Bighorn Sheep
Draft Supplemental Environmental Impact Statement
Analysis:
Technical Report

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Introduction

In response to a Payette National Forest Land and Resource Management Plan (Forest Plan) (USDA Forest Service 2003a) appeal remand by the Washington Office of the U.S. Forest Service in 2005, the Payette National Forest has completed a report, *Risk Analysis of Disease Transmission Between Domestic Sheep and Bighorn Sheep on the Payette National Forest* (Risk Analysis) (USDA Forest Service 2006a). Based on the comments and concerns received about the Risk Analysis (USDA Forest Service 2006a), the Payette National Forest convened a science panel composed of wildlife biologists, research scientists, domestic livestock experts, and veterinary experts to (1) clarify the science-based concerns regarding the Risk Analysis and (2) allow panelists to provide additional science-based information about disease transmission and its risk of occurring on the Payette National Forest for the Forest Supervisor to consider in conjunction with the Risk Analysis. The science panel met on November 2, 2006 (USDA Forest Service 2006b). In August 2007, the Payette National Forest convened an interdisciplinary team (IDT) to develop a supplemental environmental impact statement (SEIS) to the 2003 Southwest Idaho Ecogroup Land and Resource Management Plan Final Environmental Impact Statement (FEIS) (USDA Forest Service 2003b) and to supplement the Forest Plan (USDA Forest Service 2003a). The Payette National Forest received requests from the State of Idaho, State of Oregon, State of Washington, Nez Perce Tribe, Shoshone-Bannock Tribe, Shoshone-Paiute, and Confederated Tribes of the Umatilla to be involved in the SEIS process. The process was revised to include our cooperators. As a result of this consultation between the Payette National Forest and the cooperators, four major analyses were completed for the SEIS. The analysis products are a source habitat model, herd home range model, geographic population range, and relative risk rating.

Source Habitat Model

The source habitat model for bighorn sheep used in the SEIS was originally designed by the Hells Canyon Initiative (HCI) (Table 1). The HCI is managed by the Hells Canyon Bighorn Sheep Restoration Committee, which is a state, federal, and private partnership to restore Rocky Mountain bighorn sheep into the Hells Canyon Complex of Oregon, Idaho, and Washington. Source habitat is defined as those characteristics of macrovegetation that contribute to stationary or positive population growth, which is distinguished from habitats associated with species occurrence since such habitats may or may not contribute to long-term population persistence (Wisdom et al. 2000*)* This model is primarily a two-component model consisting of escape terrain and horizontal visibility. The water sources component was not used in our version of this model because the criteria used in the HCI model (>3.2 kilometers[km]) encompassed every portion of the Payette National Forest. We also did not model the lambing range.

Table 1. Hells Canyon Initiative Bighorn Sheep Habitat Model [1]

Habitat Component	Criteria	Source
Escape terrain		
Slope	$31^{\circ} \leq$ slope $\leq 85^{\circ}$	Gudorf and Sweanor 1996, Smith et al. 1991
Buffer	300 meters (m) or land areas ≤ 1,000 m wide bounded on ≥2 sides by escape terrain (500 m)	Smith et al. 1991, Gudorf and Sweanor 1996
Minimum area	1.6 hectares	Gudorf and Sweanor 1996
Horizontal visibility	Grassland, rock, open shrub, or forest cover <40%, from satellite imagery	Schirokauer 1996
Water sources	≤ 3.2 km	Smith et al. 1991, Gudorf and Sweanor 1996
Summer range	Suitable habitat within 300 m of escape terrain	Smith et al. 1991, Gudorf and Sweanor 1996, Schirokauer 1996
Winter range	Suitable habitat all aspects below 4,800 feet (ft), aspect 135°–225° above 4,800 ft	Smith et al. 1991, Gudorf and Sweanor 1996, Coggins pers. comm.
Lambing range	Escape terrain 45°–315° ≤ 1 km from water ≥ 2 contiguous ha	Gudorf and Sweanor 1996

[1] From Hells Canyon Bighorn Sheep Restoration Committee 1997

The original source habitat model needed two modifications for the current process. The first issue was that the extent geographic range of the layer model only covered the Hells Canyon Complex and not the entire Payette National Forest. The second issue concerned the vegetation layer used in the horizontal visibility component of the original model. The HCI model utilized the National Land Cover Dataset, which was too broad and contained no canopy cover information, resulting in an insufficient level of detail for the vegetation data. To solve the problems of scale and detail, we used a different vegetation dataset for horizontal visibility. We also included low canopy cover forested cover types. This use of forested types is supported by the HCI's cited literature but was not used because of the National Land Cover Dataset limitations. The escape terrain component was found to be sufficient for our needs and was used exactly as it was in the HCI model.

Our horizontal visibility component used the vegetation dataset from the LANDFIRE project (The National Map LANDFIRE 2006), an interagency effort to map vegetation and fuels data in a consistent fashion and at a scale useful at an incident level nationally. The non-forest vegetation cover types from the HCI model were crosswalked into the LANDFIRE non-forested cover types by the Payette National Forest staff. The documentation created by the HCI stated that forested cover types of less than 40 percent canopy cover can be used in the model; however, in the actual model they were not used because canopy cover was not included in the original National Land Cover Dataset. Forested cover types for canopy cover less than or equal to 30 percent were added to the model from LANDFIRE. The 30 percent canopy cover for forest cover type was chosen based on review by Payette National Forest staff using the 2004 National Agricultural Imagery Program (NAIP) 1-meter (m) full color photographs. The LANDFIRE data at 40 percent canopy cover in forested types tended to map canopy covers that appeared denser than 40 percent cover, particularly on the east side of the Payette National Forest. This discrepancy would have overestimated the amount of

source habitat available to bighorn sheep on the eastern portion of the Payette National Forest and may have contributed to some undermapping of source habitat on the western side of the Payette National Forest where the canopy covers better matched the image from the photographs. However, it appeared to be less of an error to underestimate the habitat in the west when compared to the amount that would have been overmapped in the east. We also decided to filter the habitat model to a minimum mapping size of 5 acres. The original HCI model only filtered the escape terrain component to 1.6 hectares (approximately 4 acres). The overall 5 acre minimum mapping area filter did a better job of habitat mapping because of the nature of the LANDFIRE vegetation data. The final product and the forest cover type/canopy cover choices were verified with NAIP photography and generally fit the landscape across the Payette National Forest.

The final source habitat model was compared with over 50,000 telemetry and observation points, mainly from Hells Canyon and to a lesser extent from the Salmon River Canyon; 92 percent of all known bighorn sheep telemetry points fell within the modeled source habitat. A final review of all source habitat model components and outcomes was completed by the full IDT and accepted as adequate to fulfill the needs of this analysis. Detailed information on each input and function is found in Table 2, which shows summer source habitat for bighorn sheep in Hells Canyon and the Payette National Forest. Table 3 describes the LANDFIRE cover types.

Table 2. Summer Habitat Model

Name	Explanation[1]
CON selection of non-forest cover types	This command creates the non-forested input for the horizontal visibility portion of the Bighorn Sheep Summer Source Habitat model. The input data is Existing Vegetation Type downloaded from LANDFIRE on May 2, 2007. The map algebra command is "con (F:\Bighorn\Landfire\33677953\33677953 in {12, 31, 2001, 2006, 2079, 2080, 2081, 2106, 2123, 2124, 2125, 2126, 2127, 2134, 2135, 2139, 2140, 2142, 2143, 2144, 2145, 2153, 2169, 2181, 2182, 2183, 2220, 2062, 2065, 2144, 2070, 2017, 2115, 2165},1)".
CON selection of forest cover types and canopy covers	This command creates the forested input for the horizontal visibility portion of the Bighorn Sheep Summer Source Habitat model. The input data are Existing Vegetation Type and Existing Vegetation Cover downloaded from LANDFIRE on May 2, 2007. The map algebra command is "con ((F:\Bighorn\Landfire\33677953\33677953 in {2008, 2009, 2011, 2012, 2016, 2018, 2019, 2020, 2035, 2036, 2037, 2038, 2039, 2041, 2042, 2045, 2046, 2047, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2060, 2061, 2063, 2154, 2156, 2157, 2158, 2161, 2166, 2167, 2173, 2174, 2178, 2200, 2203, 2205, 2206, 2208, 2227, 2228, 2232} and F:\Bighorn\Landfire\30745420\30745420 in {101, 102}), 1)". The canopy covers from LANDFIRE are as follows 101 Tree Cover >= 10 and < 20% 102 Tree Cover >= 20 and < 30%.
MERGE of forested and non-forest selections	This command merges the forested and non-forest components of the horizontal visibility component of the Bighorn Sheep Summer Source Habitat model. The map algebra for this command is "merge (non-forest, forest)".

Name	Explanation[1]
Project Raster from Albers to Universal Transverse Mercator (UTM)	This command changes the projection of the combined forested and non-forested vegetation components. The LANDFIRE projection was Albers NAD83, which was projected to the local projection of UTM Zone 11 NAD83.
Region Group for minimum mapping size	This Region Group command is the first step in filtering for a minimum mapping unit. This command takes the input and groups the cells based on if they touch and then gives all the touching cells the total count for that group.
CON selection of minimum mapping size of 5 acres	This command selects from the grouped input groups of cell 5 acres or larger. The map algebra for this command is "con (F:\Bighorn\Landfire\hor_vis_rg.count >= 23,1)".
"Slope >= 31 and <= 85 degrees" CON	This CON function selects slopes from the slope grid derived from the National Elevation Dataset elevation grid. The slopes selected are equal to or greater than 31° and less than or equal to 85°. This selection is as follows "F:\Bighorn\NED\deg_slp >= 31 AND F:\Bighorn\NED\deg_slp <= 85".
Region Group	This command takes the input and groups the cells based on if they touch and then gives all the touching cells the total count for that group.
CON & ZONALAREA (Single Output Map Algebra)	This command selects from the grouped input groups of cell 16000 or larger. The map algebra for this command is "con (zonalarea (slpgp) >= 16000, 1)".
CON & EUCDISTANCE LE 300 (Single Output Map Algebra)	This CON function calculates the straight line distance from the input then selects all cells less than or equal to 300 m. The map algebra for this command is "con (eucdistance (escslp) <= 300, 1)".
CON & EUCDISTANCE GT 500 (Single Output Map Algebra)	This CON function calculates the straight line distance from the input then selects all cells greater than 500 m. The map algebra for this command is "con (eucdistance (escslp) > 500, 1)".
CON & EUCDISTANCE GE 500 (Single Output Map Algebra)	This CON function calculates the straight line distance from the input then selects all cells greater than or equal to 500 m. The map algebra for this command is "con (eucdistance (gt500) >= 500, 1)".
CON & ISNULL (Single Output Map Algebra)	This CON function erases the "buff300" from "wi500" to create the final output for the escape terrain component. The map algebra for this function is "con (isnull (buff300), con (wi500 == 1, 1), 1)".
CON combines the two model components	This CON command combines the two model components so that on the cell and overlap from the two inputs appear in the final output.

[1] See Table 3 for descriptions of the LANDFIRE cover types

Table 3. LANDFIRE Cover Types

No.	Type of Vegetation
12	Snow/Ice
31	Barren
2001	Inter-Mountain Basins Sparsely Vegetated Systems
2006	Rocky Mountain Alpine/Montane Sparsely Vegetated Systems
2008	North Pacific Oak Woodland
2009	Northwestern Great Plains Aspen Forest and Parkland
2011	Rocky Mountain Aspen Forest and Woodland
2012	Rocky Mountain Bigtooth Maple Ravine Woodland
2016	Colorado Plateau Pinyon-Juniper Woodland
2017	Columbia Plateau Western Juniper Woodland and Savanna
2018	East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
2019	Great Basin Pinyon-Juniper Woodland
2020	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland
2035	North Pacific Dry Douglas-fir Forest and Woodland
2036	North Pacific Hypermaritime Sitka Spruce Forest
2037	North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest
2038	North Pacific Maritime Mesic Subalpine Parkland
2039	North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
2041	North Pacific Mountain Hemlock Forest
2042	North Pacific Mesic Western Hemlock-Silver Fir Forest
2045	Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest
2046	Northern Rocky Mountain Subalpine Woodland and Parkland
2047	Northern Rocky Mountain Mesic Montane Mixed Conifer Forest
2049	Rocky Mountain Foothill Limber Pine-Juniper Woodland
2050	Rocky Mountain Lodgepole Pine Forest
2051	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Wood
2052	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
2053	Northern Rocky Mountain Ponderosa Pine Woodland and Savanna
2054	Southern Rocky Mountain Ponderosa Pine Woodland
2055	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
2056	Rocky Mountain Subalpine Wet-Mesic Spruce-Fir Forest and Woodland
2057	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
2060	East Cascades Oak-Ponderosa Pine Forest and Woodland
2061	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
2062	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland
2063	North Pacific Broadleaf Landslide Forest and Shrubland
2065	Columbia Plateau Scabland Shrubland
2070	Rocky Mountain Alpine Dwarf-Shrubland
2079	Great Basin Xeric Mixed Sagebrush Shrubland
2080	Inter-Mountain Basins Big Sagebrush Shrubland
2081	Inter-Mountain Basins Mixed Salt Desert Scrub

No.	Type of Vegetation
2106	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland
2115	Inter-Mountain Basins Juniper Savanna
2123	Columbia Plateau Steppe and Grassland
2124	Columbia Plateau Low Sagebrush Steppe
2125	Inter-Mountain Basins Big Sagebrush Steppe
2126	Inter-Mountain Basins Montane Sagebrush Steppe
2127	Inter-Mountain Basins Semi-Desert Shrub-Steppe
2134	Columbia Basin Foothill and Canyon Dry Grassland
2135	Inter-Mountain Basins Semi-Desert Grassland
2139	Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland
2140	Northern Rocky Mountain Subalpine-Upper Montane Grassland
2142	Columbia Basin Palouse Prairie
2143	Rocky Mountain Alpine Fell-Field
2144	Rocky Mountain Dry Turf
2145	Rocky Mountain Subalpine-Montane Mesic Meadow
2153	Inter-Mountain Basins Greasewood Flat
2156	North Pacific Lowland Riparian Forest and Shrubland
2157	North Pacific Swamp Systems
2158	North Pacific Montane Riparian Woodland and Shrubland
2161	Northern Rocky Mountain Conifer Swamp
2165	Northern Rocky Mountain Foothill Conifer Wooded Steppe
2166	Middle Rocky Mountain Montane Douglas-fir Forest and Woodland
2167	Rocky Mountain Poor-Site Lodgepole Pine Forest
2169	Northern Rocky Mountain Subalpine Deciduous Shrubland
2173	North Pacific Wooded Lava Volcanic Flowage
2174	North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
2178	North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest
2181	Introduced Upland Vegetation—Annual Grassland
2182	Introduced Upland Vegetation—Perennial Grassland and Forbland
2183	Introduced Upland Vegetation—Annual and Biennial Forbland
2200	Pseudotsuga menziesii-Quercus garryana Woodland Alliance
2203	Juniperus occidentalis Woodland Alliance
2205	Tsuga mertensiana-Abies amabilis Woodland Alliance
2206	Pseudotsuga menziesii Giant Forest Alliance
2208	Abies concolor Forest Alliance
2220	Artemisia tridentata ssp. vaseyana Shrubland Alliance
2227	Pseudotsuga menziesii Forest Alliance
2228	Larix occidentalis Forest Alliance
2232	Abies grandis Forest Alliance

Bighorn Sheep Herd Home Range Modeling

Home range modeling was conducted as part of the major bighorn sheep herd analysis for the Hells Canyon Complex. The herd home range modeling made it possible to analyze the impacts of domestic sheep grazing on the Payette National Forest to the broader bighorn sheep metapopulations. The analysis showed the extent of the interchange between the different herds throughout the Hells Canyon Complex. This type of modeling also allowed the IDT to determine what areas bighorn sheep are, or have been, occupying. The tools and processes used to complete this analysis are documented in a paper published by Clifford et al. (2007). The analysis consisted of a fixed kernel home range model conducted with the observations and telemetry data collected by the HCI from 1997 through 2006. Francis Cassirer (Idaho Department of Fish and Game [IDFG]), who is the HCI project leader responsible for the telemetry database management, used the telemetry data to divide the bighorn sheep population into herds. The herd assignments were based on transplant locations and breeding groups of ewes that shared the same range. A population is based on the entirety of the breeding individuals independent of shared range. Identified herds are the Asotin, Big Canyon, Black Butte, Imnaha, Lostine, McGraw, Minam, Mountain View, Muir Creek, Myers Creeks, Quartz Creek, Redbird, Sheep Divide, Sheep Mountain, and Wenaha (Figures 1–15). Several small herds had too few points to accurately create a herd home range, so no home range modeling was conducted on them. These small herds are called 05IMREL, Lower Hells Canyon, Saddle Creek, and Upper Hells Canyon.

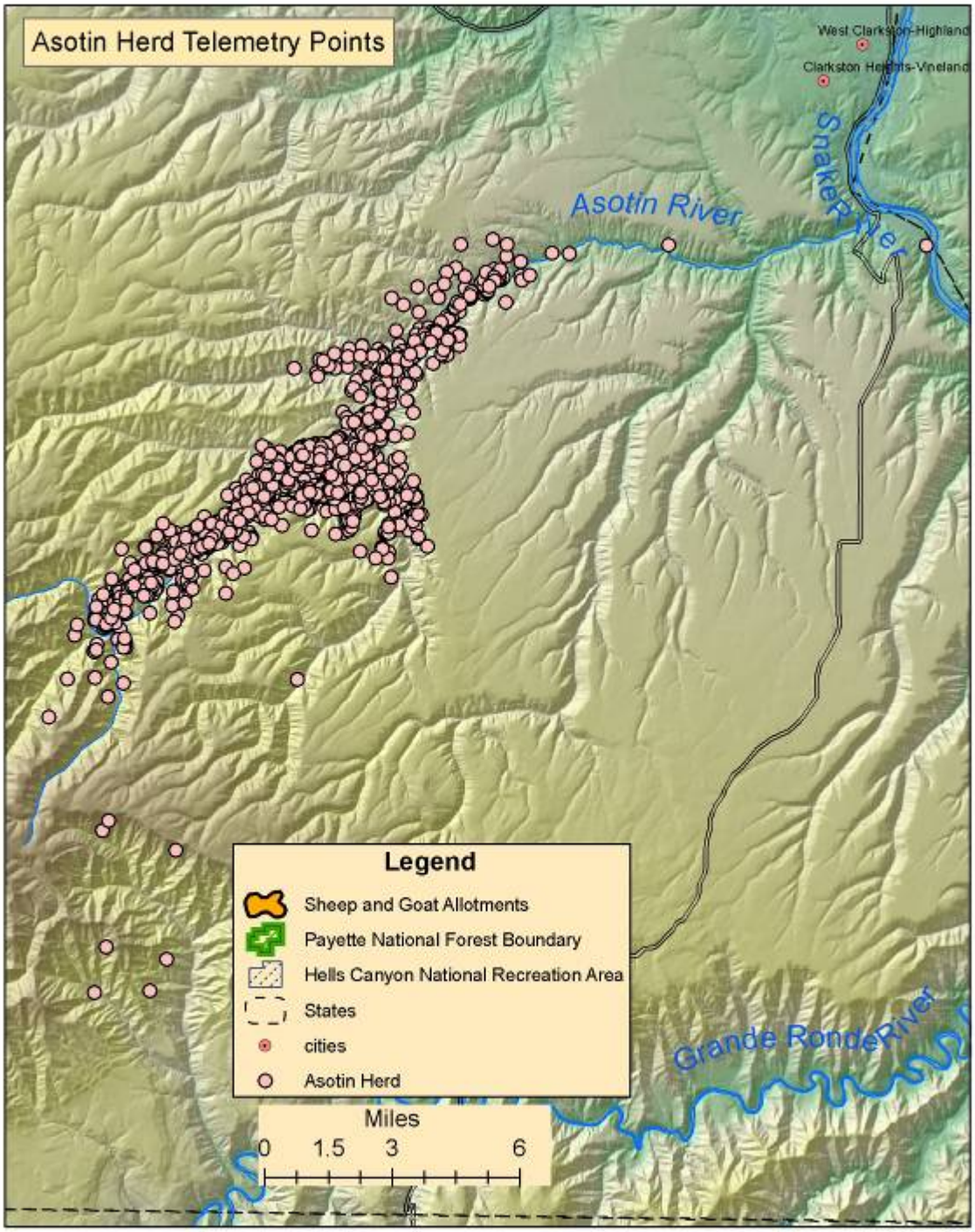

Figure 1. Asotin Herd Telemetry Points

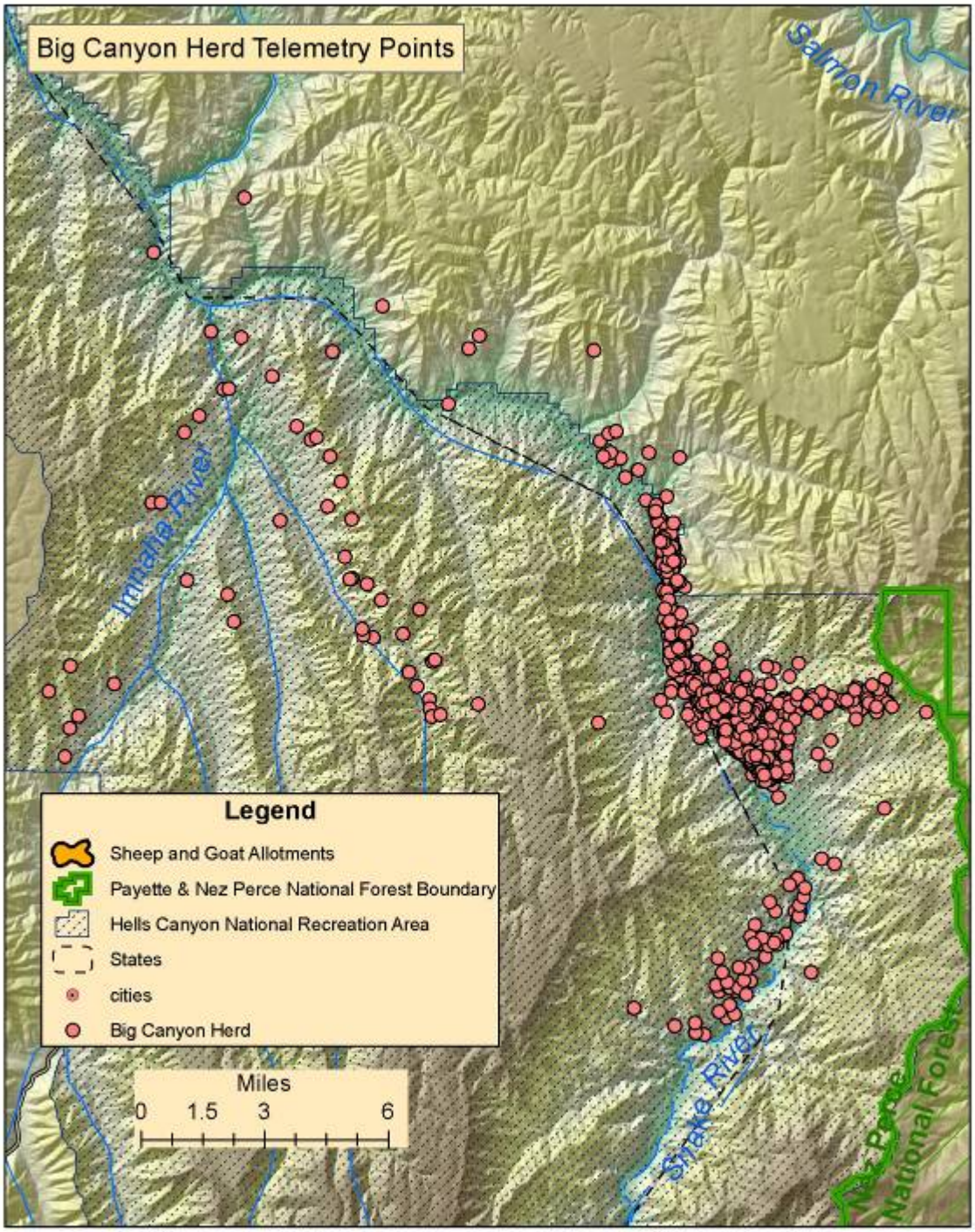

Figure 2. Big Canyon Herd Telemetry Points

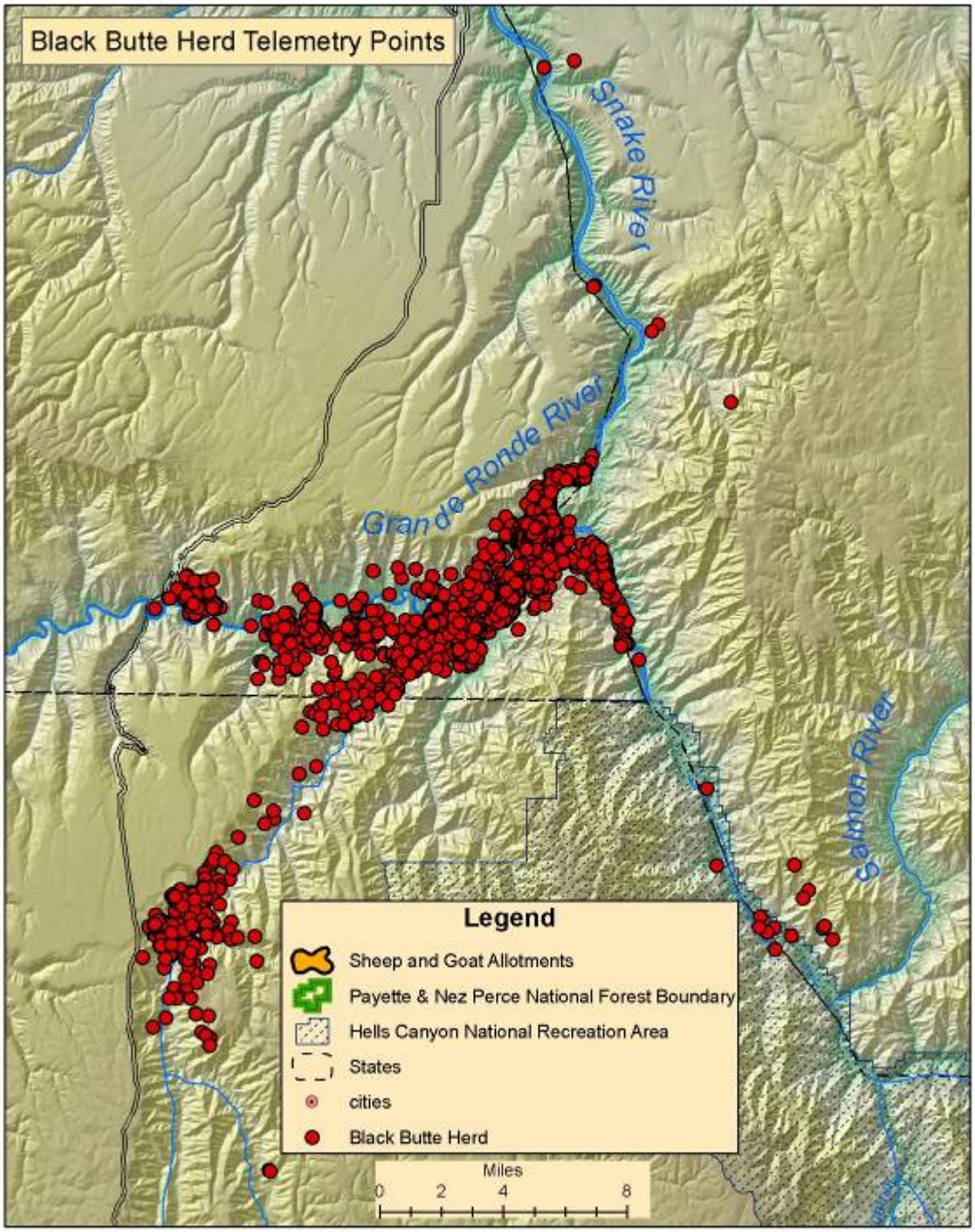

Figure 3. Black Butte Herd Telemetry Points

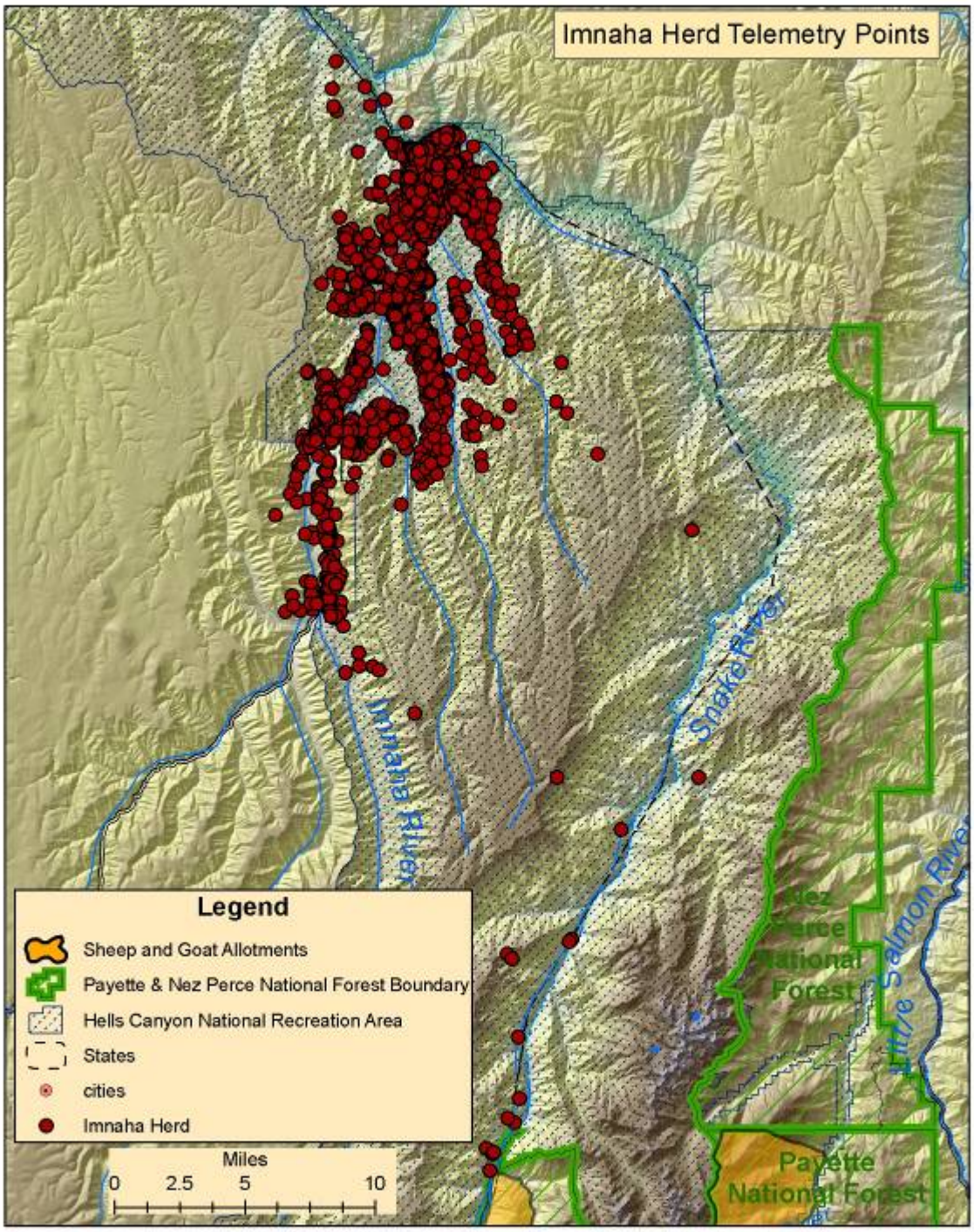

Figure 4. Imnaha Herd Telemetry Points

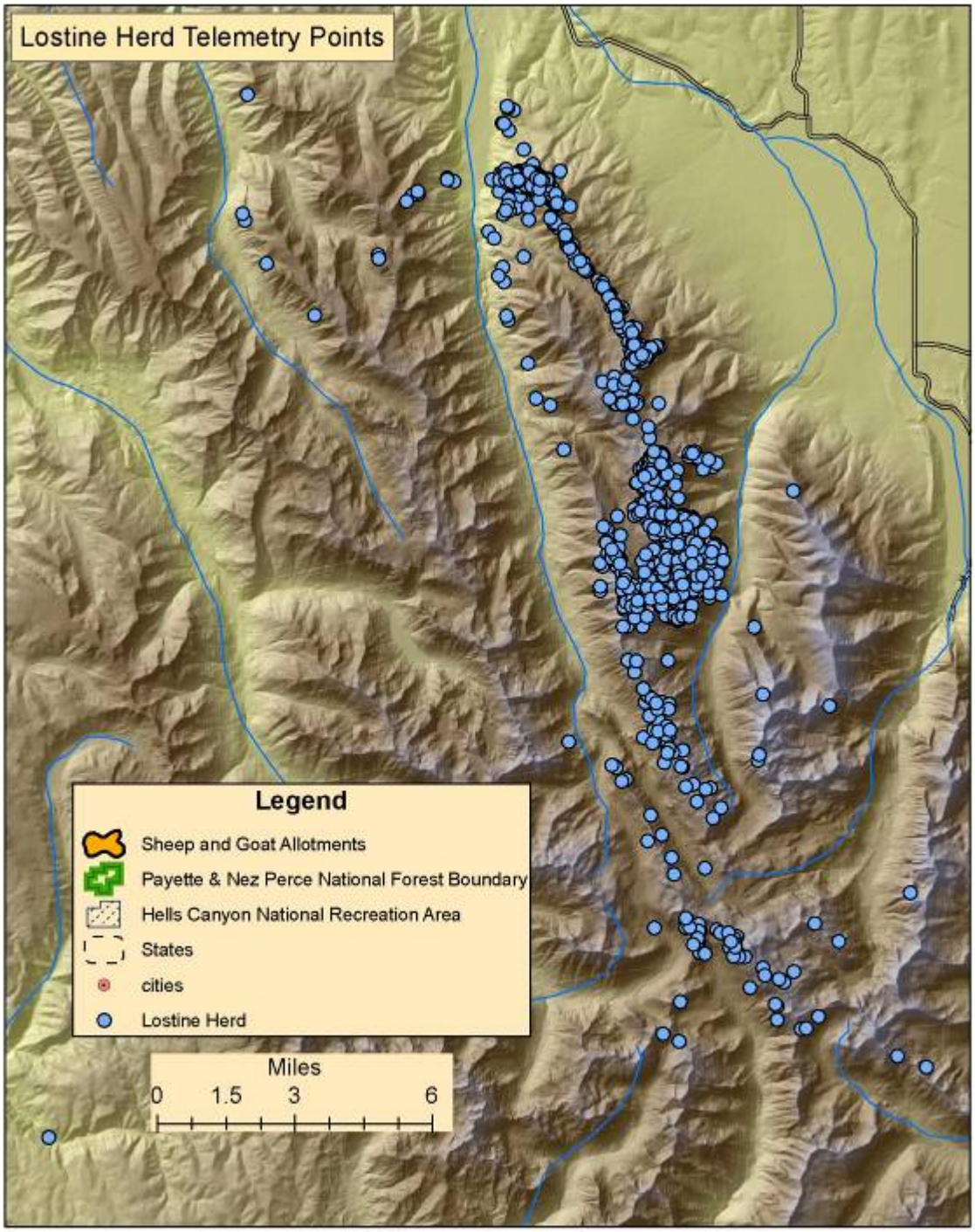

Figure 5. Lostine Herd Telemetry Points

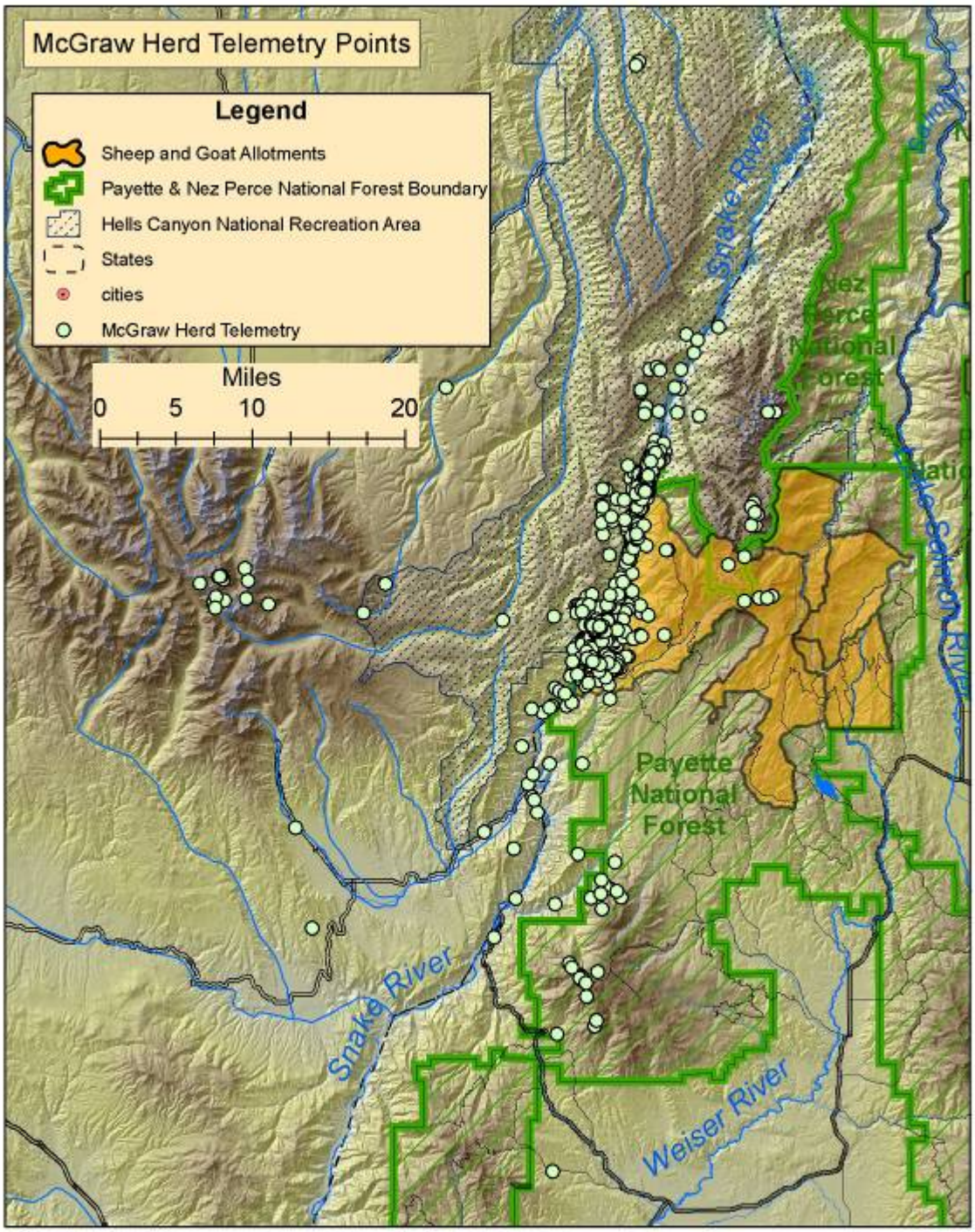

Figure 6. McGraw Herd Telemetry Points

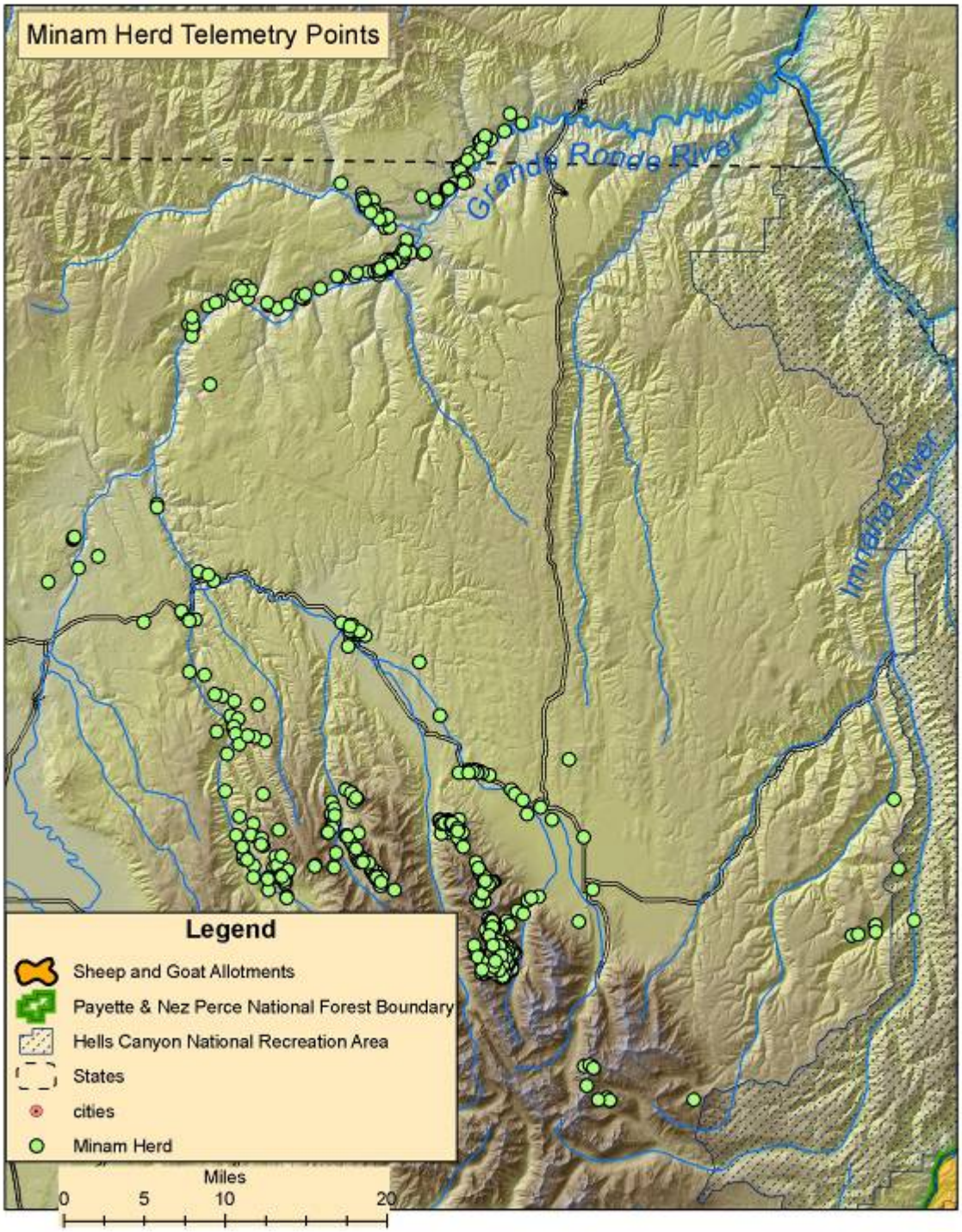

Figure 7. Minam Herd Telemetry Points

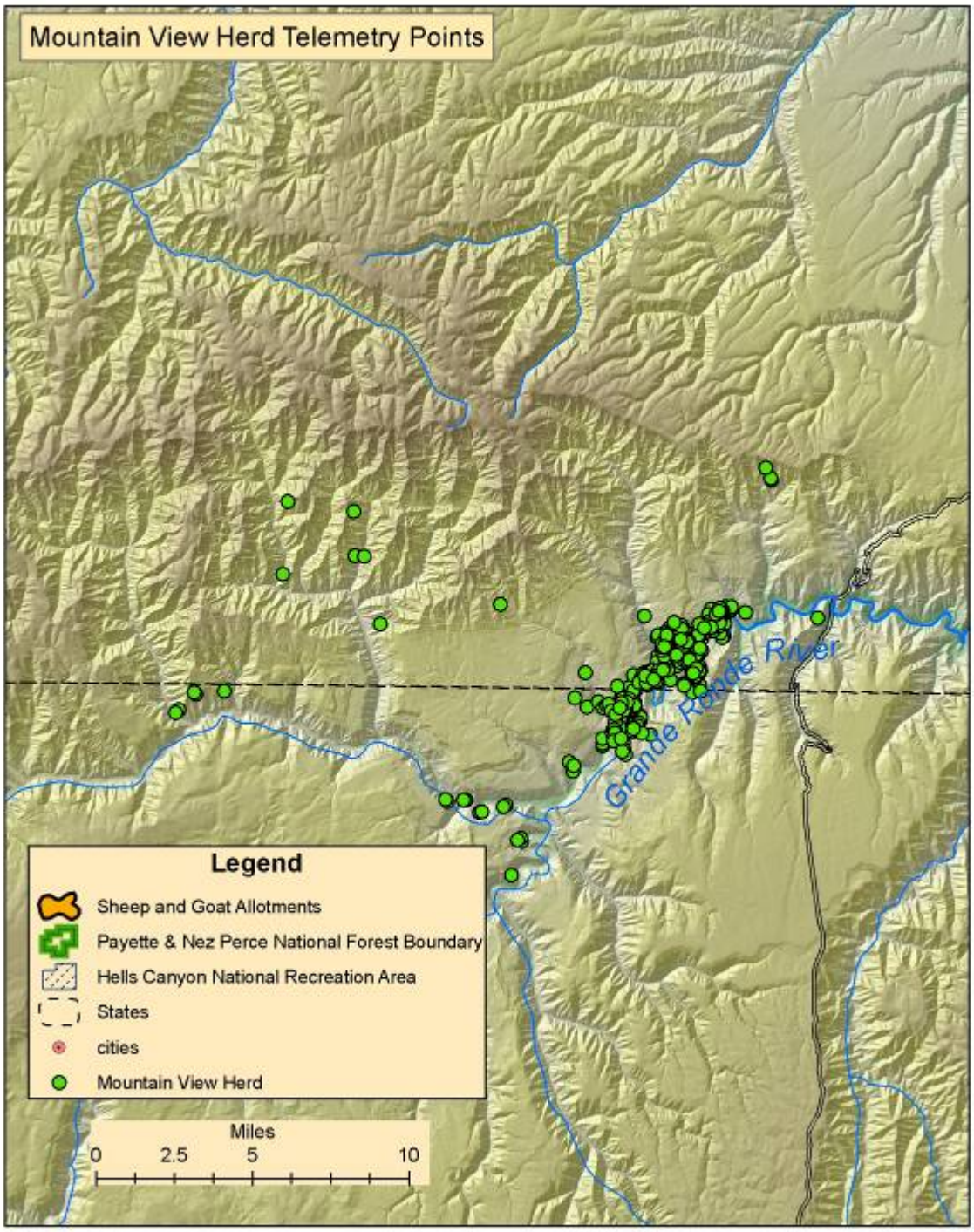

Figure 8. Mountain View Herd Telemetry Points

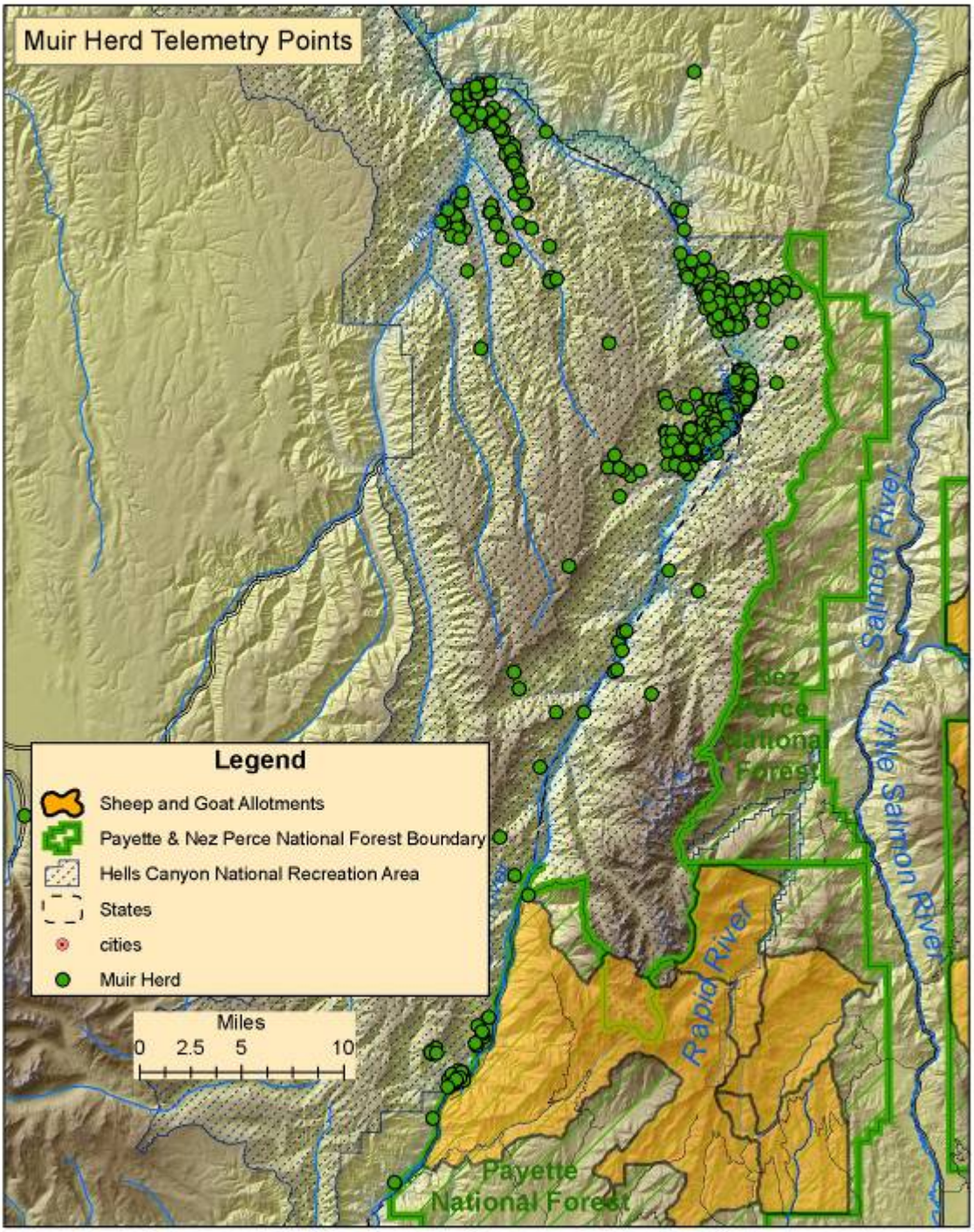

Figure 9. Muir Creek Herd Telemetry Points

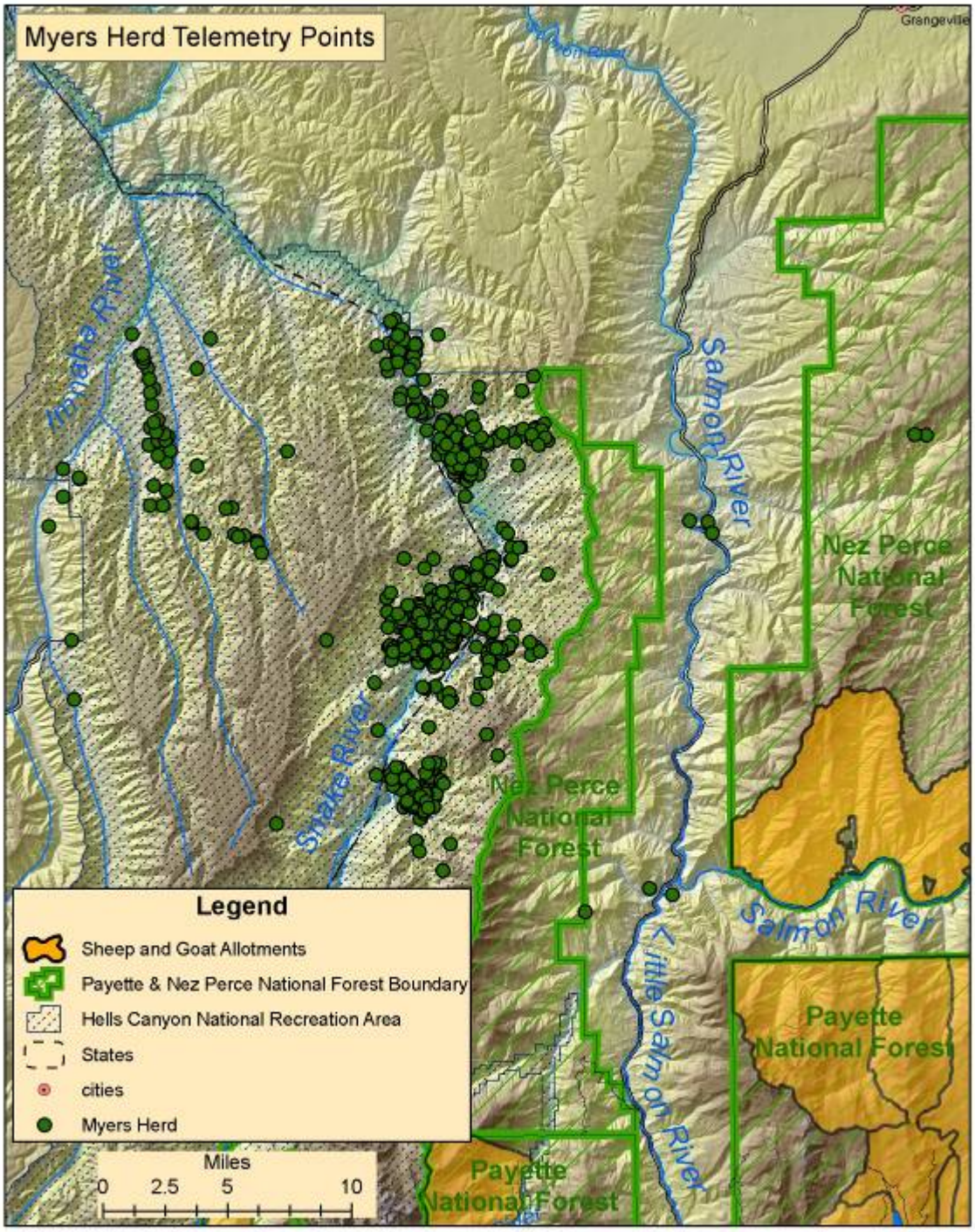

Figure 10. Myers Creek Herd Telemetry Points

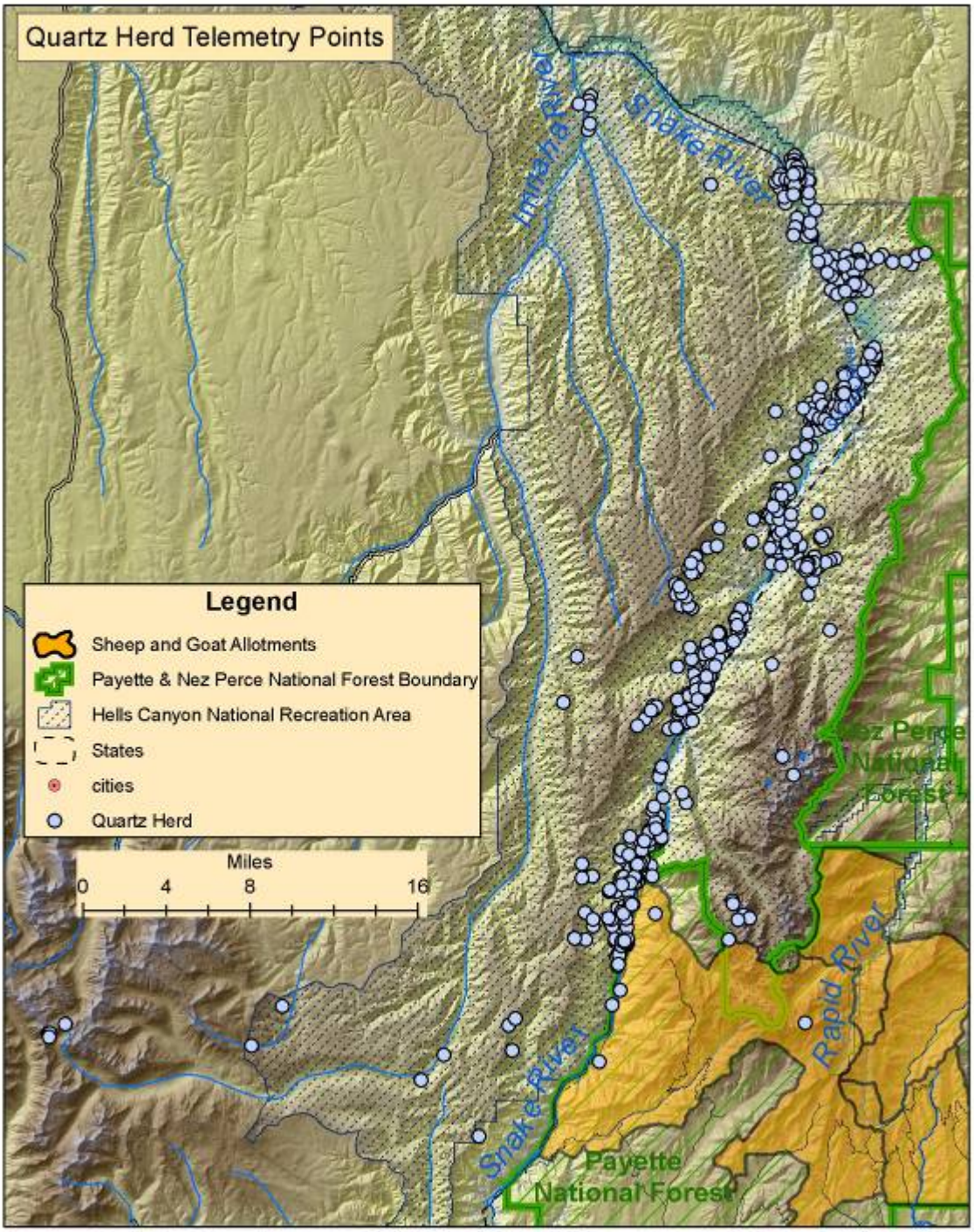

Figure 11. Quartz Creek Herd Telemetry Points

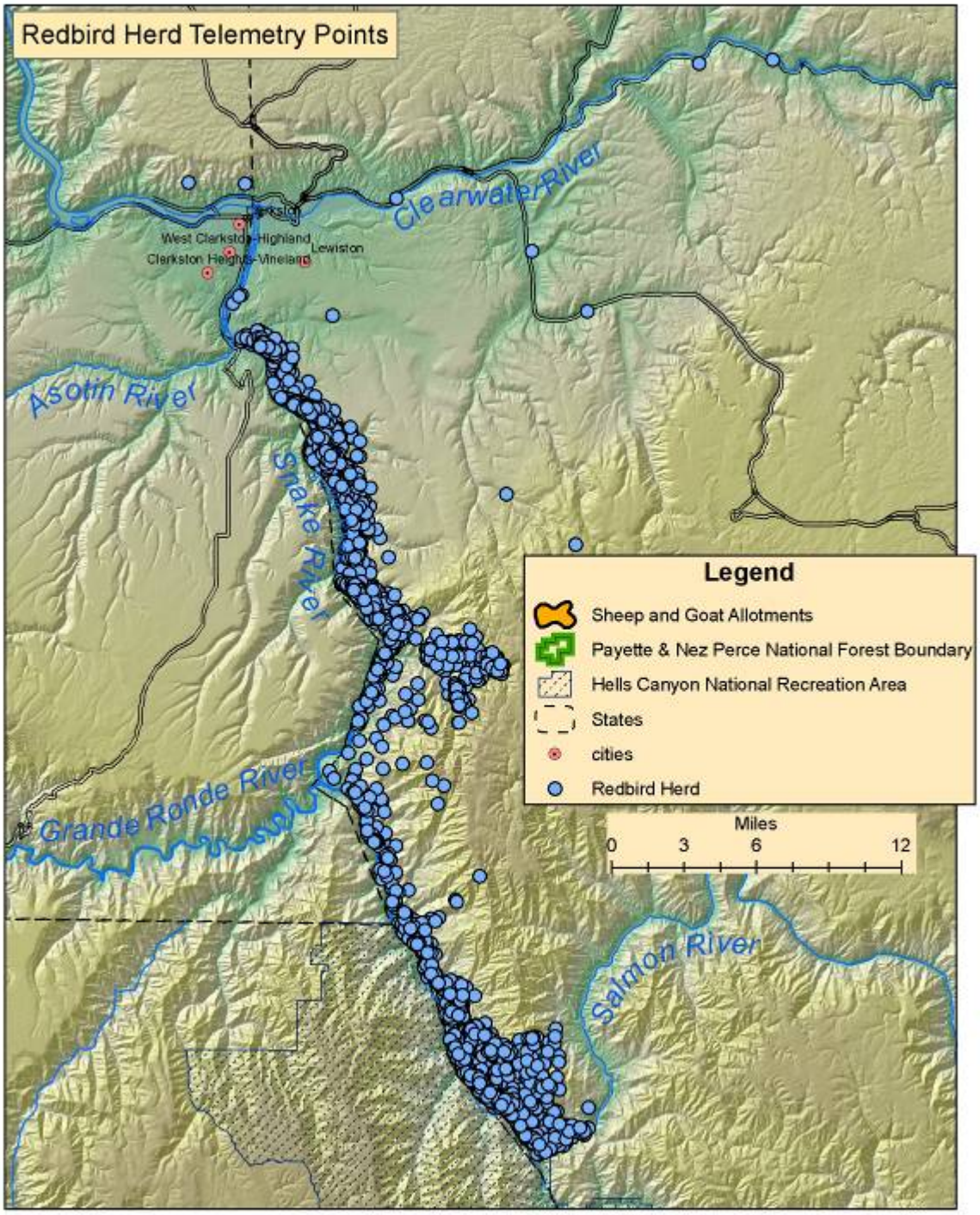

Figure 12. Redbird Herd Telemetry Points

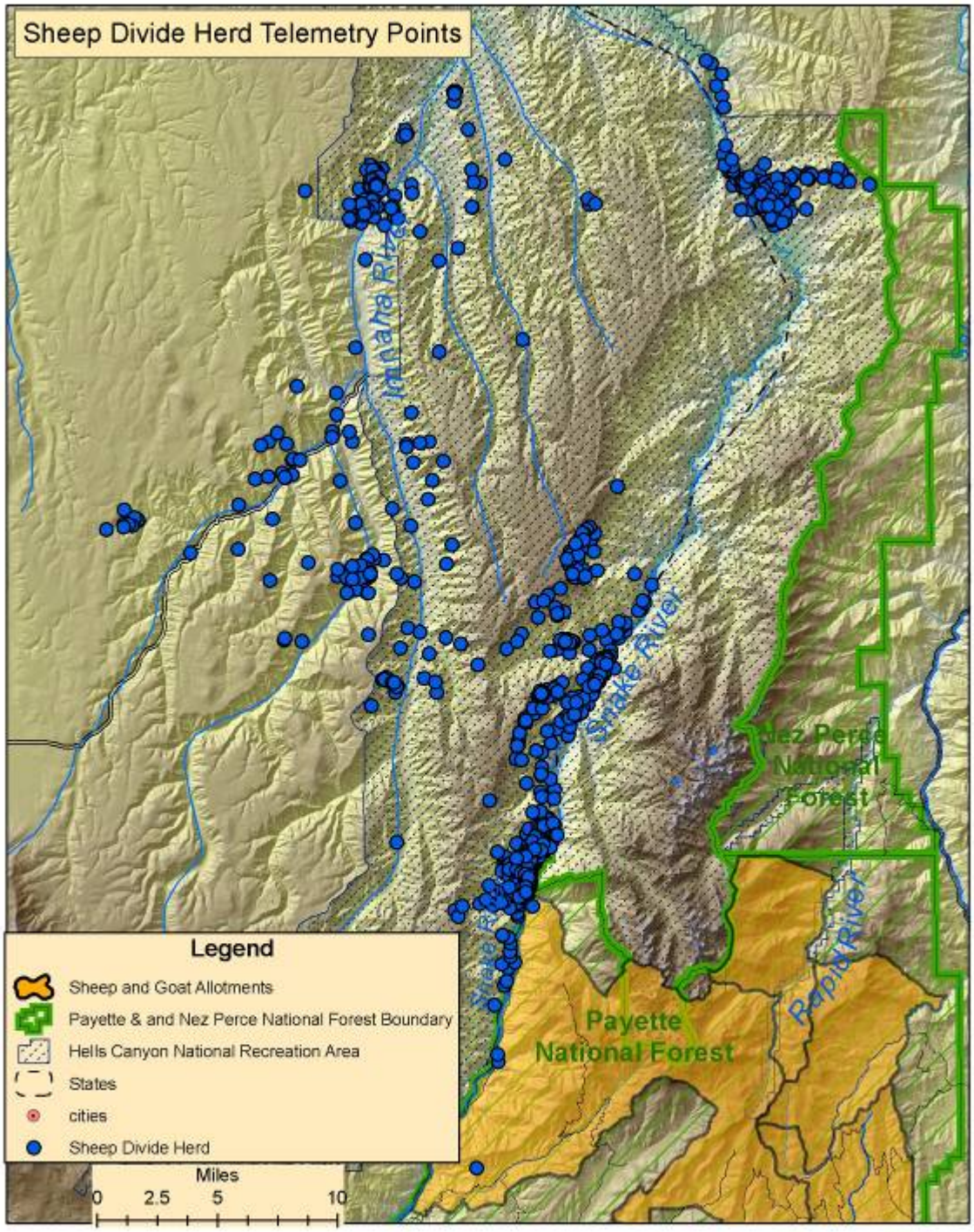

Figure 13. Sheep Divide Herd Telemetry Points

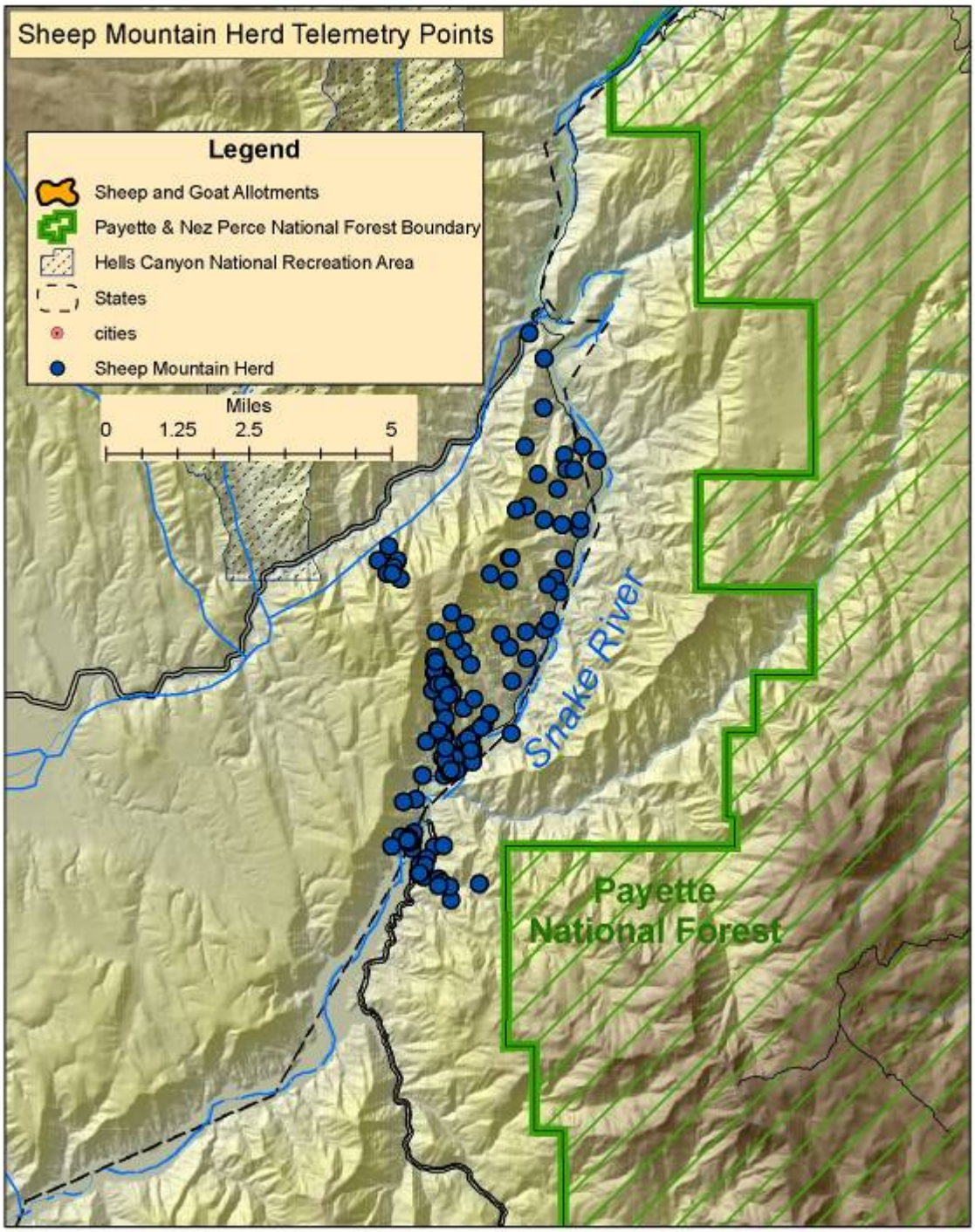

Figure 14. Sheep Mountain Herd Telemetry Points

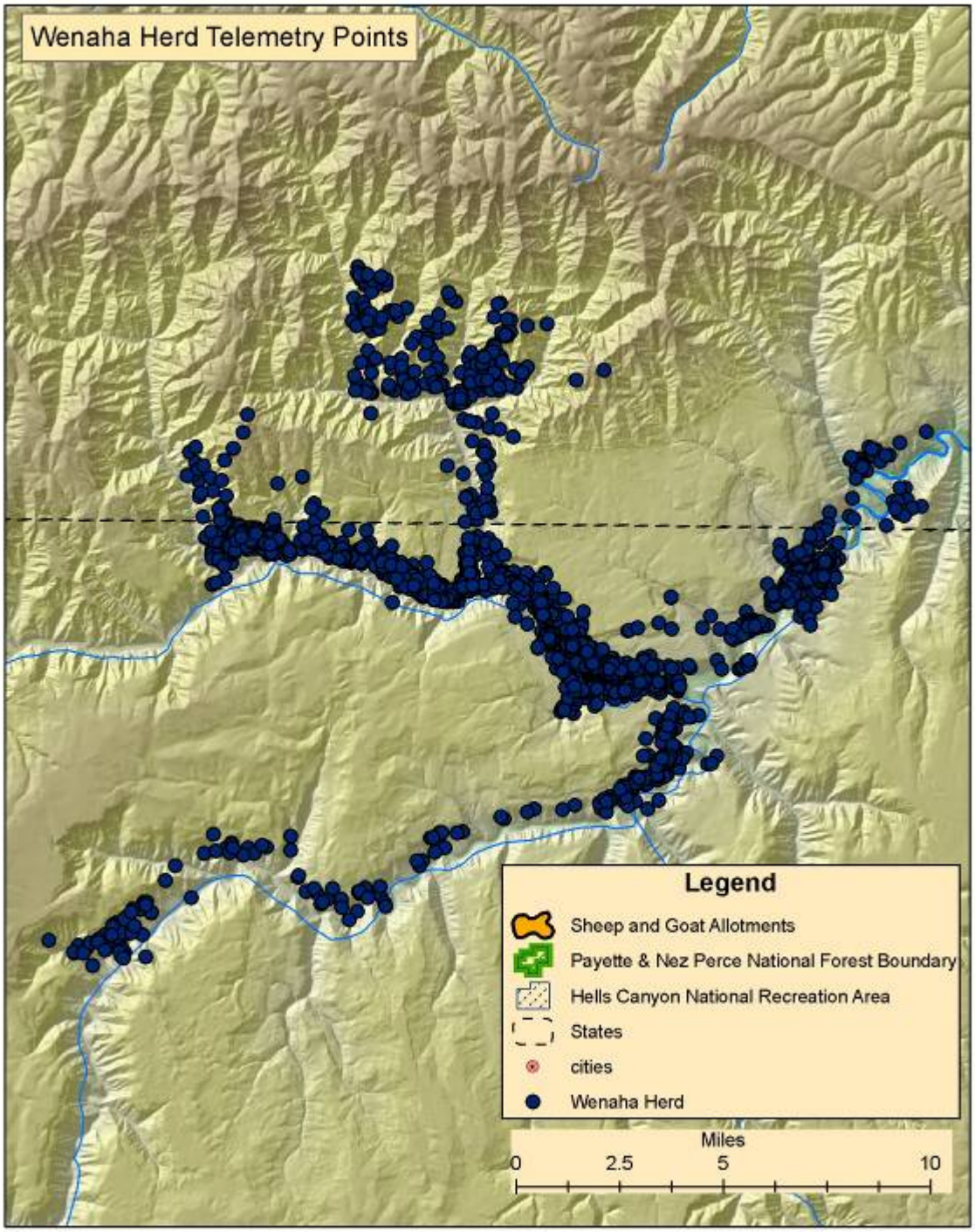

Figure 15. Wenaha Herd Telemetry Points

The home range modeling was completed with the Home Range Extension for ArcGIS® (Rodgers and Carr 1998). The home range analysis utilizes a fixed kernel analysis with a band width of 80 percent of the calculated h_{ref} value with volume contours starting at 50 percent to 100 percent in 10 percent increments. The Home Range Extension uses a standard bivariate normal probability density function to estimate the utilization distribution; h_{ref} is calculated as the square root of the mean variance in x (var x) and y (var y) co-ordinates divided by the sixth root of the number of points (Worton 1995).

$$href = n^{\frac{-1}{6}}\sqrt{\frac{\text{var}\,x + \text{var}\,y}{2}}$$

This follows the process that Clifford et al. (2007) used in their analysis. We decided to follow this process because the issue revolved around disease transmission, which is what the Clifford et al. (2007) paper was designed to analyze. The Clifford et al. (2007) paper designed a process of quantitatively measuring the risk of a disease event within three populations of California bighorn sheep in the Sierra Nevada range. Their process involved completing a home range analysis then using that analysis as one of the inputs into a Reed-Frost epidemiological disease spread model. We chose to use the home range process in the Clifford et al. (2007) paper because it was the only paper dealing with disease risk in a quantitative way. Where we differed from Clifford et al. (2007) is in the use of the Reed-Frost epidemiological disease spread model. We did not use the disease spread model because we lacked enough data in the Salmon River to run the model, so it was decided to only use home range methods at this time.

After the herd home ranges were created, they were reviewed by biologists with expertise in the Hells Canyon herds. A review of the initial modeling was needed because a fixed kernel home range analysis only takes point density into account and not other factors. This review assisted us in modifying the home range analysis based on other factors, such as habitat breaks, point errors, and abnormal movements. We also merged the Wenaha and Mountain View herds into one modeled population and the Big Canyon, Muir Creek, and Myers Creek herds into one population. The Sheep Divide and Minam herds were dropped from the final batch of herd home ranges because both herds were failed transplants, where sheep did not form a cohesive herd but scattered into several surrounding herds. After these modifications, the herd home ranges were reviewed and accepted by the entire IDT (Figures 16–25).

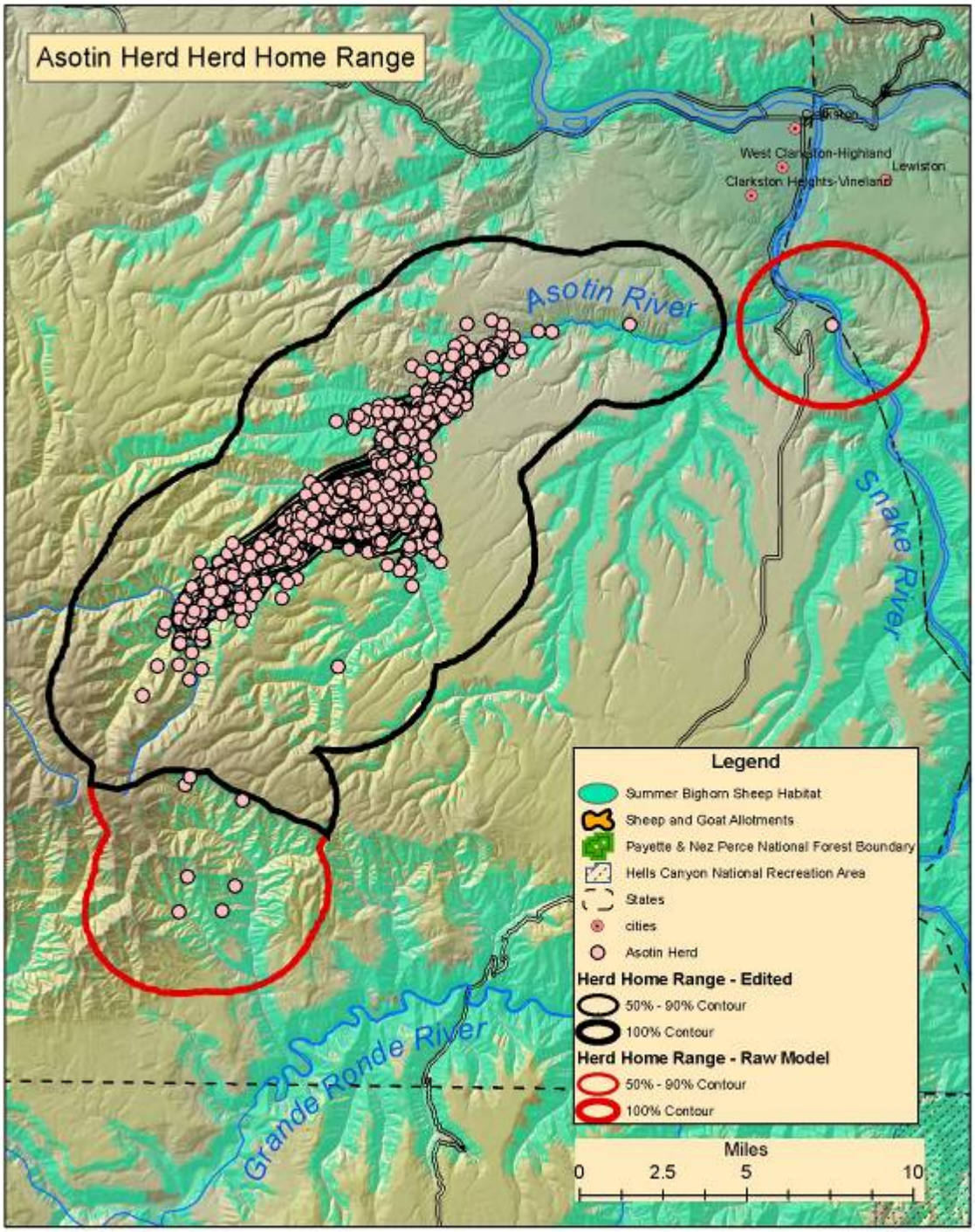

Figure 16. Asotin Herd Home Range

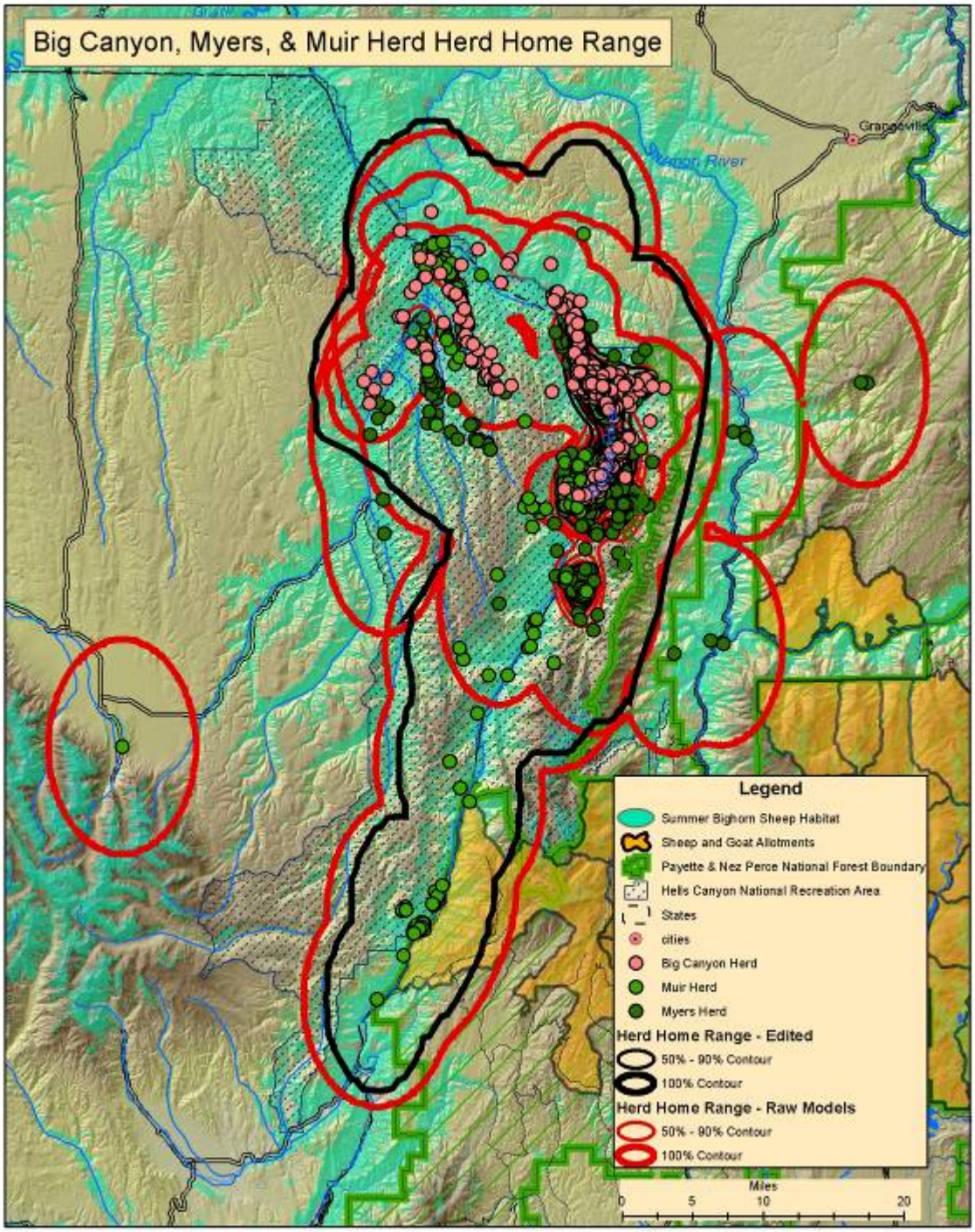

Figure 17. Big Canyon, Myers Creek, and Muir Creek Herd Home Ranges

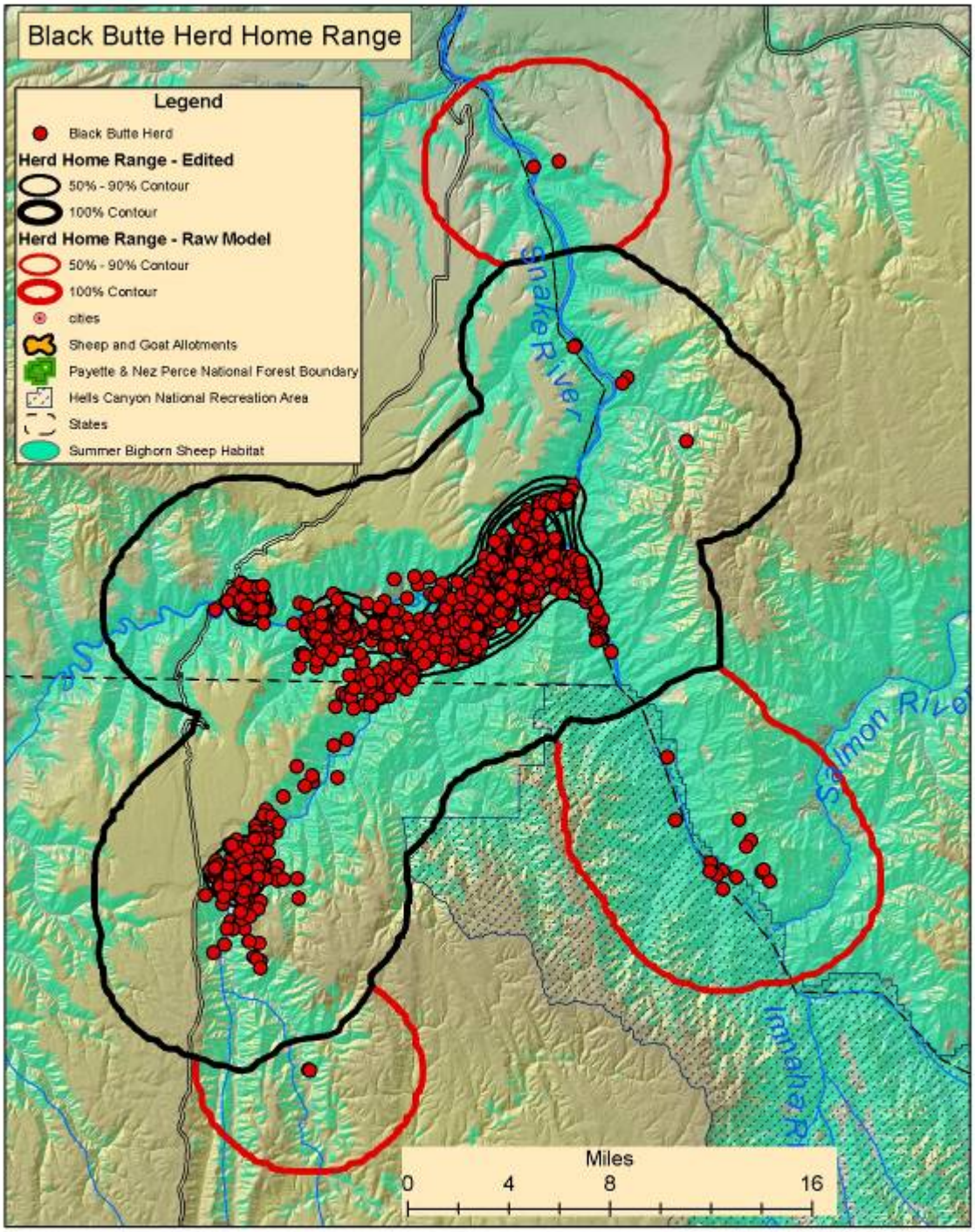

Figure 18. Black Butte Herd Home Range

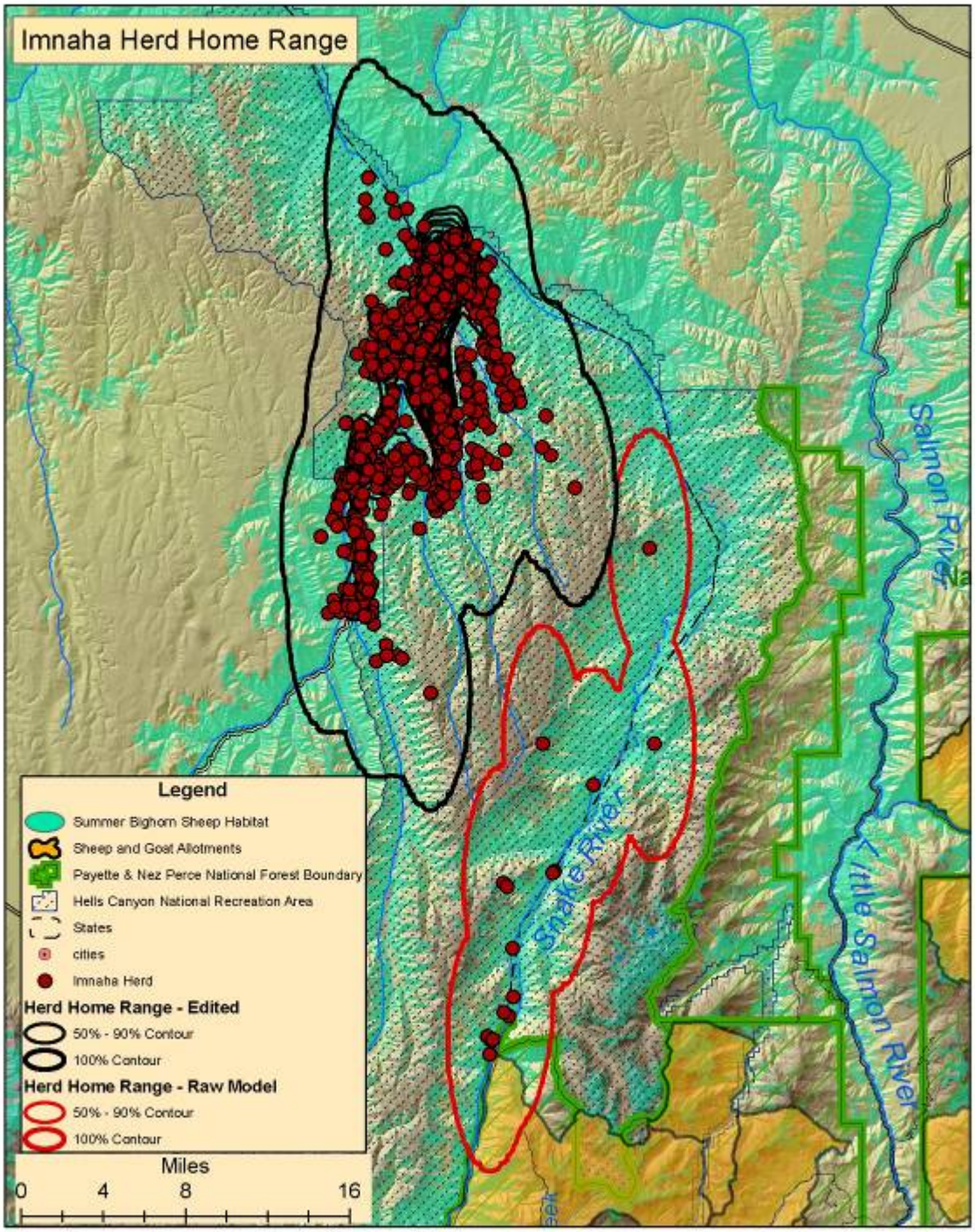

Figure 19. Imnaha Herd Home Range

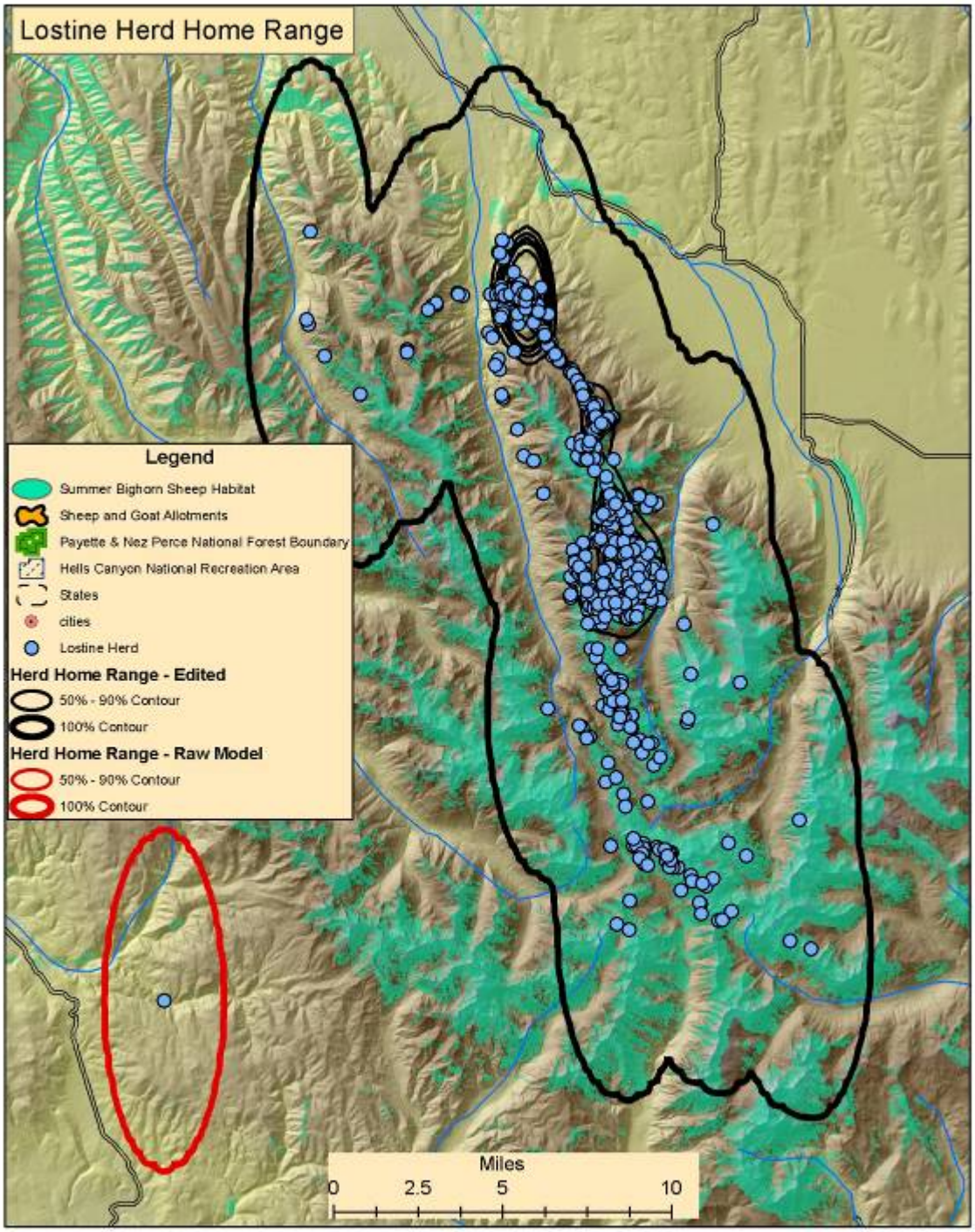

Figure 20. Lostine Herd Home Range

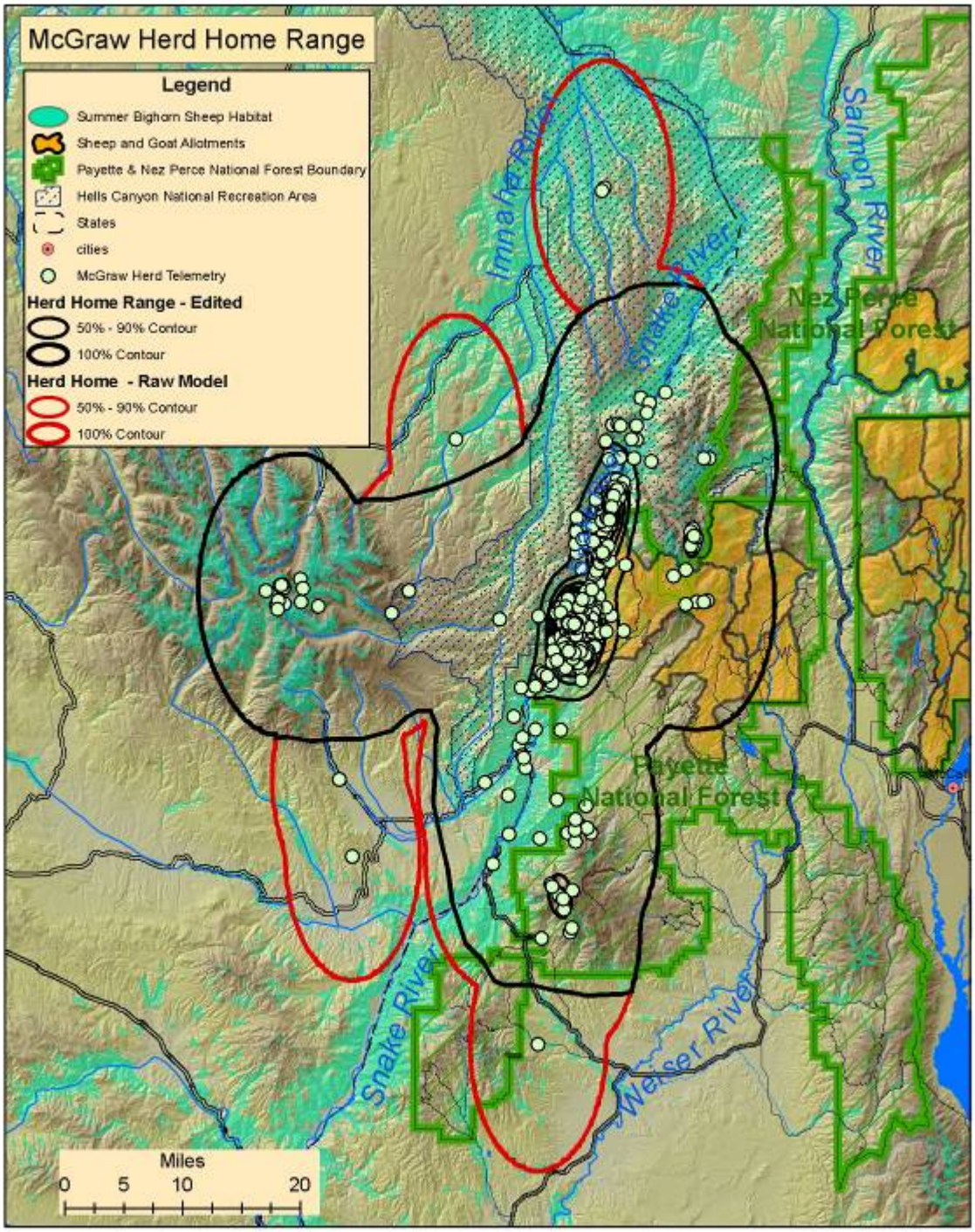

Figure 21. McGraw Herd Home Range

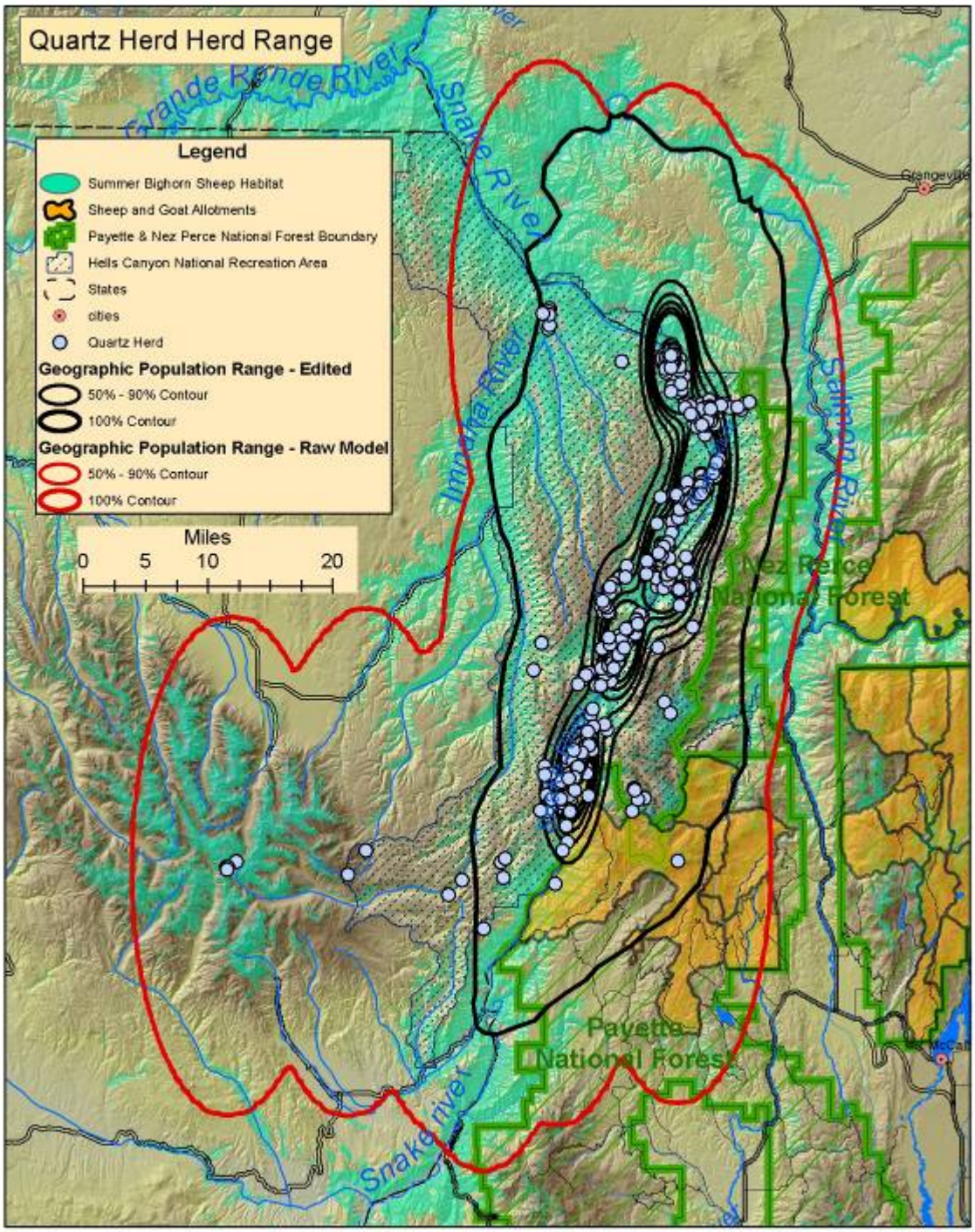

Figure 22. Quartz Creek Herd Home Range

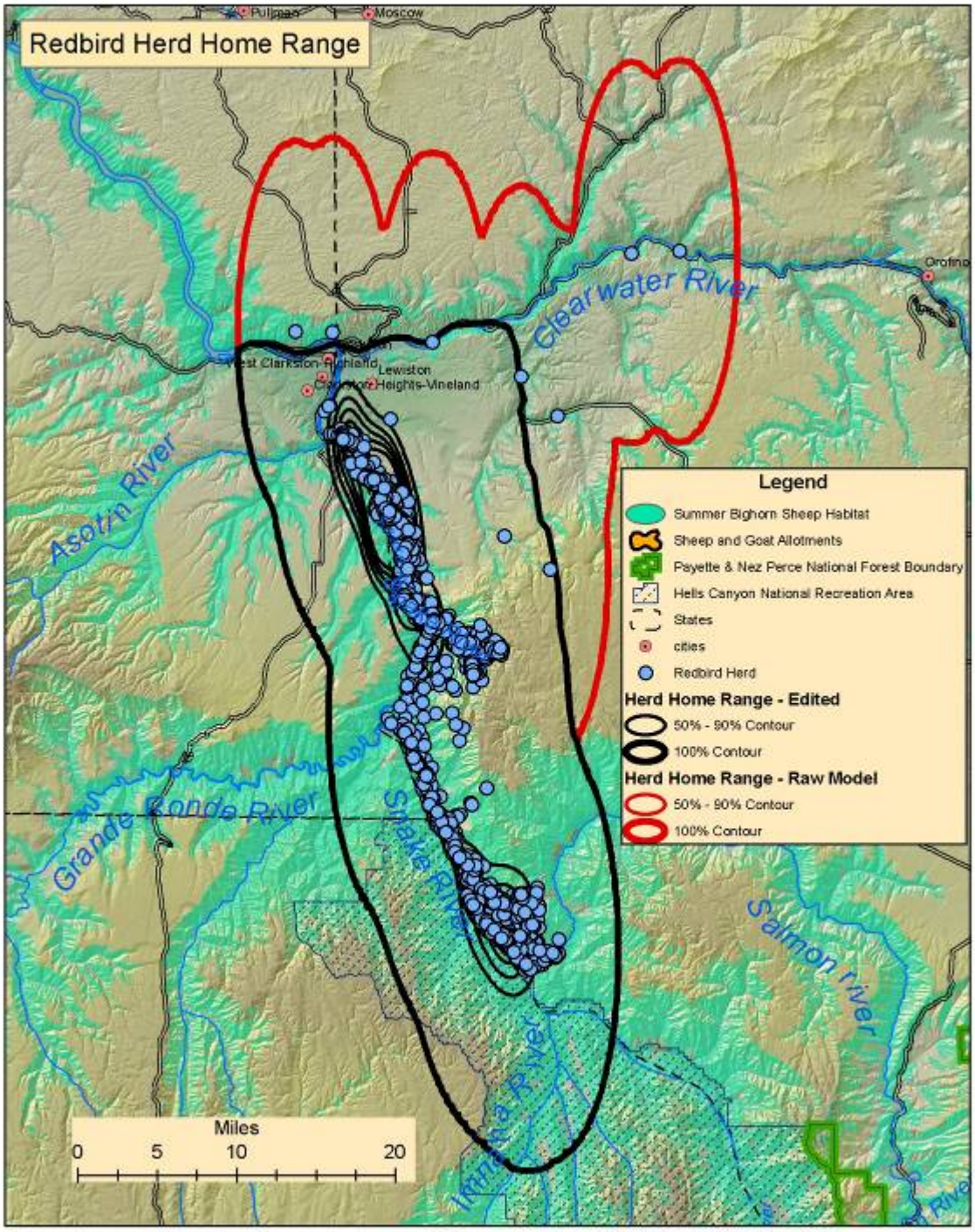

Figure 23. Redbird Herd Home Range

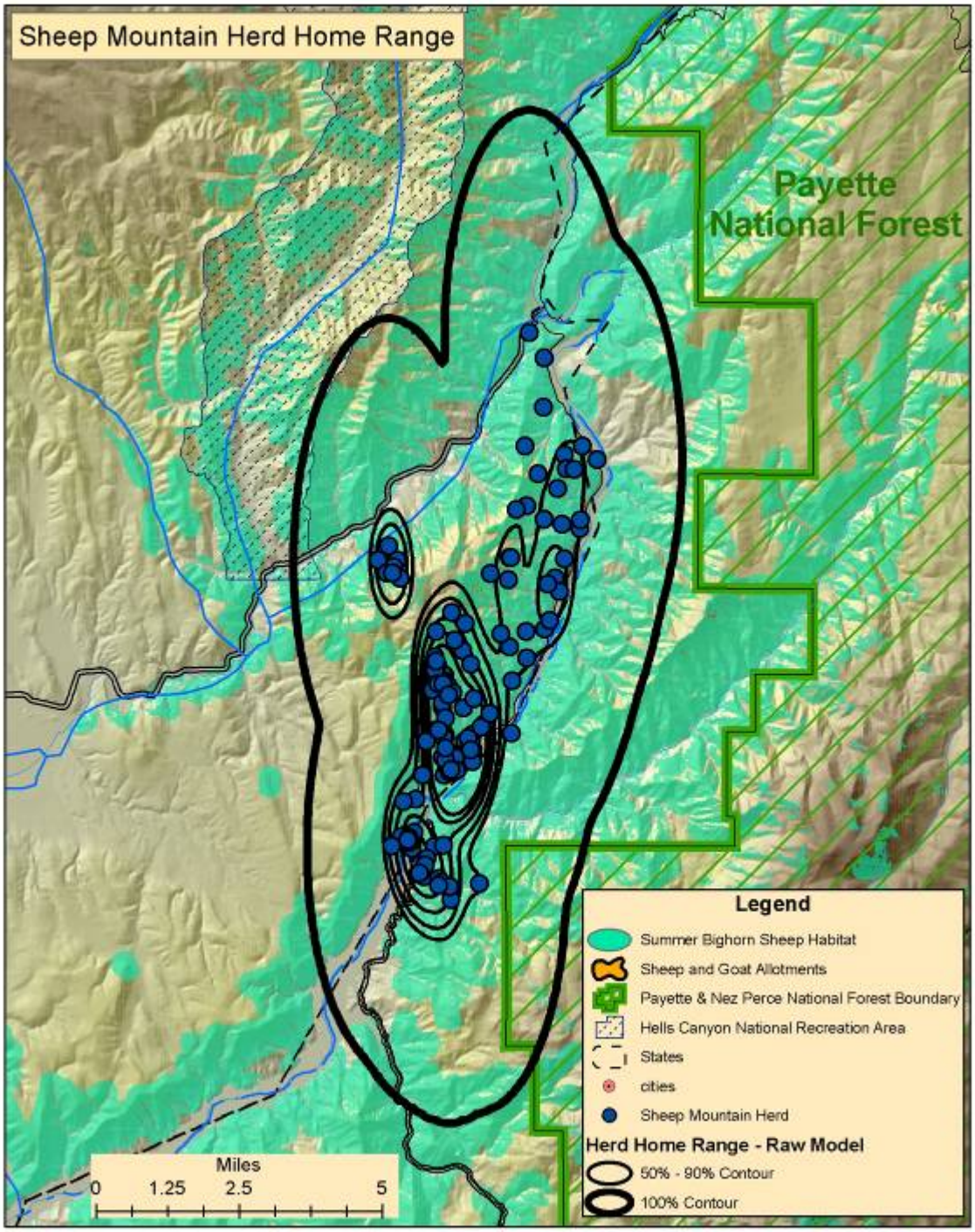

Figure 24. Sheep Mountain Herd Home Range

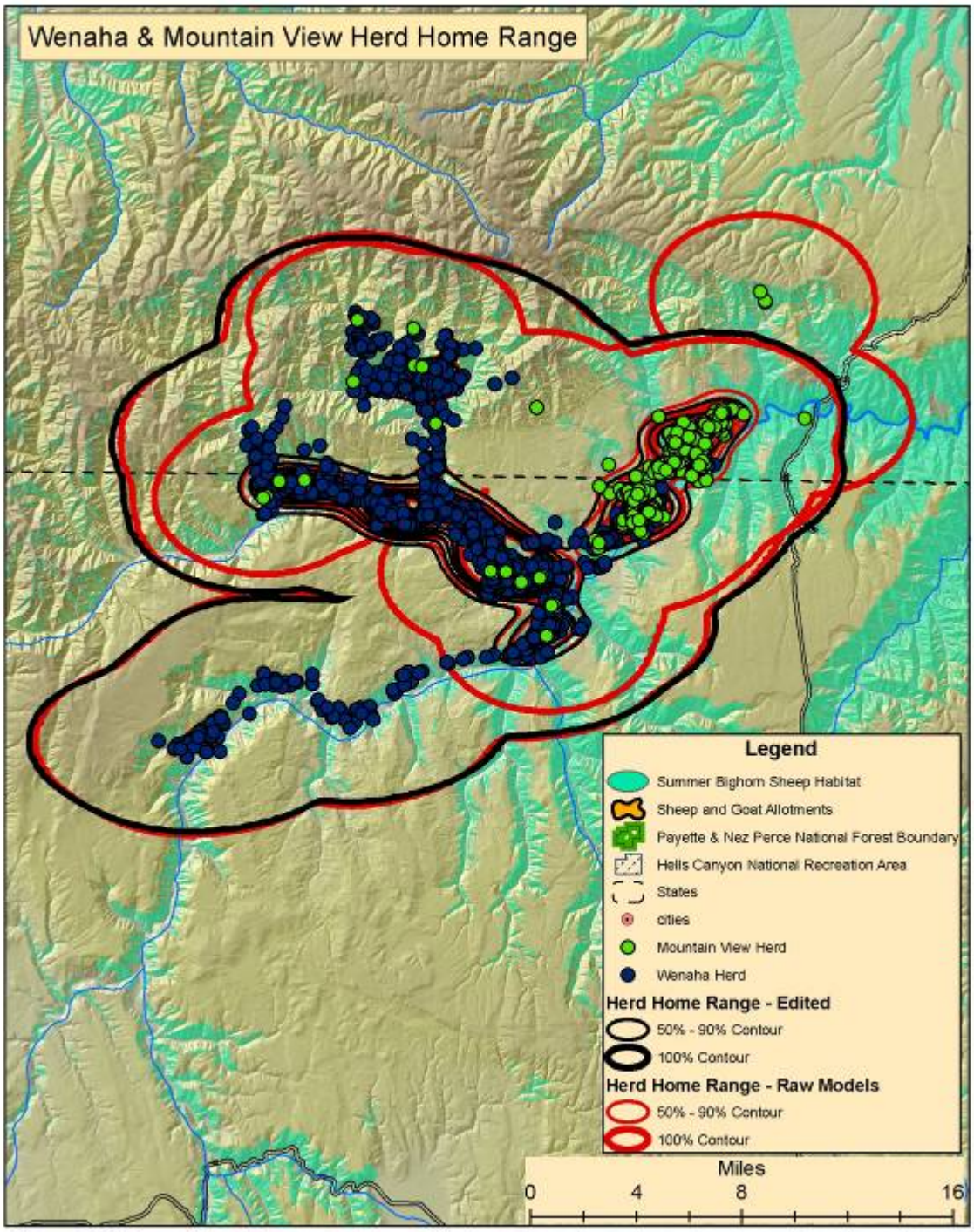

Figure 25. Wenaha and Mountain View Herd Home Range

Geographic Population Range

The IDT created the term geographic population range (GPR) because the term home range is typically used for an individual, not a herd or larger group. As defined by this project, a GPR is a range in which a group larger than a herd, but smaller than a metapopulation, occupies or has occupied in the near past. It is our closest approximation of occupied habitat at this time. The GPR for the Hells Canyon Complex was created by merging all of the final herd home range 100 percent volume contours. The Salmon River GPR was developed with a different technique because there is only 0.06 percent the level of telemetry and observation in the Salmon River herds when compared to the Hells Canyon herds. IDFG biologists initially provided a map showing the GPR based on best professional judgment and the known data at the time. This was the IDFG recommendation. This first map had only 150 telemetry points in the Salmon River Canyon. Later, we were able to collect more telemetry and observation data from sources such as the Taylor Ranch study and additional field surveys, which increased the number of telemetry points to 310.

A new step was added to create a home range analysis with all 310 telemetry points. This home range analysis was nearly identical to that of Hells Canyon, using a fixed kernel analysis and volume contours from 50 percent to 100 percent in 10 percent increments. The one modification was in the selection of the band width due to the non-herd nature of the points and their low density. The band width came from a least-squares cross-validation (LSCV). LSCV is a common method for automatically calculating the smoothing parameter. The LSCV method attempts to find a value for *h,* or band width, that minimizes the mean integrated square error by minimizing a score function (CV(h)) for the estimated error between the true density function and the kernel density estimate (Worton 1995).

$$CV(h) = \frac{1}{\pi n h^2} + \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{\left(\frac{1}{4\pi} e^{-D_{ij}/4} - \frac{1}{\pi} e^{-D_{ij}/2} \right)}{n^2 h^2}$$

Where the distance between pairs of points (*Dij*) is calculated as

$$Dij = \left[\frac{\left(X_i - X_j \right)}{h} \right]^2 = \frac{\left(X_{i(x)} - X_{j(x)} \right)^2 + \left(X_{i(y)} - X_{j(y)} \right)^2}{h^2}$$

The two separate products were spatially merged into the final GPR, which was reviewed and approved by the entire IDT (Figure 26).

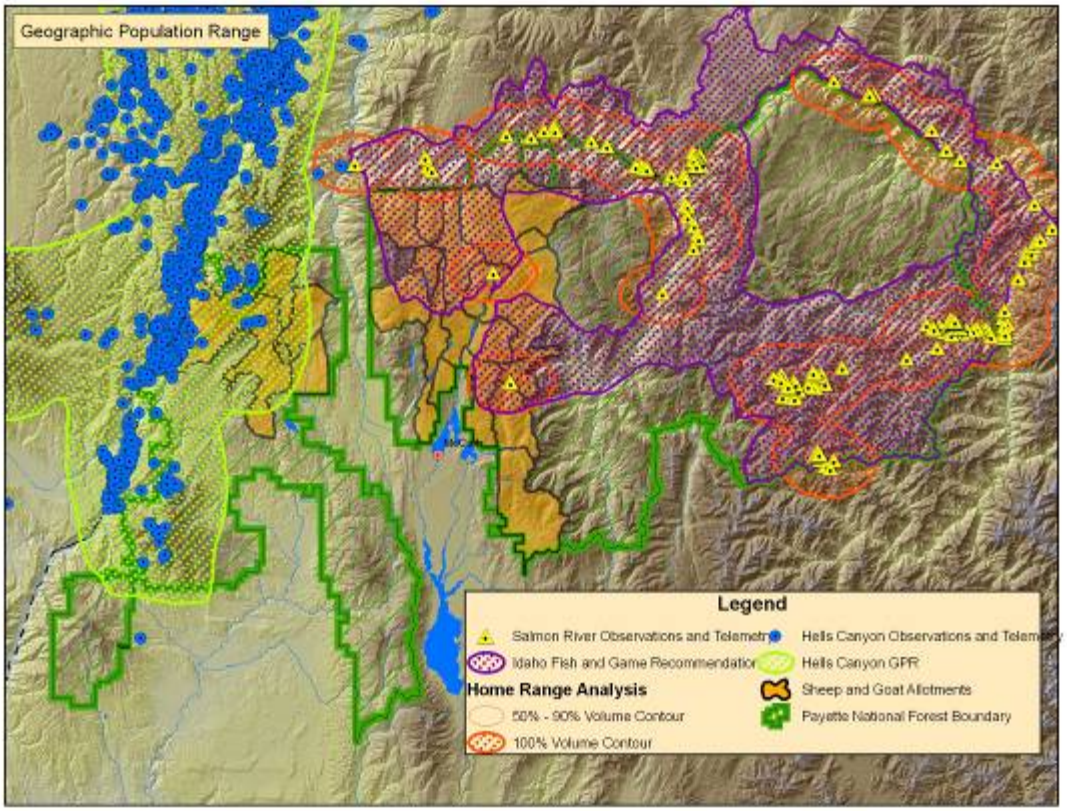

Figure 26. Geographic Population Range

Relative Risk Rating

A method was needed to analyze the alternatives for differences in the potential risk of contact between domestic sheep and bighorn sheep.[1] The method develops relative risk ratings from three input layers and merges those three layers into a single product in an additive process. The three input layers represent where bighorn sheep are and where domestic sheep and bighorn sheep could move into in the future. This final product was used to look at the relative differences of the potential risk of contact for each of the alternatives. It was a method to compare the different alternatives against each other and rate them on how much risk of contact they remove from the landscape. The ratings are only qualitative and relative, not in absolute terms.

The first input layer was the GPRs with the volume contours. The volume contours were rated from 0 to 10. The ratings started at 10 in the 50 percent volume contour and decreased

[1] The Forest Plan was developed to implement Alternative 7 from the FEIS. Because the direction tied to bighorn sheep management was found inadequate and was reversed, the Payette National Forest developed alternate management strategies to Alternative 7 for bighorn sheep. Forest Plan FEIS alternatives 1B, 2, 3, 4, 5, 6, and 7 are considered part of the range of alternatives as are those developed for this SEIS process (alternatives 7A–7K).

to 0.7 in the 100 percent volume contour. The method used to assign each of the ratings involved a power of 0.3 exponential reduction starting at 10.

$$(((((10 - 0.3 = 9.7) - 0.6 = 9.1) - 1.2 = 7.9) - 2.4 = 5.5) -4.8 = 0.7)$$

The rational for using this method is that the volume contours of the home range analysis in the GPRs depict an exponential relationship between contour lines.

This same method is utilized to assign risk values to the second input layer, which were the risk ratings given to the domestic sheep grazing allotments in the Risk Analysis (USDA Forest Service 2006a). The allotments were rated in five categories (very high, high, moderate, low, and very low) and were rated from 10 to 0 using the same method, except with an exponential reduction factor of 0.6.

$$((((10 - .6 = 9.4) – 1.2 = 8.2) – 2.4 = 5.8) – 4.8 = 1)$$

The final input layer was the source habitat layer. Source habitat was given a single risk value of 0.5 and applied as a Boolean, either present or absent, since land is either source habitat or not. The source habitat model is a static model across the landscape at any given point in time.

These three components are then "added" to produce a map of the relative risks of contact between bighorn sheep and domestic sheep across the Payette National Forest (Figure 27). The potential for the risk of contact is a function of bighorn sheep location (GPRs), their interaction with domestic sheep (rated allotments), and their available habitat (where bighorn sheep are most likely to be within the GPRs or where they could expand outside of the GPRs). When these layers are added, the result is incremental relative risk ratings applied across the Payette National Forest that varied from 0 to 20.5. The alternatives are then ranked according to how much the potential risk of contact varies with each alternative.

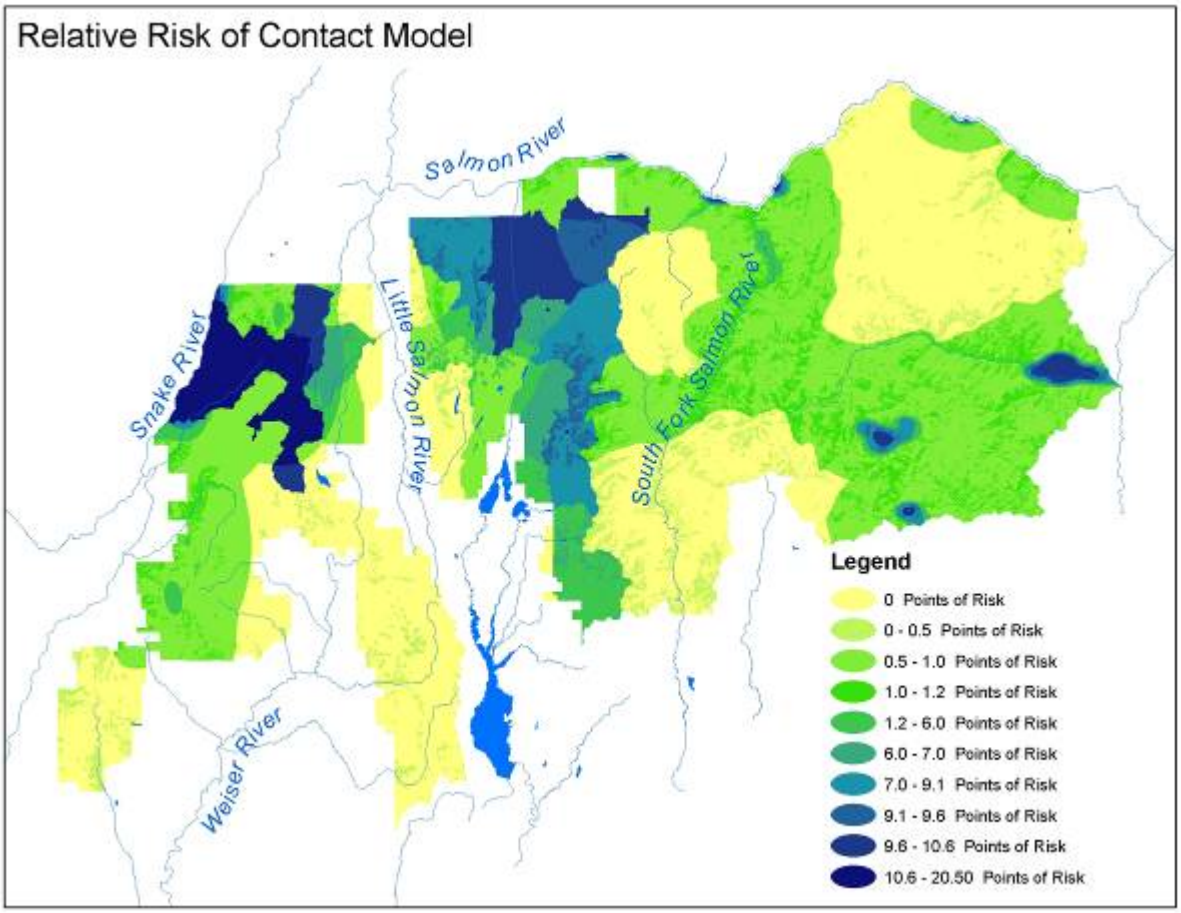

Figure 27. Relative Risk of Contact Model

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