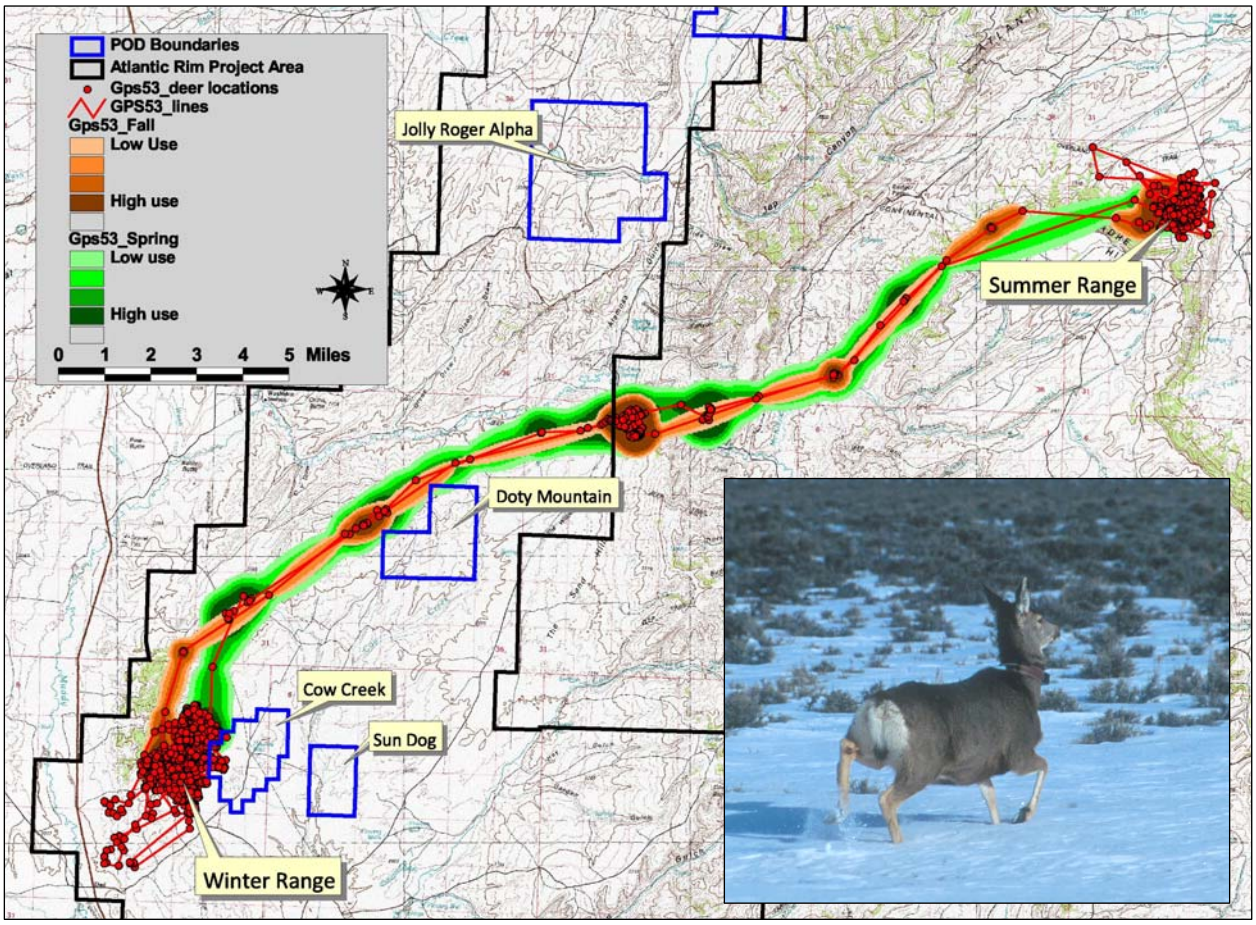
Identifying Mule Deer Migration Routes in the Atlantic Rim Project Area



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April 1, 2008

Overview

Given that 95% of the mule deer that winter in the Atlantic Rim Project Area (ARPA) are migratory (Sawyer 2007), sustaining current mule deer populations will require functional migration routes remain intact. Prior to 2000, conserving migration routes had not been a top management concern for agencies because there had been no large-scale habitat alterations in the ARPA or Baggs Herd Unit, (e.g., Bureau of Land Management [BLM] 2000*a*, BLM 2000*b*) and the landscape had remained relatively unchanged. However, the recent approval to develop 2,000 gas wells at a spacing of 8 per section and improve or construct approximately 1,000 miles of road and pipeline (BLM 2006) will result in large-scale habitat changes that could potentially impact mule deer migration routes in the ARPA. While disturbances associated with gas development may alter habitat selection and distribution patterns of wintering mule deer (Sawyer et al. 2006), it is unclear at what level of gas development migration routes are affected. Nonetheless, accurate delineation of migration routes prior to gas development and identification of high-use migratory segments would allow managers to develop proactive, rather than reactive, management prescriptions. Absent specific knowledge of migration routes, it is difficult for agencies or industry to develop gas resources in ways that minimize potential impacts to mule deer migration. Additionally, detailed information on migration routes can be used to identify habitat characteristics of migration routes and study the potential effects of proposed development on migration.

Ungulate migration routes are typically depicted by simply connecting the dots between locations of marked animals (e.g., Sawyer et al. 2005, Berger et al. 2006, White et al. 2007). However, because a line has no area associated with it (i.e., is it 10 feet or 1 mile wide?), the conservation and management value of this approach can be limited and difficult to incorporate into planning documents or on-the-ground prescriptions. Further, without specific knowledge of the relative amounts of use (e.g., high, medium, low-use) migration routes receive, it is difficult to prioritize specific segments for conservation or enhancement. Having the ability to estimate the width and relative amounts of use migration routes receive may assist agencies, industry, and non-government organizations (NGOs) with incorporating them

into land-use planning and/or identify specific segments for management or habitat improvement.

The purpose of this project was to use existing GPS data collected from mule deer in the ARPA (Sawyer 2007) to estimate the utilization distributions (UD) of population-level migration routes originating from 2 distinct winter ranges: the Dad Winter Range and Wild Horse Winter Range. A population-level route depicts the migration routes of individual animals radio-marked in their respective winter ranges (Dad or Wild Horse). The UDs provide information on both the width of population-level migration route and relative amounts of use across the route. This work was intended to provide agencies, industry, and NGO's with a science-based tool that allows mule deer migration routes to be considered in development plans and actively managed. Additionally, the methods developed for this project may be used with other GPS data sets across the state to identify migration routes of other species.

Study Area and Background Information

The Atlantic Rim Project Area (ARPA) is located in southern Carbon County (Figure 1) and encompasses 422 mi^2 south of I-80, east of WY 789, and north of WY 70. The ARPA extends approximately 48 miles between Rawlins and Baggs, and contains 64% (271 mi^2) federal, 5% (22 mi^2) state, and 31% (129 mi^2) private lands (BLM 2006). The ARPA is located in the eastern portion of the Baggs Herd Unit which includes 3 hunt areas (82, 84, 100; Figure 1). The Wyoming Game and Fish Department (WGFD) manages the Baggs Herd Unit for a post-hunting season population of 18,700 deer, but the estimated herd size has ranged from 20,200 in 2001 to 22,300 in 2005 (WGFD 2005). The ARPA supports a variety of vegetation types, but is generally characterized by rolling topography, prominent ridges, and dry canyons dominated by sagebrush (*Artemisia sp.),* black greasewood (*Sacrobatus vermiculatus*), Utah juniper (*Juniperus osteosperma*), and other mixed-shrub (*Purshia tridentata, Prunus virginiana, Amelanchier alnifolia, Chrysothamnus sp., Cercocarpus sp.*). Elevations range from 6,300 to 8,300 feet.

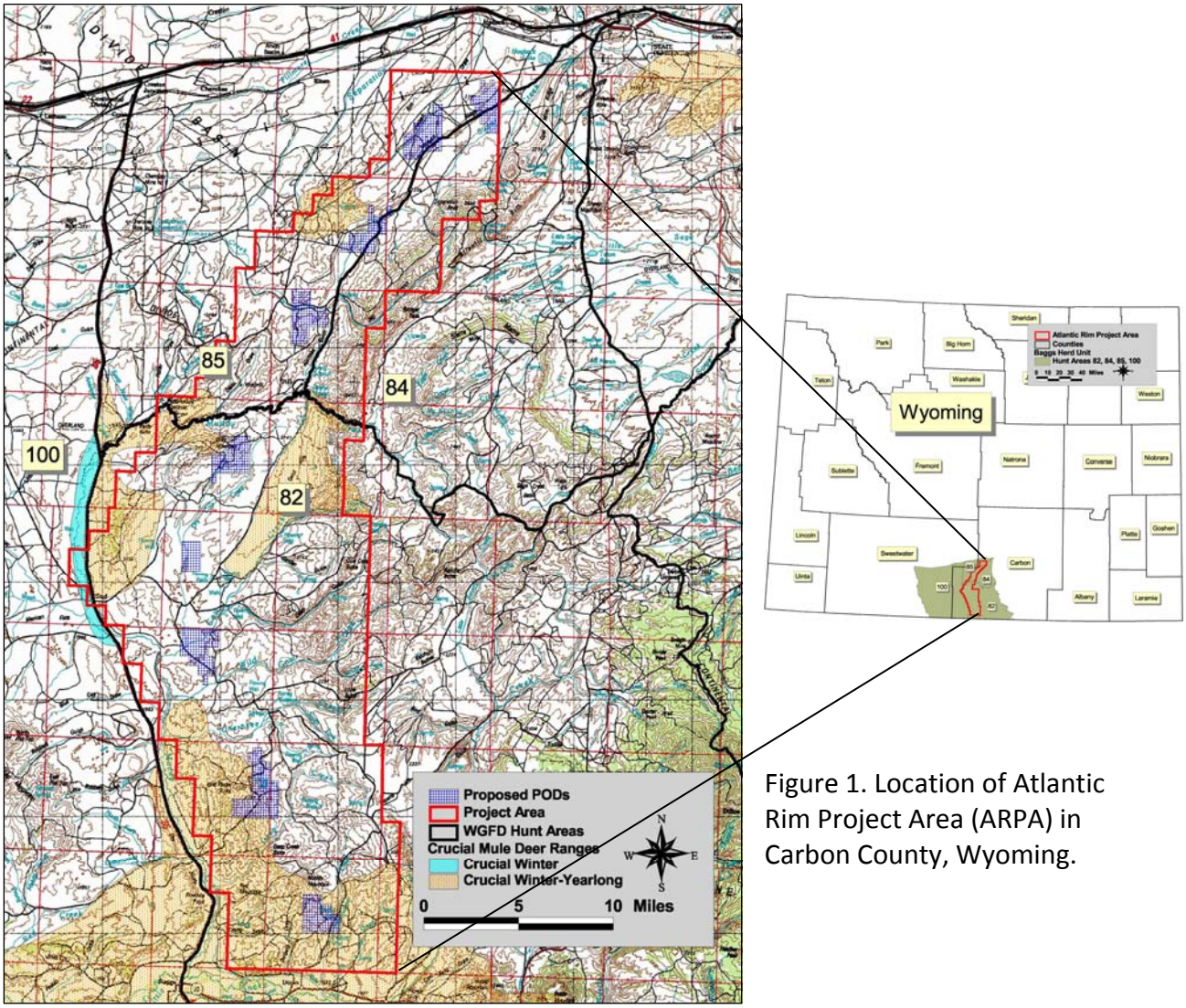

Figure 1. Location of Atlantic Rim Project Area (ARPA) in Carbon County, Wyoming.

The Baggs Herd Unit has traditionally supported one of the largest mule deer populations in the state and provided sportsmen with excellent recreational opportunities (WGFD 2005). Beginning in 2007 the BLM approved the development of >2,000 gas wells in the ARPA (BLM 2006), which is situated in the middle of the Baggs Herd Unit and includes key winter and transitional ranges. In an effort to better understand the seasonal ranges and migration routes of this deer herd prior to gas development, the WGFD in cooperation with the BLM, Anadarko Petroleum Company, Warren Resources, and Western Ecosystems Technology, Inc. (WEST) implemented the Atlantic Rim Deer Study in February 2005. This study collected >115,000 locations from 47 GPS-collared deer and successfully identified seasonal ranges and general location of migration routes (Figure 2). Two major wintering complexes were identified

in the ARPA, including the Dad and Wild Horse Winter Ranges (Figure 2). Mule deer from these winter ranges migrate an average of 26.5 miles east-northeast to their respective summer ranges (Sawyer 2007). This project focuses on identifying migration routes used by mule deer that winter in the Dad and Wild Horse Winter Ranges.

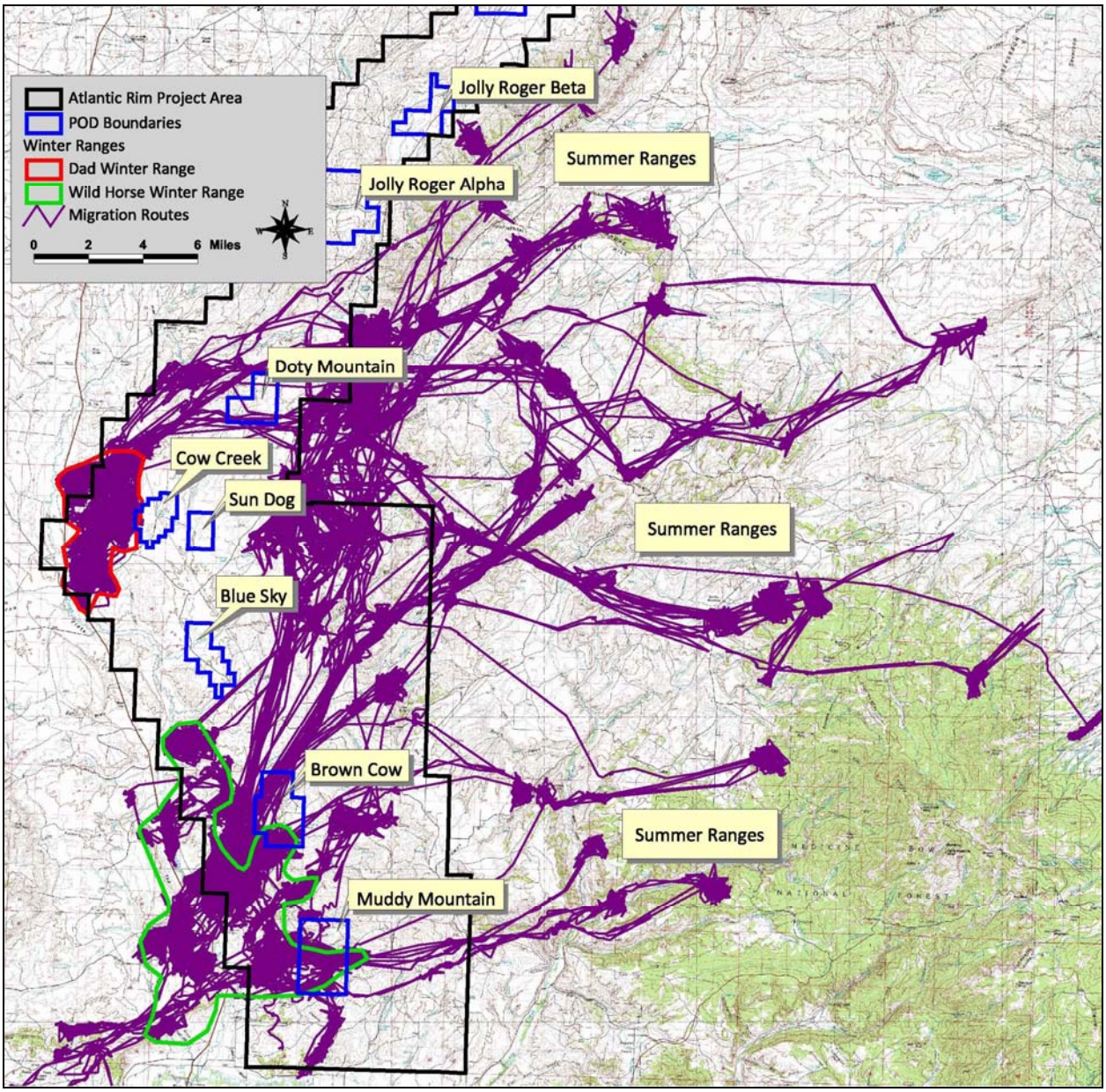

Figure 2. Movement routes of 47-GPS collared deer relative to major winter ranges and Plans of Development (POD) in the Atlantic Rim Project Area (ARPA) in south-central Wyoming, February 10, 2005 – November 15, 2006.

Methods

We used existing GPS data collected from 47 mule deer between February 2005 and November 2006 to estimate the utilization distributions (UD) of migration routes originating from the Dad and Wild Horse Winter Ranges. The UD refers to the relative frequency or probability of an animal's location over time (Worton 1987). In the case of migration routes, the UD provides a probabilistic measure of where mule deer migrations occurred. Three mule deer did not migrate and were excluded from our analysis. A portion of our GPS-collars were deployed for 1 year, while others were functioning for a full 2 years. Depending on how long the GPS-collar was deployed, an individual deer collected data for one or more spring and fall migrations (Table 1). We documented 61 migrations for the 32 mule deer in Wild Horse Winter Range and 19 migrations for the 12 mule deer in Dad Winter Range (Table 1).

We used a Brownian Bridge Motion Model (BBMM; Horne et al. 2008) to estimate UDs for migration routes of individual deer (n=44), using the sequence of GPS locations that occurred between an individual's winter and summer range during a particular migration (spring or fall; Figure 3). The BBMM uses the time elapsed between locations and the rate of movement to estimate the probability of occurrence between successive locations (Horne et al. 2008). All of our mule deer locations were collected at 2.5-hr intervals, but depending on the rate of movement, the predicted width of the migration route varied (Figure 3). Probabilities were calculated for every 50 x 50m cell in the study area. Because mule deer demonstrated a high fidelity to their migration routes across seasons (Figure 3) and years, we combined individual UDs to generate a population-level UD for both the Dad and Wild Horse migration routes (Figures 4 and 5). We color-coded the probability values into 25% quartiles and classified the top 25% as high use and the lowest 25% were as low use. The width of the UD corresponded to a 99% contour interval. Population-level UDs for migration routes in the Dad and Wild Horse Winter Ranges were generated as grid themes in ArcView.

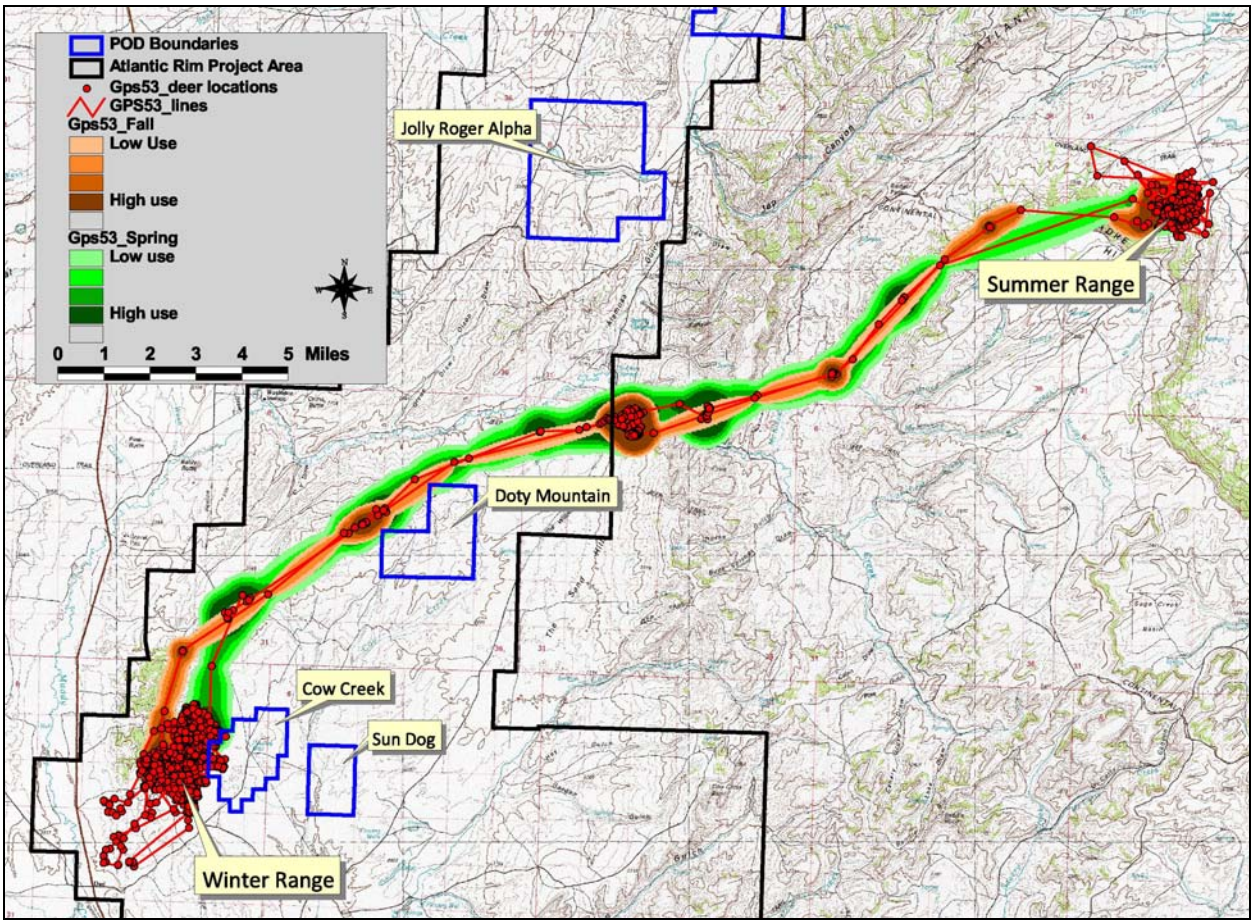

Figure 3. Illustration of individual spring (green) and fall (orange) utilization distributions (UD) estimated for migration routes of a GPS-marked mule deer. The UD estimates the width and probability of use for each migration route. Note that areas with more deer locations (low movement rate) correspond with high-use areas. Mule deer showed high fidelity to their migration routes and tended to use the same route across seasons (spring and fall) and years.

Table 1. Utilization distributions (UD) were estimated for migratory data collected from 32 GPS-collared mule deer from the Wild Horse Winter Range and 12 from the Dad Winter Range, during 2005 and 2006. The number of migrations collected for each GPS-collared deer ranged from 1 to 4.

Wild Horse Winter Range						Dad Winter Range				
Deer ID	Spring 2005	Fall 2005	Spring 2006	Fall 2006		Deer ID	Spring 2005	Fall 2005	Spring 2006	Fall 2006
GPS_1	X					GPS_3	X			
GPS_6	X					GPS_4	X			
GPS_7	X					GPS_5	X			
GPS_8	X					GPS_16	X	X	X	
GPS_9	X					GPS_17	X	X	X	
GPS_10	X					GPS_18	X			
GPS_11	X					GPS_19	X	X	X	
GPS_12	X					GPS_46			X	
GPS_14	X	X				GPS_53			X	X
GPS_15	X					GPS_57			X	
GPS_20	X	X	X	X		GPS_58			X	
GPS_21	X	X	X			GPS_59			X	
GPS_22	X	X	X							
GPS_23	X	X	X							
GPS_24	X									
GPS_25	X	X	X	X						
GPS_26	X	X	X							
GPS_27	X	X	X							
GPS_28	X									
GPS_30	X	X	X	X						
GPS_31	X	X	X	X						
GPS_48			X							
GPS_49			X	X						
GPS_51			X							
GPS_52			X	X						
GPS_54			X							
GPS_55			X							
GPS_56			X							
GPS_60			X	X						
GPS_61			X	X						
GPS_62			X	X						
GPS_63			X	X						
TOTALS	21	10	20	10		TOTALS	7	3	8	1

Results

We calculated UDs for population-level migration routes of mule deer that wintered in the Dad (Figure 4) and Wild Horse (Figure 5) Winter Ranges. The Dad UD included 19 migrations from the 12 GPS-collared mule deer, while the Wild Horse UD included 61 migrations from 32 mule deer (Table 1). The UDs represent a probabilistic measure of where both spring and fall migrations occurred during 2005 and 2006, although the fall migrations (n=24) were not represented as well as the spring (n=56). In Figures 4 and 5, the red and orange coloring represent areas with the highest probability of use, while yellow and brown represent areas with lowest probability of use. Importantly, higher-use areas (red and orange) corresponded to areas where rates of movement were slow, whereas lower-use areas (yellow and brown) corresponded to areas with high rates of movement (Figures 4 and 5). Most high-use areas within 2-4 miles of the ARPA were connected by medium-high (orange) or medium-low (yellow) areas. As mule deer moved further from winter ranges (east-northeast), common migration routes splintered into multiple, less distinct routes, where high-use areas became smaller and less abundant.

Among the PODs, high-use migration routes occurred in Doty Mountain, Brown Cow, and Muddy Mountain. While mule deer appeared to move quickly through most regions of the Doty Mountain POD, mule deer tended to spend more time in the Brown Cow and Muddy Mountain PODs.

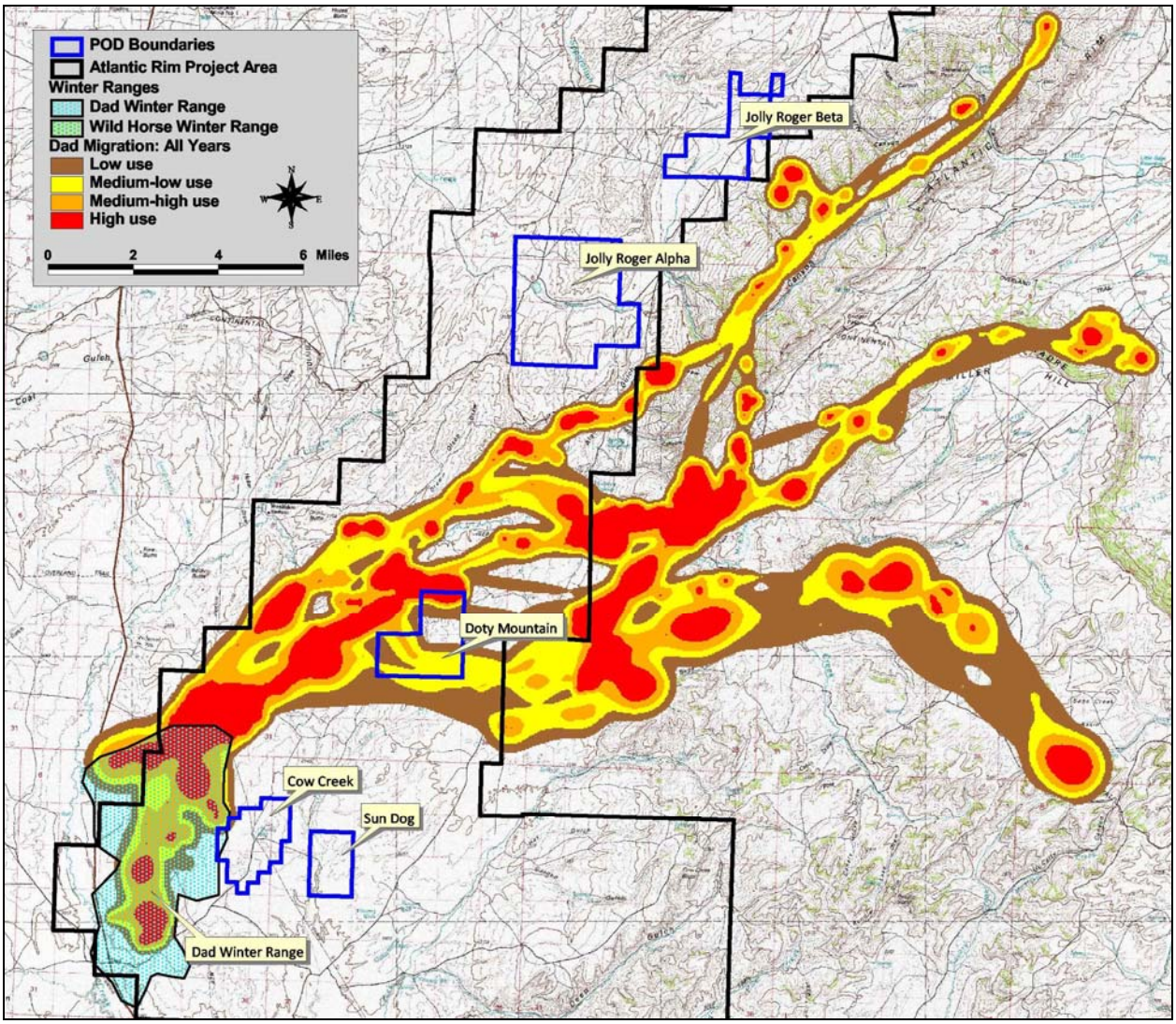

Figure 4. Estimated utilization distribution (UD) of population-level migration route in the Dad Winter Range, based on of 12 GPS-collared mule deer, including 4 fall and 15 spring migrations between 2005 and 2006.

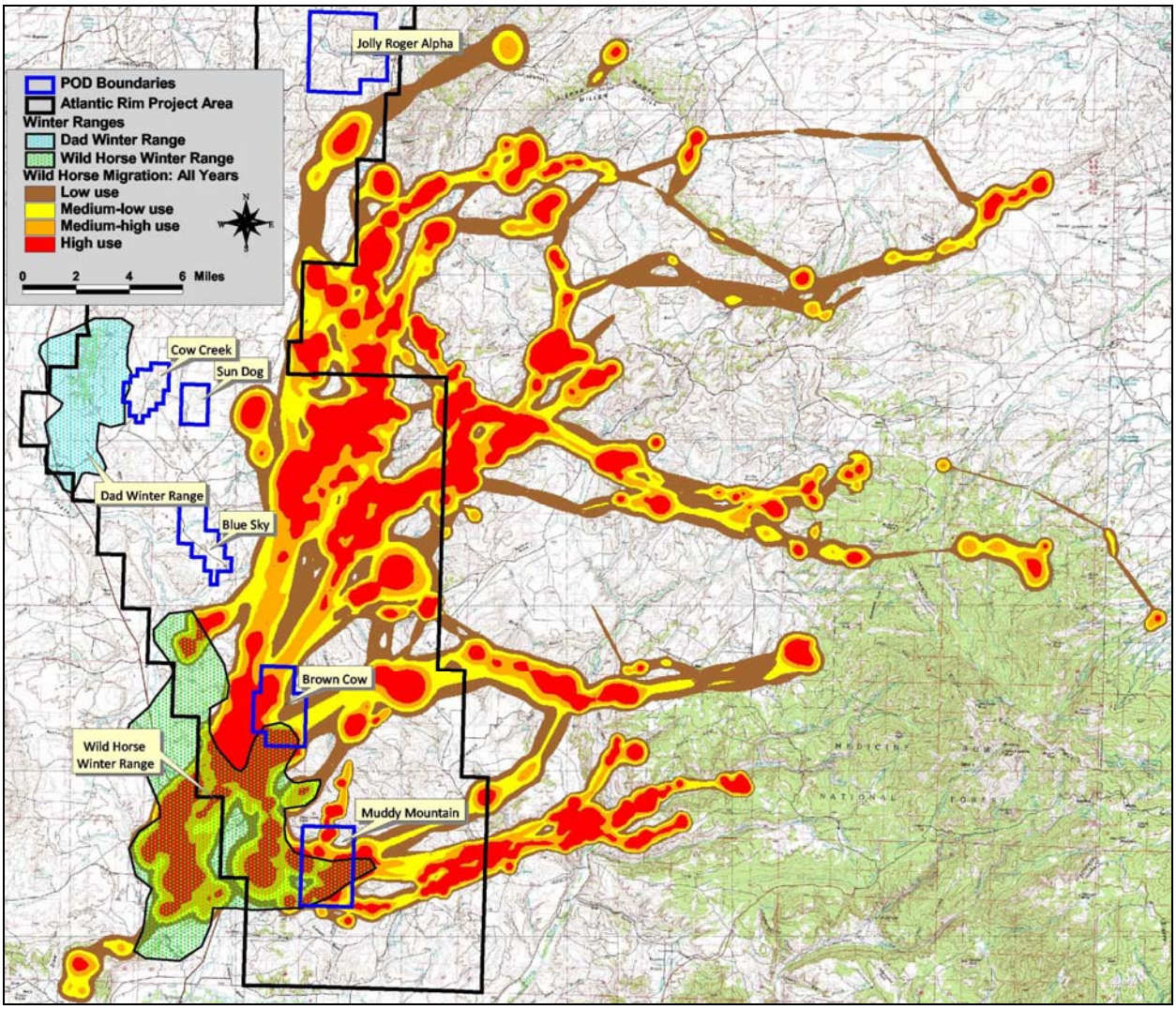

Figure 5. Estimated utilization distribution (UD) of population-level migration route for the Wild Horse Winter Range, based on 32 GPS-collared mule deer, including 20 fall and 41 spring migrations between 2005 and 2006.

Discussion and Management Implications

The UDs estimated for the Dad and Wild Horse Winter Ranges provide an objective, empirically-based, delineation of population-level migration routes in the ARPA. When relative amounts of use are mapped, as in Figures 4 and 5, the natural tendency is to interpret high-use areas as the most biologically important and low-use areas as the least important. While this interpretation is generally correct, it is important to recognize that high-use areas reflect habitats where deer moved slowly (e.g., foraging, resting) and low-use areas reflect habitats

where deer moved quickly. Thus, we assume that high-use areas provide key foraging and resting habitat, while lower-use areas provide movement corridors and connectivity between high-use areas. Of course, functional migration routes require that connectivity be maintained between high-use areas, such that deer have the ability to move between seasonal ranges. High-use areas within 2 miles of the ARPA were typically connected by medium-high (orange) and medium-low (yellow) use areas (e.g., Brown Cow to Sand Hills, or Doty Mountain to Sand Hills).

From a management perspective, distinguishing between high and low use areas across a population-level migration route may be useful for planning, mitigating, and prioritizing land-use decisions. For example, given that high-use areas provide foraging and resting habitat along the migration route, management strategies may be modified to minimize human disturbance (e.g., road construction) and habitat loss (e.g., infrastructure) in high-use areas. In contrast, low-use areas appear to function as simple movement corridors, rather than major foraging or resting areas. Accordingly, human disturbances and habitat loss occurring in low-use areas would be less likely to disturb mule deer or affect them physiologically, provided that the disturbance(s) did not include anthropogenic features (e.g., fences) that restricted mule deer movement. Because we currently do not know the threshold level(s) of development (e.g.., road density, well density, traffic levels, etc.) that will impede mule deer migration through low-use areas, a cautious or incremental development approach may be warranted.

Another important management consideration is that mule deer migration routes tend to become less distinct as distance from winter range increases (Thomas and Irby 1990). Our data suggest that common and intensively-used migration routes splintered into multiple, less distinct routes, as mule deer moved east-northeast of the ARPA. A useful analogy for this pattern is to think of the population-level migration routes as a road system, where the heavily-used routes close to winter range are analogous to interstates. As distance from winter range increases, those interstates turn into highways that receive less deer use (traffic) and eventually county roads with even lower levels of use. Accordingly, the potential for disrupting mule deer migration is greater along the interstates (close to winter range) than the county roads (far

from winter range) because those are the regions that receive the highest levels of use from the most number of deer.

We recommend that managers consider both the distance of migration routes from winter range and intensity of use that the route receives. In general, the potential to disrupt mule deer migration is greater in areas that receive higher levels of use and are close to winter range (Figure 6). Conversely, the potential to disrupt mule deer migration is lower in low-use areas or for routes further from winter range (i.e., close to summer range). We encourage agencies and industry to consider this information, in conjunction with the raw migration data (Figure 2), in development plans and management strategies associated with the ARPA. Additionally, we recommend future research efforts determine the habitat characteristics of high-use and low-use areas, such that migration routes can be targeted for habitat improvement projects.

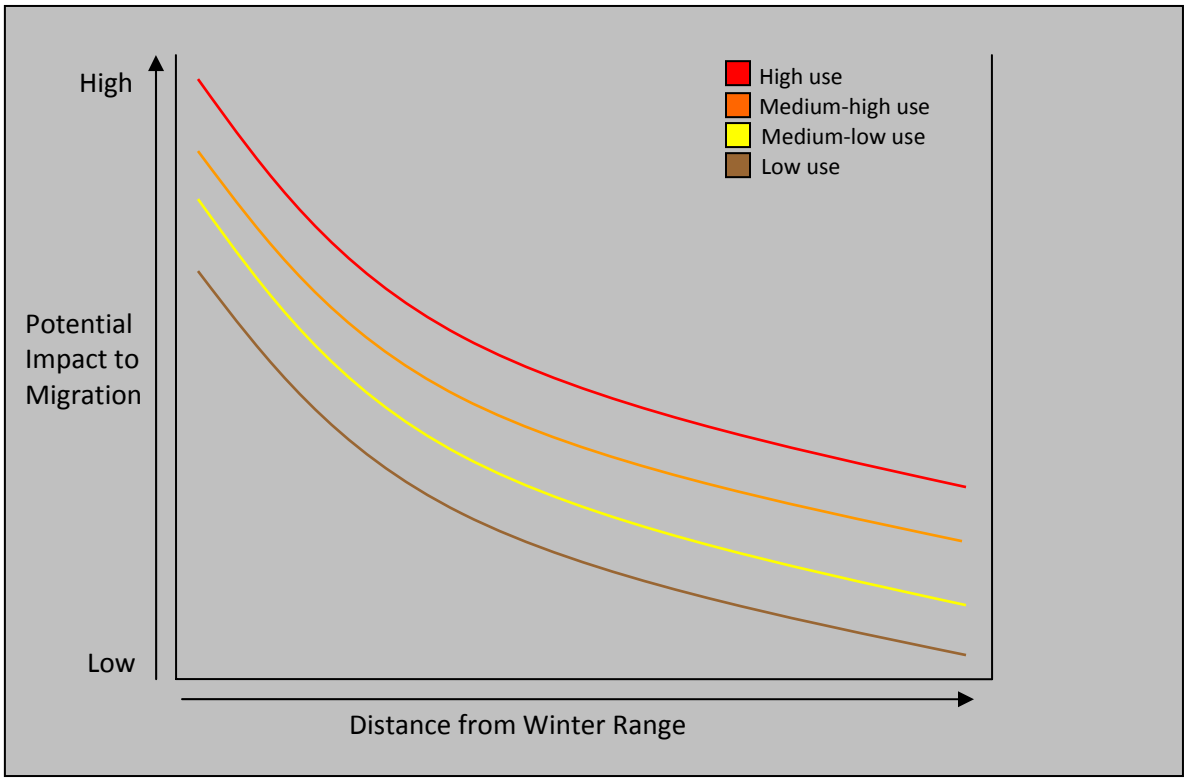

Figure 6. Predicted relationship between the potential impacts to mule deer migration and distance to winter range and levels of deer use. Potential impacts are expected to be greater in areas close to winter range and for routes receiving high levels of use.

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