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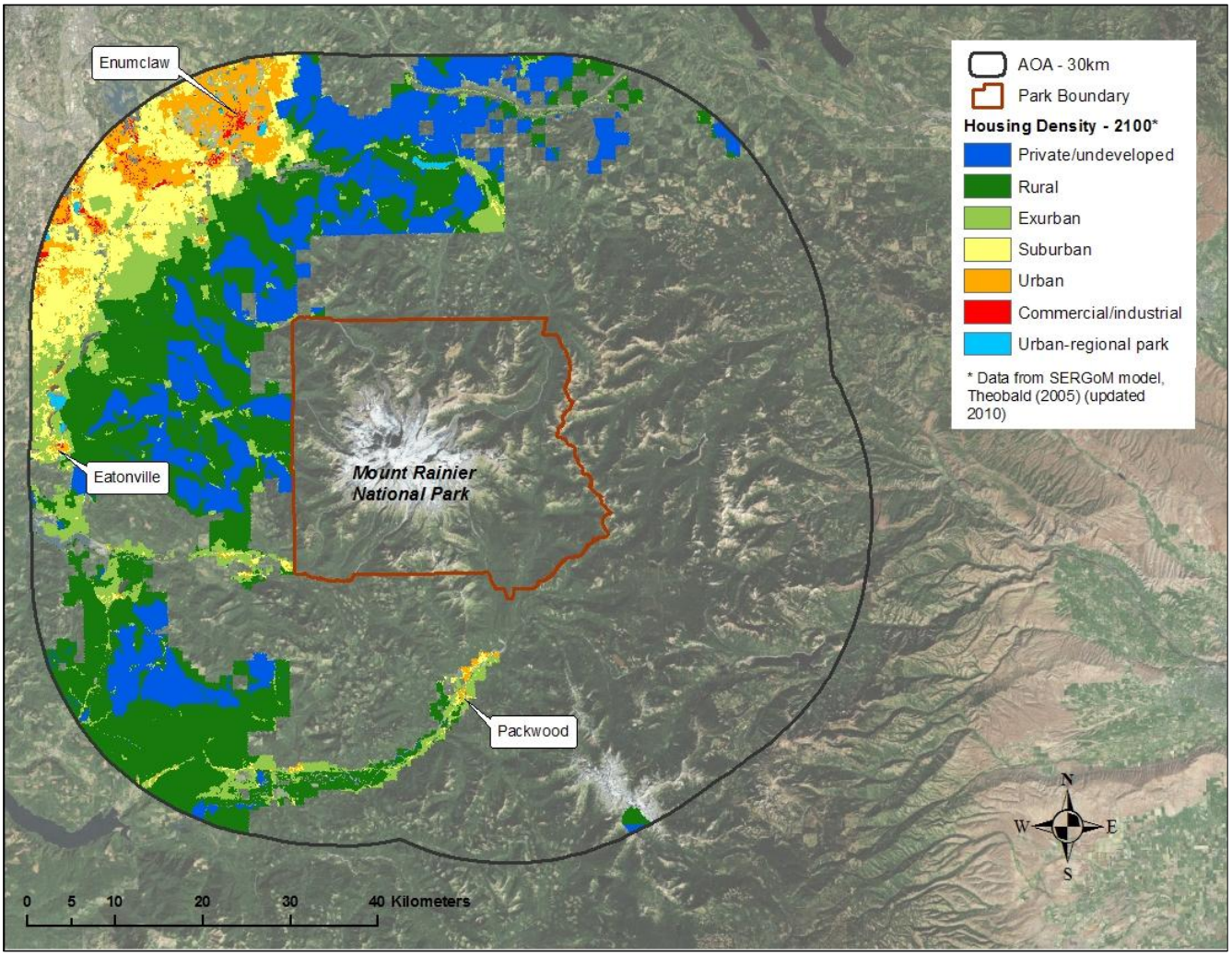
Natural Resource Stewardship and Science

NPScape Landscape Analysis for Mount Rainier National Park

Housing, Population, and Roads Metrics

Natural Resource Report NPS/NCCN/NRR—2015/1079



ON THE COVER
Map showing 2100 projected housing density for the NPScape ‘area of analysis’ for Mount Rainier National Park. Data from Spatially Explicit Regional Growth Model (SERGoM) developed by Theobald (2005).

NPScape Landscape Analysis for Mount Rainier National Park

Housing, Population, and Roads Metrics

Natural Resource Report NPS/NCCN/NRR—2015/1079

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Introduction

Responding to the need for landscape-scale information within and surrounding national parks, in 2009 the Inventory and Monitoring (I&M) Program of the National Park Service (NPS) funded NPScape, a service-wide inventory of landscape-scale data sets pertaining to all national parks (general information about NPScape can be found at http://science.nature.nps.gov/im/monitor/npscape/). Working with data from existing sources, the I&M Program provided the landscape information from NPScape to nearly 300 parks and I&M networks--covering six major categories of environmental drivers and attributes (metrics) that are key to conservation planning in NPS units. The categories are 1) population, 2) housing density, 3) roads, 4) land cover, 5) patterns of forest/grassland patches, and 6) conservation status. The metrics for these categories include historic (where data are available) and current condition, and for certain categories, future projections. The I&M Program envisions that I&M networks will refine the base information provided, select ecologically relevant study areas for analyses, and use higher resolution, local data sets if available to develop products that inform park resource management and planning.

Landscape Dynamics is one of the North Coast and Cascades Network's (NCCN) primary monitoring vital signs. Between 2007 and 2011, NCCN I&M developed and updated a vital sign monitoring protocol to assess landscape change using satellite imagery (Kennedy et al 2007, Antonova et al 2012). To date, protocol implementation has focused on detecting landscape disturbances in the Network's three largest parks: Mount Rainier (MORA), North Cascades, and Olympic National Parks. It has not yet been implemented in the Network's smaller, historical parks. Landscape-scale questions most pertinent to the smaller parks may not be best addressed with the techniques that the Network has targeted for the larger parks, and the NPScape data could prove a useful compliment to NCCN Landscape Dynamics Monitoring.

The availability of NPScape data is a relatively new opportunity for networks and parks and represents an untapped resource to assess landscape change. For this study, our overarching goal was to explore the utility of the NPScape data for supplementing the Network's Landscape Dynamics protocol, especially for the smaller parks. Our aim for this report was two-fold: 1) to assess the NPScape data for accessibility and ease of use in analyzing and producing landscape change products, and 2) to provide landscape-scale products to park managers and planners for use in natural resource conservation assessments and plans.

We selected four parks for this study: Ebey's Landing National Historical Reserve (EBLA), Lewis and Clark National Historical Park (LEWI), Mount Rainier National Park (MORA), and San Juan Island National Historical Park (SAJH) (Figure 1). In this report, we present analyses conducted for MORA on three key NPScape attributes: roads, population, and housing.

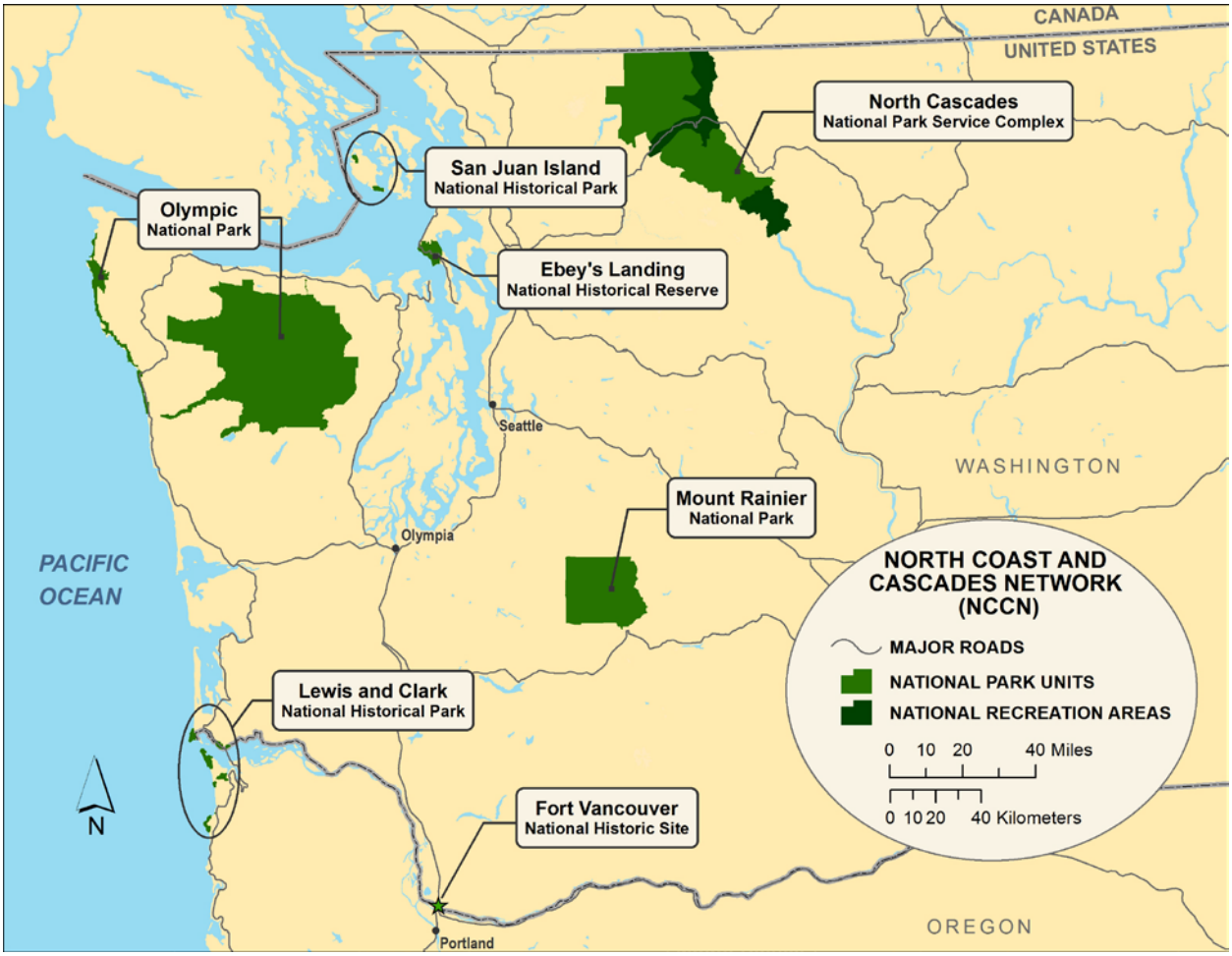

Figure 1. Location of parks within the North Coast and Cascades Network.

Methods

This NCCN project was conducted in the summer 2011, when NPScape was relatively new, and the products were released in two 'phases.' Calculating the metrics for NCCN parks required identification of appropriate input data sets, specifying an Area of Analysis (AOA) for each park, and running Python scripts developed by the Inventory and Monitoring Division (IMD SO) to calculate the landscape metrics. NPScape landscape data products provided by IMD SO were developed using data sets with national coverage and thus required evaluation of the input datasets for spatial accuracy and relevancy at the park scale. Where local data sets were available and deemed more accurate, those were substituted as inputs when the selected metrics for NCCN parks were "re-calculated." Selection of AOAs and input data sets are described here in general terms for the NCCN parks and for MORA specifically.

Area of Analysis

The first step in conducting the landscape-scale analyses was identifying a study area, or area of analysis (AOA), which would incorporate the range of influences of processes that affect park resources but that was also relevant given the resolution of the various data sets to be used. Typically, this would include the area of the park itself and some region surrounding the park.

Hansen et al. (2011) developed a methodology for delineating boundaries around protected areas, like national parks, that encompass the spatial extent of ecosystem processes and direct human influence as well as critical habitat for native organisms. This framework, the Protected Area Centered Ecosystem (PACE), offers parks and protected areas a means of customizing AOAs as needed. Hansen et al. (2011) created a PACE model for MORA, soliciting input from park staff on resource management concerns. We explored the PACE boundary developed for MORA but decided that for the purposes of this NPScape product summary, the PACE included areas for which the source data sets were not at appropriate spatial scale. For example, the PACE boundary included narrow riparian corridors along several rivers, some of which extended 100 km from the Park boundary, and were narrower than the minimum 30 km buffer area recommended by IMD SO for the 100 x 100 m cell size housing data. Moreover, the PACE boundary included areas far enough away from the Park that for the metrics summarized here, there would likely be minimal impact on Park resources.

The default AOA for NPScape products was a 30 km buffer around each park. For MORA, this included the gateway communities of Enumclaw, Eatonville, and Packwood, as well as important habitat connectivity with adjacent United States Forest Service (USFS) wilderness areas to the north, east, and south of the Park (Figure 2). This area encompassed by the 30 km buffer was considered a reasonable area of analysis to describe landscape-scale drivers that may impact park natural resources. We used this default NPScape AOA for the MORA analyses.

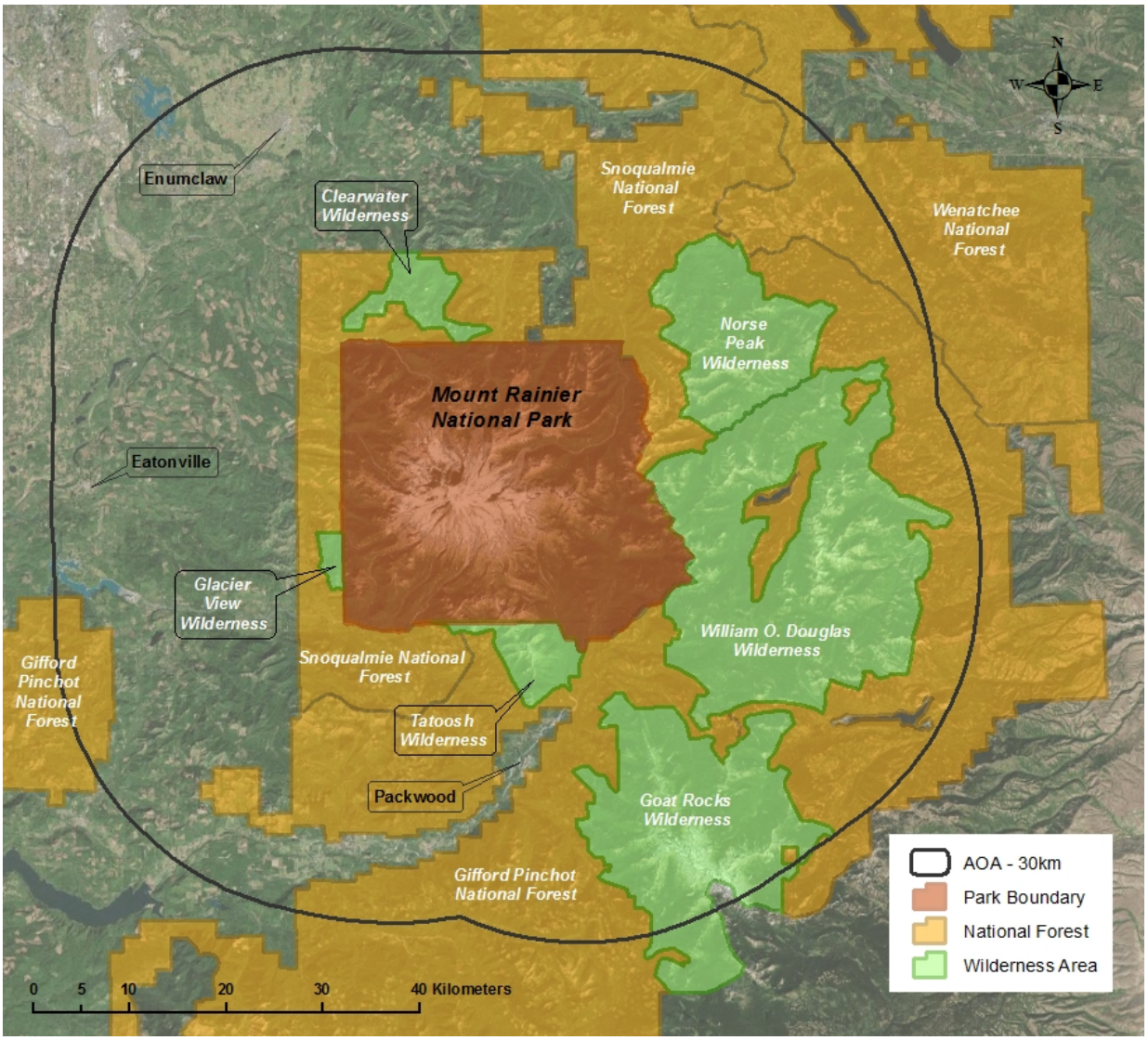

Figure 2. Location of Mount Rainier National Park in the regional context of other public lands and wilderness areas.

Housing metrics

The housing metrics selected for the NCCN project were historic, current, and projected *housing density* by decade from 1970-2100. The full suite of NPScape housing metrics produced by the I&M Program are summarized on the NPScape website at http://science.nature.nps.gov/im/monitor/npscape/measures.cfm; note that different metrics are available currently than were available at the time of this project.

Data

The housing density data were generated by the Spatially Explicit Regional Growth Model (SERGoM) developed by Theobald (2005), which modeled past, current, and future housing density from 1970 to 2100. These data included an update in 2010 (by the developer) to the original SERGoM data (version 3) provided in the Phase 1 release of NPScape. The SERGoM data were

developed by combining U.S. Census housing data with information on land ownership, protected areas, water bodies, and the density of major roads (interstates, highways, and county roads) in order to provide a more accurate allocation of housing units, across the landscape (housing units were assumed not to occur in these protected areas, including national parks, nor in waterbodies). Historic and current housing density patterns were used to develop a simulation model. Data were projected for future time steps by assuming that future growth patterns will be similar to those of the past. The data were resampled to 100 m x 100 m cell size representing 14 housing density classes for each decade from 1970 to 2100.

Processing

The SERGoM data were not modified, therefore processing entailed extracting the housing density values for the AOA. *Housing density* was calculated for the 14 density classes identified in the SERGoM data set. These classes were then lumped into seven density categories following Theobald (2005): Private undeveloped, Rural, Exurban (sprawl beyond the urban/suburban fringe), Suburban, Urban, Commercial/industrial, and Urban-regional park. For detailed steps in processing these metrics (e.g., running the Python scripts, generating the statistics), see NPScape Housing Measure – Phase 1 Metrics Processing SOP (NPS 2010a).

Population metrics

The Phase 1 release population metrics selected by the NCCN project were *total population* and *population density* by Census block group for 1990, 2000, and 2010. A Census block is the smallest geographical unit for which the United States Census Bureau tabulates 100% decennial census data, (information collected from every inhabitant and housing unit in the United States). A Census block group is a geographical unit used by the Census. Block group unit size on average is 30 blocks, but can vary considerably depending on population density and tabulates sample data (information collected from ~17% of the population) from the decennial census. The full suite of NPScape population metrics produced by the I&M Program are summarized on the NPScape website at http://science.nature.nps.gov/im/monitor/npscape/measures.cfm.

Data

A review of the IMD SO-developed products for NCCN parks indicated that the historic and projected county-level population metrics were not that informative at the small NCCN park scale, but the Census block group-level data for 1990 and 2000 were. The initial release of the Phase 1 NPScape products did not yet include the 2010 Census data, but during the course of this project, those data became available. IMD SO performed QA/QC on them for the NCCN parks so that population metrics could be calculated for this most recent decade.

Waterbodies (lakes and ponds), protected areas, and the park itself, do not have people living in them and needed to be excluded from the analyses. The National Hydrography Database waterbody data were selected for use in the NCCN project because these data included more known features from the parks than the IMD SO-provided data from the National Atlas Water Feature Areas. The protected areas data we used were those provided by IMD SO and were from the Gap Analysis Program (GAP) Protected Areas Database (PAD-US) (USGS 2011). The IMD SO-provided scripts were written with the assumption that people did not live within park boundaries. Recognizing that this assumption

may not be valid for all parks, the scripts excluded park boundaries from the PAD-US data set to allow population analysis to be conducted within park boundaries. For parks where the assumption is valid, parks could exclude park areas from the analysis using their own park boundary data. MORA does have a very small year-round population of park and concessions staff (<10 people) living within the Park boundary (Roger Andrascik, Chief of Natural and Cultural Resources, MORA, pers. comm., November 2015), but because it is so small and varies little from year to year, we treated MORA as having no population for this analysis. We used the Park boundary Geographic Information System (GIS) layer to exclude the Park area from the analysis, thereby preventing the model from calculating population increases within the Park boundary in the future projections.

Processing

Total population and *population density* were calculated for Census block group data for 1990, 2000, and 2010. The IMD SO Python script for calculating population metrics for Census block groups 'pushed' population numbers for block groups within park boundaries to surrounding areas outside park boundaries under the assumption that people do not live within park boundaries. In other words, a greater number of people (formerly counted in block groups spanning a park boundary) were now 'squeezed' into a smaller area - block groups adjacent to the park (or clipped by park boundary) - resulting in density metrics for those block groups adjacent to a park being slightly higher after processing. Similarly, areas identified as water (lakes and ponds) as well as protected areas from the GAP PAD-US were excluded from the analysis. Thus, *population density* was area-weighted, excluding areas where people were not expected to live. See NPScape Population Measure – Phase 1 Metrics Processing SOP (NPS 2010b) for details on these protected areas exclusions and analysis processing steps. These assumptions were generally valid for MORA, so no additional special processing was required.

Roads metrics

The roads metrics selected for the NCCN project were *density of all roads* and *distance from all roads* (Phase 2 release), and *area without roads* (>500 m from all roads; Phase 1 release). The full suite of NPScape road metrics produced by the I&M Program are summarized on the NPScape website at http://science.nature.nps.gov/im/monitor/npscape/measures.cfm; note that different metrics are available currently than were available at the time of this project.

Data

The NPScape roads metrics produced by IMD SO were calculated using ESRI's national roads data set. This data set was of highly variable accuracy in and around NCCN parks, so for the NCCN project, the road metrics were developed primarily from the Bureau of Land Management (BLM) Ground Transportation Roads Publication and Highways geodatabases, downloaded from the BLM Oregon State Office website in 2008 (BLM 2008). These data covered both Washington and Oregon and, after reviewing multiple data sources, were deemed to be the most accurate and representative of the roads within the AOAs surrounding all the NCCN parks. For MORA, all the roads from the BLM data set within the Park boundary were replaced with the roads in the Park's GIS roads layer as these were much more accurate.

Processing

The metrics selected for the NCCN project were calculated for the entire MORA AOA. *Density of all roads* and *area without roads* were also analyzed separately for the area within the Park boundary for comparison to the larger AOA. For detailed processing steps in calculating *areas without roads*, see NPScape Road Measure – Phase 1 Metrics Processing SOP (NPS 2010c) and for calculating *density of all roads* and *distance from roads*, see NPScape Roads Measure – Phase 2 Road Metrics Processing SOP (NPS 2010d).

Results

Summaries of the calculated landscape metrics for MORA are presented here. Results from the other NCCN parks will be summarized in future reports.

Housing

Of the 14 *housing density* classes calculated for the MORA AOA, the classes representing residential housing densities (i.e., not including the private/undeveloped, commercial/industrial, and urban-regional park categories) were lumped into the 'rural,' 'exurban,' 'suburban,' and 'urban' categories following Theobald (2005) for the time period of 1970-2010 and the additional future projections of 2040, 2070, and 2100 (Table 1). There was a general trend, over the entire time period analyzed, towards increasing density in the exurban (the three densest of the four classes), suburban, and urban categories and decreasing density in the private undeveloped and rural (except the middle density class) categories. There was no change in the commercial/industrial or urban-regional park classes (Table 1).

The greatest change among *housing density* categories between 1970 and 2010 occurred in the private/undeveloped, rural, and exurban categories, with a marked decrease in private/undeveloped density offset by a similar increase in exurban density (Figure 3). The rural housing density category showed a very slight increase over the 1970-2000 time period, followed by a slight decrease starting in 2010 and continuing in the future projections through 2100. Of the remaining housing density categories, the suburban category showed a dramatic increase, particularly in the future projections (after 2010). The urban category showed only a very slight increase, and there was no change indicated for the commercial/industrial and urban-regional park categories over the entire 1970-2100 time period (Figure 4).

The pronounced shift from low-density categories to high-density categories (excluding the lack of change in commercial and urban-regional park categories) in terms of area and spatial distribution is presented in Figure 5.

Table 1. Percentage of Mount Rainier National Park Area of Analysis in each housing density class, 1970-2010, 2040, 2070, and 2100[1].

Housing density class	Density categories[2]	1970	1980	1990	2000	2010	2040	2070	2100
Private undeveloped	Private undeveloped	14.355	11.838	10.467	8.482	8.188	8.145	8.125	8.113
< 1.5 units / sq. km.	Rural	8.915	8.887	8.587	9.330	8.964	8.545	8.510	8.464
1.5 - 3 units / sq. km.		2.011	2.690	3.324	3.400	3.447	3.629	3.604	3.564
4 - 6 units / sq. km.		2.060	2.176	2.173	2.112	1.564	1.329	1.258	1.234
7 - 12 units / sq. km.	Exurban	1.646	2.153	2.083	2.133	1.454	0.979	0.964	0.942
13 - 24 units / sq. km.		0.831	1.399	1.827	2.197	2.488	1.490	1.362	1.146
25 - 49 units / sq. km.		0.485	0.777	1.120	1.382	2.393	2.385	2.045	1.629
50 - 145 units / sq. km.		0.292	0.546	0.754	1.059	1.483	3.217	3.436	3.482
146 - 494 units / sq. km.	Suburban	0.090	0.196	0.297	0.466	0.535	0.765	1.164	1.840
495 - 1,234 units / sq. km.		0.016	0.037	0.064	0.130	0.146	0.177	0.190	0.235
1,235 - 2,470 units / sq. km.	Urban	0.001	0.003	0.007	0.021	0.021	0.022	0.025	0.032
> 2,470 units / sq. km.		0	0	0	0.003	0.002	0.003	0.003	0.003
Commercial/industrial	Commercial/industrial	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191
Urban-regional Park	Urban-regional park	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119

[1] Housing density projections were provided by SERGoM for each decade from 2010-2100 but not all decades presented here.

[2] For residential housing densities, following Theobald (2005).

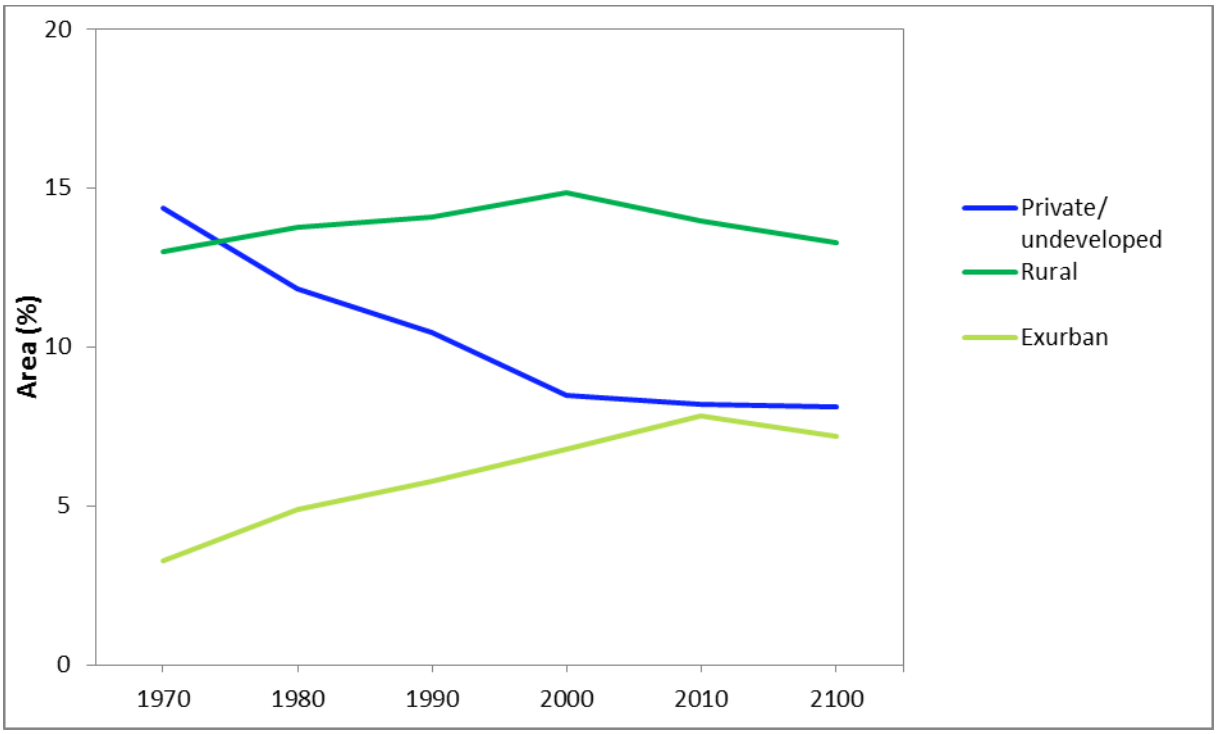

Figure 3. Change in percent area of the private/undeveloped, rural, and exurban housing density categories in the Mount Rainier National Park Area of Analysis, 1970-2100.

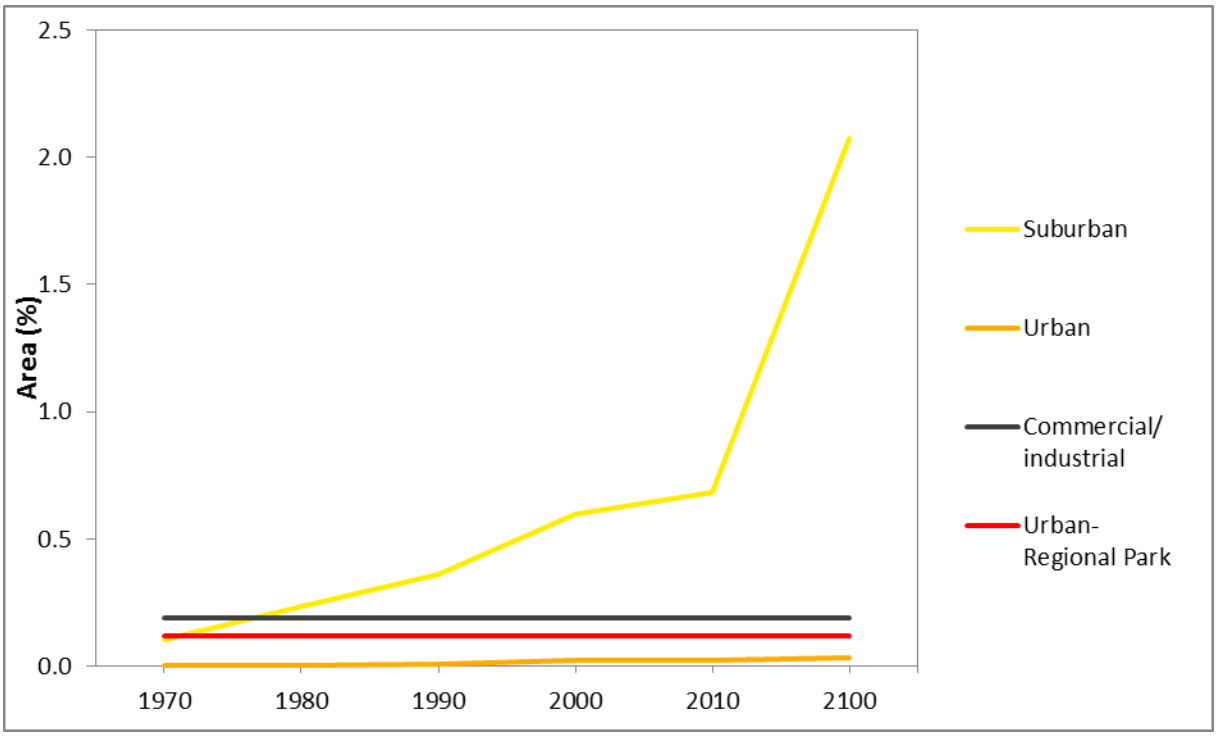

Figure 4. Change in percent area of the suburban, urban, commercial/industrial, and urban-regional park housing density categories in the Mount Rainier National Park Area of Analysis, 1970-2100.

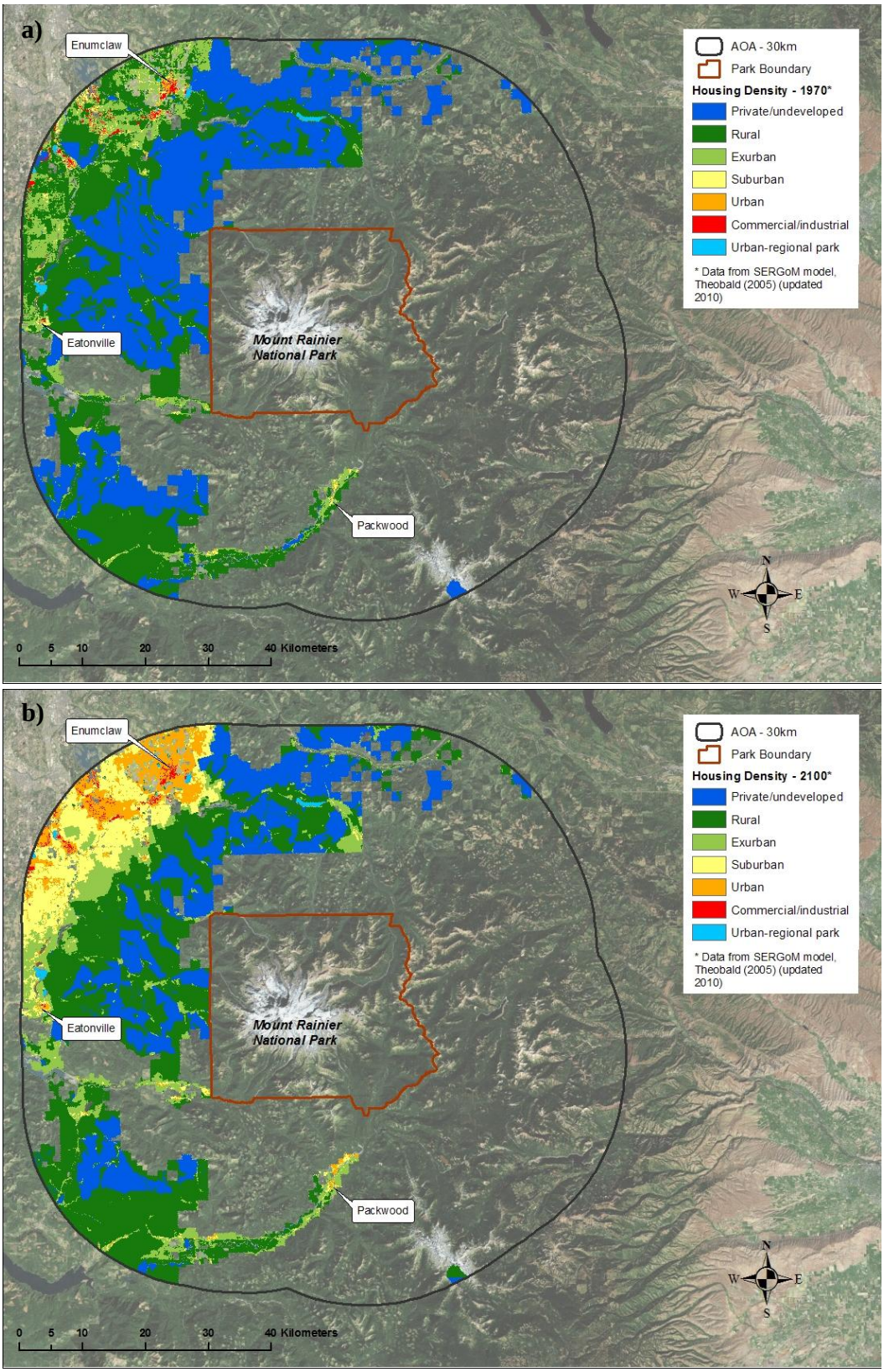

Figure 5. Size and spatial distribution of housing density categories in Mount Rainier National Park Area of Analysis between a) 1970 and b) 2100.

Projected housing density values are based on socioeconomic forecasts; where these forecasts prove incorrect, the model will not perform well. Further, the model has not performed well projecting future housing density in coastal areas or on Puget Sound islands where no change was projected in housing density categories after 2010 or 2020 (L. Nelson, GIS Specialist, NPS, pers. comm., August 2011). Within the MORA AOA, the model projected future housing density changes for each decade up to 2100. There were, however, some illogical changes in certain housing density classes that suggest some room for improvement in the model assumptions or specifications. Most notably, this included a slight decrease in the densest housing category (>2,470 units/sq km) within the AOA between 2000 and 2010 (Table 1).

Population

Both total population and population density increased dramatically (61 and 64%, respectively) over the 1990-2010 time period for the MORA AOA (Table 2, Figures 6 and 7).

Table 2. Change in total population and population density between 1990, 2000, and 2010 for the Mount Rainier National Park Area of Analysis.

Metric	1990	2000	2010	Increase between 1990-2010 (%)
Total population	97,183	133,502	156,794	61
Area-weighted density (people/km2)	11	15	18	64

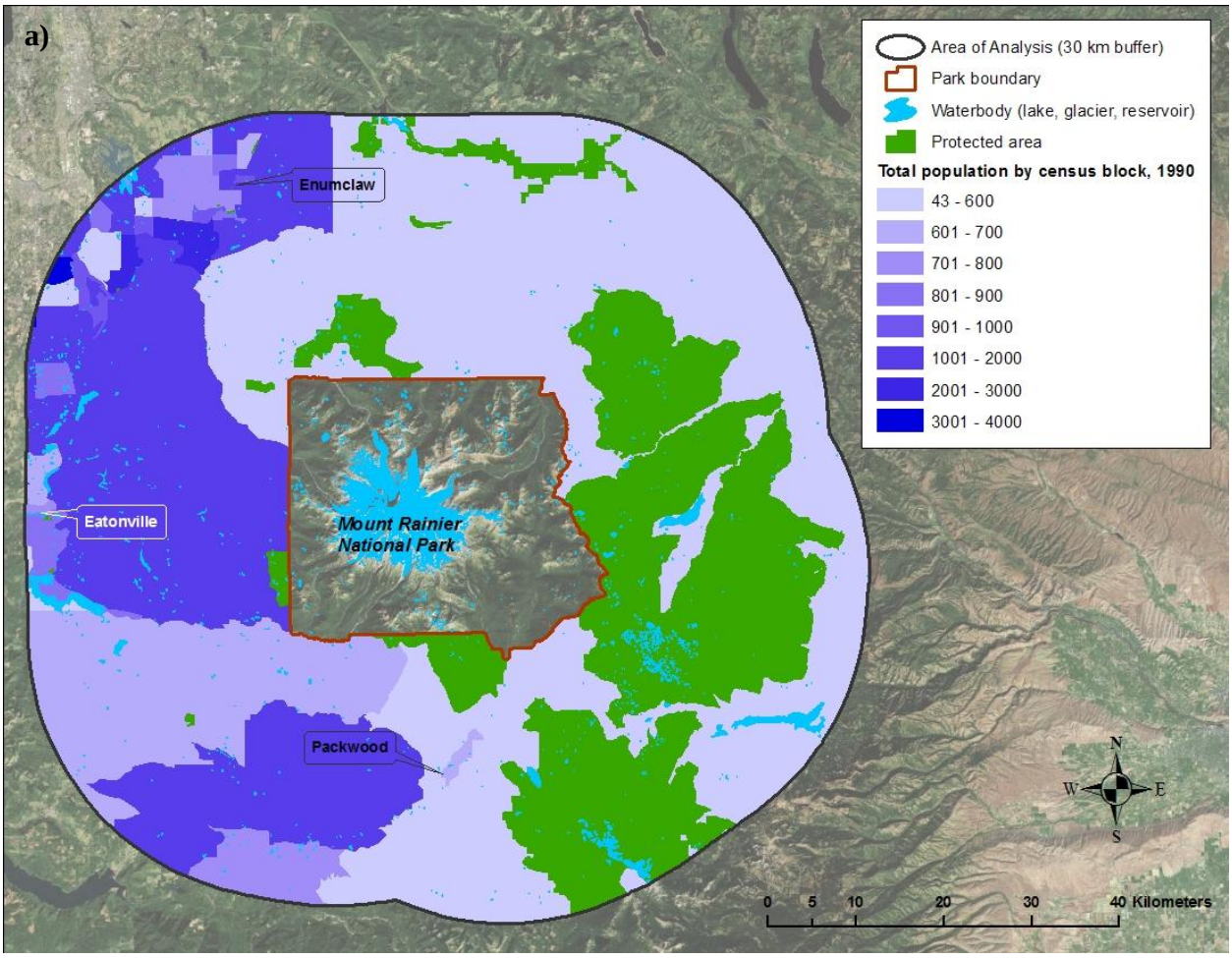

Figure 6. Total population by Census block in a) 1990, b) 2000, and c) 2010 for Mount Rainier National Park Area of Analysis.

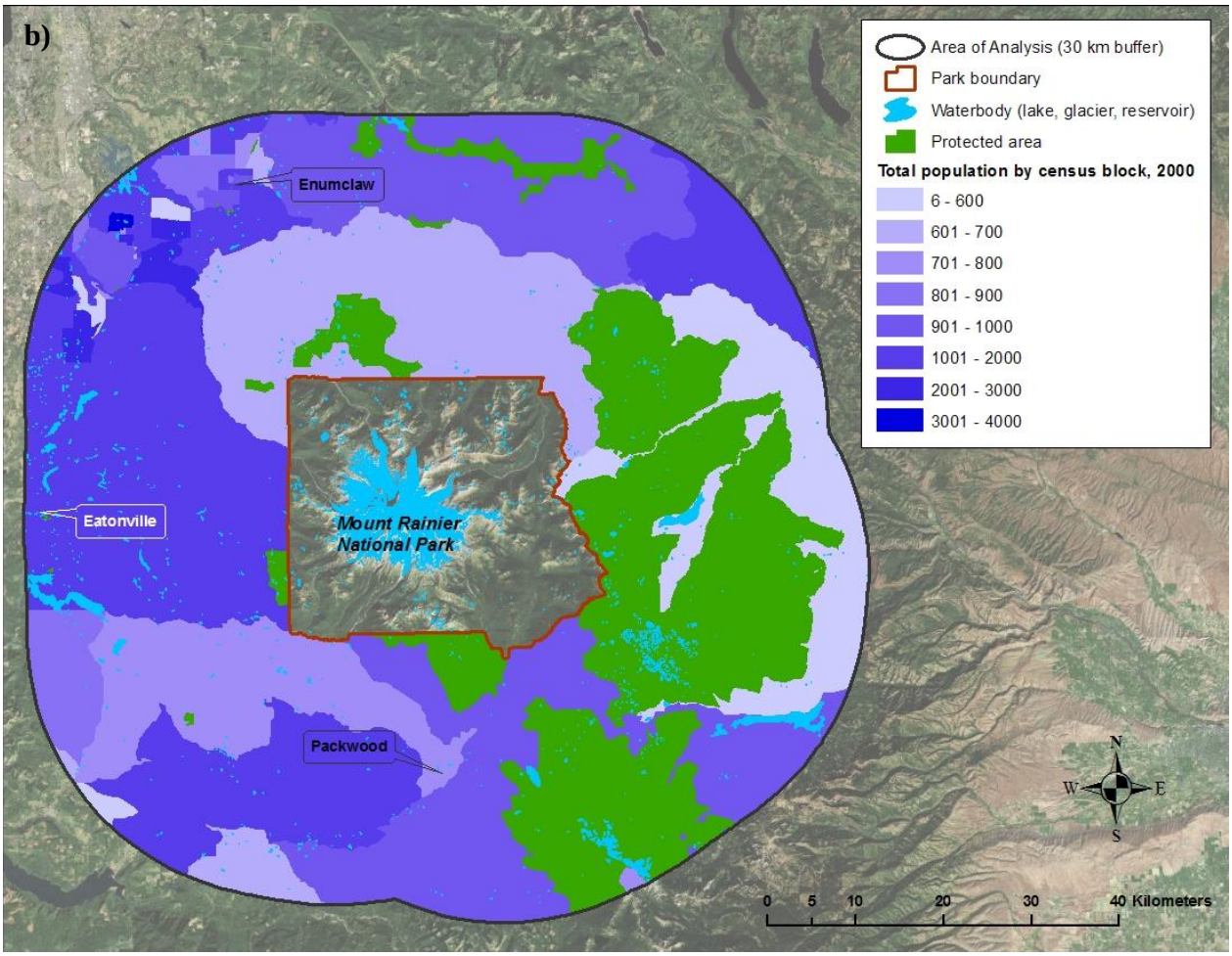

Figure 6. Total population by Census block in a) 1990, b) 2000, and c) 2010 for Mount Rainier National Park Area of Analysis (continued).

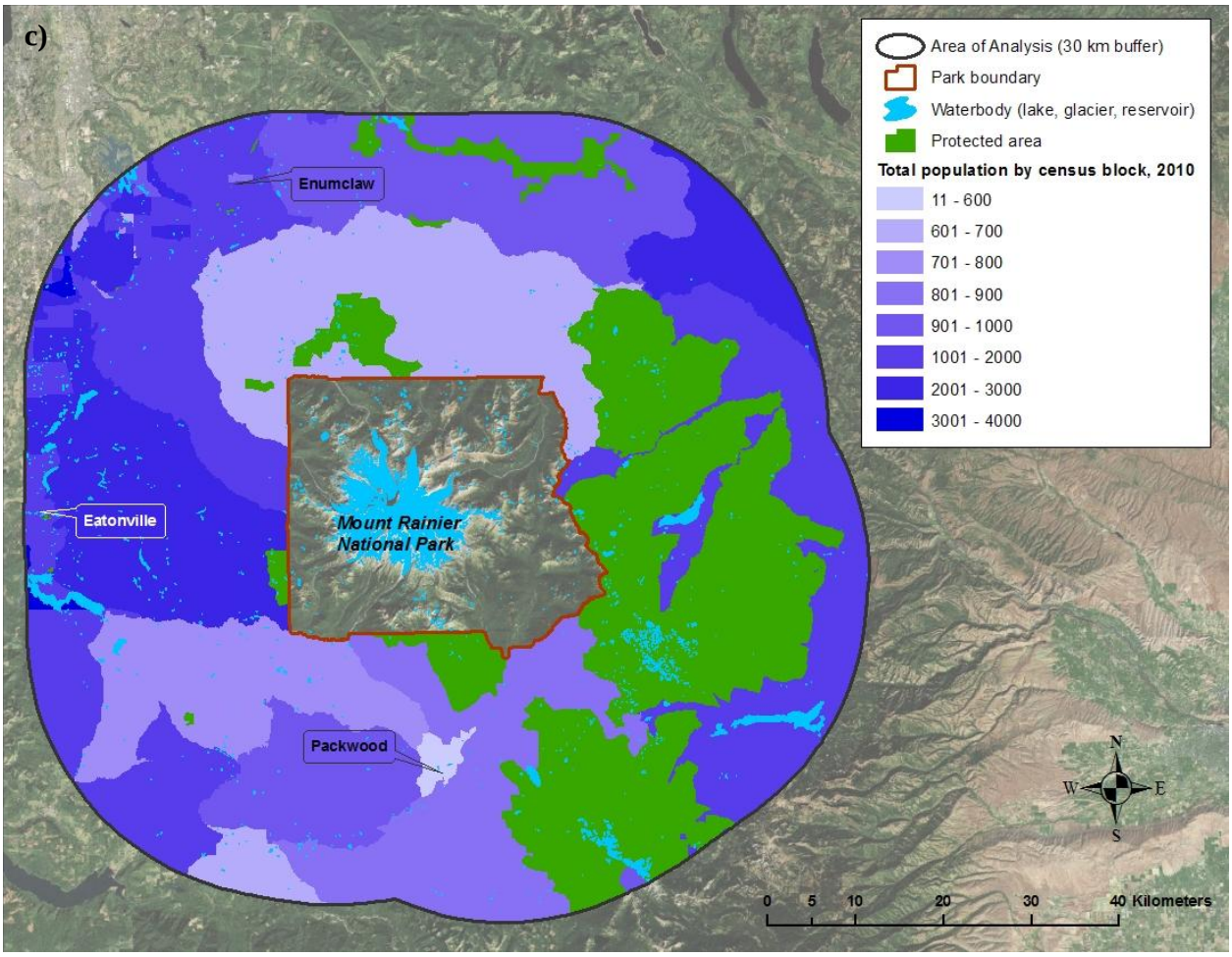

Figure 6. Total population by Census block in a) 1990, b) 2000, and c) 2010 for the Mount Rainier National Park Area of Analysis (continued).

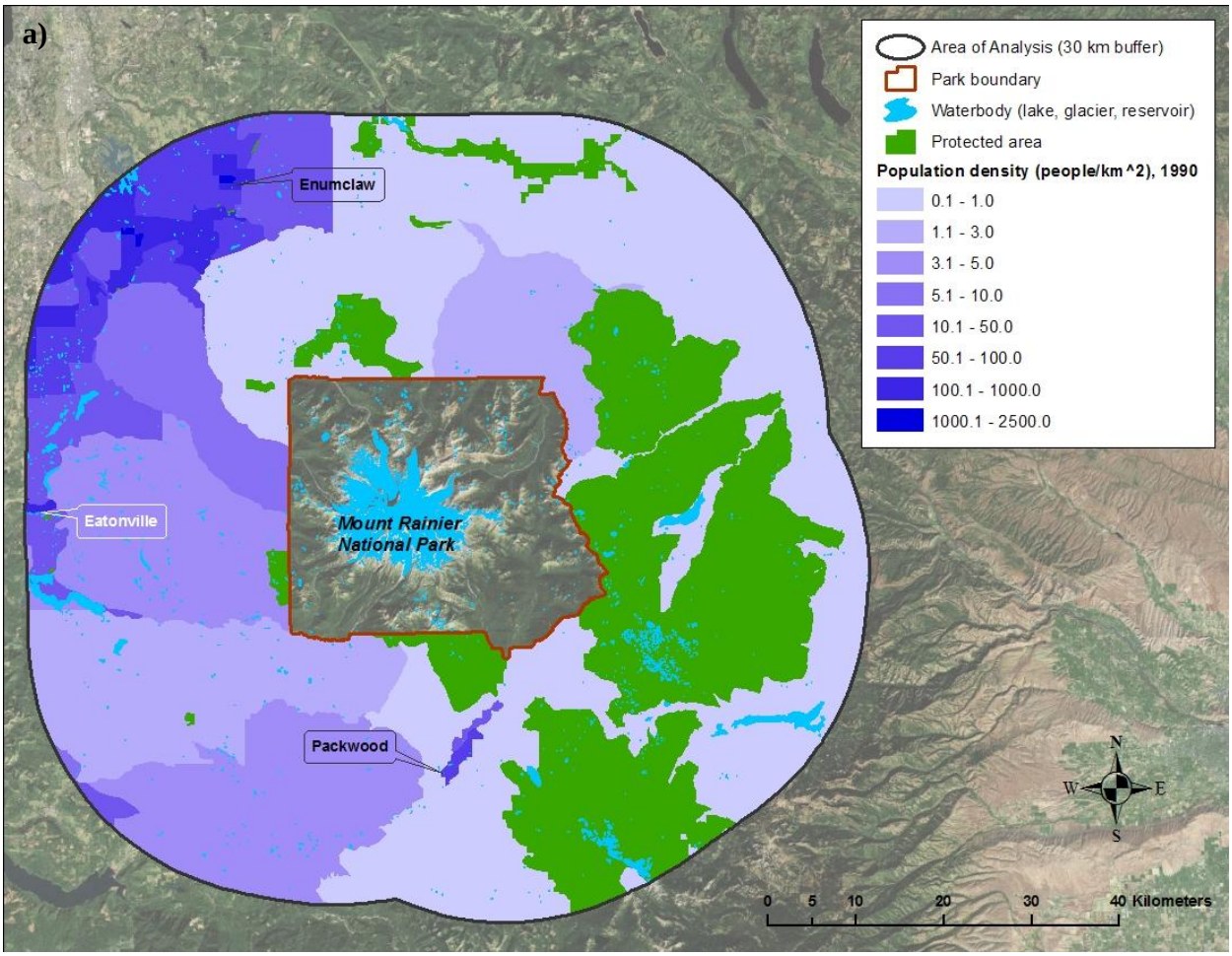

Figure 7. Trends in population density between a) 1990, b) 2000, and c) 2010 for the Mount Rainier National Park Area of Analysis.

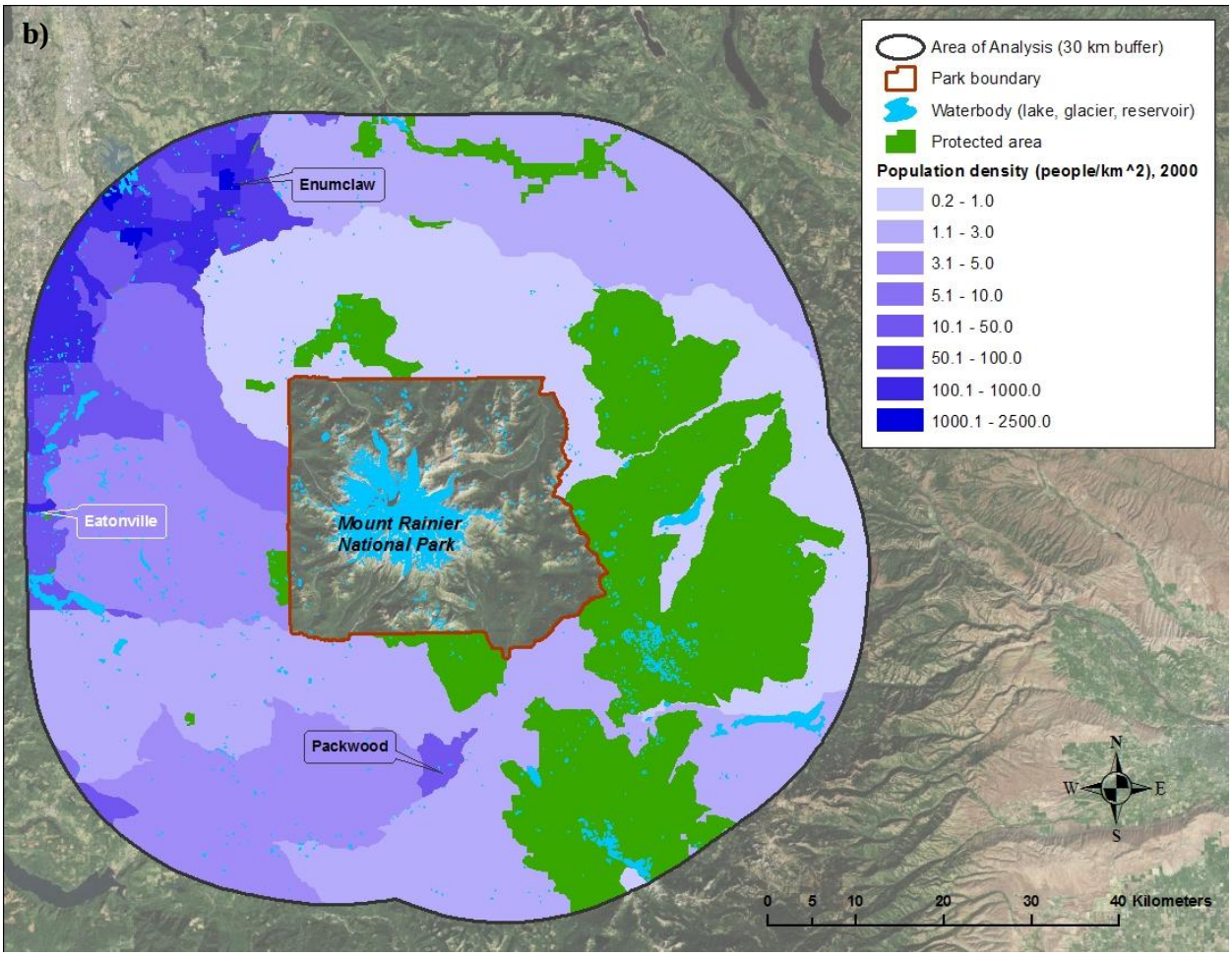

Figure 7. Trends in population density between a) 1990, b) 2000, and c) 2010 for the Mount Rainier National Park Area of Analysis (continued).

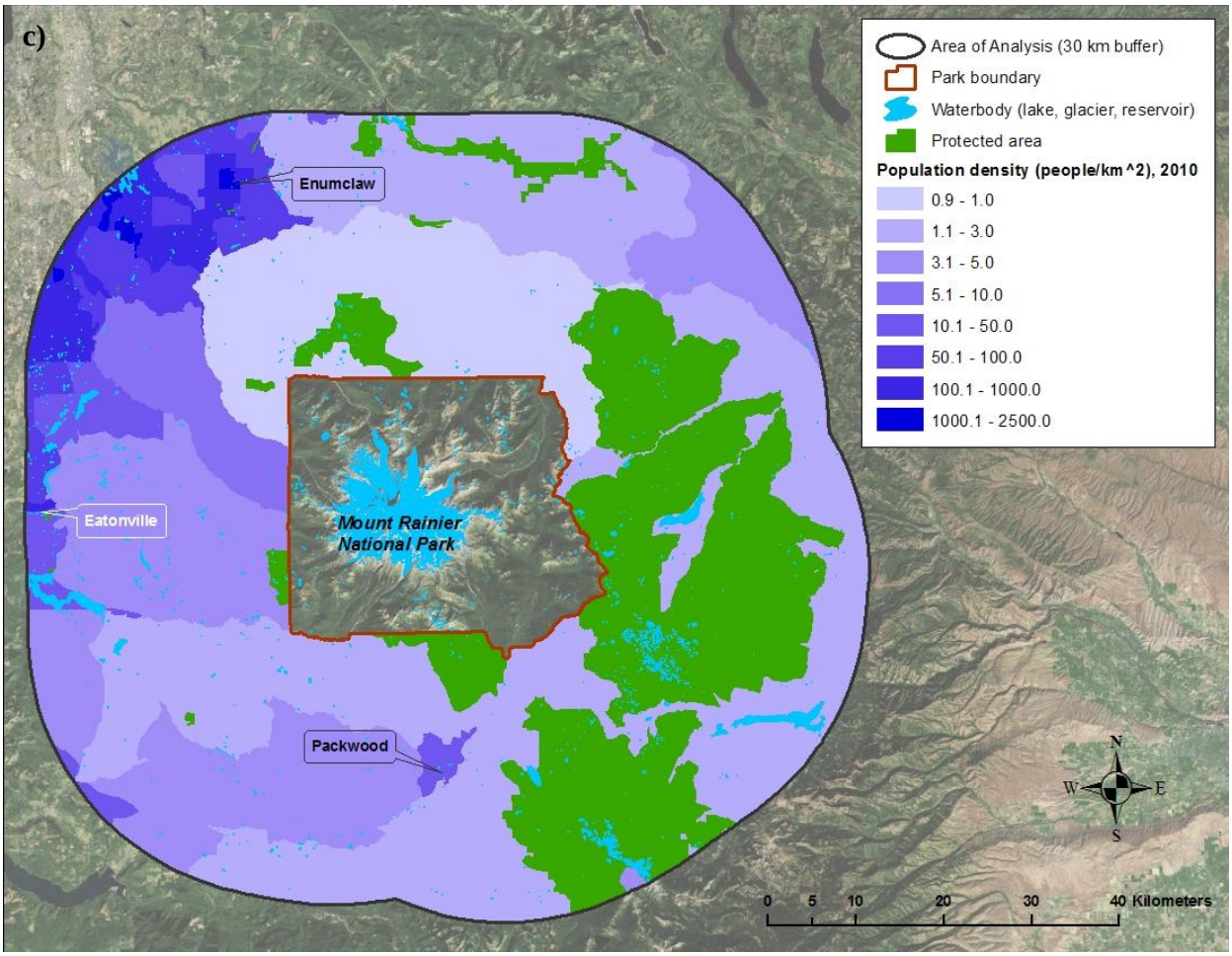

Figure 7. Trends in population density between a) 1990, b) 2000, and c) 2010 for the Mount Rainier National Park Area of Analysis (continued).

Roads

Road density was dramatically lower within the Park boundary and other protected areas than in the rest of the AOA (Figures 8 and 9).

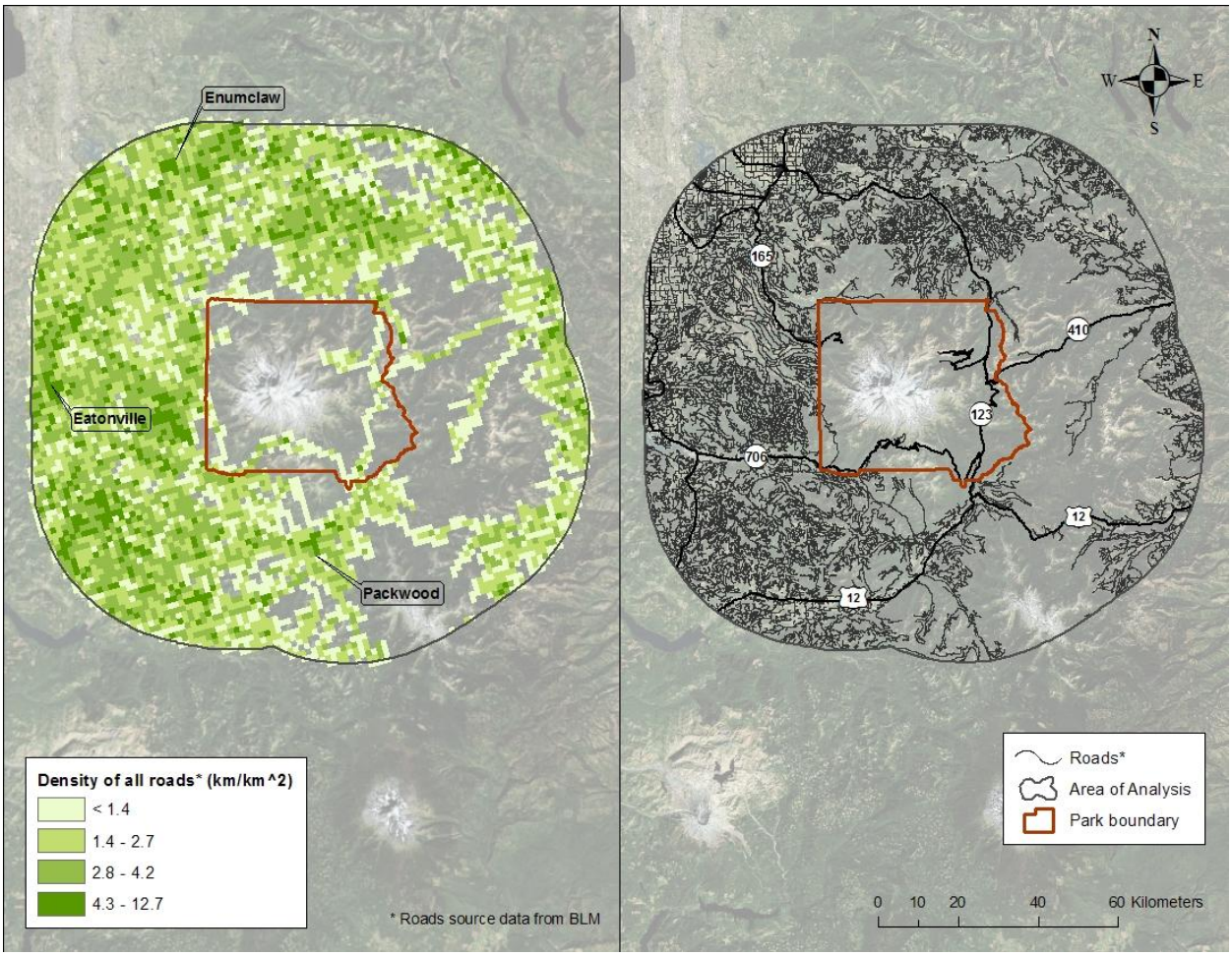

Figure 8. Density of all roads in the Mount Rainier National Park Area of Analysis.

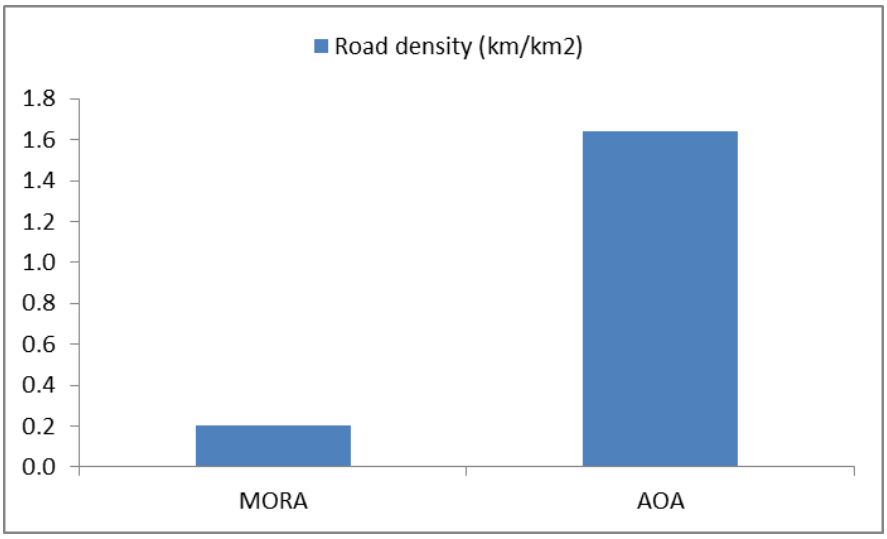

Figure 9. Comparison of road density within the Mount Rainier National Park (MORA) boundary and entire Area or Analysis (AOA).

The *distance from roads* is much greater within the Park boundary as well as in the areas directly east and southeast of the Park as compared to other areas in the AOA (Figure 10). The regions of the AOA to the west and northwest of the Park include the suburban communities of the greater Seattle and Tacoma areas whereas the regions to the east and southeast of the Park are largely USFS wilderness areas (Norse Peak, William O. Douglas, Goat Rocks, and Tatoosh), (Figure 2). More importantly, the areas to the west, southwest, and northwest also encompass privately owned timber lands in active forest management which includes building and maintaining logging roads, and these logging roads were included in the BLM roads dataset.

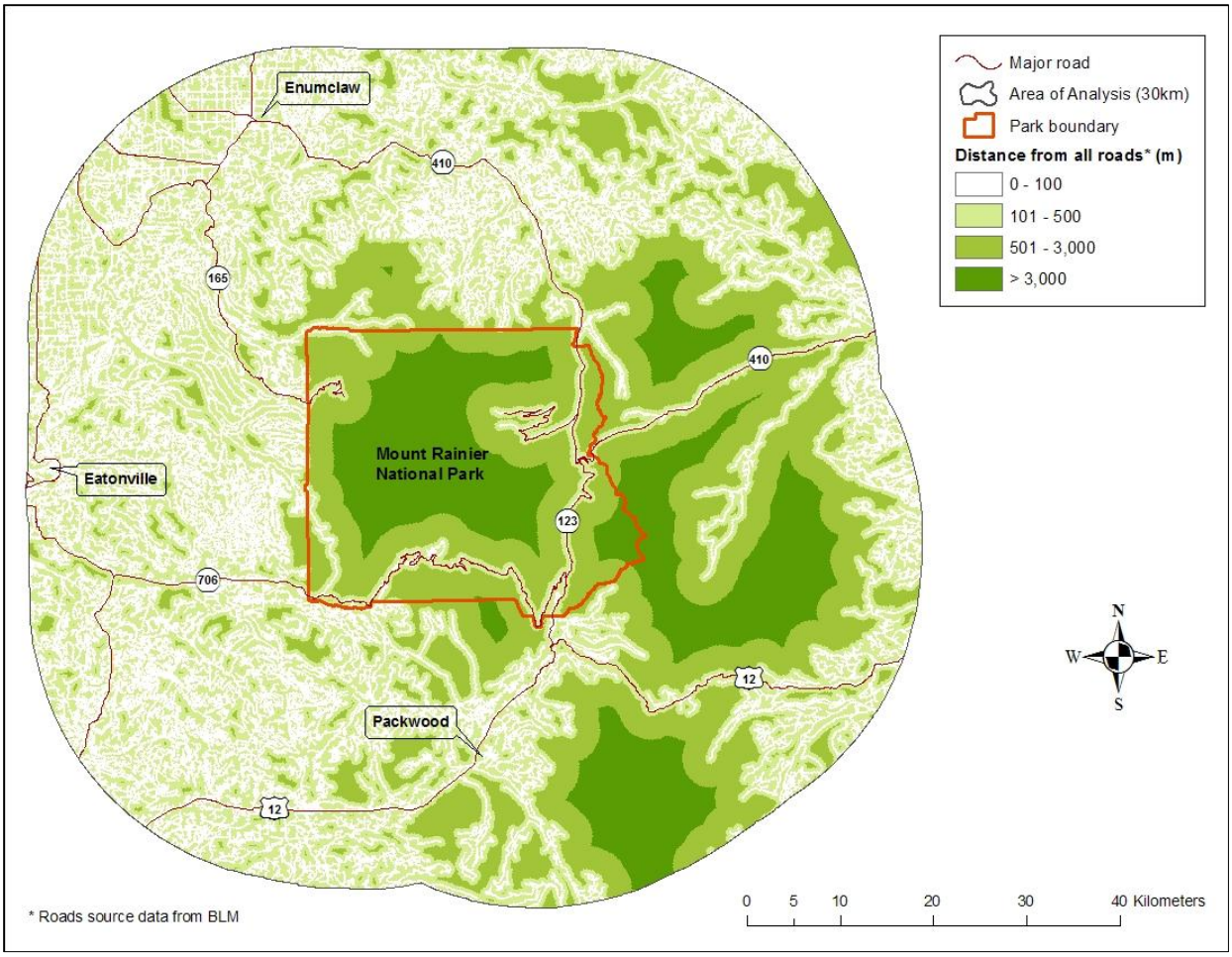

Figure 10. Distance from all roads in the Mount Rainier National Park Area of Analysis.

Roadless area patches greater than 500 m from roads are shown in Figure 11, and the largest of these patches (>100 km^2) closely correspond to the aforementioned wilderness areas. A comparison of *area without roads* as a percentage of total area within the Park boundary and the entire AOA showed that the Park had a significantly larger proportion of roadless area (84.7%) than the AOA (36.2%) (Figure 12).

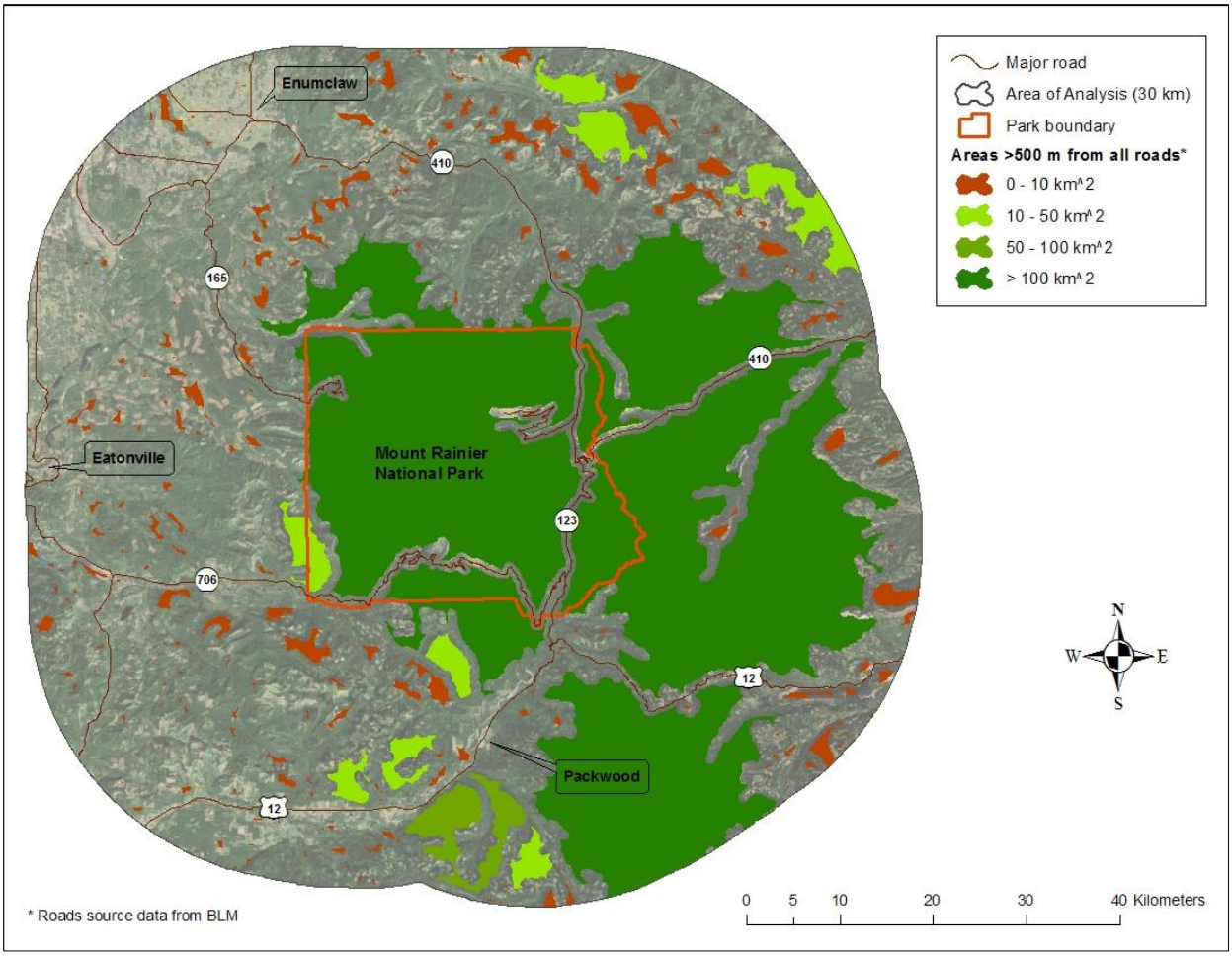

Figure 11. Roadless areas (patches >500 m from any road) in the Mount Rainier National Park Area of Analysis.

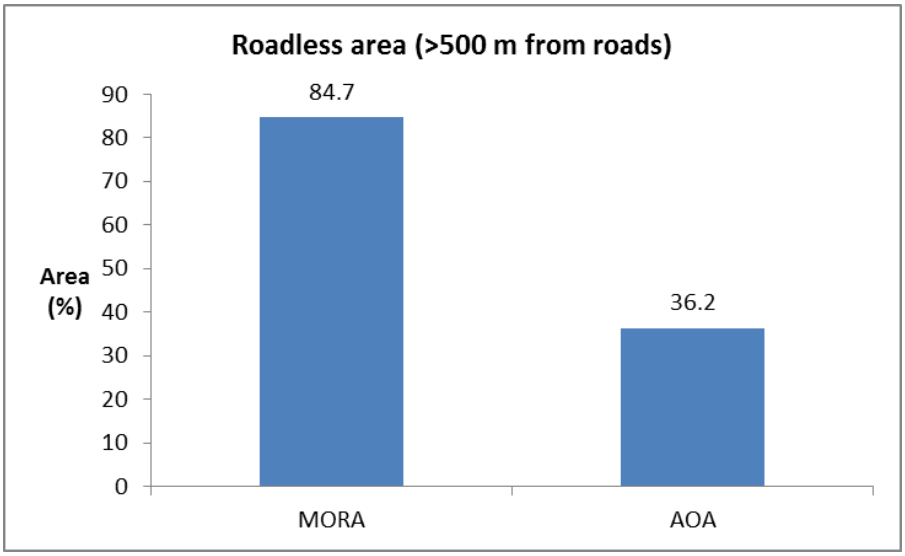

Figure 12. Comparison of roadless area (as percentage of total area) within Mount Rainier National Park (MORA) boundary and entire Area of Analysis (AOA).

Additional Considerations

In downloading and utilizing the NPScape products, which included datasets, processing tools, and SOPs, we determined the accessibility and ease of use was at an intermediate level. The NCCN was one of the first I&M networks to evaluate the NPScape products, adapt the products to customized, park-specific AOAs (except for the MORA AOA), and recalculate the metrics using at least one local data set. There was a significant amount of troubleshooting involved in downloading some of the very large data sets from the IMD SO server as well as in running the Python scripts. IMD SO staff were exceptionally helpful in providing assistance with these obstacles, most of which are presumed to be resolved in the current versions of NPScape products. Substituting a local data set (roads) for one of the IMD SO-developed products was straightforward in this case, and the SOPs were clear on format and processing requirements for using local data sets.

We have shown here how the NPScape metrics can be calculated using both IMD SO-provided and local data sets, using the NPScape tools, and presented in a format potentially useful to assess landscape changes occurring in, and especially adjacent to, parks. This information may also inform conservation planning. Future NPScape assessments should consider including other metrics not selected for this project, such as Landcover and Pattern, as these could provide additional information about changes occurring within and adjacent to park borders (see NPScape website, http://science.nature.nps.gov/im/monitor/npscape/, for more detail on these metrics). Furthermore, we recommend exploring the use of other local data sets in conjunction with a customized PACE boundary to focus a future NPScape analysis to more specific park resource management priorities.

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