PORCUPINE POPULATION AND HABITAT SURVEY OF DEVILS TOWER NATIONAL MONUMENT: FINAL REPORT

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December 30, 2016

Prepared under CESU Task Agreement P15AC00093for:

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INTRODUCTION

The North American porcupine (*Erethizon dorsatum*; hereafter porcupine) is found throughout much of the United States and Canada, however, most knowledge of porcupine ecology comes from studies in the eastern United States and boreal forests in Canada. Very little information is available on porcupine populations in habitats of the intermountain west. Though anecdotally common in Devil's Tower National Monument (DETO), the density and population status of porcupines there was largely unknown. Changes to forest resources on the monument, either through active management or natural causes (e.g. pine beetle infestation) could impact porcupine populations in DETO.

The Wyoming Natural Diversity Database (WYNDD) collaborated with DETO to: 1) conduct an inventory to determine current porcupine abundance on DETO, 2) assess habitat used by porcupines on DETO for use in resource management decisions, and 3) establish a monitoring plan that can be implemented by DETO staff to track population trends over time.

Porcupines are most detectable during winter, when movement is restricted to travel between diurnal dens and nocturnal foraging sites. Studies have reported that porcupines typically use the same den throughout the winter season, foraging in the same pocket of trees all winter long (Dodge 1967, Woods 1973, Roze 1984). Snow tracks can be used to determine where porcupines are denning and foraging. Furthermore, 'damage pockets' caused by porcupines feeding on the bark of the same group of trees all winter long, are highly visible by late winter and can serve as an index of porcupine abundance under certain scenarios (Spencer 1964). Therefore, WYNDD attempted to use systematic snow track surveys in combination with radio telemetry of individual porcupines to identify where porcupines were denning and foraging in DETO, determine the number of porcupines using specific areas, and describe damage pockets (number of trees, tree species, etc.).

In addition to documenting the abundance of porcupines in DETO and establishing a monitoring program for the monument, this work provides information on the location and type of den sites used by porcupines in DETO and documents which tree species are being used most heavily by overwintering porcupines. This information will be useful in assessing potential impacts to porcupine populations on the monument by forest management activities and/or natural disturbances such as pine beetle infestations and prescribed burning.

METHODS

Study Area

The study area encompassed all treed areas within the 1,347-acre DETO boundary. Much of the monument is dominated by Ponderosa pine (*Pinus ponderosa*) forest. Burr Oak (*Quercus macrocarpa*) occurs along many drainage bottoms throughout the park and around the administration buildings in the southern portion of the monument. Boxelder (*Acer negundo*) and Rocky Mountain juniper (*Juniperus scopulorum*) also are sparsely distributed throughout the area surrounding the administration buildings. The Belle Fourche River floodplain on the southern edge of the monument supports a mature plains cottonwood (*Populus deltoides*) forest. Plains cottonwoods have also been planted in the campground and the majority of these are large, mature trees. Aspen (*Populus tremuloides*) are largely restricted to the edge of the talus slope at the base of the tower.

Survey Protocols

WYNDD conducted systematic, foot-based surveys across DETO in 2015 and 2016. Surveys were conducted from January 14, 2015 through February 19, 2015 and from January 12, 2016 through April 29, 2016. The entire monument was divided into 6.25 hectare grid cells (Figure 1; N = 97). One to three surveyors systematically walked each cell looking for evidence of porcupines, including tracks in the snow, evidence of foraging (i.e., scars on tree bark or nip-twigs; Roze 1989), or visual observations of porcupines. Surveyors walked non-overlapping paths at a consistent pace, stopping periodically to scan nearby areas using 10X42 binoculars. All evidence of porcupines was georeferenced using standard handheld GPS units (Garmin Oregon 450 and 600). Snow tracks were followed until the trail was lost or until a porcupine was found. We characterized individual foraging trees by recording the tree species, the number of foraging scars on the trunk and branches of the tree, the diameter of the tree at breast height (DBH), and the total height of the tree. DBH was measured using a Biltmore stick and/or diameter tape (Moran and Williams 2002), and tree height was calculated using the sine method in 2015 (Bragg 2008) and measured using a Nikon Forestry Pro Laser Rangefinder in 2016. Groups of three or more trees with evidence of feeding by porcupines that were within roughly 20 meters of each other were classified as a 'foraging pocket,' and the number of trees in each foraging pocket was tallied. We assigned a tentative age category to each foraging scar (pending further investigation to accurately assess scar age) based on its overall appearance. Categories included 'fresh' (within the current winter; light-colored with a reddish boarder of fresh bark that was flush with the chewed area), 'moderate' (1 – 3 years old; covered in dried, yellow sap and the bark was raised relative to the level of the scar), or 'older' (> 3 years old; the sap had weathered away to expose dried, gray wood).

Habitat

To assess forest features promoting porcupine occupation, we conducted tree density transects centered on foraging pockets and compared that information to transects conducted at random locations throughout DETO. Transects were belts 2 meters wide and 40 meters long. All trees whose center fell within the belt were counted and the resulting tally was used to estimate tree density within the transect. Transect results were then summarized to estimate tree densities across the landscape. For each tree counted, we also recorded tree species, DBH, total height of the tree, and whether the tree had evidence of foraging by porcupines.

In order to develop landscape habitat relationships for porcupine occurrence at DETO, WYNDD developed a tree cover map of the monument digitized from publicly available aerial imagery. This tree cover map was not utilized in analyses outlined in this report but this data product may be useful for other projects occurring on the monument and is available upon request.

Capture and Marking

We attempted to capture each porcupine detected to assess sex, age, and health, and to individually mark each animal. We captured porcupines in live traps set at the base of occupied trees. Traps were checked multiple times each day to minimize the amount of time animals spent in a trap. Captured porcupines were chemically immobilized using a combination of Ketamine (5mg/kg @ 100mg/mL) and Dexmedetomidine (0.025mg/kg @ 5mg/mL) to minimize stress. Following processing, the Dexmedetomidine antagonist Atipamezole was administered (0.025mg/kg @ 5mg/mL). All immobilization and antagonist drugs were injected intramuscularly into the tail muscle. All captured porcupines were individually marked with a passive integrated transponder (PIT) tag implanted via subcutaneous injection at the base of the tail. To facilitate individual identification of porcupines not fitted with radio transmitters, we also used non-toxic livestock spray paint to give these individuals a unique color mark on the haunches. These color marks proved easily visible from the ground and from a distance, minimizing stress to the animals.

In 2015 and 2016, we fitted three and five porcupines respectively with radio transmitters (Holohil Systems Ltd., Ontario, Canada) in order to track daily activity patterns. Transmitters weighed 3.8g and were glued to a small cluster of quills between the shoulder blades. In 2015, one transmitter was fitted around the neck of a porcupine using a padded collar setup. Because this requires recapture to remove the collar we did not use this attachment method in 2016. We recorded the location of all porcupines found and attempted to relocate them on a daily basis following initial observation. All capture and marking techniques were approved by the University of Wyoming Institutional Animal Care and Use Committee (protocol #20141113DK00132-01 and #20141113DK00132-02) and follow guidelines approved by the American Society of Mammalogists for the use of wild mammals in research (Sikes et al. 2011).

Data Analysis

To compare habitat between foraging areas and random locations at DETO, we fitted models using logistic regression (SPSS 24, International Business Machines Corporation, Armonk, NY). Specifically, we included random transects and foraging areas as the dependent variable, which were coded as “0” and “1” respectively. We included the density of live trees in the overstory, the DBH of live trees in the overstory, and the interaction of these terms as covariates. A number of other variables were collected in the field but were deemed not biologically relevant or were found to be correlated with other variables included in the model and were dropped to avoid multicollinearity issues.

Models of foraging tree density and den density were generated in ArcMap 10.3.1 (Esri, Redlands, CA) using the Kernel Density Tool. For the foraging tree density model, all trees with evidence of porcupine foraging were included, regardless of the age of foraging scars. For the den use density model, all den sites with evidence of porcupine use and all den sites where porcupines were relocated were included.

RESULTS AND DISCUSSION

Summary of Survey Results

Of the 97 survey grid cells across DETO, 91 contained at least some tree cover within the monument. In 2015, we surveyed 61 grid cells and in 2016 we surveyed 78 of the cells with tree cover at least once. This represents the vast majority of the treed area of the monument. Most unsurveyed cells were only partially in DETO and had sparse tree cover.

In 2015, we located six porcupines, captured five, and fitted three with radio transmitters (Table 1). In 2016, we located six porcupines, and placed radio transmitters on five (Table 2). In other ecosystems, the primary method of finding porcupines is snow tracking, in which surveyors locate a porcupine track in the snow and follow it to either a den or foraging tree occupied by a porcupine. Unfortunately, survey efforts in both 2015 and 2016 were hampered by warm temperatures and lack of snow during the survey period. Portions of tracks were identified at several locations on the monument, but all tracks were lost over bare ground before locating porcupines. All porcupines were found by observing the animal in a feeding tree, either independently or following initial observation of fresh feeding scars in nearby trees.

All porcupines captured at DETO were female, with the exception of one male, Peppe/Zeus (Tables 1 and 2). Given the low sample size and potential for undocumented porcupines of unknown sex within or adjacent to the monument (see section on Porcupine Abundance), we do not know if this represents a true sex bias of the animals at DETO. However, female biased sex ratios have been observed by other researchers (Ilse and Hellgren 2001). All captured animals in 2015 were adults older than 2 years and all appeared to be in good health. In 2016, five of the six captured individuals were older than 2 years of age and one was a juvenile. All appeared to be in good health.

The most common evidence of porcupines was feeding scars on trees, where animals chewed bark off trees to eat the cambium (Figure 2). Fresh scars (i.e., those created within the past few months) were readily identifiable, because they were very light in color, had a reddish boarder of fresh bark that was flush with the chewed area, and sometimes had beads of clear, glistening sap (Figure 2A). Fresh scars were most useful in determining locations of porcupines currently on DETO. Older scars were more abundant on the DETO landscape than fresh scars but are still useful in determining long-term habitat use on the monument. Scars that were presumably a few years old were covered in dried, yellow sap and the bark was raised relative to the level of the scar due to tree growth subsequent to when the scar was created (Figure 2B), while even older scars were no longer yellow because the sap had weathered away to expose dried, gray wood beneath. These age categories are very coarse assumptions based on general appearance. More precisely determining the ages of these scar categories may help in assessing long term habitat use trends on DETO (Spencer 1964).

Porcupine Abundance

In 2015, we estimated that between 9 and 11 porcupines occupied DETO during the time of our surveys. This estimate was based on the fact that known porcupines in DETO in 2015 seemed to have largely non-overlapping ranges (Figure 4) and areas where known porcupines were tracked seemed to reliably contain pockets of fresh feeding scars found during surveys. In 2015, we identified three pockets of fresh feeding scars not clearly attributable to known porcupines. We therefore assume these feeding areas likely represented 2 or 3 additional animals that we did not detect during surveys. Also, only about 75% of forested areas were surveyed in 2015 making it possible that an additional two individuals could reside in these unsurveyed areas.

In 2016, we located and captured six individual porcupines. We have determined that it is unlikely that more than six porcupines occupied DETO in 2016. Contrary to 2015, there was considerable overlap in ranges of individual porcupines when considering the entire duration individuals were tracked (Figure 5). This is primarily because we tracked more individuals for a longer period of time. In early winter, most individual porcupines were found in the same general areas as they occupied in 2015 and ranges were largely non-overlapping. However, later in the winter, porcupines began to disperse throughout DETO, with some individuals leaving the administrative boundaries of DETO entirely. Additionally, the vast majority of treed areas at DETO were surveyed in 2016 without any additional porcupines being detected. This suggests that our intense ground surveys allowed us to detect most, if not all individual porcupines at DETO in the winters of 2015 and 2016. We made an assumption that it appears that the same individual porcupines were documented in both 2015 and 2016, with the exception of Grizz, who was not captured in 2015 and not observed in 2016, and Buttercup, a juvenile individual most likely born in the spring of 2015. This assumption was based on multiple lines of evidence. First, all individuals captured in 2015 were implanted with a PIT tag. All but two individuals captured in 2016 did not have PIT tags. The two that did occupied approximately the same foraging pockets and were frequently tracked to the same den sites in both years. Similarly, individuals captured in 2016 in which a PIT tag could not be located occupied approximately the same foraging pockets and den sites as porcupines tracked in 2015. Finally, a number of individuals captured in 2016 that did not have PIT tags were very similar in pelage (body, face, or a combination of the two), had similar mass to individuals captured in 2015, or had similar tooth eruption and wear patterns. These pieces of evidence taken together lead us to believe that the same individuals occupied the monument in both years.

Porcupine Habitat

Evidence of porcupine use was nearly ubiquitous in treed areas throughout DETO. This made it difficult to quantitatively infer patterns of habitat use at the scales at which collected habitat data. However, some differences were noted between foraging areas and randomly selected habitat transects. Foraging areas had moderately higher density of live trees (p = 0.080) than random areas. Also, foraging areas had a significantly higher DBH (p = 0.043) than random areas. These differences however are more complicated, as indicated by a significant interactive effect of DBH and the density of live trees (p = 0.006) which suggests that foraging areas have decreasing density of trees as DBH increase while random areas had increasing density of trees as DBH increased. It is important to note that despite having statistically significant terms, our regression model only described a very small proportion of the variance (R^2 = 0.056) between foraging areas and random sites. Additionally, the model was relatively poor at classifying foraging areas and random transects, with most misclassifications occurring as foraging areas classified as random areas. One potential explanation for the inability to characterize foraging areas is that most random transects also had some evidence of porcupine use at some point in the past. Other researchers have noted difficulty in quantifying habitat selection of porcupines at certain scales. For example, at the home range scale, porcupines selected habitats dominated by their primary food source within that specific ecosystem but habitat selection at finer scales was unclear (Morin et al. 2005). Some authors have suggested that habitat selection by porcupines may occur at the level of individual trees, where specific trees are selected for unknown reasons. One hypothesis is that selection may even occur at the molecular level (i.e. protein content, micronutrient concentrations) but this has not conclusively determined (Roze 1984, Roze 1987, Roze 1989).

Our model of foraging tree density indicates that certain areas of DETO have received considerable use by porcupines through time (Figure 6). This model also indicates that areas with a high density of trees with evidence of foraging corresponds with areas where porcupines were detected in the early winter of both 2015 and 2016. Also, this model suggests that areas with high densities of foraged trees occurred in relatively close proximity to areas with potential den sites such as sandstone cliff bands or the boulder field at the base of the tower. Porcupines largely use ponderosa pine trees for winter foraging in DETO (Figure 9). However, it is unclear if porcupines are selecting ponderosa pine or if use is simply a function of availability. At least two porcupines (Athena and Griz) were found predominantly feeding in Burr oak and cottonwood trees. Ponderosa trees used as forage by porcupines were in middle size classes, typically on the order of 10 inches DBH and 10 meters tall (Figures 10 and 11). Anecdotally, foraging pockets (i.e., collections of proximate foraging trees where porcupines spend extended periods of time) seemed to be in lower slope positions, rather than ridges, and were frequently in or on the edge of relatively dense forest, and generally were in close proximity to dens (Figures 6 and 8).

We observed different patterns of den use in 2015 and 2016. In 2015, porcupines primarily used trees as day roosts during the time of our surveys, rather than retreating to rock dens. In 2016, porcupines used both trees and rock dens but utilized rock dens much more frequently in 2016 than in 2015. It is unclear what factors influence den use, but it is likely that a combination of climatic factors such as snow pack and ambient temperature are important drivers. There are numerous den sites that have evidence of porcupine use at DETO (Figure 7). The majority of rock dens were located in caves in sandstone outcrops and were identified based on tracks, accumulation of porcupine scat, or by tracking porcupines to their location. A number of dens were located among the large boulders at the base of the tower. Cave dens tended to be south facing. It is possible that they may have been chosen to mitigate temperature extremes of the surrounding landscape, which would concord with studies in other areas. This was evidenced by temperature recordings from data loggers placed at the entrance to one such den within a band of sandstone cliffs with a southerly aspect, which showed that low temperatures within the den were higher than ambient temperatures, possibly providing a refuge from the cold. This den also had an evident area of accumulated porcupine scat at its entrance, suggesting that porcupines occupied that area. A temperature logger at that location showed daytime temperatures substantially higher than ambient temperatures, possibly providing a basking area with easy access to the den. Such conclusions are entirely speculative at this point.

Future Monitoring of Porcupines at DETO

Surveys conducted in 2015 and 2016 have resulted in a greatly enhanced understanding of porcupines at DETO. Information provided above serves as evidence of the immense survey effort required to locate individual porcupines. As a result, we suggest future monitoring efforts be focused on documenting evidence of porcupines, particularly focusing on feeding scars at a subset of grid cells in forested areas across DETO. Specifically, we recommend selecting a spatially balanced sample of grid cells weighted by our foraging density model. This will place the majority of future survey effort in areas known to support porcupines while still allowing inference to be made to all forested areas of DETO. These data can then be analyzed using an occupancy-based framework in order to better assess porcupine occupancy as it relates to changes in local habitat resulting from management actions or natural disturbance.

Acknowledgements

We sincerely thank Richard Thiel (Wisconsin Department of Natural Resources) for his insights on trapping, handling, and marking of porcupines. We also thank Jessica Sellers for her tremendous help and expertise in the field. This project would not have been possible without logistical support from Rene Ohms and many others at DETO.

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TABLES AND FIGURES

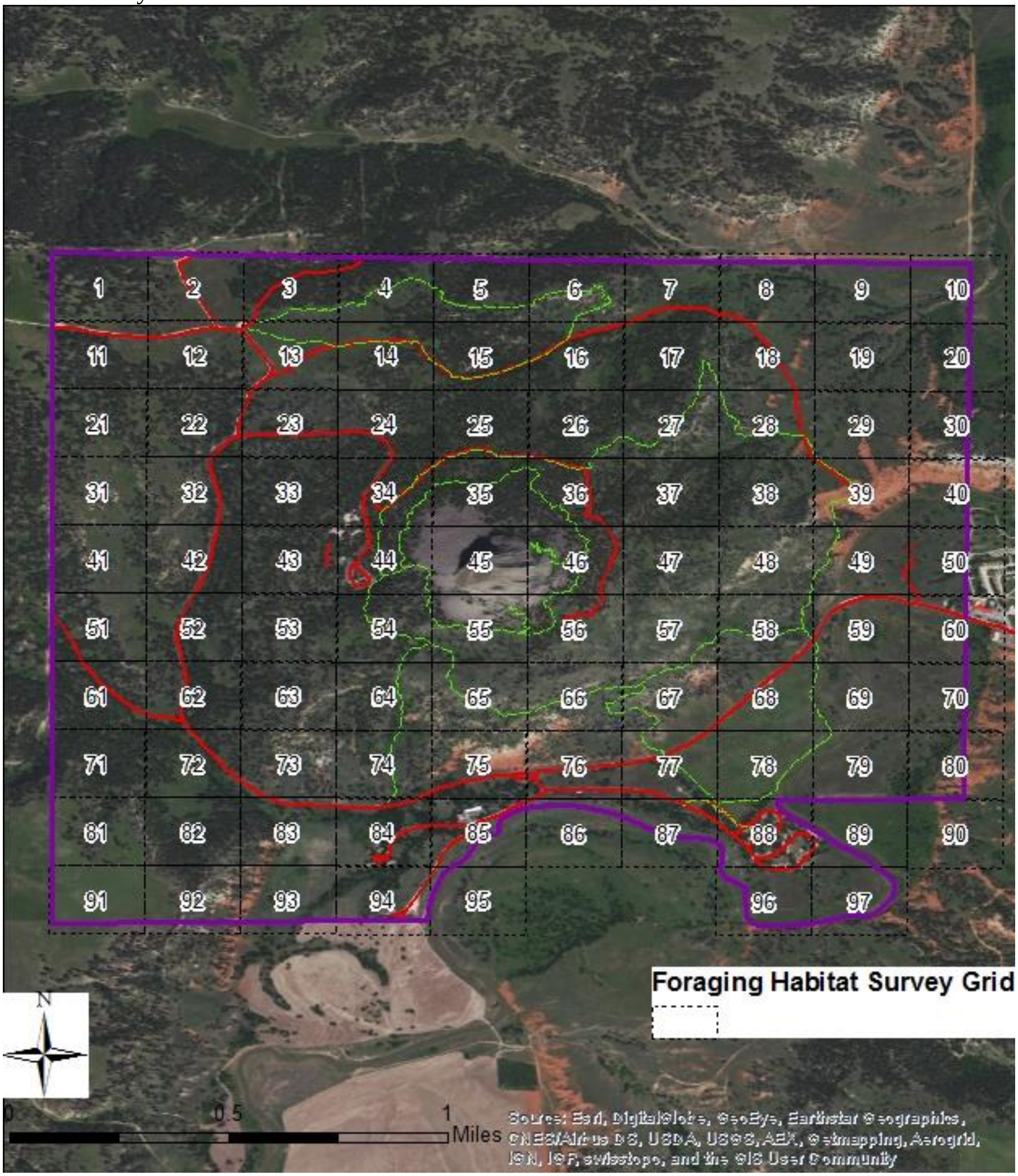
Table 1: Porcupines identified during surveys of Devil's Tower National Monument in January and February of 2015.

Porcupine Name	Capture Date	PIT Number	Sex	Age (Years)	Weight (kg)	Radio Tagged
Peppe	Jan 16	048-859-842	Male	~ 2	8.2	Yes
Petunia	Jan 20	048-775-586	Female	~ 2	6.8	No
Bowsa	Jan 29	048-572-010	Female	> 2	7.0	Yes
Athena	Jan 29	048-620-863	Female	> 2	7.24	Yes
Blondie	Feb 11	048-578-318	Female	> 2	8	No
Griz	Not Captured	None	Unknown	Unknown	Unknown	No

Table 2: Porcupines identified during surveys of Devil's Tower National Monument January through April of 2016.

Porcupine Name	Capture Date	PIT Number	Sex	Age (Years)	Weight (kg)	Radio Tagged
Peppe (AKA Zeus)	Jan 21	048-618-611	Male	> 2	8.42	Yes
Bowsa	Feb 09	048-630-122	Female	> 2	5.8	Yes
Athena	Feb 11	048-555-608	Female	> 2	6.82	Yes
Blondie	Feb 12	048-553-818	Female	> 2	6.8	Yes
Petunia	Feb 25	048-775-586	Female	> 2	5.96	Yes
Buttercup	Feb 29	048-607-287	Female	< 1	5.2	No

Figure 1: Porcupine survey grid for Devil's Tower National Monument in which foraging habitat surveys were conducted in 2015 and 2016.



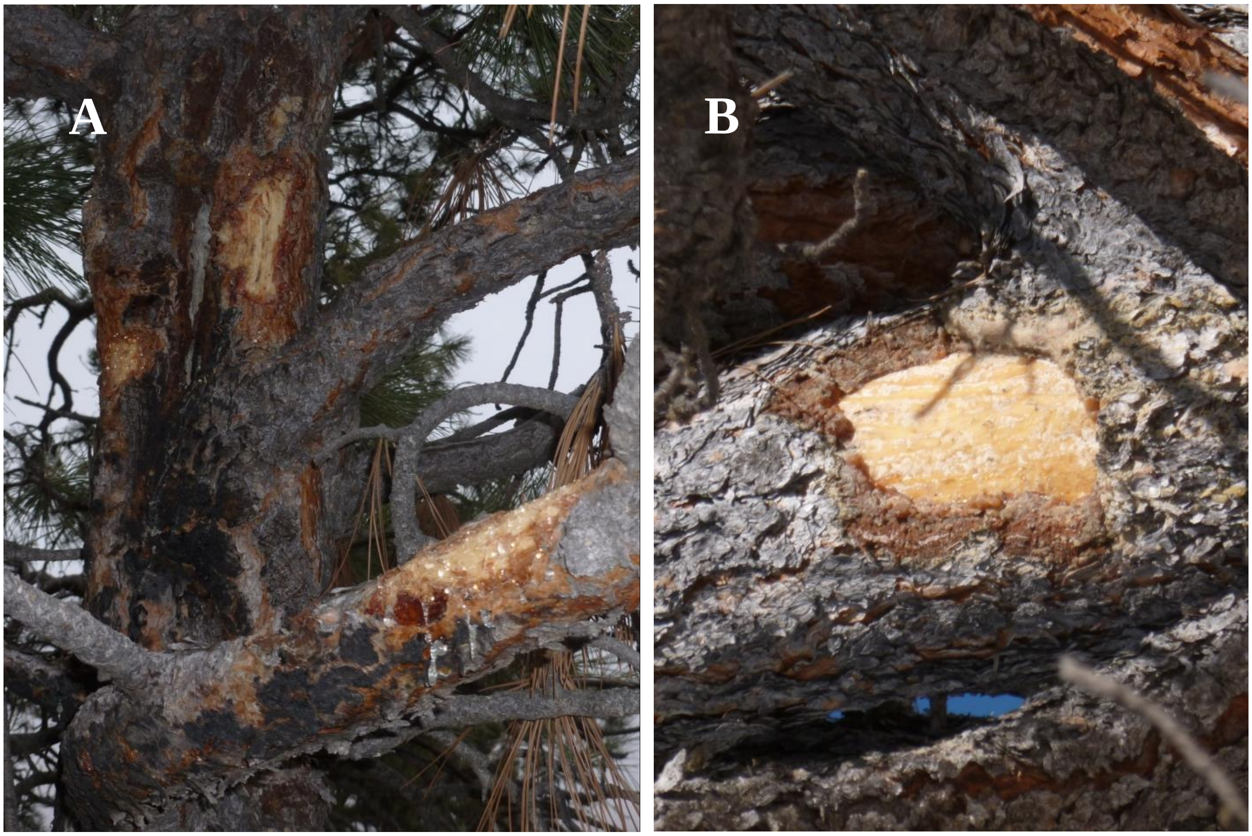


Figure 2: Examples of fresh (A) and multiple year old (B) porcupine foraging scars on ponderosa pine trees. In older scars, the sap weathers away leaving bare, grey wood.

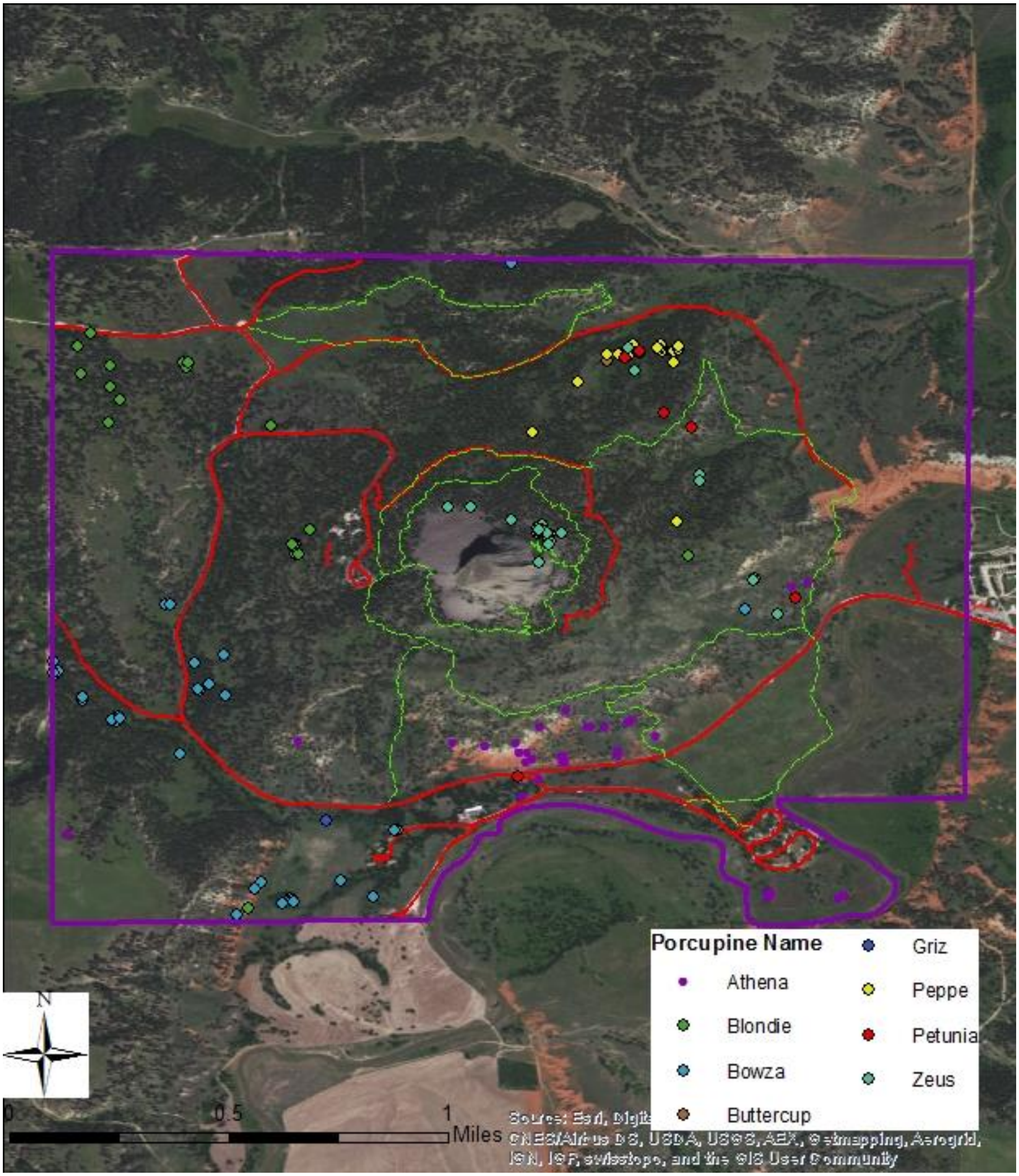


Figure 3: Locations of porcupines tracked at DETO in 2015 and 2016. Color indicates individual porcupines. Other than Peppe and Petunia, porcupine home ranges seemed to be largely non-overlapping. Note that it was determined that Peppe and Zeus were the same individual (See Abundance section above).

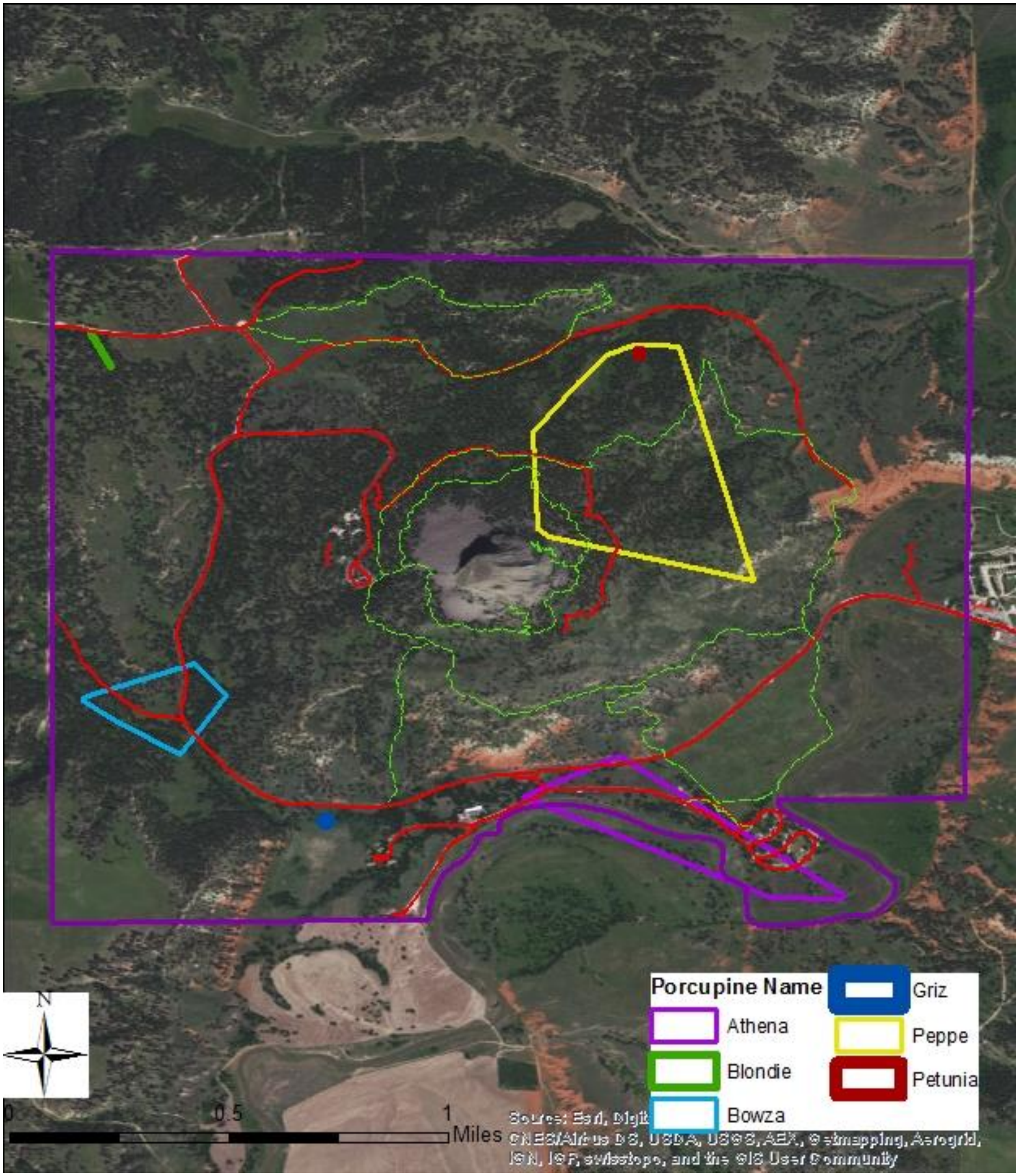


Figure 4: Minimum convex polygons of porcupines that were fitted with radio transmitters in 2015 and relocated through subsequent radio-tracking efforts (see Figure 3 for locations on which polygons were based).

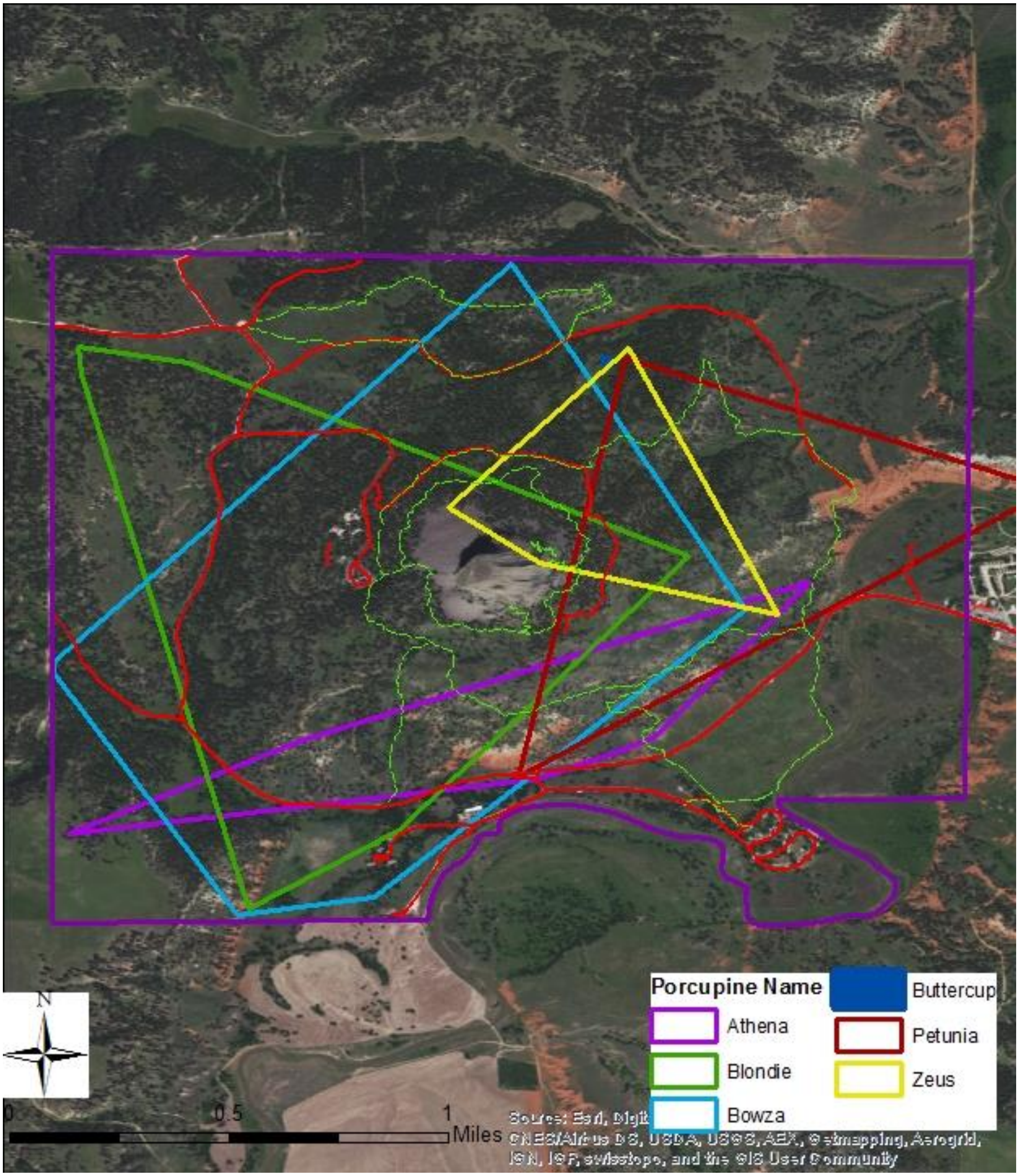


Figure 5: Minimum convex polygons of porcupines that were fitted with radio transmitters in 2016 and relocated through subsequent radio-tracking efforts (see Figure 3 for locations on which polygons were based). Note that the individual identified as Zeus in 2016 is assumed to be the same individual identified as Peppe in 2015.

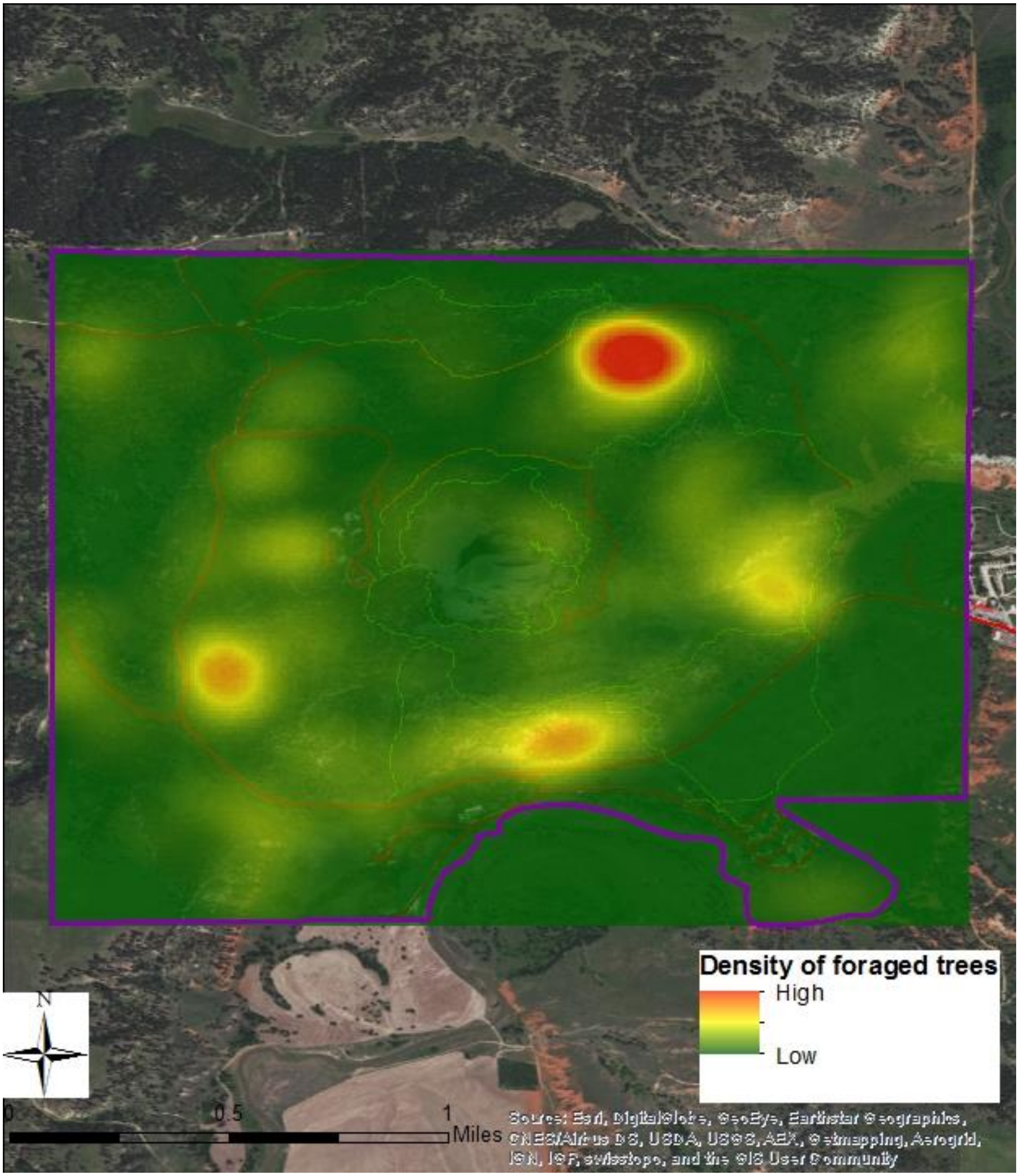


Figure 6. Model of the density of trees with evidence of foraging by porcupines at DETO.

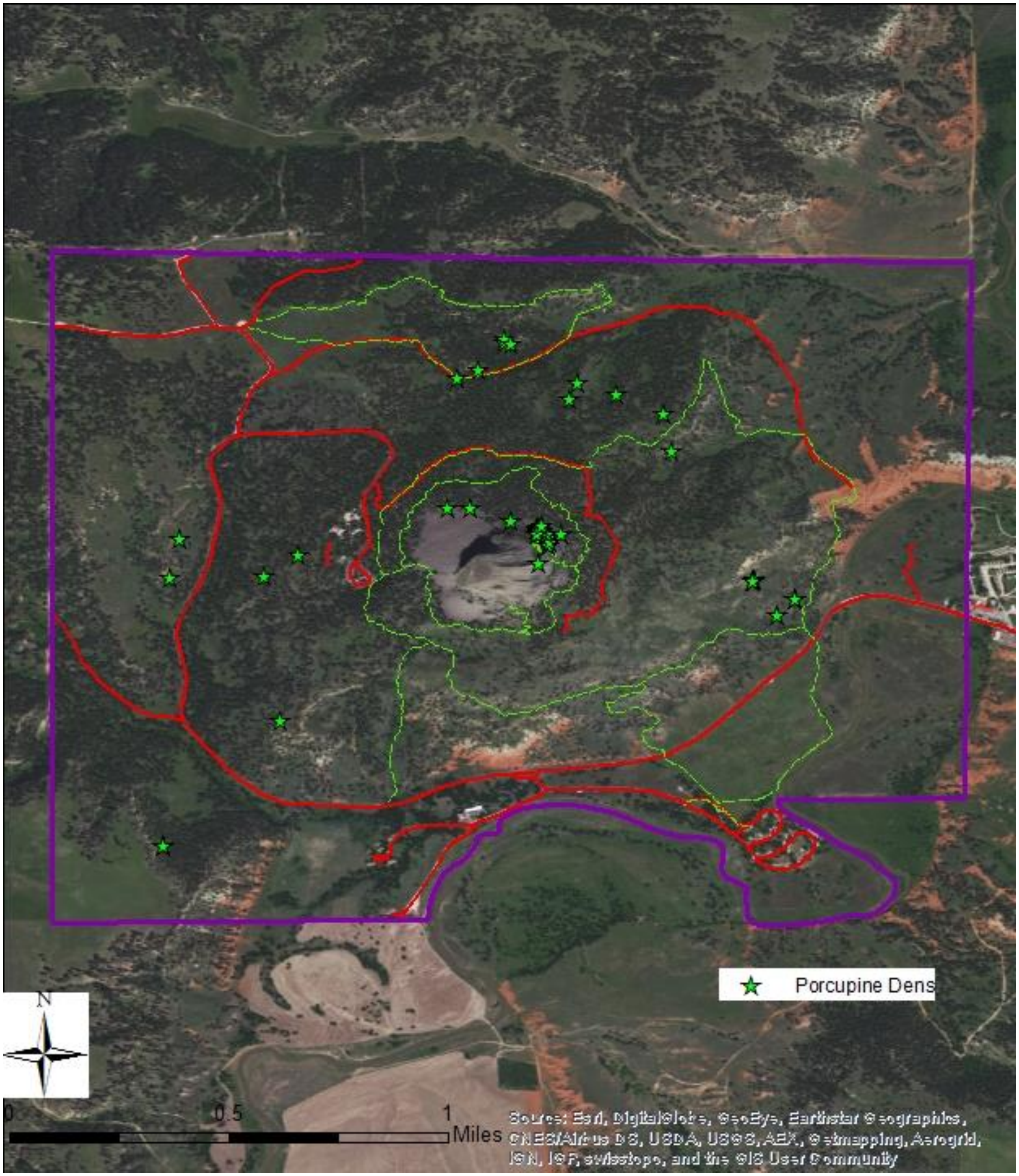


Figure 7: Porcupine dens documented during porcupine surveys and radio tracking efforts in at DETO in 2015 and 2016. Dens were located in crevices and cave-like structures in sandstone outcrops and in the boulder field near base of the tower.

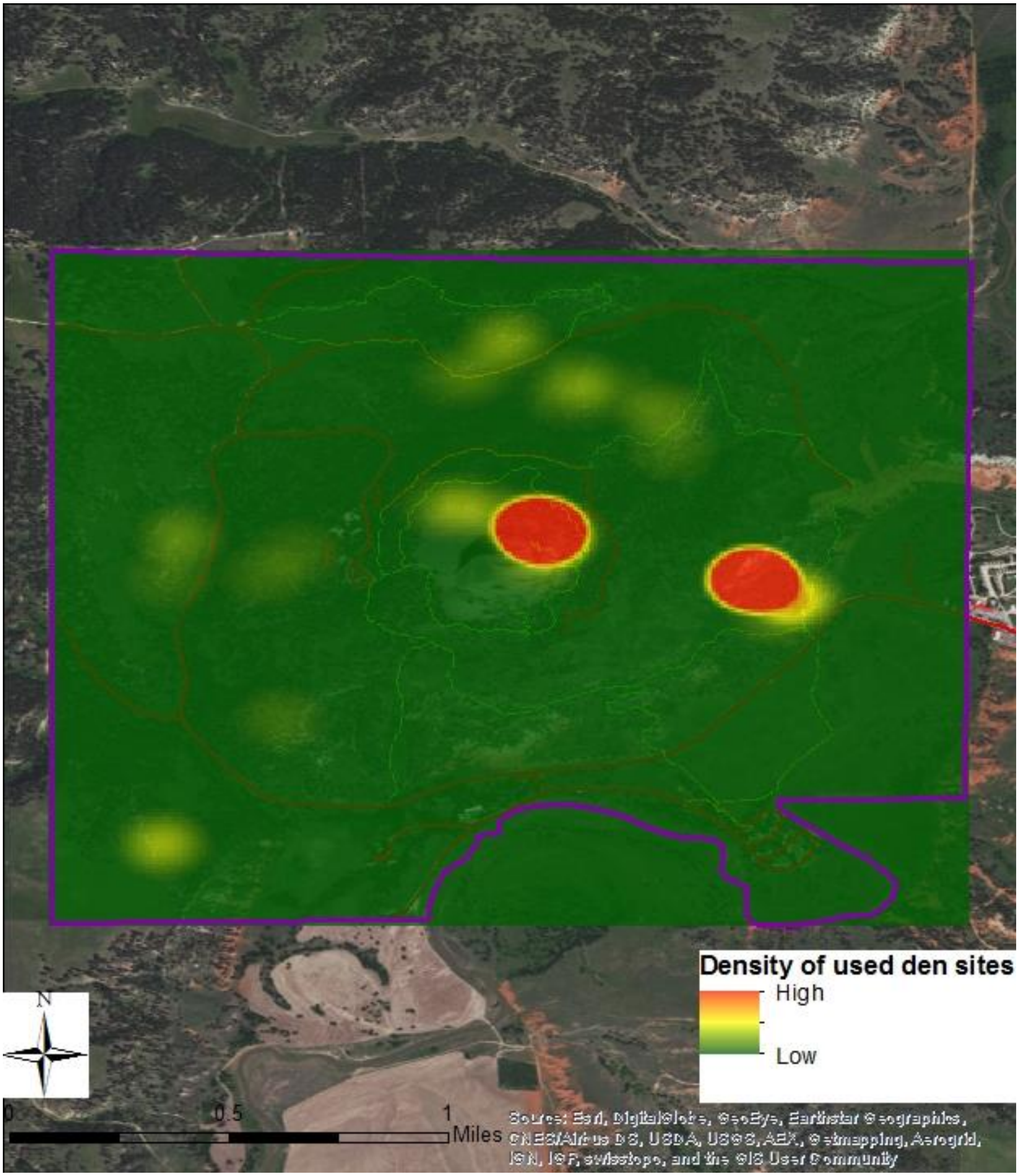


Figure 8. Model of the density of den sites used by porcupines at DETO.

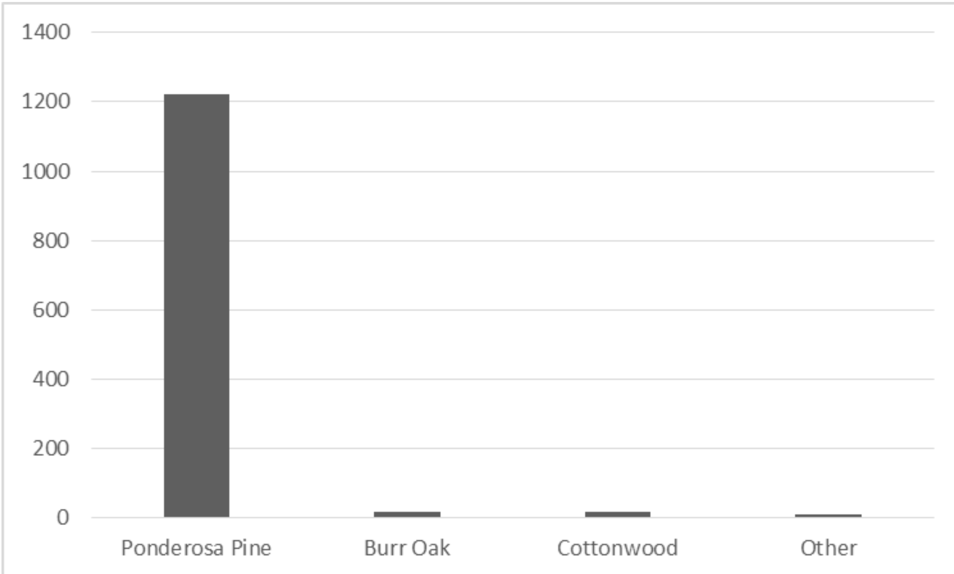


Figure 9: Number of trees (N = 1,264) at DETO that were found to have porcupine feeding scars, plotted by tree species.

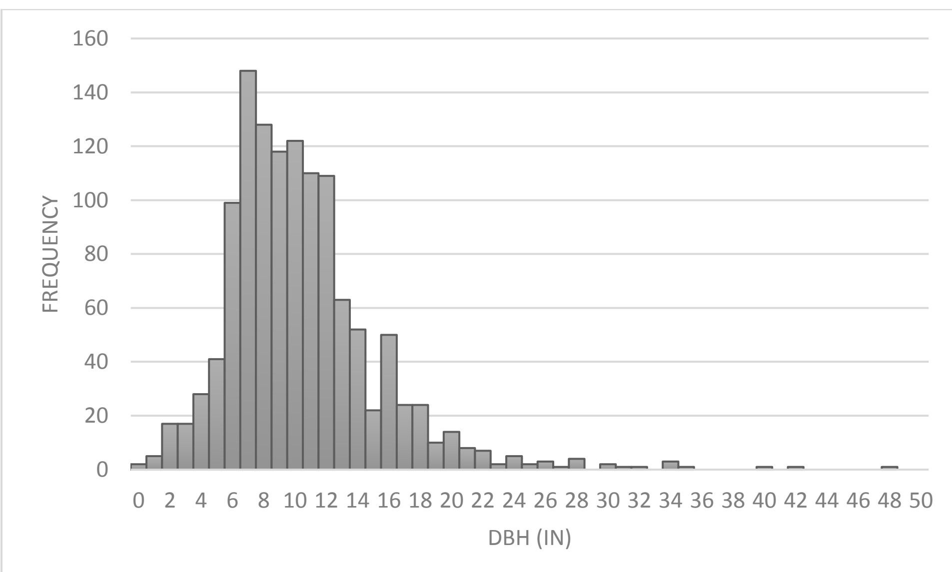


Figure 10: Distribution of ponderosa pine DBH upon which porcupine feeding scars were documented at DETO including outliers.

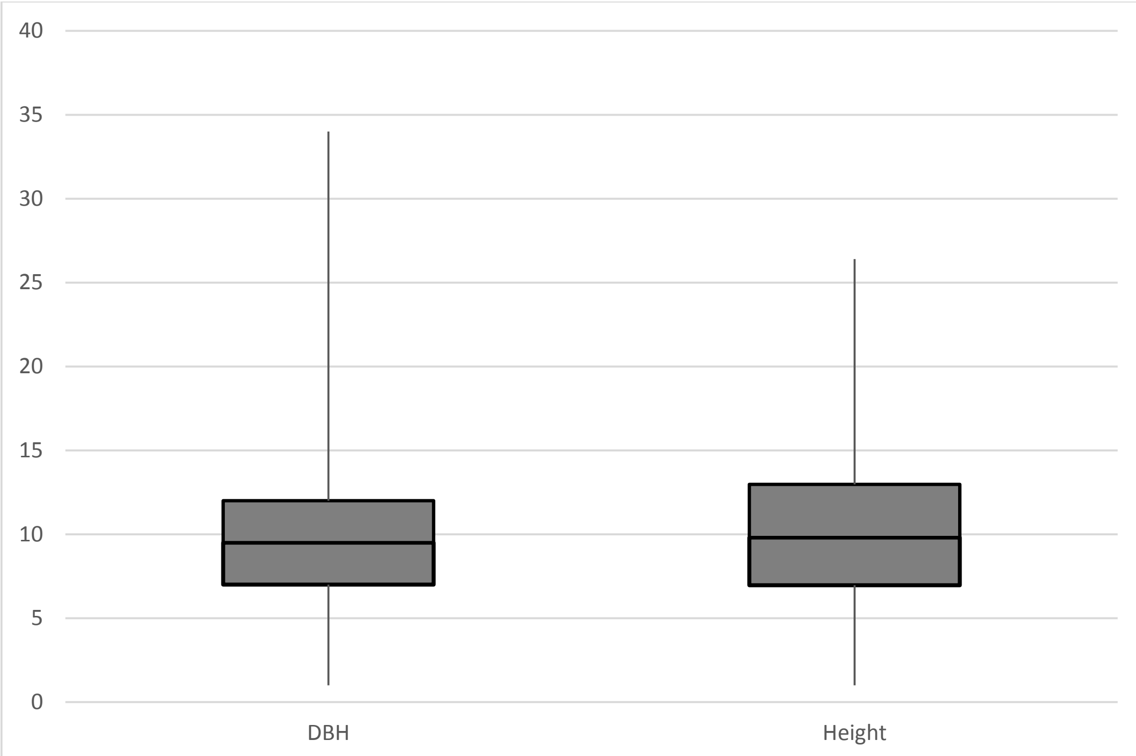


Figure 11: Diameter at breast height (inches) and total tree height (meters) of ponderosa pine trees upon which porcupine feeding scars were documented at DETO excluding outliers.