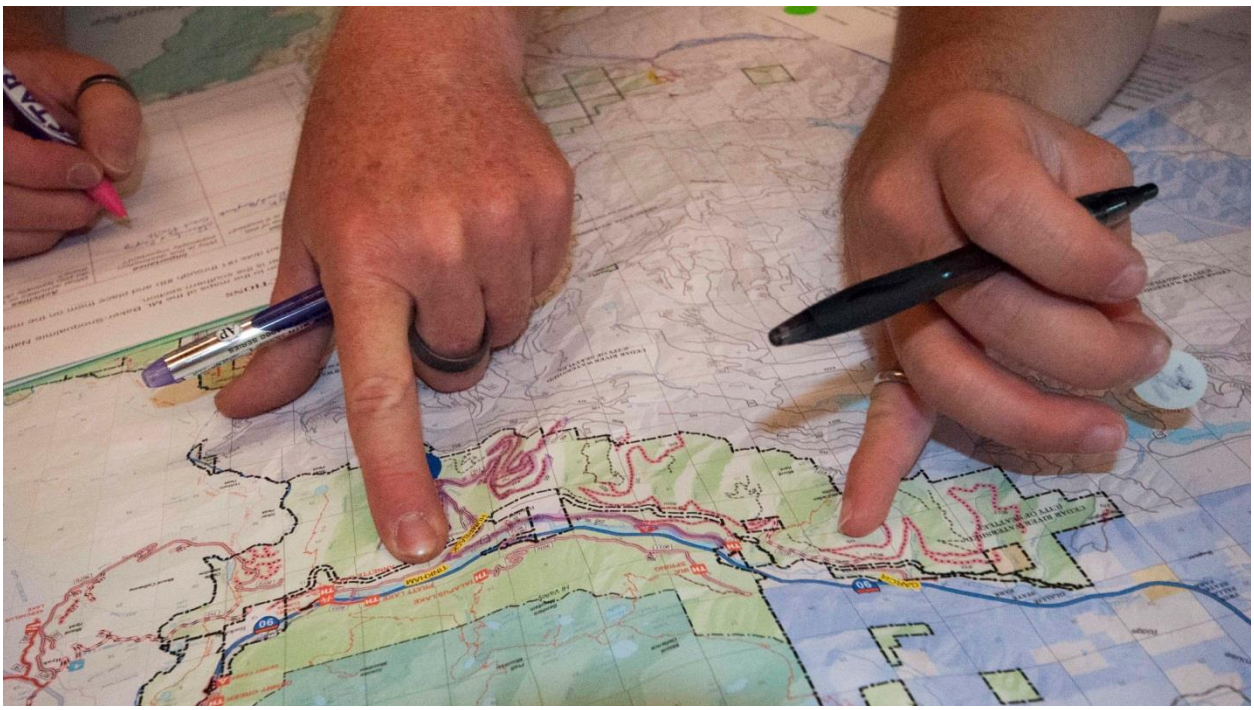
Where Do Mount Baker Snoqualmie National Forest Visitors Go and Which Roads Do They Use To Get There?

An Analysis of the Spatial Data from the 2013 Sustainable Roads Workshops



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Contents

Introduction 4

Data processing challenges 4

Data analysis 5

Density and diversity maps overview 6

Map Set 1: Combined workshops destination and road densities 7

Figure 1 – Combined workshops destination and road densities 9

Map Set 2: District destination and road densities 10

Figure 2 – Destination and road densities for the Mt Baker Ranger District 12

Figure 3 – Destinations and road densities for the Darrington Ranger District 13

Figure 4 – Destination and road densities for the Skykomish Ranger District 14

Figure 5 – Destinations and road densities for the Snoqualmie Ranger District 15

Map Set 3: Residential area destinations and road densities 16

Figure 6 – Boundaries of the Residential Areas 19

Figure 8 – Destinations and road densities for the Mountain Loop Residential Area 21

Figure 9 – Destination and road densities for the Highway 2 Residential Area 22

Figure 10 – Destination and road densities for the Everett/Skagit Residential Area 23

Figure 11 – Destination and road densities for the North/East King Residential Area 24

Figure 12 – Destination and road densities for the Pierce/South King Residential Area 25

Map Set 4: Activity destination and road densities 26

Table 1: Activity categories and example activities 26

Figure 13 – Destination and road densities for hiking 30

Figure 14 – Destination and road densities for strenuous recreation 31

Figure 15 – Destination and road densities for motorized recreation 32

Figure 16 – Destination and road densities for observation 33

Figure 17 – Destination and road densities for camping/relaxation 34

Figure 18 – Destinations and road densities for sociocultural activities 35

Figure 19 – Destinations and road densities for winter recreation 36

Figure 20 – Destination and road densities for collecting/harvesting 37

Map Set 5: Values destination and road densities 38

Table 2 – Values categories and examples of values 38

Figure 21 – Destination and road densities for access/proximity 41

Figure 22 – Destination and road densities for serenity/solitude 42
Figure 23 – Destination and road densities for aesthetic 43
Figure 24 – Destination and road densities for nature/wilderness 44
Assessing diversity of uses 45
Table 3 – Diversity of use at high density destinations for activities 45
Table 4 – Diversity of use at high density destinations for values 46
Map Set 6: Activity and value diversity for roads 47
Figure 25 – Activity diversity for roads 49
Figure 26 – Values diversity for roads 50
Conclusion 51
Appendix A – Combined workshops road density summary 53
Appendix B – Residential areas: High density destinations 55
Appendix C – Map of high destinations and roads 56
Appendix D - Kernel density and diversity index methods 57
Figure C-1 – Comparison of Shannon and Simpson index weights 59

INTRODUCTION

This report provides an overview of the key patterns that emerged from the spatial analyses of the destination and route data collected during the 2013 Sustainable Roads workshops on the Mount Baker Snoqualmie (MBS) National Forest. We excluded the pilot workshop data from the analyses because a somewhat different process was used to collect the mapped data. The data used in the analysis was collected from 262 participants in eight workshops (Bellingham, Sedro-Woolley, Darrington, Monroe, Everett, Seattle, Issaquah, Enumclaw). During the workshops, participants mapped up to eight destinations of importance to them, and in most cases, also mapped the routes they took to each destination. For each destination and its associated route, participants also provided the following information.

- Name of the place
- Why the destination is especially important
- What activities or work the participant does there
- How often the participant visits the place in a typical year
- What type of transportation the participant uses to get there

Of the 262 participants, 252 provided useable data for destinations and 246 provided useable data for roads. The dataset used in the spatial analysis contained 1733 records for destinations and 1609 records for roads. We entered the worksheet data for the destination and road mapping exercise into an Excel spreadsheet. The activities associated with each destination were grouped into eight categories (camping/relaxation, collecting/harvesting, hiking, motorized recreation, observation, sociocultural, strenuous recreation, and winter recreation). Although most people listed no more than two activities for a location, some people listed up to six different activities for certain destinations. The description of why a participant visited a particular location was similarly classified as a set of eight different values. Given the way the question was posed, many of the reasons workshop participants gave for visiting a particular place mirrored the activities in which they participated.

The spatial analysis team created map data from a roads dataset provided by MBS National Forest. The routes in the dataset were converted to lines broken at all intersections. Since the lines marked on the maps did not necessary begin or end at intersections, the digitized lines were broken at the beginning and ending vertices for analysis. Segments of state highways (SR 542, 20, 2, etc.) that were marked by participants were removed from the dataset prior to analysis. Marked county roads were retained for analysis to provide context for routes taken to certain popular destinations (e.g., Cascade River Road).

All data were checked for quality by someone who did not create the map data.

DATA PROCESSING CHALLENGES

We encountered several problems with consistency in the data while preparing the data for analysis. These problems are important to understand because they affect the conclusions that can be drawn when analyzing the data.

1) The markers used to identify destinations on the map were quite large, and if a particular location was popular, the destination points were often quite a distance removed from roads. If we could determine the specific location by matching the road marking with a name on the worksheet, then we moved those points to the correct location, rather than digitizing the exact location where they had been placed on the map.

2) Many participants marked destinations located miles away from the end of a road. We moved these points to within a half mile of the end of the corresponding marked road on the map.

3) The starting location for roads that participants marked was not consistent. Some people started from locations that were presumably near their homes, while others marked only small road segments near their destinations. Although the resulting density pattern is usually logical (the density is higher at the beginning of a road than at the end because all map marks do not cover the entire route), the inconsistent starting location can lead to less intuitive density patterns. For example, in some cases the middle part of a route is more densely marked than both the beginning and end.

4) Some participants did not clearly mark a particular road (usually using a straight line to approximate the route), especially in areas with a dense concentration of forest service roads. We made an attempt to discern the most logical route to the marked destination and used that route in the analysis.

5) A number of participants marked a destination but no route. This was often the case if the route had already been marked by someone else. If an obvious route could be discerned, then we digitized that route. If not, we retained the destination but did not include a route.

6) Certain participants marked entire road networks without specific locations. We digitized these as marked.

DATA ANALYSIS

We used ArcGIS 10.1 software to do the spatial analyses and produce maps from the workshop data. The road segments were combined using the dissolve function to calculate the number of overlapping segments. This number is the road density value, with more overlaps yielding a higher density. This density calculation was performed on all data as well as particular subsets of the data (zip code areas, activity classes, etc.). Data on the maps are classified using the same value ranges for each dataset so that the same values in each subset are represented by the same colors on each map. That means that each map may not show the full range of colors if there were not a large number of overlaps for the dataset being mapped. The highest number of overlaps for a road segment was 104.

Since the destination points marked on the map were not overlapping, we used a kernel density calculation to show the concentration of destination points. The kernel density analysis results in a map

that is similar to population density maps except that the map shows how densely destinations are spread out over an area rather than how population is distributed over an area. The higher the density, the more times the location was mapped. To take into account differences in how often participants went to the places they mapped, we weighted the destinations based on the frequency of use marked on the worksheets. Destinations listed as being used “several times a week” or “several times a month” were given a weight of 2; those listed as being used “several times a year” or “about once or twice a year or less” were given a weight of 1. Unlike road density, each kernel density calculation is symbolized with the same color palette ranging from least to greatest density, regardless of the absolute value of that density. What is most important with the destination density is to identify areas of relative high concentration, and the actually density numbers are not shown. A technical explanation of the kernel density analysis is provided in Appendix B.

DENSITY AND DIVERSITY MAPS OVERVIEW

We created five sets of road and destination density maps and one set of activity diversity maps to analyze the spatial data collected during the MBS National Forest Sustainable Roads workshops. The density maps show the frequency with which specific locations and road segments were mapped. The activity diversity maps show which roads tended to be used for a diversity of forest uses and which were used for a more limited set of activities. Each set of maps is prefaced with a narrative describing the major patterns for each map included in the set.

When interpreting the maps, it is important to remember that the destinations people mapped could represent three different types of destinations.

1) Actual destinations, such as campgrounds or waterfalls adjacent to or at the end of a road,
2) Access points to destinations located at a distance from the road, such as the top of Mt Baker or an alpine lake in a wilderness area, and
3) A road segment or road network (these were most commonly associated with motorized recreational activities).

It is helpful to think about the destinations shown on the maps as places at or near where people parked their cars, and to recognize that in many cases the participants would then go by foot, horseback, bicycle, skis, snowmobile, or all-terrain vehicle to some place further from the road. As a result, the absence of destinations in wilderness areas or other locations situated some distance away from a road indicates that those area are not directly accessible from a road, rather than that they are places where no one goes.

MAP SET 1: COMBINED WORKSHOPS DESTINATION AND ROAD DENSITIES

The combined workshops density map was created using data from all the workshops, and shows how many times the participants mapped particular roads and destinations on the entire MBS National Forest. In creating this map, we included both the destination and road densities so as to make it easier to see the relationships between them than if they were located on different maps. A list of the roads with 11 or more overlaps on the combined workshops density map is included in Appendix A; a map showing the locations of high density roads and high destination densities is included in Appendix C. To put the roads data into perspective, the MBS had 2500 miles of roads, not counting decommissioned roads. Of these, 1798 miles (72%) were mapped by at least one or more participants, and 1469 miles (59%) were marked by two or more participants.

High density destinations and roads tended to be located in the northern half of the forest, with participants most frequently mapping sites near Mount Baker and the Mountain Loop Highway. The skew toward the northern end of the forest is due to a number of factors. First, roughly two-thirds of the participants who provided spatial data were from the northern communities (Bellingham, Sedro-Woolley, Darrington, and Everett). Second, the national forest lands in the north are less fragmented, creating wilderness hiking and mountaineering opportunities that aren't available in the south. Third, the terrain in the north is much more rugged than in the south, which, as reflected in the activities density maps, many forest users find aesthetically more pleasing.

High density destinations on the Combined Workshops map included:

- Twin Lakes and Hannegan Pass northeast of Mt. Baker
- Heliotrope Ridge/Glacier View on Mt Baker's northwestern flank
- Schreibers Meadows on Mt Baker's southern slopes
- North Fork Sauk River (upper reaches around Sloan Creek)

Numerous sites in the northern half of the forest had moderately high density values, including Canyon Creek, Skyline Divide, and Artist Point/Heather Meadows on the north side of Mt. Baker; access points to several smaller peaks, such as Mt Shuksan and Mt Pilchuck; access points to Glacier Peak Wilderness at the end of the Illabot and Cascade River Roads; several sites along the east side of the Sauk and N. Fork of the Sauk River; and the area around Monte Cristo near Barlow Pass.

In the southern part of the MBS National Forest, none of the mapped destinations had high density values. The two most frequently mapped destinations in the south were the Hansen Creek area west of Snoqualmie Pass and the Naches Pass/Windy Gap area east of Enumclaw. Somewhat less frequently mapped, but still popular sites in the southern part of the forest included Blanca Lake/West Cady Ridge, the Dingford Creek/Goldmyer area, and Evans Creek (northwest of Mt Rainier). Evans Creek has a popular off-road vehicle trail system.

Roads with a large number of overlaps were concentrated in the northern part of the forest. The eastern part of the Mountain Loop Highway and the Siuattle River Road were the most frequently mapped roads (81 to 104 overlaps). Many of the roads in the Mt Baker and Mountain Loop area had 21 or more overlaps. Roads used by relatively few participants included the North Fork Stillaguamish Road and

Finney Creek Road northwest of Darrington and many smaller side roads off the Mountain Loop Highway.

In the southern part of the MBS National Forest, Beckler Road and Greenwater Road, both of which had between 81 to 104 overlaps over certain portions, were the most frequently mapped roads. Greenwater Road provides access to a large road network that is popular for off-road vehicle use. Beckler Road provides back-country hikers access into much of the Wild Sky Wilderness area. Other commonly marked roads in the southern MBS included the North Fork of the Skykomish River Road, the Middle Fork of the Snoqualmie/Goldmyer Road, and Hansen Creek Road west of Snoqualmie Pass.

Many of the shorter spur roads in the northern and southern portions of the forest were either unmapped or mapped by only a few individuals.

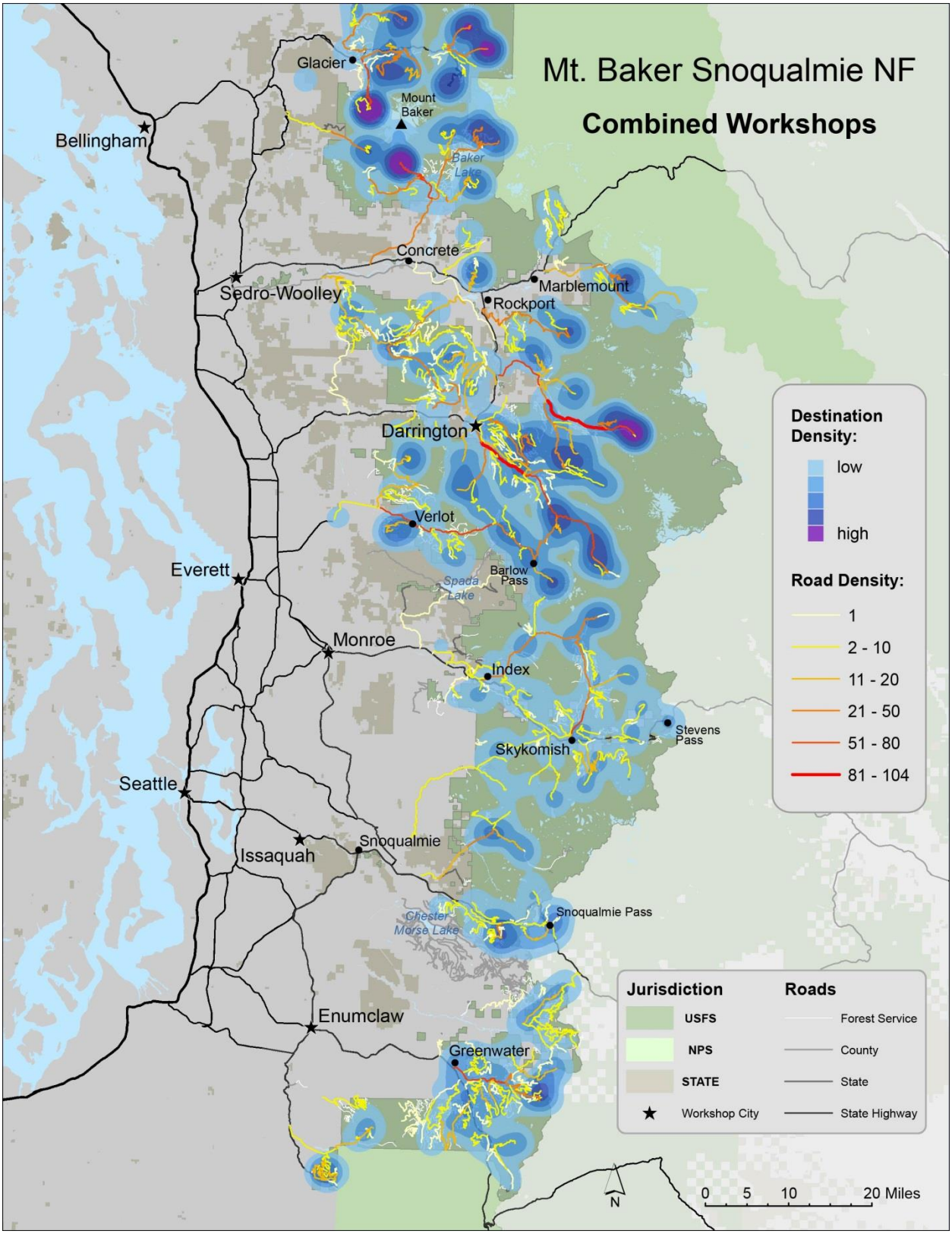


Figure 1 – Combined workshops destination and road densities

MAP SET 2: DISTRICT DESTINATION AND ROAD DENSITIES

To get a better understanding of the district-level patterns, we created road and destination density maps for each of the four Ranger Districts on the MBS National Forest. We used data from all of the workshops to develop the district maps but calculated the destination and road densities separately for each district. As a result, the maps are not merely zoomed-in versions of the forest-wide map. Rather, the district-level maps show where high density values for destinations and roads existed within each district, independently of the density values for the entire forest. This is most important for the Skykomish and Snoqualmie Ranger Districts, where fewer people mapped destinations and which therefore had a lower likelihood of having overlapping destinations or roads than the Mt Baker and Darrington Ranger Districts.

Mt. Baker Ranger District (Figure 2): Nearly all of the locations with high density values on the Mt Baker Snoqualmie were concentrated around Mt. Baker (the exception is the access point to Mt Shuksan). Heliotrope Ridge/Glacier View, Schreibers Meadows, and Hannegan Pass were most frequently mapped. Sites with moderately high values included access points to the northern part of the Mt Baker Wilderness at the end of the Canyon Creek and Twin Lakes Roads, the area around Artist Point/Heather Meadows, and the Skyline Divide area off Deadhorse Road.

Roads with the highest number of overlaps on the Mt. Baker Ranger District include Glacier Creek Road (leading to Heliotrope Ridge and Glacier Viewpoint) and Schreibers Meadows Road, both of which had between 51 and 70 overlaps. Roads in the northern part of the district with the next most number of overlaps (21 to 50) included: Canyon Creek, Twin Lakes, Hannegan, Deadhorse (leading to Skyline Divide), Wells Creek, Loomis-Nooksack, Mid-Fork Nooksack, and Baker Lake Road. South of Highway 20, the most frequently marked roads (21-50 overlaps) were Cascade River, Sibley Creek, Illabot, Finney-Cumberland, and Selegsen Roads. The majority of the roads in the southern part of the district had densities of 10 or less. A number of smaller roads off the Baker Lake road were not mapped at all.

Darrington Ranger District (Figure 3): The Darrington Ranger District's destination density map shows that people tended to go to places in the mountains southeast of Darrington. Only one destination -- the upper reaches of the Suiattle River – fell into the highest density category. However, areas in the second highest density category included: Rat Trap Pass/Circle Peak, Upper Decline Creek, North Fork Sauk Falls/Bedal Peak, and the upper reaches of the North Fork Sauk River (Sloan Peak/North Fork Sauk Trailhead/Bald Eagle Curry Gap).

Road use on the Darrington Ranger District was heavily concentrated along roads to the south and east of Darrington. The Suiattle River Road, North Fork Sauk River Road, and Mountain Loop Highway, all of which had between 81-104 overlaps along major portions, were the most frequently used roads. Dan's Creek Road, the South Side Suiattle River Road, Straight Creek Road and lower portion of Selegsen Road were also popular routes, although less frequently marked (51 to 80 overlaps). Roads with low densities were located primarily in the northwestern corner of the district, north and east of Verlot, and a number of smaller roads off the Mountain Loop Highway.

Skykomish Ranger District (Figure 4): The Blanca Lake/West Cady Ridge area in the northern part of the district was the only high density destination on the Skykomish Ranger District. Less frequently marked,

but popular destinations included Beckler Peak near the town of Skykomish; the Lake Dorothy and West Fork Foss Trailheads, which provide access into the Alpine Lakes Wilderness; Tonga Ridge, and the area along the North Fork Skykomish near Galena (northeast of Index).

Beckler Road (FS 65) and the road along the North Fork of the Skykomish River (FS 63), which together form a loop connecting the towns of Index and Skykomish north of Highway 2, had the highest number of overlaps on the Skykomish Ranger District (21 to 51 overlaps). The Rapid River Road (FS 6530) and Foss River Road (FS 6820) were also popular, albeit somewhat less frequently mapped (11-20 overlaps). The majority of the remaining roads in the Skykomish District have densities of 10 overlaps or less.

Snoqualmie Ranger District (Figure 5): On the Snoqualmie Ranger District, people tended to go to three areas: Hansen Creek west of Snoqualmie Pass, the Naches Pass/Windy Gap area northeast of Mt Rainier, and Evans Creek area northwest of Mt Rainier. Other popular, although somewhat less frequently mapped destinations were: the upper reaches of the Middle Fork of the Snoqualmie River in the northern part of the District, Snoqualmie Pass/Snow Lake, and the Huckleberry Ridge and Coral Pass areas south of Greenwater.

Greenwater Road, with 51-69 overlaps, was the most frequently marked road on the Snoqualmie Ranger District. Other popular roads were the Middle Fork of the Snoqualmie/Goldmyer Road and Hansen Creek Road west of Snoqualmie Pass. With the exception of Hansen Creek Road, Forest Service roads near I-90 were infrequently marked. The majority of the roads in the southern tip of the MBS had densities of 10 or less.

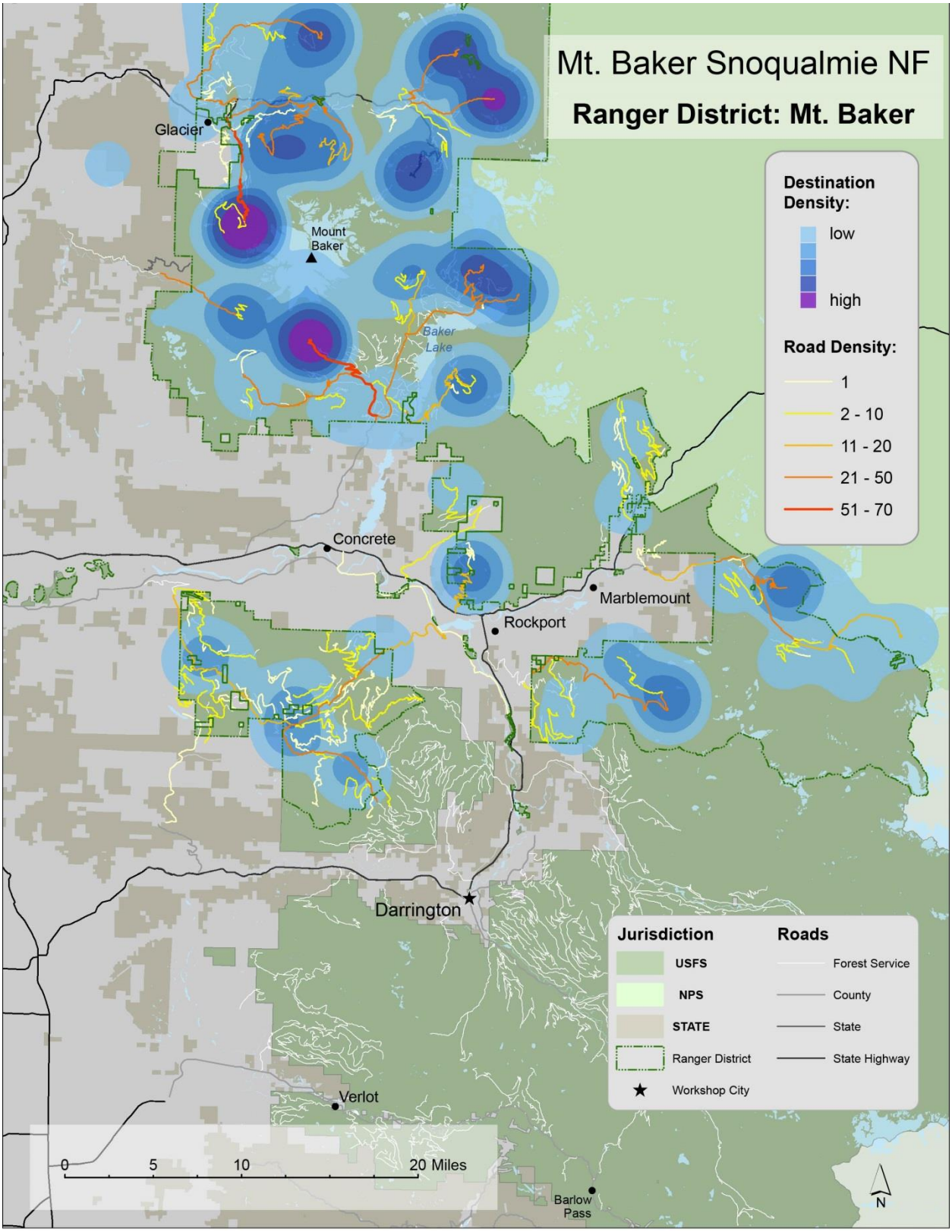


Figure 2 – Destination and road densities for the Mt Baker Ranger District

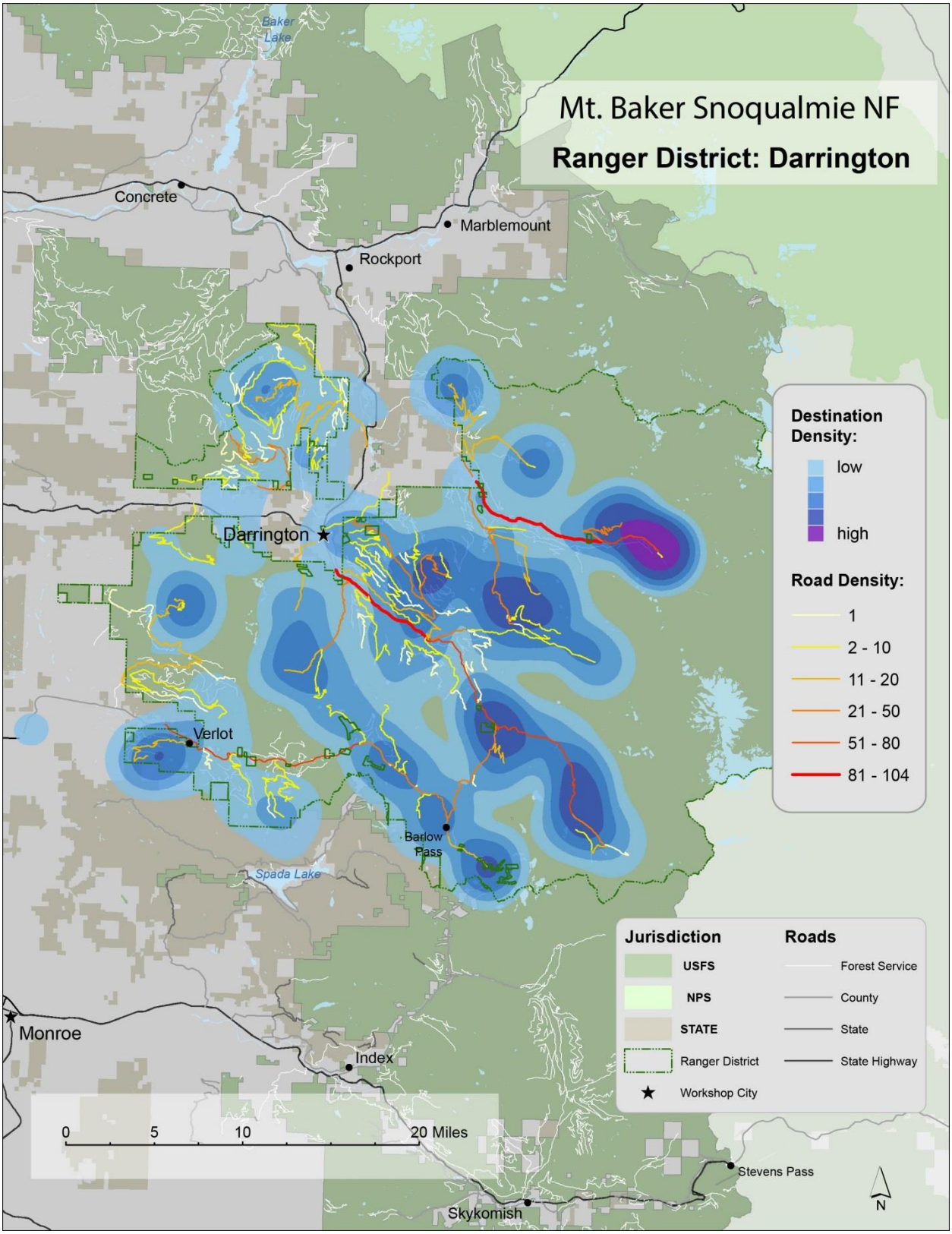


Figure 3 – Destinations and road densities for the Darrington Ranger District

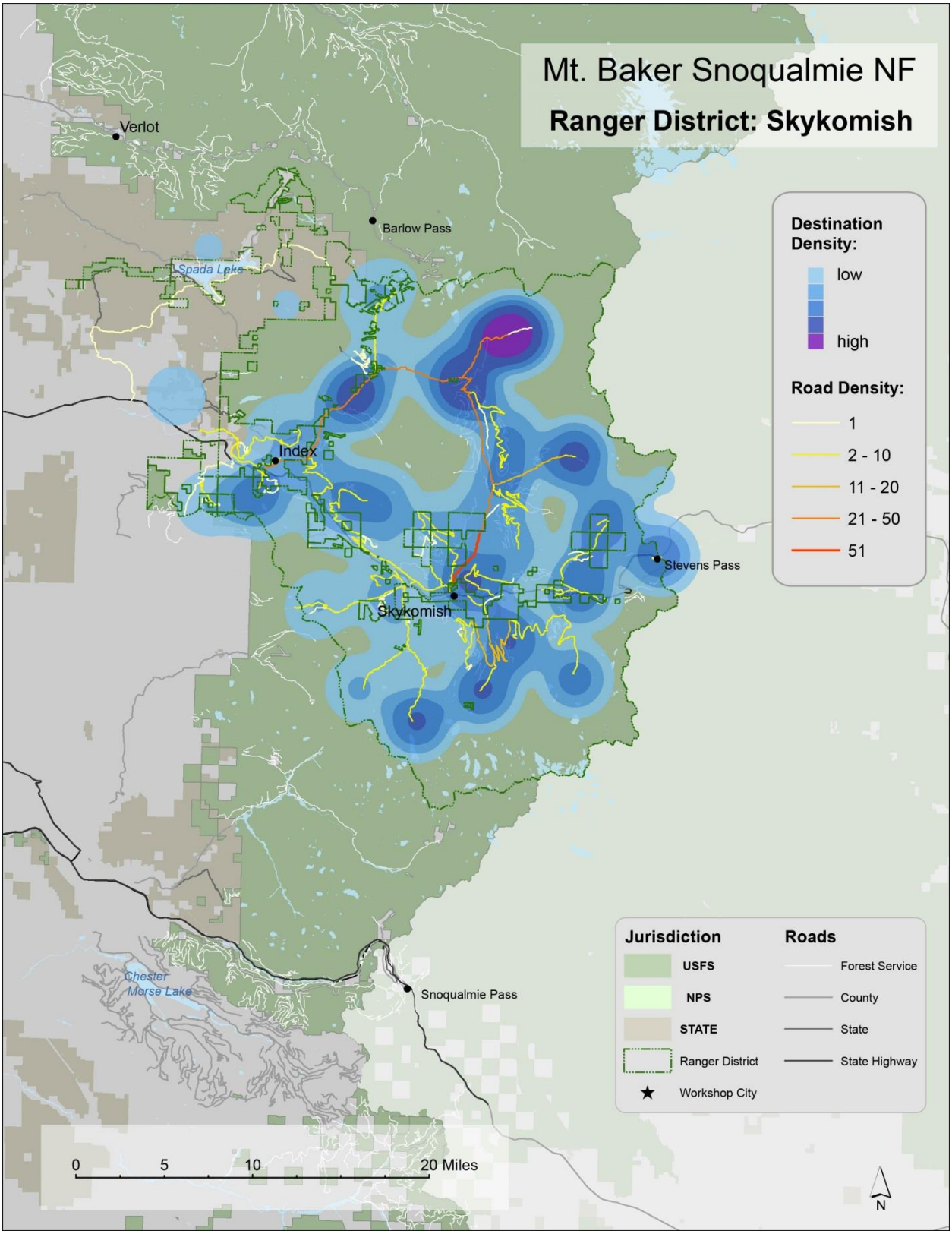


Figure 4 – Destination and road densities for the Skykomish Ranger District

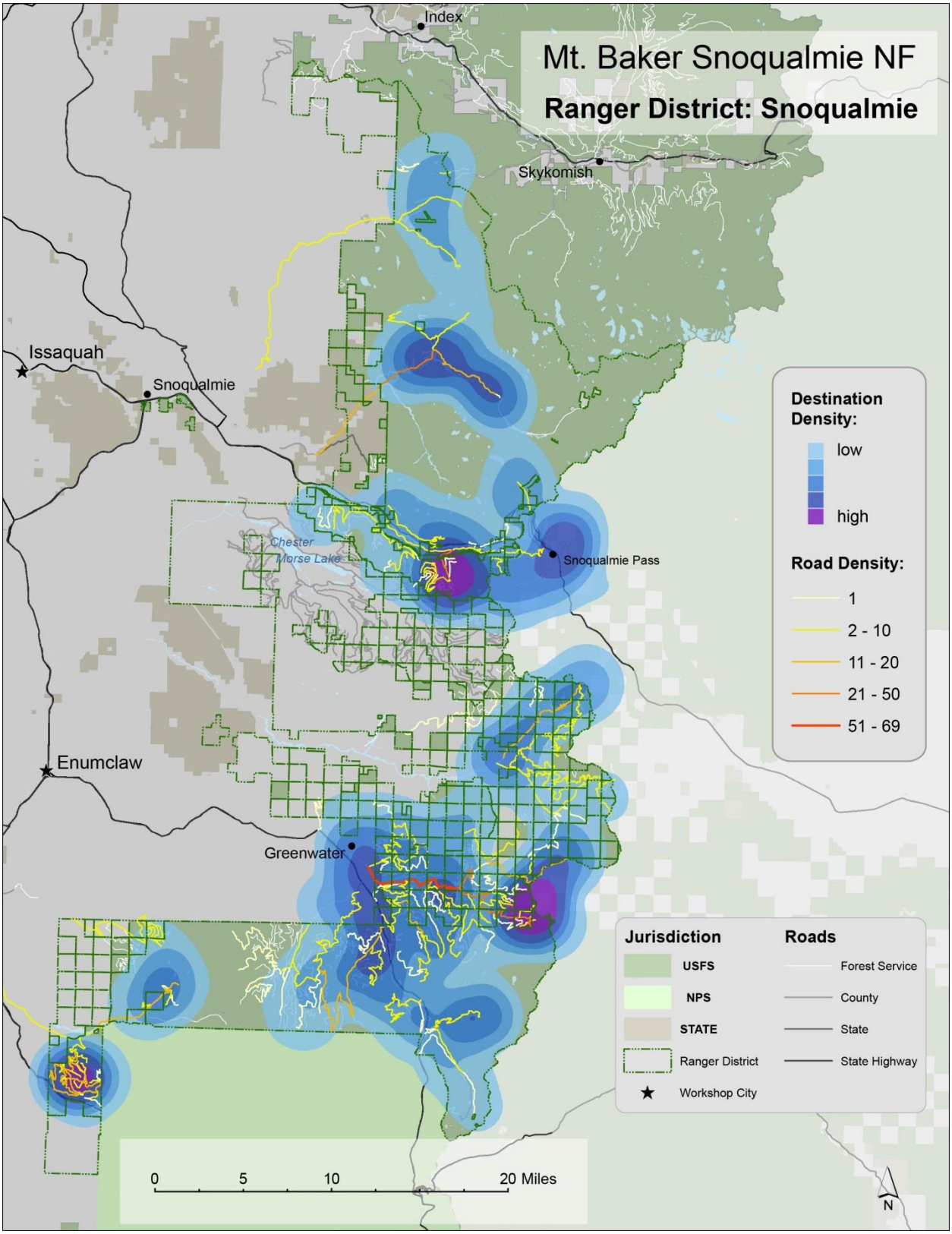


Figure 5 – Destinations and road densities for the Snoqualmie Ranger District

MAP SET 3: RESIDENTIAL AREA DESTINATIONS AND ROAD DENSITIES

We expected that where participants lived would affect which locations and roads they mapped. To verify this hypothesis, we grouped the participants into six residential areas (Whatcom, Mountain Loop, Highway 2, Everett-Skagit, North/East King, and Pierce/South King) based on their home zipcodes, and then created destination and road density maps for each area.[1] The residential areas were derived primarily from the zipcodes that dominated in each workshop, but also took into account the need to have groups of roughly the same size for our analyses. The Whatcom residential area encompasses zip codes in and around Bellingham, the Mountain Loop area includes zipcodes in and around Darrington, and the Highway 2 area includes zipcodes around Monroe and east to Stevens Pass. Because the number of participants from eastern Skagit County (many of whom had Sedro-Woolley zipcodes) was so small, we grouped them with the Everett area residents. Likewise we grouped North and East King County residents together, and South King County residents with Pierce County residents. Figure 6 shows the geographic location of each of the residential areas.

A common feature of all six residential area maps is that participants tended to go to places and use roads close to home. However, this pattern was most pronounced for Whatcom, Mountain Loop, and Pierce/South King residents, where destinations and roads with high density values were very tightly grouped in or close to the residential area. Although the highest density locations for North/East King, Skagit/Everett and Highway 2 residents were in areas close to their homes, overall their destinations were scattered over much larger areas. The table in Appendix B summarizes the high density destinations for the six residential areas.

Whatcom (Figure 7): Mount Baker was clearly the major attraction on the MBS National Forest for participants who lived in the Whatcom residential area. Heliotrope Ridge/Glacier View and Schreiber Meadows were the most frequently mapped locations, with the next most popular sites were the areas around Skyline Divide, Damfino Lake, Twin Lakes, and Hannegan Pass. Participants from the Whatcom residential area mapped very few sites south of Highway 20, and most of those were in Mountain Loop area of the Darrington Ranger District. Virtually no one from Whatcom marked destinations in the Snoqualmie and Skykomish Ranger Districts.

Roads most frequently used by Whatcom residents (31 to 39 overlaps) were clustered around Mount Baker, and included Glacier Creek, Schreibers Meadows, Loomis Nooksack, and Hannegan Pass Roads. The next most frequently mapped roads (21 to 30 overlaps), all of which were also located around Mount Baker, were Deadhorse, Canyon Creek, Twin Lakes, and the upper part of Baker Lake Road. Participants from the Whatcom residential area mapped almost no roads in the southern half of the forest.

Mountain Loop (Figure 8): Mountain Loop residents tended to go to places along the eastern portion of the Mountain Loop Highway or in sites located in or reachable through trailheads in the North Fork of

[11] Whatcom, King, and Pierce are counties .

the Sauk and Suiattle drainages. High density destinations included Grade Creek, Tenas Creek, Suiattle Trailhead area, the Upper Decline area, Rat Trap Pass/Circle Peak, North Fork Sauk Falls, and Sloan Creek area. Although Mountain Loop residents mapped a number of destinations around Mt Baker, the densities for those sites were much lower than in the mountains east of Darrington. Mountain Loop residents mapped more sites in the southern half of the MBS National Forest than Whatcom residents, but mapped no secondary concentrations.

The Mountain Loop residents' map showed high road densities only in the Mountain Loop area. The Mountain Loop Highway out of Darrington was the most frequently mapped (31 to 48), followed by the North Fork of the Sauk, Siuattle River, and Whitechuck Roads (21 to 30 overlaps). None of the roads mapped outside the Mountain Loop area had high densities, and the majority of roads in the southern half of the forest were not marked at all.

Highway 2 (Figure 9): The Highway 2 residents' destination density map had a somewhat more dispersed pattern than that on the Mountain Loop and Whatcom residential area maps. High densities for destinations were located on the Skykomish Ranger District (around West Cady RidgeRapid River, and along the North Fork of the Skykomish near Galena) and the Darrington Ranger District (Suiattle Trailhead area in the upper reaches of the Suiattle River and White Chuck/Meadow Mountain).

The Highway 2 residents' map also had several extensive secondary destination concentrations. Secondary concentrations were located around Mount Baker (Heliotrope Ridge/Glacier View and Schreibers Meadows), south and west of Darrington (Three Fingers, Bald Mountain, Coal Lake), and around Skykomish (Barclay Lake, Lake Serene, Marten Creek, Stevens Pass, West Fork Foss, Lake Dorothy, and Lake Elizabeth/Money Creek). Although Highway 2 residents marked destinations in the Snoqualmie Pass area, the densities at these locations were not very high. Only one site (Crystal Mountain) was mapped in the southern tip of the MBS National Forest.

The majority of roads mapped by Highway 2 residents had relatively low density values, with 22 being the highest number of overlaps on any road segment. The lower part of Beckler Road was the most frequently mapped (21-22 overlaps), followed by the North Fork of the Skykomish River Road, the Sauk River portion of the Mountain Loop Highway, and Whitechuck Road, all of which had between 11 and 20 overlaps. The more dispersed pattern of destinations on the Highway 2 map likely explains the relatively low road densities compared to the Whatcom and Mountain Loop residential area road densities. Many roads in the northwestern corner of the Darrington district were not marked, and only one road in the southern part of the Snoqualmie district was mapped.

Everett/Skagit (Figure 10): The map for Everett/Skagit residents also had a relatively dispersed pattern for destinations in the northern half of the MBS National Forest. Everett/Skagit residents mapped 5 high density areas: three in the Darrington District (upper reaches of the Suiattle River, Monte Cristo, Mount Pilchuck) and two in the Mount Baker District (Schreibers Meadows and Sauk Mountain). Additionally, relatively dense concentrations of sites were distributed fairly evenly from the Canadian border to

Barlow Pass. A few participants from the Everett/Skagit area mapped destinations in the southern part of the MBS National Forest, including six sites in the very southern tip of the forest.

Everett/Skagit residents mapped a much larger number of roads than their counterparts in the Whatcom, Mountain Loop, and Highway 2 residential areas. However, the densities for most roads were relatively low, with only 11 to 20 overlaps being the highest road density category. Roads with higher densities were concentrated in the northern part of the forest, primarily south and east of Darrington (i.e., Siuattle River Road, Mountain Loop Highway, the lower portion of the North Fork of the Sauk River Road) and around Mount Baker (Baker Lake Road, Schreibers Meadows Road and the lower part of Canyon Creek Road). None of the southern roads mapped by Everett/Skagit residents had high density values, and much of the road network near Greenwater was not marked at all.

North/East King (Figure 11): Destinations for North/East King residents were the most widely and evenly dispersed across the MBS National Forest. Only two destinations, the Hansen Creek area and the vicinity of Snoqualmie Pass (including Alpental Ski Area and Snow Lake), fell into the highest density category. However, numerous secondary concentrations of destinations were evident, including locations in the north (around Mt Baker), the center (sites near the Mountain Loop Highway, the Suiattle River Road, and Beckler Road), and the south (Evans Creek and the Naches Pass/Windy Gap area.

Road densities on the North/East King residential area map were very low, reflecting the extremely dispersed pattern of destinations. No roads had more than 16 overlaps. The most frequently mapped roads (11 to 16 overlaps) were the Siuattle River Road and Mountain Loop Highway in the Darrington District, Beckler Road in the Skykomish District, and the Middle Fork of the Snoqualmie/Goldmyer Road, Hansen Creek Road, and Greenwater Road in the Snoqualmie District. Although North/East King residents frequently visited destinations in the Mt Baker, Darrington, and Skykomish districts, there were many roads in those areas that they did not mark at all. Likewise, they marked very few roads in the area south of Greenwater on the Snoqualmie district.

Pierce/South King (Figure 12): The White River area of the MBS National Forest northwest of Mt Rainier was the most popular destination for Pierce/South King residents. Activities were highly concentrated in two dense road networks (Huckleberry Creek and Green Divide/Naches Pass). Pierce/South King residents also mapped a number of sites dispersed across the rest of the MBS National Forest, but no high density sites were located outside the White River area.

The only road mapped by Pierce/South King residents with a high density (31 to 45 overlaps) was the Greenwater Road (FS 70), which provides access to a large network of smaller roads heavily used by off-road vehicles. The Huckleberry Creek Road and the Green Divide spur off the Greenwater Road were the next most frequently marked routes (21 to 30). No roads north of the Green Divide had more than 10 overlaps, reflecting the Pierce/South King resident's focus on the southern tip of the forest. Many of the roads north of I-90 were not mapped at all.

Figure 6 – Boundaries of the Residential Areas

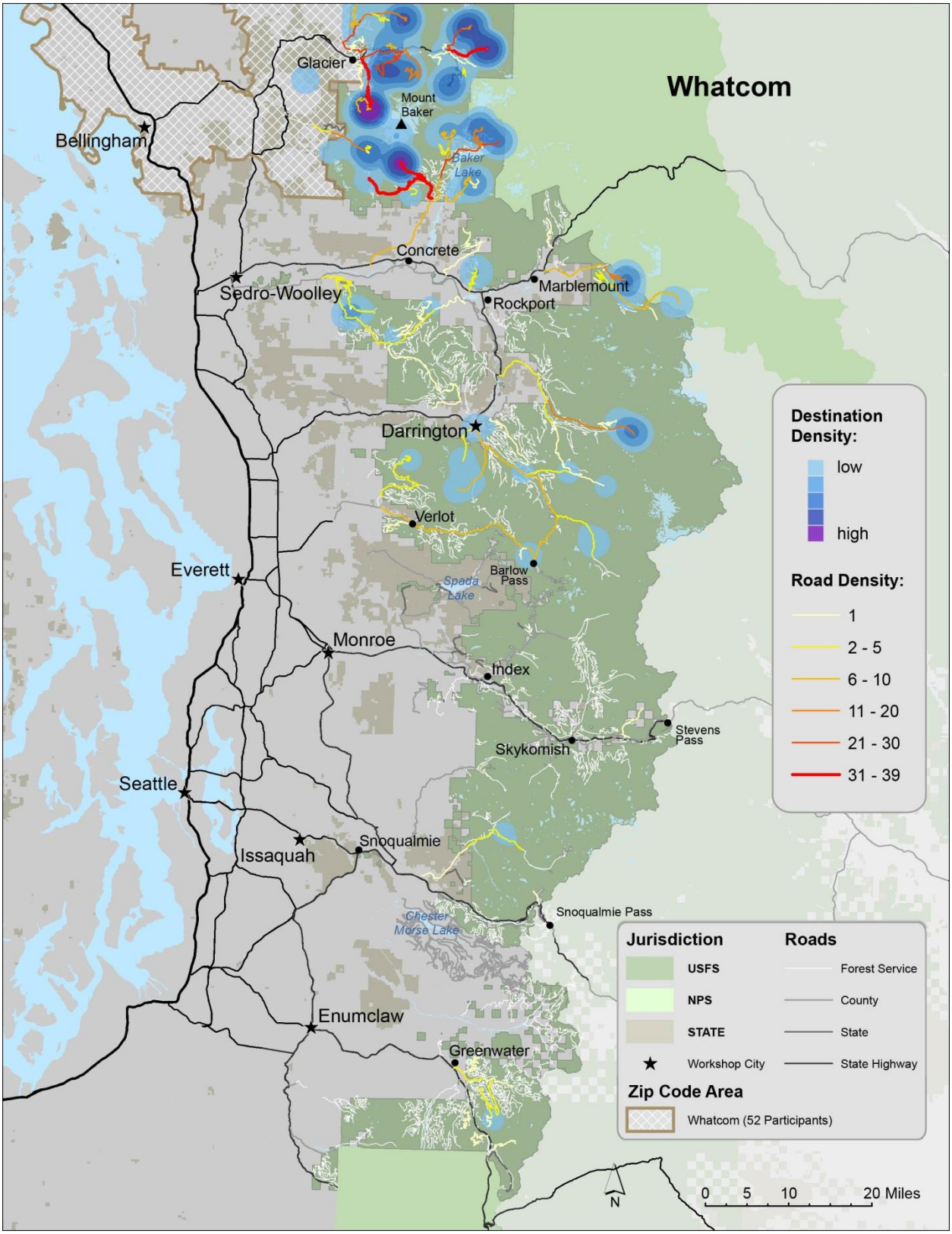


Figure 7 – Destination and road densities for the Whatcom Residential Area

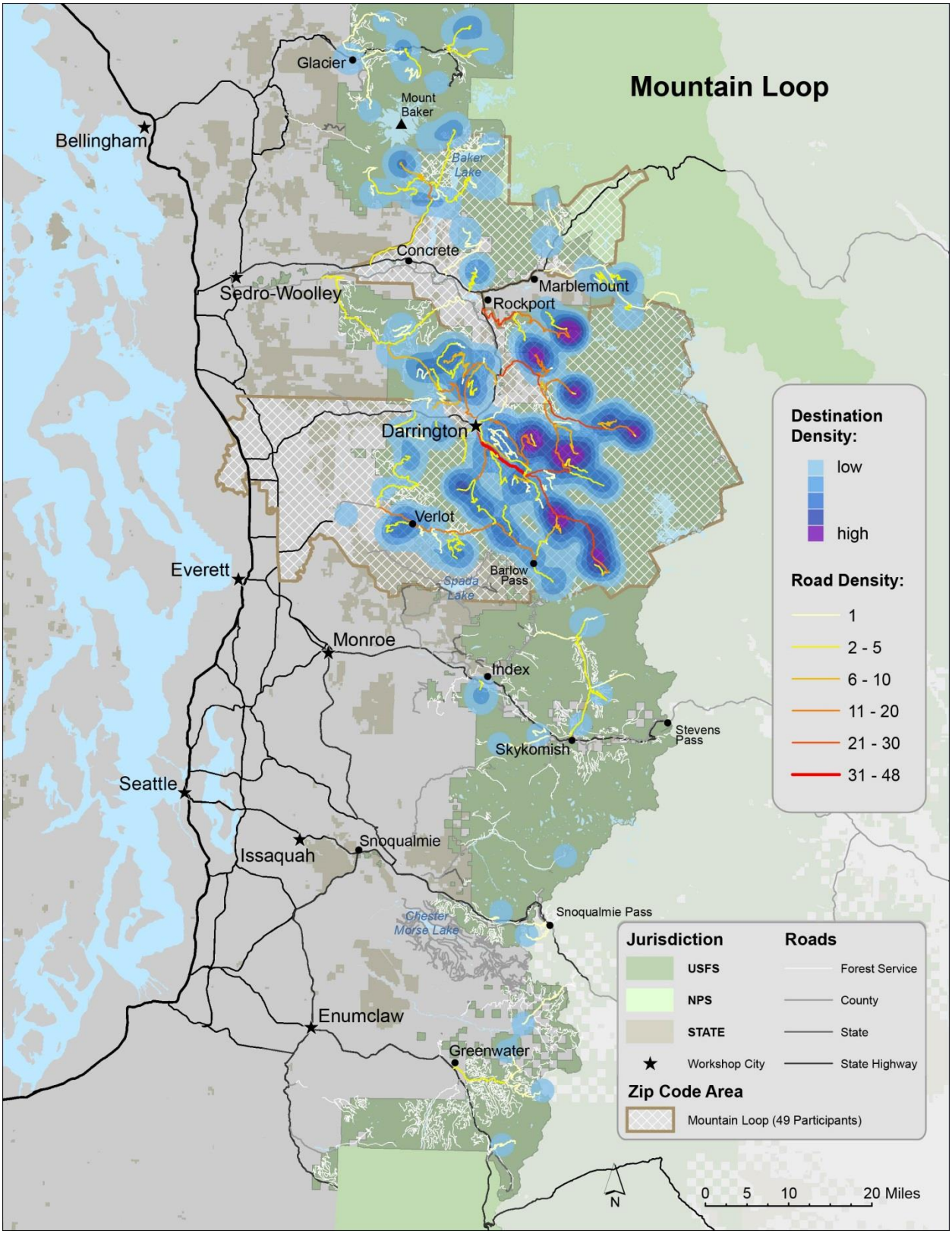


Figure 8 – Destinations and road densities for the Mountain Loop Residential Area

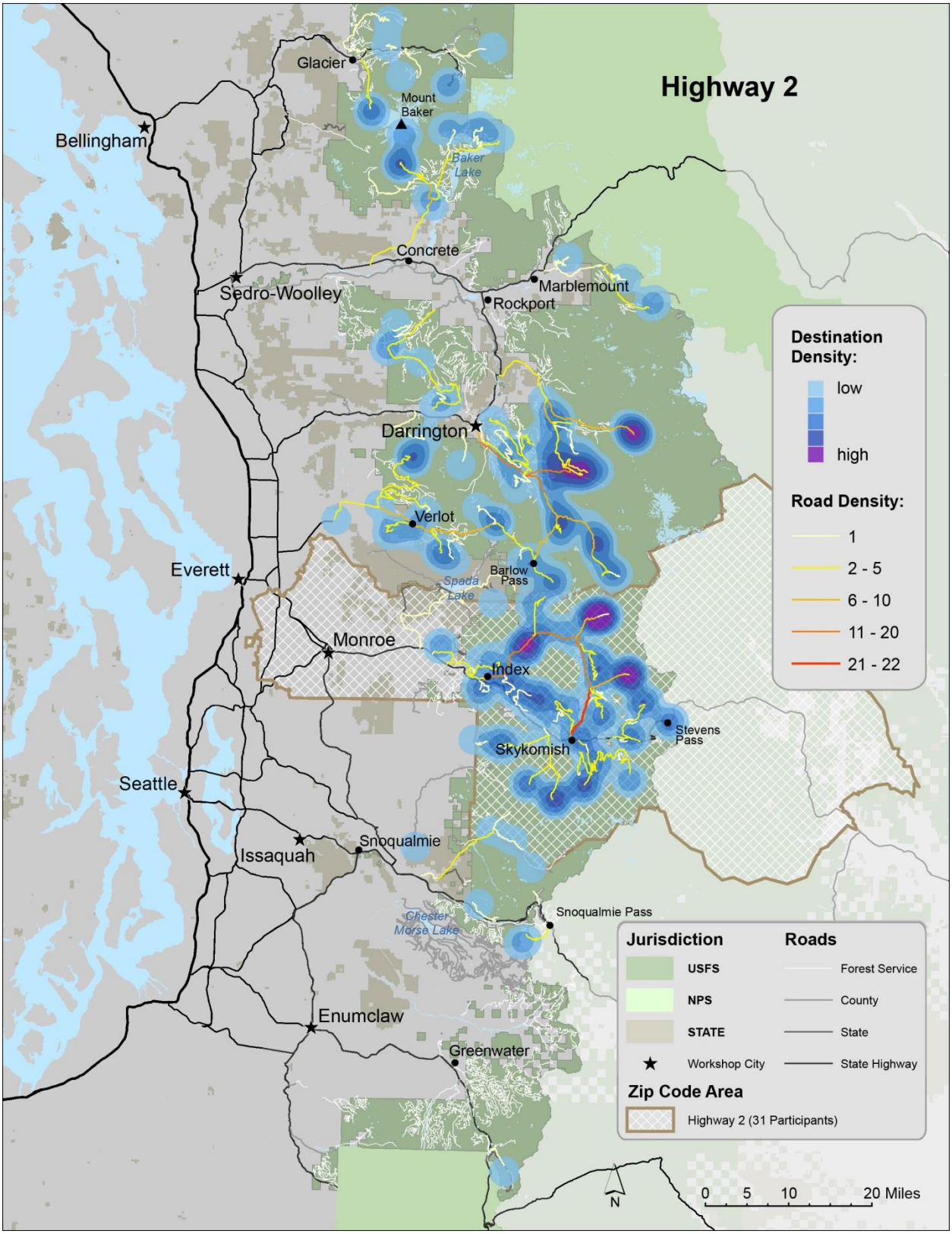


Figure 9 – Destination and road densities for the Highway 2 Residential Area

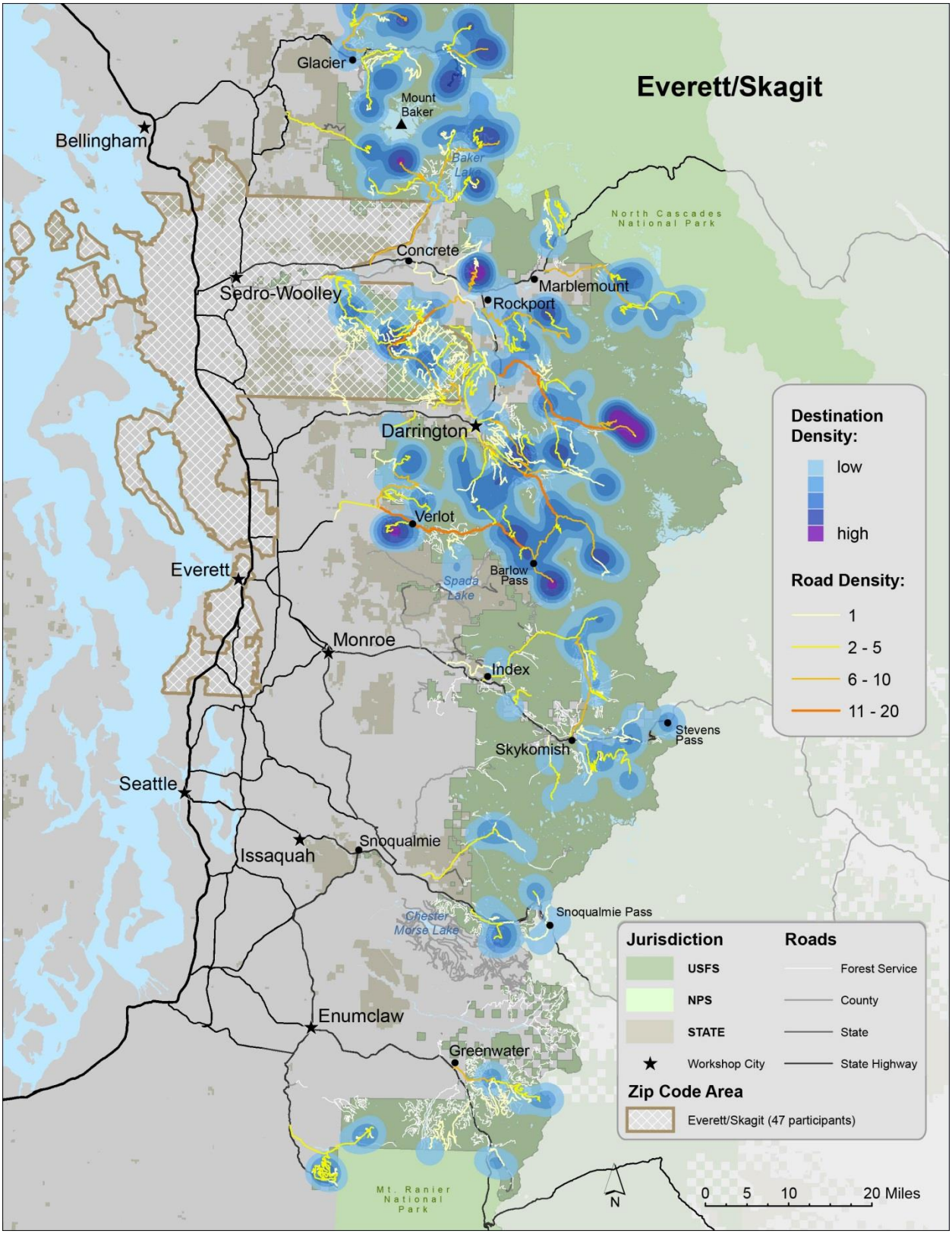


Figure 10 – Destination and road densities for the Everett/Skagit Residential Area

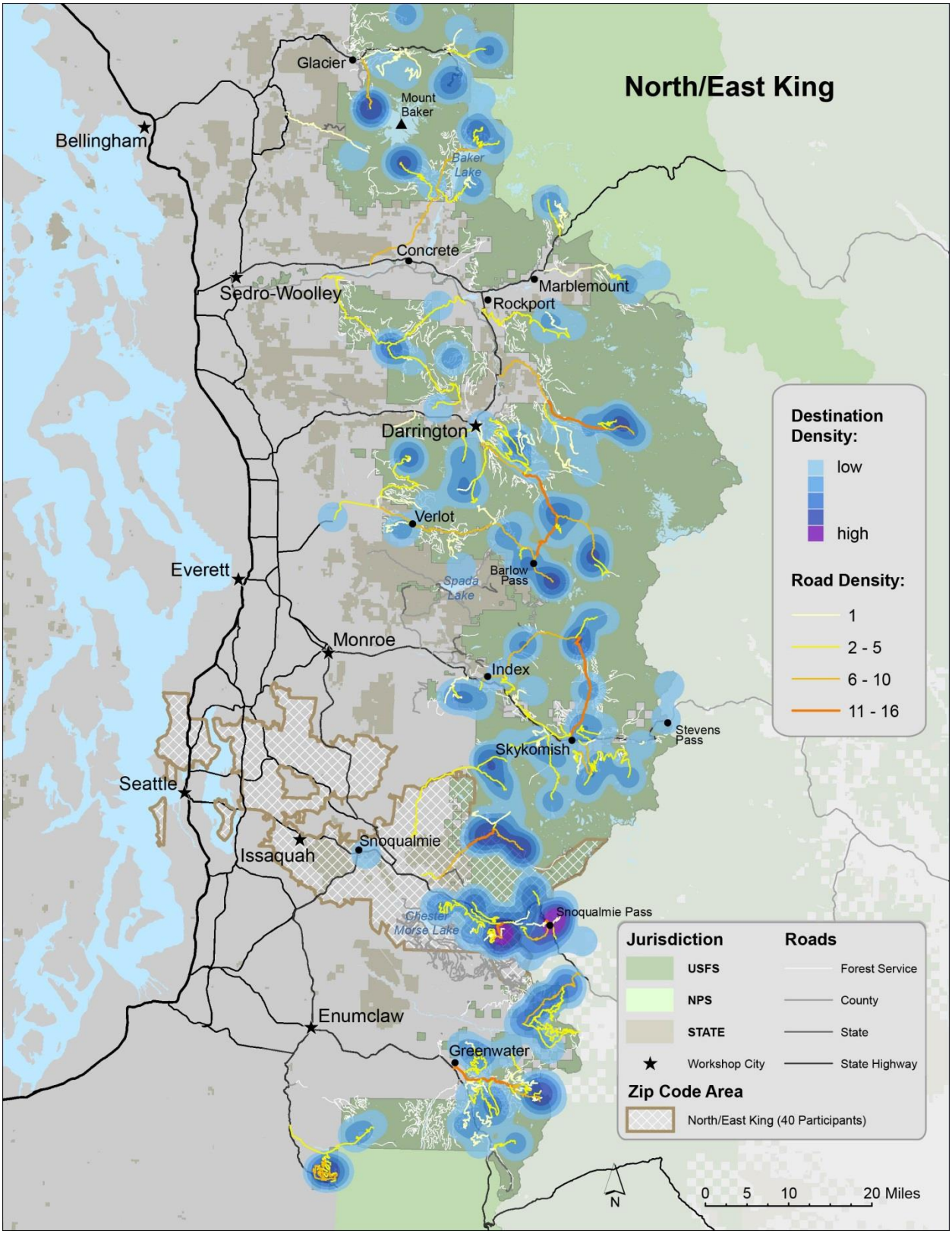


Figure 11 – Destination and road densities for the North/East King Residential Area

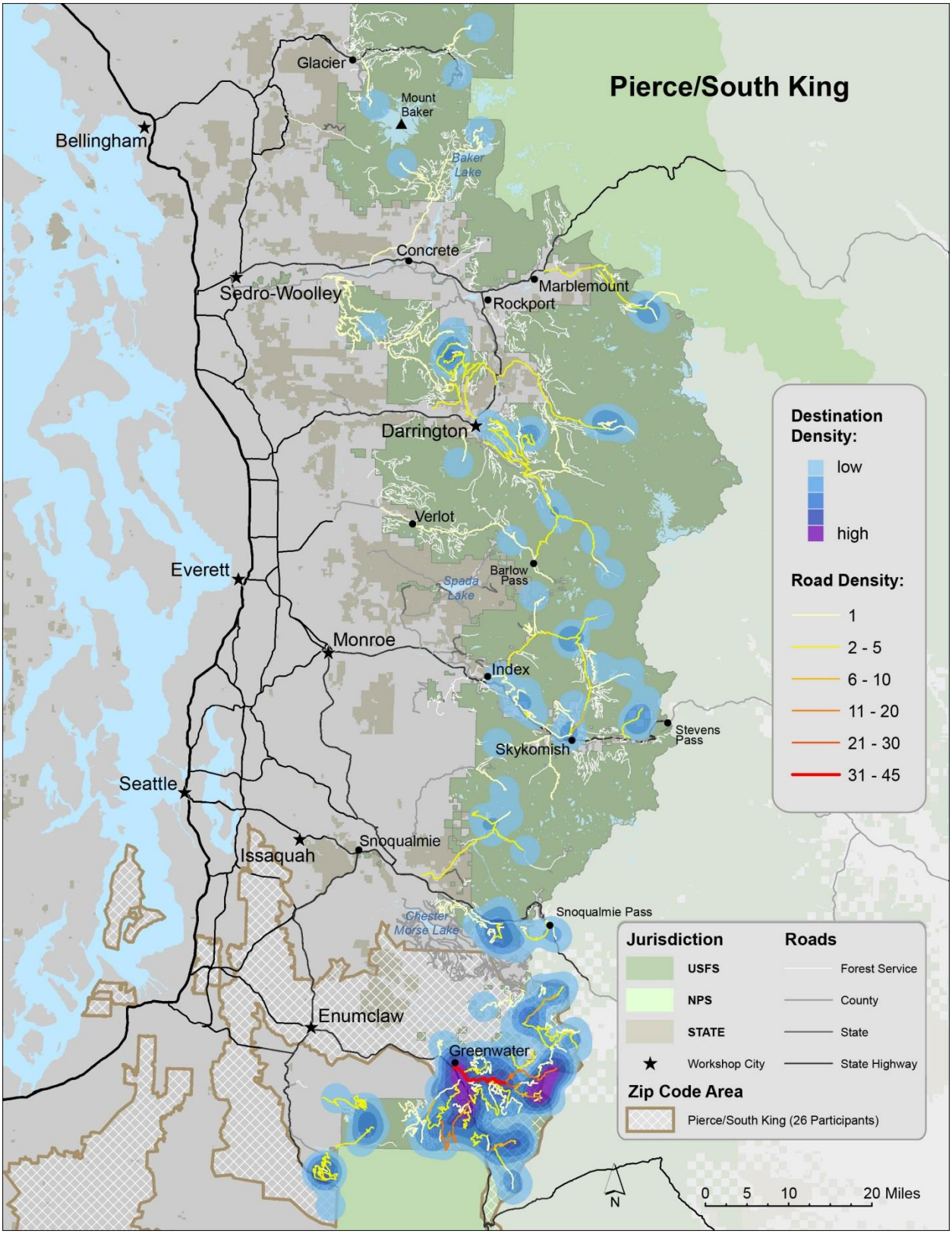


Figure 12 – Destination and road densities for the Pierce/South King Residential Area

MAP SET 4: ACTIVITY DESTINATION AND ROAD DENSITIES

As noted earlier, participants were asked to indicate the activities they participated in while at the destinations they mapped. Table 1 shows the eight activity categories used in the analysis, as well as the major activities included in and the number of destinations associated with each category. The activity maps in this section show how the patterns of destination and associated road densities differed depending on the types of activities people did in the places they mapped.

Table 1: Activity categories and example activities

Activity category	Number of destinations	Percent of destinations (out of 1733 destinations)	Examples
Hiking	913	53%	Hiking
Strenuous recreation	370	21%	Backpacking, mountaineering, rock climbing, biking, swimming, rafting
Motorized recreation	341	20%	Snowmobiling, driving, motorcycling, off-road driving, trail racing
Observation	321	19%	Photography, exploring, bird watching, wildlife viewing, sightseeing
Camping & relaxation	329	19%	Camping, visiting hot springs, picnicking, relaxing, solitude, getting away, target shooting
Sociocultural	226	13%	Trail work, research, guiding, search and rescue, fire-fighting, logging, teaching, restoration, attending festivals, spending time with family, history, tourism, riding horses
Winter recreation	208	12%	Cross-country skiing, snowshoeing, snowboarding, ice glacier skills
Collecting & harvesting	198	11%	Hunting, fishing, berry picking, Christmas tree harvesting, gathering plants, metal detecting, gold panning, rock collecting

Note: Percentages total more than 100 because participants marked multiple activities per destinattion

Hiking (Figure 13): Hiking was listed for 913 (53 percent) of the 1733destinations which had activities associated with them, and was by far the most commonly mapped activity. We therefore placed it into its own category, rather than combining it with other recreation activities, such as strenuous recreation. Participants' hiking destinations were concentrated in the north, with sites around or near Mount Baker being the most popular. A secondary concentration of hiking spots was located in the Mountain Loop area. Although some participants hiked in the Skykomish and Snoqualmie Districts, no major concentrations were mapped south of Barlow Pass. Road densities reflect the northern trend in hiking

destinations. The roads with the most overlaps (31 to 51) included: Mountain Loop Highway, Siuattle River Road, Schreibers Meadows Road, portions of Baker Lake Road, Glacier Creek Road, and Twin Lakes Road.

Strenuous Recreation (Figure 14): Destinations with high values for strenuous recreation, which includes activities such as backpacking, mountaineering, and rock climbing, were most heavily concentrated in the northern part of the Mount Baker Snoqualmie National Forest. The highest concentrations occurred around Mount Baker, with Heliotrope Ridge/Glacier View and Schreiber's Meadow being the locations most popular destinations. Relatively high values for active recreation also occurred in the Mountain Loop area, notably locations at the end of the Siuattle River Road and at sites along the North Fork Sauk River Road.

The pattern for strenuous recreation closely resembled the winter recreation pattern (Figure 19), indicating that these areas were popular for both winter and summer recreation. Although in general the Beckler Road loop in the Skykomish Ranger District was a popular site for many of the other activity categories, densities for strenuous recreation destinations were not very high in that area.

Motorized recreation (Figure 15): Motorized recreation, which included activities such as off-road vehicle riding, motorcycling, and snow mobiling, was concentrated at the northern and southern ends of the forest. Two of the three high density areas for motorized recreation – the Evans Creek area and the Naches Pass/Windy Gap area – were located on the Snoqualmie District and were popular as off-road vehicle sites. The third high density area – the area at the end of Canyon Creek Road north of Mount Baker -- is a popular site for both off-road vehicle riders and snowmobilers.

Secondary concentrations for motorized recreation are located in the Darrington Ranger District, and include: the area northwest of Darrington, several spots along the eastern portion of the Mountain Loop Highway (Grades Creeks and North Fork Sauk Falls vicinity), and the Rat Trap Pass/Circle Peak area at the end of Straight Creek Road. The Hansen Creek area west of Snoqualmie pass is another popular site for motorized recreation.

The Greenwater Road leading into the Naches Pass/Windy Gap road network had the highest number of overlaps (31-40). Other roads frequently used by motorized recreationalists were the Evans Creek road and trail network, Beckler Road in the Skykomish District; Mountain Loop Highway, Dans Creek Road, Selegsen Road, and Finney Creek Road in the Darrington District, and Canyon Creek Road in the Mt Baker District.

Camping/Relaxation (Figure 16): Camping and relaxation sites were widely dispersed through the MBS National Forest. Camping was by far the most common activity in this category, accounting for roughly 90% of the destinations listed in the camping/relaxation category. Nine areas fell into the high density category, including four around Mt Baker (Twin Lakes, Hannegan Pass, Heliotrope Ridge/Glacier View, and Schreibers Meadows; two in the Darrington District (end of the Suiattle River and the area around

the North Fork Sauk Trailhead), and three in the Snoqualmie District (Snoqualmie Pass area, Evans Creek, and the Naches Pass/Windy Gap area). No high density hotspots were located in the Skykomish Ranger District, although several moderately dense sites for hiking were located at sites adjacent to Highway 2. The high density "hotspots" in the southern tip of the MBS National Forest coincide with high density areas for motorized recreation. Roads leading to camping/relaxation with the highest number of overlaps (21-25) were the Greenwater Road and the eastern portion of the Mountain Loop Highway. The lack of high road densities reflects the dispersed pattern for camping and relaxation destinations.

Observation (Figure 17): Observation destinations were heavily concentrated in the north around Mount Baker, with Heliotrope Ridge/Glacier View and Heather Meadows/Artist Point the most frequently mapped sites. A secondary concentration is located in the Darrington District in an arc that stretches from Marblemount down through Verlot. Roads with high density values for observation included Glacier Creek Road, Schreibers Meadows Road, the South Side Suiattle River Road, Dans Creek Road, and the Mountain Loop Highway.

Sociocultural (Figure 18): Destinations mapped as important for sociocultural activities tended to be both numerous and dispersed. Among the hotspots were: West Cady Ridge off Beckler Road, the upper reaches of the Siuattle River, North Fork Sauk Falls area along the Mountain Loop Highway, the upper reaches of the North Fork Sauk, and Heliotrope Ridge/Glacier View on Mount Baker. Different activities dominated at the various hotspots: horse-riding was an important activity in the upper reaches of the Suiattle and North Fork of the Skykomish; volunteer activities were dominant in the Sloan Creek area; guiding was important in the Heliotrope Ridge/Glacier View area. Secondary concentrations occurred at Mt Pilchuck and Three Fingers in the Darrington District, and also at Schreibers Meadows on the south side of Mount Baker. Roads with the highest number of overlaps for the sociocultural activity category included Beckler Road, the eastern portion of the Mountain Loop Highway (along the Sauk River), the North Fork Sauk River Road, and the Siuattle River Road.

Winter recreation (Figure 19): Winter recreation sites were concentrated around Mount Baker. The highest density areas were at Heliotrope Ridge/Glacier View and Schreiber's Meadow. An analysis showed that 29, or 76 percent of the 38 features mapped in these two hotspots were skiing (cross-country), with snow or ice climbing being the second most common (5 features). Interestingly, the Mount Baker Ski area, a downhill ski facility, did not show up in the highest density category, although it did fall within the second highest density category. Indeed, none of the area's downhill ski areas (Stevens Pass, Alpental at Snoqualmie Pass, Crystal Mountain near Mt Rainier) had high density values. This is not as surprising as it might seem since the downhill areas are all located off major highways. Roads with high density values (11-20 overlaps) for winter recreation were Schreibers Meadows Road, Loomis Nooksack Road, and Glacier Creek Road, all of which provide access to Mount Baker.

Collecting and Harvesting (Figure 20): Hunting and fishing were the most common activities in this category, together being associated with 73 (75%) of the 98 destinations in the collection and harvesting category. Gathering – especially berry picking – was the next most common activity in this category, and was associated with 27 (27.6%) of the 98 collecting and harvesting destinations. Rockhounding was associated with 8% of the collecting and hunting destinations.

All of the high density collecting and harvesting sites were very heavily concentrated in the area east and south of Darrington, although collecting and harvesting locations were mapped in most parts of the forest. The densest concentrations were at the following sites: the Slide Lake area on the Illabot Road; several spots along the Siuattle River (Grade Creek, Boulder Lake, and the Suiattle/Downey Creek area); White Chuck/Meadow Mountain/Rat Trap Pass/Circle Peak; Upper Decline, and the Sloan Creek area (at the head of the North Fork of the Sauk River); and the Crevice Creek/North Fork of the Stilly area northwest of Darrington.

The roads most frequently used to get to collecting and harvesting destinations included the Mountain Loop Highway, the Siuattle River Road, the North Fork of the Sauk River Road, and Illabot River Road. Secondary clusters for collecting and harvesting were located around Mount Baker, around the Beckler Road Loop, in the Hansen Creek area west of Snoqualmie Pass, and around Greenwater in the White River area of the Snoqualmie Ranger District.

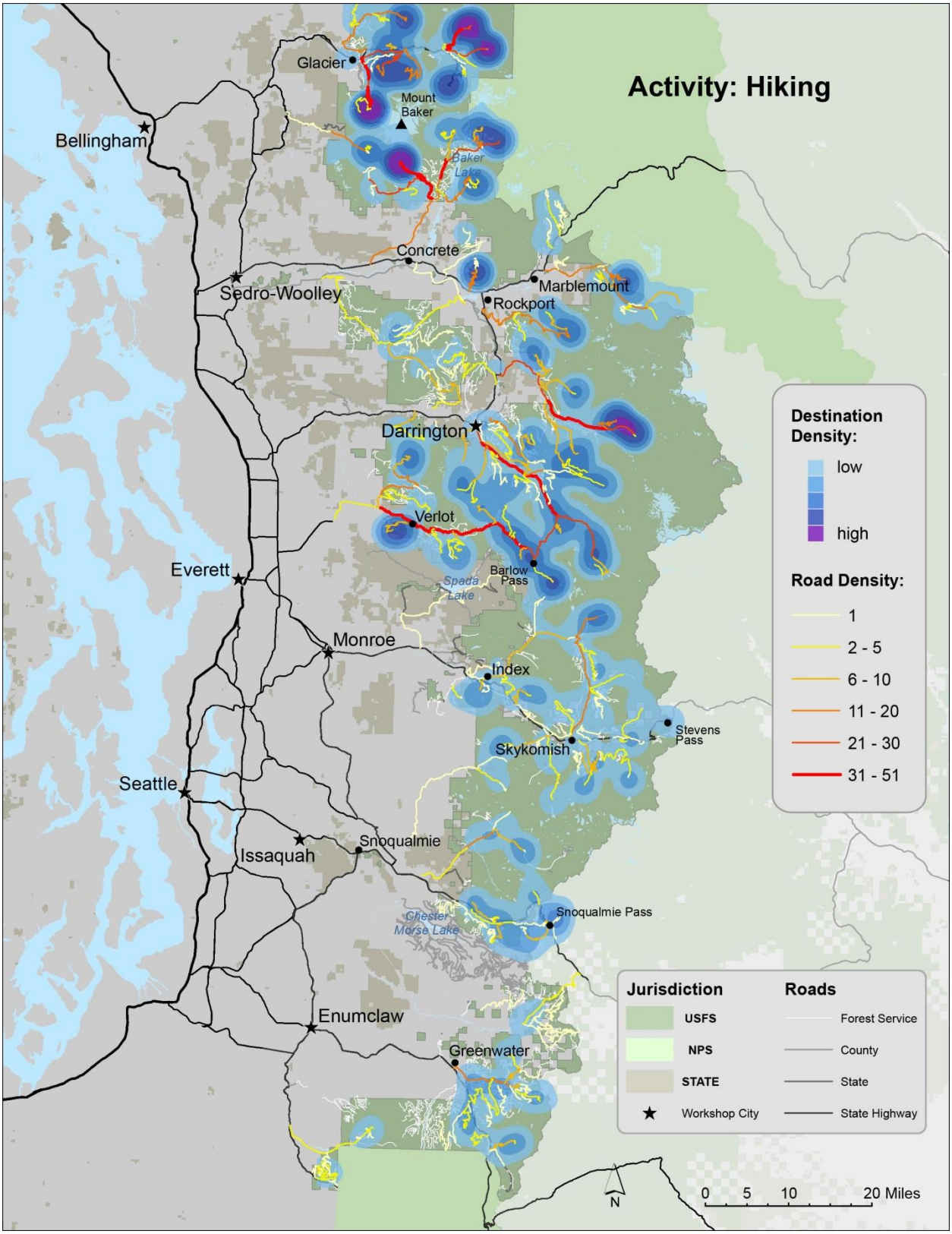


Figure 13 – Destination and road densities for hiking

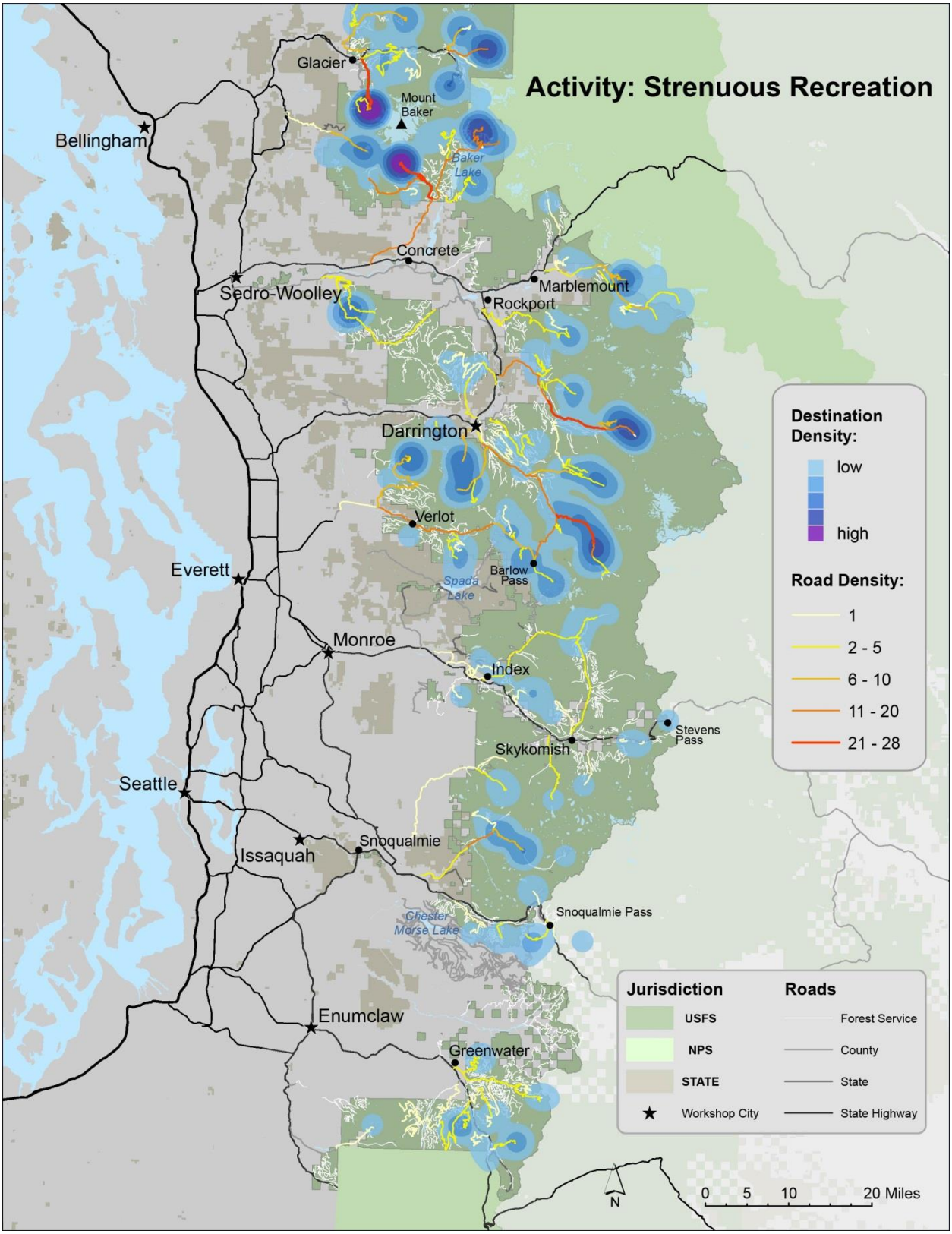


Figure 14 – Destination and road densities for strenuous recreation

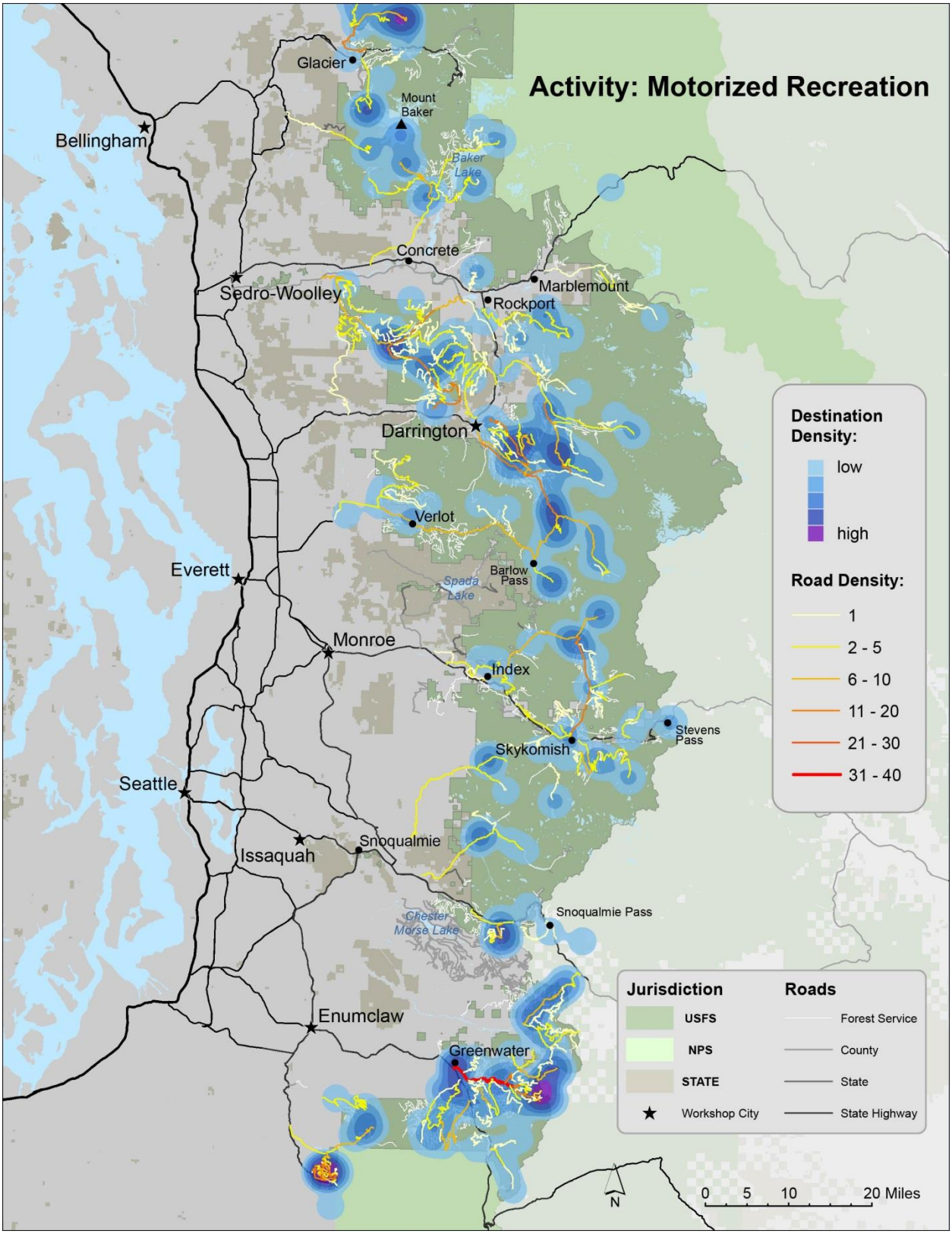


Figure 15 – Destination and road densities for motorized recreation

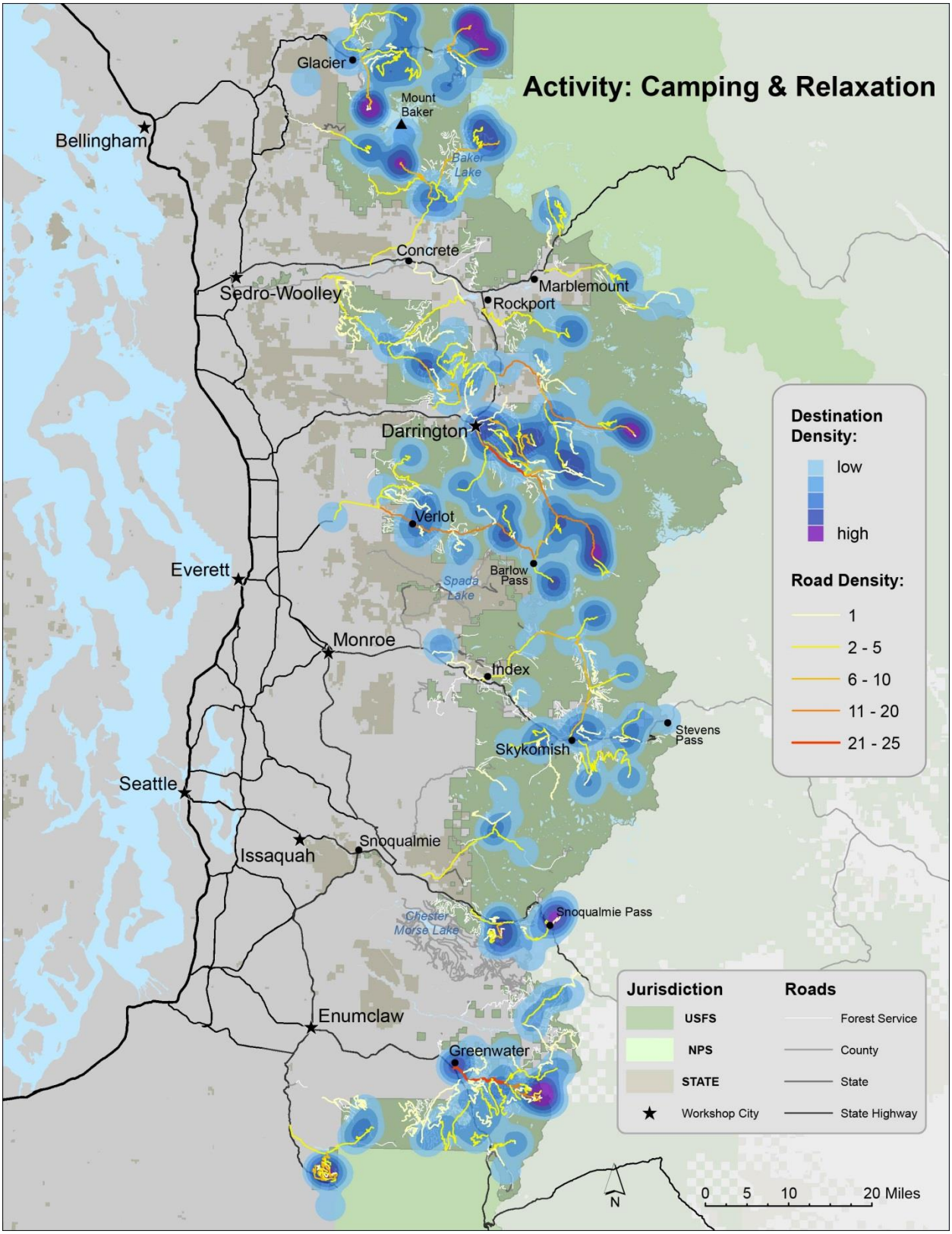


Figure 16 – Destination and road densities for observation

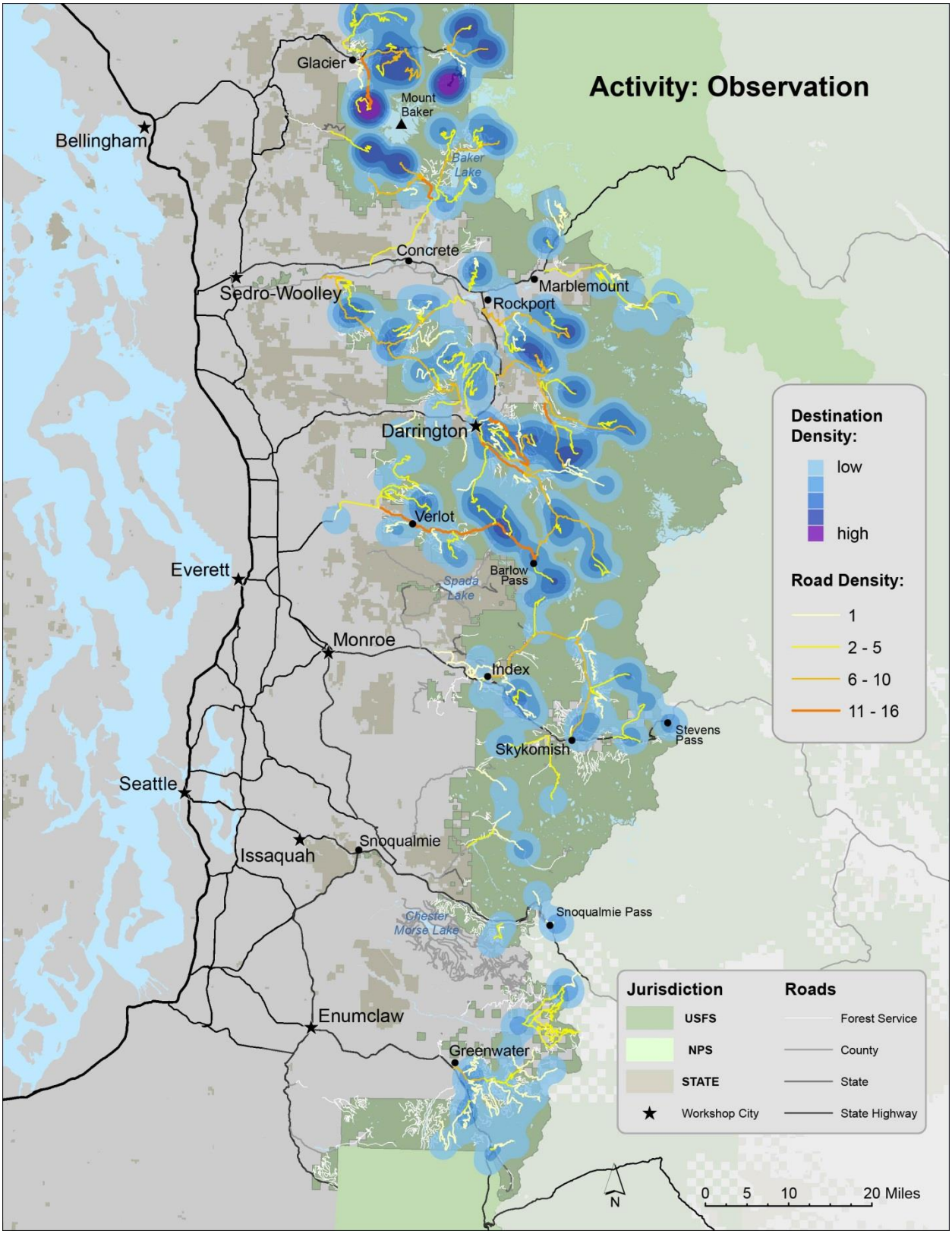


Figure 17 – Destination and road densities for camping/relaxation

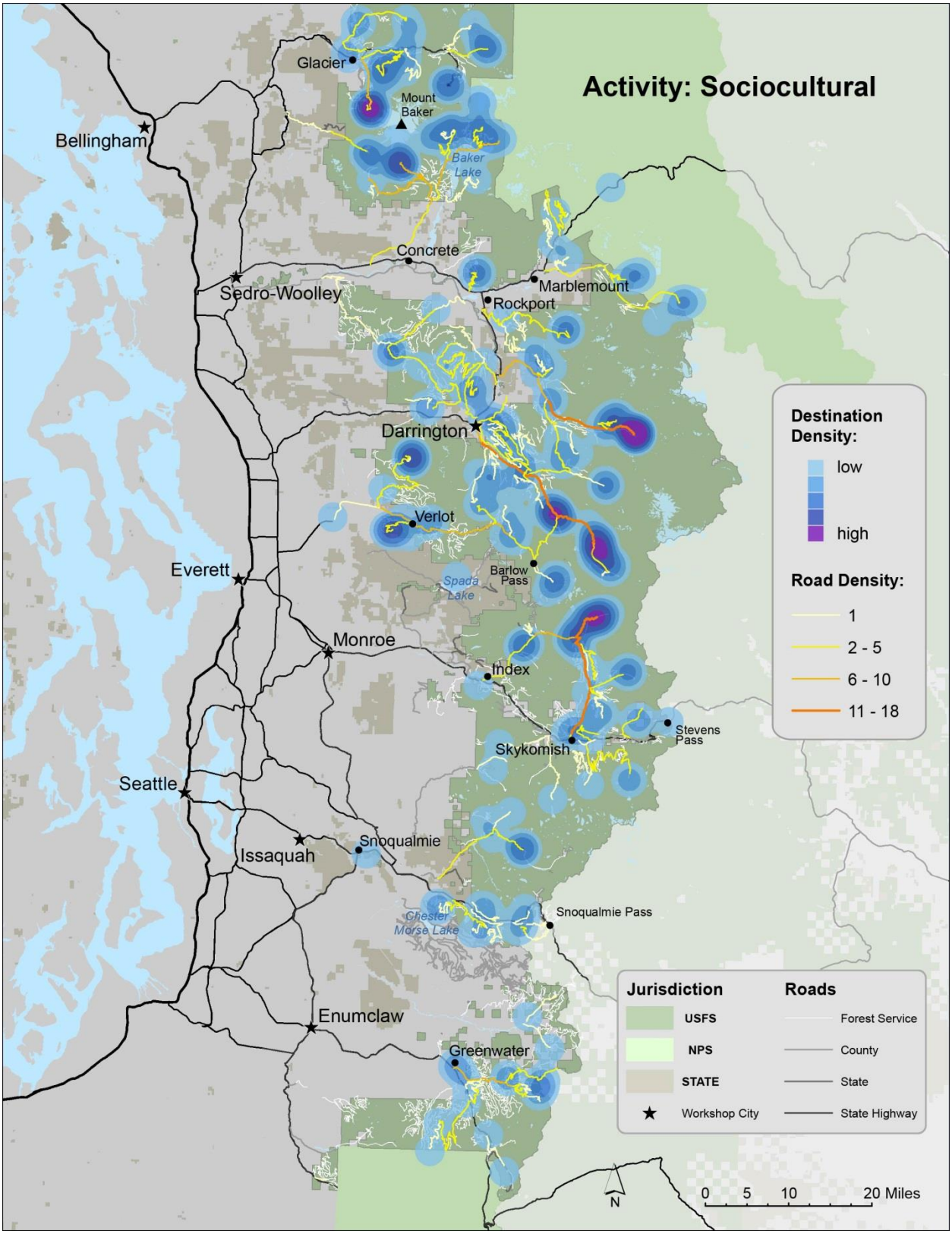


Figure 18 – Destinations and road densities for sociocultural activities

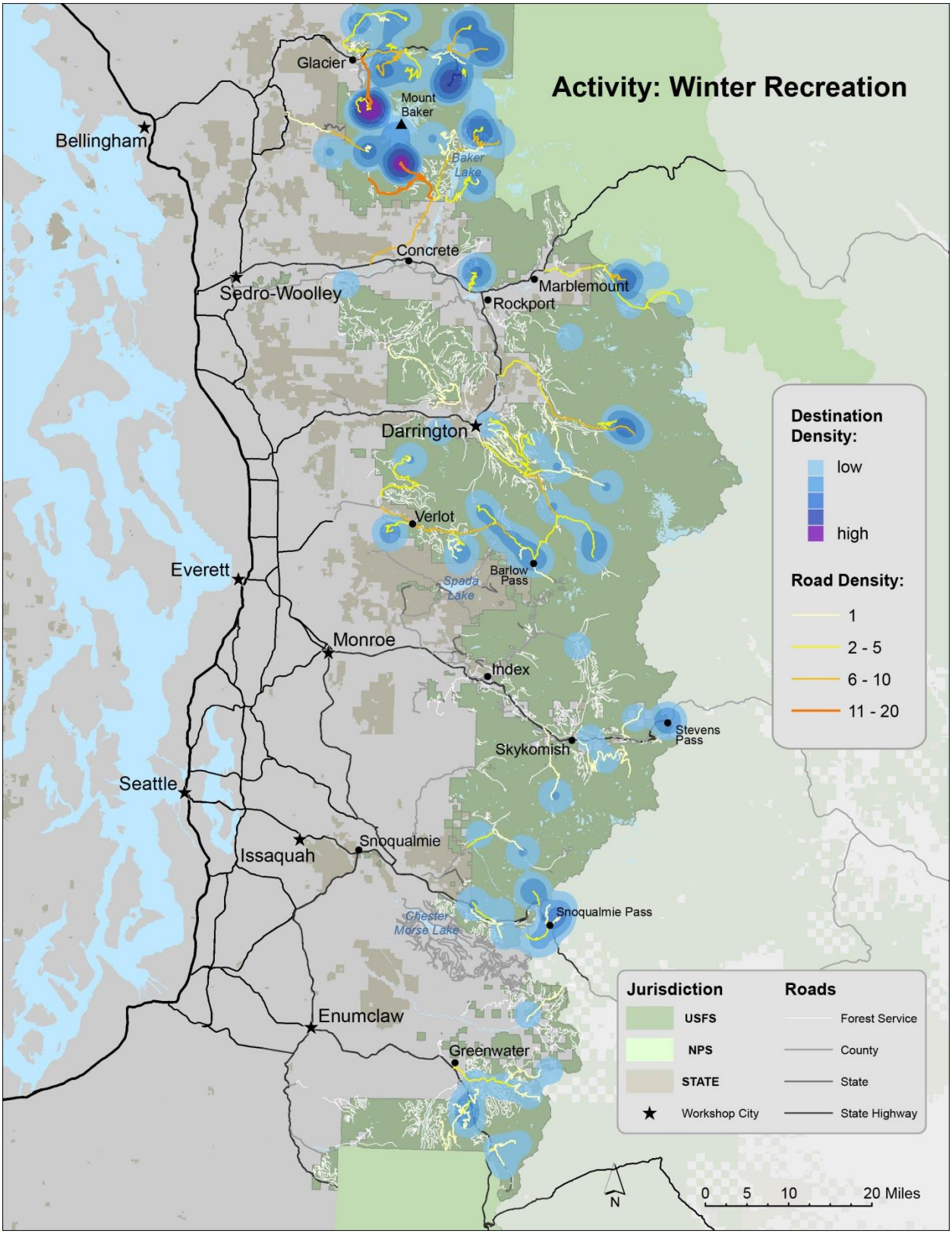


Figure 19 – Destinations and road densities for winter recreation

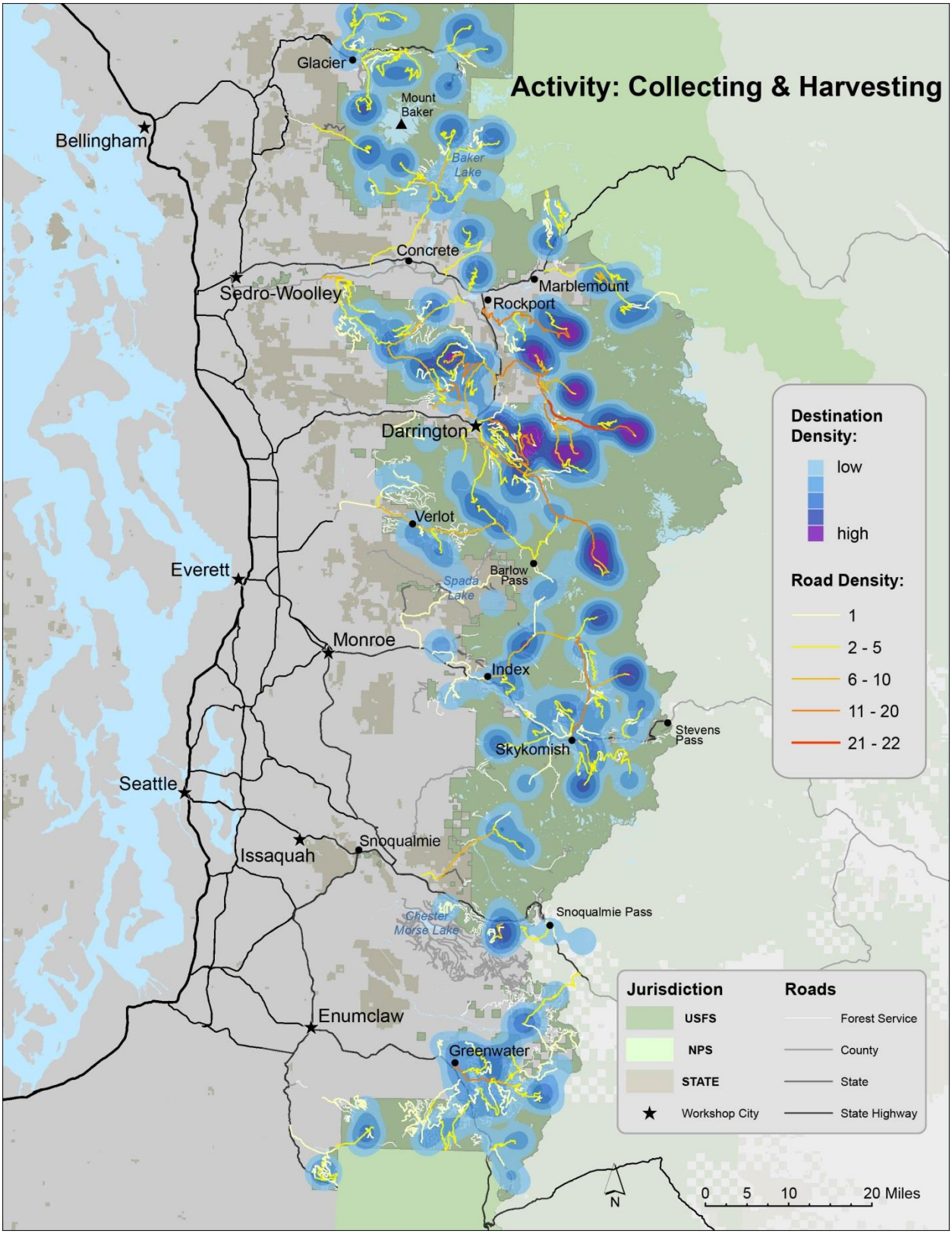


Figure 20 – Destination and road densities for collecting/harvesting

MAP SET 5: VALUES DESTINATION AND ROAD DENSITIES

For each destination, participants described why the area was important to them, an indicator of the type of values associated with it. Table 2 lists the major values we derived from the data and the number and percent of destinations having each value. Four of the values (sociocultural, economic/work, subsistence, and recreation) closely mirror the kinds of activities people listed, corresponding to the activity categories "sociocultural" (which includes economic activities), "collecting and harvesting", and the various "recreation" categories. Indeed, in many cases participants used the identical words or phrases to describe both the activities done at their destinations and the importance of the destination to them. The other four values (access/proximity, serenity/solitude, aesthetic, and nature/wilderness) are quite different in that they can't be readily equated with specific activities. We developed a set of maps to show how these four values and the roads associated with sites having those values, were distributed across the MBS National Forest.

Table 2 – Values categories and examples of values

Values	Number of destinations	Percent of destinations (out of 1733 destinations)	Examples
Recreation	865	50%	Snowmobiling; camping; hiking; motorcycling; picnicking; driving; skiing; horseback riding; ATV/4x4; snowshoeing; mountaineering; climbing; biking; mining/prospecting
Access/Proximity	433	25%	Mentions: "access", "close", "easy", "convenient", or "connect"
Aesthetic	377	22%	Views; scenery; beauty; mentions a visual description (i.e. "fall color"); sightseeing; photography
Nature/Wilderness	224	13%	Wilderness; mentioned natural feature (i.e. flowers, trees, wildlife, lake); untouched, clean
Sociocultural	192	11%	Family; friends; kids; take visitors; community; cook out; history; memories; tradition; collect data; teach/learn; events; archaeology; dams
Subsistence	138	8%	Hunting; fishing; berry picking; mushroom picking
Serenity/Solitude	63	4%	Serenity; escape; peaceful; quiet; relaxation; "mental recovery"; clear head; solitude; remoteness; spiritual; joy
Economic/Work	62	4%	Economic; work; timber/logging; restoration

Note: Percentages do not total to 100 because participants could list multiple reasons for why the place was especially important to them

Access/Proximity (Figure 21): Overall, destinations marked important for access/proximity were scattered across the MBS National Forest. Mt Baker (Hannegan Pass, Heliotrope Ridge/Glacier View, and Schreibers Meadows) and the upper reaches of the Suiattle River had the highest concentrations for access/proximity, but secondary dense spots were located in the N Fork Sauk, around Snoqualmie Pass, and near Greenwater and Naches Pass/Windy Gap.

High density roads for access/proximity tended to be located in the north, with the Suiattle River Road having the most overlaps (31-34). Roads with the next highest number of overlaps (21-30) included Glacier Creek Road, Hannegan Pass Road, Schreibers Meadows Road, the Mountain Loop Highway, and the North Fork Sauk River Road. In the southern half of the forest, Greenwater Road had the highest densities (21-30 overlaps).

In addition to the many short spur roads that were unmarked throughout the forest, the following road networks were largely unmarked: the entire Upper Clearwater road network, a large percentage of the road networks around Greenwater and Snoqualmie Pass, the road networks east and west off Beckler Road, large portions of the road network between the Mountain Loop Highway and the Suiattle River Road, and most of the road network northwest of Darringon.

Serenity/Solitude (Figure 22): Destinations with the value "serenity/solitude" were both widely and relatively evenly dispersed. Locations with high densities for serenity/solitude included: Wells Creek and Ridley Creek on Mount Baker, the Upper Decline area east of the Mountain Loop Highway, Mt Pilchuck, and Hansen Creek at Snoqualmie Pass. Secondary dense areas are located throughout the forest, including in areas that are popular for motorized recreation. Road densities were very low, reflecting the high degree of dispersion of this value. Overall, the density distribution for serenity/solitude highlights how sense of place differs depending on the individual. Where one person might feel an area is too crowded or noisy, another might find that place relaxing and peaceful.

Aesthetic (Figure 23): Destinations valued for aesthetics were heavily concentrated around Mount Baker and in the Mountain Loop area. Locations with high aesthetic densities included: Artists Point/Heather Meadows, Skyline Divide, Heliotrope Ridge/Glacier View, Schreibers Meadows, and Upper Decline (southeast of Darrington). An additional dozen destinations in the second-highest density category were scattered across the Darrington and Mount Baker Ranger Districts. Many of the features marked as important for aesthetics were associated with mountain peaks and likely were valued for the views they provided. None of the high density spots for aesthetics were located in the southern half of the forest, and Blanca Lake/West Cady Ridge was the only spot south of Barlow Pass that fell into the second highest density category area. One possible explanation for the northern skew to the aesthetic density pattern is that participants overall experience rugged landscapes as more aesthetically pleasing. Road densities for aesthetics largely reflect the spatial distribution of the destination densities, with most of the routes used to access destinations valued for aesthetics located around Mt Baker or in the Mountain Loop area. However, two roads in the southern half of the forest had relatively high densities (Beckler Road and Greenwater Road). Although no dense concentrations for aesthetics are found in the

Greenwater area, destinations valued for aesthetics are dispersed throughout the White River area. Even though no one location has a high density for aesthetics, because nearly everyone visiting the area travels on Greenwater Road, the cumulative traffic on that road explains its high density.

Nature/Wilderness (Figure 24): Destinations with the value “nature/wilderness” were widely dispersed across the forest. Areas with high density included Heliotrope Ridge/Glacier View, Hannegan Pass, and the upper reaches of the Suiattle River. However, numerous destinations fell into the next highest density category, including additional sites around Mount Baker, a number of locations in the Mountain Loop area, as well as the Dingford Creek, Snoqualmie Pass, and Greenwater areas in the Snoqualmie Ranger District. Roads with the highest number of overlaps (11-17) for this category included the Suiattle River Road and Hannegan Pass Road.

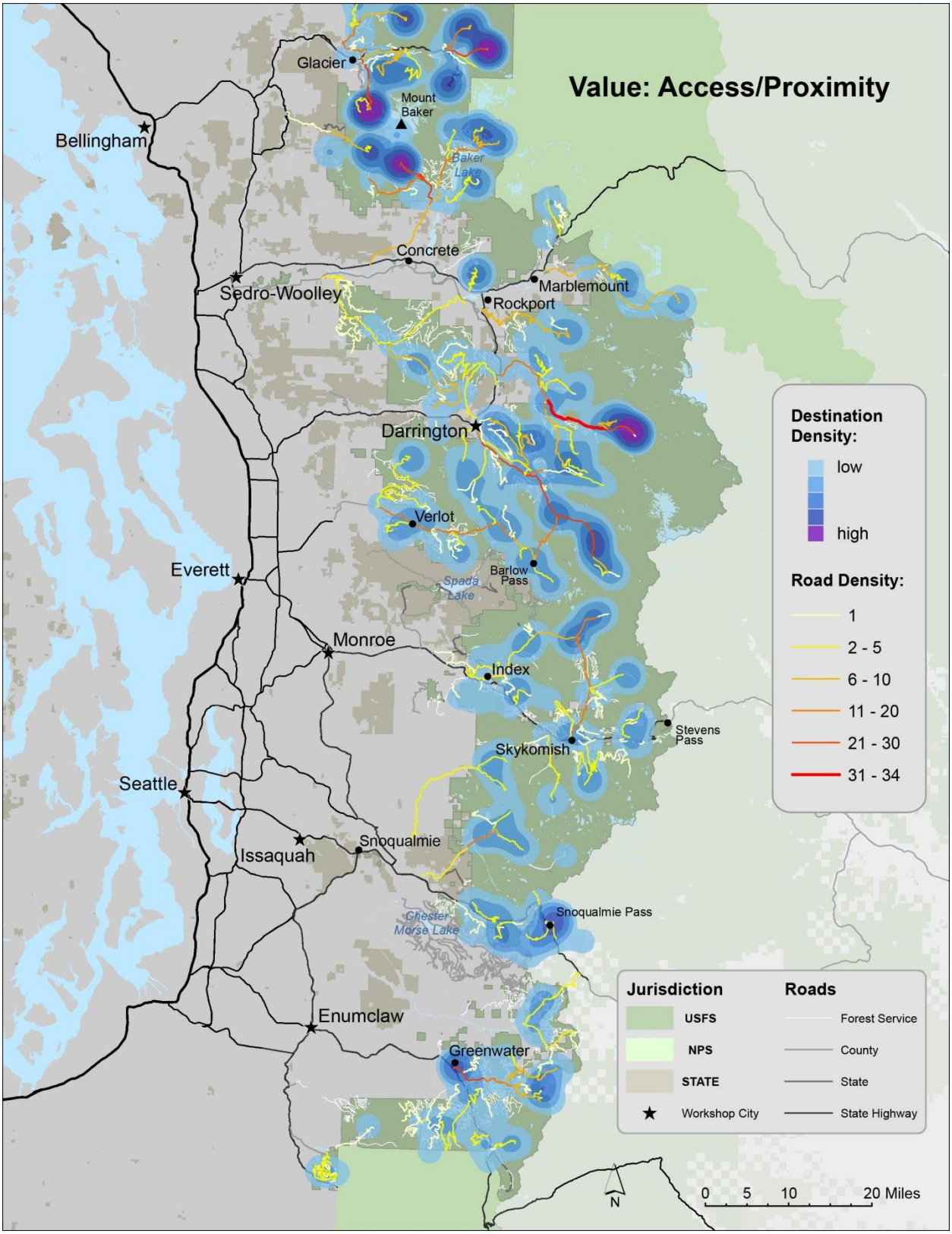


Figure 21 – Destination and road densities for access/proximity

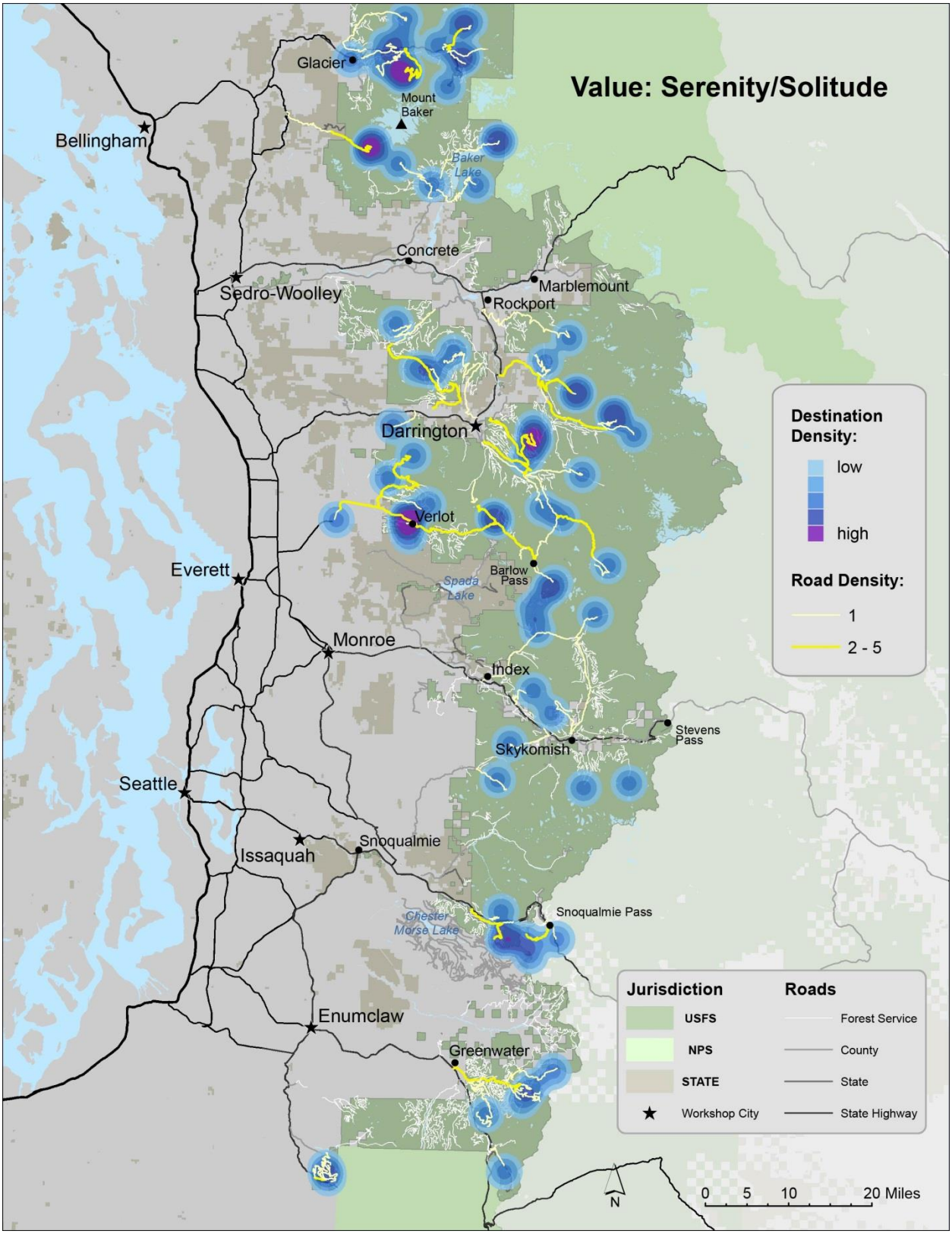


Figure 22 – Destination and road densities for serenity/solitude

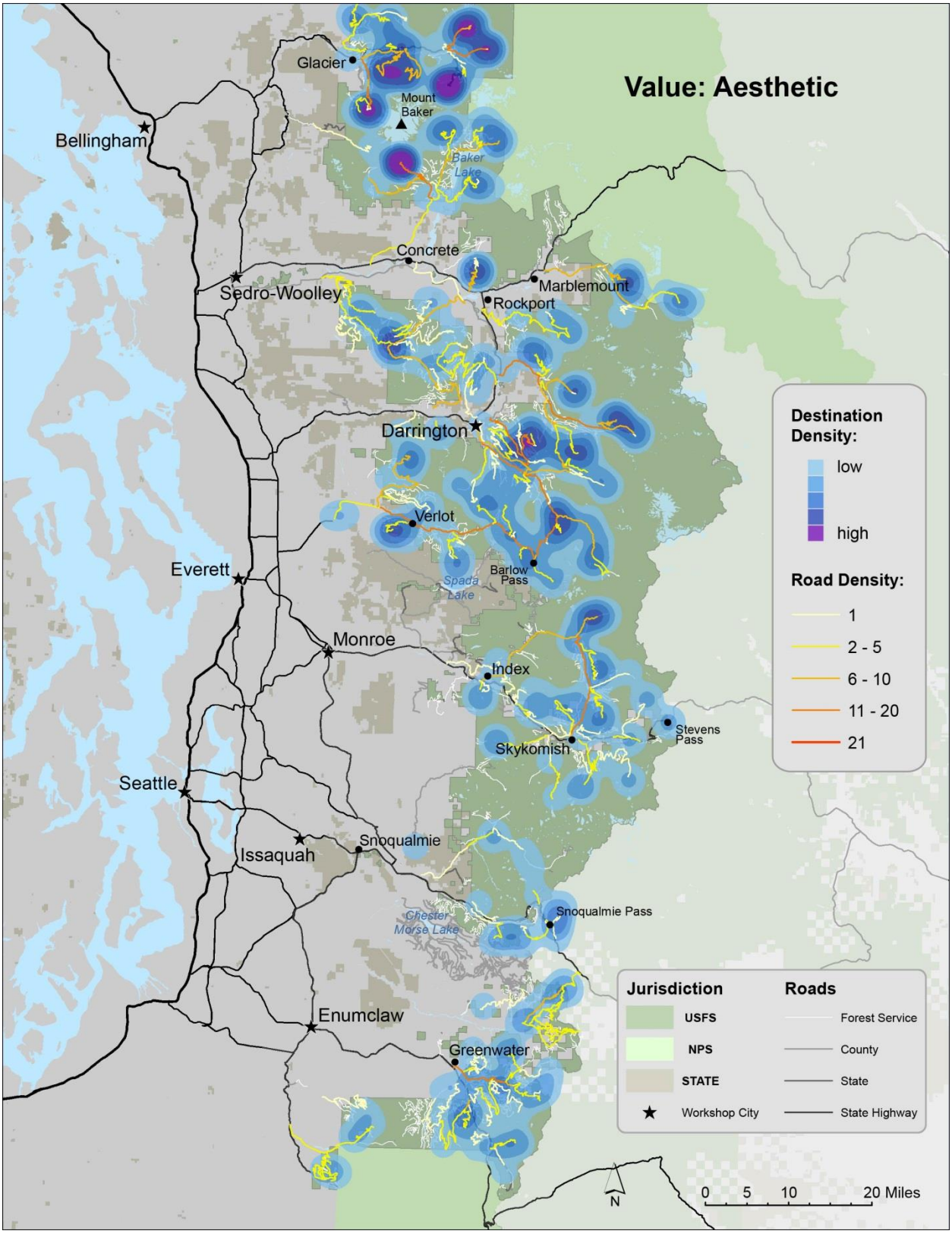


Figure 23 – Destination and road densities for aesthetic

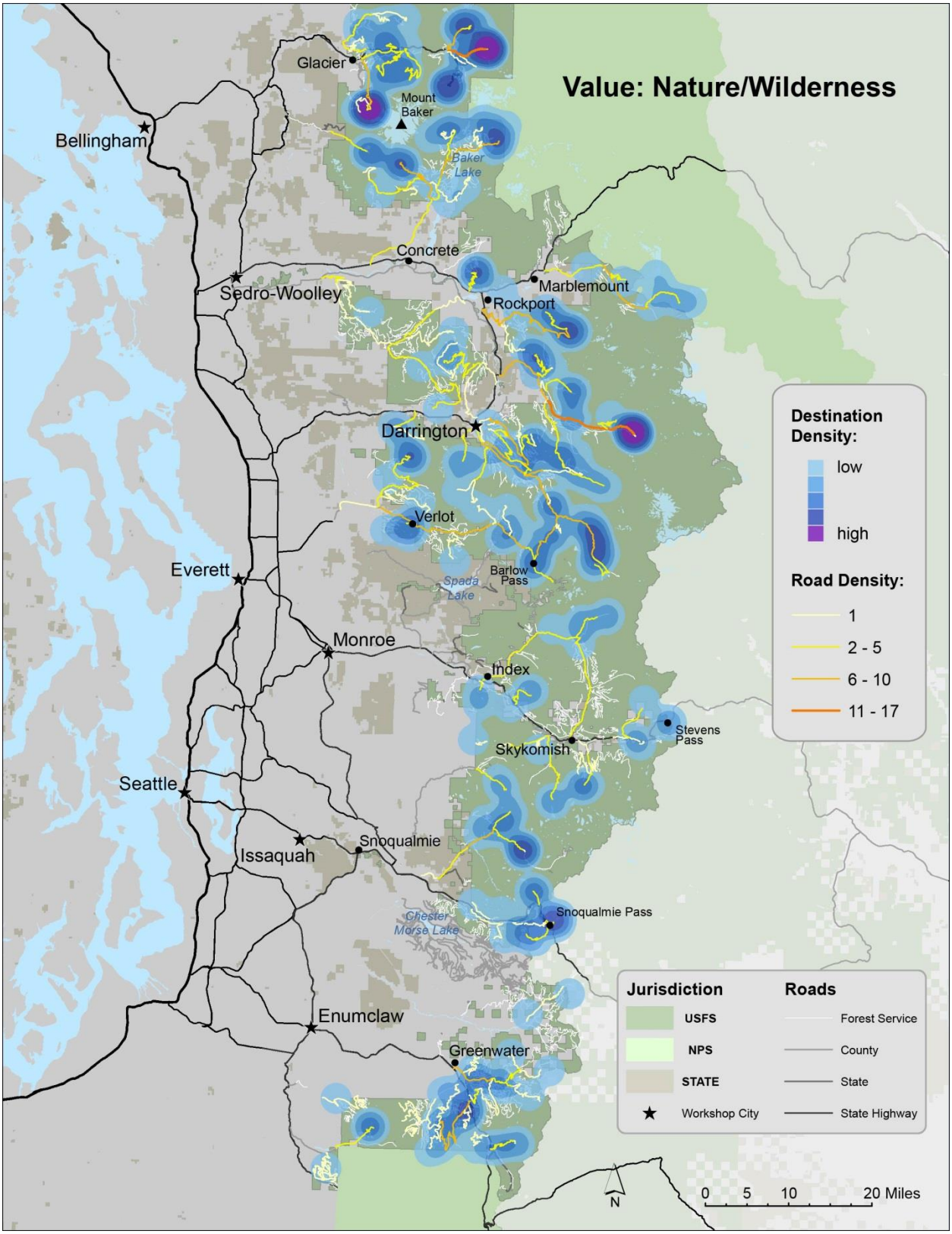


Figure 24 – Destination and road densities for nature/wilderness

ASSESSING DIVERSITY OF USES

In deciding which roads to keep open, one potential selection criterion is the extent to which a road serves many types of users. One approach to assessing diversity of use is to explore the extent to which high density areas for different types of activities and values coincide. As shown in Table 3, Heliotrope Ridge/Glacier View, Schreibers Meadows, and the Upper Suiattle are the destinations that are most diverse in terms of the types of activities marked.

Table 3 – Diversity of use at high density destinations for activities

Ranger District/Destination	Camping	Collecting/ Harvesting	Hiking	Motorized Recreation	Observation	Sociocultural	Strenuous Recreation	Winter Recreation	Number of activities
Mt Baker District									
Artist Point/Heather Meadows					X				1
Canyon Creek				X					1
Heliotrope Ridge/Glacier View	X		X		X	X	X	X	6
Hannegan Pass	X		X						2
Schreibers Meadows	X		X				X	X	4
Twin Lakes	X		X						2
Darrington District									
Upper Decline		X							1
Grade Creek		X							1
North Fork Sauk Falls						X			1
North Fork Stillaguamish		X							1
Rat Trap Pass/Circle Peak		X							1
N. Fork Sauk/Sloan Creek	X	X				X			3
Tenas Creek/Boulder Lake		X							1
Upper Illabot		X							1
Upper Suiattle	X	X	X			X			4
Skykomish District									
Blanca Lake						X			1
Rapid River		X							1
Snoqualmie District									
Evans Creek	X			X					2
Naches Pass/Windy Gap	X			X					2
Hansen Creek	X	X							2
Snoqualmie Pass	X								1
Total number of sites	10	10	5	3	2	5	2	2	

Similarly, Table 4 shows where high densities for values coincide. Areas where more than one value are associated with high density destinations include Heliotrope Ridge/Glacier View, Hannegan Pass, Schreibers Meadows, Upper Decline, and the Upper Suiattle River. Tables 3 and 4 provide a starting point for thinking about how to assess diversity of uses associated with particular destinations, and a useful next step would be to develop similar tables for the second highest density values for destinations.

Table 4 – Diversity of use at high density destinations for values

Ranger District/Destination	Access/ Proximity	Aesthetics	Economics	Nature/ Wilderness	Recreation	Serenity/ Solitude	Sociocultural	Subsistence	Number of values
Mt Baker District									
Artist Point/Heather Meadows		X							1
Hannegan Pass	X	X		X					3
Heliotrope Ridge/Glacier View	X		X	X	X				4
Ridley Creek						X			1
Schreibers Meadows	X		X		X				3
Skyline Divide		X							1
Twin Lakes		X							1
Wells Creek						X			1
Darrington District									
Grade Creek								X	1
Mt Pilchuck						X			1
Rat Trap Pass/Circle Peak								X	1
Upper Decline		X				X		X	3
Upper Suiattle	X			X	X				3
Monte Cristo							X		1
Snoqualmie District									
Hansen Creek						X			1
Total number of sites	4	5	2	3	3	5	1	3	

MAP SET 6: ACTIVITY AND VALUE DIVERSITY FOR ROADS

Although an assessment of the diversity of uses associated with destinations is helpful, it is also important to be able to attach a diversity rating to specific roads or road segments. We could not find any examples of a road use diversity index in the scientific literature. We therefore experimented with using species diversity indices to measure road use diversity.

The two most common species diversity indices (Shannon Index and Simpson Index), take into account variety and balance. In our case, variety specifies how many different activities participants reported engaging in at destinations reached by using a given road. Balance specifies how evenly distributed the responses were among the different activities. For example, if 50 people used a road for skiing and 2 used it for rockhunting, it would be rated less diverse than a road where 25 people used the road for skiing and 25 used if for rockhunting.

The Inverted Simpson Index emphasizes common species more heavily, and the Shannon Index emphasizes rare species. Since this is the first analysis of activities diversity along forest roads, we are interested in a view of diversity that focuses on the common activities, and so we consider the Inverted Simpson index more appropriate for our use. A technical explanation of the differences between the Shannon and Inverted Simpson indices, as well as additional details on our rationale for using the Inverted Simpson index is provided in Appendix D.

It is important to recognize that the diversity value is not a measure of how much a road is used, but rather provides a means for assessing the diversity of uses or values associated with that road.

<u>Activity diversity</u> (Figure 25): Figure 25 shows the results from using the inverted Simpson Diversity Index for measuring road use diversity. From north to south, the roads with high diversity values were:

- Mid-Fork Nooksack Road (west of Mt Baker)
- Upper end of the Suiattle River Road
- North Side Sauk River Road
- Dans Creek Road
- Whitechuck Road
- Mountain Loop Highway (between Whitechuck Road and North Fork Sauk Falls)
- North Fork Sauk River Road (between North Fork Sauk Falls and North Fork Sauk)
- North Fork Skykomish River Road
- Beckler Road (first two miles)
- Martin Creek Road (FS 6710)
- Middle Fork of the Snoqualmie/Goldmyer Road (from Pratt Creek to Taylor Creek)
- FS 72 (from intersection with State Highway 410 for about 2 miles)
- Huckleberry Creek Road (from intersection with State Highway 410 for about 1.5 miles)

Note that while there is some overlap between road or road segments with high densities and those with high diversity, the correspondence is not one to one. For example, if Figure 25 is compared with the overall workshop road densities (Figure 1), Greenwater Road falls in the second highest density but it is

only moderate to low in terms of the diversity of activities that are associated with its use. In the Skykomish District, the situation for Martin Creek is the reverse: it had a relatively low density of use, but fell into the second highest category for diversity of use.

Values diversity (Figure 26): Roads with high diversity for values were most heavily concentrated in the Darrington Ranger District, including the following roads:

- North Fork Stillaguamish Road/Crevice Creek
- Dans Creek
- Upper Divide Creek
- Upper reaches of Clear Creek
- Far upper end of North Fork Sauk River Road

The only other road with a high diversity for values was FS 6090, on the south slope of Mount Catherine just west of Snoqualmie Pass. The relationship between activity diversity and values diversity is complex, and only one road (Dans Creek Road southeast of Darrington) fell into the high diversity category for both values and activities. Many roads with low activity diversity had high values diversity, but the opposite was also true as many roads with high activity diversity had low values diversity. One possible explanation for a low activity-high values diversity combination is that people doing similar activities may do so for very different reasons. Alternatively, it may be that persons engaging in the activity do so for a variety of reasons. To identify plausible explanations for these types of relationships, however, requires delving deeper into the underlying data structure to determine which particular activities and values are associated with particular configurations of activity diversity and values diversity.

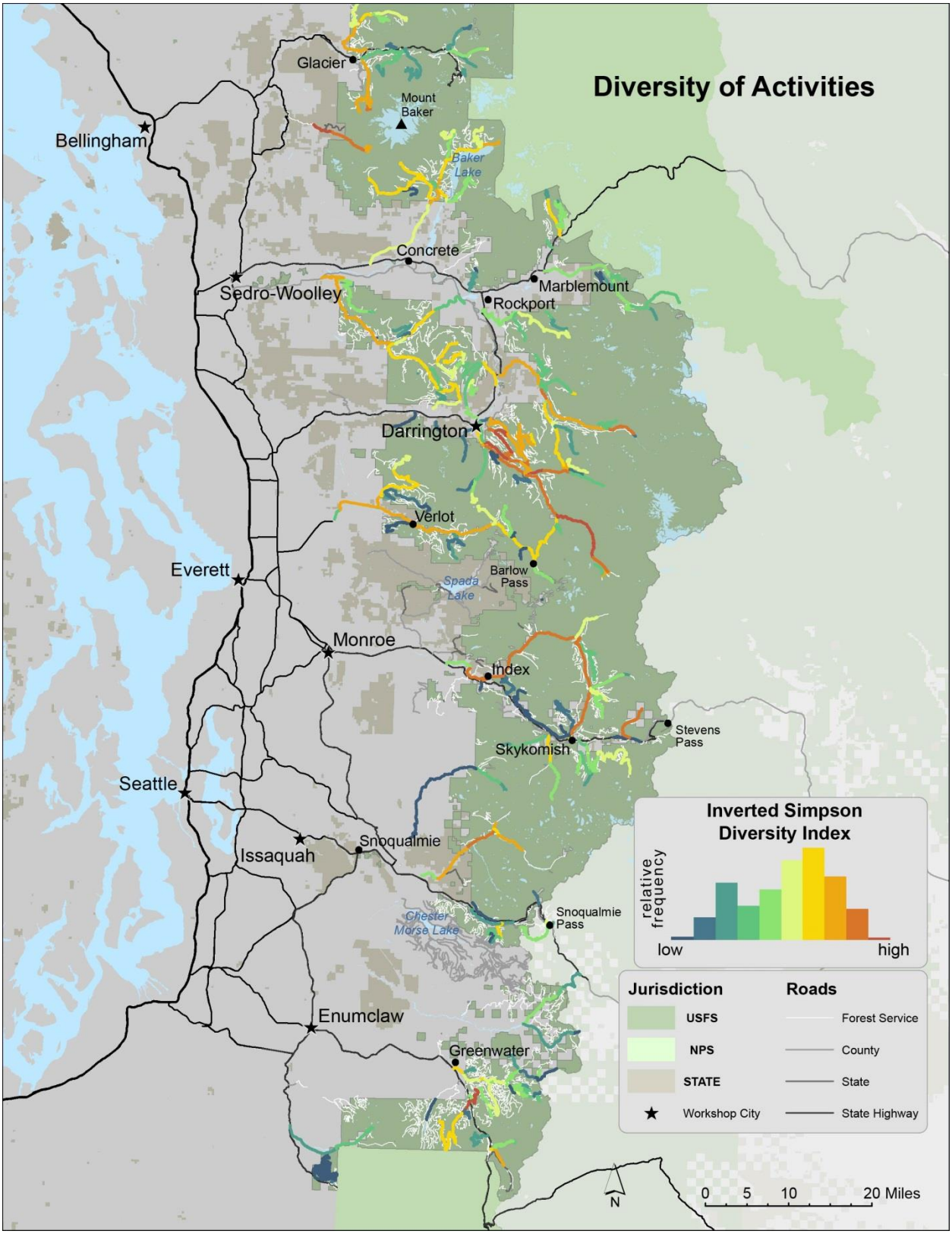


Figure 25 – Activity diversity for roads

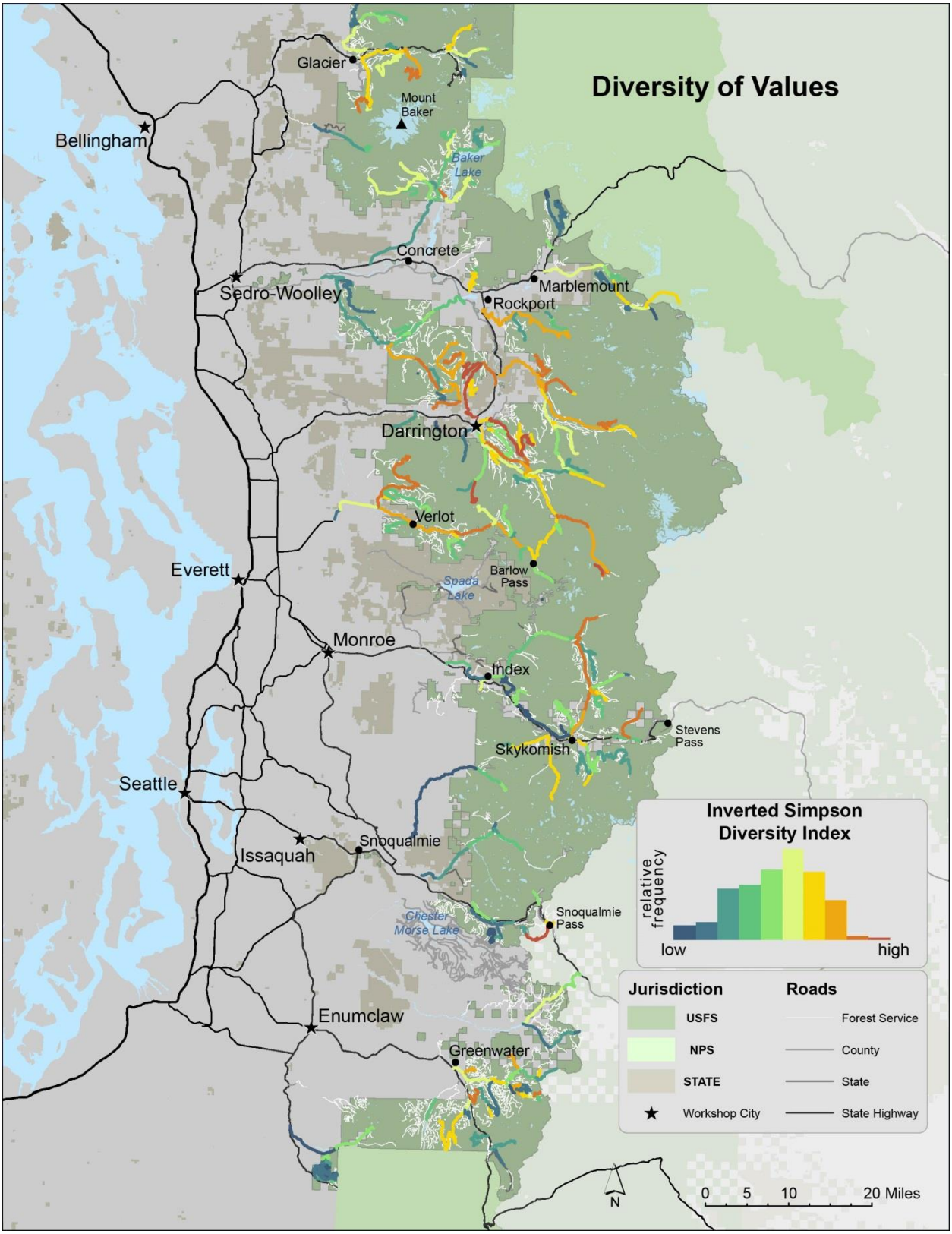


Figure 26 – Values diversity for roads

CONCLUSION

The MBS Sustainable Roads workshops produced a rich dataset that can be explored in a variety of ways to arrive at better understandings of where people go on the forest, which routes they use to get there, what kinds of activities they participate in, and the reasons these places are important to them. Some of the key patterns, lessons learned, and recommendations for future work are discussed below.

Key patterns

- Workshop participants had a strong tendency to go to places and travel along roads in the northern half of the forest. Specifically, sites around Mount Baker and places located in the mountains east of the Mountain Loop Highway figured most prominently as destinations for many activities. Mount Baker was the main destination for winter recreationists (non-motorized uses), strenuous recreation, and observation activities, such as scenic drives and photography. It was also the most frequent destination for hikers, although hiking tended to be more widely dispersed. For collecting/harvesting and sociocultural activities, sites in the Darrington Ranger District were the most popular. Additionally, people engage in a more diverse set of activities in the northern part of the forest. The fact that the residential area analyses showed that people tend to go to places close to home, however, suggests that the skew to the north is at least partly due to the composition of the workshop participants, two-thirds of whom came from northern communities.

- Although the southern half of the forest was less frequently visited overall (and roads used correspondingly less frequently), it is an important area for residents of Pierce County and South King County. It also is important destination for certain outdoor activities, notably motorized recreation and camping. The Greenwater road network in particular is heavily used for a variety of activities.

- Participants were least likely to go to destinations or use roads in the Skykomish Ranger District. Beckler Road was the only road in this district that consistently fell into the high density category. Many of the roads in this district had 10 or fewer overlaps.

Lessons learned

- The key lesson learned through our analyses is that it is important to explore the underlying structure within the overall dataset from a variety of angles. While overall patterns of use are important, it is equally critical to understand how different segments of the population use the forest, where they go, and which routes they take to get there. For example, the activity maps indicate quite clearly that roads that are important for motorized recreationalists are quite different than the roads that are important for mountain climbers. Likewise, when considering which roads to close, a residency analysis can shed light on how particular road closures might affect residents in different communities. In addition to looking at road use for different kinds of

activities and values, other analyses that would be useful include breakdowns by age, gender, income level and ethnicity. The last two are particularly important for addressing federal requirements for taking environmental justice considerations into account when making resource management decisions. Fine-level analyses of these types are useful for identifying more clearly the types of activities and population segments most likely to be affected by closures of particular roads.

Recommendations for future work

- The approach pioneered through the Sustainable Roads Cadre workshops is useful as a first step for identifying which destinations and roads people use and at what level of intensity they use them. In moving forward, we recommend that the MBS (or other organizations involved with road closures) consider structuring a similar type of data collection process in which participants are asked to identify which roads they could accept being closed. This could facilitate the road closure decision making process by identifying a set of roads for which generalized agreement exists that they can be closed.

- At the same time, the Sustainable Roads Cadre's focus on identifying roads that people use or consider important also yields valuable data. However, many of the most frequently mapped destinations and routes described in this report are associated with roads, such as the Mountain Loop Highway, that are highly unlikely to be closed. To sharpen the focus of the workshops, we recommend that future mapping exercises be structured so that Forest Service roads that will definitely remain open (such as major paved roads) be identified as such and left out of the mapping process. This would enable participants to focus on mapping destinations that are associated with roads that will potentially be closed.

- Given the Forest Service's multiple use mandate, it is critical that further investigation be done regarding how to assess the diversity of values and activities associated with particular roads or road segments. Our brief exploration and experimentation with analyzing activity and values diversity for roads suggests that it is feasible to adapt existing diversity indices to road closure planning applications. However, more testing is needed to arrive at better understandings of how to interpret and compare diversity index values.

APPENDIX A – COMBINED WORKSHOPS ROAD DENSITY SUMMARY

Road Name and Number	Road Density 81-104 (Very High)	Road Density 51-80 (High)	Road Density 21-50 (Medium)	Road Density 11-20 (Low)
Mt Baker Vicinity				
Glacier Creek (FS 39)		X		
Schreibers Meadows (FS 13)		X		
Canyon Creek (FS 31)			X	
Twin Lakes (FS 3065)			X	
Hannegan (FS 32)			X	
Wells Creek (33)			X	
Deadhorse (FS 37)			X	
Middle Fork Nooksack (upper part) (FS 38)			X	
Loomis Nooksack (FS 12)			X	
Baker Lake Highway (FS 11)			X	
Marten Lake (FS 1130)				X
Shuksan (FS 1152)			X	
East Bank Baker Lake/Anderson (FS 1106/1107)				X
Highway 20 Vicinity				
Sauk Mtn (FS 1030)				X
Cascade River Road (FS 15)			X	X
Sibley Creek (FS 1540)			X	
Illabot (FS 16)			X	
Finney Creek-Cumberland (FS 17)			X	X
Segelsen (FS 18)			X	
North Mtn (FS 2810)				X
Texas Pond (FS 2811)				X
North Fork Stillaguamish (FS 28)				X
Crevice Creek (FS 2840)				X
Mountain Loop Vicinity				
Siuattle River Road (FS 26)	X	X		
Grade Creek (FS 2640)				X
Tenas Creek (FS 2660)				X
Green Mountain (FS 2680)			X	
S. Side Siuattle (FS 25)			X	
Circle Creek (FS 2703)				X
Straight Creek (FS 27)			X	

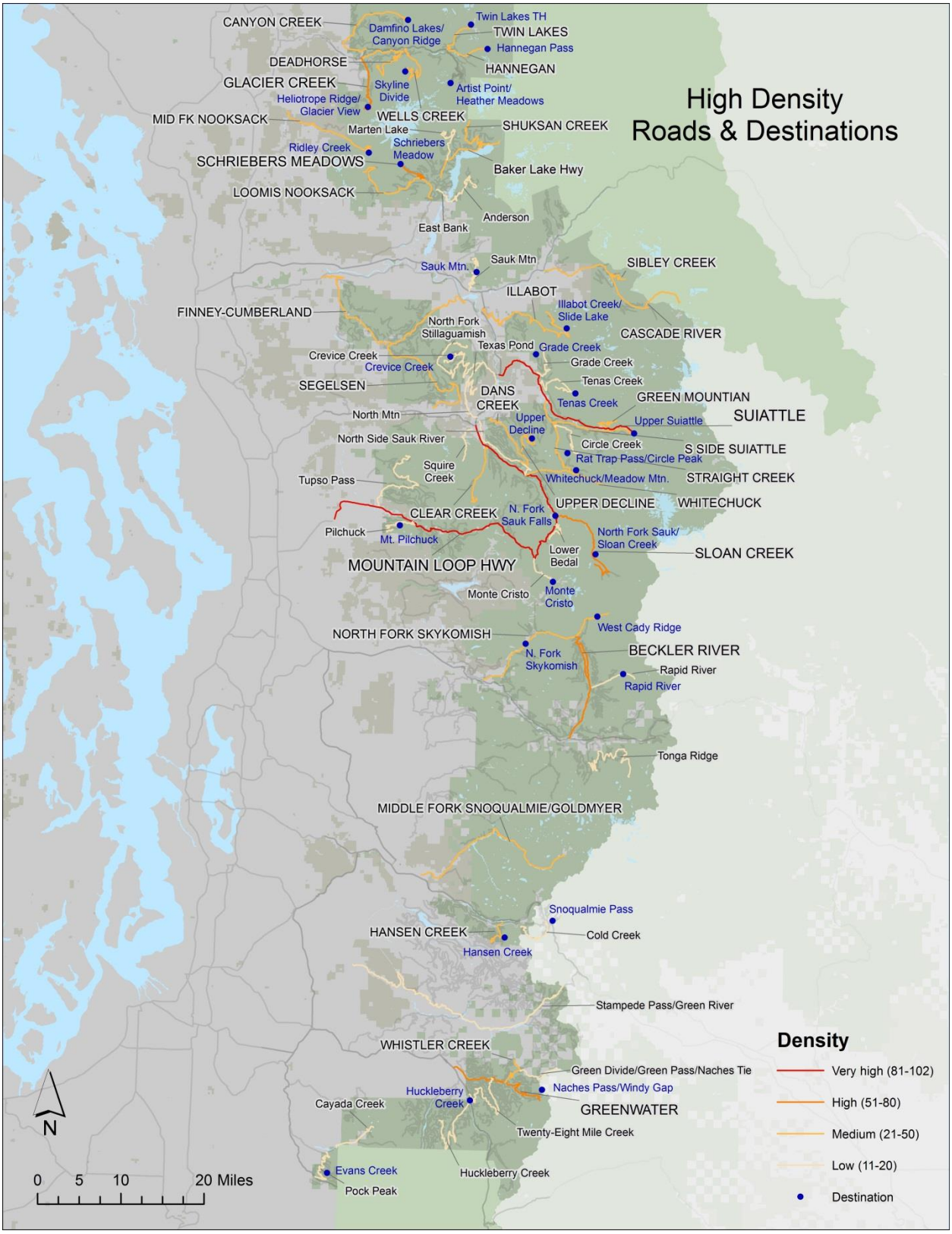
Appendix A (continued)

Road Name and Number	Road Density 81-104 (Very High)	Road Density 51-80 (High)	Road Density 21-50 (Medium)	Road Density 11-20 (Low)
Mtn Loop Highway (FS 20)	X			
Sloan Creek (N. Fork of the Sauk) (FS 49)		X	X	
Lower Bedal (FS 4096)				X
Monte Cristo				X
Pilchuck (FS 42)				X
Tupso Pass (FS 41)				X
Squire Creek (FS 2040)				X
Clear Creek (FS 2060)			X	X
North Side Sauk River (FS 22)				X
Dans Creek (FS 24)			X	
Upper Decline (FS 2435)			X	
Whitechuck (FS 23)(first 2 miles)			X	
Highway 2 Vicinity				
Beckler Road (FS 65/6550)		X	X	
Rapid River (FS 6530)				X
North Fork Skykomish (FS 63)			X	
Tonga Ridge (FS 6830) - lower part				X
Snoquamlie Pass Vicinity				
Hansen Creek (FS 5510)			X	X
Cold Creek (FS 9070)				X
Middle Fork Snoqualmie/Goldmyer (FS 56)			X	X
Greenwater/Evans Creek Vicinity				
Greenwater (FS 70)		X	X	
Whistler Creek (FS 7030)			X	
Green Divide/Green Pass/Naches Tie (FS 036/FS 7038)				X
Stampede Pass/Green River Rd (FS 54)				X
Huckleberry Creek (FS 73)				X
Twenty-Eight Mile Creek (FS 72)				X
Cayada Creek (FS 7810)				X
Poch Peak (FS 7920 and associated Evans Creek off-road trail network)				X

APPENDIX B – RESIDENTIAL AREAS: HIGH DENSITY DESTINATIONS

Destination	Whatcom	Mountain Loop	Highway 2	Everett-Skagit	North/East King	Pierce/South King
Mt Baker District						
Heliotrope Ridge/Glacier View	X					
Illabot Creek/Slide Lake		X				
Sauk Mountain				X		
Schreibers Meadows	X			X		
Darrington District						
Upper Decline		X				
Grade Creek		X				
Whitechuck/Meadow Mountain			X			
Monte Cristo				X		
Mount Pilchuck				X		
North Fork Sauk Falls		X				
Rat Trap Pass/Circle Peak		X				
Sloan Creek		X				
Tenas Creek		X				
Upper Suiattle		X	X	X		
Skykomish District						
W. Cady Ridge			X			
North Fork Skykomish			X			
Rapid River			X			
Snoqualmie District						
Naches Pass/Windy Gap						X
Hansen Creek					X	
Huckleberry Creek Rd.						X
Snoqualmie Pass					X	
Number of sites	2	8	5	5	2	2

APPENDIX C – MAP OF HIGH DESTINATIONS AND ROADS



APPENDIX D - KERNEL DENSITY AND DIVERSITY INDEX METHODS

Kernel density

To show the concentration of destination points, we used a kernel density function. This calculation produces an output of destinations per square mile for each cell in a raster dataset. The kernel function is fitted to each destination point with its highest value at that point decreasing to zero at an established search radius distance. The sum of the kernel values overlapping each cell center is divided by the cell area to calculate density. The larger the search radius value used, the more generalized the density pattern. For our calculations, we used a search radius of 15,000 feet at a cell size of 100 feet. We also weighted each point based on the frequency of visits noted in the survey. Destinations listed as being used "several times a week" or "several times a month" were given a weight of 2; those listed as being used "several times a year" or "about once or twice a year or less" were given a weight of 1.

Diversity index

Diversity metrics are most commonly used in studies of species diversity. Two popular metrics are the Shannon Index and the Simpson Index (Simpson 1949; Shannon & Weaver 1962). The Shannon Index is calculated as

$$D = -\sum_{i}^{n} p_i \ln p_i$$

where D is diversity, and p is the proportion of a given species, i, in a population with n different species.

The Simpson Index is based off of the following formula:

$$D = \sum_{i}^{n} p_i^2$$

If this equation is used by itself to represent diversity, areas of higher diversity will have lower diversity scores. Since this is counter-intuitive there are two common transformations of the index. The first formulation is calculated as:

$$1 - D$$

The second formulation, referred to as the Inverse Simpson index, is calculated as:

$$\frac{1}{D}$$

The Shannon and Inverse Simpson indices lie along a continuum of related diversity indices (Hill 1973). At one end of this continuum rare species are weighted most heavily, and at the other end common species are weighted most heavily. The Inverted Simpson Index emphasizes common species more heavily, and the Shannon Index emphasizes rare species (Figure C-1). Since this is the first analysis of

activities diversity along forest roads, we are interested in a view of diversity that focuses on the common activities, and so we consider the Inverted Simpson index more appropriate for our use. We feel there is one drawback to the Inverted Simpson, however. The index has a maximum value of n, or the number of activity classes. While this makes sense conceptually, having an index that can range from 0 to 1 allows for easier interpretation by those unfamiliar with the logic behind diversity indices. We therefore use the following metric to represent diversity for our study

$$\frac{1}{nD}$$

And since we have eight activity classes, this equals

$$\frac{1}{8D}$$

This index is useful because it maintains the distribution of the Inverted Simpson index, always has a value between 0 and 1, and can be easily converted back to the more commonly used Inverted Simpson metric for comparison with other studies that may use more or fewer activity classes.

We calculated diversity by compiling the counts for each activity class for each road segment. In many cases participants mentioned as many as 6 different activities for a given road. We weighted each activity equally since there was no way to tell which one was done more frequently.

References

Hill, M.O. 1973. Diversity and evenness: A unifying notation and its consequences. *Ecology* 54(2):427-432.

Shannon, C.E. 1948. A mathematical theory of communication. *The Bell System Technical Journal* 27:379-423; 623-656.

Simpson, E.H. 1949. Measurement of diversity. *Nature* 163: 688.

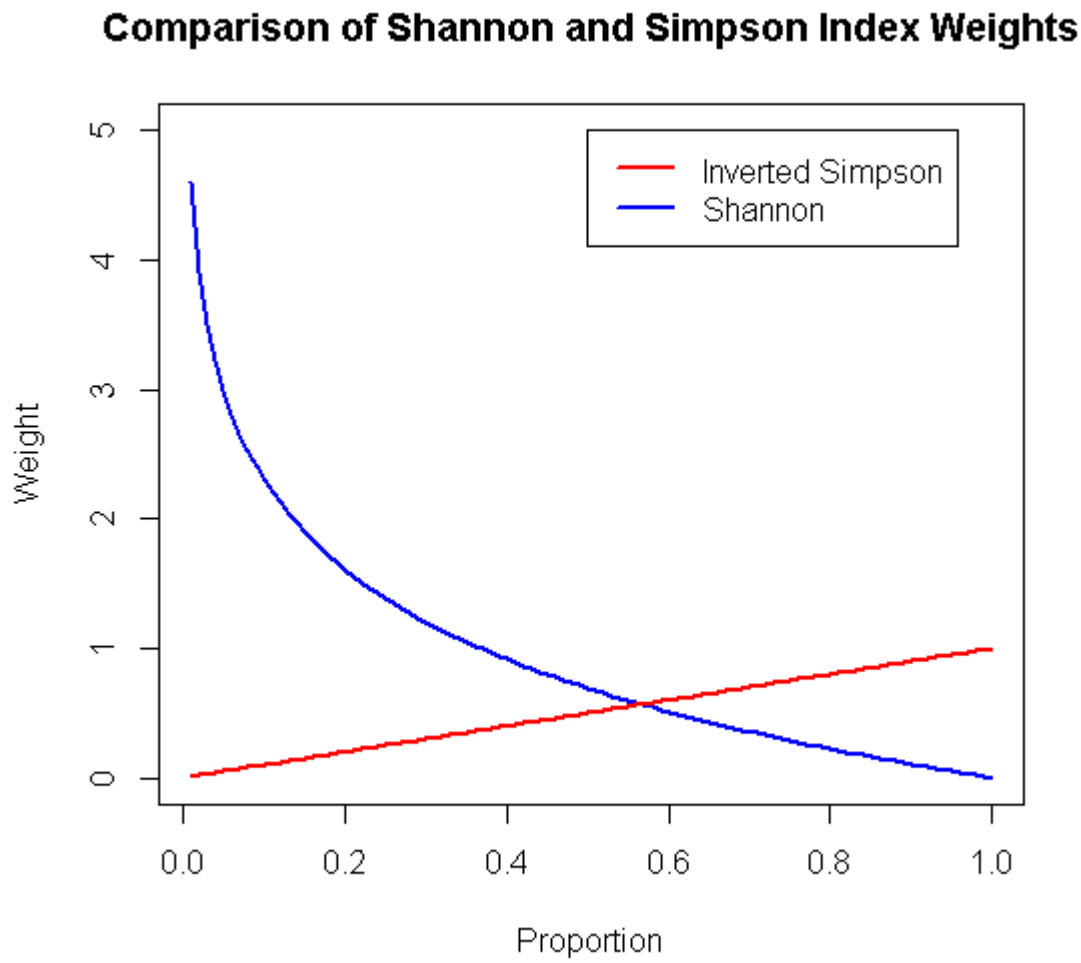


Figure C-1 – Comparison of Shannon and Simpson index weights: Both the Simpson and the Shannon index can be interpreted as being the sum of weighted proportion values: $D = \sum_i^n w_i * p_i$, where w is the weight, p is the proportion for a given species, i, out of n total species. For the Shannon index $w_i = \ln p_i$, and for the Simpson index $w_i = p_i$. A plot showing the weights for each proportion shows that species with larger proportions are weighted more heavily in the Simpson index and smaller proportions are weighted more heavily in the Shannon index.