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Socio-Ecological Interactions in the National Forests and Grasslands of Central Oregon: A Summary of Human Ecology Mapping Results

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Report for the Deschutes and Ochoco National Forests
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Table of Contents

List of Tables

List of Figures

I. Executive Summary

We developed an interactive web mapping survey application for collecting public data from forest users about places they value in Central Oregon's national forests and grassland. The project aimed to facilitate data collection on human connections to the Deschutes National Forest, Ochoco National Forest, and Crooked River National Grassland. The purpose was to generate socio-spatial data describing the connections people have with these public lands to inform future planning.

Methods. Data were gathered in 2016-2017 using an online survey that included both an interactive web map and a set of closed and open-ended questions. The map-based survey elicited data about six major themes: 1) **Locations** of important places; 2) **Activities** engaged in at those places; 3) **Benefits** (i.e., economic, recreation, etc.) associated with those places; 4) **Features**, (physical and built) that were most important at those places; 5) **Social environment** that participants preferred; 6) **Threats and management concerns** for the identified places. The mapping survey was followed by a series of demographic questions and questions aimed at eliciting participant views on natural resources and the environment. Both online and offline survey strategies were used with a large majority of the data collected online. Surveys were also provided in Spanish and were accessible to the visually impaired. A total of 542 individuals participated in the mapping surveys, resulting in the collection of 2038 useable points. For the spatial data, kernel density analysis was used to show how points were spatially concentrated. Diversity and frequency ratio calculations were also performed, and the data were disaggregated to show results for each ranger district individually.

Respondent characteristics. Compared to the average Oregonian, research participants had higher incomes, higher education levels, and were 91 percent Caucasian (compared to 85 percent statewide). Participants were fairly evenly distributed across age categories and 48 percent were female. More than one-third (36 percent) had lived in the area for less than five years; one-fourth had lived in the area for more than 20 years. Sixty-one percent of respondents resided in central Oregon (Crook, Jefferson, or Deschutes Counties), with the majority living in Bend.

Highlighted Results

Frequency of forest use. Respondents visited the national forests and grassland more frequently than they used other public and private lands. Almost half of the respondents visited the Deschutes National Forest at least once a week. Frequency of use of the Ochoco National Forest and Crooked River National Grassland was lower (a few times a year).

Ecosystem benefits. Participants were asked to rate the importance of a number of ecosystem benefits forests provide. Outdoor recreation, habitat, clean air and water, and scenery were

described as being 'very important' by more than 80 percent of respondents. In contrast, fewer than 25 percent of the respondents marked commercial forest harvesting, mineral, oil, and gas, grazing, and harvesting food as 'very important'.

Density mapping. People selected up to five areas in Central Oregon that were important to them. For the Deschutes National Forest, areas of very high density are found west of Bend (Mt. Bachelor, South Sister, and Green Lakes), and at Paulina Lake and East Lakes in the Newberry Crater National Volcanic Monument. In the Crooked River National Grassland, Gray Butte was a high density area. For the Ochoco National Forest, the area near Walton Lake was most prominent (See Figure 6.1).

Benefits associated with mapped places. For each point placed on the map, participants were asked to select up to three benefits they associated with the place. Benefits that participants strongly associated with their important places included: scenery and beauty, recreation and fitness, and solitude and escape.

Outdoor activities. The most common outdoor activity was hiking (44 percent), followed by 'strenuous recreation' (mountain biking, running, backpacking) (22 percent), camping (20 percent), hunting/fishing/gathering (18 percent) and observation (14 percent). Large hotspots for hiking were located in the area west of Bend as well as at Paulina and East Lakes. 'Strenuous recreation' was concentrated along the Cascade Lakes Highway west of Bend, as well as around Gray Butte in the Crooked River National Grassland. Backpacking occurred almost exclusively in the Three Sisters Wilderness. Mountain biking was mostly marked in the area west of Bend. Water sports were concentrated around a number of different lakes and rivers. 'Non-strenuous recreation' (e.g., walking, picnicking, and relaxing), was common near Bend and also at Paulina and East Lakes. Hunting was concentrated predominantly in the Ochoco National Forest, while fishing took place along rivers and lakes in the Deschutes National Forest.

Social environment. A large majority of respondents wish to be around 'a few people,' with the next largest group being those that prefer to be 'alone.' Only a small percentage of participants enjoy being around 'many people.' Participants who preferred to be alone often marked locations in the Ochoco National Forest whereas those who preferred to be around 'a few people' generally marked areas of high-use density.

Threats. Participants were asked an open-ended question about potential threats to their outdoor experience in each place marked. 'Crowds' were the most commonly noted threat, with nearly twice as many responses as the second most commonly noted threat: 'other user conflict.'

People felt the greatest threat of 'crowds' at the high-density sites. 'Other user conflict' was most concentrated directly west of Bend and in other hotspots across the forests.

Features. Participants could select a list of physical or built features for each marked location, including: lake, river or stream, waterfall, mountain, forest, grassland, meadow, wetland, lava field, historic buildings, or recreation facilities. No notable patterns could be discerned.

II. Introduction

A. Study Purpose and Approach

In 2015, the US Forest Service's Pacific Northwest Research Station, Portland State University, Deschutes National Forest (DNF), Ochoco National Forest (ONF), US Forest Service Region 6, and Discover Your Forest embarked on a collaborative project to understand spatial patterns of public use on the national forests and grassland of Central Oregon and the ecosystem benefits attached to those places. We developed an interactive web mapping survey application for collecting data from the public, including both local and nonlocal visitors, regarding the places they value in Central Oregon's national forests and grassland. The project, which aimed to facilitate data collection on human connections to the DNF, ONF, and Crooked River National Grassland (CRNG, managed by the ONF), became known as the Human Ecology Mapping (HEM) project. At the time the project began, the DNF and ONF anticipated that they would be revising their forest/grassland plans in the near future. The HEM project aimed to generate socio-spatial data layers describing the myriad connections people have with these public lands, which would inform future planning efforts.

The DNF and ONF Forest Leadership Teams saw the web map survey as a tool with potential to help them meet two of the 2012 Forest Planning Rule requirements simultaneously. First, the 2012 Planning Rule calls for forest plan developers to take into account the plan area's ecosystem services – including cultural services — when developing plan components. Although the biophysical services of forest ecosystems are relatively well-documented and biophysical data are integrated into forest planning analyses, cultural services data are much less readily available. Even when available, much cultural services data are in formats that forest planners cannot incorporate into a Geographic Information System (GIS) for analysis with other types of planning-relevant data. Second, the 2012 Planning Rule also calls for transparent and collaborative forest planning processes that effectively engage the public. The HEM partnership sought to address the need to incorporate cultural services while effectively engaging the public through developing a tool which could both enable the collection of spatially explicit data about human uses and values associated with the DNF, ONF, and CNRG, while also being capable of reaching a broad and geographically dispersed set of stakeholders.

The tool is meant to provide data that can support the assessment phase of forest planning as well as support other planning processes that rely on social data, such as travel management planning, recreation planning, wilderness planning, and planning for nontimber forest products, to name a few.

The planning team included staff from both the Deschutes and Ochoco National Forests, especially public affairs staff as well as planning and recreation; Discover Your Forest (DYF), a non-governmental organization devoted to enhancing connections between people and their public lands; and the research team from Portland State University (PSU) and Pacific Northwest (PNW) Research Station. Funding was provided by US Forest Service Region 6 and the Pacific Northwest Research Station. The project was designed collaboratively by the planning team. DYF hosted the website that provided access to the survey. Recruitment and outreach was coordinated by the public affairs staffs at DNF and ONF and DYF. The research team (PSU and PNW) was responsible for geospatial analysis and documenting final results.

B. Types of Data Collected

The interactive web map survey and the associated non-spatial general survey included a series of close and open-ended questions aimed at collecting data that would give land managers a better understanding of human-forest/grassland connections. The mapping portion of the application was designed to collect data about each participant's relationship to up to five specific places. The map-based survey elicited data about six major themes.

1) **Locations** of places perceived as important
2) **Activities** the participant engages in at those places
3) **Benefits** (i.e., economic, recreation, etc.) participants associated with those places
4) **Features**, physical and built, that are most important to the participant at those places
5) **Social environment** that participants prefer at the places they've marked as important
6) **Threats and management concerns** associated with the identified places

The mapping survey was followed by a series of questions designed to collect demographic information about the participants, learn more about the groups that influence participant views on natural resources and the environment, and general information regarding their connections with central Oregon forests. The general forest connections data collected included

such things as which forests/grasslands in central Oregon the participants visit (but not specific locations on those forests/grasslands), the frequency with which they visit those areas, and the importance that they attach to specified forest/grassland benefits (i.e., grazing, wood products, recreation opportunities, wildlife habitat, etc.).

Because it was possible that some participants would not have visited any of the administrative units included in the study, we created a separate web survey for non-forest/grassland users. This application was a slightly modified version of the general non-spatial survey developed for forest/grassland users. The questions included in the map and general surveys are provided in Appendix A. Additionally, we developed versions of both the forest/grassland user and non-forest/grassland user web applications for Spanish-speaking and visually-impaired participants.

C. Tool Details

The HEM tool appears to be a seamless web application, but it is actually comprised of many components relying on different software applications and storage on multiple servers. Users accessed the survey from the Discover Your Forest landing page with a welcome greeting, statement of purpose, and links to the basic survey, the Spanish language survey, and the survey for the visually impaired. Before accessing the web mapping application, users were required to sign a consent form. If they agreed to take the survey, they were asked whether or not they used the forests and grasslands of Central Oregon. They were directed to different surveys based on their answer. The consent form and forest use question were designed using Qualtrics, an online research software platform. The web mapping survey itself was comprised of the following components.

1. **Instruction page** that explained operating details.
2. **Basemap** that was custom designed using ArcGIS Desktop, made interactive using ArcGIS Server, and hosted on a PSU Server. The map had three zoom scales (1:63,000, 1:250,000, and 1:800,000). Landscape features were removed from adjacent national forests to encourage participants to only map within the boundaries of DNF, ONF, and CRNG. Roads and cities were provided for context.

3. **Points layer** and accompanying popup box that was created using an ESRI geodatabase and hosted in ArcGIS Online as a feature service.
4. **Web application** that was created using JavaScript, Hypertext Markup Language (HTML), and Cascading Style Sheets (CSS) and integrated with the map and point layer with instructions and Anonymous Identification Number (AIN) functionality. The web application was hosted in the Amazon cloud.

The non-spatial general surveys that followed the mapping application were designed using Qualtrics. Data obtained by the survey were stored in PSU's Qualtrics account on their network.

We created an offline version of the survey tools for use on tablets using two applications: Collector for ArcGIS for the mapping survey and Survey 123 for ArcGIS for the general non-spatial survey. The two applications did not seamlessly integrate in the same way as the online version of the tool; users needed to open three distinct applications in order to complete both the mapping survey and the general non-spatial survey. The three applications were: (a) a consent form on the Survey123 app, (b) an interactive map with pop-up survey boxes on the Collector app, and (c) a general non-spatial survey on the Survey123 app. The user was instructed to open each application, complete the activity, and then close the application. Data from the offline surveys were uploaded to the cloud when the tablets were connected to the internet.

D. Number of Respondents

The interactive mapping tool went live in early October 2016 and data were collected for a calendar year closing at the end of September 2017 (see Figure 2.1). There was a large initial response during the first month the survey was available, but participation dropped significantly until an uptick occurred during the summer months. This summer uptick was associated with increased outreach, but the other spikes in participation cannot be tied to particular events. The offline application had a trial run in February 2017 but afterwards was not used until the summer months of 2017.

In total, 459 survey participants provided useable data through the online mapping application, at an average of more than 4 points per participant. An additional 75 people completed the

nonspatial survey without mapping any points. Thirty people stated that they did not use the forest and fourteen of these Individuals took the nonspatial survey anyway. A total of 83 participants provided useable data through the offline survey but marked an average of only 2.3 points per participant. Between the two surveys, there were 542 total mapping participants who created 2038 useable points (see Table 2.1). More than 1000 additional individuals clicked the survey link but provided no information at all. No individual took the Spanish language version of the survey, and two people took the survey for the visually impaired.

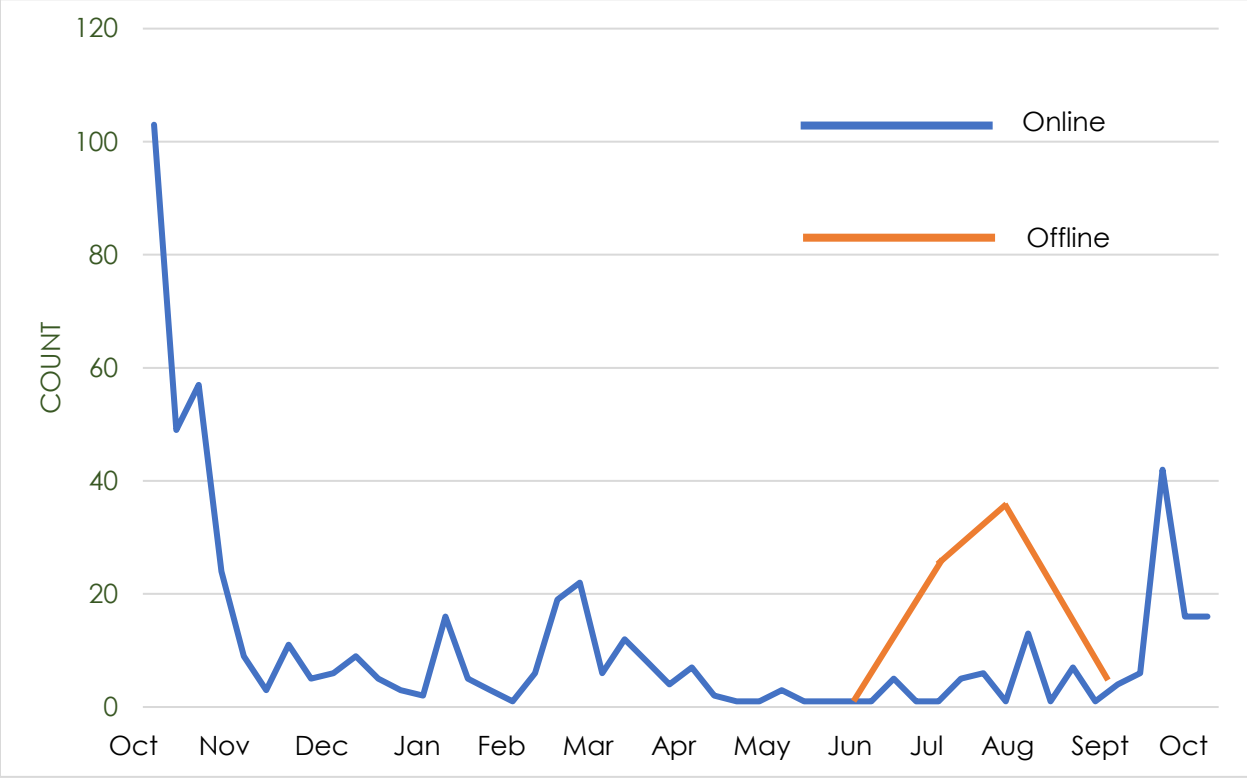

Figure 2.1 – Survey response rate

Table 2.1 Survey responses

Response type	Number	Points marked	Points per participant
Online application	459	1847	4.0
Offline application	83	191	2.3
Total	542	2038	3.84

III. Study Site

A. Location

Our study gathered spatially-explicit data about values and uses associated with the DNF, the ONF, and the CRNG (Figure 3.1). These three administrative areas are located on the eastern slopes of the Cascade Range in Central Oregon. Central Oregon is defined here by three counties: Jefferson, Crook, and Deschutes. The largest city is Bend, Oregon, where the population of the metropolitan area was 169,954 in 2013.

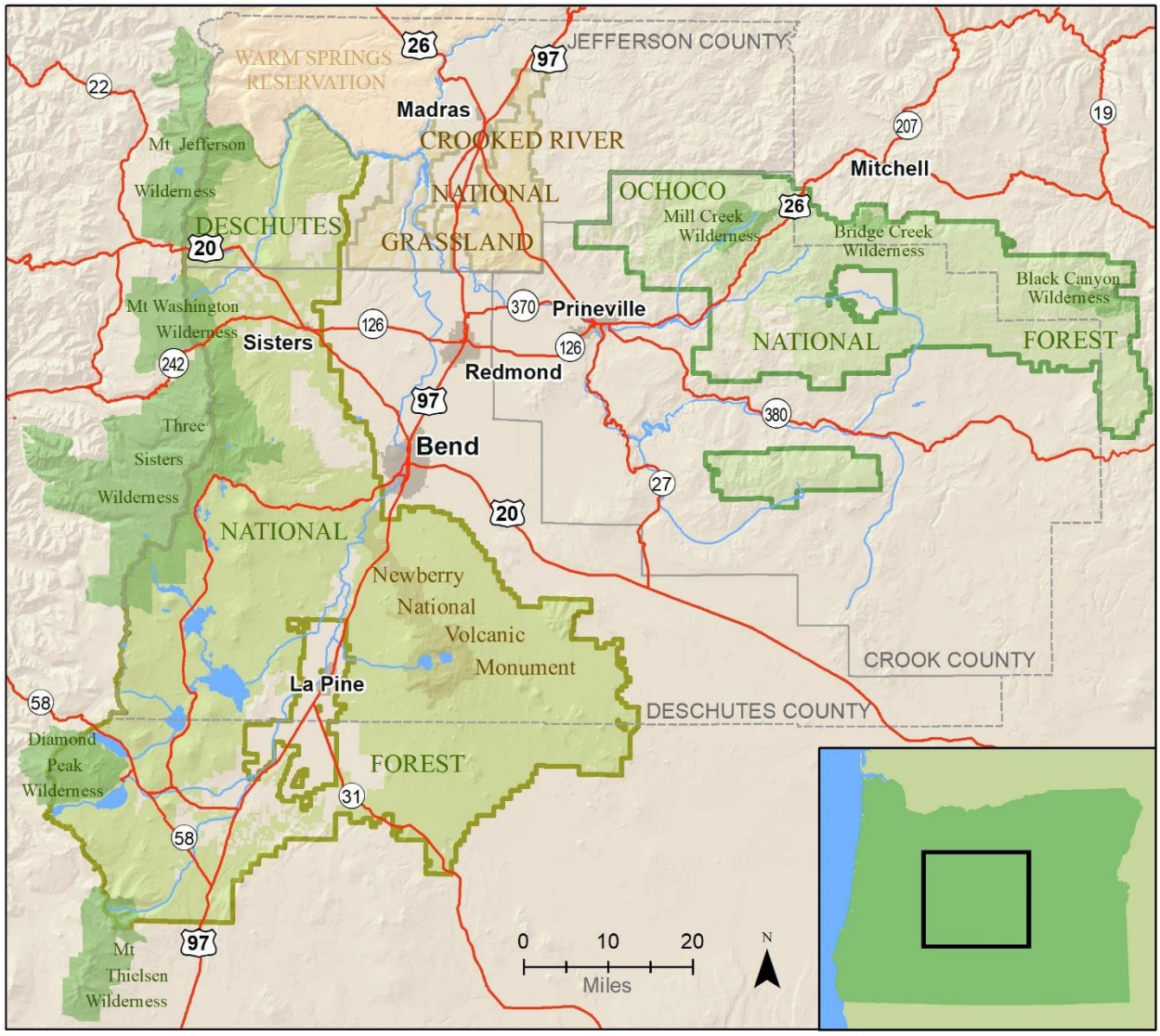

Figure 3.1 – HEM study area

B. Ownership pattern

As indicated in Table 3.1, the boundaries of the DNF, ONF, and CRNG together encompass nearly 3 million acres, covering a large portion of central Oregon. The three administrative units differ significantly in size, with the DNF covering twice as much area as the ONF, and more than 10 times as much area as the CRNG. Roughly half the lands within the boundaries of the CRNG, and 16 and 15 percent of the DNF and ONF respectively, are not federally owned or administered by the US Forest Service. The majority of these inholdings are privately held. The CRNG is administered by the ONF. Although administered separately, the DNF and ONF often collaborate on management plans.

Table 3.1 – Acreage of administrative units included in the project

Administrative Unit	National Forest System Acreage	Other Acreage*	Total Acreage
Deschutes National Forest	1,596,900	257,029	1,853,929
Ochoco National Forest	851,033	128,056	979,089
Crooked River National Grassland	112,357	61,272	173,629
DNF, ONF, and CRNG	2,560,290	446,357	3,006,647

*Lands within National Forest or Grassland boundaries which are not federally owned or administered by the USFS.
Source: USDA-FS. 2012. Land areas of the National Forest System. Washington Office FS-383.

The Confederated Tribes of the Warm Springs (CTWS) Indian Reservation, home to members of the Ichishikin, Kitsht Wasco, and Numu peoples, is located along the DNF's northwestern boundary. The CTWS have reserved rights to usual and accustomed sites located within the DNF, ONF, and CRNG, as do the Confederated Tribes of the Umatilla Indian Reservation and the Burns Paiute. The majority of the study area is located within Jefferson, Deschutes, and Crook Counties, which together comprise the central Oregon region.

C. Demographic and Economic Context

With an estimated population of 94,520 in 2017[1], Bend is the largest city in the study area, as well as the economic hub of central Oregon. The next largest city, Redmond, has a population of 30,011; it is followed by the towns of Prineville (pop. 10,055) and Madras (pop. 6,831). The two other major settlements in central Oregon — Sisters and LaPine — have substantially smaller populations with 2,701 and 1,864 inhabitants respectively.

The Tri-County area (i.e., Crook, Deschutes, and Jefferson) is one of Oregon's fastest growing regions[2]. The Tri-County area's population increased by 10.1 % between 2010 and 2016, an increase considerably higher than the state's overall population growth during the same period. However, most of that growth took place in Deschutes County, which had a population increase of 11.8% between 2010 and 2016. Looking further back in time, the population of the Tri-County area has more than doubled since 1990, with population growth in Deschutes County again being the primary source. Population growth in central Oregon is driven by in-migration, with the fastest growing age group being persons aged 65 or over.[3]

Through most of the 20th century, logging, agriculture, and ranching were the mainstays of the central Oregon economy. Although all three sectors were important across the region, agriculture was particularly important for Madras and Redmond; ranching and the wood products industry for Prineville; and the woods products industry for Bend. During the late 1980s and 1990s, globalization of lumber markets, increased mechanization in the wood products industry, and reduced access to timber on federal forest lands, led to a decline in the relative importance of the natural resource sector in central Oregon's economy.[4] At the same time, large numbers of new residents were attracted to the area by the area's dry climate and mild winters, comparatively low (at the time) housing prices, and abundant outdoor recreation opportunities. The combination of rapid and sustained population growth created a decades-long demand for new housing, offices, and other construction, resulting in a strong real estate

[1] Population data are 2017 population estimates from American FactFinder.
[2] Data for this paragraph obtained from the following source:
Economic Development for Central Oregon. 2017. 2017 Central Oregon Profile. EDCO: Bend, OR.
[3] Shorack, T. July 4, 2016. Baby boomers are on the rise in central Oregon. Bend Bulletin.
[4] Unless otherwise noted, material for the rest of this paragraph was sourced from Walker, P., Walker, P.A., and Hurley, P.T. 2011. Planning Paradise. University of Arizona Press: Tucson.

and construction industries in the area. At the same time, the arrival of tens of thousands of natural "amenity" migrants drawn by the area's natural beauty and outdoor recreation opportunities enabled the region's recreation and tourism industries to expand and thrive. In Deschutes County, developers and city and county planners supported the development of several destination resorts, many of which included golf courses, as well as major infrastructure investments, such as transforming Bend's former mill district into a major shopping area and development of an extensive bike and walking trail system. Development associated with the ski industry was noticeable in Sunriver, which is close to Mt. Bachelor Ski Resort. These changes transformed the regional economy from one based primarily on natural resource extraction and related manufacturing to one based on a services, tourism, and leisure industries.

However, economic restructuring in central Oregon has been very uneven, with Deschutes County being impacted much more heavily than either Jefferson or Crook County.[5] Agriculture, particularly irrigated crops such as grass seed, hay, and mint, and to a lesser degree, ranching and wood products harvesting, continue to contribute substantially to Jefferson County's economy. Livestock and timber production, and to a lesser extent, irrigated agriculture, continue to be important contributors to Crook County's economy. Nonetheless, signs of change are increasingly visible in both Crook and Jefferson Counties. Destination resorts have been built in both counties, and, high tech companies, such as Apple and Facebook, have recently established major data centers in Prineville. In addition, the area is attracting telecommuters, consultants, and others who work at home and can choose where to live.

D. Physical characteristics[6]

The DNF, ONF, and CRNG differ substantially in their topography, vegetation cover, and other biophysical characteristics. Of the three administrative units, the DNF, is the most diverse in its

[5] Sources for this paragraph:
EDCO. 2016. Prineville Area Profile (2016). Prineville/Crook County Economic Development: Prineville, OR.
EDCO. 2016. Madras/Jefferson County Profile. Madras/Jefferson County Economic Development: Madras, OR.

[6] Data for this section draws on the following documents:
Ochoco National Forest. 1989. Land and Resource Management Plan. Parts 1-3.
Crooked River National Grassland. 1989. Land and Resource Management Plan. Parts 1 and 2.
ONF/CRNG. 1989. Final Environmental Impact Statement. Land Management and Resource Plan. Parts 1-3.
Deschutes National Forest. 1990. Land Management and Resource Plan. Parts 1-3.
Deschutes National Forest. 1990. Final Environmental Impact Statement. Land Management and Resource Plan. Parts 1-3.

landscape types and vegetation. The craggy peaks and clear alpine lakes of the central Cascade Range are located along the forest's western border; the central and eastern portions of the forest are dominated by high desert lava lands and other volcanic formations. Two major rivers, the Deschutes and Metolius, flow through the forest. Elevations range from a high of 10,358 on South Sister, one of the region's many alpine peaks, to a low of 1,950 feet at Lake Billy Chinook, a man-made reservoir in the high desert region on the north end of the forest where the Crooked, Deschutes, and Metolius Rivers meet. Precipitation varies from less than 15 inches per year in the lower elevations of the Deschutes to more than 140 inches in the upper Cascades. The DNF supports a wide variety of vegetation types, which follow a gradient from west to east and from high to low elevation. True fir and mountain hemlock dominate at higher elevations, these stands grade into Douglas fir and ponderosa pine stands, which in turn grade into ponderosa and/or lodgepole pine stands, followed by juniper-sagebrush plant communities, and big and low sagebrush communities in the driest areas along the forest's southeastern boundary. In its early years, the DNF was managed primarily for timber and, to a lesser extent, forage production. However, with the implementation of the Northwest Forest Plan in 1994, the annual volume of timber sold on the forest dropped substantially. Between 2010-2017, the DNF sold an average of 53.2 MMBF of timber annually[7], substantially less than the annual average of 175.4 MMBF sold between 1981 and 1988.[8]

Although the DNF has a multiple use mission, recreation and tourism have increasingly come to dominate its management concerns. The Deschutes has numerous recreation sites, including three scenic byways, five wilderness areas, six wild and scenic rivers, a national volcanic monument, and a national recreation area. Additionally, Mt Bachelor (elevation of 9,068 feet), which is located just 20 miles west of Bend, is the Pacific Northwest's biggest downhill ski area. The DNF's diverse set of landscapes and abundance of recreational sites, offers visitors from near and far a variety of outdoor recreation opportunities including hiking, camping, fishing, hunting, skiing, climbing, kayaking, snowmobiling, off-road vehicle riding, and many others.

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[7] Haggerty, M. 2017. U.S. Forest Service Cut and Sold Reports for All Convertible Products by Region, State, and National Forest, 1980 to 2017: Interactive Map. Headwaters Economics: Missoula, MT. https://headwaterseconomics.org/county-payments/history-context/commercial-activities-national-forests/

[8] Deschutes National Forest. 1990. Land Management and Resource Plan. Parts 1-3.

Commercial outfitters and guides offer tours and rent equipment, such as mountain bikes, catering to visitors from Portland and Seattle. White-water rafting on the Deschutes River is especially popular and the DNF administers a number of permits to guiding companies.

The ONF is the eastern-most portion of our study site. The Ochoco Mountains, Maury Mountains, and North Fork of the Crooked River headwaters are located within the forest's boundaries. The ONF is divided into three ranger districts (not counting the CRNG) — Lookout Mountain, Paulina, and Snow Mountain Ranger Districts — but the adjacent Malheur National Forest manages the Snow Mountain Ranger District. There are three wilderness areas (Bridge Creek, Black Canyon, and Mill Creek) and one wild horse territory (Big Summit Wild Horse Territory). Although the ONF is mountainous, the terrain is relatively gentle compared with the Cascades to the west and the Wallowas to the east. Precipitation varies from 11 inches per year in the lower elevations to 33 inches in higher elevations. Lookout Mountain (6,926 feet) is the highest point. Ponderosa pine is the dominant tree species in the ONF. However, vegetation types vary by elevation and aspect, with ponderosa pine dominating at mid-elevations and on southern and western slopes at higher elevations. Moist mixed conifer stands are found at higher elevations on north and east facing slopes. Lower elevations are dominated by juniper, sagebrush, and grasses. Major resources on the forest include forage, particularly for summer grazing, firewood, timber, and wildlife, including sizeable elk, deer, and wild horse populations. The ONF offers visitors numerous recreation opportunities, including hiking, camping, hunting, fishing, rockhounding, among other activities. However, the ONF has opted to emphasize dispersed recreation and many sites have no or limited facilities.

The CRNG was established from lands that had previously been homesteaded, but which reverted to the federal government in the 1930s when many homesteaders abandoned their land or opted to sell it back. Topography on the CRNG varies from rolling hills and buttes to sheer canyons along the Deschutes and Crooked Rivers. Gray Butte (5,108 feet above sea level) is the highest spot on the CRNG; the lowest point (2,241 feet above sea level) is near Madras. Precipitation averages 10.5 inches per year. The CNRG's native plant communities (bluebunch wheatgrass and Idaho fescue interspersed with sagebrush, rabbitbrush, bitterbrush, and juniper) have been heavily modified over the past century through farming of non-native crops

by homesteaders, and subsequent seeding to wheatgrass by Grassland managers to improve forage in grazing allotments.[9] Additionally, western juniper has gradually expanded into the Grassland, leading to concerns about the long-term viability of plant and wildlife species characteristic of the native sagebrush steppe ecosystem. The Grassland is managed for multiple uses, but forage production and wildlife habitat maintenance are its primary goals. Recreation opportunities include camping, boating, horseback riding, rock hounding, target shooting, and many other activities.

[9] Data on the CRNG's vegetation was obtained from:
USDA-Forest Service. 2004. Crooked River National Grassland Vegetation Management/Grazing Environmental Impact Statement. Crooked River National Grassland and Ochoco National Forest: Jefferson County, OR.
Rowland, M.M.; Suring, L.H.; Tausch, R.J.; Geer, S.; Wisdom, M.J. 2008. Characteristics of western juniper encroachment into sagebrush communities in central Oregon. USDA Forest Service Forestry and Range Sciences Laboratory, La Grande, Oregon 97850, USA.

IV. Analysis Methods

A. Recruitment

Initially, links to the online survey were distributed by ONF and DNF public affairs officers to known stakeholders and interested community members. In addition, Discover Your Forest used direct outreach to members, partner organizations, and a target list of stakeholders to recruit study participants. Other members of the study team sent links directly to relevant organizations. For the offline data gathering, staff equipped with tablets at public events approached prospective candidates to participate in the mapping survey.

B. Data Processing

The large majority of the data were collected online using two different programs (ArcGIS Online and Qualtrics). Once downloaded, the two sets of data needed to be joined together. This task was accomplished using the Anonymous Identification Number generated for each participant that was entered in the pop-up box for each point and at the beginning of the non-spatial survey. A small number of surveys were discarded because the data join could not be accomplished.

We intentionally structured the web map to discourage participants from mapping places located outside the three administrative units, and with a few exceptions, we excluded from our analysis any points that fell outside those boundaries. We retained points that were placed outside the boundaries but were given the name of a place within the boundaries. Also, if points were placed within a mile of the boundaries and given the name of a place that encompassed area both inside and outside the boundaries (e.g., Three Sisters Wilderness), they were retained. Lastly, we kept points that marked places that were within a mile of the boundaries but likely accessed by trail from a location within the boundaries.

Certain attributes were collected as unformatted text and these data fields were categorized for analysis. For the non-spatial survey data, groups that influence views on forest management were divided into 11 categories (see Chapter V). For the spatial data, activities and threats were divided into 11 and 12 categories respectively (see Chapter VI).

A small subset of the survey data was collected offline on tablets using Collector for ArcGIS and Survey123 for ArcGIS. These data were uploaded after connecting to the internet and processed in the same manner as the online data. The online and offline datasets were then combined and analyzed together.

C. Density Calculations

We used a kernel density calculation to show the concentration of points. The kernel density analysis results in a map that is similar to population density maps except that the map shows how densely the places marked by the participants are spread out over the landscape rather than how population is spread out over an area. The higher the density, the more times an area was marked on the map.

Each kernel density calculation is symbolized with a color palette ranging from least (lighter colors) to most dense (darker colors), regardless of the absolute value of the density. In other words, what these maps emphasize are areas of relative high concentration. The actual density is not necessarily comparable from map to map.

D. Diversity Calculations[10]

We adapted a species diversity index, specifically the Inverted Simpson index, to show the diversity of activities within a specific area. Diversity indexes take into account both variety of uses and balance of uses. In this case, variety specifies how many different activity categories are noted for a given area. Balance specifies how evenly distributed the different activities are. For example, if 75 people listed horseback riding and 25 people listed running as activities, that would be less diverse than if 50 people listed horseback riding and 50 people listed running as activities.

E. Frequency Ratio

We explored the relationship between points marked by participants and forest plan management categories by calculating a frequency ratio. This calculation tells us whether or not the survey points are randomly distributed across the forest plan management categories.

The frequency ratio is calculated in three steps. For each forest plan category, we calculated the percent of the total area covered by each category. We also calculated the percent of survey points located in each category. We then divided the percent of the total area for each category by the percent of survey points in each category. The result is the frequency ratio, and this number is useful for determining whether survey points were disproportionately placed (or absent from) each forest plan category. Frequency ratios less than 1 indicate that there are more survey points in a given category than would be expected given the amount of area in each category.

[10] A detailed description of the diversity calculation is provided in the Mt Baker-Snoqualmie Sustainable Roads Strategy Report, Appendix D: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd487192.pdf

V. Results of the Nonspatial Survey

A. Demographics

Overall, the survey had 542 total responses, although each respondent did not answer every demographic question. There is no single census population group to which one can compare the survey demographics. Central Oregon residents comprised 61% of the survey respondents and Oregon residents 95.8%. Table 5.1 displays the relevant demographics of the Tri-County area and the state of Oregon for comparison.

Table 5.1 – Select demographics for the tri-county area and the state of Oregon (American Community Survey 2013-2017).

Demographic	Oregon	Deschutes	Crook	Jefferson
Median Age	39.2	42.1	48	40.6
% White	84.9	93.6	92.6	70.0
% Bachelor's degree or higher	32.3	33.7	17.9	16.9
Median income	$56,119	$59,155	$41,777	$48,464

The demographics of this study's participants do not generally reflect that of any general population, with a few notable exceptions. One of these exceptions was gender; of the 522 participants that responded to the gender question, 52% were male and 48% were female.

There was a wide distribution by age, with the vast majority of respondents between 31 and 74 years, but the average respondent age of 50 is higher than census median (39.2) for Oregon (Figure 5.1).

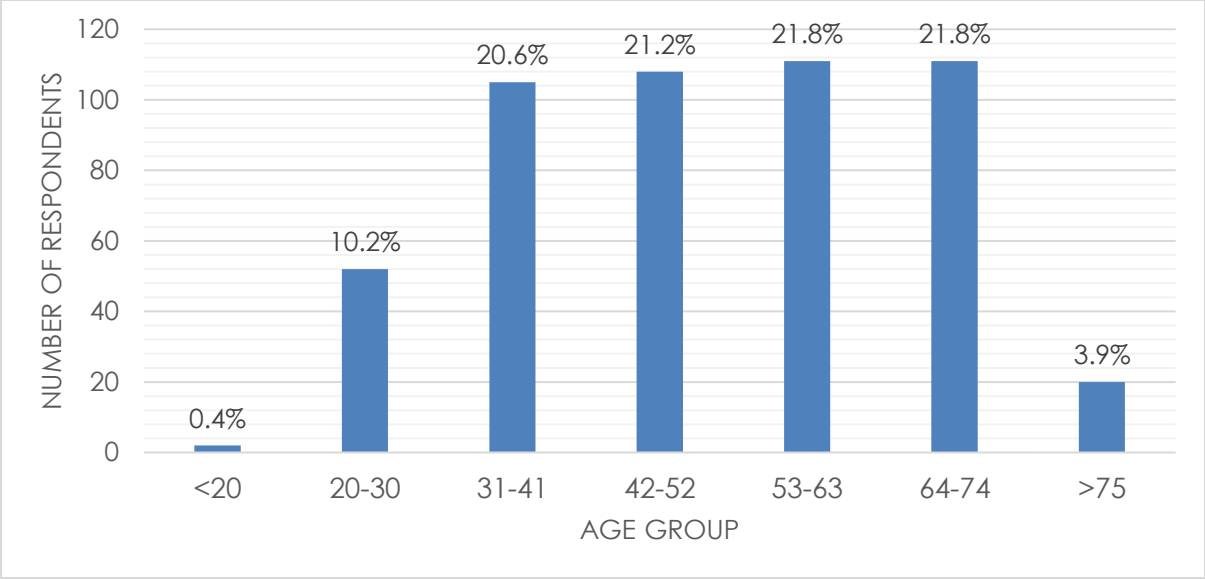

Figure 5.2 – Survey age groups: 509 Respondents

Although efforts were made to capture a diverse range of ethnic populations, 91% of participants were of White or Caucasian descent. Although this percentage is fairly consistent with the percent of white population in Deschutes County (93.6%) and Crook County (92.6%), it does not reflect the diversity found in Jefferson County (70%) or Oregon (84.9%).

Participants had much higher education levels than average, based on Oregon census estimates (Figure 5.2). In our sample, a large proportion of respondents had 4-year college degrees or higher (73%), compared to 32.3 % for Oregon, 33.7% for Deschutes County and 17.9% for Crook County.

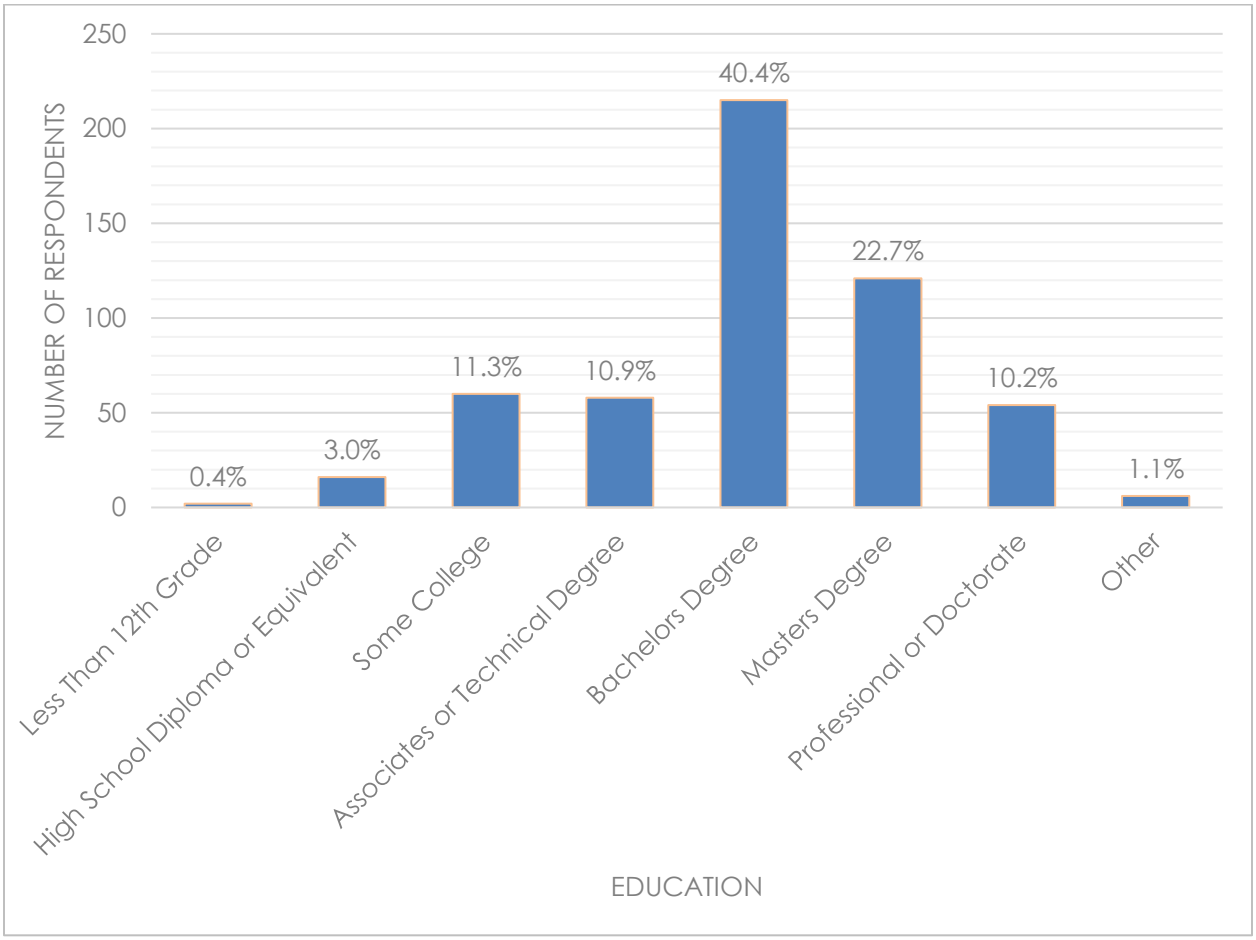

Figure 5.2 – Survey education level: 532 respondents

Income levels of research participants also tended to be much higher on average than census numbers (Figure 5.3). Twenty-eight percent of the respondents earned $100,000 or more, and more than half the respondents had a household income of more than $75,000. In comparison, the median household income was $56,119 in Oregon, $59,155 in Deschutes County, and $41,177 in Crook County.

Figure 5.3 – Survey income level: 474 respondents

B. Group affiliation

One of the questions in the nonspatial survey asked participants to list up to three organizations that influenced their views on natural resource management. We grouped these organizations into eleven categories (Table 5.2), and the results of the survey are shown in Figure 5.4. Environmental advocacy groups were the most commonly mentioned, slightly edging out Nature and Trail groups. The fourth largest category, Other Outdoor, is comprised of a wide range of interest groups including whitewater rafting (11 groups), paragliding (7 groups), mountain biking (5 groups), running (4 groups), and climbing (2 groups). For more detail about the groups listed by survey respondents, see Appendix B.

Table 5.2 – Definitions of group categories

Group Categories	Definition
Environmental Advocacy	Organizations geared toward lobbying, environmental advocacy, and activism related to nature and the environment.
Friends of / Land Trusts	Organizations that engage in stewardship or place-based caretaking, such as 'friends of' groups and land trusts.
Nature	Organizations focused on conservation of specific species or wildlife that are not primarily activists.
Trails	Organizations focused on building, maintaining, and improving trails for hiking, biking, or equestrian use.
Equestrian	Organizations focused on horses, mules, and other equestrian activities.
Hunting and Fishing	Organizations that promote conservation related to hunting or fishing or who promote those activities.
Non-motorized Snow Recreation	Organizations geared toward non-motorized winter use.
Other Outdoor	Activity-based organizations, such as biking, climbing, rafting, or running clubs.
Natural Resources	Public, public-private, multi-lateral or private organizations geared toward resource management, such as collaboratives, conservation groups or partnerships.
Motorized Recreation	Organizations geared to motorized uses of public lands.

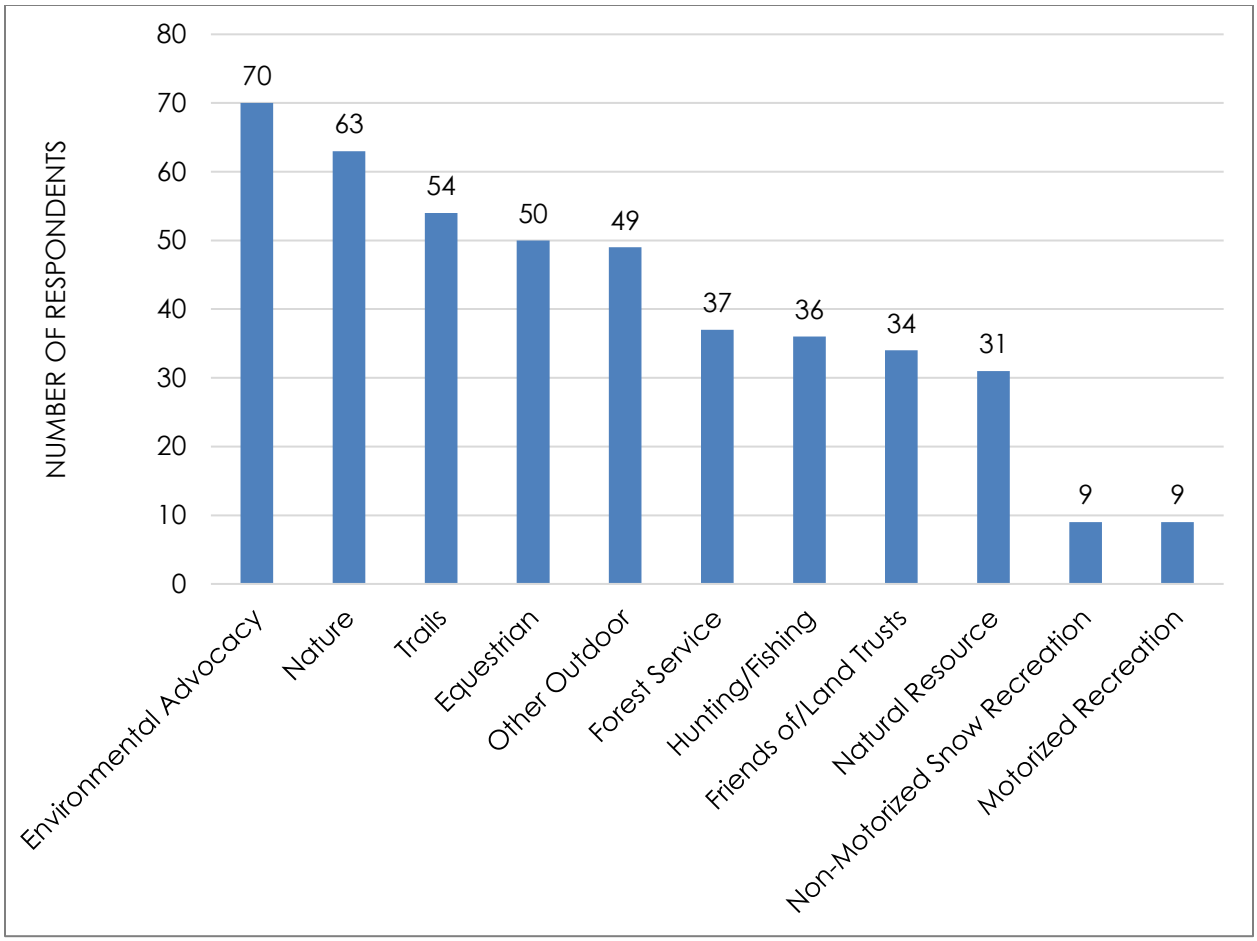

Figure 5.4 – Groups that influence views on forest management: 442 respondents.

C. Length of Residence in Area

The sample included a high proportion of short-term residents to the area (36%), reflecting the population changes noted in Chapter III (Figure 5.5). In addition, 25% of respondents had lived in the area more than 20 years.

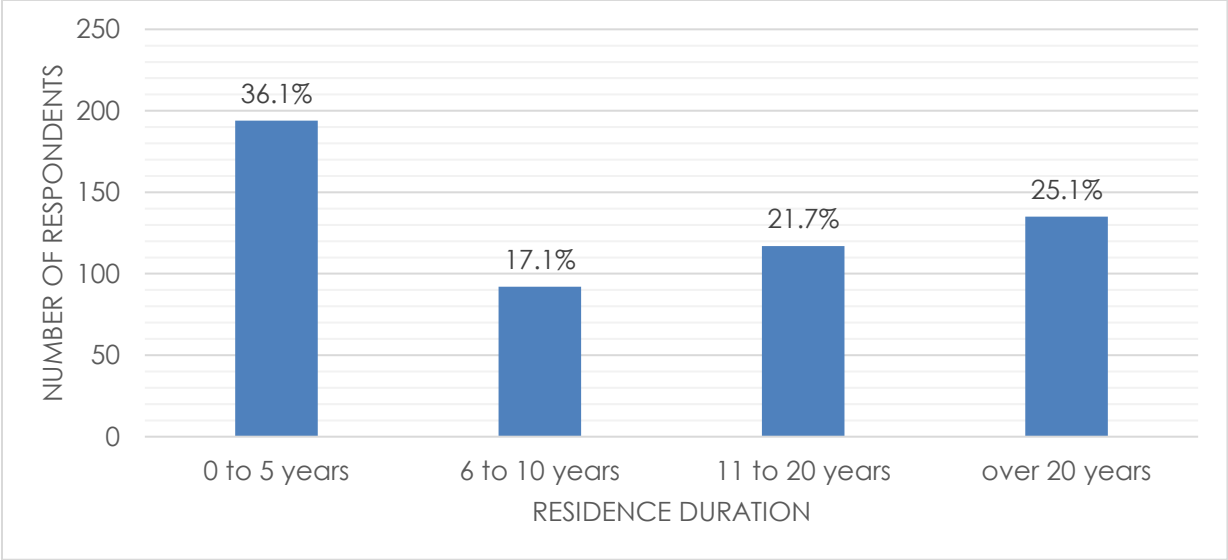

Figure 5.5 – Length of residence in area, 538 respondents

D. Top places where participants live

The places with the highest resident response to the survey are shown in Figure 5.6. Residents of Bend made up 42% of the survey respondents. Central Oregon residents comprised 79% of the survey respondents, with 37 participants from Jefferson County, 67 participants from Crook County, and 325 participants from Deschutes County.

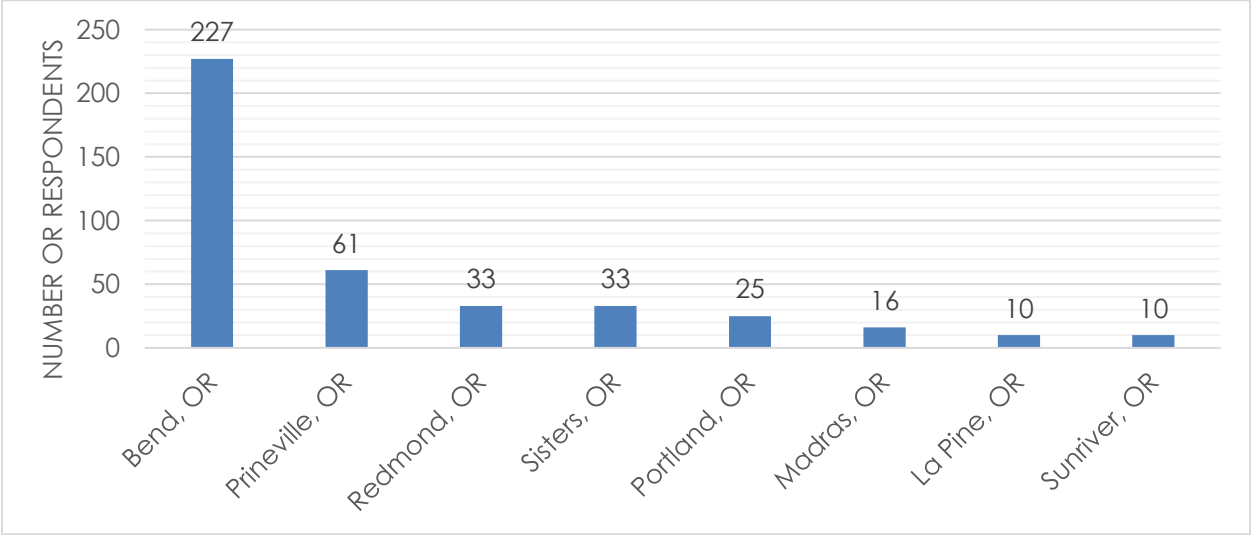

Figure 5.6 - Places with highest number of survey respondents

The spatial patterns of the important places marked by residents of the top five cities in terms of response (Bend, Prineville, Sisters, Redmond and the Portland area) are shown in Figure 5.7. Respondents from Bend, Prineville and Sisters typically marked places close to where they lived. Respondents from centrally-located Redmond marked a more dispersed set of locations, while visitors from the Portland Metro area tend to congregate at the most popular central Oregon recreation destinations, the majority of which are in the Deschutes National Forest.

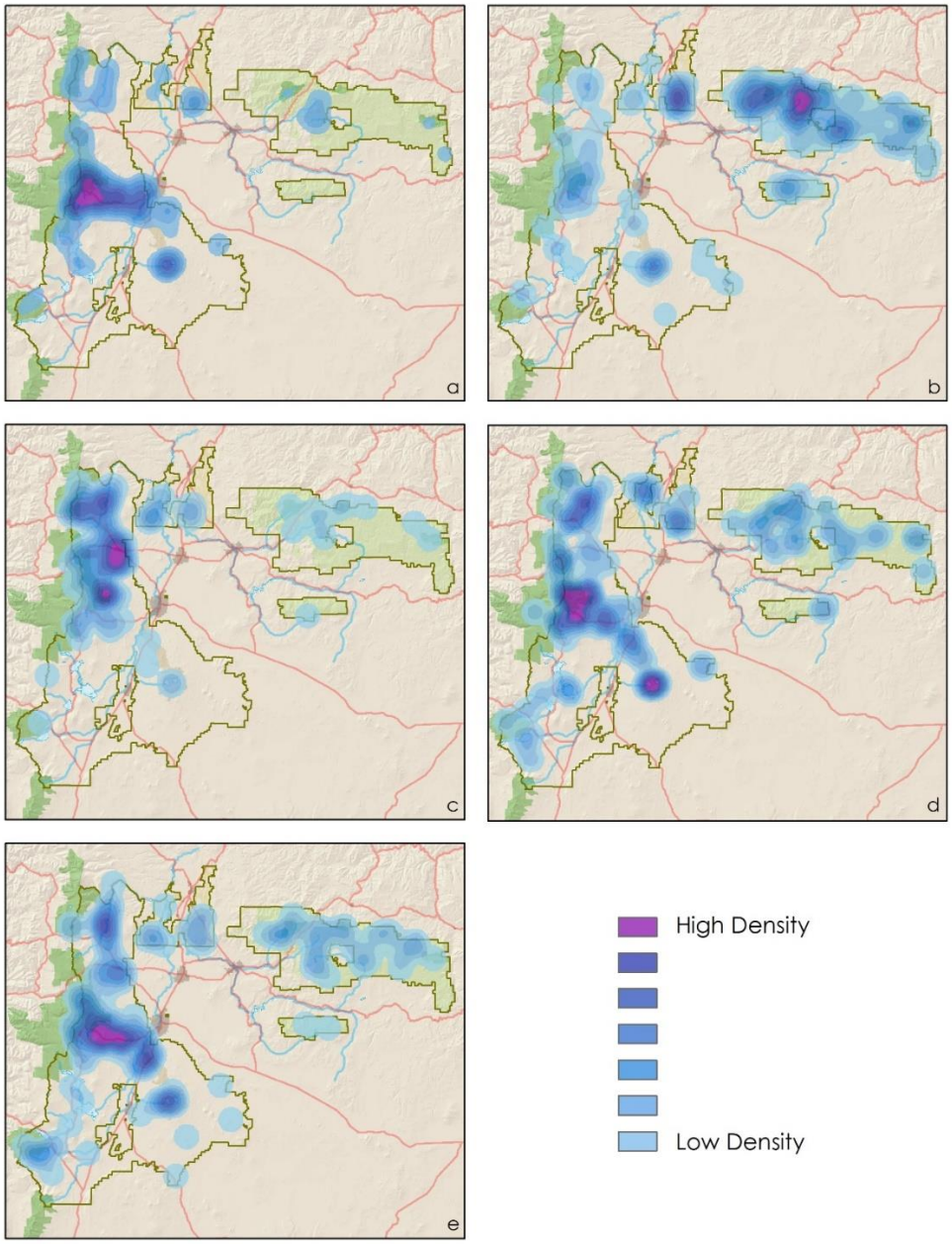

Figure 5.7 - Where residents of different cities visit. a) Bend – 890 points, b) Prineville – 235 points, c) Sisters – 132 points, d) Redmond – 132 points, e) Portland area – 164 points

E. Frequency of forest use

Almost half of the respondents used the Deschutes National Forest at least once a week (Figure 5.8). Frequency of use of the Ochoco National Forest and Crooked River National Grassland was decidedly lower, generally just a few times a year at best. However, respondents used the national forests and grassland more frequently than they used other public and private lands.

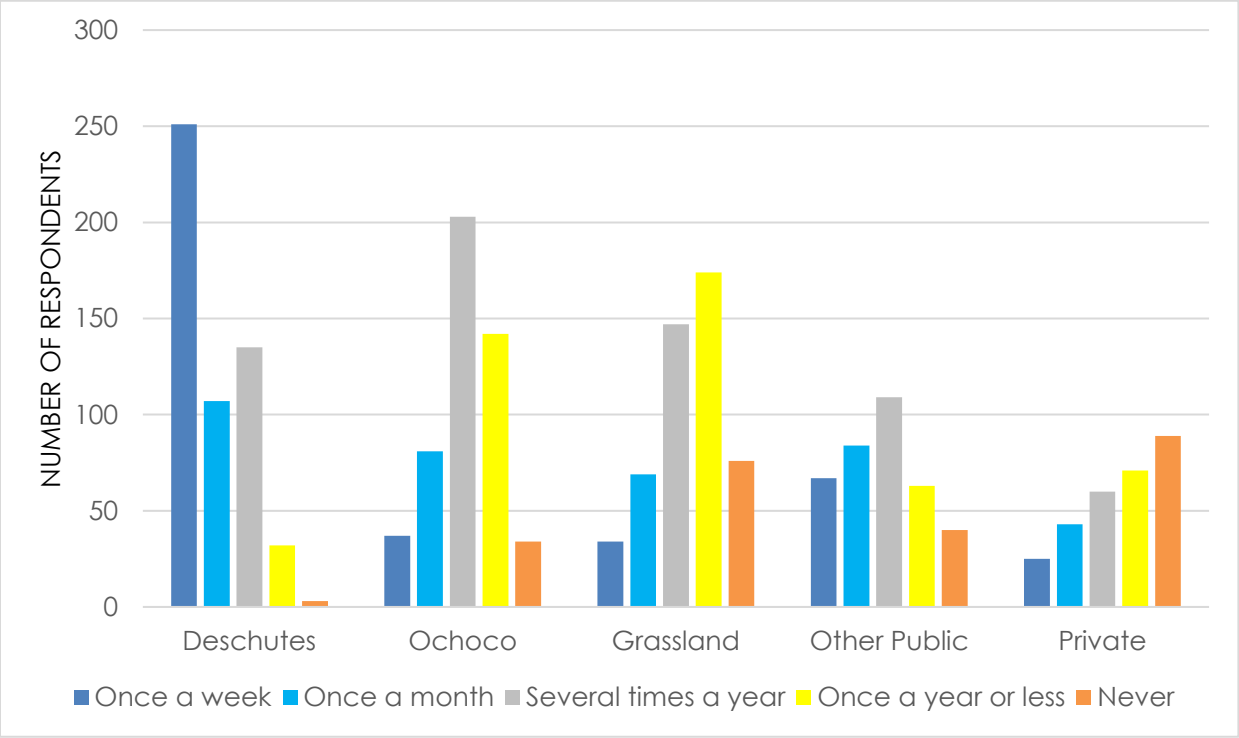

Figure 5.8 – Frequency of visits to public lands in Central Oregon: 542 respondents

F. Ecosystem services

Participants were asked to rate the importance of a number of ecosystem services provided by the forests (Figure 5.9). Outdoor recreation, habitat, clean air and water, and scenery were found to be 'very important' by more than 80% of the respondents. In contrast, commercial wood, mineral oil and gas, and grazing (cattle and bison) were marked as important by fewer than 50% of the respondents. These general responses indicate the changing nature of forest use in the area, with traditional extractive forest uses being replaced by recreation and conservation.

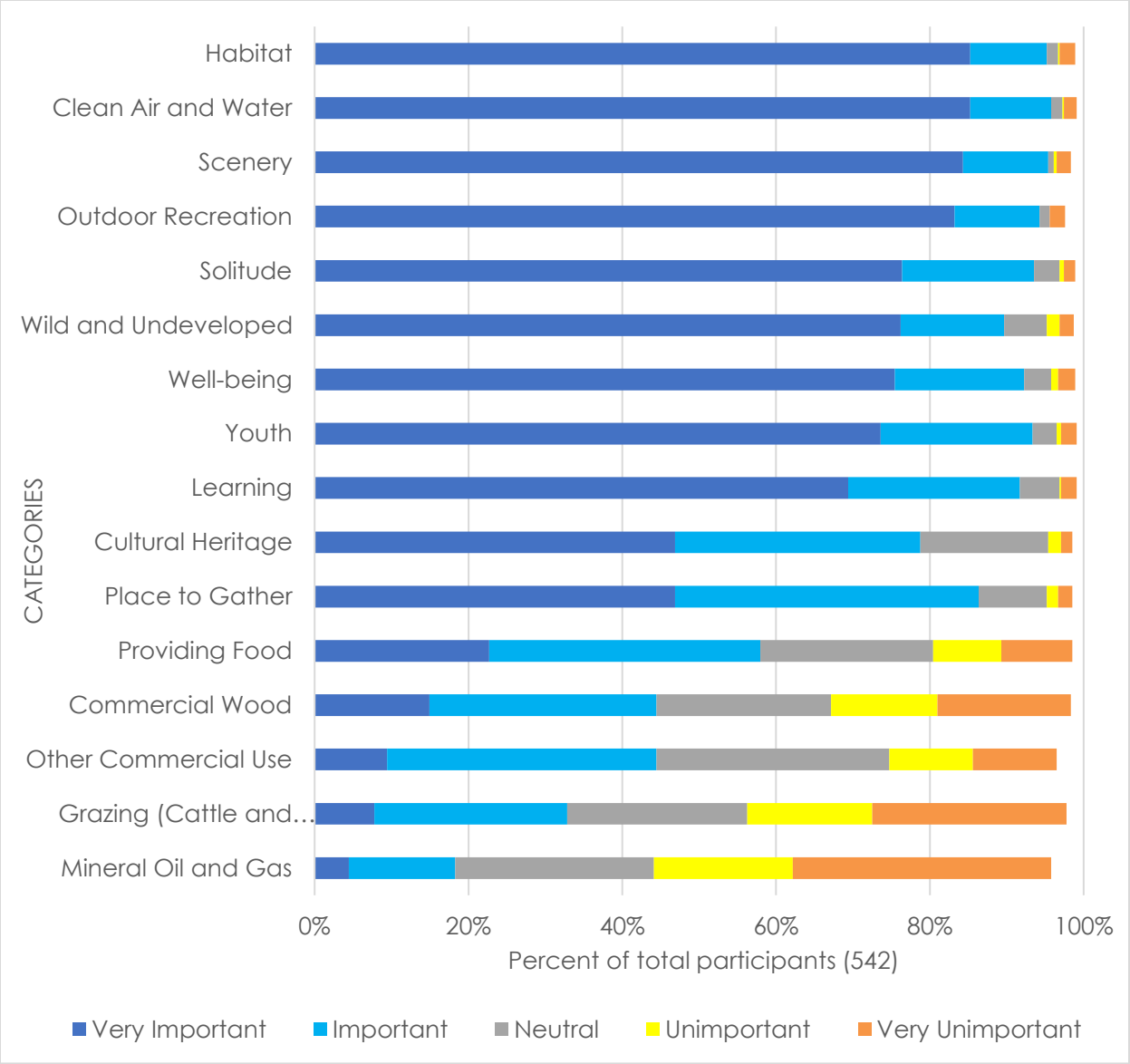

Figure 5.9 – Importance of ecosystem services: 542 respondents

VI. Mapping Survey Results

A. Overall

The 542 survey participants placed a total of 2,038 points on the map, indicating locations within the DNF, ONF, and CRNG that they considered important. Figure 6.1 shows the density of all points. Areas of very high density can be found west of Bend (Mt. Bachelor, South Sister, and Green Lakes), at Paulina and East Lakes in Newberry Crater National Volcanic Monument, near Gray Butte in the CRNG, and the western portion of the ONF around Walton Lake.

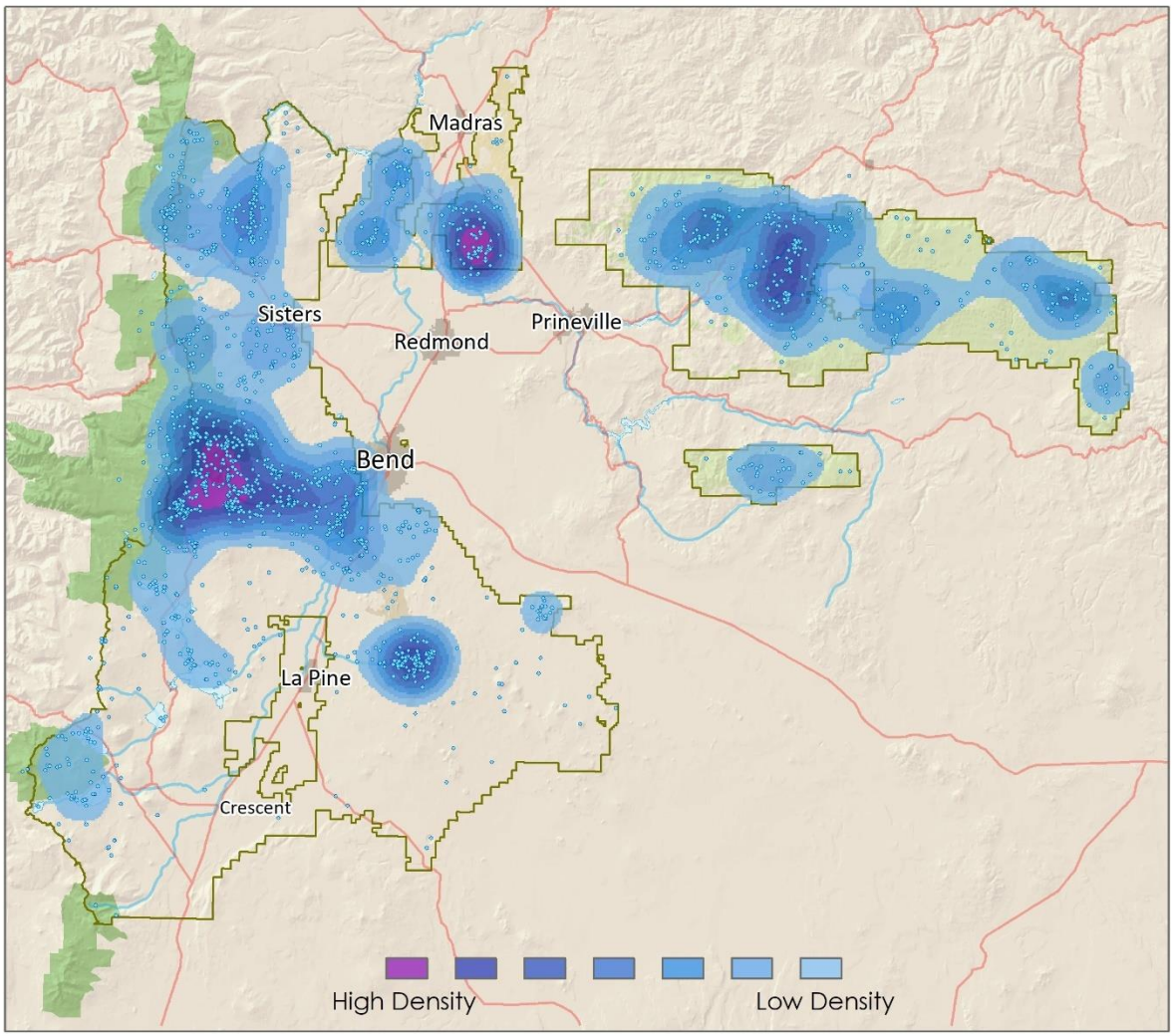

Figure 6.1 – Density of all points placed by participants, n = 2038

An alternate way to delineate dense concentrations of points is to calculate statistically significant hot and cold spots (Figure 6.2)[11]. Comparing this map to Figure 6.1 shows that the method that measures the statistical significance of cold and hot spots identifies many of the same areas of dense point concentrations. However, it also identifies areas that may be somewhat less evident in the density map, such as the area along the Metolius River. For the sake of simplicity, we show density maps in this report. However, one should keep in mind that the statistical significance of the spatial distributions shown on any map in this report can be calculated.

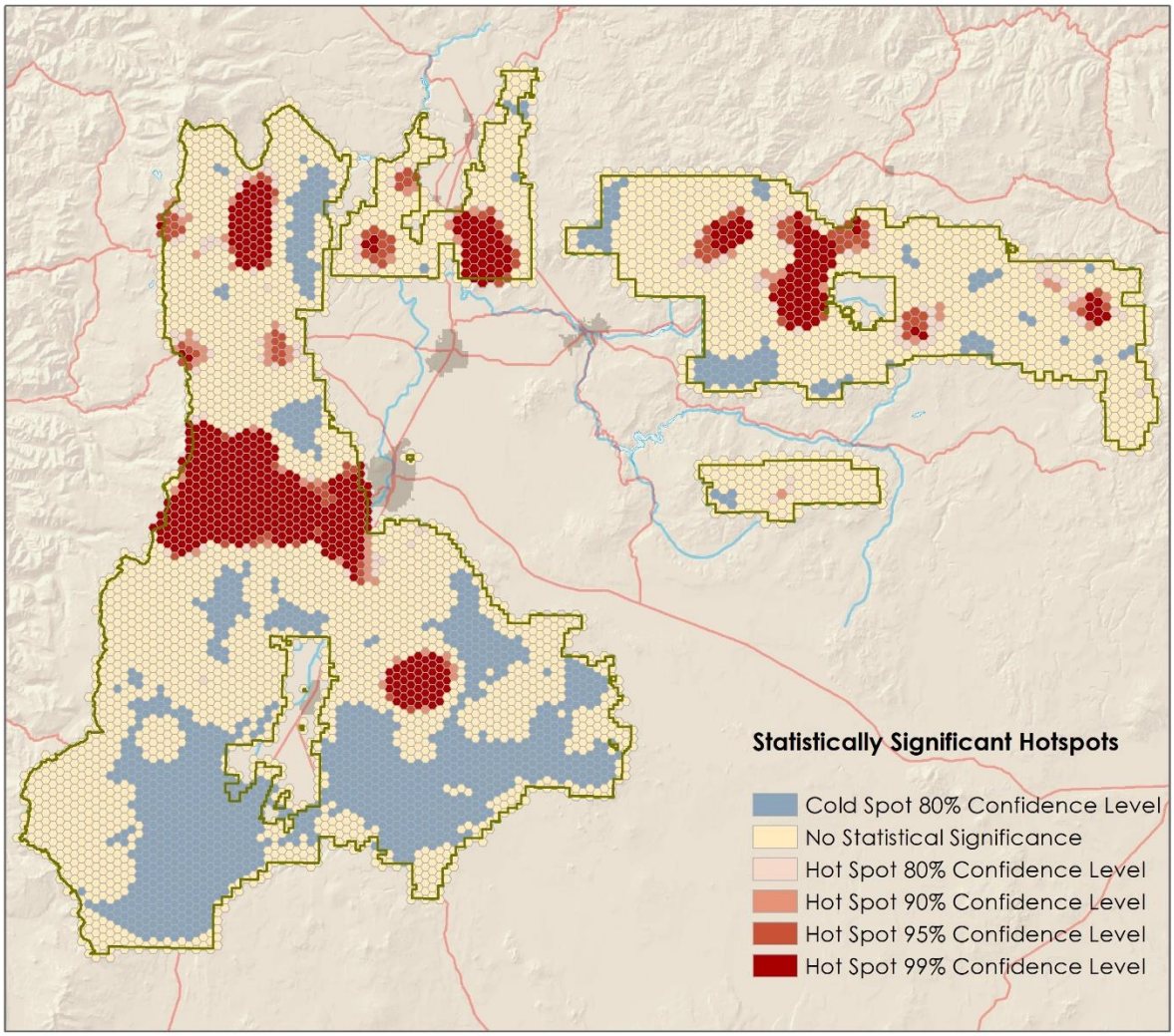

Figure 6.2 – Statistically significant hot spots and cold spots of points placed by participants, n = 2038

[11] The Getis-Ord Hot Spot Analysis Tool in ArcGIS was used for this calculation. Hexagon grid cells are one square mile in area.

B. Benefits

For each point placed on the map, participants were asked to select from a pick list up to three benefits they associated with the place. Figure 6.3 shows responses from the 2,038 placed points. Participants strongly associated their important places with the benefits of scenery and beauty, and recreation and fitness, followed by solitude and escape. Other benefits were chosen far less often.

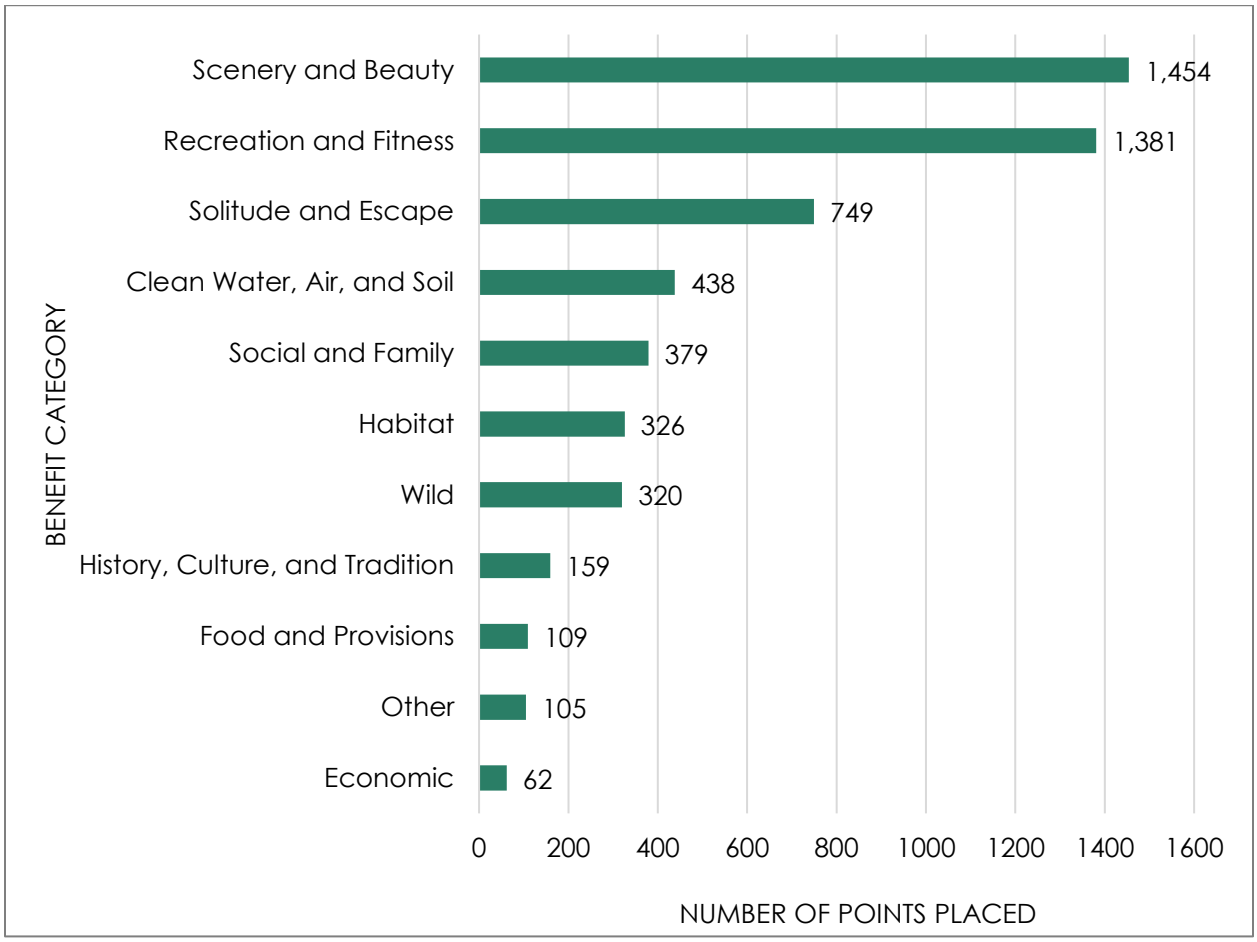

Figure 6.3 – Forest benefits associated with points placed by participants

A comparison of five selected benefits illustrate how benefits chosen by participants overlapped (Figure 6.4). The most commonly chosen benefits can be found concentrated in the same hotspots noted above. However, the CRNG and ONF had low densities for the benefits "social and family", and "wild".

Figure 6.4 – Density of points for select forest benefits: a) Scenery and Beauty, 1,454 points; b) Recreation and Fitness, 1,381 points; c) Social and Family, 379 points; d) Solitude and Escape, 749 points; e) Wild, 320 points

C. Activities

For each point they marked, survey participants were asked to list any activity they participate in at the place they marked. We consolidated these activities into eleven activity types (Figure 6.5).

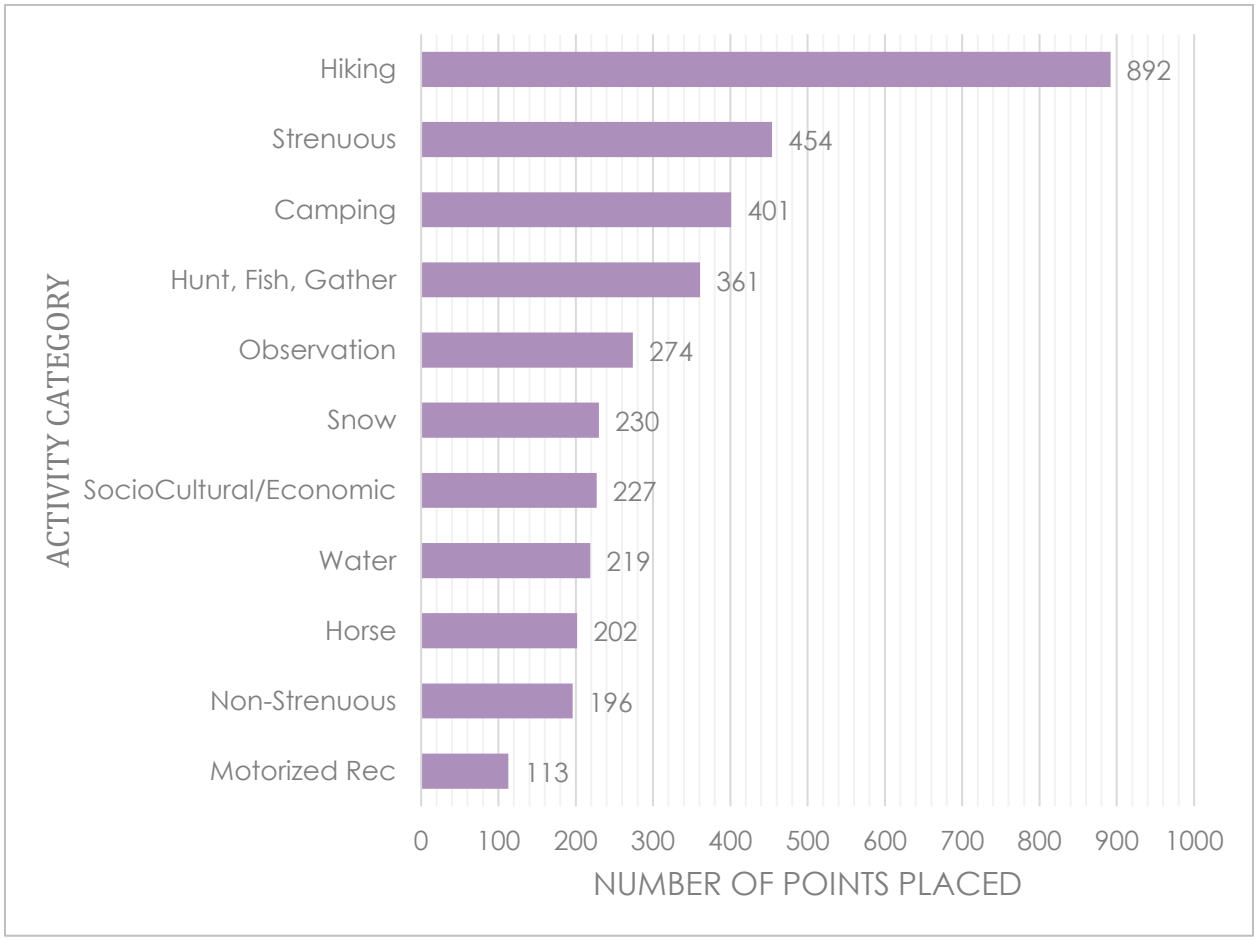

Figure 6.5 – Activity categories associated with points placed by participants

To illustrate how these categories were created, in Figure 6.6 we show subcategories for four of these eleven activity types. These subcategories are the primary activities for each group; all activities for each category are not shown. For more detail about the categorization of groups, see Appendix B.

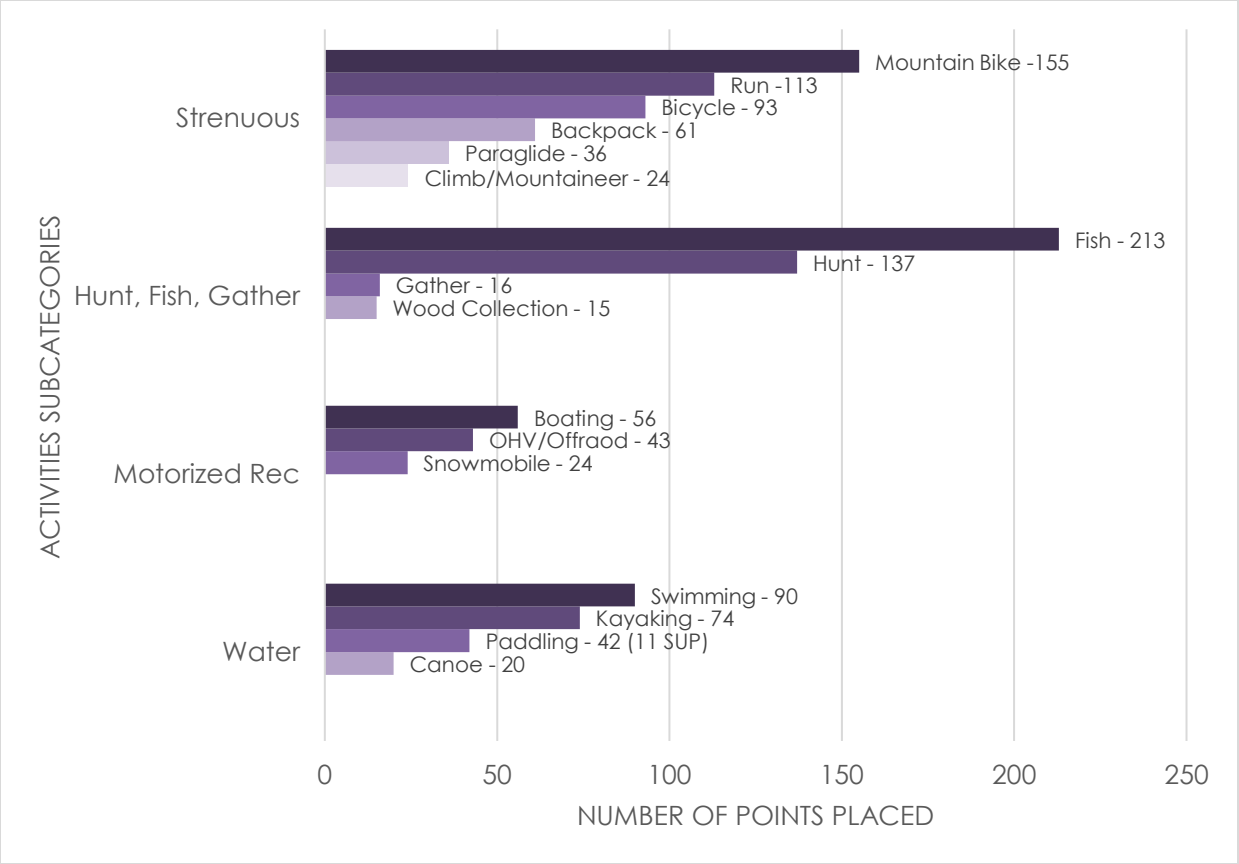

Figure 6.6 – Select activity subcategories associated with points placed by participants

Density maps of eight activity categories, shown in figure 6.7 and 6.8, demonstrate the different spatial patterns for these activities. Hiking, far and away the most popular activity, had large hotspots in the area west of Bend as well as at Paulina and East Lakes. Strenuous recreation, comprised mainly of backpacking, running, and mountain biking, was concentrated along the Cascade Lakes Highway west of Bend, as well as around Gray Butte in the CRNG. Water sports such as rafting, kayaking, swimming, paddle boarding, or any other non-motorized water activity are concentrated around lakes and rivers. In contrast, the hunt, fish, and gather activity shows a large number of hotspots dispersed throughout the forests.

Figure 6.7 – Density of points for four activity categories: a) Hiking, 892 points; b) Strenuous Recreation, 454 points; c) Water, 219 points; d) Hunt, Fish, Gather, 361 points.

Non-strenuous recreation, which includes activities such as walking, picnicking, and relaxing, tends to be concentrated near Bend and at Paulina and East Lakes. Motorized recreation, such as boating, snowmobiling, and OHV use, has concentrations around a variety of lakes and popular snowmobiling areas. Camping generally follows the overall density pattern, as do horse-related activities, with an additional concentration of horse-related activities near Sisters and the southern end of the CRNG.

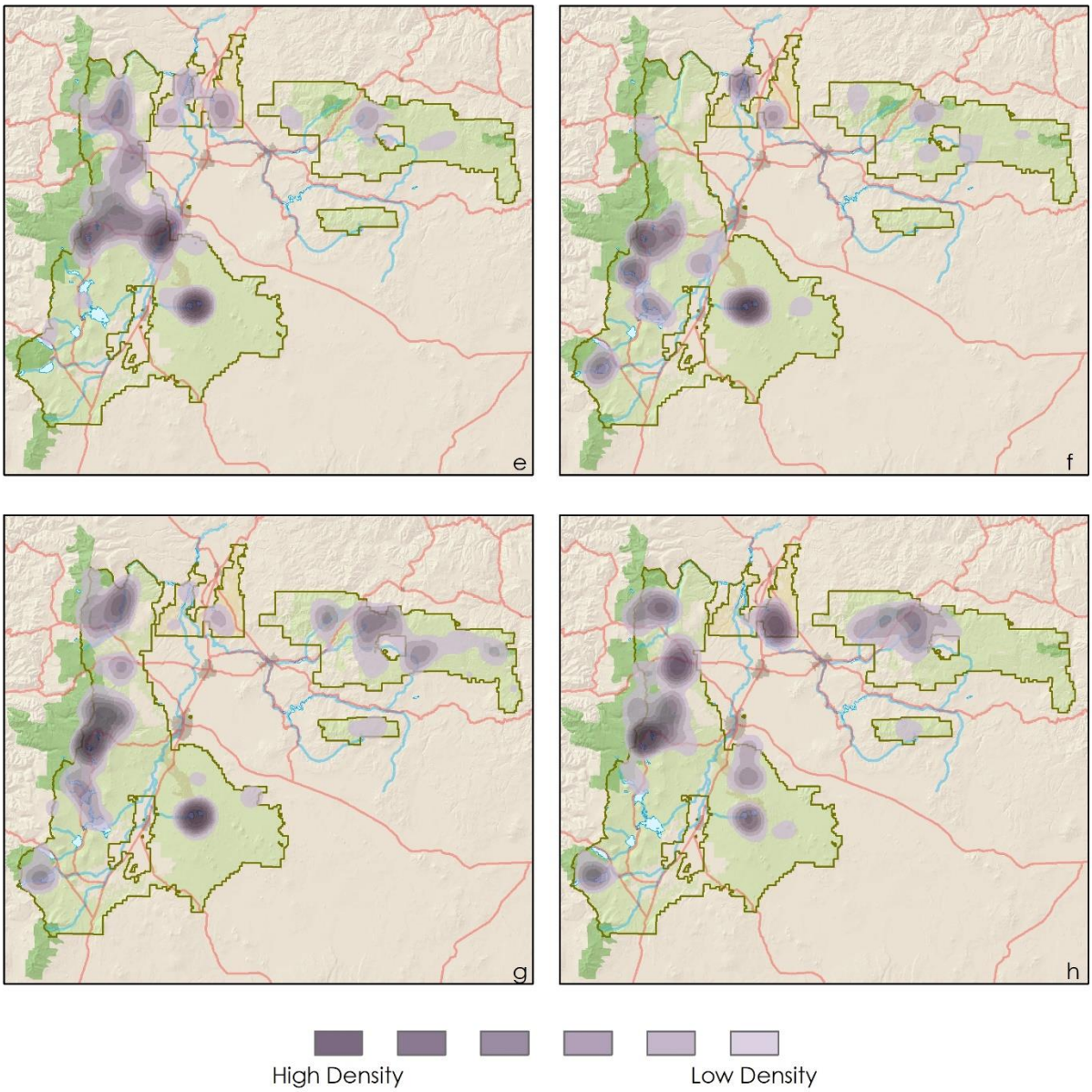

Figure 6.8 – Density of points for four activity categories: e) Non-strenuous Recreation, 196 points; f) Motorized Recreation, 113 points; g) Camping, 401 points; h) Horse-related, 202 points

The collection of density maps in Figure 6.9 show four activity subcategories with distinctive use patterns. Hunting takes place predominantly in the ONF while fishing takes place along rivers and lakes in the DNF. Backpacking is focused almost strictly in the Three Sisters Wilderness area whereas most mountain biking occurs in the area west of Bend. A fairly large number of points (at least 50) is required to map individual subcategories of activities. If enough data are available, then spatial patterns can be identified for specific activities that differ from the overall density patterns of all activities.

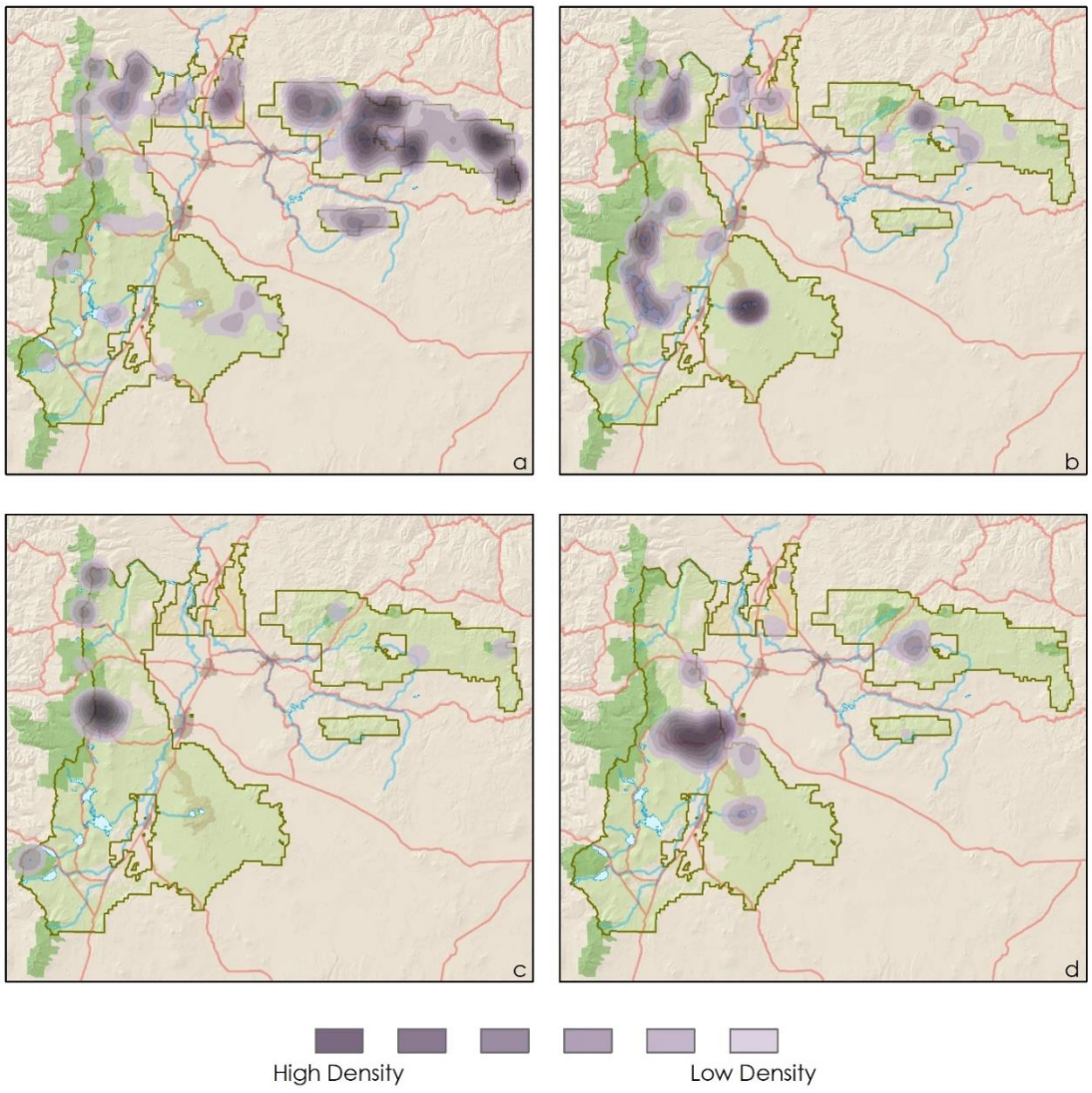

Figure 6.9 – Density of points for select activity subcategories: a) Hunting, 137 points; b) Fishing, 213 points; c) Backpacking, 61 points; d) Mountain biking, 155 points

We can also visualize the variety and balance of activities by calculating diversity. The higher the diversity number the more that an area caters to multiple activities and has a good balance of those activities. Low numbers indicate areas where just a few uses are predominant. We calculated a diversity index for activities within recreation zones provided by the DNF and ONF (Figure 6.10).

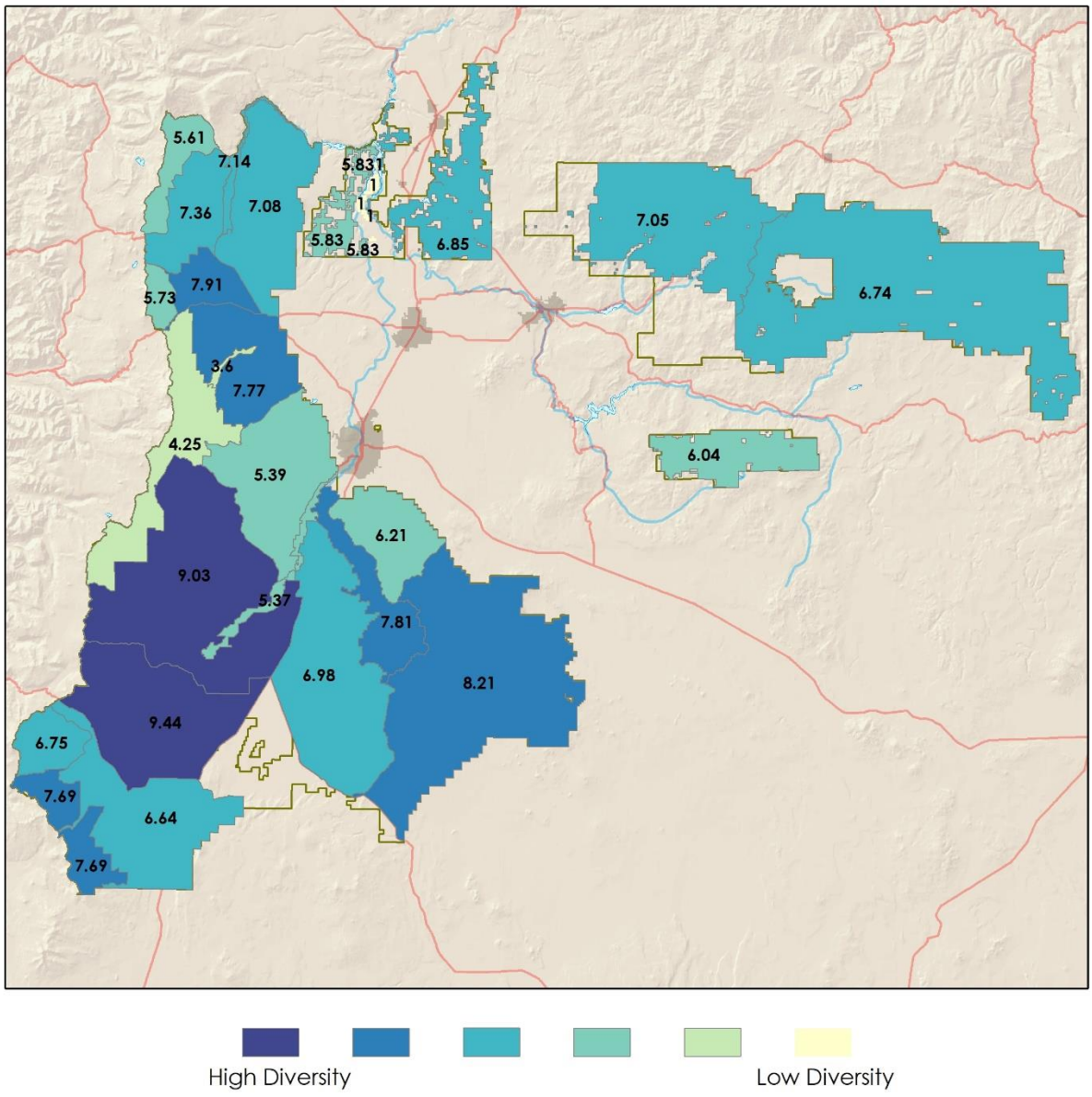

Figure 6.10 – Diversity of activities by recreation zones

Areas of very high activity diversity occur in the recreation zones west and southwest of La Pine along the Deschutes River and around nearby lakes. The high density use areas west of Bend do not see an accompanying high diversity of uses.

Figure 6.11 provides a detailed visualization of how various activities are distributed within recreation zones in the DNF; the size of the pie chart is proportional to the number of points placed in the recreation zone. One can see that certain recreation zones are dominated by just a few activities (shown as large slices of the pie).

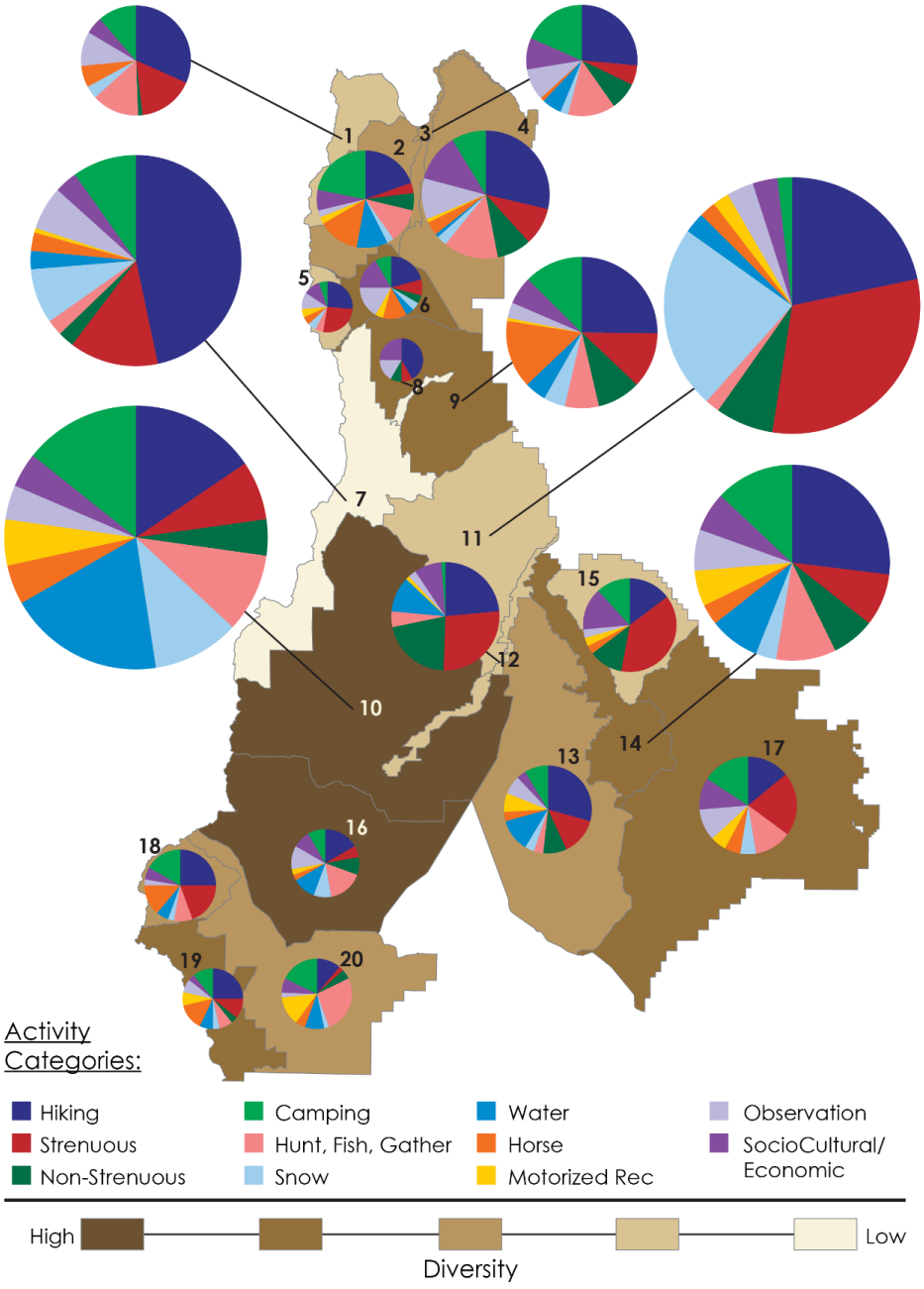

Figure 6.11 – Proportional pie chart of diversity of activities in DNF

Figure 6.12 shows the same visualization of activity diversity for the ONF and CRNG. The ONF has a greater diversity of activities than the CRNG, although it is not as diverse in general as the DNF. There is also a somewhat different suite of dominant activities in the ONF compared to the DNF, with more hunting, fishing and gathering, observation, and camping.

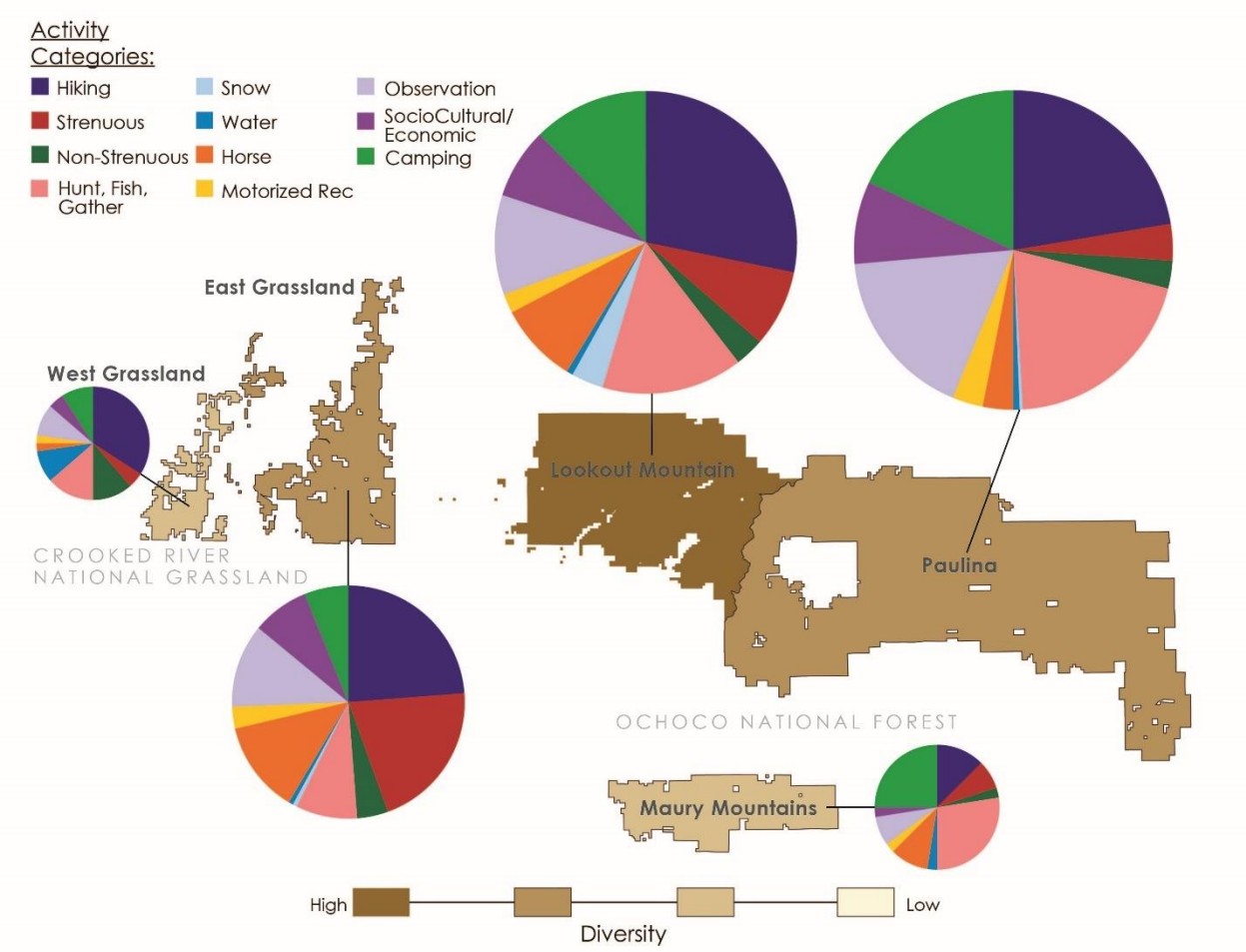

Figure 6.12 – Proportional pie chart of diversity of activities in ONF and CRNG

D. Social Environment

When it came to participants' preferred social environment (Figure 6.13), results indicate a large majority wish to be around a few people, with the next largest group being those that prefer to be alone. Only a small percentage of participants enjoy being around many people. The density maps for preferred social environment revealed that participants who preferred to be alone marked locations across the ONF, while those who preferred to be around a few people counterintuitively marked popular areas west and south of Bend, along the Metolius River, and near Gray Butte.

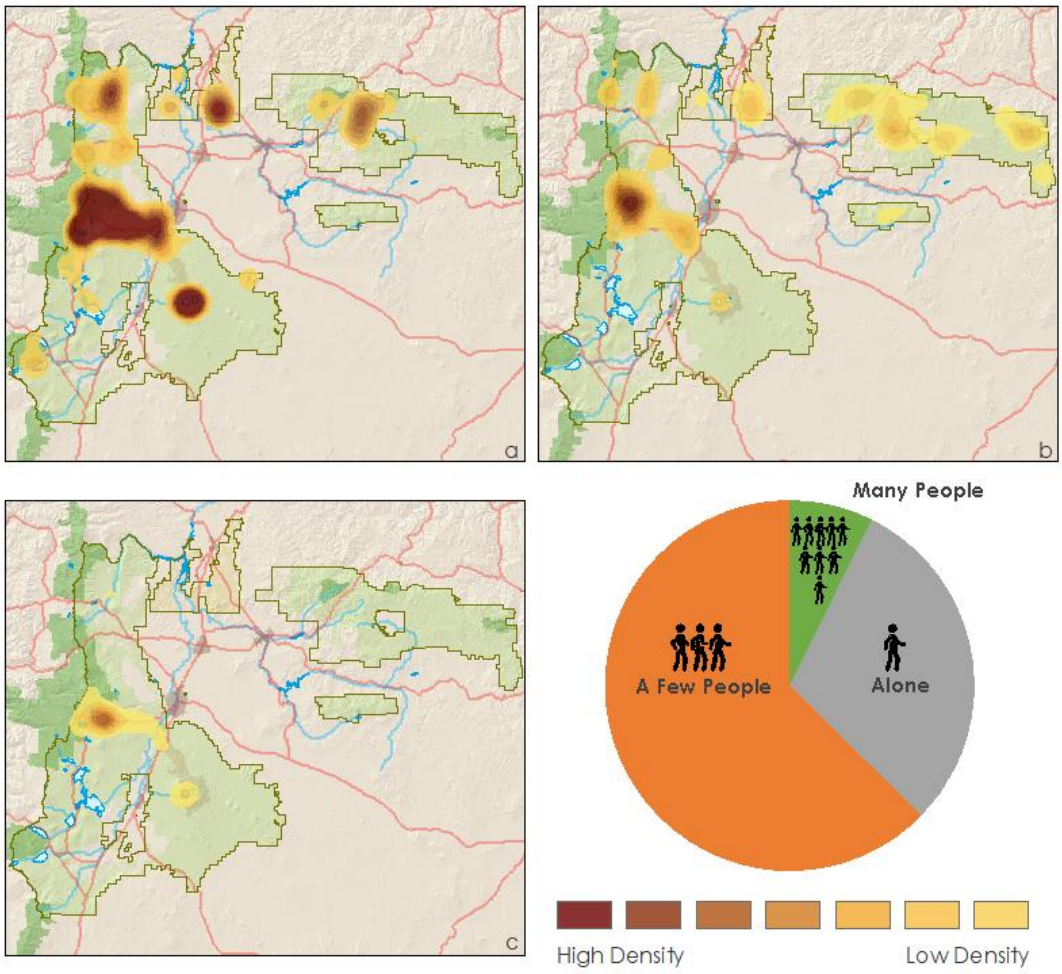

Figure 6.13 – Density and distribution of points for preferred social environment: a) A Few People; b) Alone; c) Many people

These patterns may be explained by how the survey question was interpreted. It is unclear if participants answered the question based on the size of group with which they went to the place or the number of people they actually hoped to encounter.

E. Threats

Participants were asked if there were threats to their experience at the place they marked, and they could respond in detail in a text box. These perceived threat responses were grouped into twelve categories (Figure 6.14). Crowds were the most commonly noted threat, with nearly twice as many responses as the second most commonly noted threat, other user conflict.

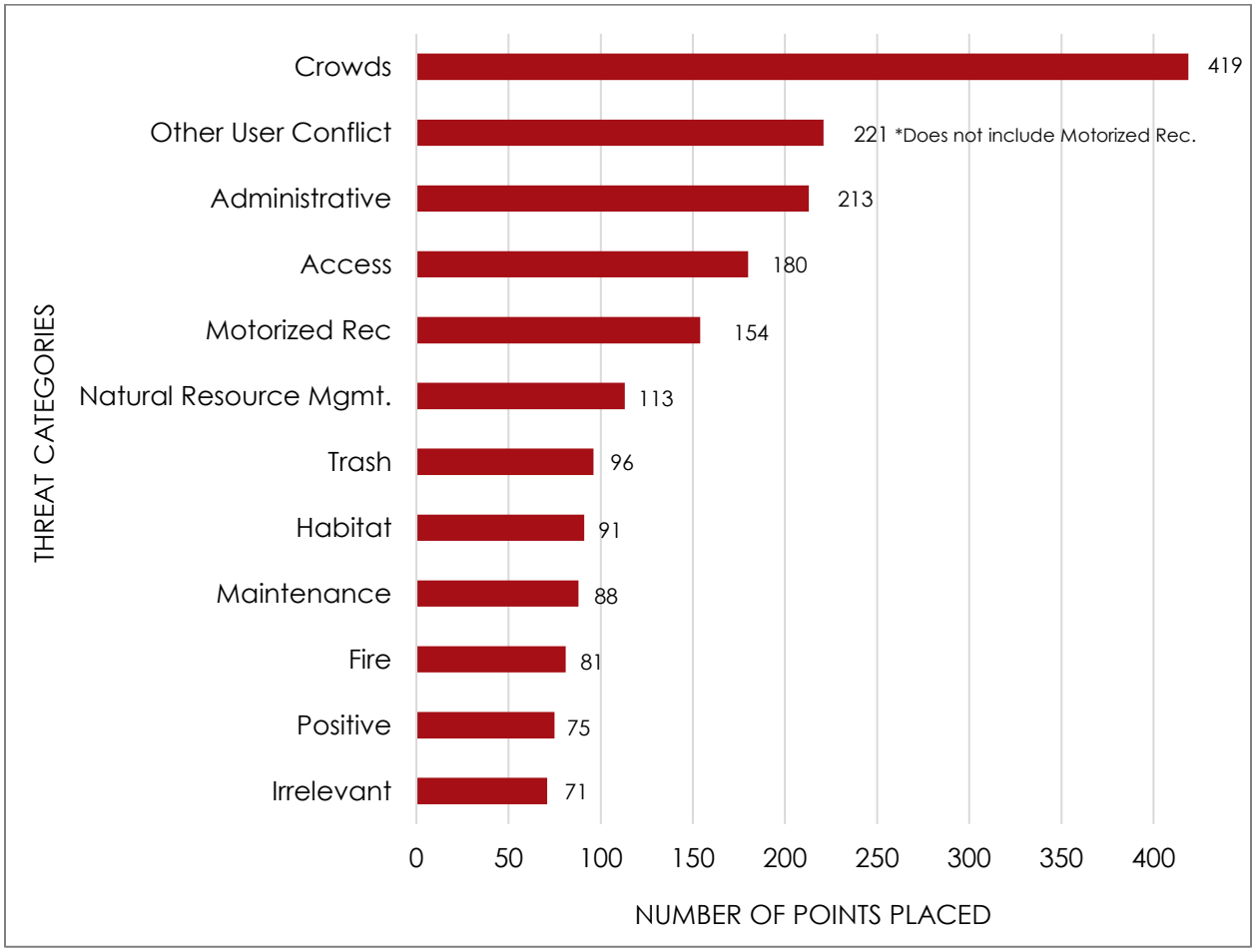

Figure 6.14 – Threat categories associated with points placed by participants

Where practical, threats were broken down into subcagetories to further understand participants' concerns. Figure 6.15 displays the threat subcategories for crowds, other user conflict, administrative, access, motorized recreation, and maintenance. Most comments related to crowds were about crowding in a general sense. In the administrative category, participants

believed that over/under regulation of the area, prices/fees that were too low/too high, infrastructure problems, and too much/too little control of dogs on trails were the greatest threats. For motorized recreation, the ATV subcategory was of greatest concern, while snowmobiles were mentioned far fewer times. The "Other user conflict" category had the most subcategories, including bikes, horses, dogs, shooting/hunting, and horse campsite issues. Participants also commented on a wide array of user behaviors, such as fireworks, drone use, generators, general misuse of the area, long term homeless sites, noise, and rowdy, insensitive groups.

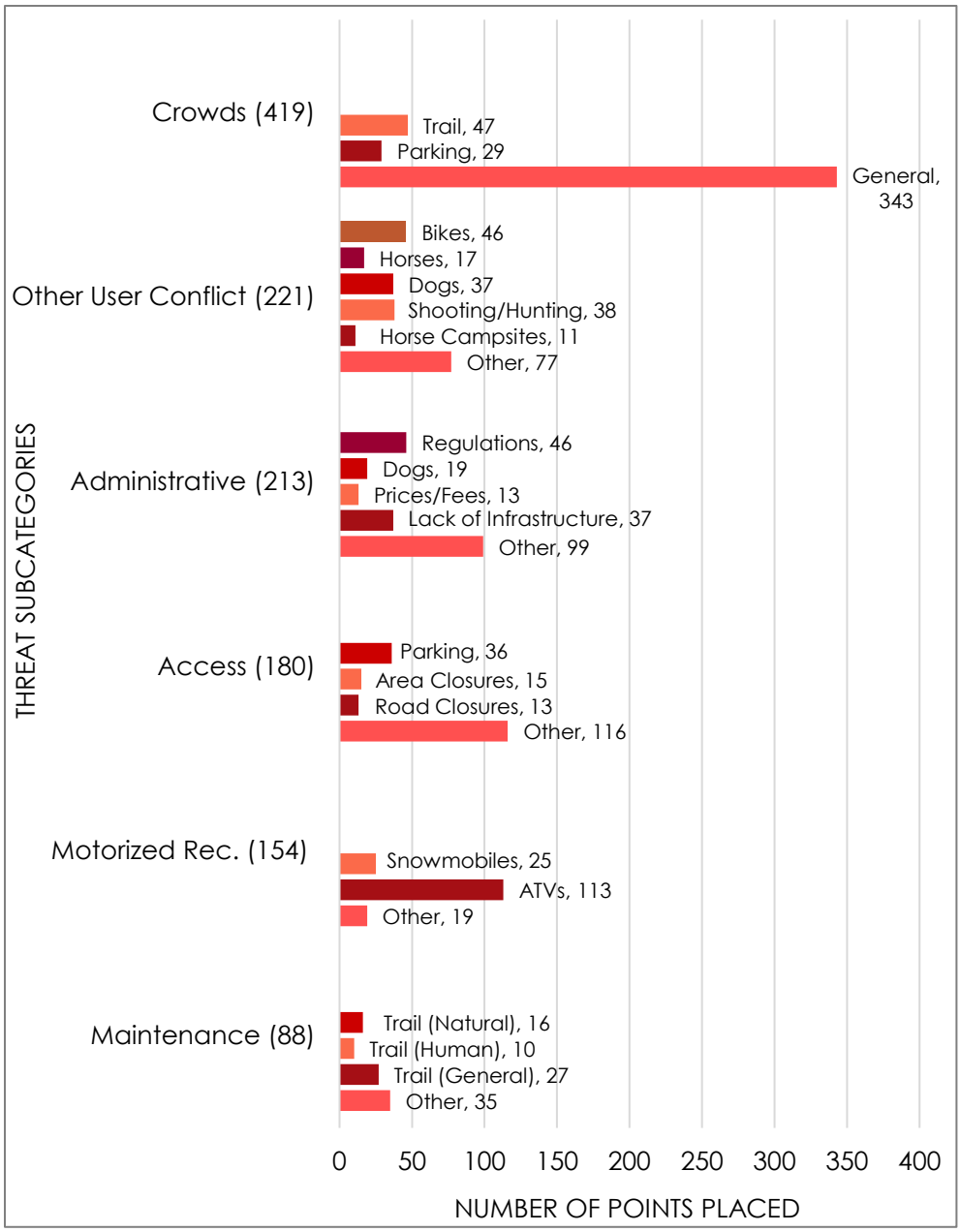

Figure 6.15 – Select threat subcategories associated with points placed by participants

Density maps for complaints about crowds, other user conflict, natural resource management (typically timber or grazing related), and motorized recreation illustrate varied densities and dispersions of these threats (Figure 6.16). Perhaps unsurprisingly, the crowds threat has a density pattern similar to the overall point density. Other user conflict is most concentrated directly west of Bend, but is also found in other hotspots across the forests. Natural resource management and motorized recreation threats are more dense in the ONF than other areas.

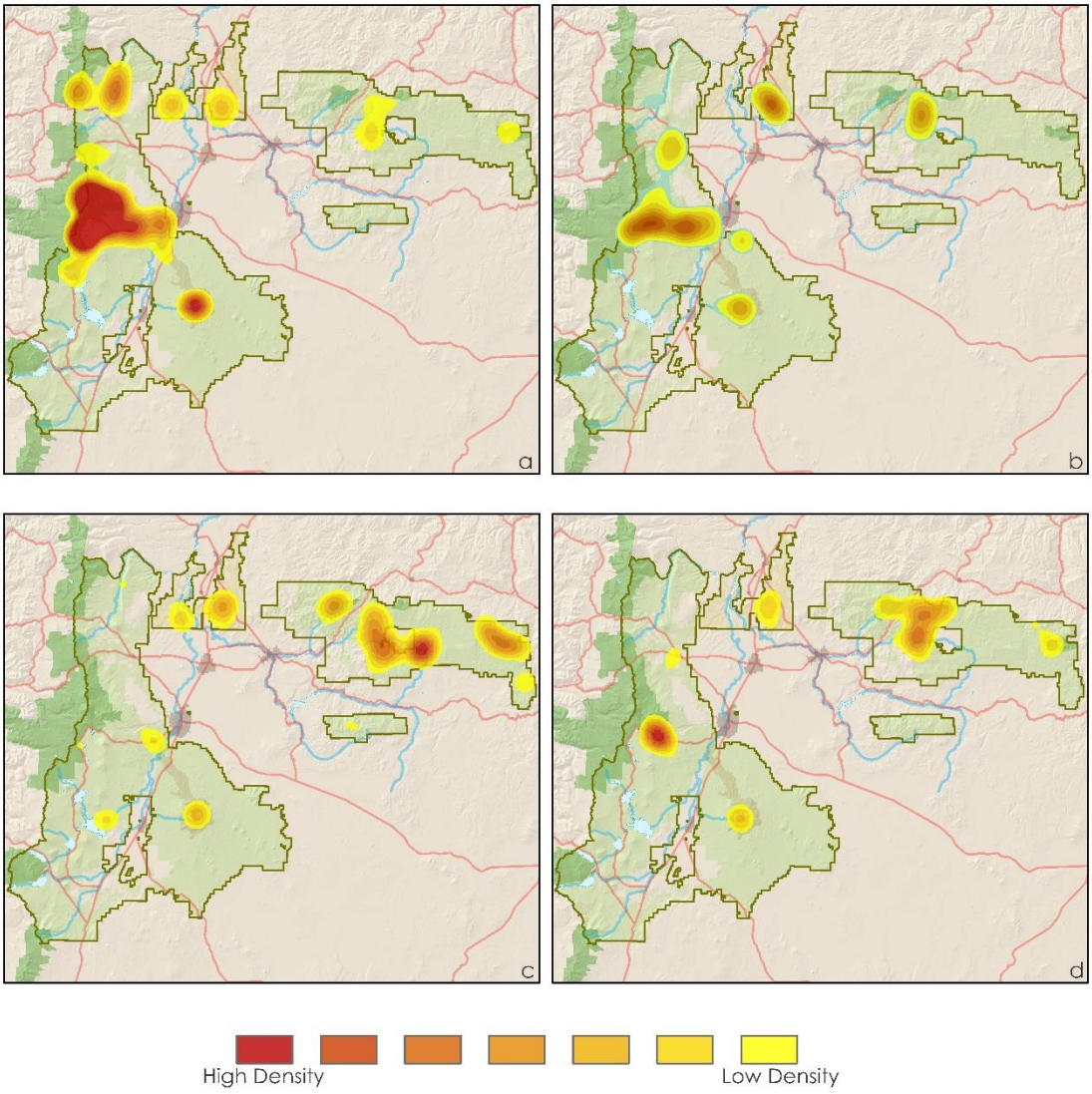

Figure 6.16 – Density of points for select threats: a) Crowds, 419 points; b) Other User Conflict, 221 points; c) Natural Resource Management, 113 points; d) Motorized Recreation, 154 points

A diversity index for threats was also calculated by recreation zone (Figure 6.17). The resulting spatial pattern indicates that areas in the far north and far south of the DNF, west side of the ONF, and east side of the CRNG have a very high diversity of threats.

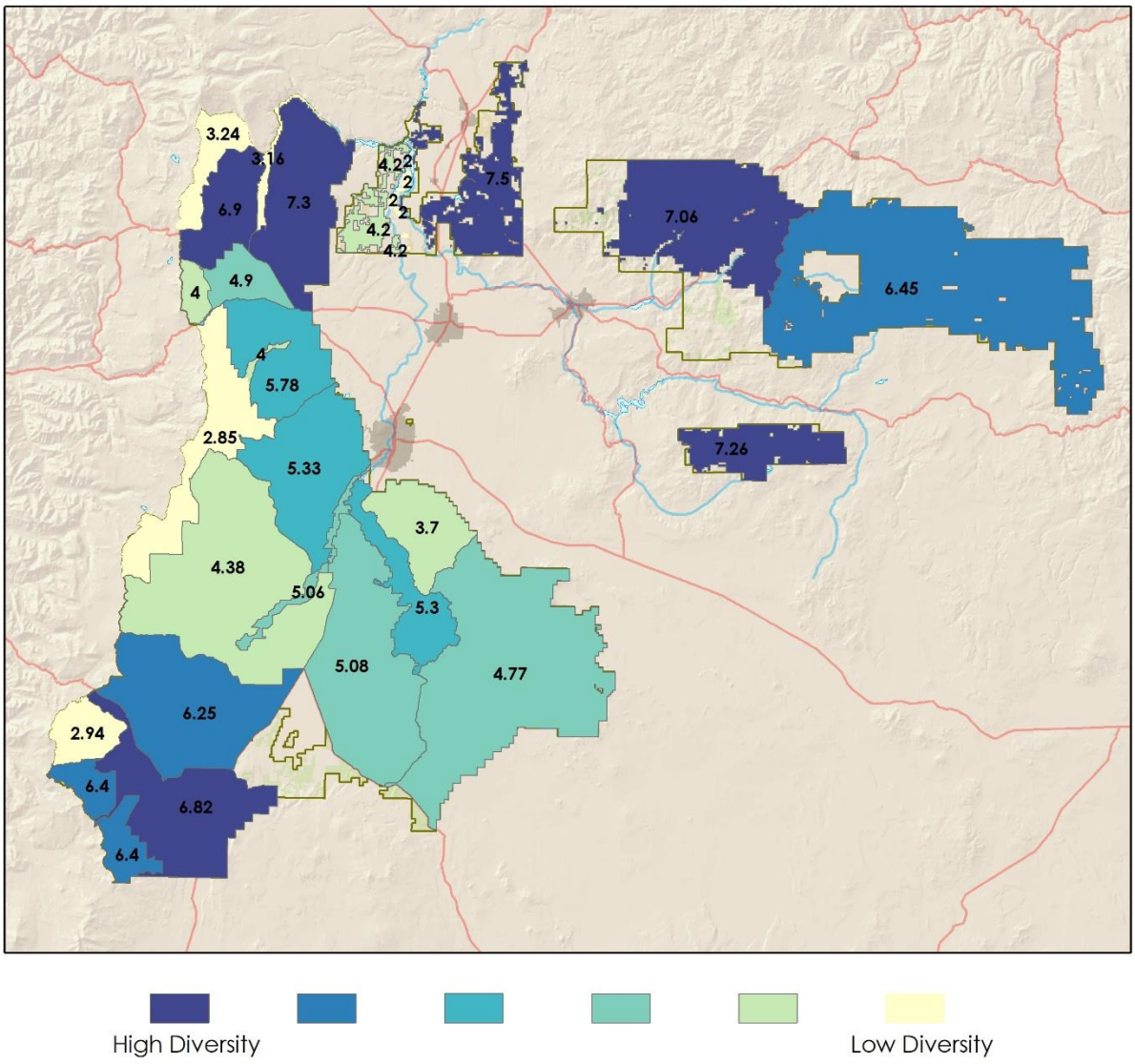

Figure 6.17 – Diversity of threats by recreation zones

Figure 6.18 provides a detailed visualization of how various threats are distributed within recreation zones in the DNF. The high density use areas west of Bend do not have a particularly high diversity of perceived threats, with complaints mainly regarding crowding, access, and

other user conflict. As might be expected, backcountry areas by their very nature have the lowest diversity of threats.

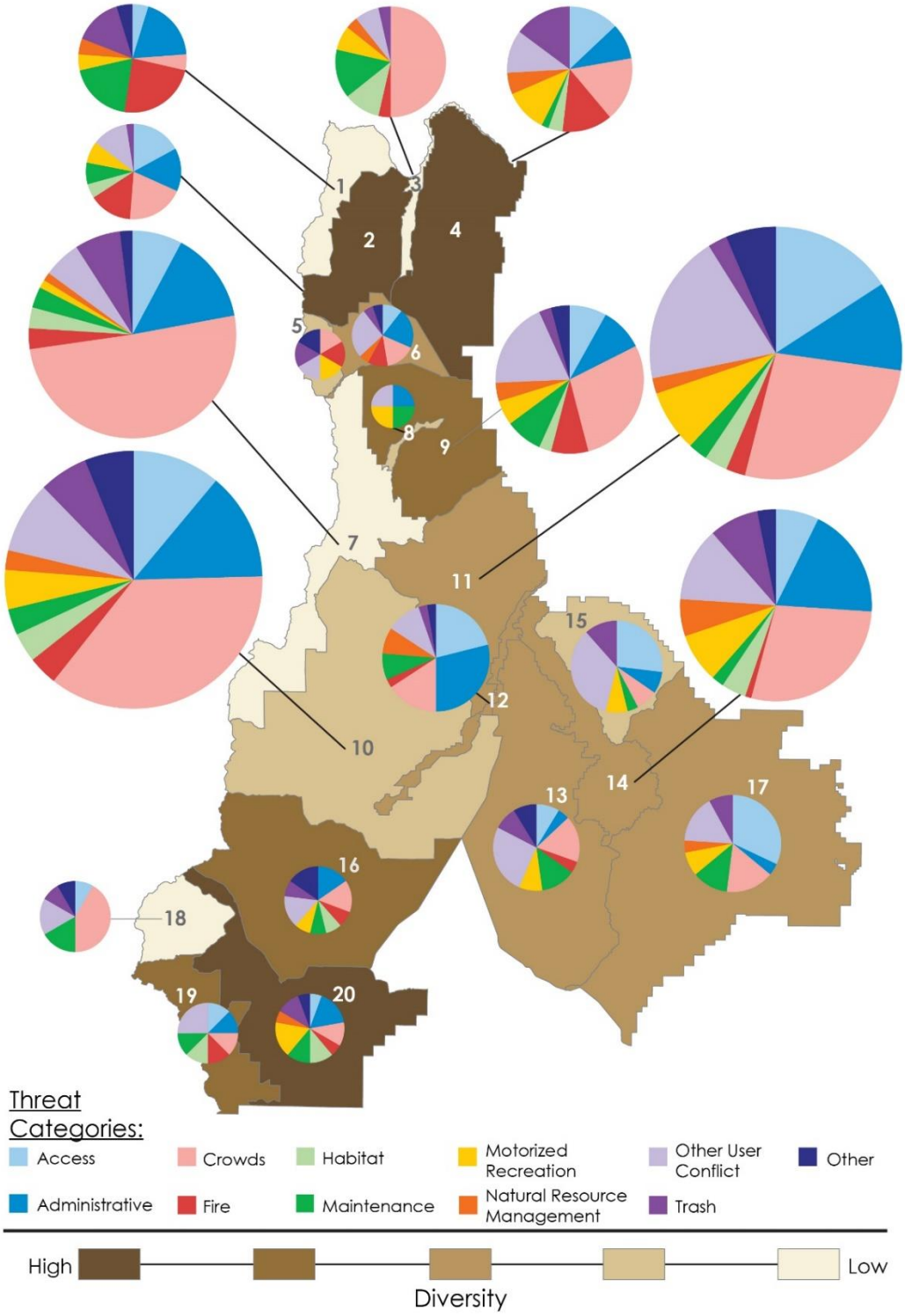

Figure 6.18 – Proportional pie chart of diversity of threats in DNF

Figure 6.19 shows the same visualization of threat diversity for the ONF and CRNG. As noted earlier, natural resource management and motorized recreation threats are more common in the ONF compared to the DNF, and crowding is much less of an issue. The East Grassland has the greatest diversity of threats of any recreation unit.

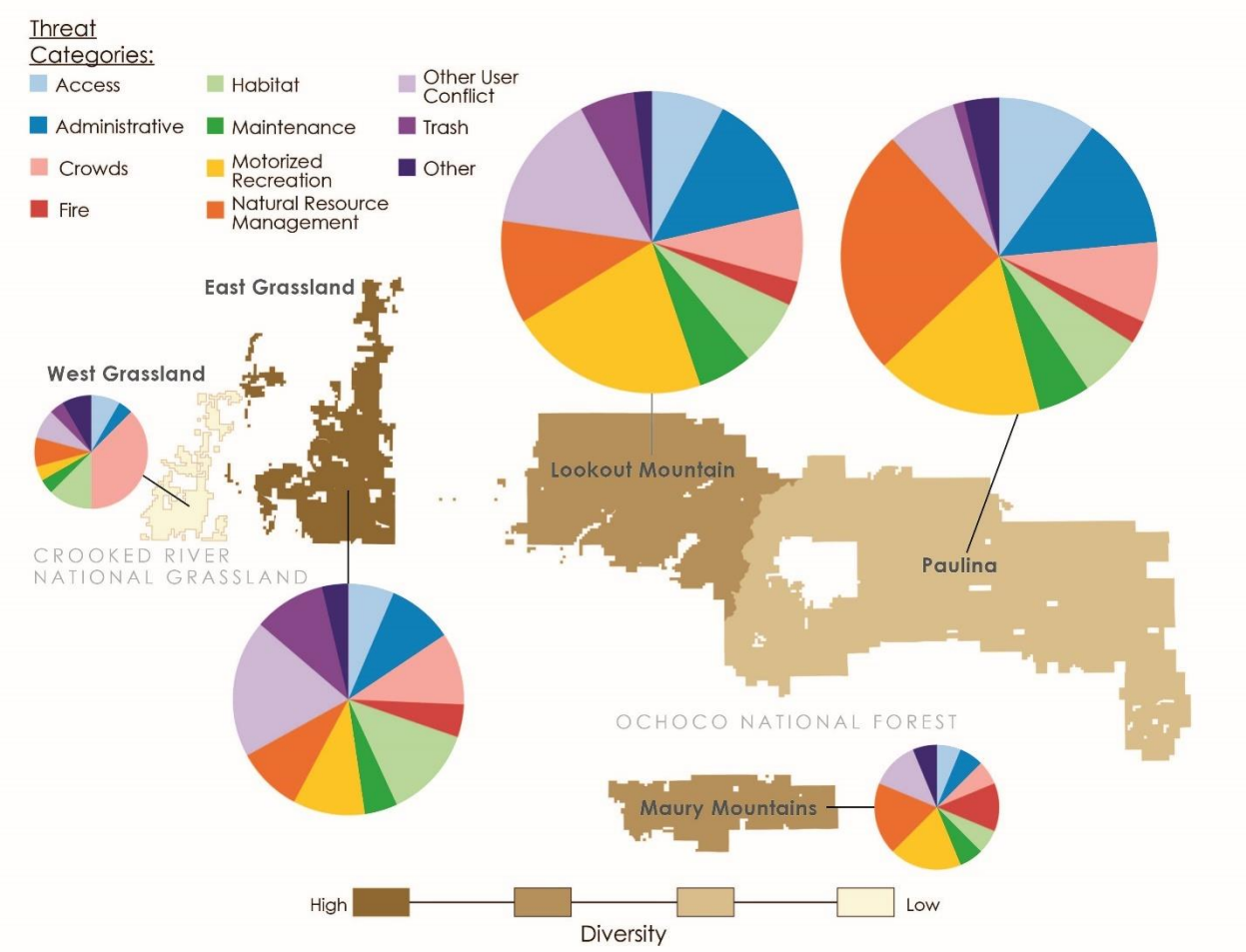

Figure 6.19 – Proportional pie chart of diversity of threats in DNF

F. Features

Participants could select from a pick list the physical or built features that are most important at the marked location. These features included lake, river or stream, waterfall, mountain, forest, grassland, meadow, wetland, lava field, historic buildings, or recreation facilities. No notable patterns could be discerned from these data.

VII. Results by Ranger District

We disaggregated the survey responses by ranger district (Sisters, Bend-Fort Rock, Crescent, Lookout Mountain, Paulina, and CRG – Figure 7.1). Doing so revealed spatial patterns that were hidden in the overall density results dominated by the hotspot located along the Cascades Lake Highway west of Bend. We calculated densities using only points that fell within each respective district.

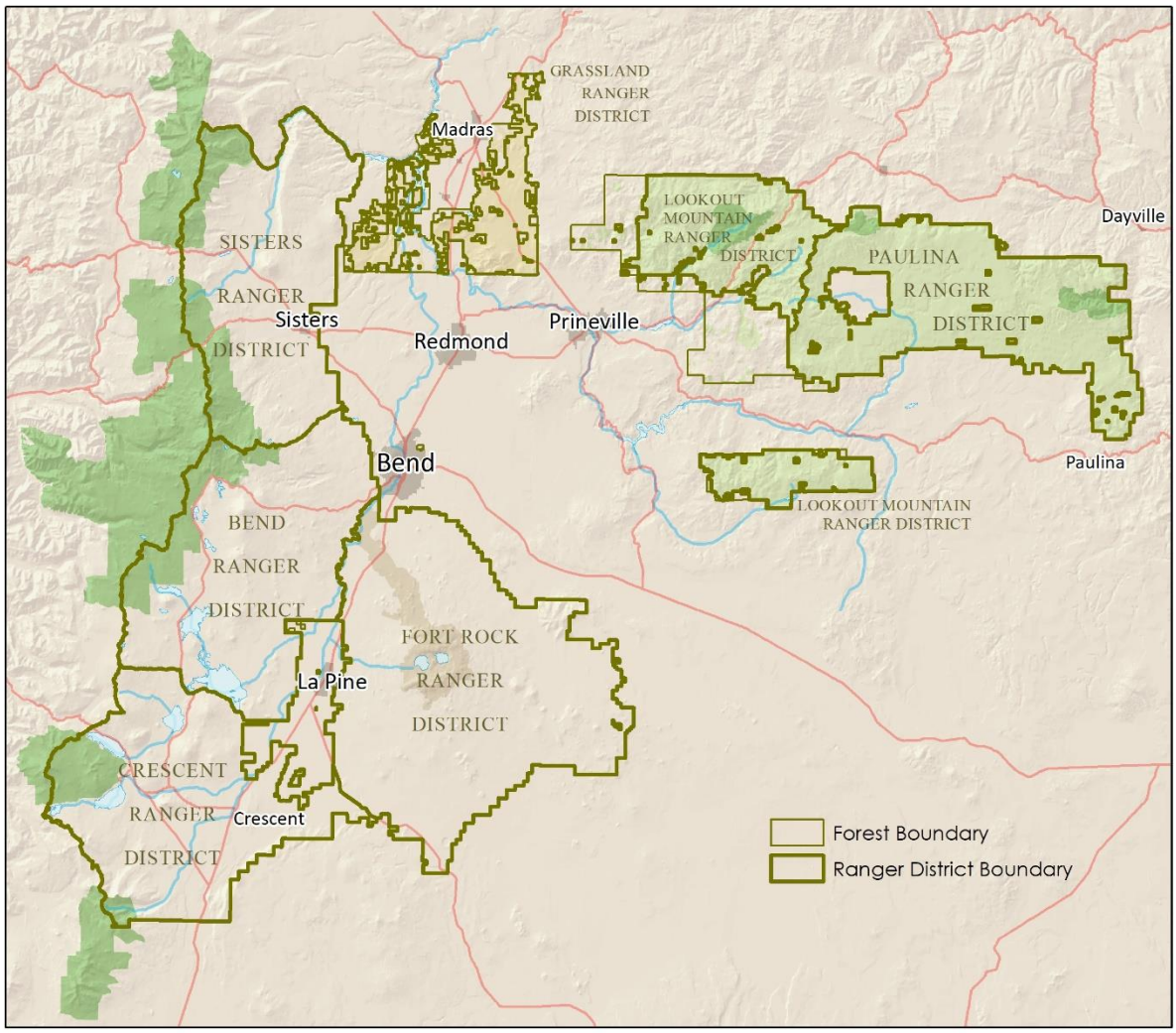

Figure 7.1 – Ranger districts for Deschutes National Forest, Ochoco National Forest, and Crooked River National Grassland.

The density of points placed within the Sisters Ranger District is depicted in Figure 7.2. The concentration of points along the Metolius River is more pronounced than it was in the overall density map. Since the boundary of the Sisters/Bend-Fort Rock Districts passes through the Cascades Lake Highway hotspot found in the overall density map, we are now able to discern more specific hotspots in that area. For the Sisters Ranger District those specific hotspots are Green Lakes, South Sister/Broken Top, and Three Creek Lake.

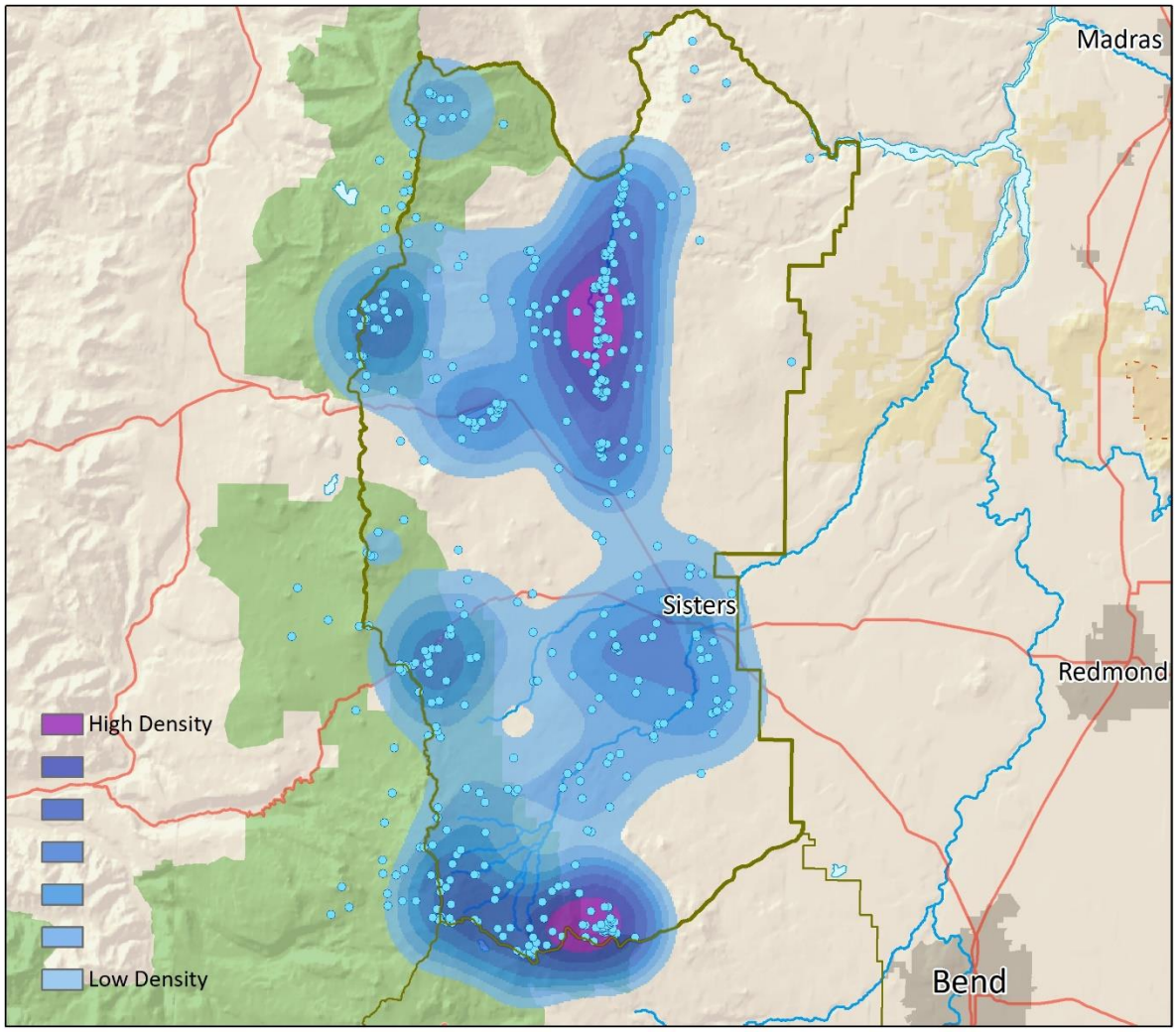

Figure 7.2 – Sisters Ranger District

For the Bend-Fort Rock Ranger District, those smaller hotspots including Mt. Bachleor, Elk Lake, and Lava Lake (Figure 7.3), as well as the already defined hotspot at Paulina and East Lakes. Notable is the relatively small number of points placed at certain large popular lakes and reservoirs, such as Wickiup, Crane Prairie, and Cultus.

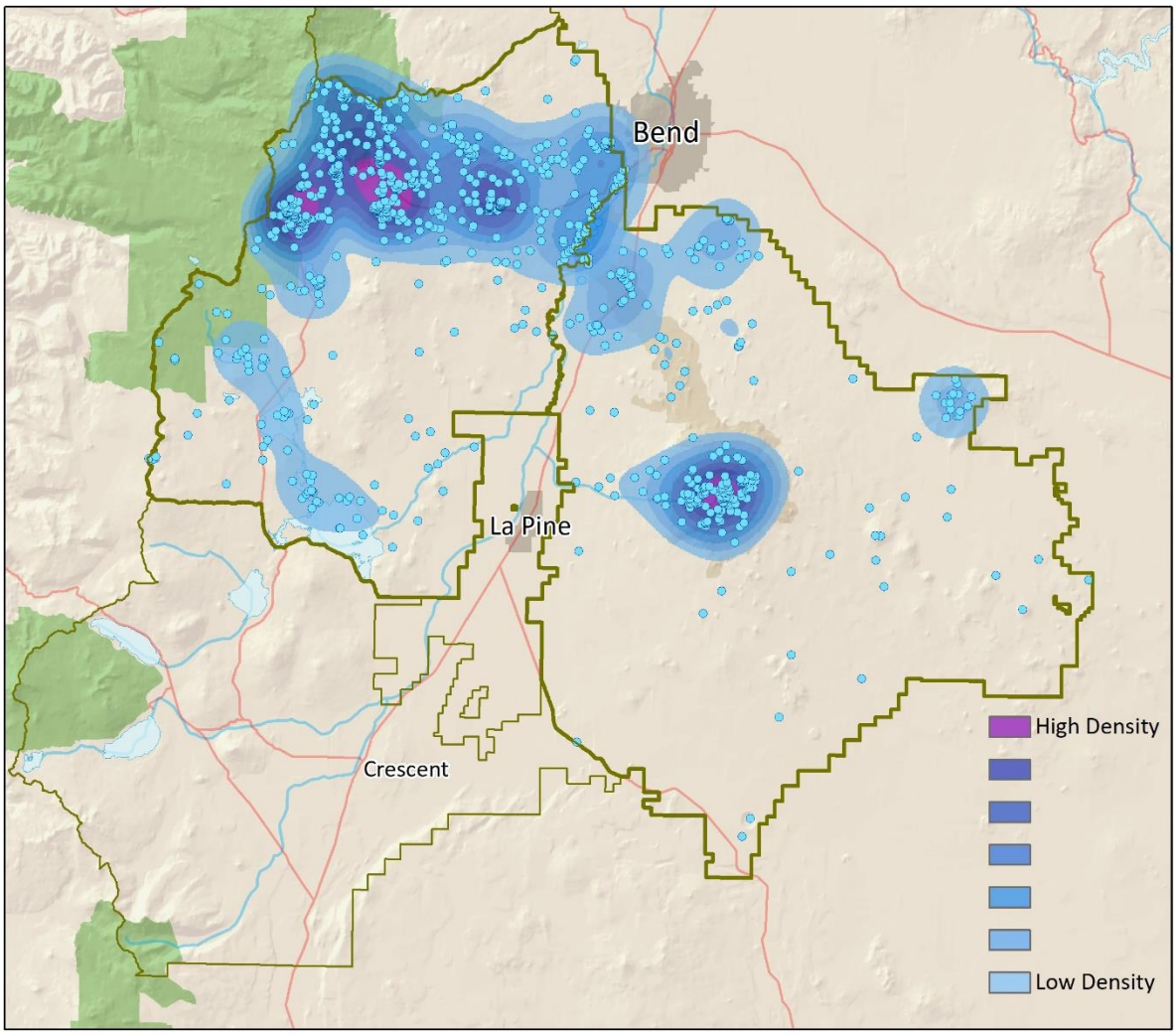

Figure 7.3 – Bend/Fort Rock Ranger District

There were relatively few points (74) placed in the Crescent Ranger District (Figure 7.4), and as expected they were most dense around Crescent and Odell Lakes. Few points were placed at Davis Lake.

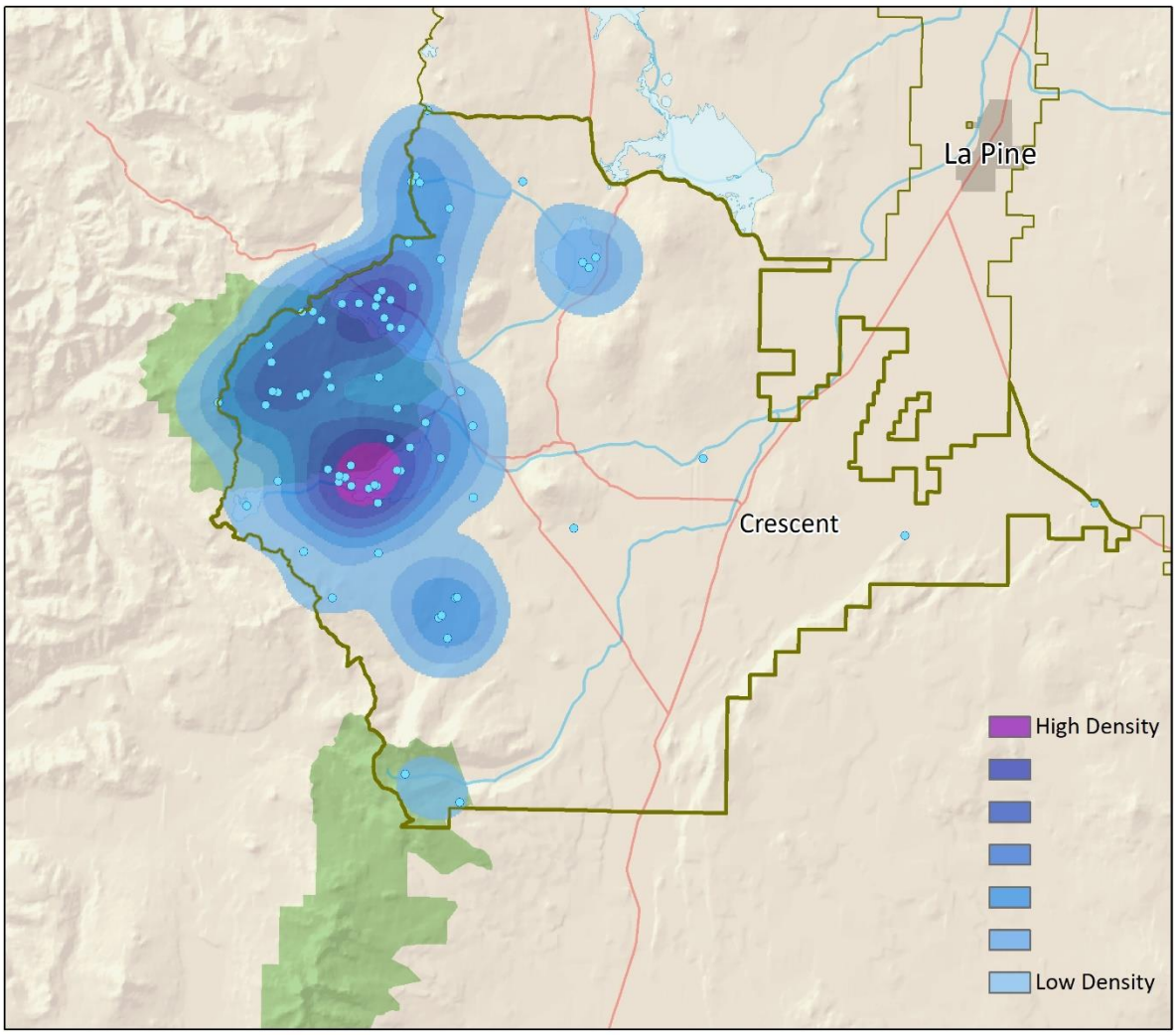

Figure 7.4 – Crescent Ranger District

The points placed in the Lookout Mountain Ranger District generated two main hotspots: The Lookout Mountain/Walton Lake area, and along the road to Mill Creek Wilderness (Figure 7.5).

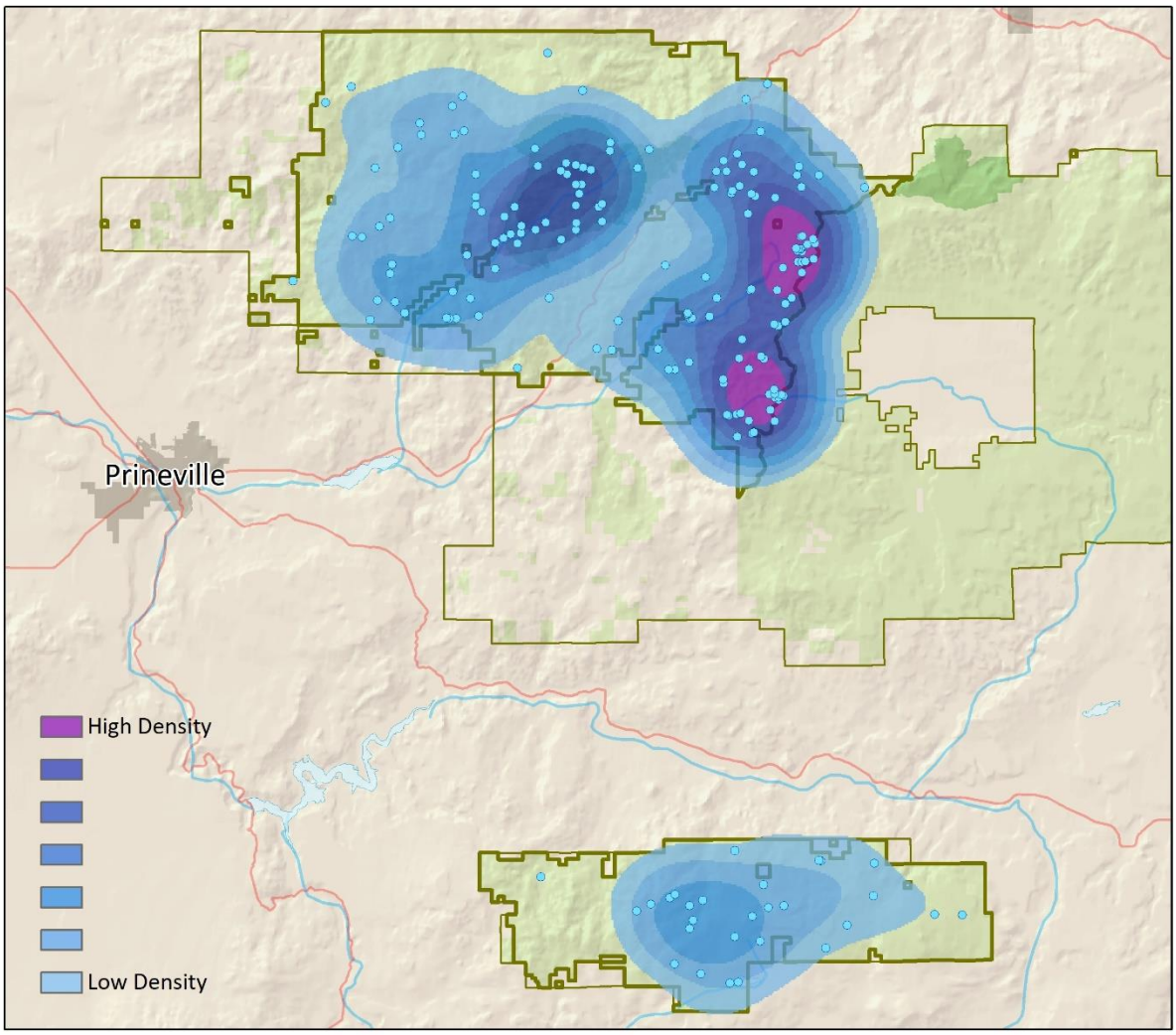

Figure 7.5 – Lookout Mountain Ranger District

The Paulina Ranger District indicated a pattern of well distributed uses, with a few notable hotspots associated with the Bridge Creek and Black Canyon Wilderness areas (Figure 7.6).

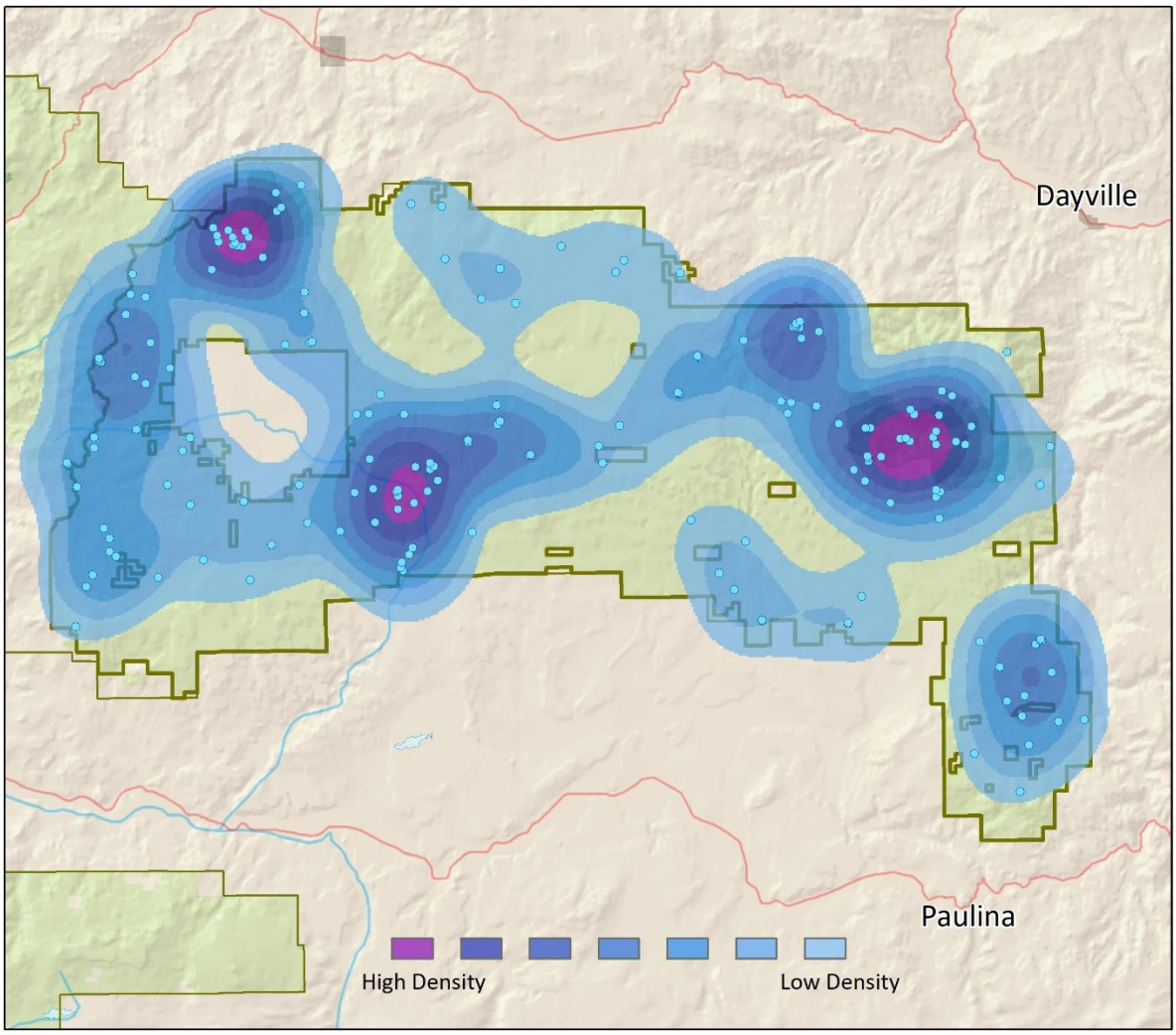

Figure 7.6 – Paulina Ranger District

In the Crooked River Grassland Ranger District, points are most dense around Lake Billy Chinook, along the Deschutes River, and in the Gray Butte/Skull Hollow area near Smith Rock State Park.

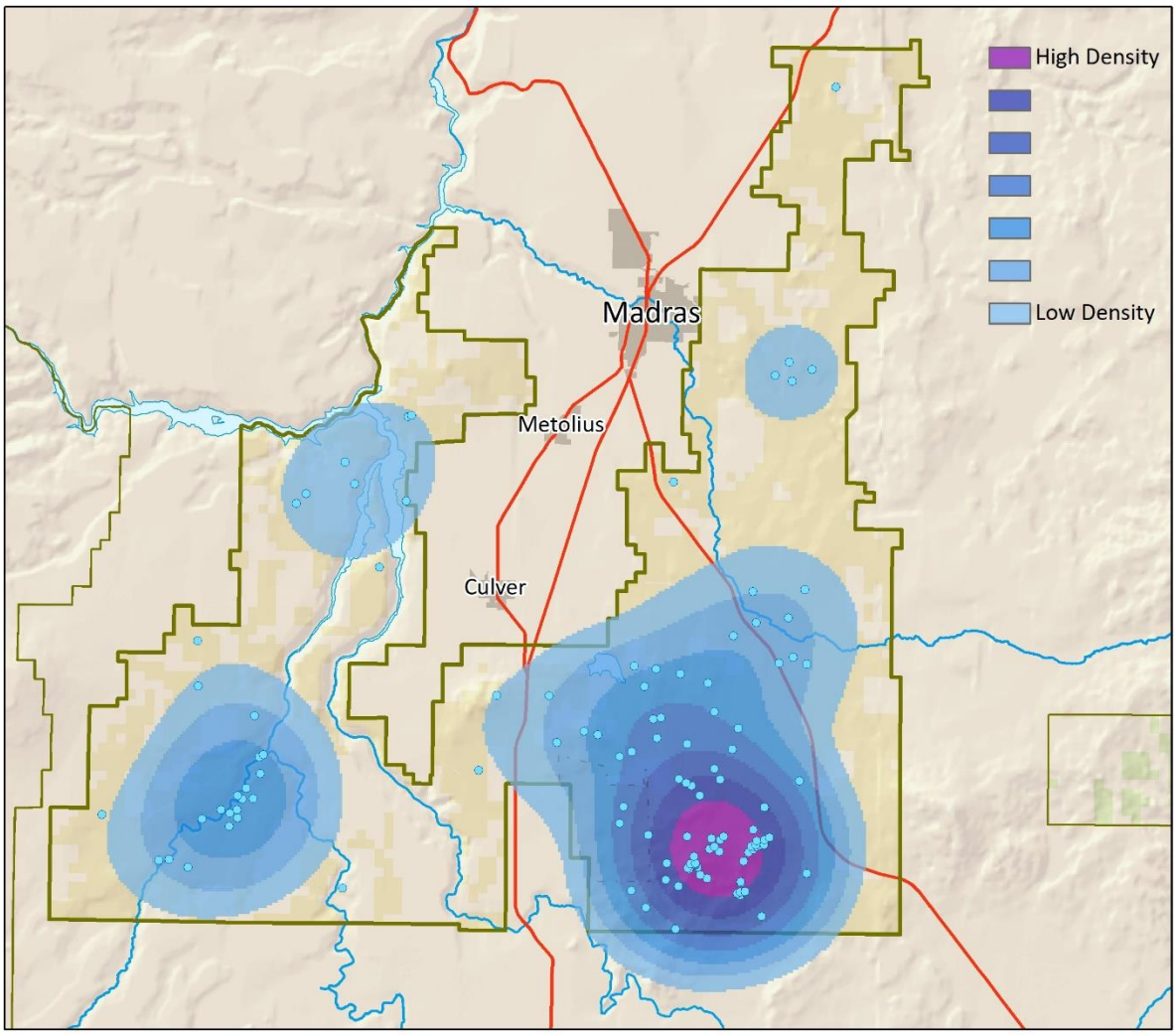

Figure 7.7 – Crooked River Grassland Ranger District

VIII. Forest Management Plans – Frequency Ratio

We used frequency ratio calculations to explore the relationship of points marked by participants and forest plan management categories. Figure 8.1 shows a consolidated version of the forest plan management categories for DNF with a number of small specialty management areas grouped together.

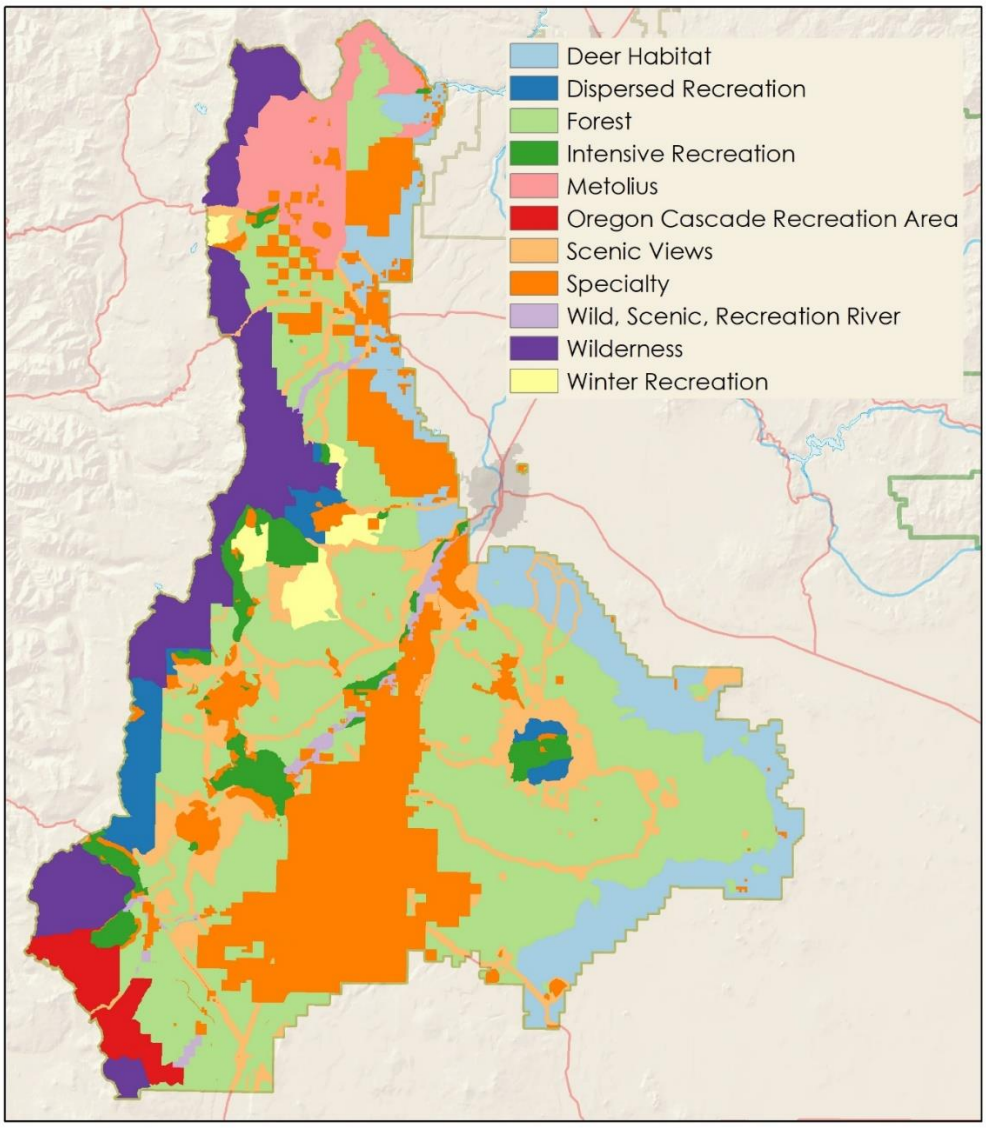

Figure 8.1 – Deschutes forest plan management categories

Using the percent of total area for each forest plan category and the total points in each area, we calculated the frequency ratios shown in Table 8.1. The results reveal that despite representing

only 3.4% of the total forest area, the *intensive recreation* category accounted for 26.1% of the total survey points, resulting in a frequency ratio much less than 1. This number indicates that participants use these areas far more than would be expected given small size of the area. In contrast, the general *forest* category has frequency ratio of 3.5, indicating that, although it has a large area (34.9% of total), respondents placed disproportionately few survey points (9.8% of total) within it. Any category with a frequency ratio less than 1 has more frequent use than would be expected given the size of the area.

Table 8.1 – Frequency ratio for each Deschutes forest plan management category

Forest Plan Category	Number of Points	% of Points	Category Area (Sq. Mi)	% of Category Area	Frequency Ratio
Intensive Recreation	365	26.05%	102.85	3.37%	0.13
Wild, Scenic, Recreation River	50	3.57%	26.85	0.88%	0.25
Dispersed Recreation	88	6.28%	76.78	2.51%	0.40
Wilderness	243	17.34%	285.94	9.36%	0.54
Winter Recreation	38	2.71%	50.26	1.65%	0.61
Metolius	100	7.14%	134.10	4.39%	0.61
Scenic Views	184	13.13%	296.11	9.69%	0.74
Deer Habitat	63	4.50%	324.36	10.62%	2.36
Specialty	121	8.64%	634.03	20.75%	2.40
Oregon Cascade Recreation Area	12	0.86%	67.01	2.19%	2.56
Forest	137	9.78%	1,056.50	34.58%	3.54
Total	**1,401**	**100%**	**3,055**	**100%**	

The same calculations were conducted for the CRNG and ONF forest plan management categories with small specialty management areas grouped together (Figure 8.2). Frequency ratio results are shown in Table 8.2.

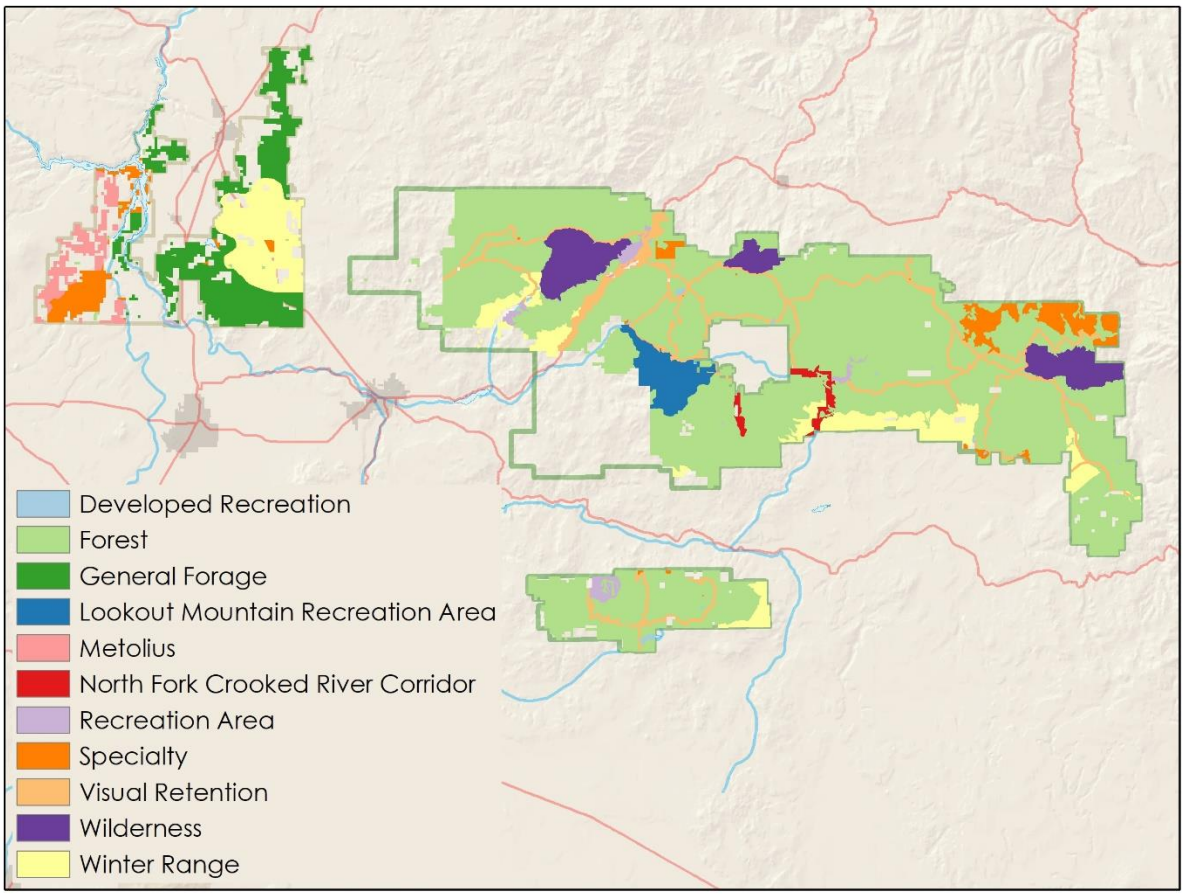

Figure 8.2 – Ochoco National Forest and Crooked River National Grassland forest plan management categories

For the CRNG and ONF forest plan management categories, the *developed recreation* category had the lowest frequency ratio, indicating that despite its small area (0.2% of total area), this category has a disproportionately large amount of survey points (4.9% of total) within its boundaries. In comparison, the general *forest* category covers 62.7% of the total area, but with only 36.4% of the total survey points, had disproportionately fewer points than would be expected.

Table 8.2 – Frequency ratio for each Ochoco National Forest and Crooked River National Grassland forest plan management category

Forest Plan Category	Number of Points	% of Points	Category Area (Sq. Mi)	% of Category Area	Frequency Ratio
Developed Recreation	24	4.85%	1.93	0.17%	0.04
North Fork Crooked River Corridor	9	1.82%	6.74	0.59%	0.33
Lookout Mountain Recreation Area	33	6.67%	24.97	2.20%	0.33
Wilderness	52	10.51%	55.43	4.89%	0.47
Specialty	41	8.28%	46.63	4.11%	0.50
General Forage	72	14.55%	85.67	7.55%	0.52
Visual Retention	44	8.89%	66.19	5.84%	0.66
Recreation Area	5	1.01%	10.16	0.90%	0.89
Metolius	6	1.21%	19.95	1.76%	1.45
Winter Range	29	5.86%	105.15	9.27%	1.58
Forest	180	36.36%	710.95	62.69%	1.72
Total	**495**	**100%**	**1,134**	**100%**	

IX. Discussion

A. Approaches to data collection

The main benefits of the online survey were 1) it allowed participation of non-local population, 2) spatial data could be downloaded directly rather than needing to be created from paper maps, and 3) once the survey was designed, there was minimal impact on staff time compared to the logistics required for workshop data collection. The initial distribution of links to the online survey by ONF and DNF public affairs officers was highly successful; almost half of the total number of survey respondents participated in the first month that the survey was available. Expanding the number of groups contacted in this manner might have increased both the number and the diversity of survey respondents. However, without any further active promotion of the survey, respondents averaged about only ten/month over the next eight months. An uptick in participation was noted during the last month of the survey when Discover Your Forest implemented several approaches to reach members of the public through both social media and physical signage. Since this effort occurred at the end of the survey, it is difficult to judge what the impact might have been if it had started earlier.

Offline data were collected using iPads during the summer months, but for a number of reasons, this effort was less successful than we had anticipated. First, although large public events such as festivals attract a broad cross section of the public, these people are not generally interested in spending twenty minutes filling out a survey. Participants who did fill out the survey under these conditions marked half as many locations as those who took the survey at home or work, and they were easily distracted. Second, the survey was administered by a single individual at most of the events. Recruiting participants and then guiding them through the survey is not a task for one person. Participation rates increased significantly when more than one person was involved. Third, the survey was less user-friendly on an iPad than on a laptop/desktop where the survey was seamless. Offline, the user had to open three separate apps, which required guidance from the survey administrator. Additionally, they had to use a touchpad rather than a mouse, and in a number of cases had to deal with glare on the tablet screen.

The survey was quite long. Although the goal was to create a survey that most people could complete in 10 minutes, in practice it took many people 20-25 minutes to complete. Having a survey of this length may be less of an issue if respondents take the survey at home or work, but it proved to be a major issue for collecting data in the field. The number of questions that participants had to answer about each individual point was especially problematic. This

number should be kept to the necessary minimum to avoid survey fatigue. A much shorter survey might be successfully used at public events or other field locations, but administering the survey in the field using tablets requires a trade-off in terms of how much data will be available to analyze.

Typically, PPGIS studies of national forest use attract a predominantly male (usually about a 2:1 ratio), older, higher income, and higher educated demographic compared to the population at large[12]. The participants in this survey largely reflect this same demographic, with the exception of gender, which was close to that of the general population. Since reliable data on the average demographic of forest users is unavailable, it is not possible to tell how the survey demographic compares with that of the average demographic of actual forest users. It is possible that the demographics of the respondents are similar to those forest users most engaged in how the forest is managed. Nonetheless, it is clear that certain groups are underrepresented, especially racial minorities and the less-educated members of the public. However, an online survey is unlikely to reach these underrepresented groups even with intensive outreach or a language-specific survey such as the Spanish-language version created for this effort. Focus group workshops would be the best way to reach these missing populations.

B. Approaches to analysis

The mapping survey was designed to collect data at the scale of the entire forest and the analysis was generally conducted at that same scale. The heavy use of the area to the west of Bend resulted in a hotspot of use that in many cases dominated the overall pattern of use. Subdividing the data by ranger districts was particularly useful as it provided more detailed use patterns. Many of the recreation zones had enough data points for detailed analysis, but some infrequently marked areas did not. If the intent is to explore even more specific site locations, in most cases more respondents (more data points) are needed.

The data collection was limited to three defined scales, and the accuracy of the point placement is dependent on the scale at which each point was placed. If the map was zoomed out to the forest scale, point placement can be off by a significant distance; points placed at the zoomed in scale will be more accurately placed. In future applications, we recommend that the application be configured so that points can only be placed at the most zoomed in scales.

[12] Brown, G. (2012). Public Participation GIS (PPGIS) for Regional and Environmental Planning: Reflections on a Decade of Empirical Research, *URISA Journal* Vol. 25, No. 2: pp 7-18.

Two data analysis techniques were particularly helpful. First, sub-setting the data into smaller categories (e.g., specific activities, where a respondent lives) provides a wealth of detailed spatial patterns. The only caveat is that a number of characteristics, such as very specific activities, may not have a enough points to usefully map. Second, the diversity index calculation can complement the analysis of basic use patterns. The method provides a way to look at not just how many different uses an area has but also whether certain activities dominate. To use this tool, subdivisions of the forest are needed, and recreation zones proved to be useful for this purpose. Other subdivisions could be used as well, such as forest plan categories.

C. Spatial patterns

A few main hotspots dominated the overall pattern of point placement: the area west of Bend in the DNF (Mt. Bachelor, South Sister, and Green Lakes), at Paulina and East Lakes in Newberry Crater National Volcanic Monument, near Gray Butte in the CRNG, and the western portion of the ONF in the general vicinity of Walton Lake. Certain areas, especially the large lakes in the southern part of DNF had fewer respondents than might be expected. The frequency ratio results indicated that the heaviest use occurred in areas that are already managed for a variety of recreation uses, while many of the general forest areas experienced infrequent use.

The answers to the question regarding place-specific activities resulted in detailed information about these marked locations. Some activities, such as hiking, camping, and horseback riding have widespread use patterns while others are more concentrated. Mountain biking, running, and other strenuous recreation activities occur mainly near Bend in the DNF and Gray Butte in the CRNG. Hunting takes place mainly in the ONF and fishing/water-bases activities in the DNF. A high concentration of activities does not necessarily correspond to a diverse set of activities. The high usage areas near Bend have some of the least diversity of uses. Not unexpectedly, the Three Sisters Wilderness, while heavily used, has the least diversity of activities.

The place-specific threats question also provided a rich set of data that could be especially valuable to planners. Complaints related to crowding were mainly noted in the heavily used area west of Bend. Conflicts with other users were also concentrated in that area as well as in other hotspots of use throughout the forests and grassland. Threats related to tradition resource use, such as grazing and timber-cutting, were noted predominantly in the ONF, as were motorized recreation threats. A high diversity of threats was noted in the northern (Metolius River) and southern (Deschutes River) ends of the DNF, and in both the CRNG and the ONF.

The high use areas near Bend had the least diverse set of complaints, focused mainly on crowding, access, and administrative issues.

The place-specific benefits and social environment questions did not produce particularly distinct patterns that varied from the overall use pattern. Scenery/beauty and recreation/fitness were by far the most common benefits associated with most places in the forest, and the overwhelming majority of respondents wished to have a social environment with a few people rather than being alone or around many people.

Based on the data collected in this survey, the use of the Deschutes National Forest is clearly dominated by recreationists of many different types. These users are likely to visit the areas of the forest closest to where they live, and visit them frequently. On the other hand, the Ochoco National Forest is not as heavily or frequently used as the DNF, most likely at least partly because of its distance from the most populated areas, as well as its lack of recreational opportunities. The ONF is in the process of transitioning from an extraction-oriented landscape to one that is recreation-focused, with all the expected conflicts that may result from such a change.

D. Human ecology mapping outcomes workshop

On March 14, 2018, we co-hosted with Forest and Regional staff a day-long workshop for District, Forest, and Regional planners and specialists likely to have a need for social science data in their jobs. Nearly 30 Forest Service employees participated in the workshop, which was held in Redmond, Oregon. The workshop's interactive discussions focused on identifying ways to analyze our data so that Forest Service staff could readily use the resulting maps and charts. More than 100 maps and charts were created for the workshop focusing on data analysis at the district level.

During the discussions, participants identified a number of additional analyses they would like to see conducted. For example, wildlife biologists would like to see a map overlaying the human ecology mapping data with wildlife areas so that they could more easily identify potential areas of conflict. Recreation planners were interested in having maps broken down into finer use categories so that they could more easily identify areas where wilderness users and mountain bikers congregate.

The workshop participants were very supportive of the project. As the following quotes illustrate, they described a number of ways in which the data could help them with their jobs.

"This feeds our wilderness strategy effort – it helps to tell the story visually with user comments beyond what we can get through trailhead registration information."

"It's a great visual resource to increase awareness of high-density use areas."

"It can be used for near-term planning, not just plan revision."

What became clear after a day of discussion is that future human ecology mapping projects should consider all possible ways that the data could be used.

X. Acknowledgements

We would like to thank the numerous persons who participated in project design and implementation.
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Willamette National Forest
Cheryl Friesen
Presidential Management Fellows
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USDA-Forest Service Intern
Katherine Stanton
Discover Your Forest
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APPENDIX A – Survey questions

How do you connect with the Deschutes and Ochoco National Forests and Crooked River National Grassland?

The purpose of this survey is to gather information that can help guide future land management planning and decisions on the Deschutes and Ochoco National Forest and the Crooked River National Grassland. If you agree to participate, we will ask you about your relationship to natural spaces in central Oregon. For people who use the national forests of central Oregon, we will ask you to identify places of importance. Next, we will ask you to share additional information about the public lands you visit and how you benefit from them. We will share the information gathered from the survey with the Forest Service, and will publish the results in journal articles and fact sheets.

The survey will take 10 to 15 minutes to complete. There are no foreseeable risks to you from taking the survey. Your participation is voluntary and you may skip questions or stop at any time. We will not ask you to provide information that can be used to identify you. Your answers will improve understandings of how people use and value these public lands and may help guide their future management.

This survey is sponsored by Discover Your Forest in collaboration with researchers at Portland State University. Discover Your Forest is a local non-profit partner dedicated to promoting stewardship, conservation education and volunteer programs on the Deschutes and Ochoco National Forests and Crooked River National Grassland. For more information, go to: www.discoveryourforest.org

If you have questions about your rights or welfare as a participant in the survey, please contact:
PSU Institutional Review Board, Office of Research Integrity 1600 SW 4th Ave., Market Center Building, Ste. 620; Portland, OR 97201 (503) 725-2227 or 1 (877) 480-4400

If you have questions about the survey itself, please contact:
Dr. Rebecca McLain, Assistant Research Professor Portland State University, Institute for Sustainable Solutions Tel: (503) 725-9940 Email: mclainrj@pdx.edu

- Yes, I consent to participate in this survey.
- No, I do not wish to participate in this survey.

Do you use the Deschutes National Forest, Ochoco National Forest, or Crooked River National Grassland?

- Yes
- No

NOTE: If the above question is answered yes, the respondent continues on to the mapping survey below. If the question is answered no, the mapping survey is skipped.

BEGIN MAPPING SURVEY (splash page):

CONNECTIONS WITH FORESTS AND GRASSLANDS OF CENTRAL OREGON SURVEY

This survey has two parts:

1. Mapping activity: On the following page you will see an interactive map of the forests and grasslands of central Oregon. You will be asked to add up to 5 important places to the map and answer some questions about these places. This activity has been optimized for use with desktop or laptop computers.

2. Questionnaire: After the mapping activity, you will be asked to answer some additional questions about yourself and your relationship with the forests and grasslands of central Oregon.

Your Participation is Anonymous:

Once the map appears, you start the survey by clicking on the blue button to get your anonymous identification number (AIN). Please write the number on a piece of paper. You will need to report it on the following pages.

MAP

Instructions:

Please identify up to 5 places in the Deschutes National Forest, Ochoco National Forest, Crooked River National Grassland that are important to you

Step 1 Click here for your anonymous identification number

Step 2 Pan and zoom to find desired location on the map

Step 3 Click on a colored dot in the panel below, then add to map. Start with location 1.

Answer the pop-up survey questions. Close pop-up box only when done.

Step 4 Repeat above steps for up to 5 total locations.

Step 5 Click here when you have completed the mapping activity.

Pop-Up Box Questions:

Anonymous identification number

What is the name of the place?

What benefit do you associate with this place?

- Scenery and Beauty
- Recreation and Fitness
- Solitude and Escape
- Clean Water, Air, Soil
- Social and Family
- Habitat
- Wild
- History, Culture, and Tradition
- Food and Provisions
- Economic
- Other

Select a second benefit or leave blank.

Select a third benefit or leave blank.

What activities do you do at this place?

What kind of social environment do you seek at this place?

- Alone
- A Few People
- Many People

What feature makes this place stand out?

- Lake

River or Stream

Waterfall

Mountain

Forest

Grassland

Meadow

Wetland

Lava Field

Historic Buildings

Recreation Facilities

Select a second feature or leave blank.

Select a third feature or leave blank.

What, if anything, threatens or detracts from your experience at this place? Are there changes you would like to see that would improve your experiences here?

END MAPPING SURVEY

About You

These questions tell us a little bit more about who you are and how you relate to the forests and grasslands of central Oregon.

What is your anonymous identification number (AIN)?

Where do you currently live? (city/town)

What is your zip code?

How long have you lived in your community? (number of years)

What organizations do you belong to that best reflect your views about natural resources and the environment? List up to 3.

What interests do you have, or activities do you engage in, that best reflect your views about natural resources and the environment? List up to 3.

Which statement below best describes you?

- I am an employee of the US Forest Service.
- I rely on the national forests and grasslands to make a living or to sustain my household.
- The national forests and grasslands are highly important to my lifestyle, health, fitness, and well-being.
- I visit the national forests and grasslands occasionally with family, friends, out-of-town guests, or organized groups (e.g., school, church, civic).
- I am glad that the national forests and grasslands are there, but I don't visit often.
- I don't know much about the forests or grasslands and I don't go there at all.

Which national forests and grasslands in central Oregon do you visit or use?

	Once or twice a week	About once a month (10-12 times/year)	Several times a year (2-9 times/year)	Once a year or less	Never
Deschutes National Forest					
Ochoco National Forest					
Crooked River National Grassland					
Other public or tribal lands					
Private forests or rangelands					

NOTE: If respondent previously answered that they did not use the Deschutes National Forest, Ochoco National Forest, or Crooked River National Grassland, they were asked the following question in lieu of the question above:
What are some reasons why you do not visit forests, parks, grasslands, or other outdoor places?

Check all that apply.

- *Not interested or motivated*
- *No reason to go there*
- *No reliable transportation*
- *Lack of time; too busy*
- *Budget constraints*
- *Do not have outdoor experience*
- *Not sure where to go*
- *Mobility constraints*
- *Prefer indoor activities*
- *Prefer staying close to home*
- *Family/companions not interested*
- *Don't feel welcome there*
- *Not comfortable in the wild*
- *Other*

Additional thoughts:

Forest Benefits

How important are each of these forest and grassland benefits to you?

	Very Unimportant	Unimportant	Neutral	Important	Very Important
Wood for lumber, pulp, and other products for commercial use					
Grazing land for cattle, bison, sheep					
Other forest products for commercial use (mushrooms, firewood, greens)					
Providing food, firewood or other products for personal or household use					
Outdoor recreation use (hike, fish, camp, ski,					

picnic, off-highway vehicles)					
Place for improving fitness, health, emotional or spiritual well-being					
Place for youth to be outside in nature					
Place for learning about the natural world					
Opportunity for solitude and quiet					
Scenery and natural beauty					
Cultural heritage, historical value, or active cultural use					
Place to gather with family, group, or community; sharing outdoor traditions					
Habitat for wildlife, fish, and plants					
Source of clean air, soil, or water					
Wild, undeveloped natural spaces					
Other					

More About You

These final questions help us know that we are reaching a wide range of people who rely on public lands in central Oregon. We know some of these questions are sensitive. We will not be reporting this information, sharing with others, or storing it in a way that you can be identified. Also, you are free to skip any question.

What is your gender?

What year were you born?

What race or ethnicity do you identify with?

What is your highest level of education completed?

- Less than 12th grade
- High school diploma or equivalent
- Some college
- Associate's or technical degree
- Bachelor's degree
- Master's degree
- Professional degree or doctorate
- Other
- Prefer not to answer

What is your annual household income?

- Less than $25,000
- $25,000-$49,999
- $50,000-$74,999
- $75,000-$99,999
- $100,000 or more
- Prefer not to answer

APPENDIX B – Categorization of Groups and Activities

GROUP CATEGORIES	ORGANIZATIONS
Environmental Advocacy	The Wilderness Society, Central Oregon Landwatch, Oregon Wild, Sierra Club, Water Watch, Environment Oregon, Great Old Broads for Wilderness, Natural Resources Defense Council, Leave No Trace,, Oregon League of Conservation Voters, Wildlife Ecology Institute, Western Environmental Law, Greenpeace, OSPIRG, Oregon Environmental Council, Environmental Defense Fund,, Center for Biological Diversity, Protect Our Winters
Friends of / Land Trusts	Friends & Neighbors of the Deschutes Canyon Area, Deschutes Land Trust, Discover Your Forest, Trust for Public Land, Columbia Land Trust, Friends of the Metolius, Friends of the Central Cascade Wilderness, Crater Lake Natural History Association, Friends of the Samamish River, Friends of Mildred Kanipe Park, Friends of Elijah Bristow State Park, Friends of the Gorge, Friends of the Inyo, McKenzie River Trust, The Freshwater Trust
Trails	Sisters Trails Alliance, Pacific Crest Trail Association, Central Oregon Trail Runners, Washington Trails Association, Central Oregon Trail Alliance, Northwest Trail Alliance, Sustainable Trails Coalition, Salem Hiking Meetup, Bend Hikers Meetup, Tillamook Trail Patrol, Bend Trails, Greater Oakridge Area Trails
Other Outdoor	Desert Air Riders, American Whitewater, Bend Paddle Trail Alliance, Bend Bikes, Surf Rider Foundation, US Hang and Paragliding Association, Heart of Oregon Corps, Durango Running Club, Cascade Mountaineers, Backcountry Babes, The Obsidians, Oregon Kayak and Canoe Club, Dog Pac, Central Oregon Running Klub, International Mountain Bike Association, Willamette Kayak and Canoe Club, Mazamas, Evergreen Bike Club, Central Oregon Masters Aquatics, Cascade Paragliding Club, American Alpine Institute, The Access Fund, Oregon Whitewater Association, Northwest Youth Core, American Mountain Guides Association, Traditional Archers of Oregon, World Kayak, Lower Columbia Canoe Club
Equestrian	Oregon Equestrian Trails, Back Country Horsemen, Jackson County Horsemans Association, Crooked River Ranch Riders, American Endurance Ride Conference, Redmond Saddle Club, Oregon Dressage Association, Pacific Northwest Endurance Riders
Nature	Oregon Natural Desert Association, Audubon Society, Oregon Master Naturalists, Nature Conservancy, Native Plant Society of Oregon, Deschutes River Conservancy, Arbor Day Foundation, Channel Island Nature Conservancy, National Wildlife Association, The Wildlife Society, Xerces Society, Central Oregon Wild Horse Coalition American Rivers, High Desert Museum, National Wildlife Federation, Oregon Eagle Foundation, World Wildlife Fund, Mt St Helens Institute. Children's Forest of Central Oregon, Surf Rider Foundation

Natural Resources	Upper Deschutes Watershed Council, Crooked River Watershed Council, Deschutes Collaborative Forest Project, Crook County Natural Resources – PAC, Oregon State Parks, Society of American Foresters, National Park Service, BLM, Oregon Cattleman's Association, Crooked River Weed Management Area, Healthy Forests, Healthy Communities, Oregon Women for Agriculture, Crook County Stockgrowers, Oregon Farm Bureau, Upper Deschutes River Coalition, Bend Parks and Recreation, Crook County Parks and Recreation, OSU Pyromaniacs, Deschutes County Weed Board, North Unit Irrigation District, SW Middle Fork Willamette Collaborative, Coos County Parks Advisory Committee, American Fisheries Society, Jefferson County Stockgrowers, River Management Society, OSU College of Forestry, Association for Fire Ecology, Oregon Women in Timber, ODFW, Oregon land and Water Alliance, Society for Range Management, Ochoco Forest Restoration Collaborative, Society of Ecological Restoration, American Fisheries Society
Hunting and Fishing	Oregon Hunters Association, Rocky Mountain Elk Foundation National Wild Turkey Federation, Trout Unlimited, Backcountry Hunters and Anglers, Native Fish Society, Theodore Roosevelt Conservation Partnership, Ducks Unlimited, Mule Deer Foundation National Hunting Association, North American Fishing Club, Central Oregon Flyfishers, Steamboaters
Motorized Recreation	Ochoco Snow Sports, Mt. Jefferson Snowmobile Club Pacific Northwest 4-Wheeldrive Association, Lodgepole Dodgers Central Oregon Motorcycle and ATV Club, Deschutes County 4-Wheelers, Oregon State Snowmobile Association, High Desert 4-Wheelers, Central Oregon Snow Busters and Ochoco Snow Mobilers, Blue Ribbon Coalition
Nonmotorized Snow Recreation	Central Oregon Nordic Club, Meissner Nordic, Mt Bachelor Sports Education Foundation, Oregon Nordic Club, Grand Mesa Nordic Council, State SnoPark Committee, National Ski Patrol, Pacific Sled Dog and Skijore Association, Central Oregon Avalanche Association
Other	

ACTIVITY CATEGORIES	ACTIVITIES
Hiking	
Strenuous Recreation	Backpacking, bicycling, hang-gliding, paragliding, mountain biking, bouldering, climbing, running, trail running, exercise
Camping	Winter camping, horse camping, family camping, RV camping
Hunt, Fish, Gather	Hunting, fishing, shed hunting, bow hunting, trapping, turkey and grouse hunting, small game hunting, deer hunting, mushroom

	picking, fire wood cutting, fly fishing, harvesting, horn hunting, rockhounding, mining, berry picking, picking apples
Observation	Photography, bird watching, wildlife watching, admire views and scenery, geology, stargazing and astronomy, intact high elevation forests, ecology, high elevation trees and wildflowers, botanical research, enjoy large pine & fir, nature sound recording, observe and feed the fish, flower identification, look at bunch grasses and shrubs, history, observe nature, check out tadpoles, explore caves, watch the falls, observe wild horses, old gold mines and beautiful forest environment, adventure, explore
Snow - nonmotorized	Alpine skiing, snowboarding, backcountry skiing, snow kite, cross country skiing
Water - nonmotorized	Kayaking, floating, paddling, swimming, sailing, canoeing, waterfall plunging, rafting, wading, SUP, whitewater rafting
Motorized Recreation	dirt biking, operate Class II vehicle, ATV riding, snowmobiling, boating, motorcycle riding, 4 X 4, jet ski, water skiing
Horse	Horseback riding, trail riding, horseback endurance riding
Nonstrenuous Recreation	Picnicking, relaxing, read, walk, day trip to the lake, hot springs, day use
Sociocultural/Economic	Experience/ enjoy solitude, reflection time, Enjoy its beauty, enjoy scenery, work, getting away from it all, learn, driving, restore, family time, tours, education, socializing, recreate, work/volunteer, stop and stare, eat, pray love, enjoy the history, where my parents and I once spent our summers, family winter get away, favorite area for Christmas tree hunting, be outdoors, socialize with friends, get away / relax away from others, , eat and drink, contemplate, contemplate volcanic power, enjoy quiet, school groups, interpretive panels, create art, tour visitor center, volunteering, meditation, trail maintenance, geocaching, escape,

	clearing PCT, breath deep, I work wildland fires, I live here, used to work there, listen to music, let dog swim, manage fire dryland, dog training, my wedding reception was a group campout here, remember lost family members, reminisce, research, sightseeing, target practice, timber sale, tourism, clearing out invading pine, archery, bird dog trials, falconry

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