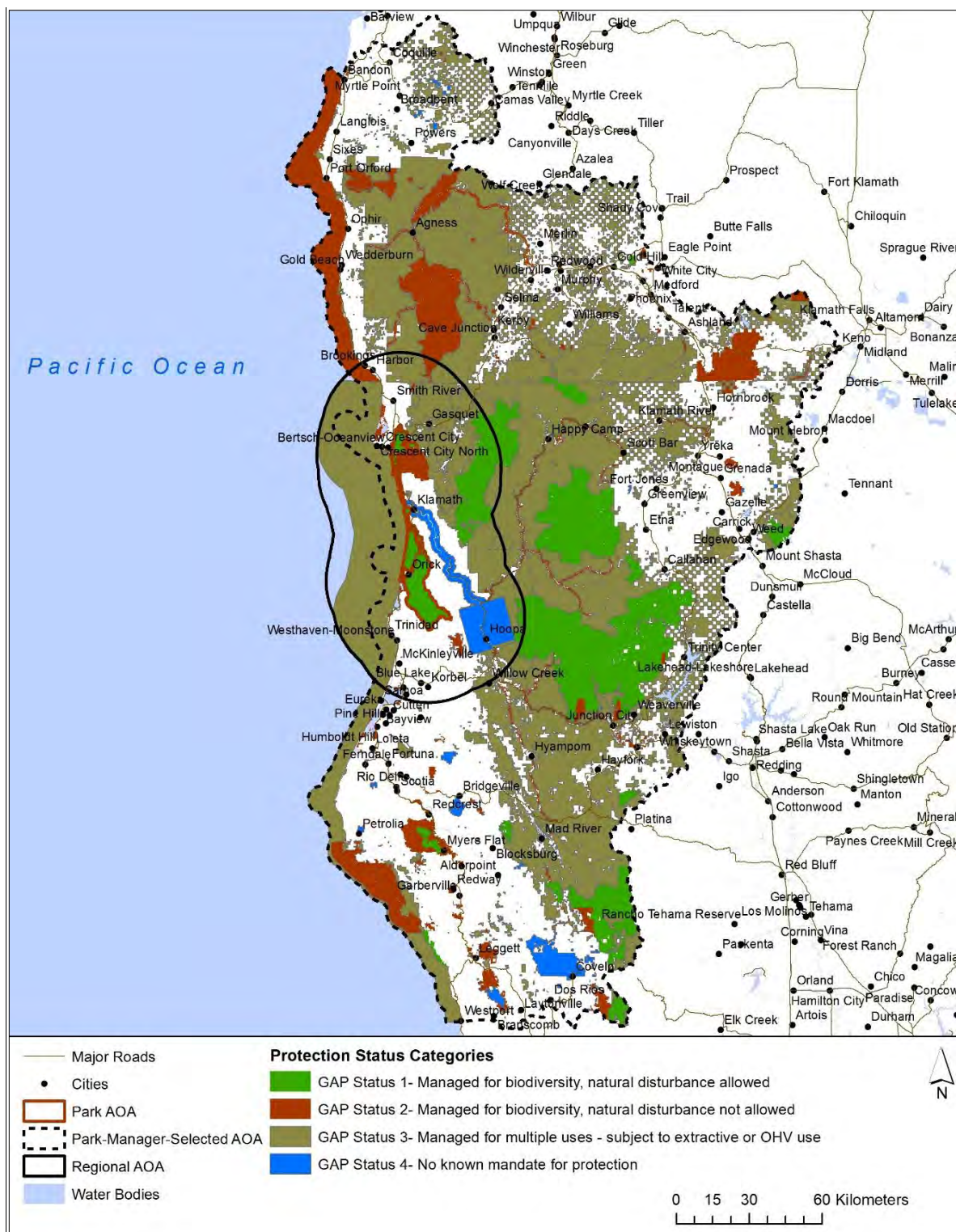


Figure 6. Protection status category in the Regional and Park-Manager-Selected Areas of Analysis (AOA), using 2012 data from the USGS Gap Analysis Program (GAP) Protected Areas Database for the US. Due to errors in the source data, this map shows less GAP Status 2 than actually occurs on the ground, particularly within Prairie Creek Redwoods State Park.

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 most abundant 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).

For the Regional AOA, the source data did not extend to the entire AOA. Approximately 23% (2,147 km²) was outside of the source data area, although we know that this was ocean. Percentages reported below are only within the area covered by the source data. In the Regional AOA, *Evergreen Forest* comprised 58% (2006) and 57% (2011) of the land cover, *Mixed Forest* comprised 9% (2006 and 2011), and *Shrub/Scrub* comprised 8% (2006 and 2011) of the land cover (Table A3 in Appendix A). *Open Water* also made up a large percentage at 16% (2006 and 2011) of the Regional AOA because this AOA extends into the ocean. Other classes each covered less than 3% of the AOA.

Similarly, in the Park-Manager-Selected AOA, *Evergreen Forest* was 57% (2006) and 56% (2011) of the land cover, *Shrub/Scrub* was 17% (2006) and 18% (2011) of the land cover, *Herbaceous* was 5% (2006) and 6% (2011) of the land cover, and *Mixed Forest* was 5% (2006 and 2011) of the land cover (Table A4 in Appendix A). *Open Water* also made up a large percentage at 6% (2006 and 2011) of the Park-Manager-Selected AOA because this AOA extends into the ocean. Other classes each covered less than 3% of the AOA. Note that like the Regional AOA, the source data did not extend to the entire AOA; however, this was a small area at 0.27%, or 142 km², and similarly was all ocean.

In the Park AOA, *Evergreen Forest* represented 68% (2006 and 2011) of the land cover, and *Mixed Forest* represented 14% (2006 and 2011) of the land cover. *Open Water* also made up 5% (2006 and 2011) of the Park AOA because this AOA extends into the ocean (Table A5 in Appendix A). Other classes each covered less than 4% of the AOA.

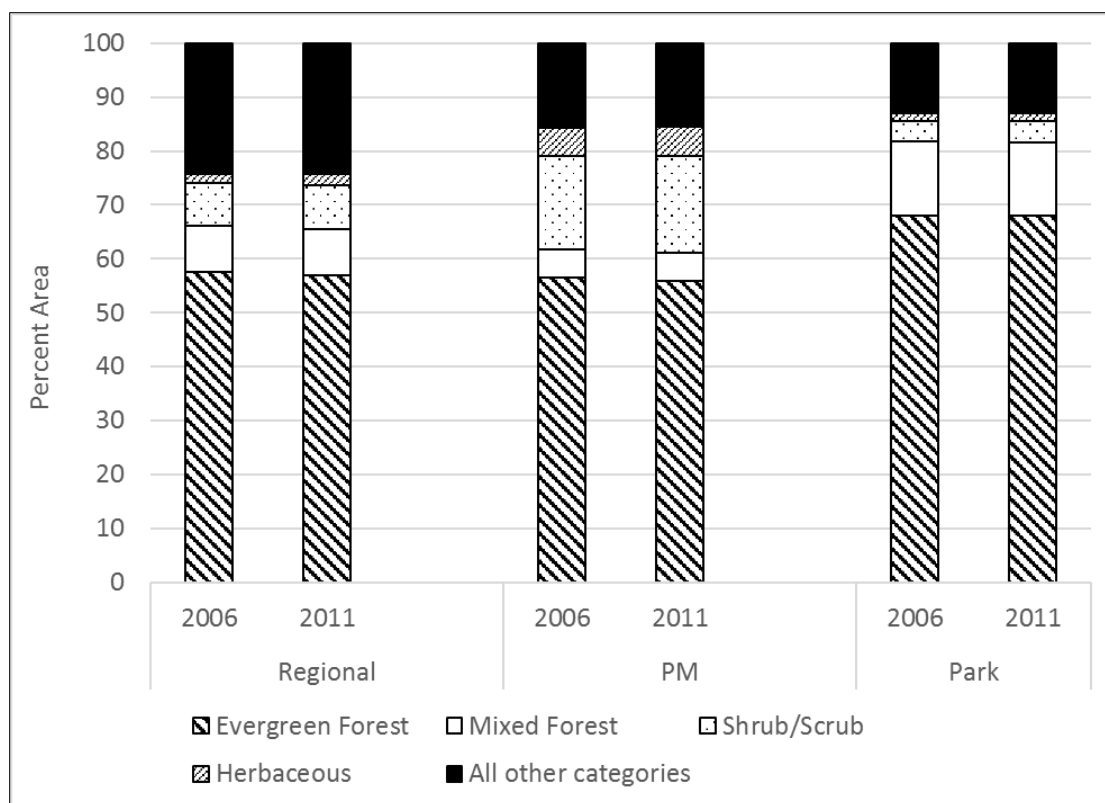


Figure 7. Percentage of National Land Cover Data Level 2 classes in Regional, Park-Manager-Selected (PM), and Park Areas of Analysis for 2006 and 2011.



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 A6–A8 in Appendix A). This lowest impervious surface class occurred in greater than 75% of the Regional AOA, greater than 96% of the Park-Manager-Selected AOA, and greater than 98% of the Park AOA. The Regional AOA shows only 75% in the 0%-2% category in Table A6 (Appendix A) because the source data did not extend to all of the AOA. If this background (ocean) area is removed, the value is greater than 97%. Likewise, less than 0.3% of the area had a high amount of impervious surface (50%–100% impervious surface class).

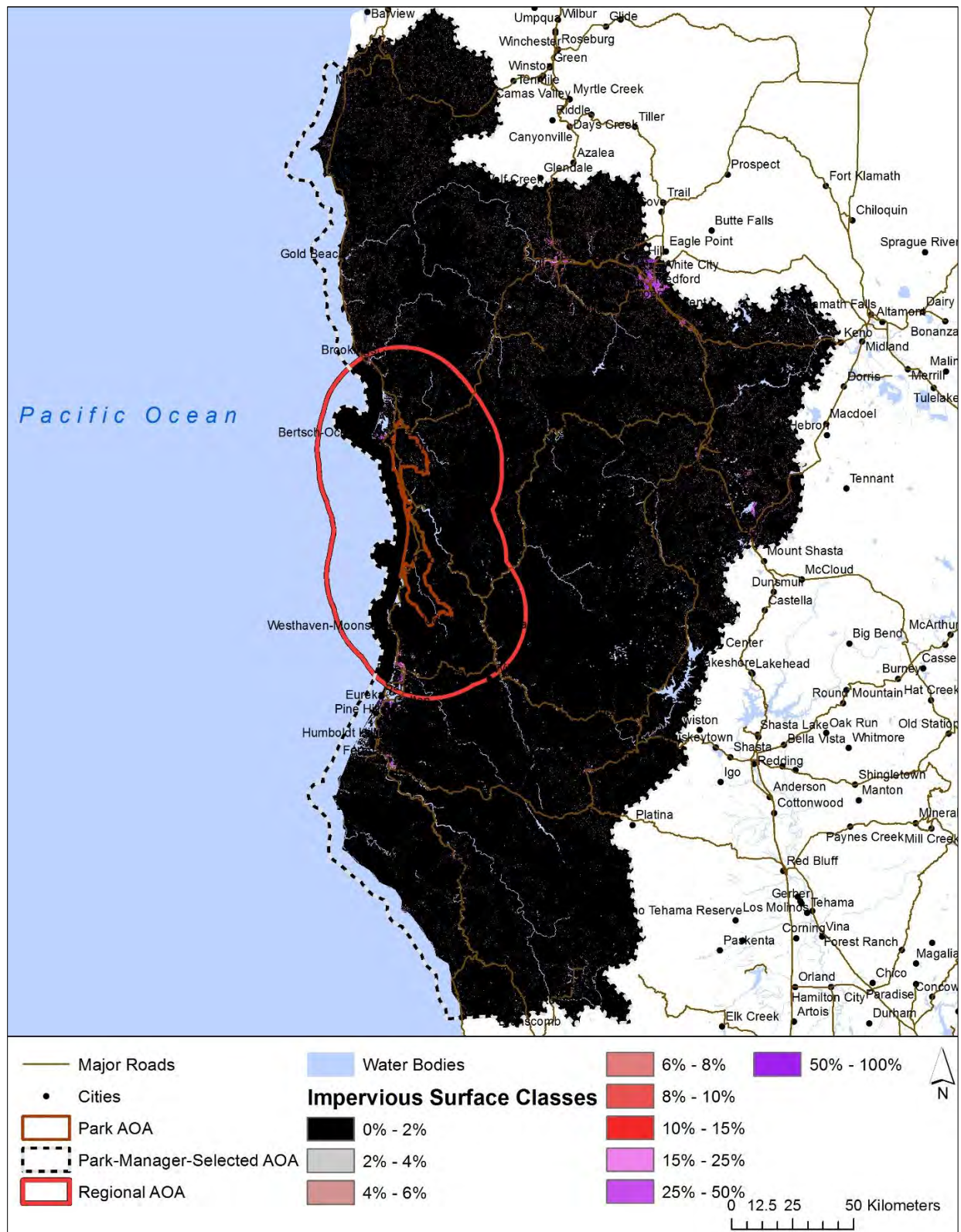


Figure 9. Impervious surface area at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA) in 2011.

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 95% of the Regional AOA (excluding ocean), 94% of the Park-Manager-Selected AOA (excluding ocean), and 96% of the Park AOA (Figure 10; Tables A9–A11 in Appendix A).

At all three AOAs, little change in *Natural* and *Converted* land area (km²) has occurred since 2006. Most of the *Converted* areas were around towns/cities; some *Converted* areas were agricultural. *Converted* areas throughout AOAs also included roads.



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

Landscape Pattern

Note that in this section, the ocean is not included in these values; percentages only include those areas on land.

Morphology

Forest

Forest covered the greatest portion of the landscape in 2011. In the Regional AOA, 80% of the land area (excluding ocean) was forested (Figure 11). Forest was categorized as *Core* (49%), *Edge* (28%), and *Bridge* (11%) (Table A12 in Appendix A) (see Methods, Table 5, for pattern definitions). There was a similar pattern in the Park-Manager-Selected AOA. Forest covered 67% of the area (excluding ocean) and was characterized as *Core* (35%), *Edge* (31%), and *Bridge* (23%) (Table A12 in Appendix A).

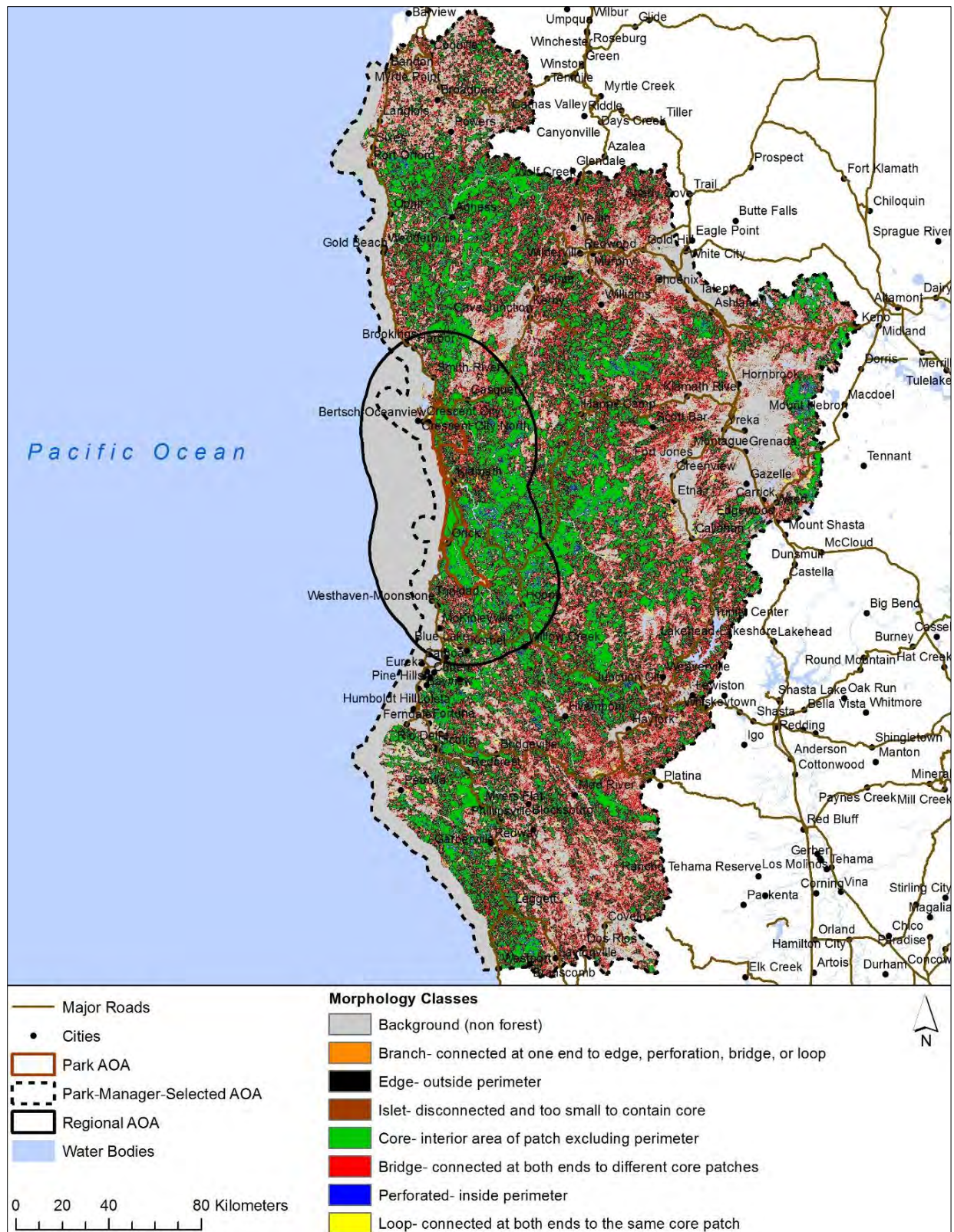


Figure 11. National Land Cover Data forest morphology classification for the Regional and Park-Manager-Selection Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>).

Grassland

In 2011, excluding ocean, grassland occurred in approximately 3% of the Regional AOA land area and approximately 7% of the Park-Manager-Selected AOA land area (Table A13 in Appendix A). In the Regional AOA, grassland was categorized primarily as *Islet* (63%), followed by *Edge* (17%) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected AOA, grassland was categorized primarily as *Islet* (50%), followed by *Edge* (17%) and *Bridge* (17%) (Figure 12).

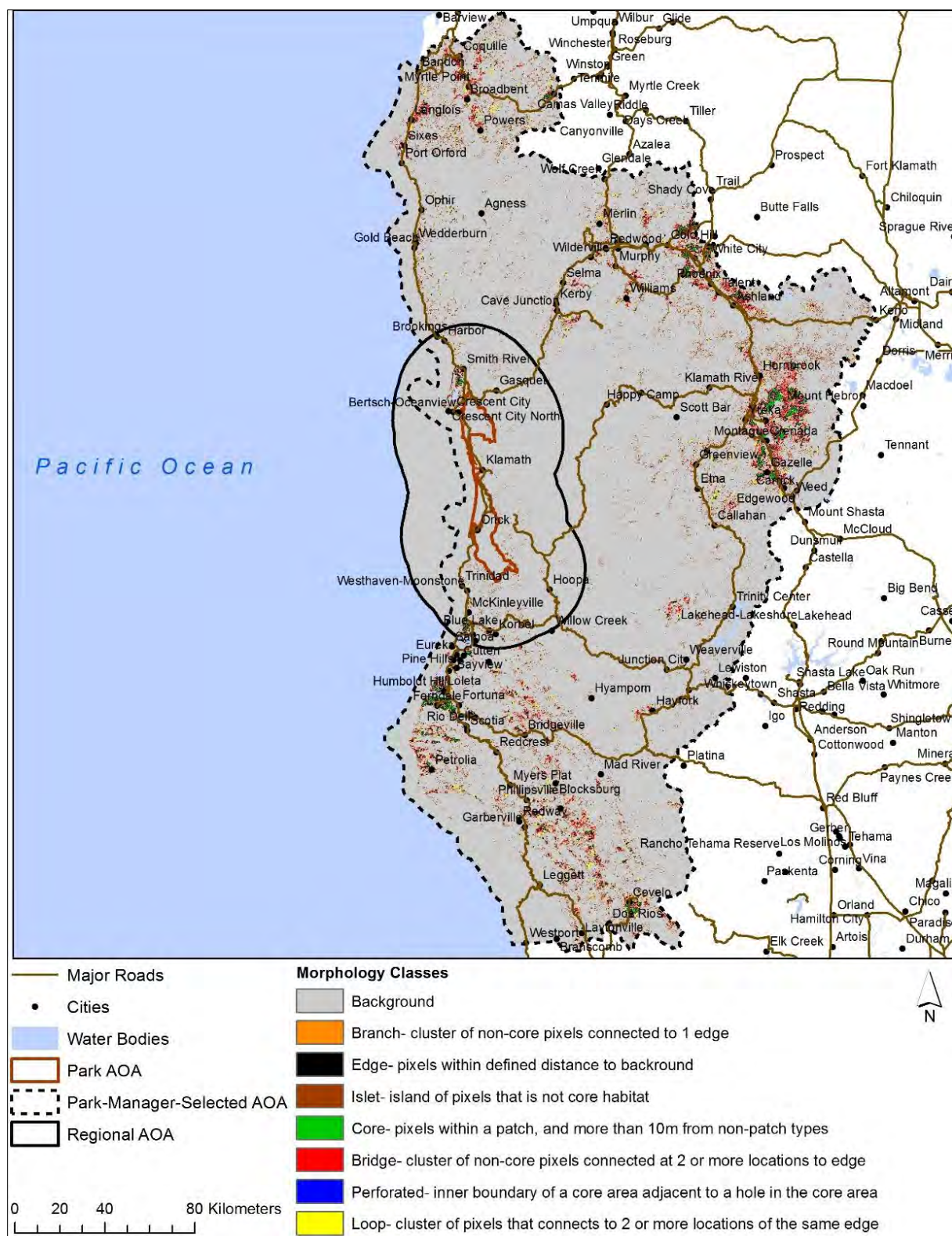


Figure 12. National Land Cover Data grassland morphology classification for the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>).

Shrubland

Excluding ocean, shrubland comprised 10% of the Regional AOA land area and 19% of the Park-Manager-Selected AOA land area. In the Regional AOA, shrubland was categorized primarily as *Islet* (67%), followed by *Bridge* (15%) (see Methods, Table 5, for pattern definitions). In the Park-Manager-Selected AOA, shrubland was categorized primarily as *Islet* (54%), followed by *Bridge* (24%) (Figure 13; Table A14 in Appendix A).

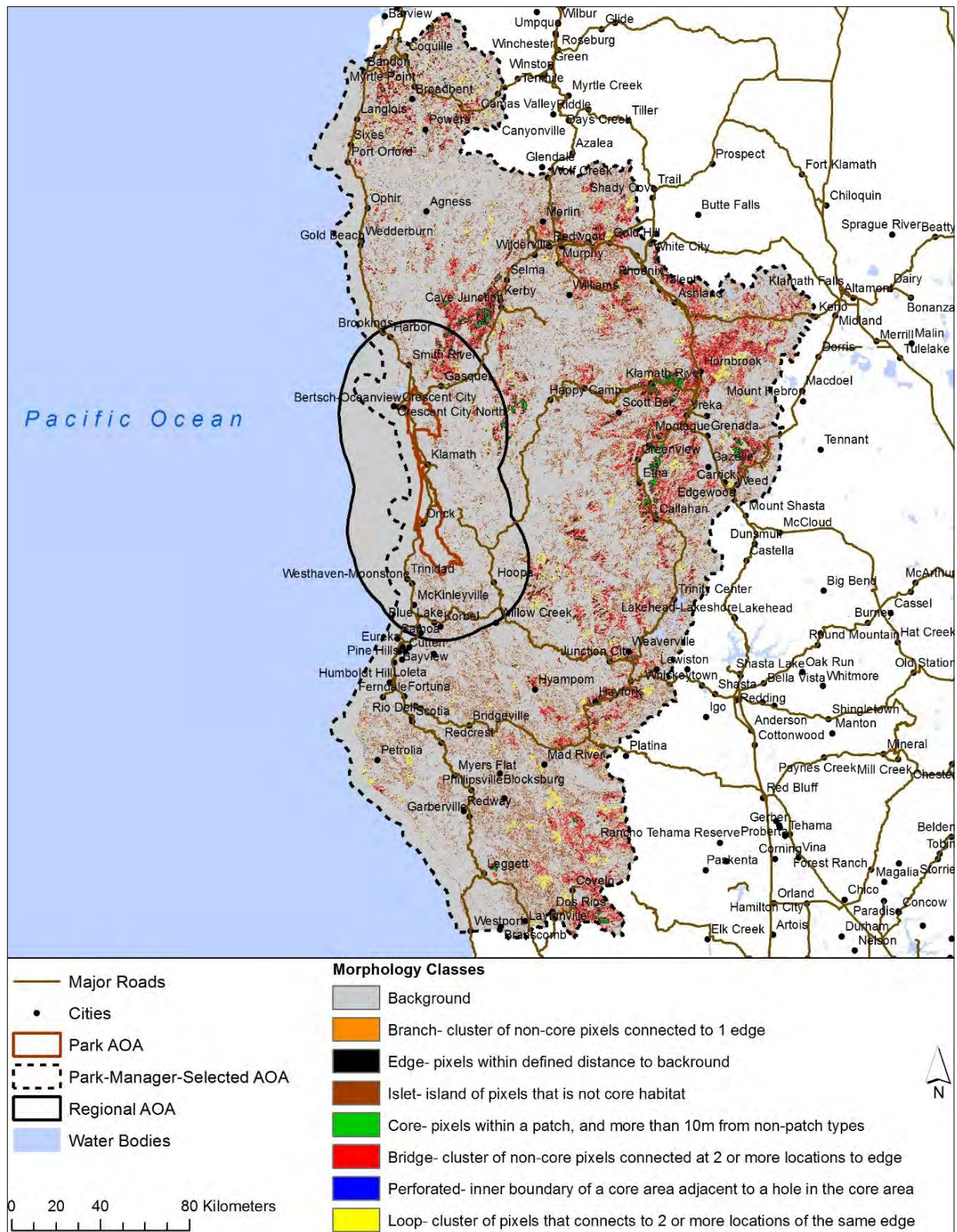


Figure 13. National Land Cover Data shrubland morphology classification for the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011. Terms used in the legend were taken from the US Forest Service (<https://forestthreats.org/research/tools/landcover-maps/mspa>).

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 and Park-Manager-Selected AOAs, most land area was in the >1000 km² patch size category (Figure 14; Table A15 in Appendix A).

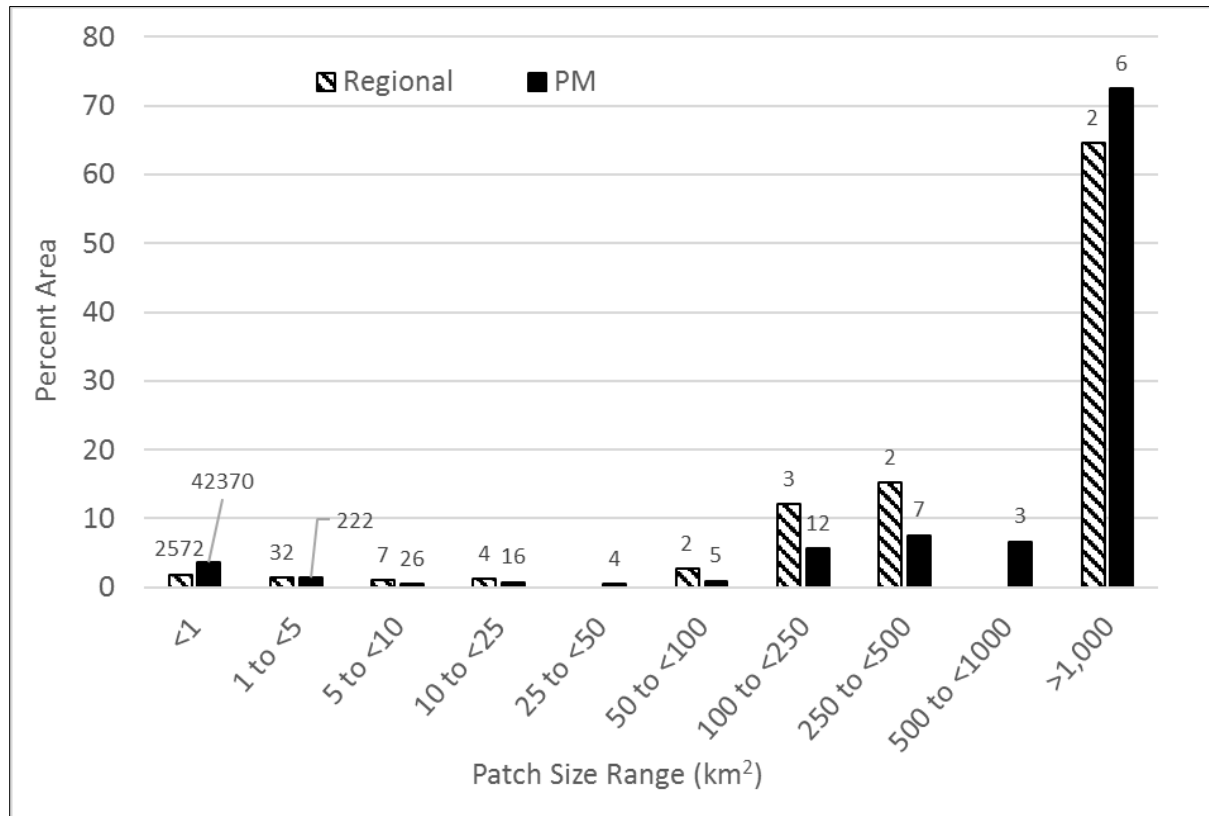


Figure 14. Percentage of area within each patch size category for forestlands in the Regional and Park-Manager-Selected (PM) Areas of Analysis in 2011. The number at the top of each bar is the number of patches comprising the area.

Grassland Patch Size

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

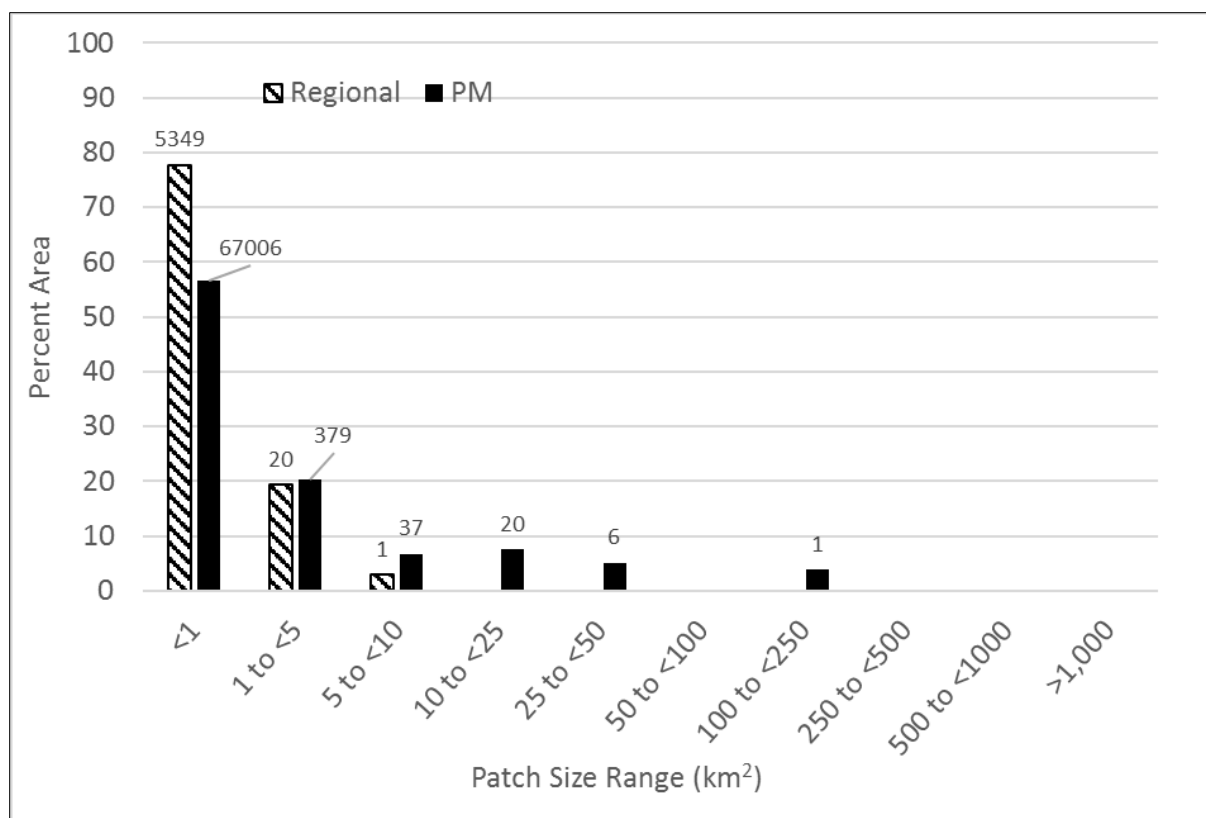


Figure 15. Percentage area within each patch size category for grasslands in the Regional and Park-Manager-Selected (PM) Areas of Analysis in 2011. The number at the top of each bar is the number of patches comprising the area.

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 in Appendix A).

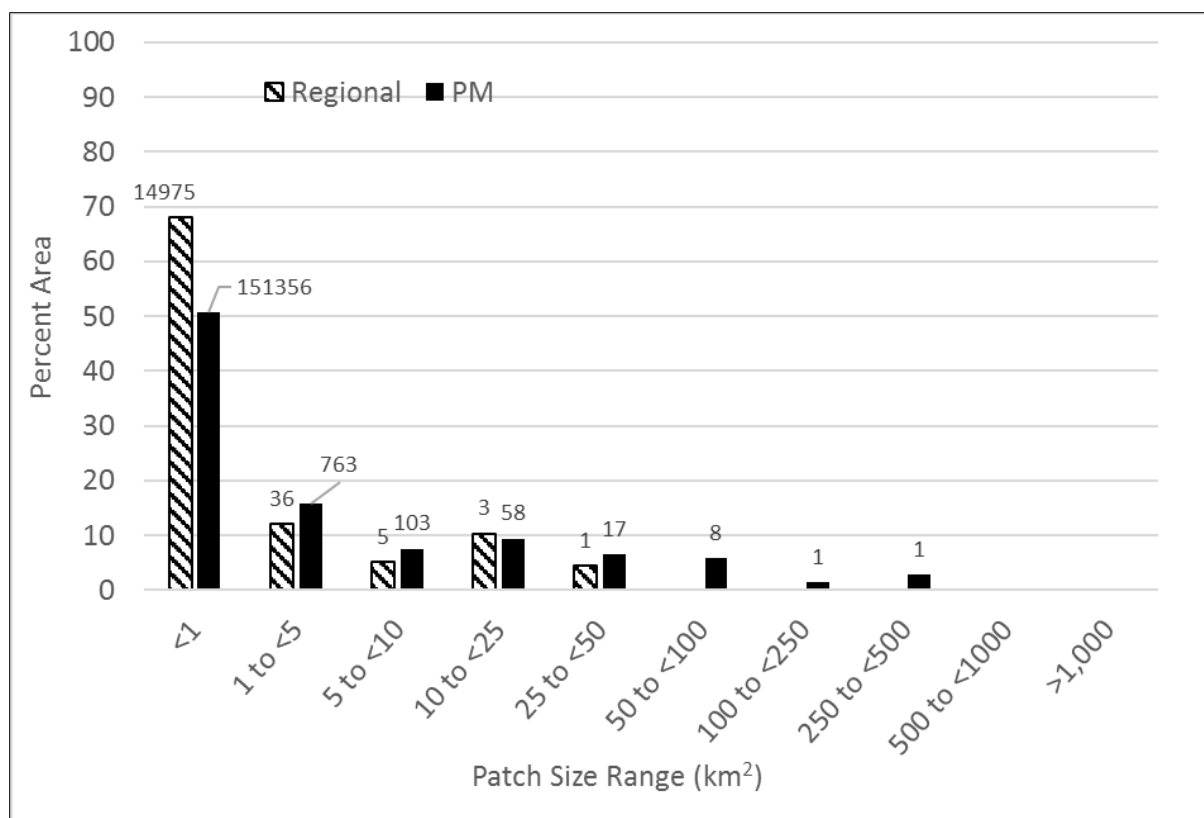


Figure 16. Percentage area within each patch size category for shrublands in the Regional and Park-Manager-Selected (PM) Areas of Analysis in 2011. The number at the top of each bar is the number of patches comprising the area.

Area Density

The majority of forest cover within the Regional AOA occurred in the *Intact* density class (53%), followed by the *Dominant* density class (21%) in 2011 (Table A18 in Appendix A). See the Methods, Table 6, for density class definitions. Similarly, for the Park-Manager-Selected AOA, 36% was in the *Intact* density class, and 24% was *Dominant* (Figure 17; Table A18 in Appendix A).

Grasslands and shrublands were predominantly in the *Patchy* density class followed by the *Rare* density class (Figures 18 and 19, Tables A19 and A20) in Appendix A.

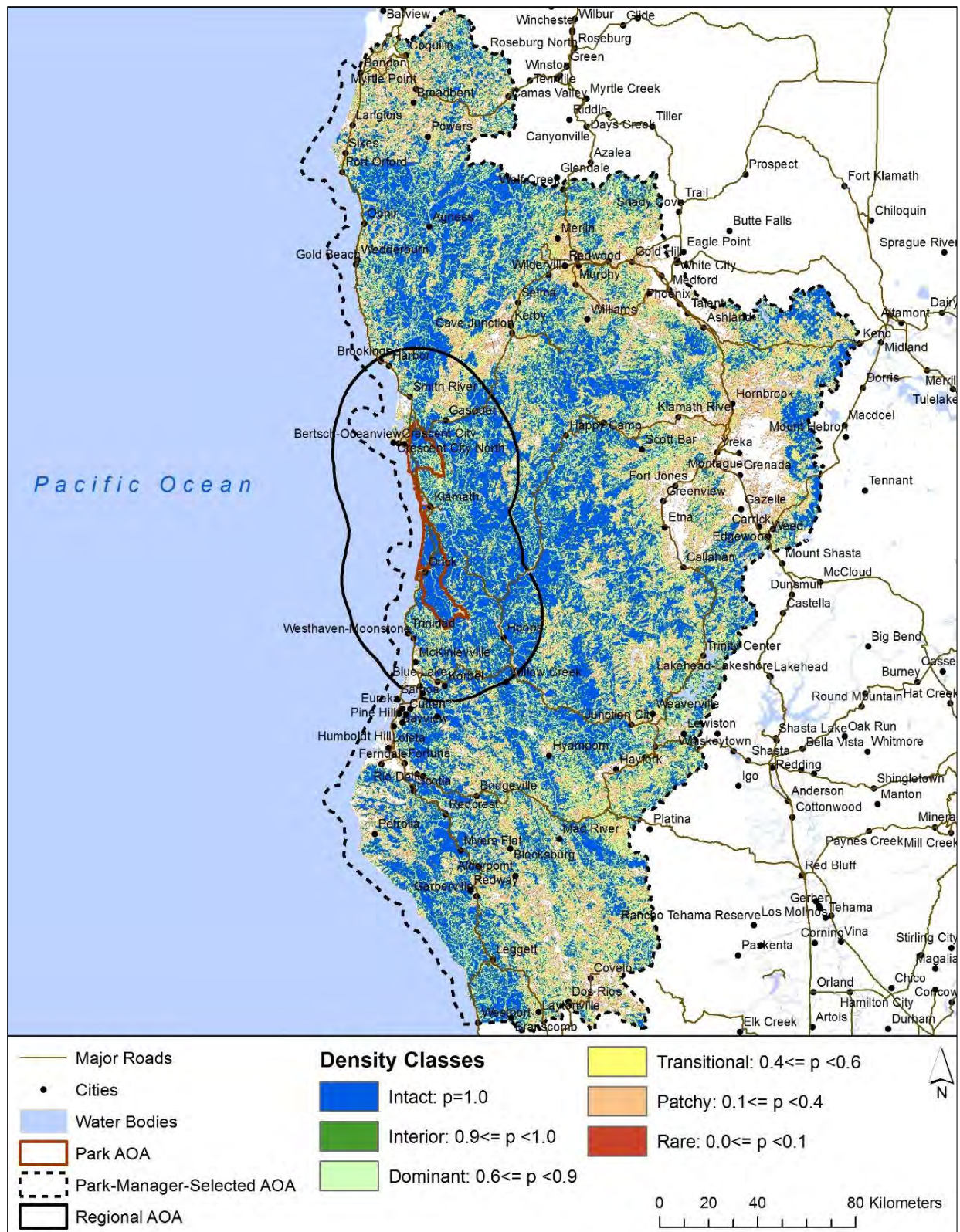


Figure 17. National Land Cover Data forest density classes for Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2011.



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

Redwood is surrounded by housing developments, mostly categorized as *Rural* (<7 units/km²) (see Methods, Table 7, for housing density categories) (Figure 20). The Regional and Park-Manager-Selected AOAs encompass many towns and cities. Both AOAs, however, include large sections of land with no housing, which are primarily in national forests.

Since 1970, the area considered *Rural* has decreased. In 1970, this area comprised 88.3% of the Census areas within the Regional AOA and over 91.7% in the Park-Manager-Selected AOA (Tables A21 and A22 in Appendix A, Figures 21 and 22). By 2010, *Rural* area decreased to 78.8% of the Regional AOA and 83.2% of the Park-Manager-Selected AOA.

During the same time frame, the *Exurban* class (7–145 units/ km²) increased from 6.3% to 15.0% in the Regional AOA and from 5.7% to 13.8% in the Park-Manager-Selected AOA.

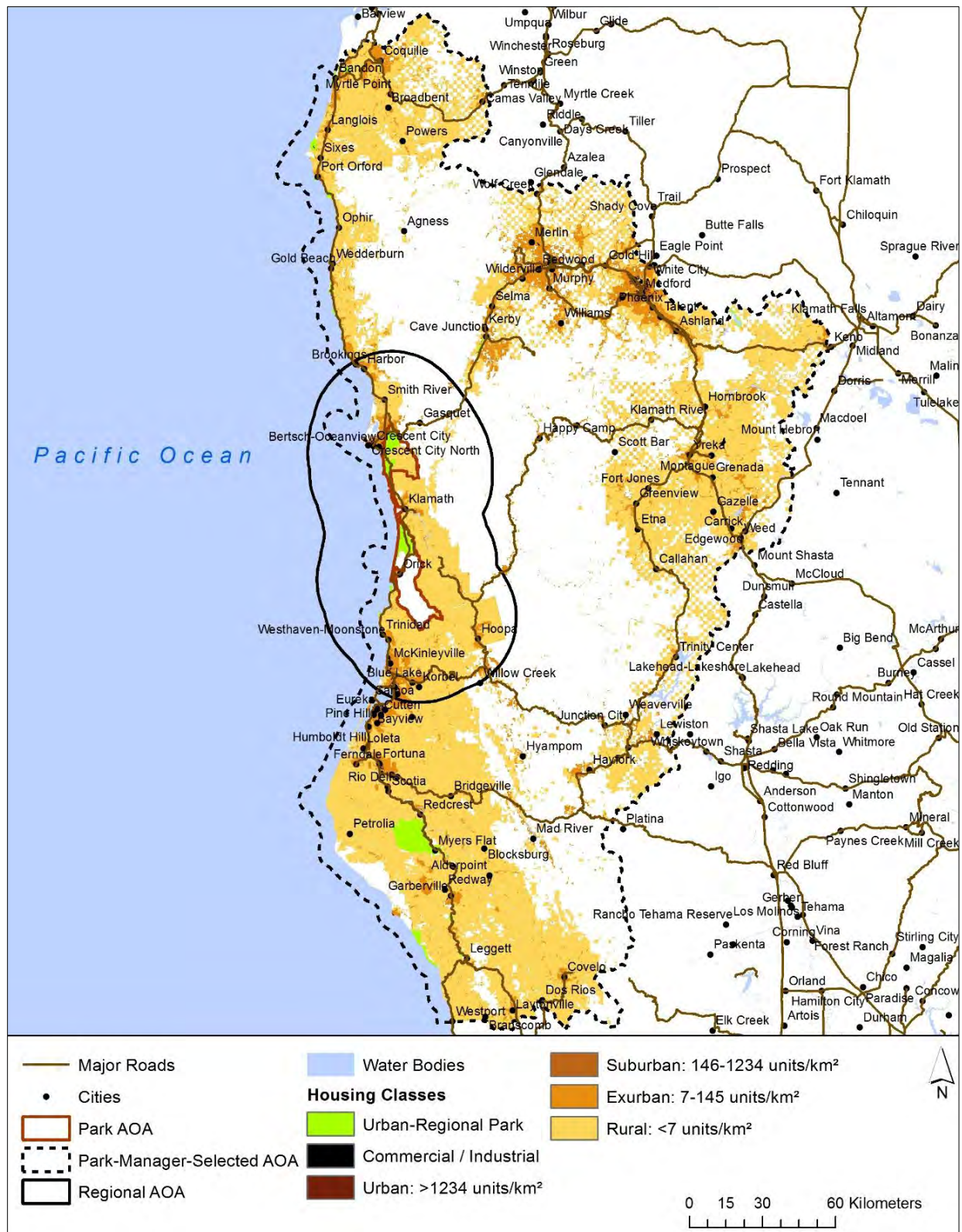


Figure 20. Housing classes in the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2010. No data exist for white areas.

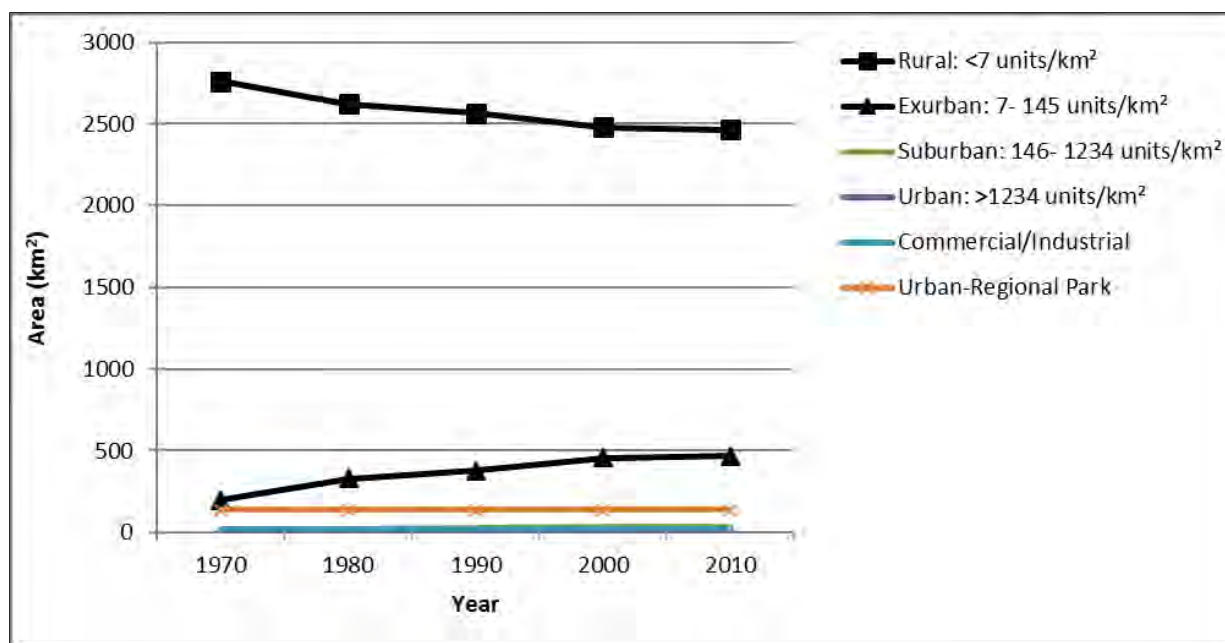


Figure 21. Area (km²) in each housing class from 1970 to 2010 in the Regional Area of Analysis.

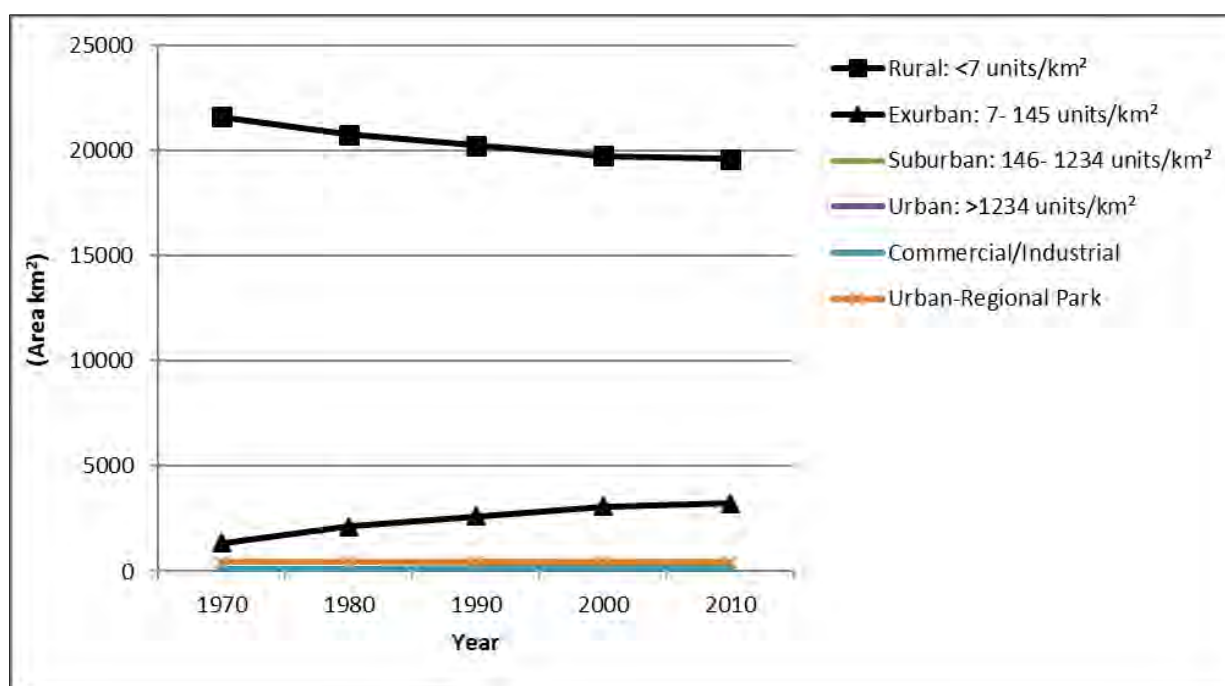


Figure 22. Area (km²) in each housing class from 1970 to 2010 in the Park-Manager-Selected Area of Analysis.

Total Population

The population is relatively low around Redwood (Figure 23) with highest populations in Brookings, Crescent City, and the areas between McKinleyville and Fields Landing. Because the Park-Manager-Selected AOA is large, it includes cities such as Medford and Grants Pass. Between 1990 and 2010, the population increased by 19% in the Regional AOA and by 23% in the Park-Manager-Selected AOA. The population within the Regional AOA was approximately 71,916 in 1990, 81,139 in 2000, and 85,726 in 2010 (Table A23 in Appendix A). The population within the Park-Manager-Selected AOA was 424,059 in 1990, 484,805 in 2000, and 521,114 in 2010 (Table A24 in Appendix A).

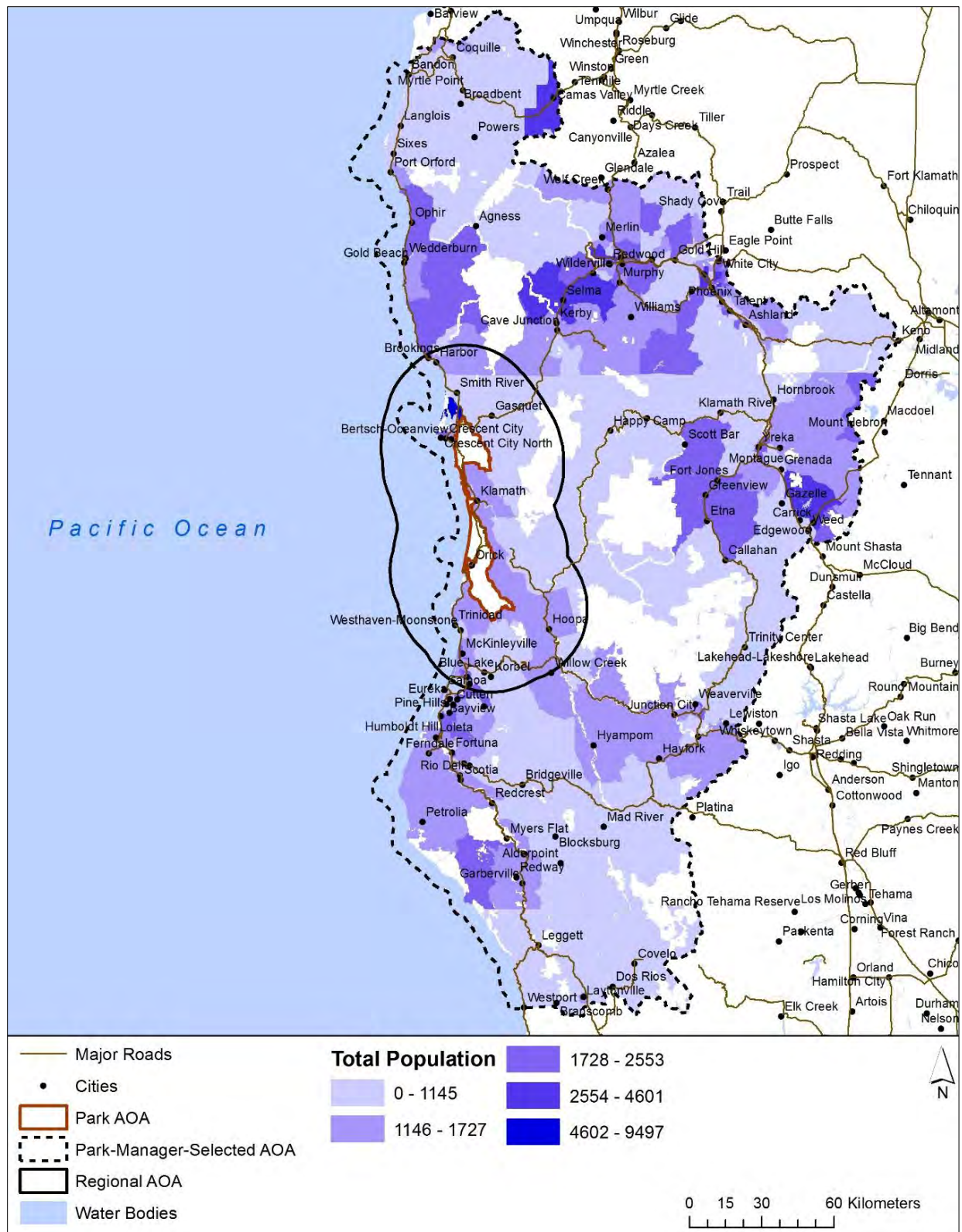


Figure 23. Total population in the Regional and Park-Manager-Selected Areas of Analysis (AOA) in 2010.

Population Density

The population density (individuals per square kilometer) for the Regional AOA increased from 14.86 in 1990, to 17.83 in 2000, to 17.70 in 2010 (Table A23 in Appendix A, Figures 24 and 25).

The population density for the Park-Manager-Selected AOA increased from 47.91 in 1990, to 46 in 2000, to 49.48 in 2010 (Table A24 in Appendix A, Figures 24 and 25).

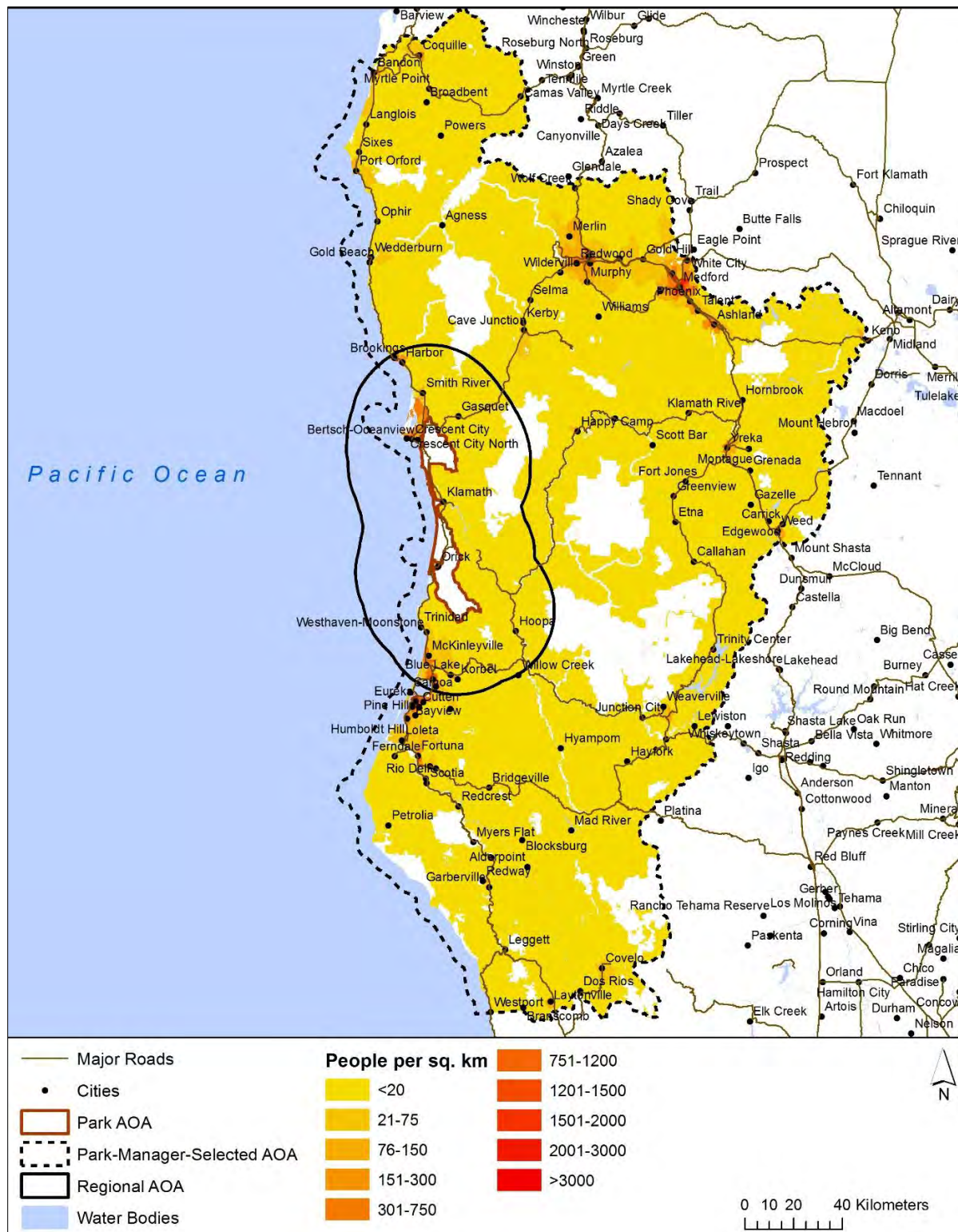


Figure 24. Population density from Census Block-Groups that intersect the Regional and Park-Manager-Selected Areas of Analysis (AOAs) in 2010. Areas where people are assumed to be absent were masked out; this included water and PAD-US protected areas (Status 1 and 2—areas that are primarily maintained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

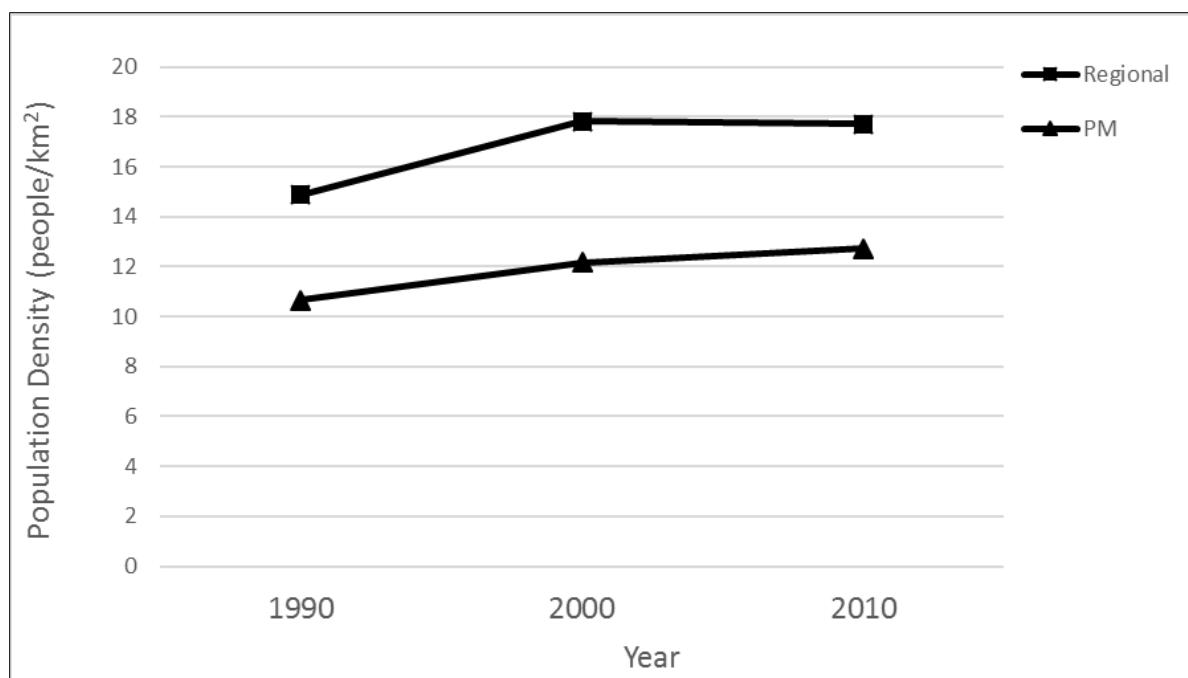


Figure 25. Population density (people/km²) from 1990 to 2010 at Regional and Park-Manager-Selected (PM) Areas of Analysis. Areas where people are assumed to be absent were masked out; this included water and PAD-US protected areas (Status 1 and 2—areas that are primarily maintained in a natural state).

Roads

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

Road Density

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

Between 2010 and 2015, road density (km/km²) decreased slightly in both the Regional and Park-Manager-Selected AOAs. Regional AOA road density was 1.05 in 2010 and 2015 (Figures 26 and 27; Table A25). Park-Manager-Selected AOA road density was 1.29 in 2010 and 1.28 in 2015 (Figures 26 and 27, Table A26 in Appendix A). 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 1.70 in 2016 (Figures 26 and 28; Table A27 in Appendix A).

In 2015, total road length in the Regional AOA was 9,802.5 km and 68,010.8 km in the Park-Manager-Selected AOA. In 2016, total road length was 972.0 km in the Park AOA (Tables A25–A27 in Appendix A).

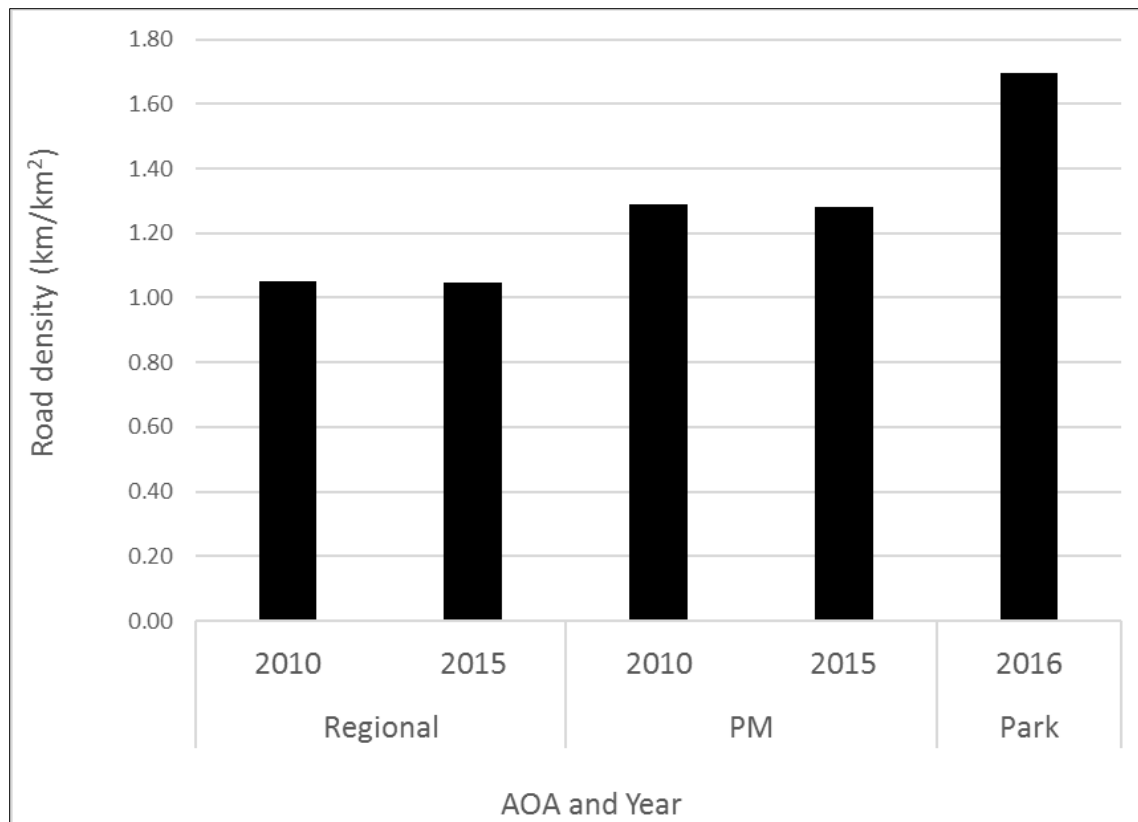


Figure 26. Road density (km/km²) in 2010 and 2015 at the Regional and Park-Manager-Selected (PM) Areas of Analysis (AOA), and in 2016 at the Park AOA. Note that the 2016 Park analysis was done with Redwood National and State Parks-supplied data, whereas the Regional and Park-Manager-Selected analyses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

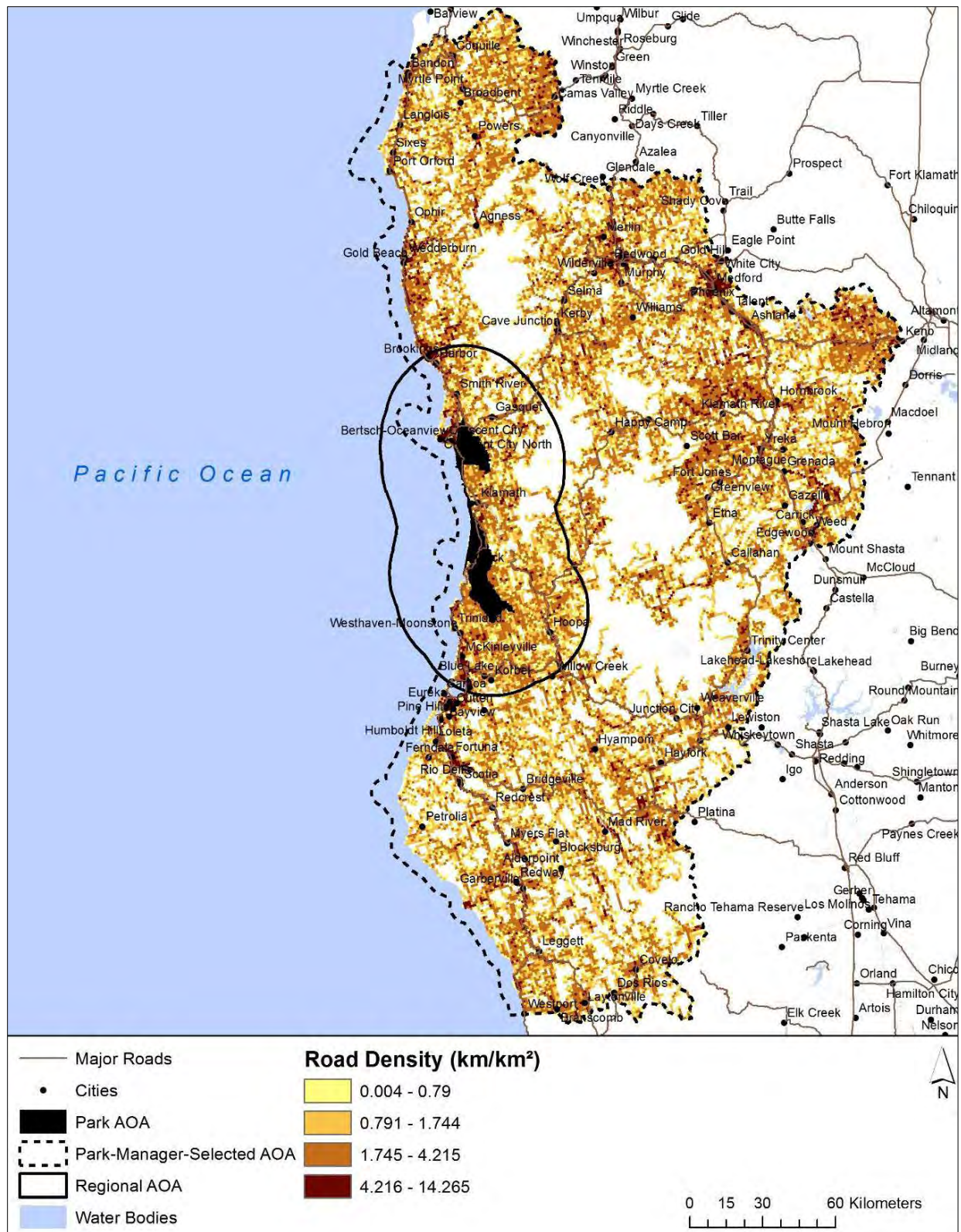


Figure 27. Road density (km/km²) using 2015 US Census Bureau TIGER data at the Regional and Park-Manager-Selected Areas of Analysis (AOA). See Figure 28 for Park AOA.

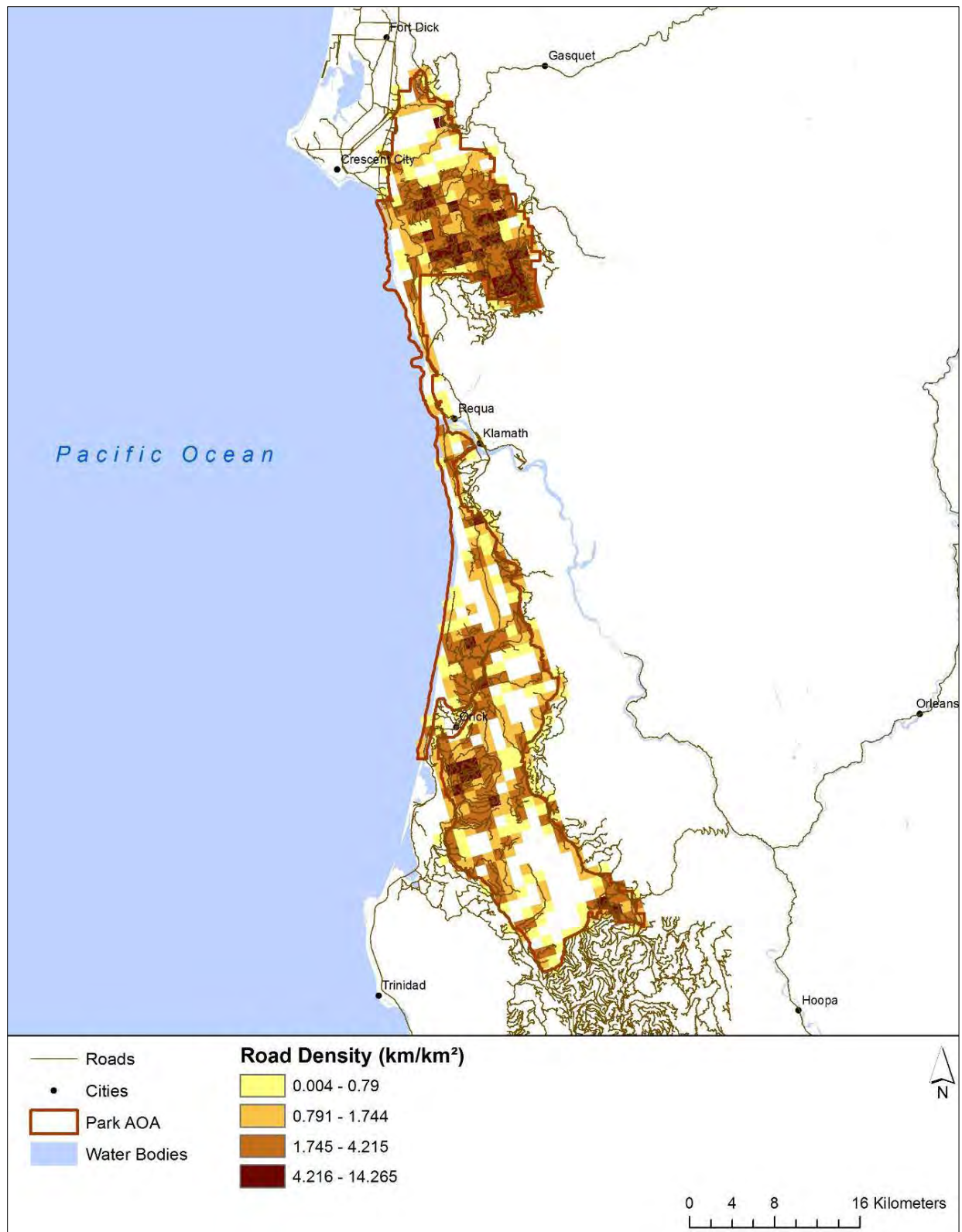


Figure 28. Road density (km/km²) using 2016 Redwood National and State Parks data within the Park Area of Analysis (AOA).

Distance from Roads

With the exception of the ocean, areas that were the greatest distance from roads were generally national forest land, particularly wilderness areas (Figures 29 and 30).

Using Park data from 2016, areas further from roads were northeast of Crescent City and the old growth forests in the southern section of the Park.

Roadless Areas

Excluding the ocean, the bulk of the roadless areas were in US Forest Service wilderness areas including the Trinity Alps Wilderness (Shasta-Trinity National Forest), Marble Mountain Wilderness (Klamath National Forest), Siskiyou Wilderness (Six Rivers National Forest), and the Kalmiopsis Wilderness (Rogue River- Siskiyou National Forest).

There was little change in roadless areas between 2010 and 2015. In both 2010 and 2015, the Regional AOA contained five patches greater than 100 km², totaling approximately 3,385 km² (Figure 31; Table A28 in Appendix A). However, in this AOA, there is one large roadless section in the ocean which covered roughly 2,293 km².

The Park-Manager-Selected AOA also contained large roadless areas. In both 2010 and 2015, 18 roadless patches greater than 100 km² existed and had a total area of approximately 8,980 km² in 2010 and 9,052 km² in 2015 (Figure 31; Table A29 in Appendix A). Like the Regional AOA, this AOA also contained some large roadless areas in the ocean including one patch that was 795 km² and one patch that was 185 km²; other ocean patches were less than 100 km².

Within the Park AOA (2016 data), there was one continuous roadless area covering 67.2 km² (Figure 32; Table A30 in Appendix A); most roadless areas were within the 1–10 km² category.



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 Redwood National and State Parks data within the Park Area of Analysis (AOA).

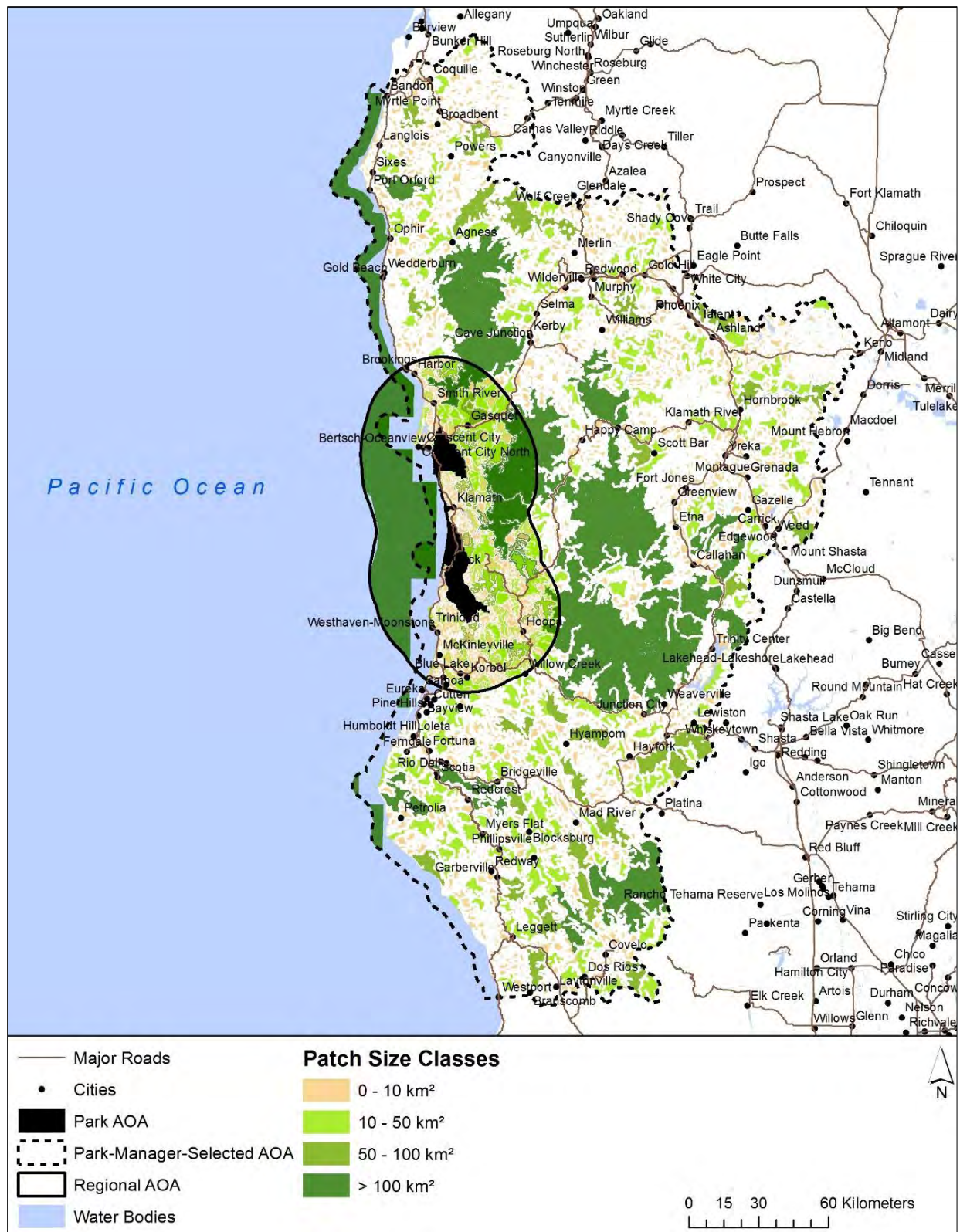


Figure 31. Roadless areas using 2015 US Census Bureau TIGER data for the Regional and Park-Manager-Selected Areas of Analysis (AOA). See Figure 32 for Park AOA.

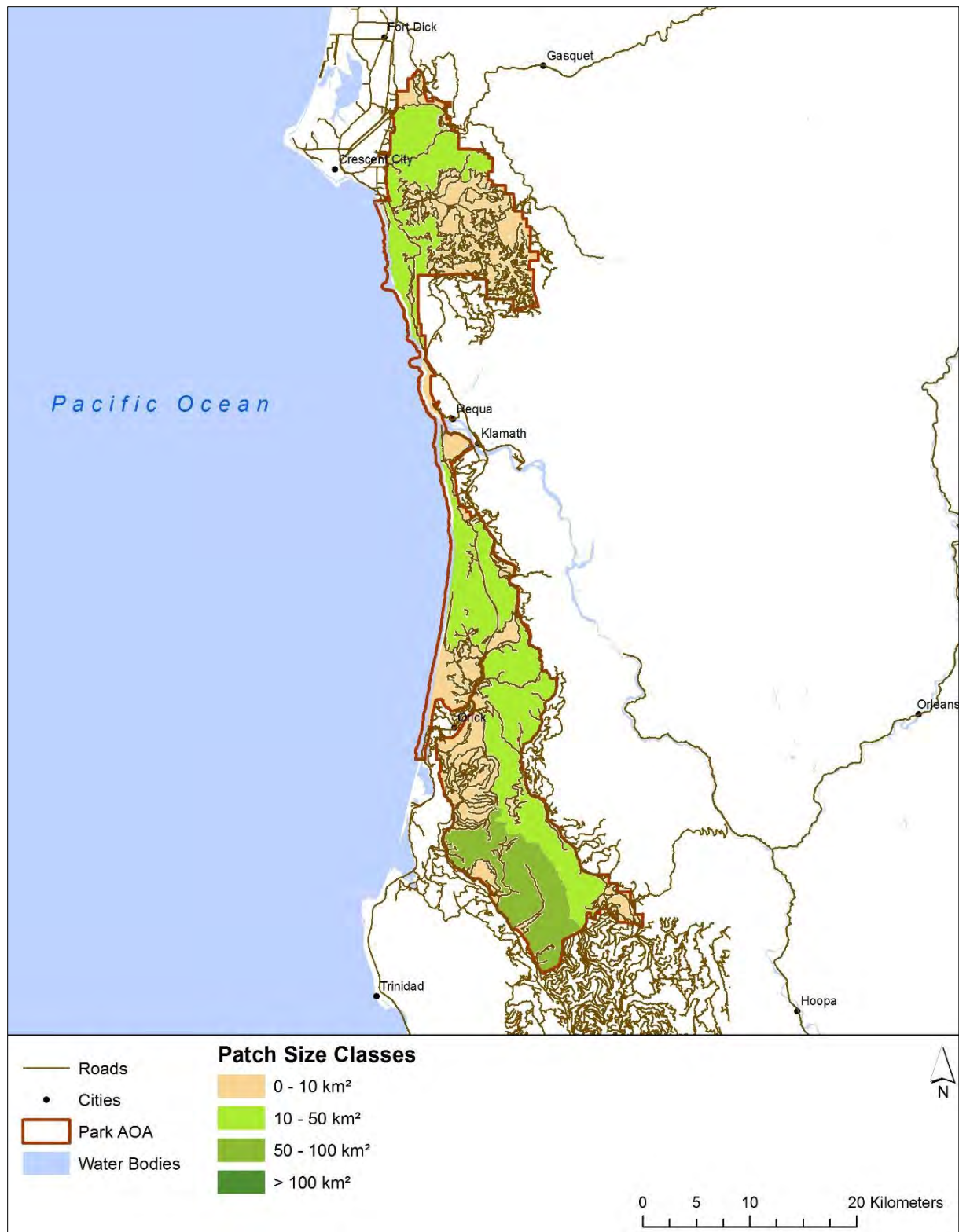


Figure 32. Roadless areas, using 2016 Redwood National and State Parks data within the Park Area of Analysis (AOA).

Disturbance

In the Regional AOA, a cumulative total area of 1,233.6 km² was disturbed from 1999 to 2012 (Tables A31–A33 in Appendix A). *Wildfire* affected the most area (608.5 km²), followed by *Clearcut* (227.3 km²), and *Unknown* (138.5 km²) (see Methods, Table 9, for disturbance category definitions). These account for 49.3%, 18.4%, and 11.2%, respectively, of the total disturbed areas within the Regional AOA.

Figure 33 shows disturbed area by year within each of the three AOAs. Figure 34 presents percentage in each disturbance category for each AOA, and Figure 35 illustrates areas affected by major disturbance type.

In the Park-Manager-Selected AOA, from 1999 to 2012, the total disturbed area was 12,608.7 km² (Tables A34–A36 in Appendix A). *Wildfire* affected the most area (6,853.1 km²), followed by *Other Mechanical* (1,488.5 km²), and then *Unknown* (1,483.1 km²). These account for 54.4%, 11.8%, and 11.8%, respectively, of the disturbed areas within the Park-Manager-Selected AOA.

For the Park AOA, from 1999 to 2012, the total disturbed area was 46.8 km² (Tables A37–A39 in Appendix A). *Prescribed Fire* affected the most area (27.8 km²) followed by *Wildfire* (6.8%) and *Unknown* (4.6%). These disturbance types account for 59.3%, 14.6%, and 9.7%, respectively, of all the disturbed areas within the Park AOA.

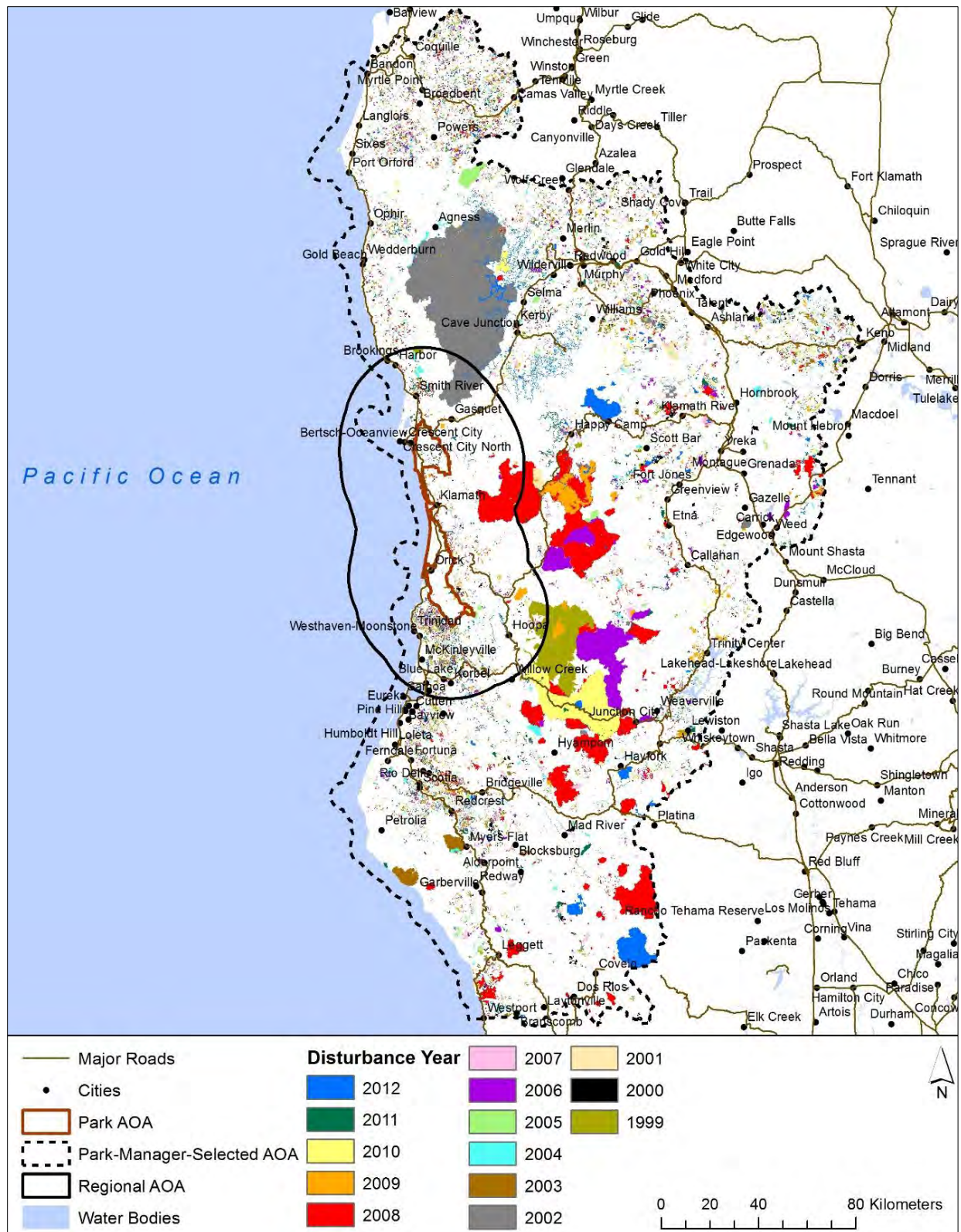


Figure 33. Locations of disturbances by year (1999–2012) at Regional, Park-Manager-Selected, and Park Areas of Analysis (AOA).

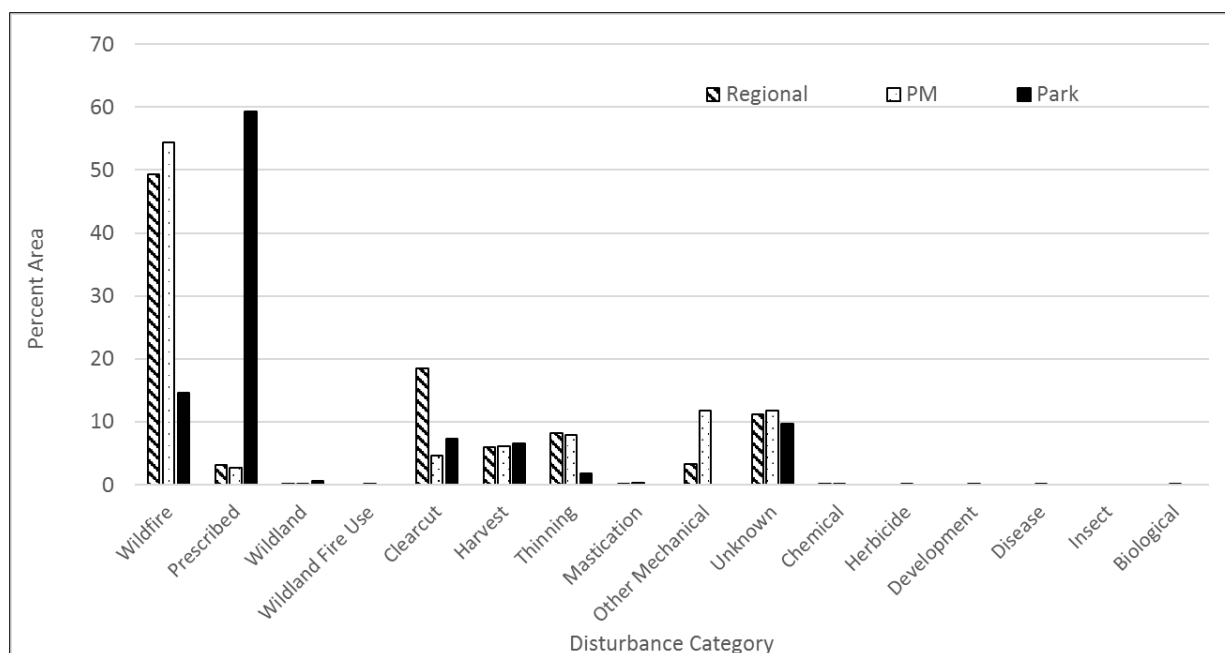


Figure 34. Percentage area (area disturbed/total disturbed area for that Area of Analysis) affected by each disturbance type from 1999 to 2012, at the Regional, Park-Manager-Selected (PM), and Park Areas of Analysis.

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.

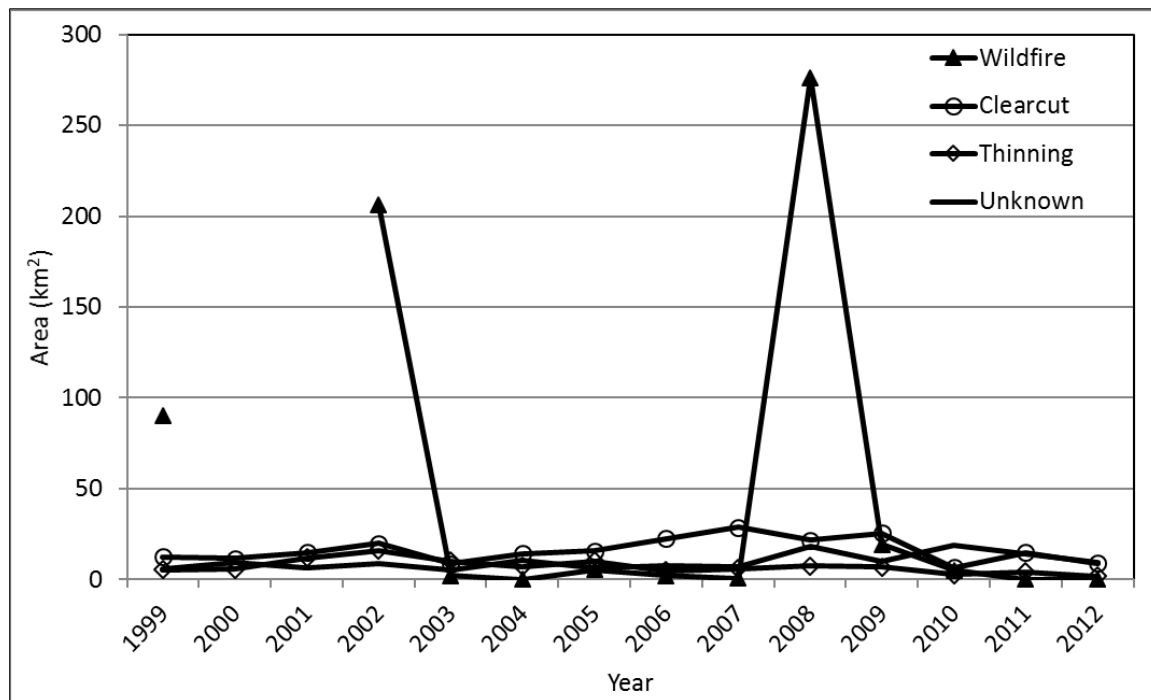


Figure 36. Total area (km²) affected by the four largest disturbance types, by year, for the Regional Area of Analysis. Complete disturbance type values are in Tables A31–A33.

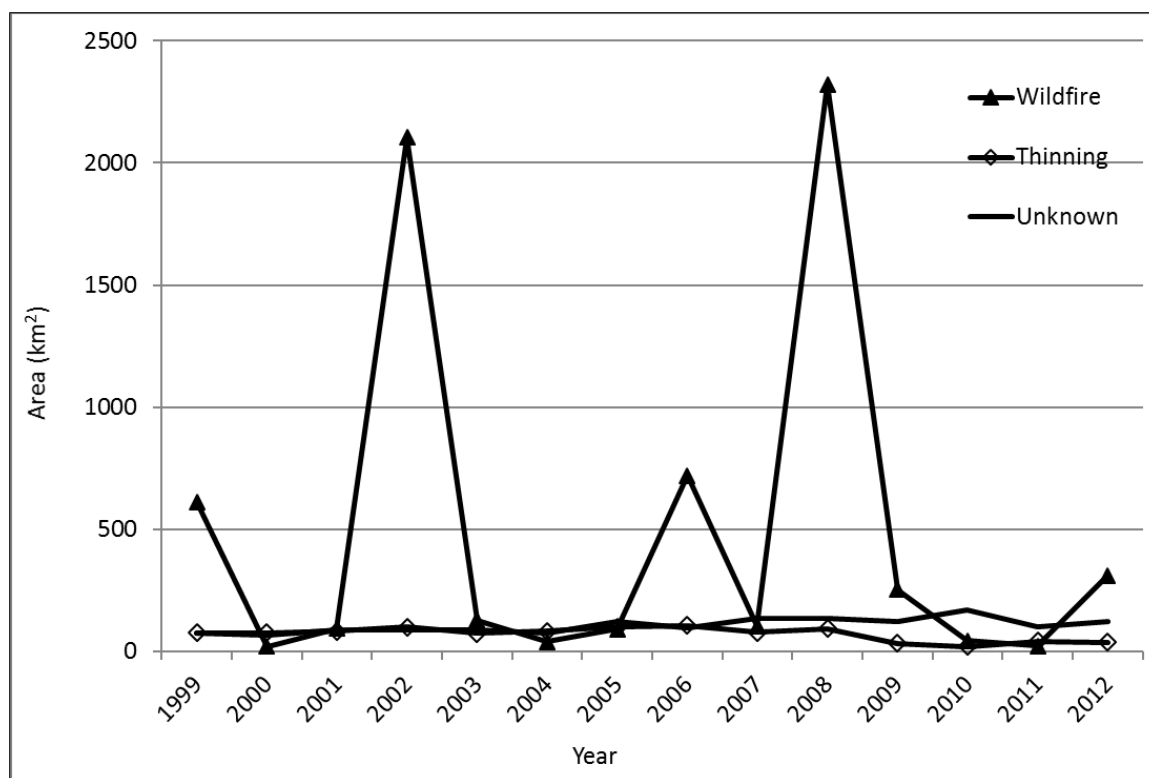


Figure 37. Total area (km²) affected by the four largest disturbance types, by year, for the Park-Manager-Selected Area of Analysis. Complete disturbance type values are in Tables A34–A36.

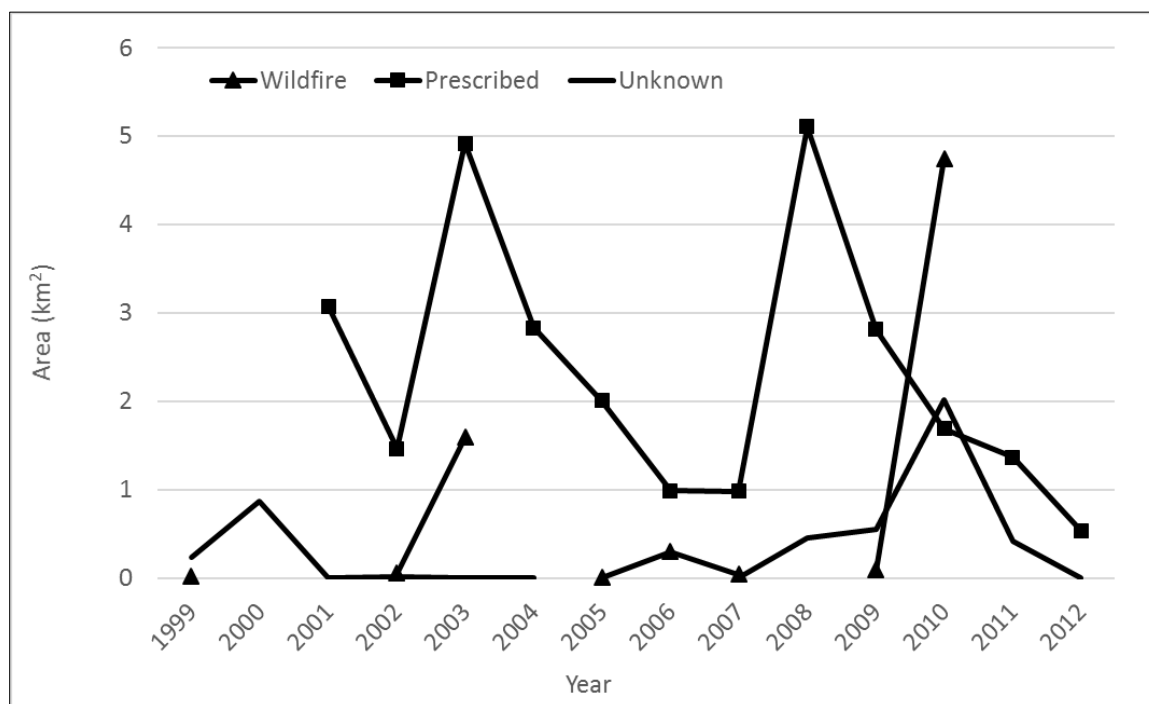


Figure 38. Total area (km²) affected by the three largest disturbance types, by year, for the Park Area of Analysis. Complete disturbance type values are in Tables A34–A36.

Discussion

This report summarizes landscape level information about Redwood National and State Parks and its surrounding areas from largely regional- and national-level datasets. Where data were available, areas outside the Park were largely managed by the Bureau of Land Management and US Forest Service; much of the public land had a GAP Conservation Status of 3, which means that even though the area has protection from conversion of natural land, extractive use is allowed. Area within the Park boundary was primarily GAP Conservation Status 1 or 2, which protects it from conversion of natural land; lands of these statuses also exist outside the Park as large US Forest Service wilderness areas. The vegetation within the Park, Regional, and Park-Manager-Selected AOAs was primarily evergreen forest. Within the forested areas, there were many large intact patches. Grassland and shrubland existed in the study area in small patches. Most of the land area in all three AOAs was considered to be in natural condition, with few impervious surfaces. The areas around the Park were characterized by low total population and low housing density with the exception of a few small cities within the two larger AOAs. There were roads throughout the AOAs; largest areas without roads were in US Forest Service wilderness areas. A variety of disturbances occurred in all three AOAs, including fire and logging.

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 in themselves, there is also power in taking an integrated approach. A land manager could look for correlation and causation by examining these changes along with data from other indicators such as disturbances, protection status and ownership, housing, and landscape patterns. In addition, integrating these data with finer scale projects, including vegetation and landbird monitoring surveys, detailed vegetation maps, and park-specific projects such as prescribed burning and invasive plant management actions, will help provide an integrated look at ecosystem dynamics.

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

This report for Redwood summarizes data from 2006 to 2016 (varies by indicator) and was developed as a “proof of concept” for the Klamath Network land cover and 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, to be 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 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)	2790.14	29.80	6831.69	12.90
Forest Service (USFS)	2612.70	27.90	21273.76	40.16
Native American Land	580.15	6.20	838.64	1.58
National Park Service (NPS)	350.19	3.74	352.20	0.66
State Park & Recreation	229.45	2.45	557.37	1.05
Fish and Wildlife Service (FWS)	55.00	0.59	1070.25	2.02
State Fish and Wildlife	17.04	0.18	107.98	0.20
Other State Land	15.92	0.17	30.07	0.06
State Department of Natural Resources	3.01	0.03	48.42	0.09
City Land	1.29	0.01	25.64	0.05
Regional Agency Land	0.24	<0.01	6.09	0.01
County Land	0.13	<0.01	15.73	0.03
Unknown	–	–	65.35	0.12
The Nature Conservancy (TNC)	–	–	39.76	0.08
Private Landowner	–	–	34.48	0.07
Bureau of Indian Affairs (BIA)	–	–	22.40	0.04
Bureau of Reclamation (BOR)	–	–	12.55	0.02
State Department of Land	–	–	1.03	<0.01
Land Trust	–	–	0.86	<0.01
Other Federal Land	–	–	0.76	<0.01
State University	–	–	0.21	<0.01
Unavailable Data	2708.42	28.92	21635.55	40.84

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 AOA 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	927.77	9.91	5054.24	9.54
2	Managed for biodiversity, natural disturbance NOT allowed	376.87	4.02	4435.69	8.37
3	Managed for multiple use	4764.06	50.88	20863.53	39.39
4	No known mandate	586.56	6.26	981.78	1.85
N/A	Unavailable	2708.42	28.92	21635.55	40.84

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	1163.40	16.12	1164.16	16.13
Developed, Open Space	204.73	2.84	203.98	2.83
Developed, Low Intensity	27.75	0.38	27.82	0.39
Developed, Medium Intensity	20.79	0.29	21.42	0.3
Developed, High Intensity	3.60	0.05	3.72	0.05
Barren Land	36.82	0.51	43.64	0.6
Deciduous Forest	163.51	2.27	162.77	2.26
Evergreen Forest	4152.64	57.54	4111.62	56.97
Mixed Forest	626.10	8.68	622.75	8.63
Shrub/Scrub	561.03	7.77	582.32	8.07
Herbaceous	128.57	1.78	145.17	2.01
Hay/Pasture	65.87	0.91	65.83	0.91
Cultivated Crops	7.76	0.11	7.86	0.11
Woody Wetlands	29.86	0.41	29.72	0.41
Herbaceous Wetlands	24.77	0.34	24.43	0.34

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	3326.69	6.30	3324.92	6.29
Perennial Snow/Ice	18.85	0.04	18.89	0.04
Developed, Open Space	1505.07	2.85	1500.89	2.84
Developed, Low Intensity	240.26	0.45	239.81	0.45
Developed, Medium Intensity	114.35	0.22	119.9	0.23
Developed, High Intensity	27.90	0.05	29.12	0.06
Barren Land	448.93	0.85	338.16	0.64
Deciduous Forest	1007.66	1.91	1003.21	1.9
Evergreen Forest	29877.26	56.56	29566.88	55.97
Mixed Forest	2758.37	5.22	2721.31	5.15
Shrub/Scrub	9103.26	17.23	9451.58	17.89
Herbaceous	2849.38	5.39	2964.62	5.61
Hay/Pasture	763.08	1.44	761.56	1.44
Cultivated Crops	435.89	0.83	434.98	0.82
Woody Wetlands	195.45	0.37	195.35	0.37
Herbaceous Wetlands	156.04	0.30	157.27	0.3

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	25.98	4.53	25.98	4.53
Developed, Open Space	18.72	3.27	18.72	3.27
Developed, Low Intensity	0.72	0.13	0.72	0.13
Developed, Medium Intensity	0.44	0.08	0.45	0.08
Developed, High Intensity	0.15	0.03	0.15	0.03
Barren Land	5.74	1.00	5.8	1.01
Deciduous Forest	17.38	3.03	17.26	3.01
Evergreen Forest	390.27	68.10	389.48	67.96
Mixed Forest	78.40	13.68	77.6	13.54
Shrub/Scrub	21.76	3.80	22.82	3.98
Herbaceous	8.81	1.54	9.38	1.64
Hay/Pasture	0.55	0.10	0.55	0.1
Cultivated Crops	0.45	0.08	0.45	0.08
Woody Wetlands	2.64	0.46	2.7	0.47
Herbaceous Wetlands	1.11	0.19	1.05	0.18

Table A6. 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%	7050.50	75.30	7050.27	75.29
2% - 4%	43.06	0.46	42.94	0.46
4% - 6%	18.44	0.20	18.30	0.20
6% - 8%	12.57	0.13	12.47	0.13
8% - 10%	9.33	0.10	9.23	0.10
10% - 15%	16.41	0.18	16.24	0.17
15% - 25%	19.72	0.21	19.50	0.21
25% - 50%	22.29	0.24	22.37	0.24
50% - 100%	24.90	0.27	25.90	0.28
Background	2146.43	22.92	2146.43	22.92

Table A7. Area and percentage of AOA by Impervious Surface class 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%	51325.64	96.89	51322.71	96.89
2% - 4%	363.51	0.69	362.90	0.69
4% - 6%	213.22	0.40	212.55	0.40
6% - 8%	144.79	0.27	144.08	0.27
8% - 10%	102.59	0.19	101.94	0.19
10% - 15%	166.32	0.31	165.00	0.31
15% - 25%	170.82	0.32	169.15	0.32
25% - 50%	191.29	0.36	191.33	0.36
50% - 100%	150.27	0.28	158.79	0.30
Background	142.37	0.27	142.37	0.27

Table A8. 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%	563.26	98.28	563.25	98.28
2% - 4%	4.82	0.84	4.82	0.84
4% - 6%	1.28	0.22	1.28	0.22
6% - 8%	0.66	0.12	0.66	0.12
8% - 10%	0.50	0.09	0.50	0.09
10% - 15%	0.75	0.13	0.75	0.13
15% - 25%	0.65	0.11	0.66	0.11
25% - 50%	0.58	0.10	0.58	0.10
50% - 100%	0.63	0.11	0.63	0.11

Table A9. Area and percentage of AOA in *Natural* or *Converted* land in the Regional AOA, for 2006 and 2011.

Land Cover Type	2006		2011		% Change in Area
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA	
Natural	6886.71	95.42	6886.59	95.42	<0.01
Converted	330.51	4.58	330.63	4.58	0.04

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

Land Cover Type	2006		2011		% Change in Area
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA	
Natural	49741.88	94.16	49742.18	94.16	<0.01
Converted	3086.56	5.84	3086.26	5.84	-0.01

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

Land Cover Type	2006		2011		% Change in Area
	Area (km ²)	Percentage of AOA	Area (km ²)	Percentage of AOA	
Natural	552.08	96.33	552.08	96.33	<0.01
Converted	21.04	3.67	21.04	3.67	0.02

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

Classification	Park-Manager-Selected			Regional		
	Area (km ²)	Percentage of AOA	Percentage of Forest	Area (km ²)	Percentage of AOA	Percentage of Forest
Background (non- forested)	19484.07	36.78	NA	4436.79	47.38	NA
Branch	1054.18	1.99	3.15	146.59	1.57	2.98
Edge	10407.15	19.65	31.08	1366.31	14.59	27.73
Islet	1131.55	2.14	3.38	80.65	0.86	1.64
Core	11757.46	22.20	35.11	2432.95	25.98	49.38
Bridge	7732.67	14.60	23.09	556.65	5.94	11.30
Perforated	898.53	1.70	2.68	246.30	2.63	5.00
Loop	505.22	0.95	1.51	97.40	1.04	1.98

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

Classification	Park-Manager-Selected			Regional		
	Area (km ²)	Percentage of AOA	Percentage of Grassland	Area (km ²)	Percentage of AOA	Percentage of Grassland
Background (non-grassland)	49244.63	92.97	NA	9152.64	97.75	NA
Branch	218.12	0.41	5.85	14.46	0.15	6.85
Edge	623.05	1.18	16.72	35.65	0.38	16.89
Islet	1842.55	3.48	49.45	133.61	1.43	63.32
Core	216.52	0.41	5.81	10.13	0.11	4.80
Bridge	621.02	1.17	16.67	10.97	0.12	5.20
Perforated	2.35	<0.01	0.06	0	0	0
Loop	202.57	0.38	5.44	6.19	0.07	2.93

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

Classification	Park-Manager-Selected			Regional		
	Area (km ²)	Percentage of AOA	Percentage of Shrubland	Area (km ²)	Percentage of AOA	Percentage of Shrubland
Background (non Shrubland)	43519.23	82.16	NA	8781.32	93.78	NA
Branch	383.88	0.72	4.06	20.08	0.21	3.45
Edge	884.90	1.67	9.36	47.54	0.51	8.16
Islet	5107.59	9.64	54.04	392.16	4.19	67.34
Core	275.33	0.52	2.91	16.89	0.18	2.90
Bridge	2296.14	4.33	24.29	87.18	0.93	14.97
Perforated	5.48	0.01	0.06	0.65	0.01	0.11
Loop	498.25	0.94	5.27	17.83	0.19	3.06

Table A15. Count and total area by patch size range for forest in the Park-Manager-Selected and Regional AOAs, for 2011.

Patch Size Range, in km ²	Park-Manager-Selected		Regional	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	42370	1194.67	2572	92.06
1 to <5	222	470.90	32	69.39
5 to <10	26	170.18	7	50.00
10 to <25	16	252.62	4	58.30
25 to <50	4	160.35	0	0
50 to <100	5	316.22	2	131.92
100 to <250	12	1879.96	3	597.86
250 to <500	7	2540.77	2	747.50
500 to <1000	3	2225.99	0	0
>1,000	6	24275.09	2	3179.81
Total	42671	33486.75	2624	4926.84

Table A16. Count and total area by patch size range for grassland in the Park-Manager-Selected and Regional AOAs, for 2011.

Patch Size Range, in km ²	Park-Manager-Selected		Regional	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	67006	2106.71	5349	164.10
1 to <5	379	753.97	20	40.74
5 to <10	37	250.47	1	6.17
10 to <25	20	283.04	0	0
25 to <50	6	190.51	0	0
50 to <100	0	0	0	0
100 to <250	1	141.49	0	0
250 to <500	0	0	0	0
500 to <1000	0	0	0	0
>1,000	0	0	0	0
Total	67449	3726.19	5370	211.01

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

Patch Size Range, in km ²	Park-Manager-Selected		Regional	
	Count	Total Area (km ²)	Count	Total Area (km ²)
<1	151356	4788.38	14975	396.45
1 to <5	763	1492.81	36	69.95
5 to <10	103	714.10	5	30.06
10 to <25	58	892.39	3	60.38
25 to <50	17	609.75	1	25.48
50 to <100	8	551.75	0	0
100 to <250	1	138.59	0	0
250 to <500	1	263.83	0	0
500 to <1000	0	0	0	0
>1,000	0	0	0	0
Total	152307	9451.60	15020	582.32

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

Pattern Density Classification	Park-Manager-Selected			Regional		
	Area (km ²)	Percentage of Forested Area	Percentage of AOA	Area (km ²)	Percentage of Forested Area	Percentage of AOA
Rare	1738.18	3.88	3.28	101.38	1.74	1.08
Patchy	5926.11	13.24	11.19	402.31	6.90	4.30
Transitional	4582.86	10.24	8.65	385.93	6.62	4.12
Dominant	10735.32	23.99	20.27	1193.74	20.48	12.75
Interior	5535.65	12.37	10.45	680.14	11.67	7.26
Intact	16226.56	36.26	30.63	3065.26	52.59	32.74
Total	44744.68	100.00	84.47	5828.76	100.00	62.25

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

Pattern Density Classification	Park-Manager-Selected			Regional		
	Area (km ²)	Percentage of Grassland Area	Percentage of AOA	Area (km ²)	Percentage of Grassland Area	Percentage of AOA
Rare	2607.18	23.85	4.92	211.08	29.06	2.25
Patchy	4591.29	41.99	8.67	319.91	44.05	3.42
Transitional	1392.16	12.73	2.63	77.70	10.70	0.83
Dominant	1451.27	13.27	2.74	73.20	10.08	0.78
Interior	417.86	3.82	0.79	20.16	2.78	0.22
Intact	473.54	4.33	0.89	24.24	3.34	0.26
Total	10933.29	100.00	20.64	726.29	100.00	7.76

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.

Pattern Density Classification	Park-Manager-Selected			Regional		
	Area (km ²)	Percentage of Shrubland Area	Percentage of AOA	Area (km ²)	Percentage of Shrubland Area	Percentage of AOA
Rare	5082.31	18.96	9.59	537.36	26.30	5.74
Patchy	11797.84	44.01	22.27	967.94	47.37	10.34
Transitional	4477.66	16.70	8.45	252.50	12.36	2.70
Dominant	3888.14	14.51	7.34	201.25	9.85	2.15
Interior	877.38	3.27	1.66	45.24	2.21	0.48
Intact	681.17	2.54	1.29	39.16	1.92	0.42
Total	26804.50	100.00	50.60	2043.45	100.00	21.82

Table A21. Area, percentage of total area, and percentage of census area by housing density class in the Regional AOA, for 1970–2010.

Regional Housing Density Classes	1970	1980	1990	2000	2010
Rural (<6 units/ km ²)	2759.59	2620.45	2563.63	2480.55	2464.41
Percent of Total Area	29.47	27.99	27.38	26.49	26.32
Percent of Census Area	88.28	83.83	82.01	79.31	78.83
Exurban (7–146 units/ km ²)	197.55	327.86	377.33	454.45	468.30
Percent of Total Area	2.11	3.50	4.03	4.85	5.00
Percent of Census Area	6.32	10.49	12.07	14.53	14.98
Suburban (146–1235 units/ km ²)	13.15	21.62	28.53	35.41	36.35
Percent of Total Area	0.14	0.23	0.30	0.38	0.39
Percent of Census Area	0.42	0.69	0.91	1.13	1.16
Urban (>1235 units/ km ²)	0.24	0.60	1.04	1.87	1.92
Percent of Total Area	<0.01	0.01	0.01	0.02	0.02
Percent of Census Area	0.01	0.02	0.03	0.06	0.06
Commercial/Industrial	17.64	17.64	17.64	17.64	17.64
Percent of Total Area	0.19	0.19	0.19	0.19	0.19
Percent of Census Area	0.56	0.56	0.56	0.56	0.56
Urban-Regional Park	137.69	137.69	137.69	137.69	137.69
Percent of Total Area	1.47	1.47	1.47	1.47	1.47
Percent of Census Area	4.40	4.40	4.40	4.40	4.40
Total Area	9363.69	9363.69	9363.69	9363.69	9363.69
Total Census Area	3125.86	3125.86	3125.86	3127.61	3126.31

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

Park-Manager-Selected Housing Density Classes	1970	1980	1990	2000	2010
Rural (<6 units/ km2)	21587.50	20749.54	20237.94	19747.69	19586.27
Percent of Total Area	40.75	39.17	38.21	37.28	36.98
Percent of Census Area	91.71	88.15	85.98	83.87	83.18
Exurban (7-146 units/ km2)	1348.13	2139.13	2617.47	3083.20	3237.31
Percent of Total Area	2.55	4.04	4.94	5.82	6.11
Percent of Census Area	5.73	9.09	11.12	13.09	13.75
Suburban (146- 1235 units/ km2)	80.60	124.89	155.29	182.64	188.81
Percent of Total Area	0.15	0.24	0.29	0.34	0.36
Percent of Census Area	0.34	0.53	0.66	0.78	0.80
Urban (>1235 units/ km2)	3.08	5.75	8.61	12.69	14.07
Percent of Total Area	0.01	0.01	0.02	0.02	0.03
Percent of Census Area	0.01	0.02	0.04	0.05	0.06
Commercial/Industrial	89.76	89.76	89.76	89.76	89.76
Percent of Total Area	0.17	0.17	0.17	0.17	0.17
Percent of Census Area	0.38	0.38	0.38	0.38	0.38
Urban-Regional Park	429.63	429.63	429.63	429.63	429.63
Percent of Total Area	0.81	0.81	0.81	0.81	0.81
Percent of Census Area	1.83	1.83	1.83	1.82	1.82
Total Area	52970.79	52970.79	52970.79	52970.79	52970.79
Total Census Area	23538.70	23538.70	23538.70	23545.61	23545.85

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

Measure	1990	2000	2010	1990–2000 Percentage Change	2000–2010 Percentage Change
Number of Census Blocks	74	70	71	–	–
Corrected Area (km2)	4839.19	4551.78	4842.60	–	–
Population	71915.6	81139.3	85725.6	12.83	5.65
Population Density (population/km2)	14.9	17.8	17.7	19.95	-0.69

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

Measure	1990	2000	2010	1990–2000 Percentage Change	2000–2010 Percentage Change
Number of Census Blocks	435	404	408	–	–
Corrected Area (km ²)	39789.94	39811.5	40915.67	–	–
Population	424058.7	484804.5	521113.8	14.32	7.49
Population Density (population/km ²)	10.7	12.2	12.7	14.26	4.59

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

Measure	2010	2015
Length (km)	9850.51	9802.45
Density (km/km ²)	1.05	1.05

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.

Measure	2010	2015
Length (km)	68405.73	68010.84
Density (km/km ²)	1.29	1.28

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

Measure	2016
Length (km)	971.96
Density (km/km ²)	1.70

Table A28. Count and total area by roadless area size category in the Regional AOA, using 2010 and 2015 US Census Bureau TIGER data. Note that at one large roadless area is ocean.

Roadless Area Categories	2010		2015	
	Count	Total Area (km ²)	Count	Total Area (km ²)
0-10 km ²	1070	915.37	1087	933.06
10-50 km ²	63	1495.70	61	1474.69
50-100 km ²	11	745.52	11	745.22
> 100 km ²	5	3383.77	5	3384.58

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. Note that several large roadless areas are ocean.

Roadless Area Categories	2010		2015	
	Count	Total Area (km ²)	Count	Total Area (km ²)
0-10 km ²	3132	3595.91	3130	3649.25
10-50 km ²	226	4816.5	223	4724.17
50-100 km ²	33	2264.68	33	2282.66
> 100 km ²	18	8979.65	18	9052.31

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

Roadless Area Categories	Count	Total Area (km ²)
0-10 km ²	166	89.92
10-50 km ²	9	199.84
50-100 km ²	1	67.24
> 100 km ²	0	0

Table A31. Area and percentage of AOA affected by fire related disturbances in the Regional AOA, for 1999–2012. Note that the AOA extends into the ocean; therefore the percent of AOA values are lower than if they only included land area.

Year	Wildfire		Prescribed		Wildland	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	90.18	0.96	0.56	0.01	–	–
2001	–	–	–	–	–	–
2000	–	–	3.22	0.03	0.67	0.01
2002	206.14	2.20	1.97	0.02	1.83	0.02
2003	2.30	0.02	5.72	0.06	–	–
2004	0.19	<0.01	3.91	0.04	–	–
2005	5.51	0.06	2.31	0.02	–	–
2006	2.20	0.02	1.84	0.02	–	–
2007	0.61	0.01	2.73	0.03	–	–
2008	276.29	2.95	5.68	0.06	–	–
2009	19.23	0.21	3.48	0.04	–	–
2010	5.28	0.06	3.62	0.04	–	–
2011	0.11	<0.01	2.67	0.03	–	–
2012	0.42	<0.01	1.60	0.02	–	–
Total	608.46	6.50	39.32	0.42	2.50	0.03

Table A32. Area and percentage of AOA affected by logging related disturbances in the Regional AOA for 1999–2012. Note that the AOA extends into the ocean; therefore the percent of AOA values are lower than if they only included land area.

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	12.66	0.14	8.27	0.09	5.48	0.06	–	–	–	–
2000	11.61	0.12	12.77	0.14	5.83	0.06	–	–	–	–
2001	14.91	0.16	11.30	0.12	11.97	0.13	–	–		
2002	19.93	0.21	11.11	0.12	15.99	0.17	–	–	0.48	0.01
2003	8.67	0.09	7.29	0.08	10.09	0.11	–	–	0.81	0.01
2004	14.18	0.15	6.56	0.07	7.16	0.08	0.15	<0.01	11.99	0.13
2005	15.70	0.17	4.53	0.05	10.27	0.11	–	–	2.32	0.02
2006	22.74	0.24	3.73	0.04	4.93	0.05	0.21	<0.01	1.85	0.02
2007	28.95	0.31	2.01	0.02	6.02	0.06	–	–	1.39	0.01
2008	21.69	0.23	1.35	0.01	7.66	0.08	0.59	0.01	4.47	0.05
2009	25.61	0.27	2.21	0.02	6.84	0.07	0.17	<0.01	1.79	0.02
2010	6.59	0.07	0.94	0.01	2.79	0.03	–	–	0.85	0.01
2011	15.03	0.16	0.67	0.01	4.24	0.05	0.20	<0.01	4.81	0.05
2012	9.09	0.10	1.83	0.02	2.02	0.02	–	–	9.32	0.10
Total	227.35	2.43	74.58	0.80	101.29	1.08	1.32	0.01	40.08	0.43

Table A33. Area and percentage of AOA affected by disturbances other than fire and logging in the Regional AOA for 1999–2012. Note that the AOA extends into the ocean; therefore the percent of AOA values are lower than if they only included land area.

Year	Chemical		Unknown	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	–	–	5.70	0.06
2000	–	–	9.54	0.10
2001	–	–	6.61	0.07
2002	–	–	8.97	0.10
2003	–	–	5.06	0.05
2004	–	–	10.48	0.11
2005	–	–	6.60	0.07
2006	–	–	7.90	0.08
2007	–	–	7.16	0.08
2008	0.13	<0.01	18.40	0.20
2009	–	–	9.84	0.11
2010	–	–	18.79	0.20
2011	–	–	14.22	0.15
2012	–	–	9.26	0.10
Total	0.13	<0.01	138.53	1.48

Table A34. Area and percentage of AOA affected by fire related disturbances in the Park-Manager-Selected AOA for 1999–2012. Note that the AOA extends into the ocean; therefore the percent of AOA values are lower than if they only included land area.

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	612.06	1.16	10.09	0.02	1.19	<0.01	–	–
2000	19.60	0.04	16.80	0.03	1.54	<0.01	–	–
2001	91.76	0.17	8.70	0.02	2.53	<0.01	–	–
2002	2103.95	3.97	13.53	0.03	3.72	0.01	–	–
2003	126.92	0.24	17.13	0.03	6.09	0.01	–	–
2004	38.49	0.07	34.48	0.07	1.00	<0.01	–	–
2005	89.70	0.17	27.43	0.05	0.20	<0.01	–	–
2006	718.44	1.36	20.18	0.04	0.93	<0.01	–	–
2007	103.11	0.19	46.41	0.09	3.45	0.01	–	–
2008	2322.28	4.38	21.27	0.04	–	–	–	–
2009	251.38	0.47	36.58	0.07	–	–	–	–
2010	43.45	0.08	20.39	0.04	–	–	0.17	<0.01
2011	21.50	0.04	41.91	0.08	–	–	–	–
2012	310.44	0.59	19.36	0.04	0.03	<0.01	–	–
Total	6853.08	12.94	334.23	0.63	20.67	0.04	0.17	<0.01

Table A35. Area and percentage of AOA affected by logging related disturbances in the Park-Manager-Selected AOA for 1999–2012. Note that the AOA extends into the ocean; therefore the percent of AOA values are lower than if they only included land area.

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	34.14	0.06	63.11	0.12	76.54	0.14	0.36	<0.01	39.58	0.07
2000	34.02	0.06	71.11	0.13	75.71	0.14	0.64	<0.01	43.05	0.08
2001	38.25	0.07	88.39	0.17	82.25	0.16	3.36	0.01	37.06	0.07
2002	43.36	0.08	89.56	0.17	98.70	0.19	2.46	<0.01	45.99	0.09
2003	27.11	0.05	47.55	0.09	73.34	0.14	5.62	0.01	66.69	0.13
2004	42.81	0.08	45.07	0.09	82.76	0.16	6.85	0.01	88.34	0.17
2005	37.21	0.07	40.92	0.08	99.17	0.19	4.67	0.01	67.60	0.13
2006	47.68	0.09	55.48	0.10	105.31	0.20	4.01	0.01	80.07	0.15
2007	63.72	0.12	45.33	0.09	76.95	0.15	4.58	0.01	57.83	0.11
2008	68.97	0.13	105.28	0.20	91.77	0.17	0.96	<0.01	43.74	0.08
2009	59.54	0.11	49.27	0.09	32.52	0.06	0.53	<0.01	44.55	0.08
2010	28.58	0.05	10.00	0.02	19.38	0.04	0.14	<0.01	595.11	1.12
2011	49.09	0.09	37.80	0.07	42.10	0.08	5.71	0.01	19.21	0.04
2012	19.59	0.04	33.66	0.06	37.02	0.07	1.98	<0.01	259.64	0.49
Total	594.07	1.12	782.55	1.48	993.52	1.88	41.87	0.08	1488.47	2.81

Table A36. Area and percentage of AOA affected by disturbances other than fire and logging in the Park-Manager-Selected AOA for 1999–2012. Note that the AOA extends into the ocean; therefore the percent of AOA values are lower than if they only included land area.

Year	Development		Disease		Biological		Chemical		Herbicide		Unknown	
	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	Area (km ²)	% of AOA
1999	–	–	–	–	–	–	–	–	–	–	75.36	0.14
2000	–	–	–	–	–	–	–	–	–	–	66.94	0.13
2001	–	–	–	–	–	–	–	–	–	–	86.67	0.16
2002	–	–	–	–	–	–	–	–	–	–	86.72	0.16
2003	–	–	–	–	–	–	–	–	–	–	87.05	0.16
2004	–	–	–	–	–	–	–	–	–	–	74.51	0.14
2005	–	–	0.34	<0.01	–	–	–	–	–	–	120.05	0.23
2006	–	–	–	–	–	–	–	–	–	–	97.97	0.18
2007	–	–	0.27	<0.01	–	–	–	–	–	–	136.30	0.26
2008	–	–	3.59	0.01	–	–	0.13	<0.01	–	–	135.72	0.26
2009	–	–	–	–	0.11	<0.01	–	–	0.02	<0.01	122.52	0.23
2010	–	–	0.01	<0.01	–	–	–	–	–	–	169.52	0.32
2011	0.01	<0.01	–	–	–	–	0.15	<0.01	4.89	0.01	101.47	0.19
2012	–	–	–	–	0.42	<0.01	–	–	7.03	0.01	122.28	0.23
Total	0.01	<0.01	4.21	0.01	0.53	<0.01	0.29	<0.01	11.94	0.02	1483.08	2.80

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

Year	Wildfire		Prescribed Fire		Wildland Fire	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	0.02	<0.01	–	–	–	–
2000	–	–	–	–	–	–
2001	–	–	3.07	0.54	0.26	0.05
2002	0.05	0.01	1.46	0.26	–	–
2003	1.59	0.28	4.92	0.86	–	–
2004	–	–	2.83	0.49	–	–
2005	<0.01	<0.01	2.00	0.35	–	–
2006	0.30	0.05	0.99	0.17	–	–
2007	0.04	0.01	0.98	0.17	–	–
2008	–	–	5.11	0.89	–	–
2009	0.09	0.02	2.81	0.49	–	–
2010	4.75	0.83	1.69	0.29	–	–
2011	–	–	1.37	0.24	–	–
2012	–	–	0.53	0.09	–	–
Total	6.83	1.19	27.77	4.85	0.26	0.05

Table A38. Area and percentage of AOA affected by disturbances other than fire and logging in the Park AOA for 1999–2012.

Year	Clearcut		Harvest		Thinning		Other Mechanical	
	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA	Area (km ²)	% of AOA
1999	1.86	0.32	0.03	0.01	0.09	0.02	–	–
2000	1.08	0.19	1.77	0.31	–	–	–	–
2001	0.47	0.08	<0.01	<0.01	–	–	–	–
2002	0.01	<0.01	1.30	0.23	0.26	0.05	–	–
2003	–	–	–	–	–	–	–	–
2004	–	–	–	–	–	–	–	–
2005	–	–	–	–	–	–	–	–
2006	0.01	<0.01	–	–	0.03	0.01	–	–
2007	<0.01	<0.01	–	–	<0.01	<0.01	–	–
2008	<0.01	<0.01	–	–	0.39	0.07	–	–
2009	0.01	<0.01	–	–	0.01	<0.01	–	–
2010	–	–	–	–	–	–	–	–
2011	0.02	<0.01	–	–	0.03	<0.01	–	–
2012	<0.01	<0.01	–	–	<0.01	<0.01	–	–
Total	3.46	0.60	3.10	0.54	0.82	0.14	–	–

Table A39. Area and percentage of AOA affected by disturbances other than fire and logging in the Park AOA for 1999–2012.

Year	Unknown	
	Area (km ²)	% of AOA
1999	0.23	0.04
2000	0.87	0.15
2001	<0.01	<0.01
2002	0.02	<0.01
2003	<0.01	<0.01
2004	<0.01	<0.01
2005	—	—
2006	—	—
2007	<0.01	<0.01
2008	0.45	0.08
2009	0.55	0.10
2010	2.02	0.35
2011	0.41	0.07
2012	<0.01	<0.01
Total	4.56	0.80

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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