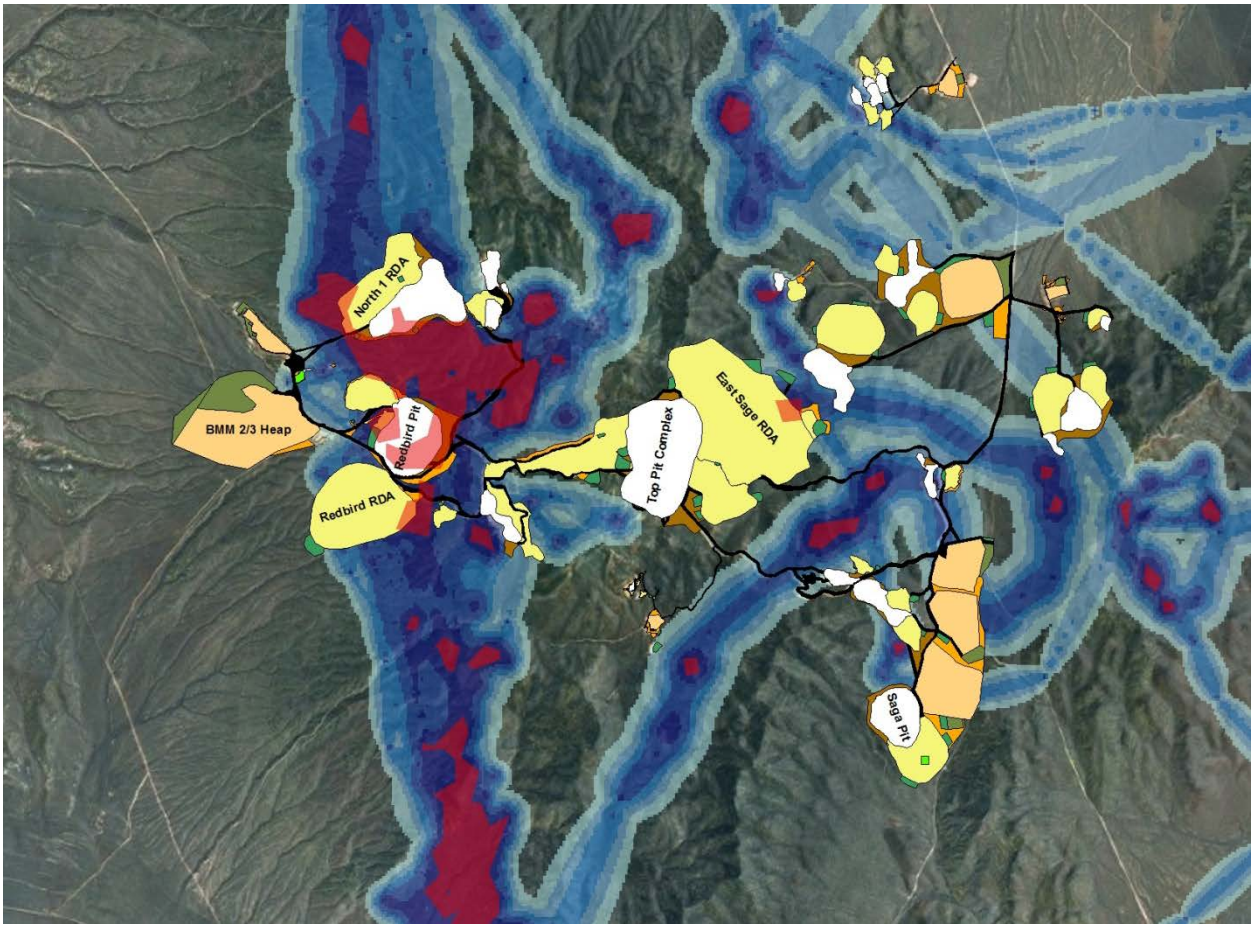
Mule deer migration and the Bald Mountain Mine – a summary of baseline data



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WEST Inc.

NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

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Mule deer buck navigating obstacles near Kings Canyon, Nevada during the fall 2011 migration. Photo credit: Tim Torell

SUGGESTED CITATION

Sawyer, H and M. Brittell. 2014. Mule deer migration and the Bald Mountain Mine – a summary of baseline data. Western Ecosystems Technology, Inc., Laramie, WY.

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INTRODUCTION

The Ruby deer herd occupies all of management area (MA) 10 and utilizes portions of MA 12 and MA 13 as winter range. The Nevada Department of Wildlife (NDOW) considers this deer herd to be the most important deer resource in the state in terms of population size and recreational opportunity. Barrick Gold Corporation is proposing to expand its Bald Mountain Mine to develop additional mineral resources. The existing mine and proposed expansion is located in the southern portion of the Ruby Mountains where crucial deer winter ranges are located and migratory corridors connect the seasonal ranges of this important deer herd (Fig. 1). Currently, mule deer are able to navigate through the network of open pits, rock disposal areas (RDA), haul roads, and ancillary facilities. However, the potential effects of such disturbance on migratory behavior have not been specifically evaluated and the proposed mining expansion could negatively impact deer if it affects their ability to migrate or utilize stopover habitat. To better understand the potential impacts of such disturbance on migratory mule deer and provide information to improve planning, the NDOW, University of Nevada Reno, and Barrick Gold Corporation initiated the Bald Mountain Mule Deer Collaring Project in 2012 – an effort aimed at collecting baseline GPS data to assess migratory patterns of deer that utilize the Bald Mountain Mine area. We note that the baseline data was not collected prior to mineral development; rather it was collected under existing mine conditions (2012-2013) and before proposed expansion of mine.

In February 2014, Western Ecosystems Technology, Inc. (WEST) was contracted by NDOW to provide an independent analysis and assessment of the migration data collected to date. The specific objectives of the WEST analysis was to: 1) identify a population-level migration route from the marked sample of mule deer, 2) identify the high-use movement corridors within the larger population-level route, 3) identify stopover habitat within the population-level route, and 4) evaluate movement rates of mule deer relative to existing BMM infrastructure. These analyses were intended to summarize baseline data and provide agencies and industry with the information they need to improve mule deer management and develop mineral resources in ways that minimize impacts to migratory mule deer.

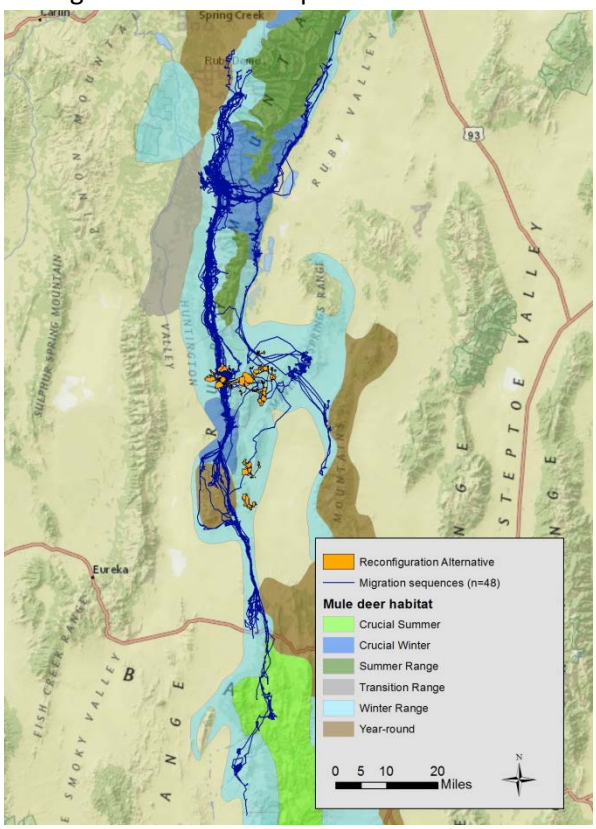

Figure 1. Location of Bald Mountain Mine (Reconfiguration Alternative) relative to mule deer seasonal ranges and migration sequences in the Ruby Mountains.

METHODS

Capture and Data Collection

In January 2012, NDOW captured 12 mule deer from the Ruby Mountain herd near those areas potentially affected by the Bald Mountain Mine expansion. Another 28 deer were captured in 2013 to increase the sample size. All mule deer were equipped with GPS collars programmed to collect 1 location every hour October 1 through April 30, and 1 location per day May 1 through September 30. Of the 40 collars deployed, 37 functioned properly and of those, 34 remained on deer through at least one migration cycle. Our analysis was restricted to 31 deer that were migratory (Table 1). We considered animals migratory if there was a clear and discernable movement between seasonal ranges.

Table 1. Mule deer ID# and migration seasons, where "1" represent migration sequences that were available for each animal.

Deer ID	Spring 2012	Fall 2012	Spring 2013	Fall 2013	Total	Notes
E115	0	0	1	0	1	
E148	0	0	1	0	1	fall shifted to 1/day locations
E165	1	0	1	1	3	
E166	1	1	1	0	3	spring partial, shift to 1/day locations
E168	1	1	1	0	3	
E169	1	1	1	0	3	
E170	1	1	1	0	3	partial sp12
E172	1	0	0	0	1	
E173	1	1	1	0	3	
E174	1	1	1	1	4	
E177	1	1	1	0	3	sp12 partial, shift to 1/day locations
E269	0	0	1	0	1	
E270	0	0	1	0	1	
E271	0	0	1	0	1	
E272	0	0	1	0	1	sp13 partial, shift to 1/day
E273	0	0	1	0	1	
E274	0	0	1	0	1	
E275	0	1	0	0	1	
E276	0	0	1	0	1	
E279	0	0	1	0	1	
E281	0	0	1	0	1	
E282	0	0	1	0	1	
E287	0	0	1	0	1	
E288	0	0	0	0	0	No migration
E314	0	0	1	0	1	
E316	0	0	1	0	1	
E321	0	0	0	0	0	No migration
E322	0	0	1	0	1	
E323	0	1	0	0	1	
E324	0	0	1	0	1	
E325	0	0	0	0	0	No migration
E326	0	0	1	0	1	
E998	0	0	1	0	1	
E999	0	0	1	0	1	
TOTAL	9	9	28	2	48	

Migration Patterns

Population-level migration routes: We used the Brownian bridge movement model (BBMM; Horne et al. 2007) to estimate individual and population-level migration routes from GPS data. The BBMM estimates the probability of use, or a utilization distribution (UD), for a sequence of locations. Migration sequences for the spring and fall migration of each animal were identified manually (Table 1), as locations between distinct winter and summer ranges, including the 12-hr period prior to and following migration (Sawyer et al. 2009). Once migration sequences were extracted from GPS data, we used the "BBMM" package in R (Nielson et al. 2012) to estimate UDs for individual routes. Individual UDs were then averaged to estimate a population-level migration route (Sawyer et al. 2009, White et al. 2010). Assuming a representative sample of animals, the population-level migration route reflects both the spatial extent of a migratory population, as well as the intensity of use within the migration route.

Stopover sites: A key advantage of the BBMM approach is that it allows route segments used as stopover sites (i.e., foraging and resting habitat) to be discerned from those used primarily for movement. Stopovers are important to migratory mule deer because they allow animals to maximize energy intake by migrating in concert with plant phenology (Sawyer and Kauffman 2011). We identified stopover sites from the population-level migration route as the top 10% of UD values. In some instances, where roads or fences or other semi-permeable barriers bisect a migration route and delay animal movements, it is possible that a stopover site could be created as an artifact of the barrier rather than preferred habitat. Here, we assume that the current conditions in the Ruby Mountains and Bald Mountain Mine are permeable to mule deer and that stopovers reflect habitat preferences and not simply areas where deer movements are delayed for extended periods because of some sort of anthropogenic disturbance (e.g., RDA or access road).

High-use routes: Another benefit of the BBMM approach is that when multiple migration routes radiate from a common winter range, as is often the case with mule deer, we can identify which of those routes are more heavily used than others. By overlaying the 99% contour of each animal's migration route, we calculated the proportion of marked animals that used each migration segment. This step is especially helpful for agencies, industry, and other stakeholders to prioritize which routes are most critical or important. Based on the proportion of the sampled population (<10%, 10 to 20%, or >20%) that used each route segment, we categorized route segments into low, moderate, and high-use areas. In this application, the level of use simply reflects the proportion of sampled animals that used each route or corridor (Sawyer et al. 2009).

Movement rates relative to mine boundaries: Assuming GPS fix success is high (>90%), calculating movement rates relative to the energy development boundaries may compliment the BBMM analysis and provide baseline data to compare with future years of development (Sawyer et al. 2013). We used GPS data from migratory mule deer to calculate movement rates inside and outside of project area boundaries. For the purposes of this analysis, we used four different facility area boundary definitions, including: 1) the existing surface disturbance (ESD) as digitized by NDOW in December 2013, 2) the No Action Alternative that reflects authorized infrastructure as of the 2009 BLM FEIS, 3) the Proposed Action that reflects full development as identified in current NEPA document (Preliminary Draft EIS July 2013), and 4) the Reconfiguration Alternative as provided by AECOM in April 2014. Our intent with using the three different project area definitions was to allow NDOW and others to evaluate various development scenarios and accommodate differences in GIS layers. For each analysis, we considered any segment that overlapped with the project boundary as part of the development, whereas non-development segments did not overlap any part of the facility boundary. We created paired plots to illustrate differences in movement rates inside and outside the project area boundaries. We used a

simple paired two-sample *t*-test to test for differences in movement rates inside and outside the project areas, where animals were pooled across seasons and years.

RESULTS

Migration Patterns

Population-level migration route: We estimated the population-level migration route from 48 migration sequences (37 spring, 11 fall) collected from 31 individual deer between 2012 and 2013 (Figs. 2-6). The 1-hr GPS intervals resulted in relatively low Brownian motion variance (mean = 1,363, SD = 723) compared to other mule deer studies where GPS fix intervals were 2.5-hr (mean = 2,679, SD = 280; Sawyer et al. 2009) or 4-hr (mean = 5,622, SD = 4558; Coe et al. *In preparation*). A low BMV results in more precise estimates of the migration route UD. In other words, the width of the estimated migration route decreases as BMV decreases.

Stopover sites: The population-level route contained distinct stopover areas where mule deer spent the majority of their time during migration. Most stopovers occurred in the north and central parts of the migration route (Figs. 3-6), and along the west side of the Ruby Mountains. Relative to the Bald Mountain Mine, there was a prominent stopover site just north of the Redbird Pit (Figs. 7-10)

High-use routes: Based on the proportional level of use, there was one distinct route that most animals used to move from winter ranges near US Highway 50 north into the Ruby Mountains (Figs. 11-14). The high-use route extends approximately 85 miles and ranges from 0.25 to 1.25 miles in width. Moving from south to north, the route splits for approximately 2 miles near the south end of Bald Mountain Mine and again for approximately 6 miles north of the mine, from Overland Pass to Sherman Mountain (Fig. 13). The high-use route ends just north of the Harrison Pass Road, where deer split off to continue migrations along both the east and west side of Ruby Mountains. Relative to the Bald Mountain mine, the high-use route appears to split at the Redbird Pit, then pass through the western portions of the North 1 rock disposal area (Figs. 15-18).

Movement rates relative to mine boundaries: Across all seasons (spring 2012, fall 2012, and spring 2013) and project boundary definitions (Existing Surface Disturbance, No Action Alternative, Proposed Action, and Reconfiguration Alternative), mule deer consistently had higher movement rates inside mining areas compared to outside (Figs. 19-22). Although fewer deer were available for analysis with the Existing Surface Disturbance boundary (Fig. 19), movement rates of deer were higher (t_{17}=3.57, P=0.002) inside the mine areas (mean = 0.47 km/hr) compared to outside (mean = 0.13 km/hr). Under the Proposed Action (Fig. 20), the mean rate of deer movement was higher (t_{30}=3.69, P<0.001) inside the mine boundaries (mean = 0.35 km/hr) compared to outside (mean = 0.13 km/hr). The mean rate of deer movement was higher (t_{27}=5.11, P<0.001) inside the mine boundaries (mean = 0.33 km/hr) of the No Action Alternative (Fig. 21) compared to outside (mean = 0.13 km/hr). And similarly, the mean rate of deer movement was higher (t_{27}=4.81, P<0.001) inside the mine boundaries (mean = 0.41 km/hr) of the Reconfiguration Alternative (Fig. 22) compared to outside (mean = 0.14 km/hr).

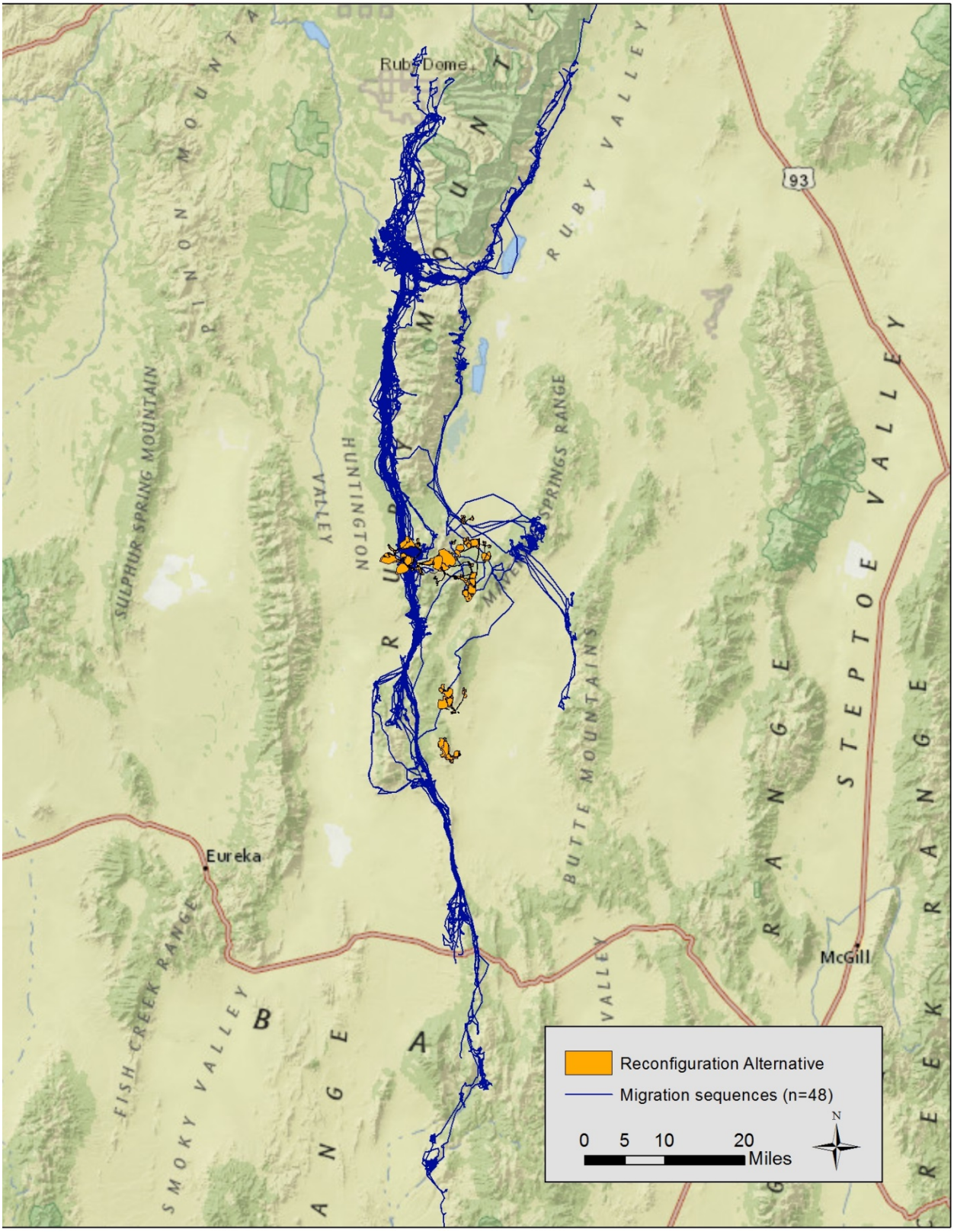

Figure 2. Between 2012 and 2013, 48 migration sequences were collected from 31 individual mule deer.

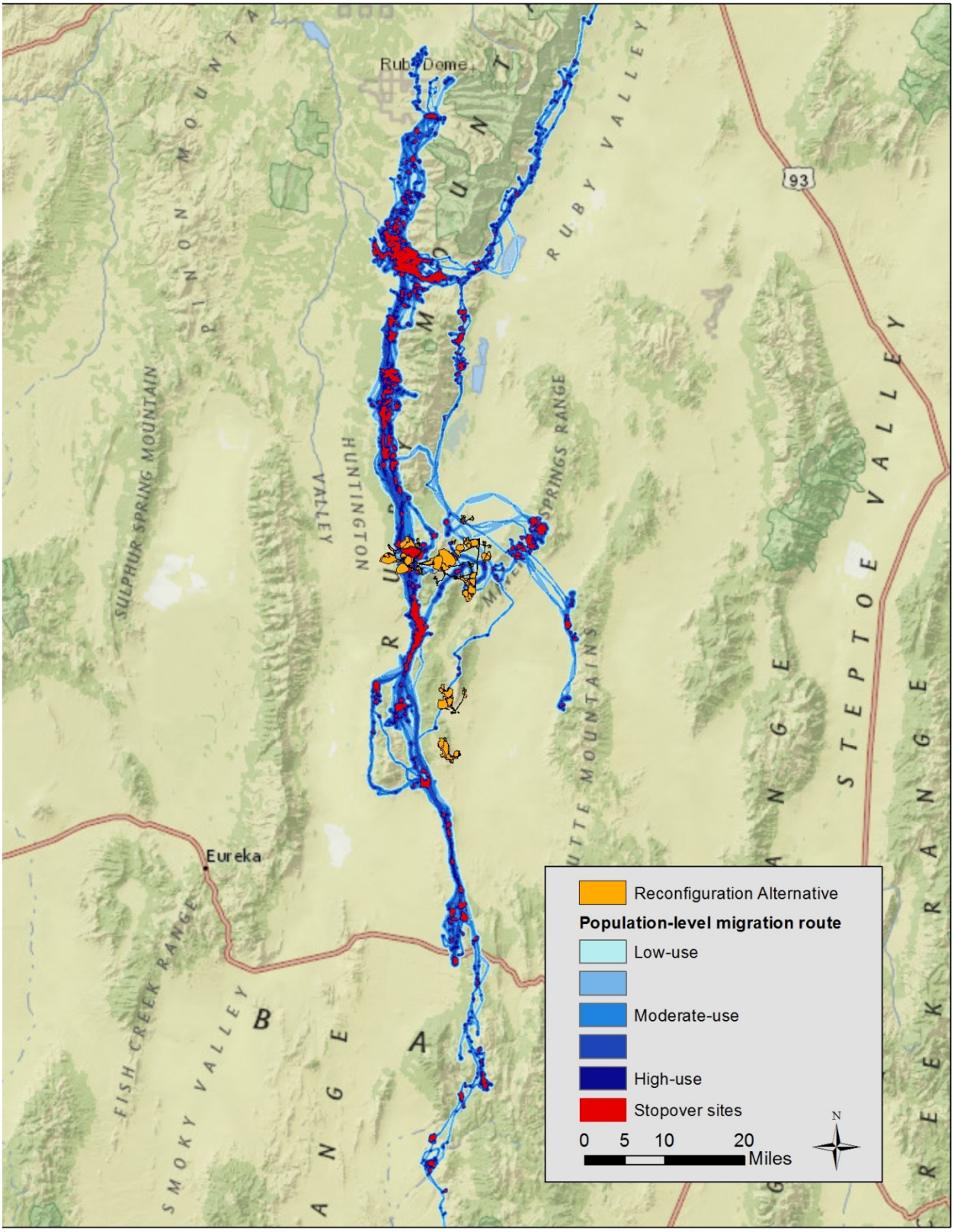

Figure 3. Population-level migration route and stopover sites estimated for the Ruby mule deer herd, 2012-2013.

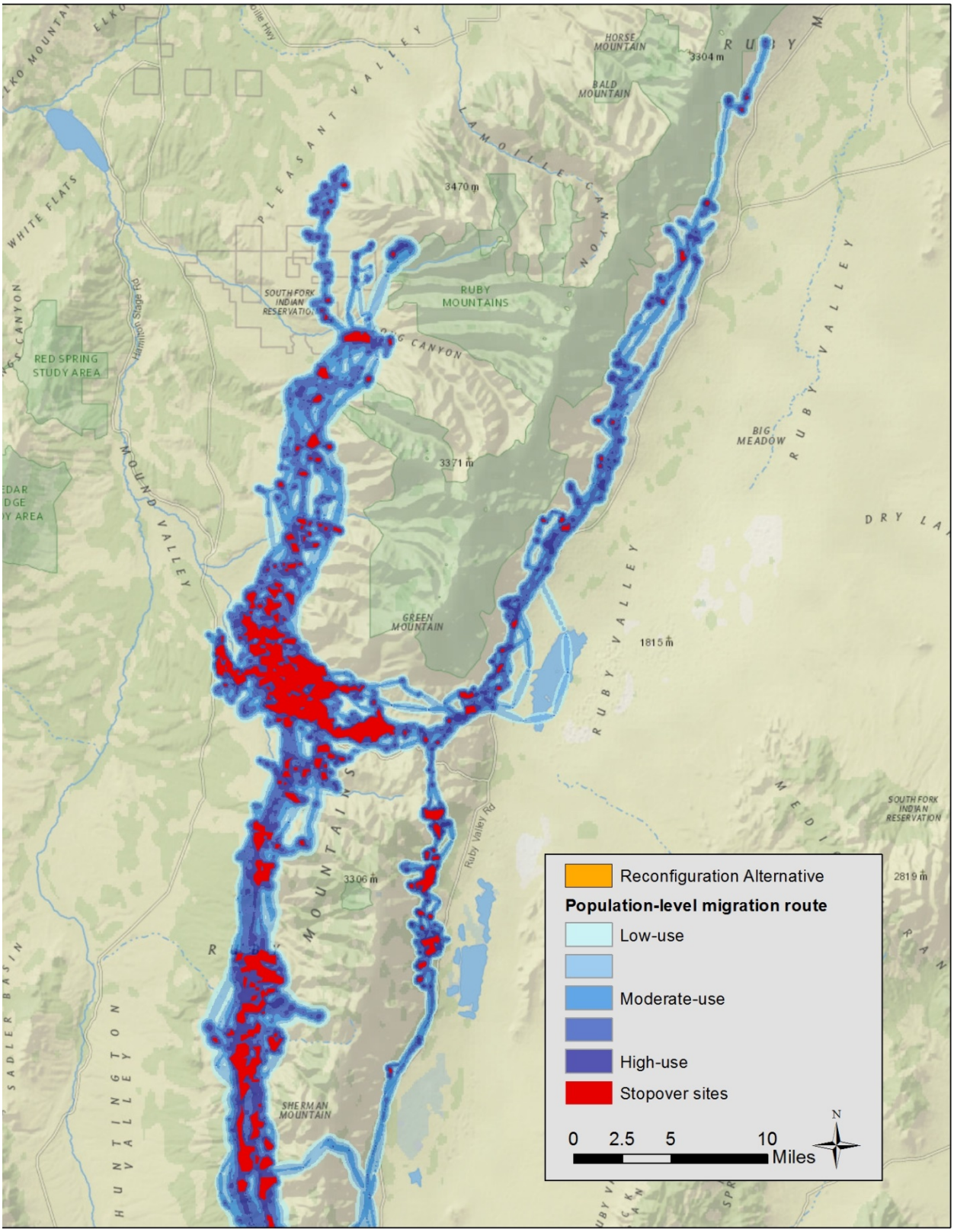

Figure 4. Population-level migration route and stopover sites for the northern part of the Ruby mule deer herd, 2012-2013.

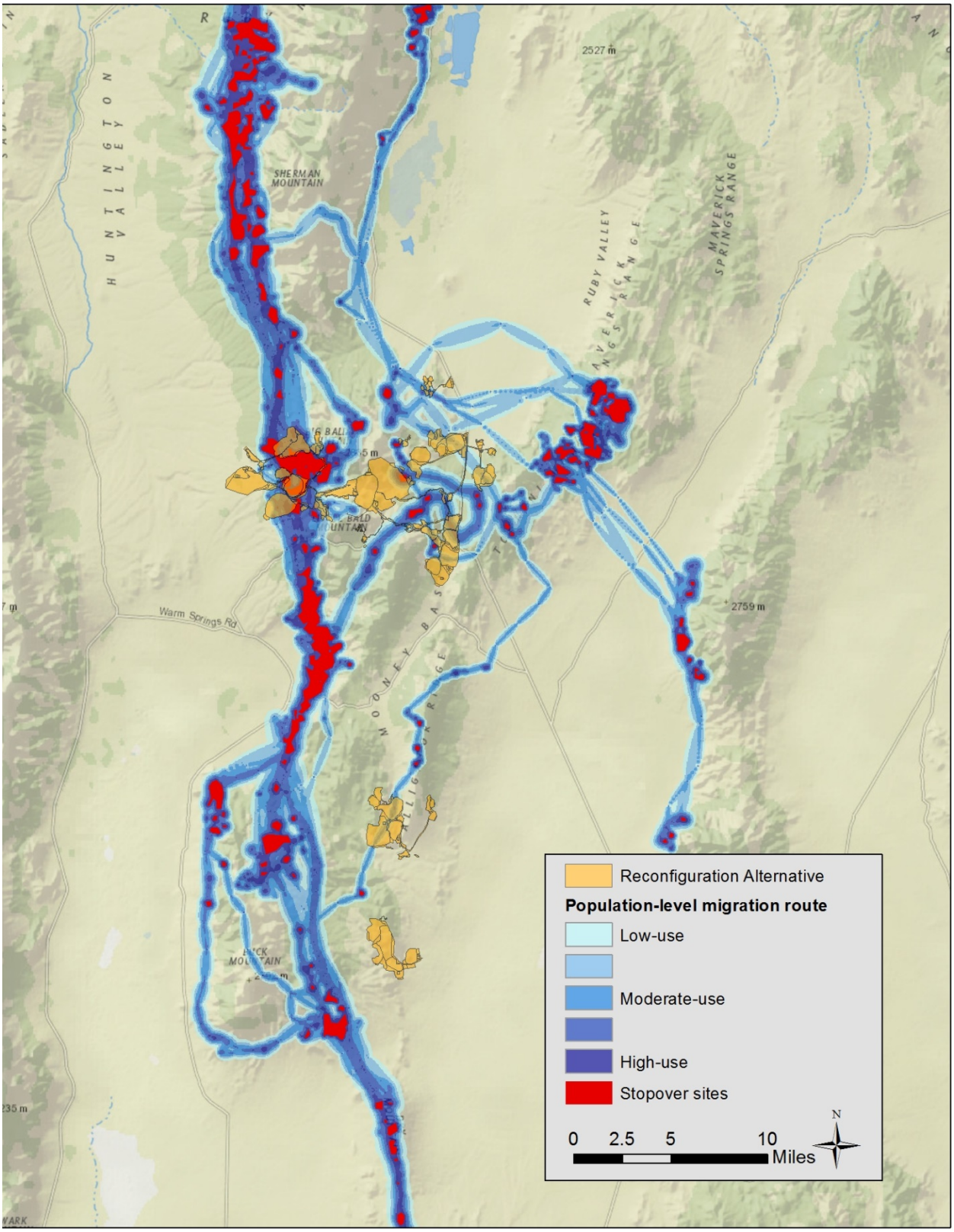

Figure 5. Population-level migration route and stopover sites for the central part of the Ruby mule deer herd, 2012-2013.

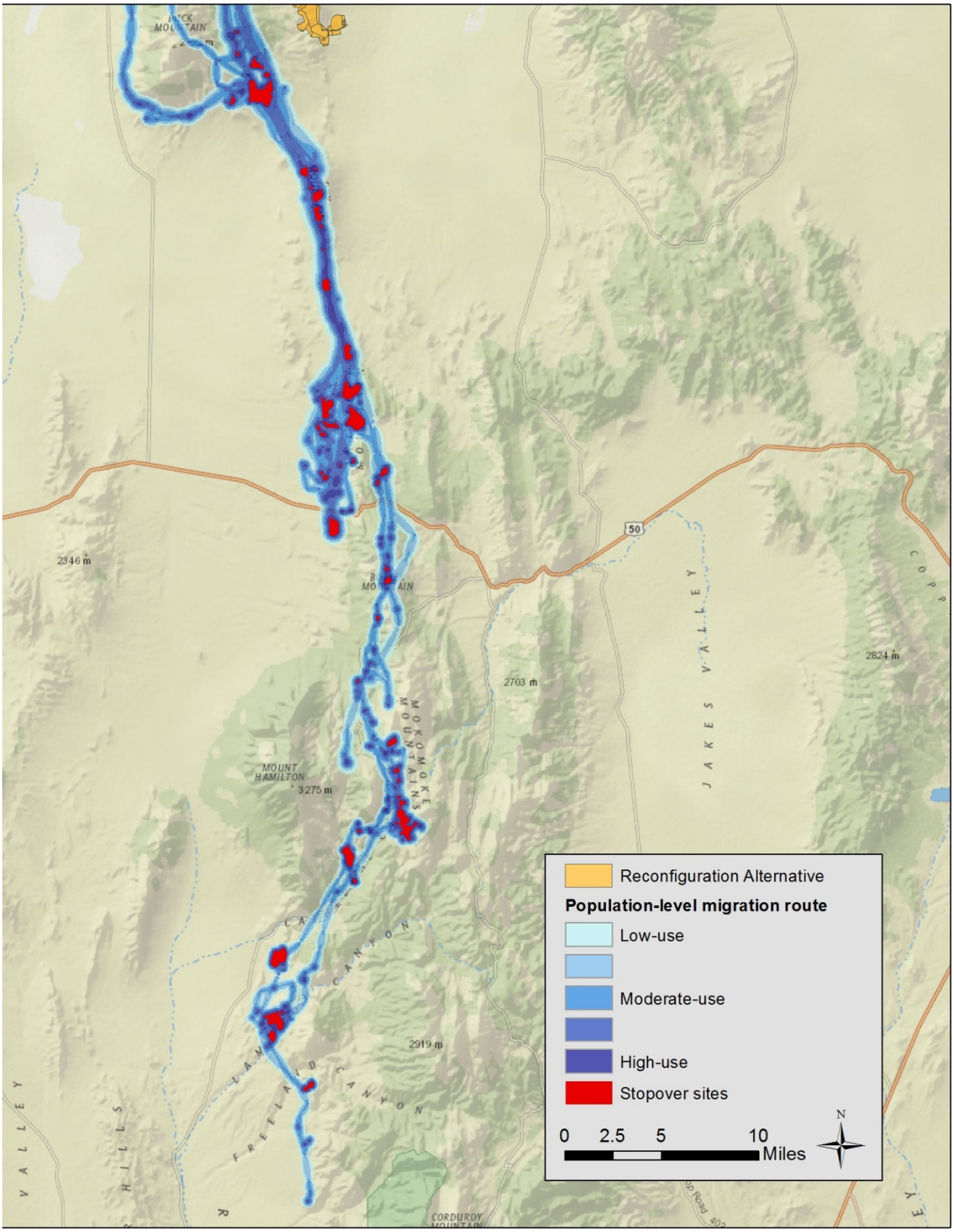

Figure 6. Population-level migration route and stopover sites for the southern part of the Ruby mule deer herd, 2012-2013.

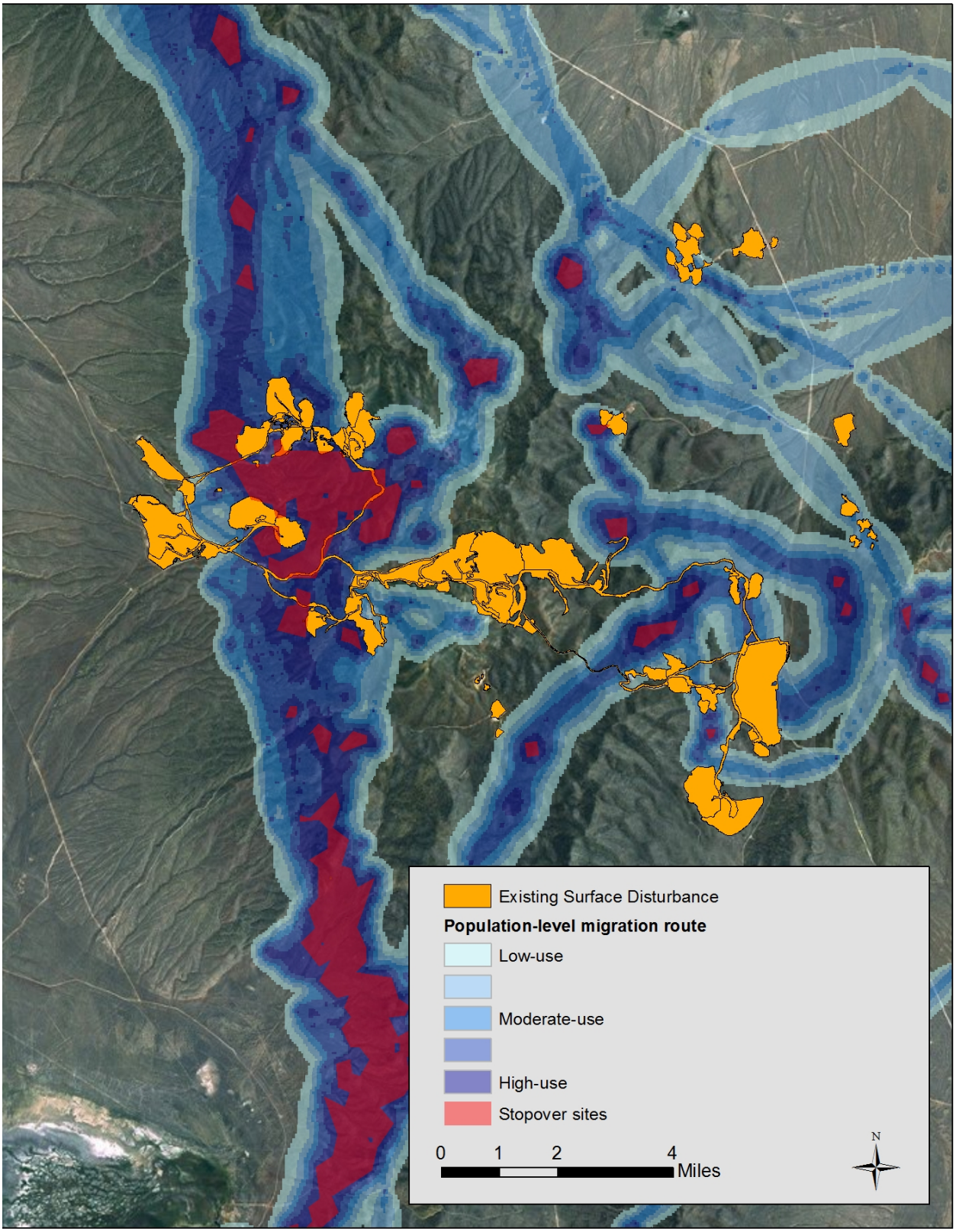

Figure 7. Population-level migration route and stopover sites relative to the Bald Mountain Mine – Existing Surface Disturbance.

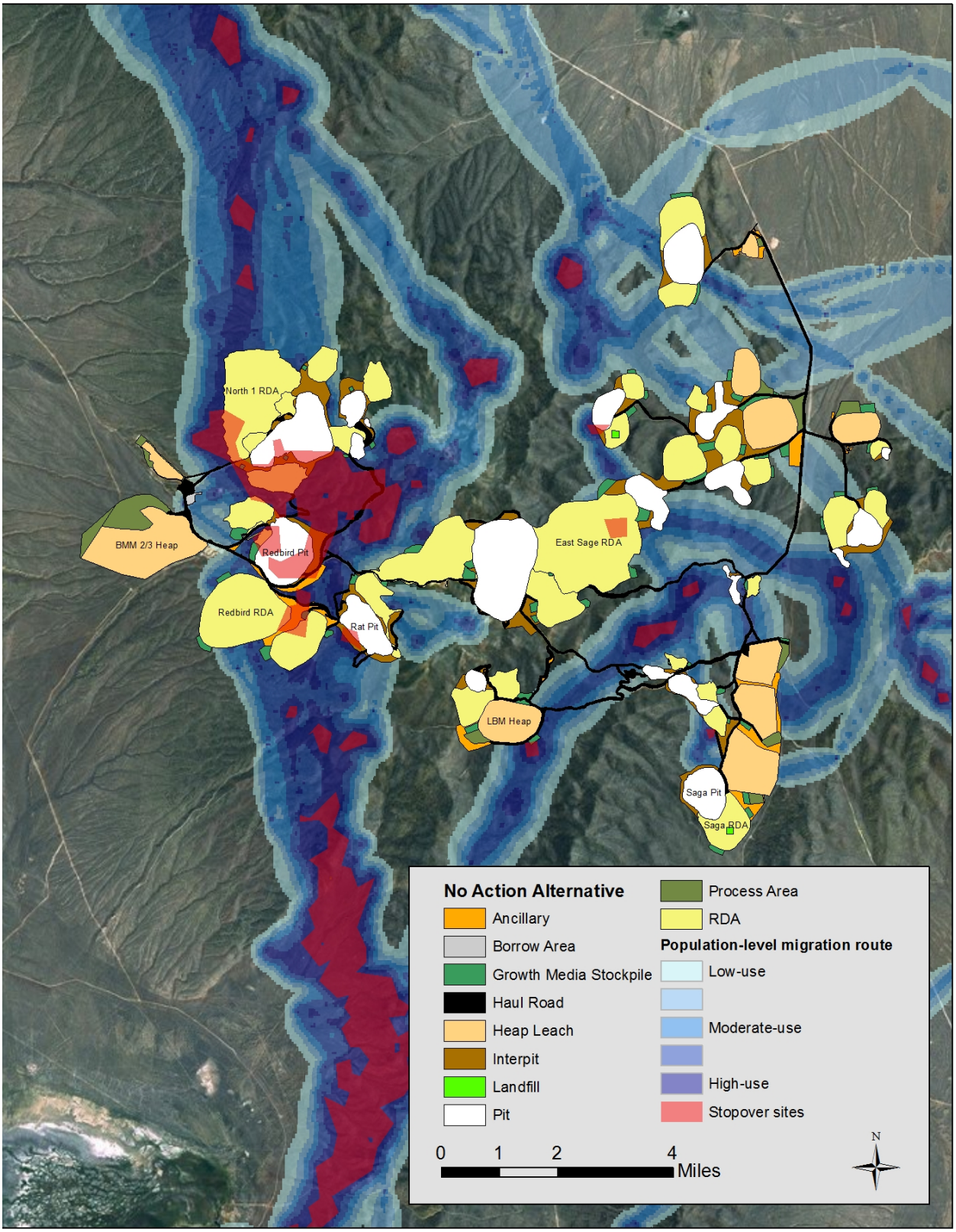

Figure 8. Population-level migration route and stopover sites relative to the Bald Mountain Mine – No Action Alternative.

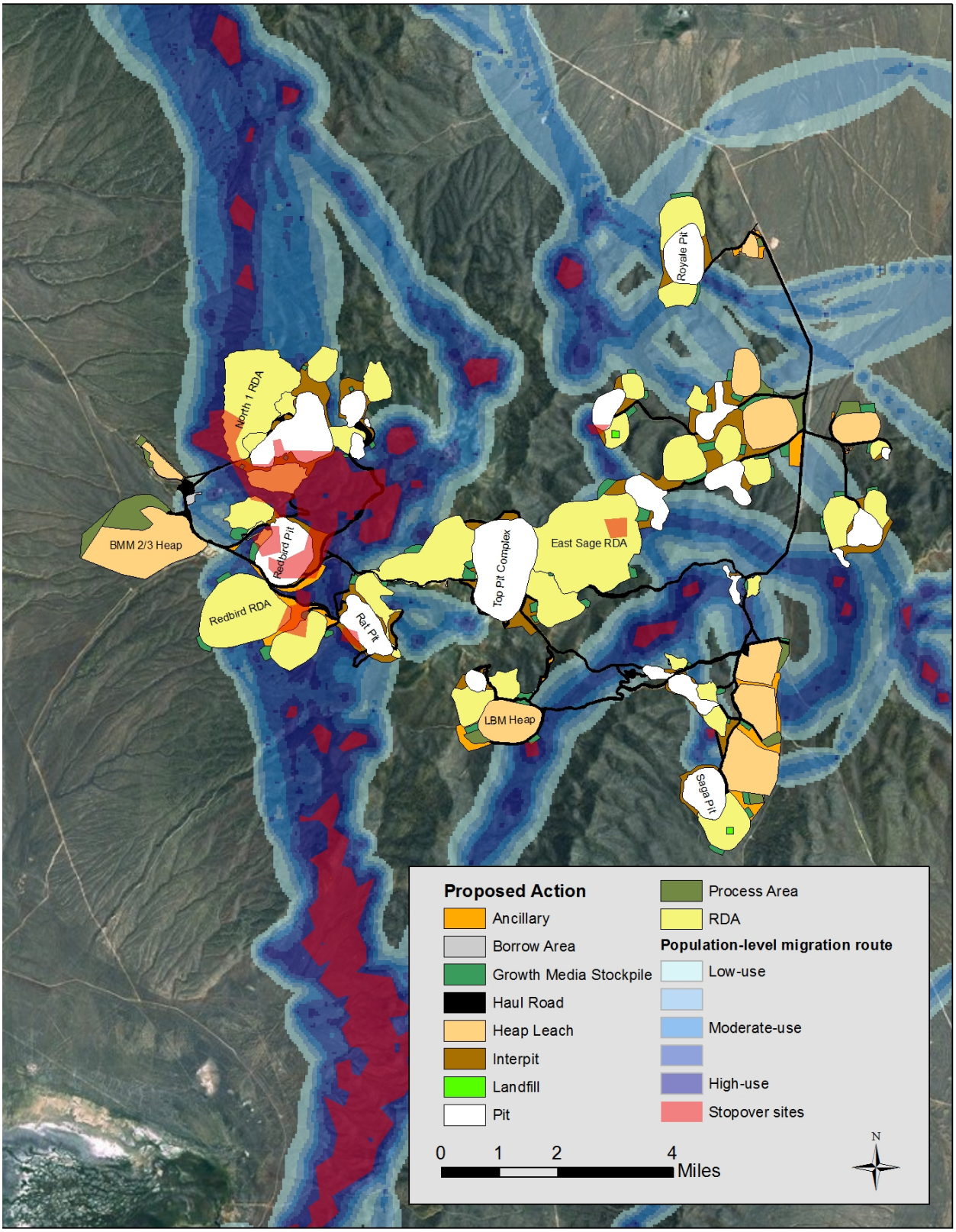

Figure 9. Population-level migration route and stopover sites relative to the Bald Mountain Mine – Proposed Action.

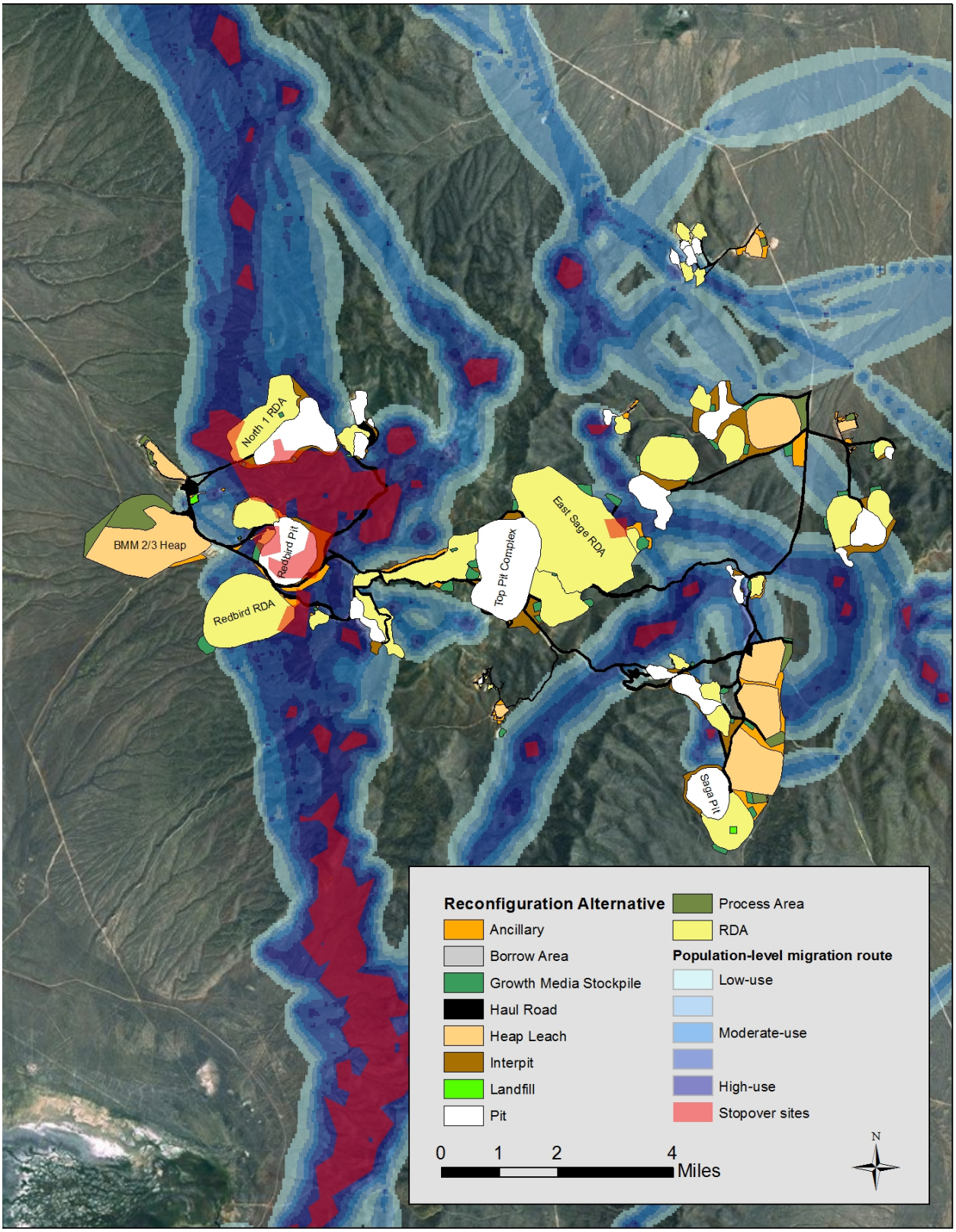

Figure 10. Population-level migration route and stopover sites relative to the Bald Mountain Mine – Reconfiguration Alternative.

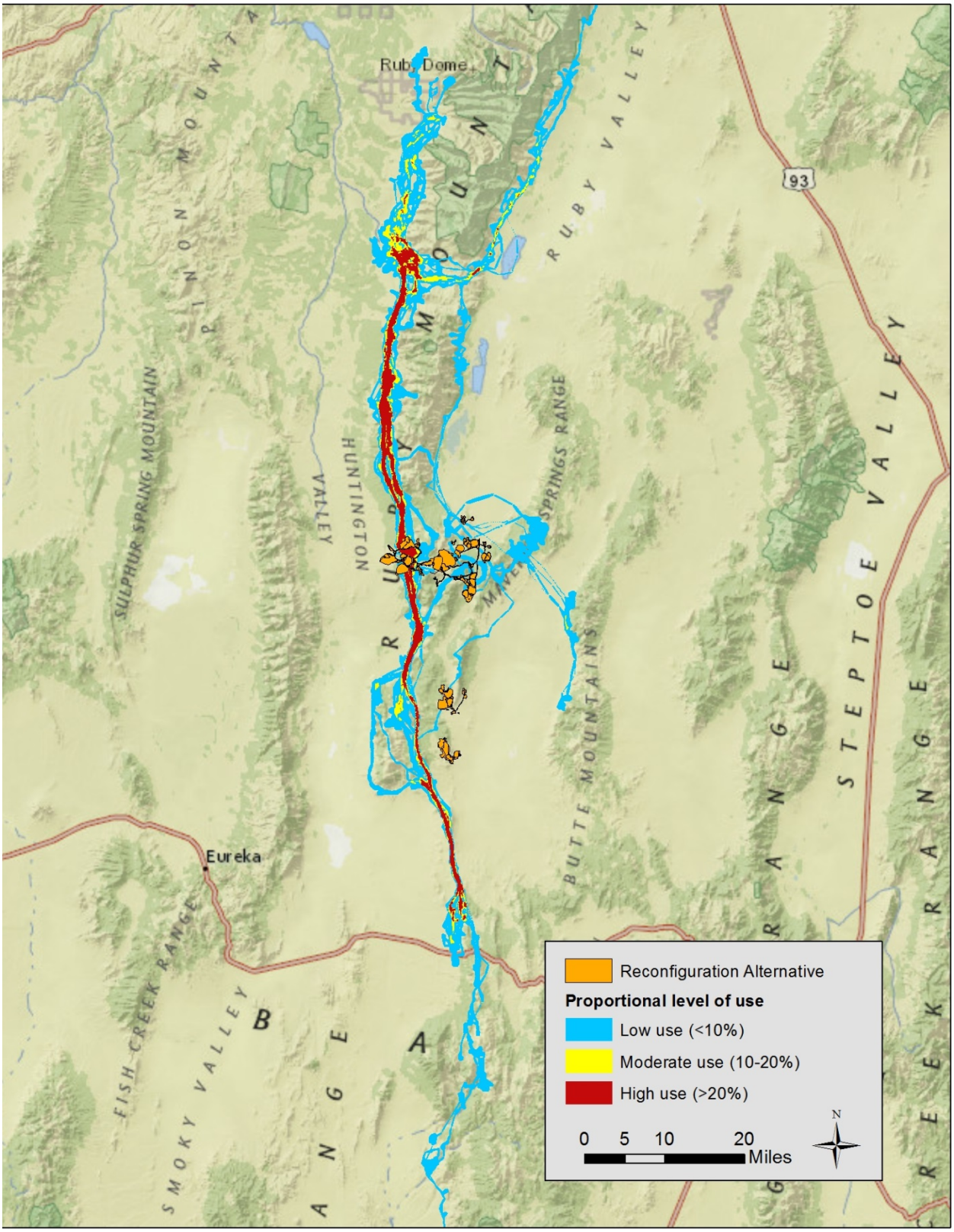

Figure 11. Low, moderate, and high-use segments within the population-level migration route of the Ruby mule deer herd, 2012-2013.

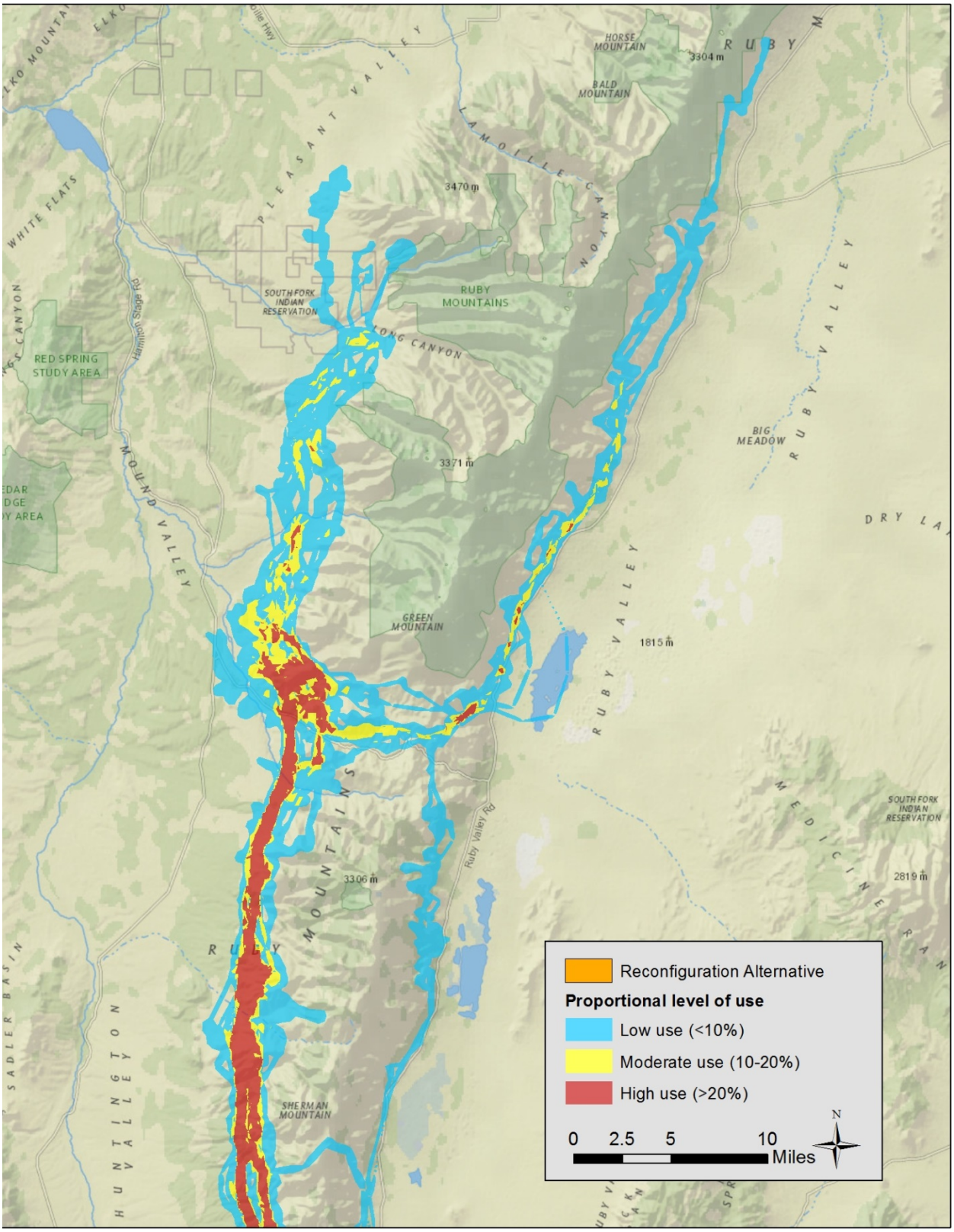

Figure 12. Low, moderate, and high-use segments in the northern part of population-level migration route of the Ruby mule deer herd, 2012-2013.

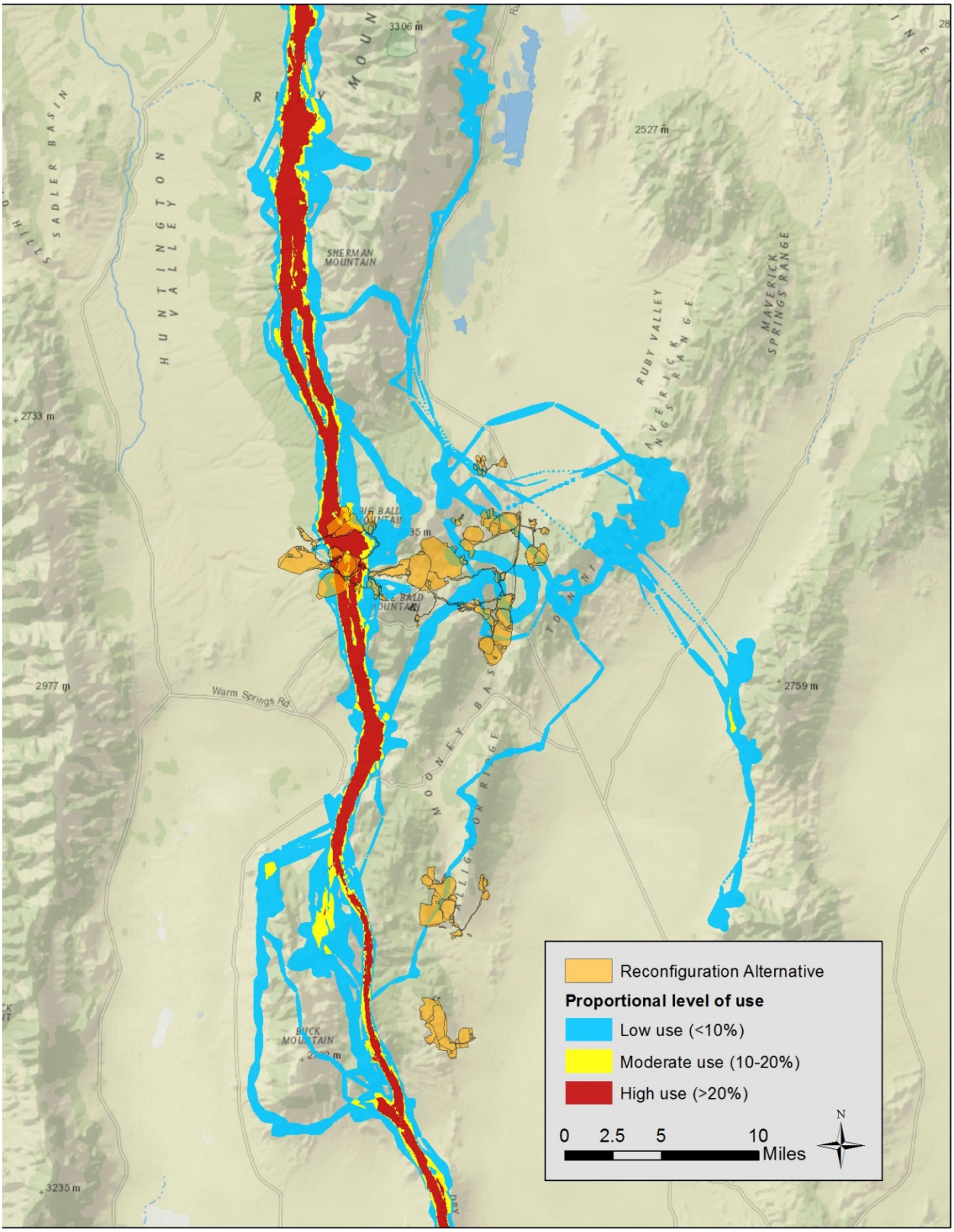

Figure 13. Low, moderate, and high-use segments in the central part of population-level migration route of the Ruby mule deer herd, 2012-2013.

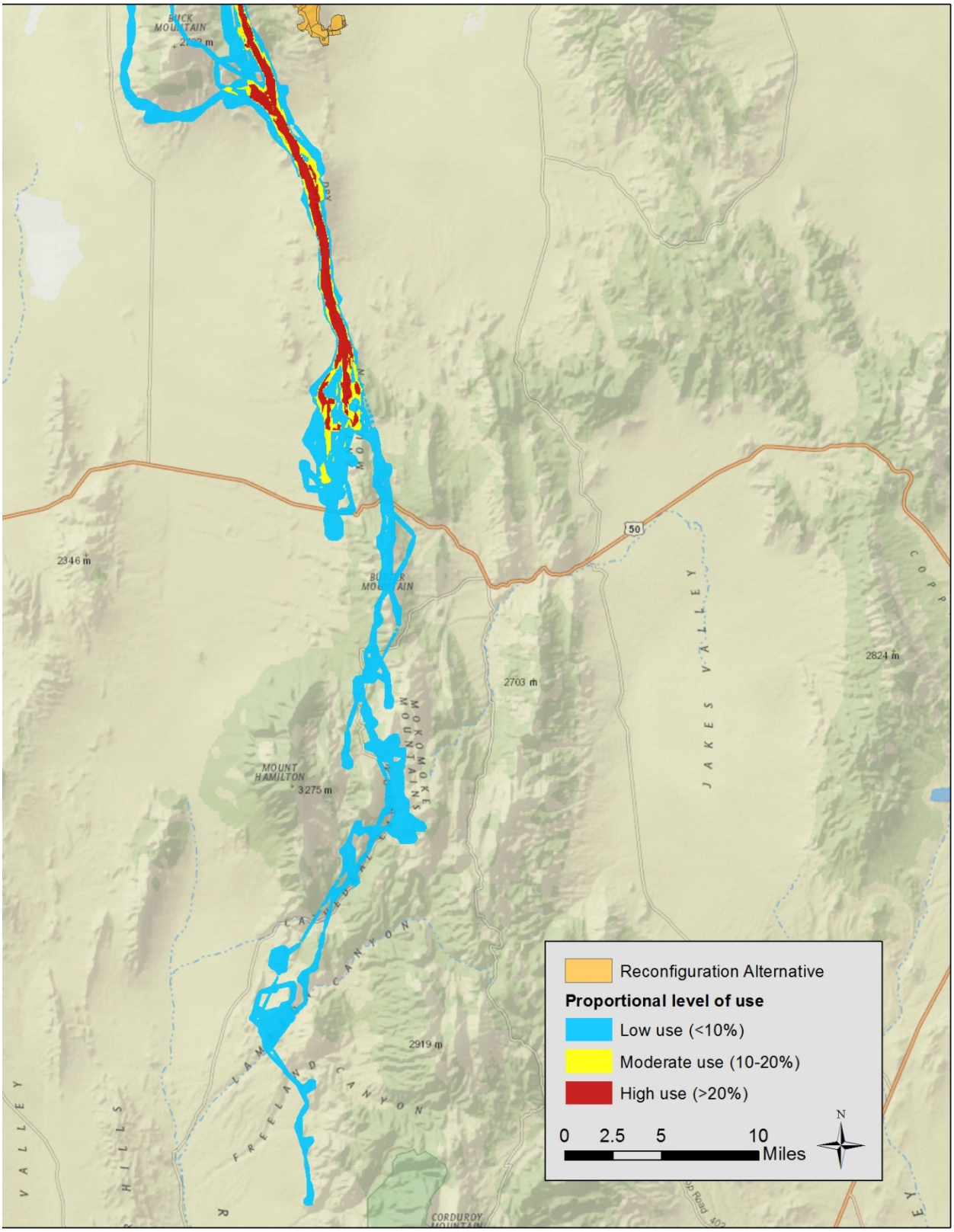

Figure 14. Low, moderate, and high-use segments in the southern part of population-level migration route of the Ruby mule deer herd, 2012-2013.

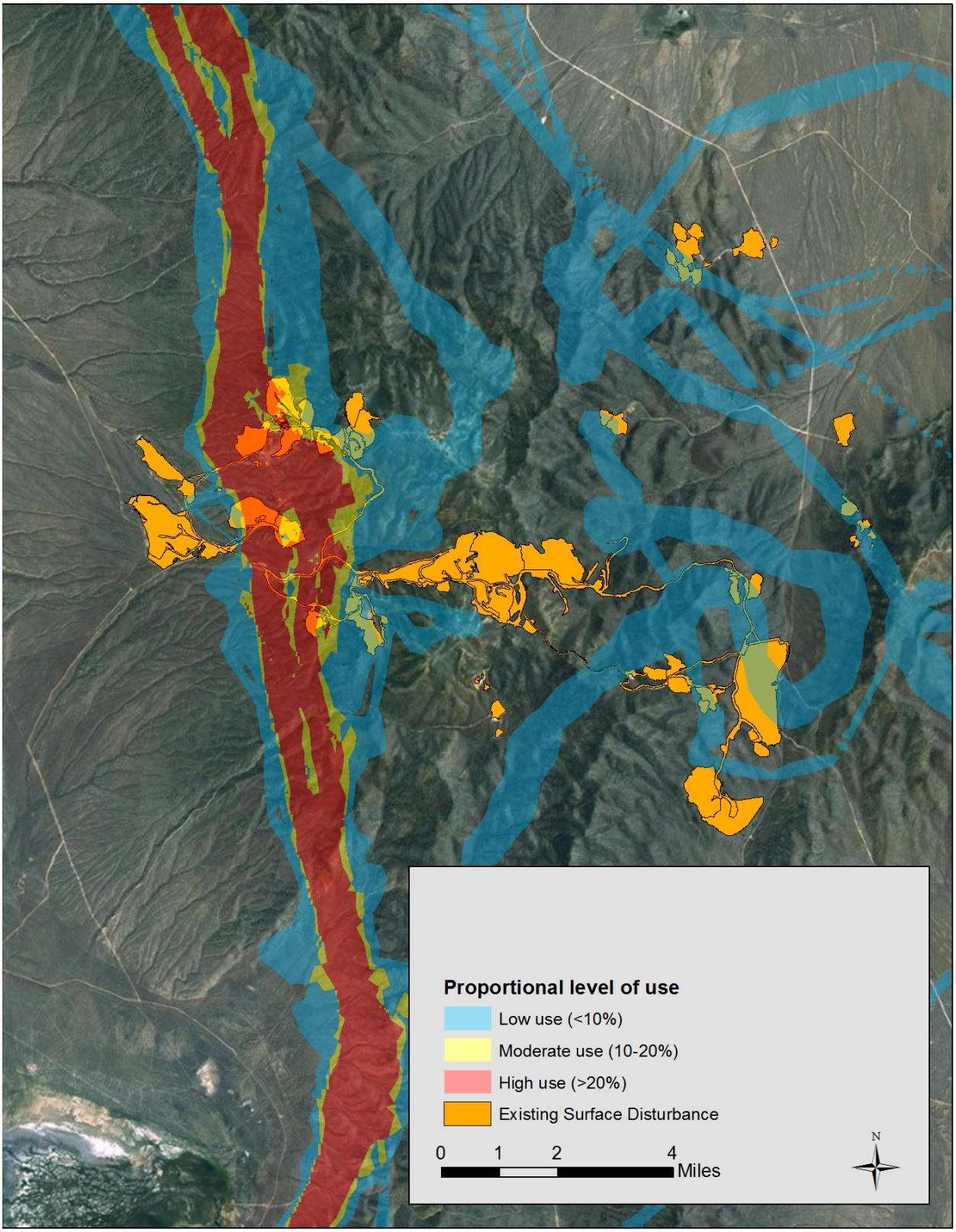

Figure 15. Low, moderate, and high-use segments relative to the Bald Mountain Mine – Existing Surface Disturbance.

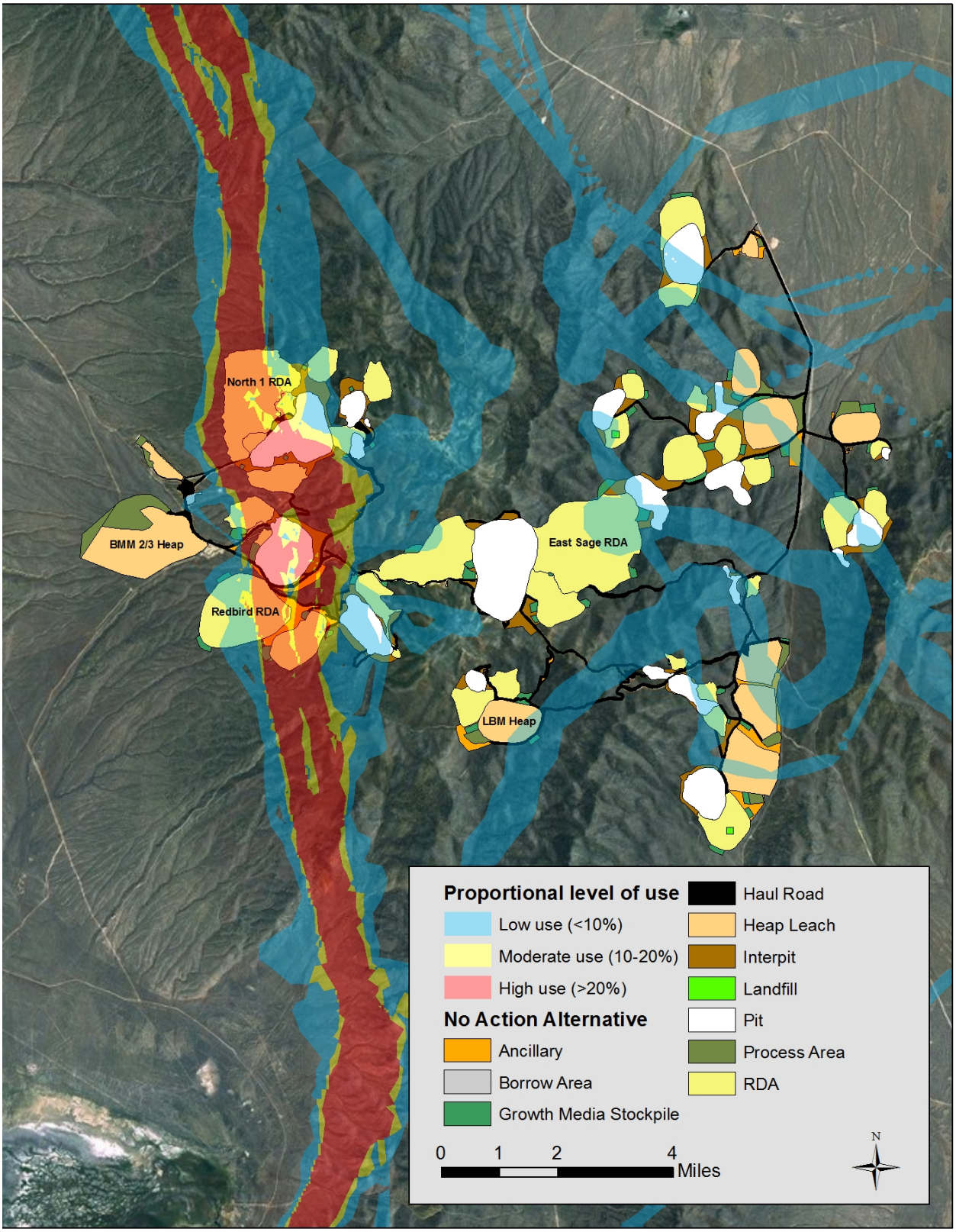

Figure 16. Low, moderate, and high-use segments relative to the Bald Mountain Mine – No Action Alternative.

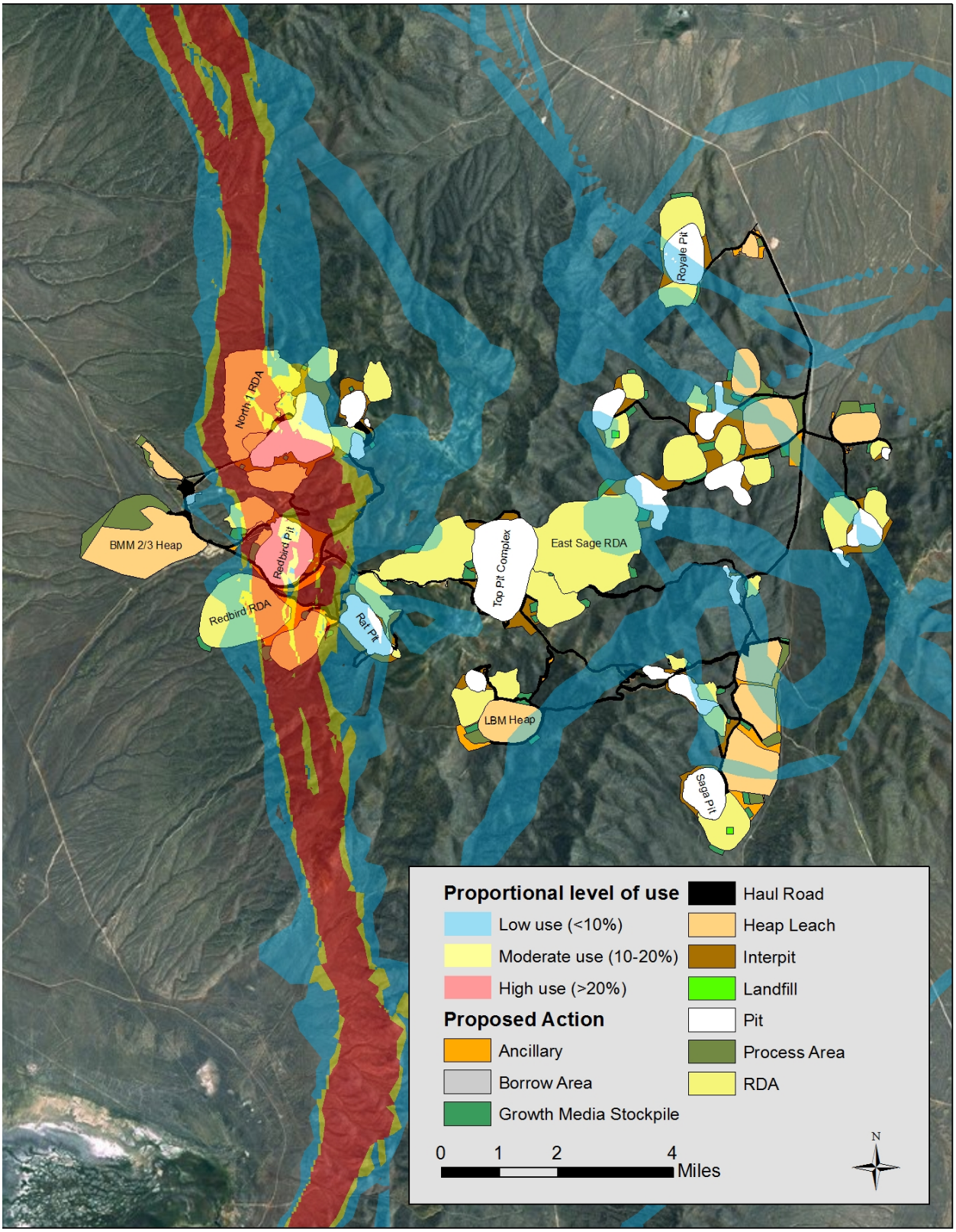

Figure 17. Low, moderate, and high-use segments relative to the Bald Mountain Mine – Proposed Action Alternative.

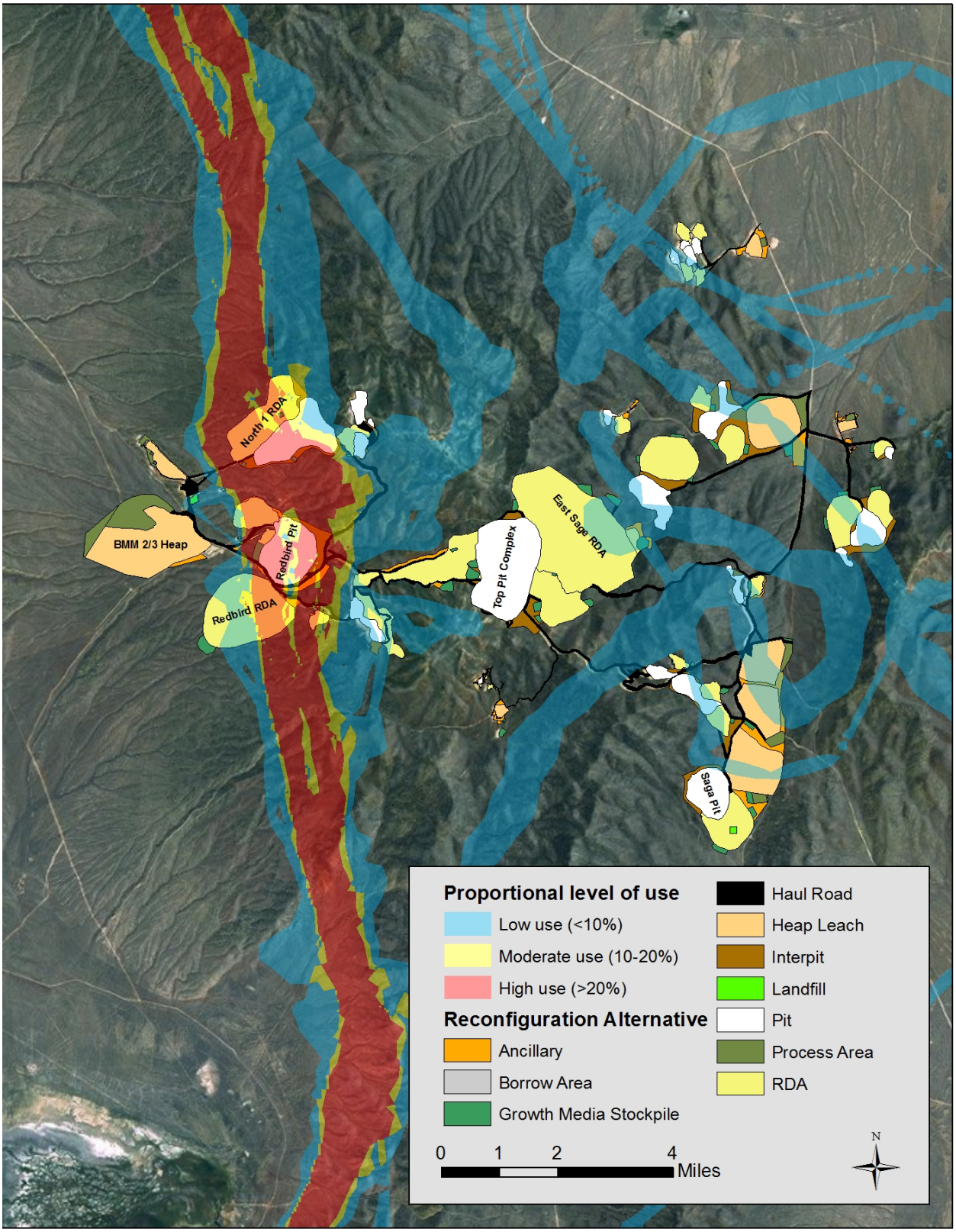

Figure 18. Low, moderate, and high-use segments relative to the Bald Mountain Mine – Reconfiguration Alternative.

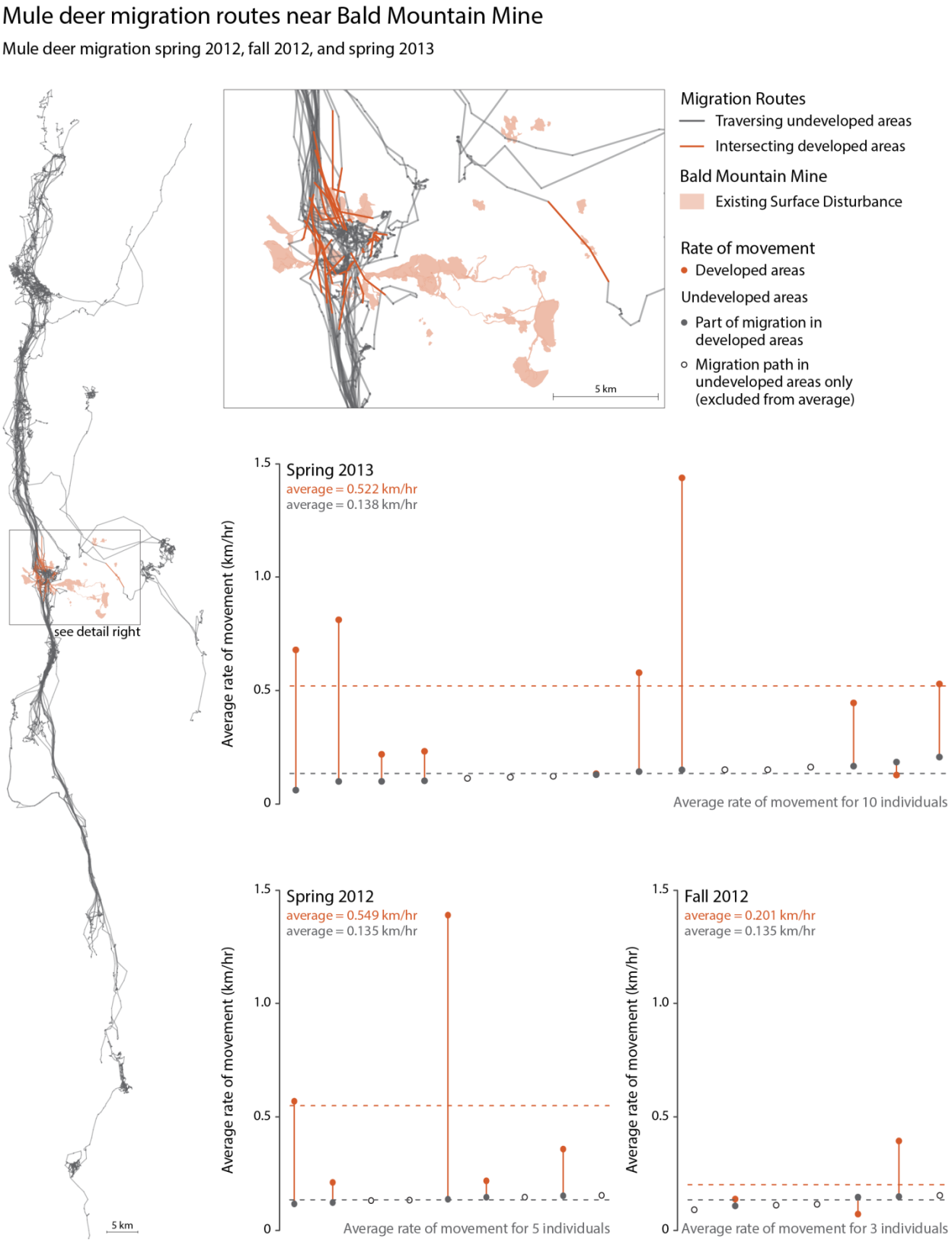

Figure 19. Movement rates of mule deer inside and outside of Bald Mountain Mine (Existing Surface Disturbance) during spring and fall migrations. Movement rates were higher inside disturbed areas.
Note: Compared to other alternatives, fewer animals cross through the existing surface disturbance because it covers less area.

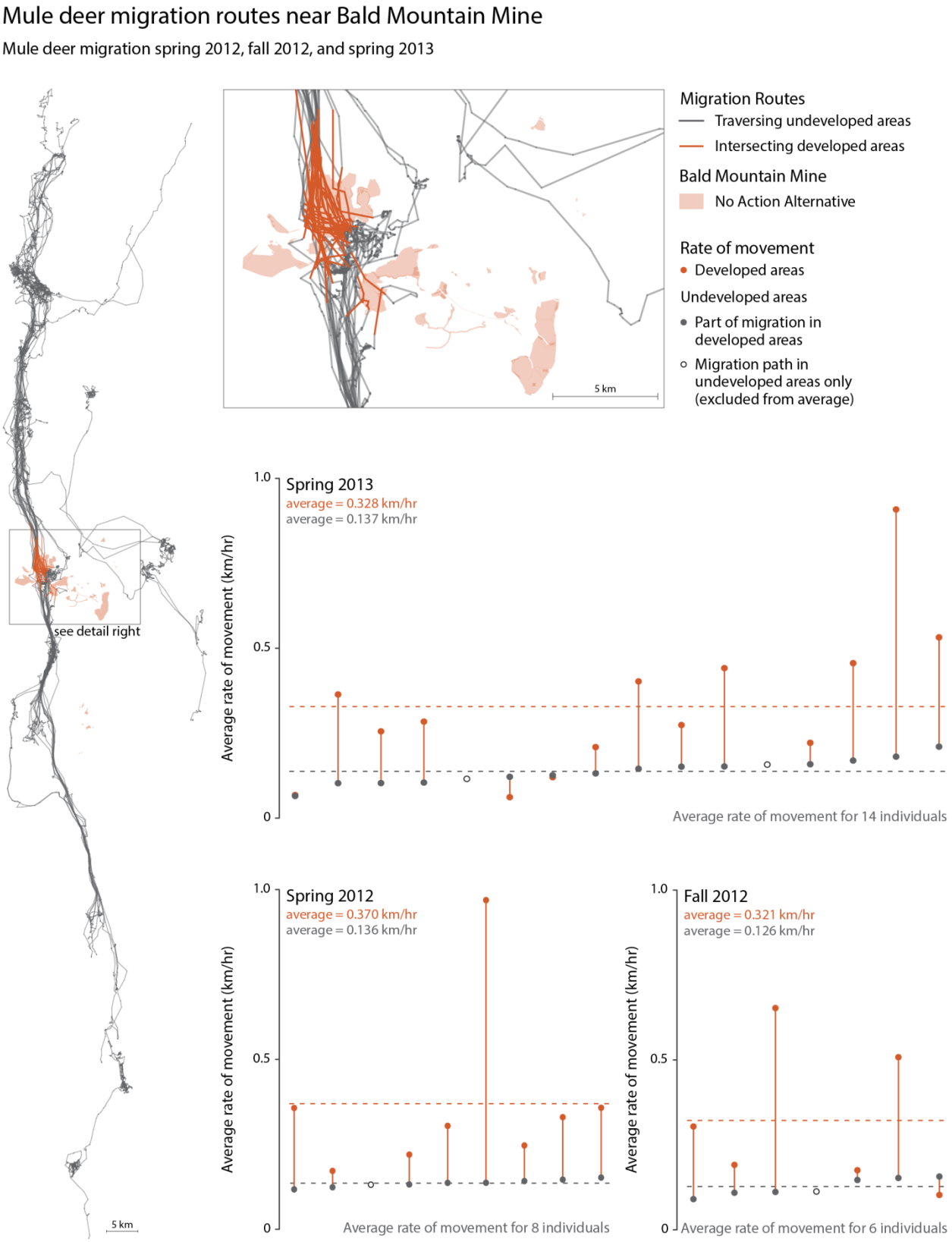

Figure 20. Movement rates of mule deer inside and outside of Bald Mountain Mine (No Action Alternative) during spring and fall migrations. Movement rates were higher inside disturbed areas.

Figure 21. Movement rates of mule deer inside and outside of Bald Mountain Mine (Proposed Action) during spring and fall migrations. Movement rates were higher inside disturbed areas.

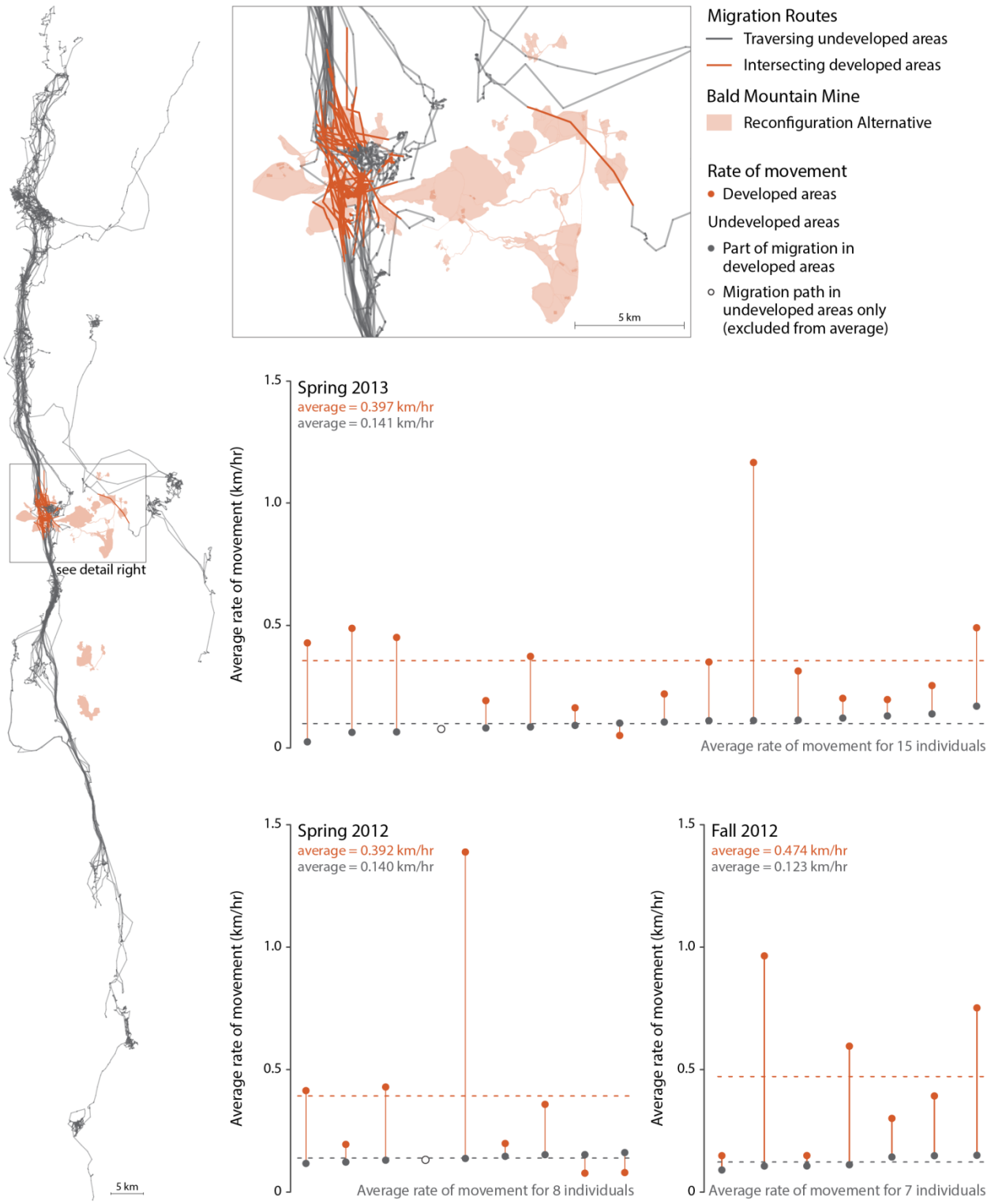

Figure 22. Movement rates of mule deer inside and outside of Bald Mountain Mine (Reconfiguration Alternative) during spring and fall migrations. Movement rates were higher inside disturbed areas.

DISCUSSION

Managing ungulate populations that migrate long distances is inherently difficult because of the mix of land ownership, land-use patterns, and jurisdictional boundaries. Mule deer in the Ruby Mountains migrate 45 to 125 miles between seasonal ranges and cross lands administered by the Bureau of Land Management (BLM), US Forest Service (USFS), US Fish and Wildlife Service (USFWS), Bureau of Indian Affairs (BIA), and private land owners (see Appendix A). Identifying where migration routes occur can help agencies and other stakeholders improve management of migratory populations in landscapes with complex ownership and land-use patterns. Provided with fine-scale movement data like those from GPS-collars, it is now possible to identify: 1) population-level migration routes, which reflect the spatial extent and intensity of use of migration pathways used by a particular population, 2) stopover sites that represent areas where animals spend >90% of their time during migration, and 3) high-use routes that represent route segments that are used by a disproportionate number of animals in the population (Sawyer et al. 2009). Here, we used GPS data collected by NDOW to identify each of these migration characteristics for mule deer in the Ruby Mountains.

The population-level route provides a basis from which all routes may either be protected, or from which a prioritization process can be initiated to determine which route segments should be targeted for management or conservation (e.g., habitat improvement, fence removal, conservation easement, development guidelines, leasing stipulations). In the multiple-use landscapes of the Intermountain West, protection of the entire population-level route may not be feasible, so developing an intuitive and biologically-sound prioritization strategy is necessary. Recent work with mule deer in Wyoming (Sawyer et al. 2009, Sawyer and Kauffman 2011, Sawyer et al. 2014) suggests that both stopovers and high-use routes can provide clear and effective ways to prioritize which route segments should be targeted for conservation and considered in the planning process (e.g., National Environmental Policy Act [NEPA] documents, resource management plans [RMP]). From a biological perspective stopovers are important because they allow mule deer to migrate in concert with changes in vegetation phenology, which in turn improve their ability to maximize energy intake and improve body condition (Sawyer and Kauffman 2011). Because mule deer tend to use the same stopovers across years and seasons (Sawyer and Kauffman 2011), the conservation of these areas should have long-term benefits for mule deer. Additionally, focusing conservation efforts on high-use routes makes biological sense because those are the routes that receive the most use. From a management perspective, these two metrics are more likely to be viewed as reasonable by stakeholders because they only represent a small fraction of the overall population-level route (e.g., stopovers are only 10% of population-level route). In short, managers generally recognize the need for compromise in multiple-use landscapes, and therefore can focus conservation efforts only on the most critical parts of the migration route (i.e., stopovers and high-use routes).

A case in point is the Bald Mountain Mine and its proposed expansion – an area comprised of federal lands managed for multiple-use and bisected by a migration route that one of Nevada's largest deer herd relies on to access seasonal ranges both north and south of the mine. The population-level route clearly shows where these deer migrate relative to the Bald Mountain Mine, but attempting to protect this entire route may not be feasible where federal lands are administered for multiple-use. In contrast, focusing conservation efforts on stopover sites and high-use routes can help facilitate the development of mining or other land-use plans such that impacts to mule deer are minimized. Specifically, the location of new access roads, haul roads, RDAs, and other mine infrastructure could be sited to avoid or minimally disturb stopover sites and high-use routes. Avoiding or minimizing disturbance in stopover sites can help maintain the overall functionality of the migration route (Sawyer et al. 2013), while conserving the high-use route(s) can guard a large portion of the population from potential impacts.

There is a growing body of literature that indicate migrating mule deer increase their rate of movement when they encounter human disturbance and infrastructure (Lendrum et al. 2012, 2013, Sawyer et al. 2013). Consistent with these studies, the Ruby mule deer moved more quickly through the Bald Mountain Mine compared to other parts of the migration route. This pattern was evident regardless of which GIS disturbance layer was used (i.e., Existing Surface Disturbance, No Action Alternative, Proposed Action, or Reconfiguration Alternative). How such changes in movement rate affect mule deer demography is unknown, but recent studies have shown increased rates in deer movement can affect stopover use (Sawyer et al. 2013) and timing of migration (Lendrum et al. 2013). Further, because fitness is so strongly influenced by fat accumulation during the growing season (Cook et al. 2004, Parker et al. 2009, Tollefson et al. 2010, Hurley et al. 2014), lost foraging opportunities during migration certainly have the potential to incur energetic and demographic costs. So, although deer may continue to migrate through moderate levels of development and maintain connectivity to their distant seasonal ranges, behavioral changes like increased rates of movement may reduce the functionality (e.g., stopover use) of routes (Sawyer et al. 2013) and potentially reduce the nutritional benefits of migration (e.g., Albon and Langvatn 1992, Hebblewhite et al. 2008).

The data summarized here should provide a reasonable baseline for comparison with data collected during and after proposed mine expansion. However, future study of mule deer migration and resource extraction could be improved by monitoring the same individual animals through time, with frequent year-around data acquisition, so that individual and population-level movement (e.g., Bunnefeld et al. 2011) and survival metrics can be examined in more detail.

MANAGEMENT IMPLICATIONS

Migratory ungulates far outnumber their non-migratory counterparts (Fryxell and Sinclair 1988). Thus, maintaining functional migration routes will play a critical role in sustaining abundant ungulate populations (Sawyer et al. 2013). Because protecting migration routes in their entirety is rarely feasible outside of national parks, we suggest that managers focus conservation efforts on stopover sites and high-use routes, where minimizing habitat loss and human disturbance aims to benefit the most deer and protect the core of the migration route (Sawyer et al. 2009). Incorporating both stopover sites and high-use routes into planning documents (e.g., NEPA, RMPs) can help minimize impacts to migratory populations and allow stakeholders to better consider the trade-offs between various development alternatives. Ideally, other areas along the migration route that are not considered stopover sites or high-use should not be ignored altogether, but managed to maintain connectivity (i.e., ensure animal movement is not completely impeded). In these areas, certain levels of development and human disturbance may be feasible and not elicit any noticeable effects on migratory behavior (Sawyer et al. 2013).

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Mule deer migration routes and land ownership patterns

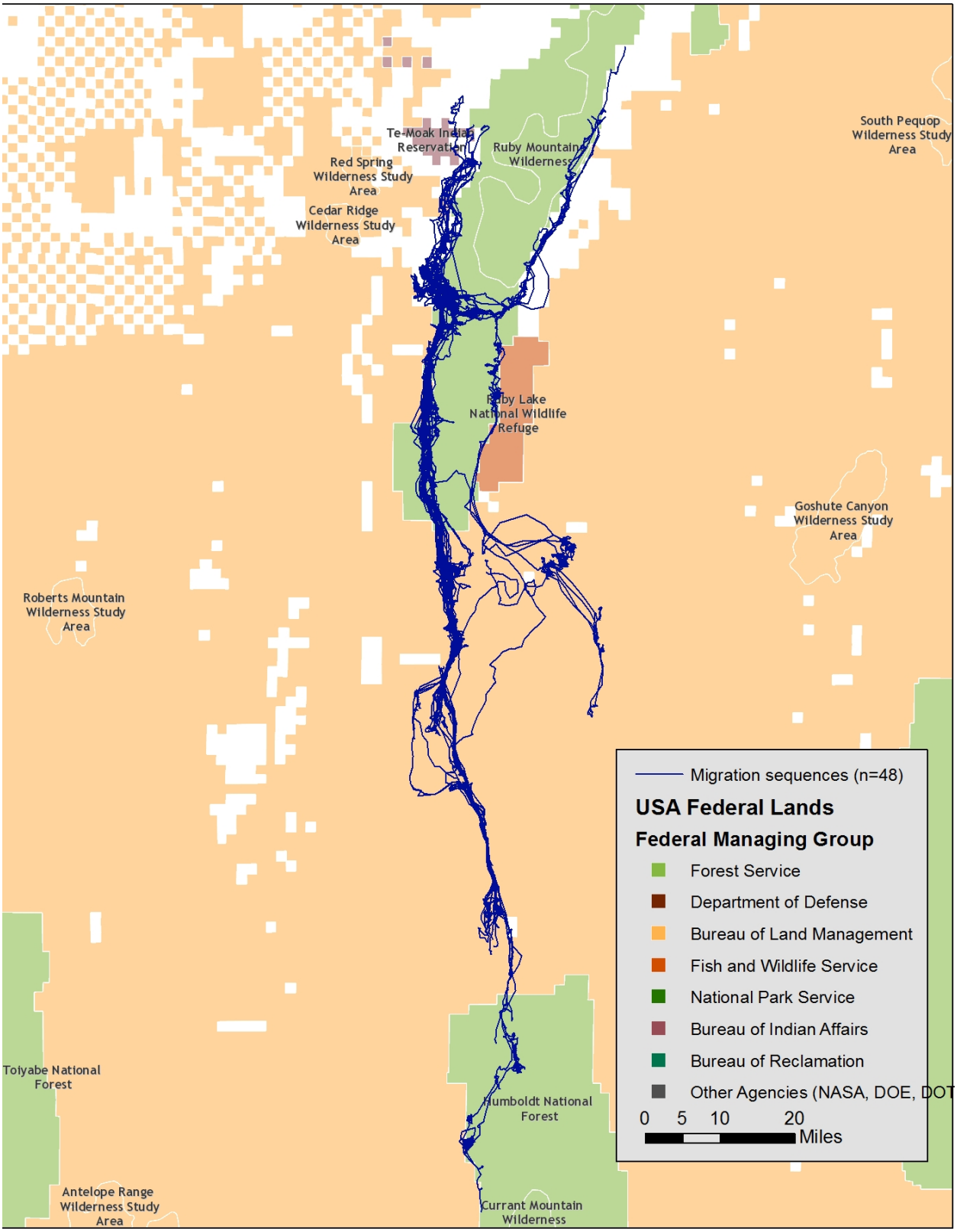

Figure A-1. Mule deer migrate across lands administered by BLM, USFS, USFWS, BIA, and private land owners.