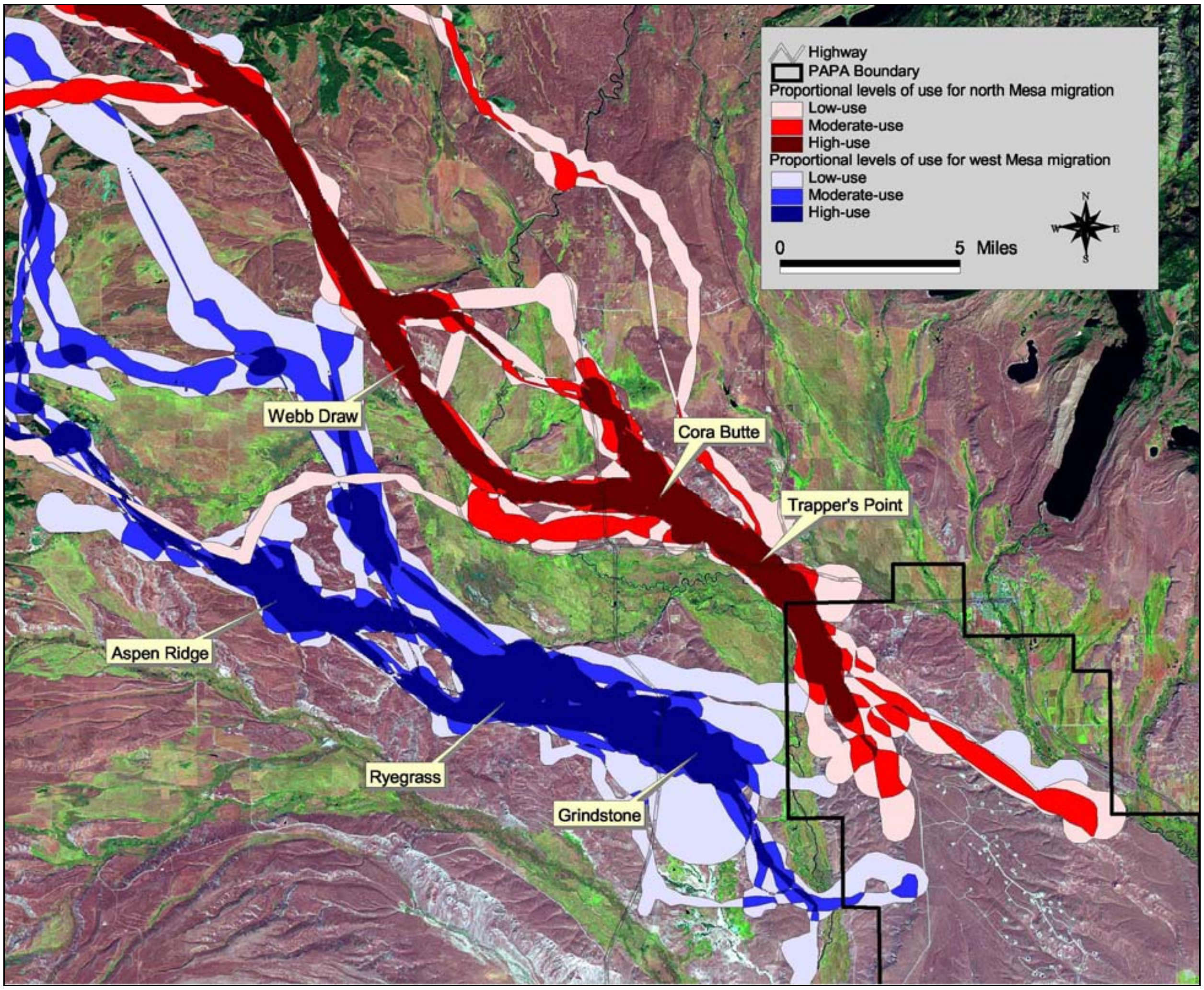
Identifying mule deer migration routes to and from the Pinedale Anticline Project Area



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Introduction

The Pinedale Anticline Project Area (PAPA; Fig. 1) in western Wyoming provides crucial winter habitat to 3,000-5,000 mule deer that migrate 40-100 miles to summer in portions of four different mountain ranges, including the Gros Ventre Range, Wyoming Range, Snake River Range, and Salt Range (Sawyer et al. 2005). The PAPA also contains one of the largest natural gas reserves in North America and has been among the most productive gas fields in Wyoming since development began in 2000. As gas field development in the region continues to expand (Bureau of Land Management [BLM] 2000, 2008), it has become increasingly important to determine where migration routes of mule deer occur, particularly in and adjacent to large gas fields such as the PAPA. The goal of this project was to identify major migration routes and critical stopover areas used by mule deer on the PAPA, such that agencies and industry have the best available information to develop energy resources and ensure continued migration of mule deer.

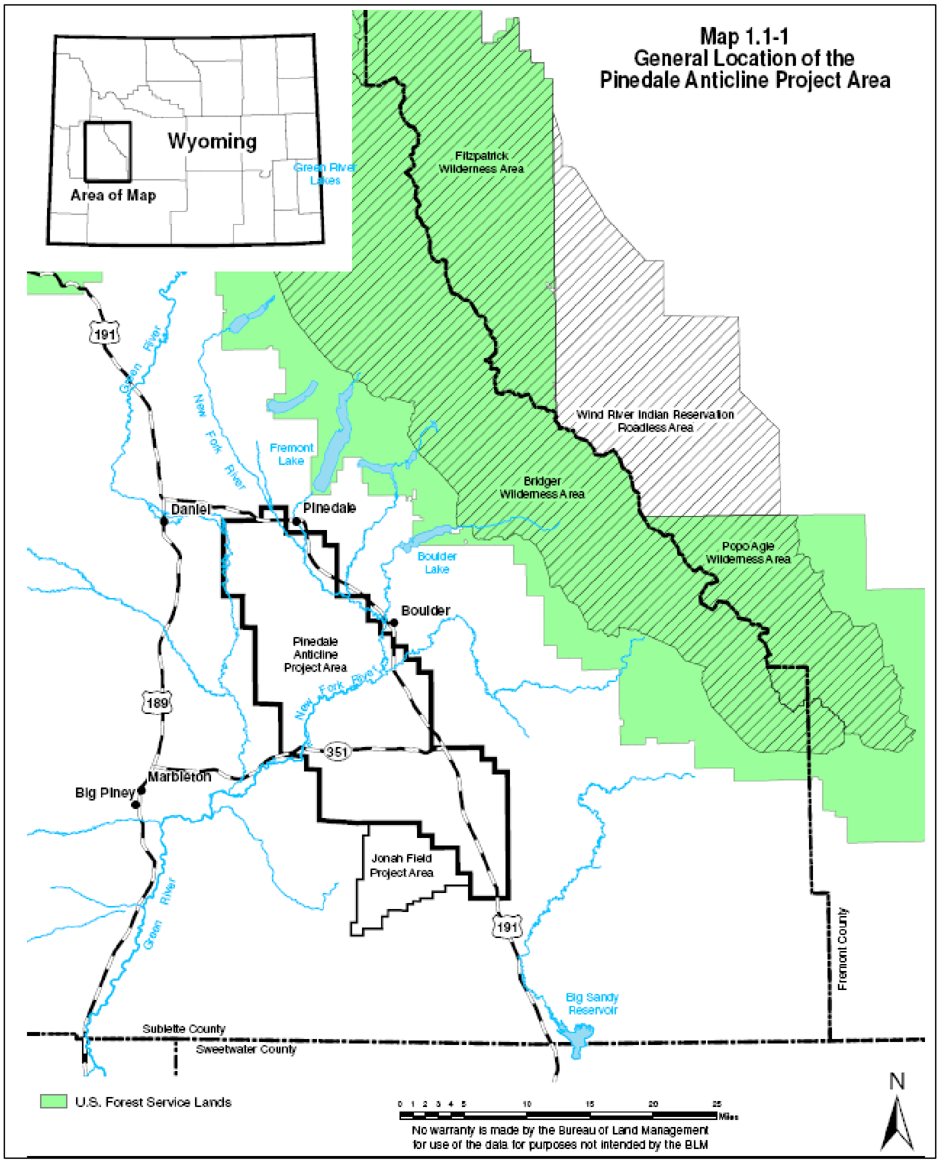

Figure 1. Location of the Pinedale Anticline Project Area (PAPA) in western Wyoming (from BLM 2008).

Until recently, the standard approach to delineating migration routes was to equip animals with global positioning system (GPS) collars and simply connect-the-dots between consecutive GPS locations (Fig. 2). This approach has been useful for identifying the timing and general location of migration routes (e.g., Sawyer et al. 2005, Berger et al. 2006, White et al. 2007). However, the drawback of this approach is that it produces a line that has no area associated with it (i.e., is the route 10 feet wide or a mile wide?), which makes it difficult to incorporate such information into land-use plans or on-the-ground management (Sawyer et al. 2009). Additionally, there is no means to combine routes of individual animals to assess migration at the population-level. Typically, agencies are interested in the migration routes of a population, rather than a few individuals. Thus, in this work we used a new method of estimating migration routes, referred to as the Brownian bridge movement model (BBMM; Horne et al. 2007). The BBMM estimates the probability of use along a migration route. Varying levels of use along the route allow segments used as stopover sites (i.e., foraging and resting habitat) to be discerned from those used primarily for movement (Figure 3; Sawyer et al. 2009). Additionally, this approach may be used to combine routes of individual animals, such that a population-level migration route can be estimated (Sawyer et al. 2009).

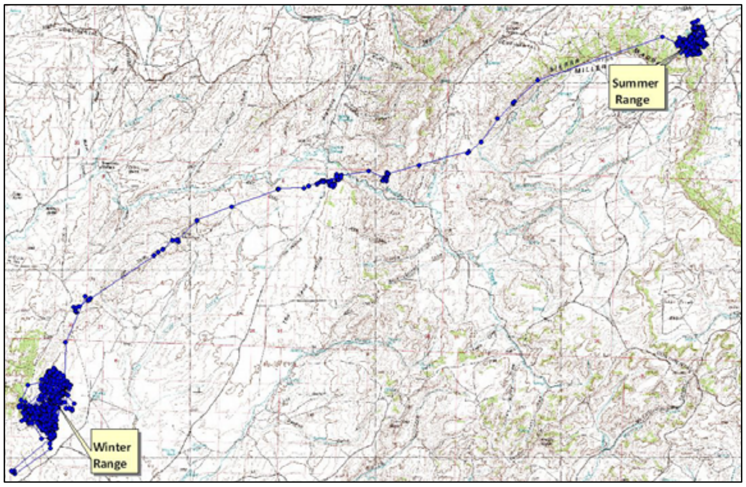

Figure 2. Example of connecting the dots to depict a migration route.

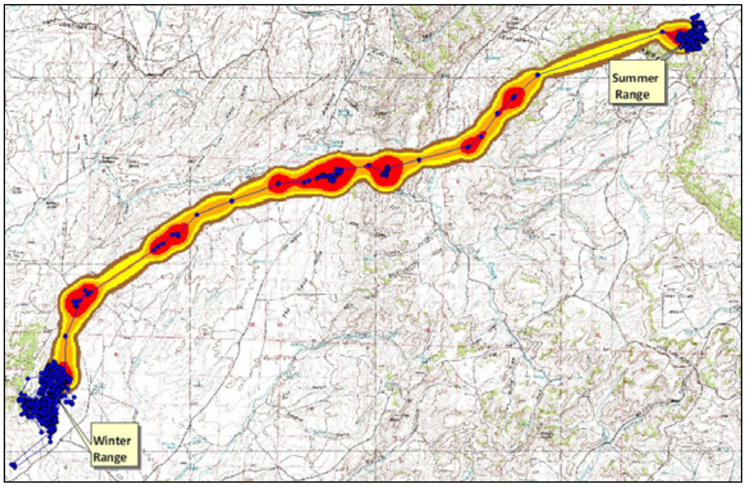

Figure 3. Example of the BBMM estimating a migration route. This route has an area associated with it and stopover sites (red) can be distinguished from movement corridors (orange and yellow).

Methods

We used GPS radio-collars to collect migratory movement data from 26 mule deer that wintered in, or immediately adjacent to, the PAPA. Locations were collected at two- or three- hr intervals and GPS success was 99%. We followed the methods outlined by Sawyer et al. (2009) whereby we: 1) used the BBMM (Horne et al. 2007) to estimate migration routes of individual deer, 2) combined individual routes to estimate a population-level migration route, 3) delineated which segments of the population-level route were used as stopover sites versus those used as movement corridors, and 4) illustrated which segments of the population-level route were used by the largest proportion of the sampled population. Because mule deer demonstrate a high fidelity to their migration routes across seasons and years (Sawyer et al. 2009), we estimated population-level migration routes for two distinct migratory segments: mule deer that migrated north off the PAPA and those that migrated west.

Results

We calculated population-level migration routes for a sample of mule deer that migrated northerly (Figs. 4 and 6) and westerly (Figs. 5 and 7) off the PAPA (Table 1). The northern migration route, which we refer to as “Mesa North”, included 14 fall migrations and one spring migration, collected from 15 mule deer between 2003 and 2008 (Table 1). The western migration route, which we refer to as “Mesa West”, included nine fall and six spring migrations, collected from 11 mule deer between 2005 and 2008 (Table 1). The population-level migration routes (Figs. 4-7) represent a probabilistic measure of where migrations occurred, although the spring migrations (*n*=7) were not represented as well as the fall (*n*=23). Spring migration data were not readily available because most of the GPS collars were programmed to collect only one location per day during the later portion of the spring migration. Population-level migration routes were characterized by a series of stopover sites, presumably used for foraging and resting, that were connected by movement corridors through which deer moved quickly (Figs. 4 and 6). As mule deer moved further from winter ranges (north and west), common migration routes splintered into multiple, less distinct routes, where stopover sites became smaller.

Route segments along the population-level route did not receive equal levels of use; rather, some were used by a larger proportion of the population than others (Figs. 5 and 7). For the Mesa North population, the route used by the most deer went through Trapper’s Point, west across Cora Butte and US 191, crossed the Green River, then north across Webb Draw and Beaver Rim to the south Hoback Rim, and ended in Noble Basin before splintering into multiple routes. For the Mesa West population, the route with the highest level of use went west from Grindstone Draw and into the Ryegrass, continued westerly to Aspen Ridge and Brodie Draw, then northwest to Merna Butte. From Merna Butte the route splits, with one heading west into the Horse Creek drainages, while the other heads north into the upper Hoback.

Table 1. Individual identification, migration period, and winter range of GPS-collared mule deer used to estimate population-level migration routes

Deer ID	Migration Period	Winter Range/Migration Route
GPS839	Fall 2005	Mesa North/Trapper's Point
GPS839	Fall 2007	Mesa North/Trapper's Point
GPS841	Fall 2005	Mesa North/Trapper's Point
GPS844	Fall 2006	Mesa North/Trapper's Point
GPS847	Fall 2005	Mesa North/Trapper's Point
GPS858	Fall 2005	Mesa North/Trapper's Point
GPS860	Fall 2008	Mesa North/Trapper's Point
GPS863	Spring 2003	Mesa North/Trapper's Point
GPS867	Fall 2008	Mesa North/Trapper's Point
GPS874	Fall 2007	Mesa North/Trapper's Point
GPS896	Fall 2007	Mesa North/Trapper's Point
GPS848	Fall 2005	Mesa North/Trapper's Point
GPS870	Fall 2006	Mesa North/Trapper's Point
GPS871	Fall 2007	Mesa North/Trapper's Point
GPS884	Fall 2008	Mesa North/Trapper's Point
GPS837	Fall 2005	Mesa West-Grindstone/Ryegrass
GPS843	Fall 2005	Mesa West-Grindstone/Ryegrass
GPS847	Spring 2007	Mesa West-Grindstone/Ryegrass
GPS848	Fall 2005	Mesa West-Grindstone/Ryegrass
GPS869	Fall 2008	Mesa West-Grindstone/Ryegrass
GPS880	Spring 2007	Mesa West-Grindstone/Ryegrass
GPS882	Fall 2007	Mesa West-Grindstone/Ryegrass
GPS882	Spring 2007	Mesa West-Grindstone/Ryegrass
GPS885	Fall 2008	Mesa West-Grindstone/Ryegrass
GPS885	Spring 2007	Mesa West-Grindstone/Ryegrass
GPS8829	Fall 2007	Mesa West-Grindstone/Ryegrass
GPS878	Fall 2007	Mesa West-Grindstone/Ryegrass
GPS885	Fall 2007	Mesa West-Grindstone/Ryegrass
GPS885	Spring 2008	Mesa West-Grindstone/Ryegrass
GPS8829	Spring 2007	Mesa West-Grindstone/Ryegrass

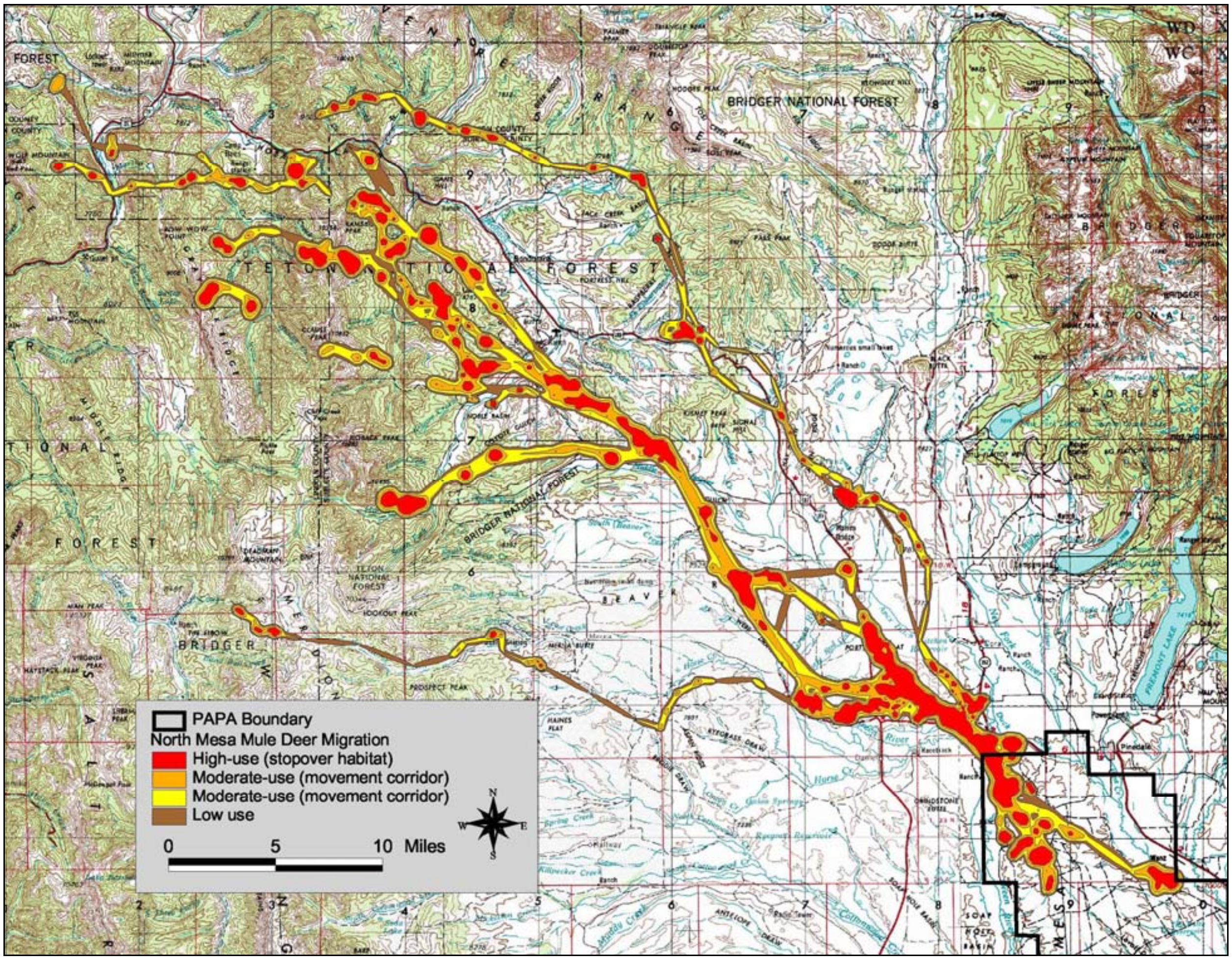

Figure 4. Population-level migration route for mule deer (n=15) that migrate in a northerly direction off of the Pinedale Anticline Project Area (PAPA). Red areas represent migratory segments where deer spent the most time are termed stopover sites. Orange and yellow segments represent migratory corridors where deer spent less time and moved relatively quickly.

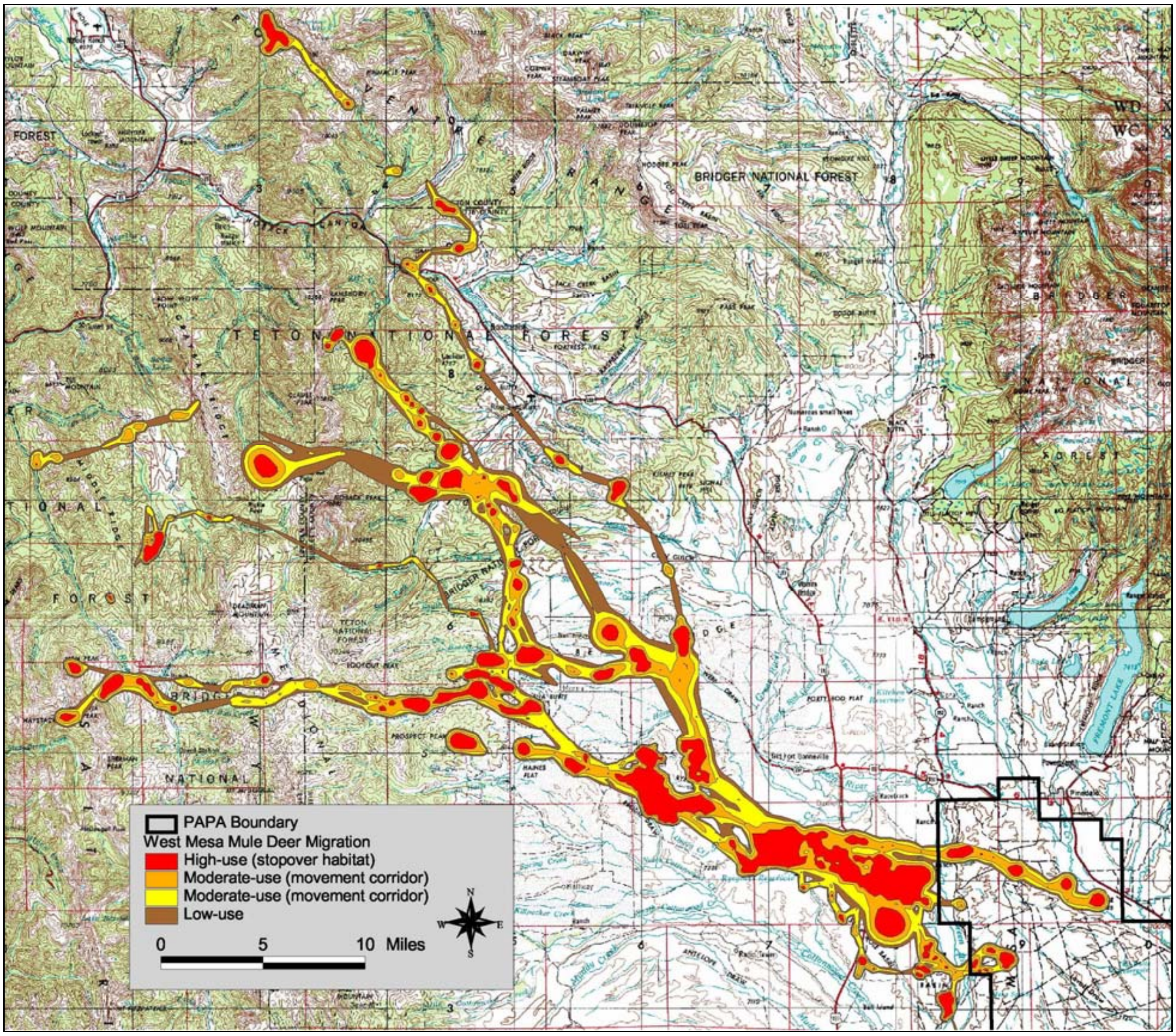

Figure 5. Population-level migration route for mule deer (n=15) that migrate in a westerly direction off of the Pinedale Anticline Project Area (PAPA). Red areas represent migratory segments where deer spent the most time are termed stopover sites. Orange and yellow segments represent migratory corridors where deer spent less time and moved relatively quickly.

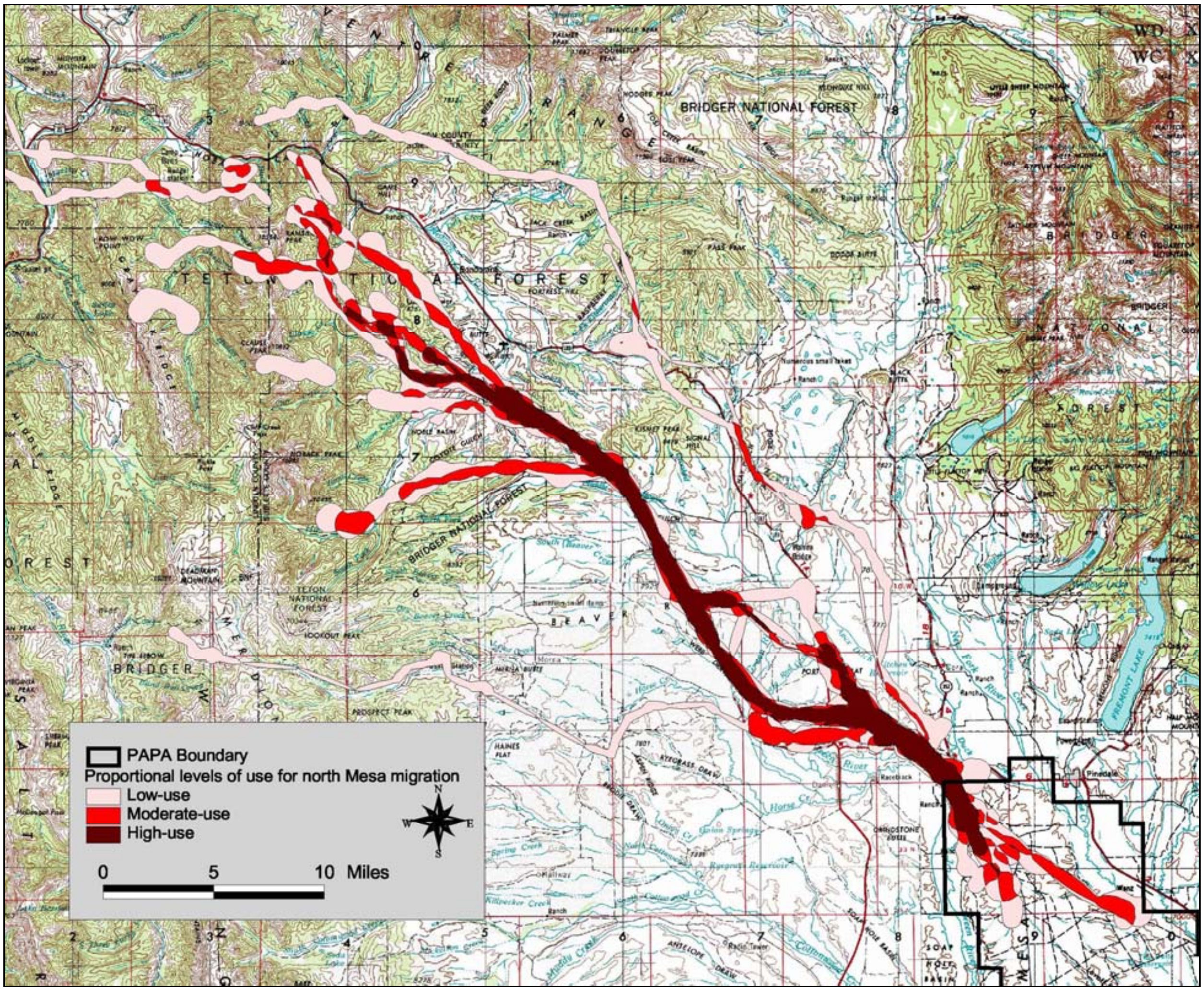

Figure 6. Population-level migration route for mule deer (n=15) that migrate in a northerly direction off of the Pinedale Anticline Project Area (PAPA). Darker areas represent migratory segments that were used by the largest proportion (>20%) of the sampled population.

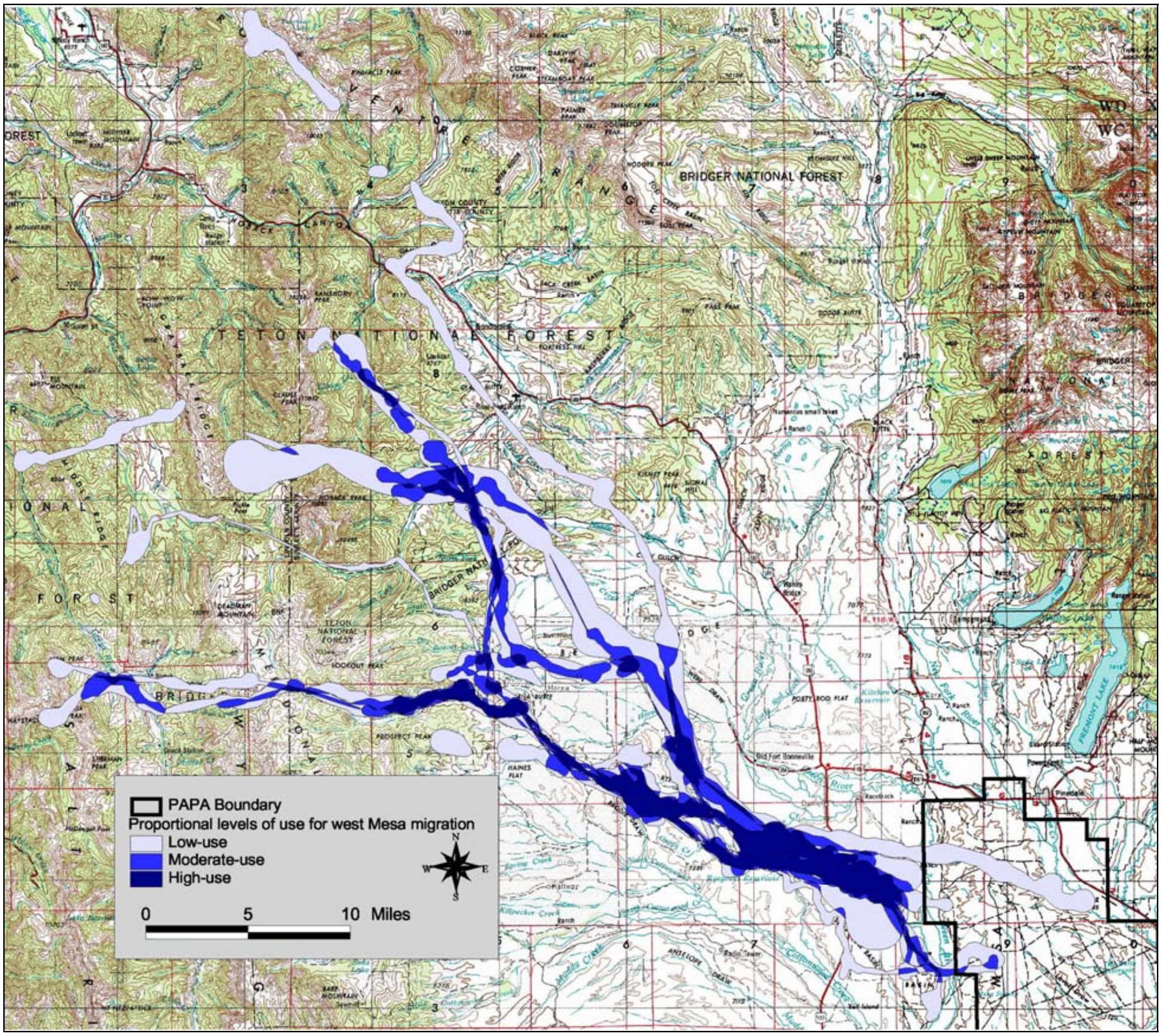

Figure 7. Population-level migration route for mule deer (n=15) that migrate in a westerly direction off of the Pinedale Anticline Project Area (PAPA). Darker areas represent migratory segments that were used by the largest proportion (>20%) of the sampled population.

Discussion and Management Implications

The management of migratory ungulates is especially difficult because of the long distances travelled, the mix of land ownership, and the various habitat types involved. Our results provide agencies and industry with a science-based tool that allows them to consider mule deer migration routes in landscape-level planning in and adjacent to the PAPA (Fig. 8). Population-level migration routes provide a means to identify which routes are used by the most deer and which route segments function as stopover habitat versus movement corridors. Our results may be used to prioritize routes based on the amount of use they receive. Although multiple migration routes originated from both Mesa North and Mesa West winter ranges, some routes were used by more deer than others. Routes that receive the most use are especially important because a large proportion of the deer herd rely on them. Additionally, distinguishing route segments used as stopover sites versus those used as movement corridors can provide biological rationale for resolving where infrastructure should be located if it overlaps with the migration route. Sawyer et al. (2009) suggested that stopover sites may be more susceptible to human disturbance because they provide key foraging and resting habitat, which mule deer avoid if disturbed. In contrast, habitat loss or human disturbance in a movement corridor is less likely to affect the ability of mule deer to continue traveling along such paths. Of course, this assumes that the development or disturbance does not create a complete barrier such that deer cannot move through the area. The Trapper's Point Bottleneck is a good example of the movement corridor that continues to function, even though it is bisected by a two-lane highway. Accordingly, Sawyer et al. (2009) recommended that stopover sites be managed to minimize habitat loss and human disturbance, whereas movement corridors be managed to maintain connectivity (i.e., ensure animal movement is not impeded).

Recognizing where migration routes occur, how wide they are, and how much use they receive will be key components for maintaining mule deer migrations to and from one of the largest natural gas reserves in the world. Results from this project will be provided in digital format to the BLM Pinedale Field Office for distribution to PAPA operators, Wyoming Game and Fish Department, and non-government organizations. These migration routes could be refined with larger samples sizes. As mule deer monitoring efforts continue in this region (e.g., Pinedale Anticline Planning Office [PAPO] studies), we recommend that migration routes be updated periodically to ensure the best available data are used. Further, given the large number of big game GPS studies occurring in the upper Green River Basin (e.g., Big Piney elk, WGFD feedground elk, PAPO pronghorn), we recommend: 1) these migration routes be refined as more mule deer data are collected, and 2) new migration routes for pronghorn and elk be developed where data are available .

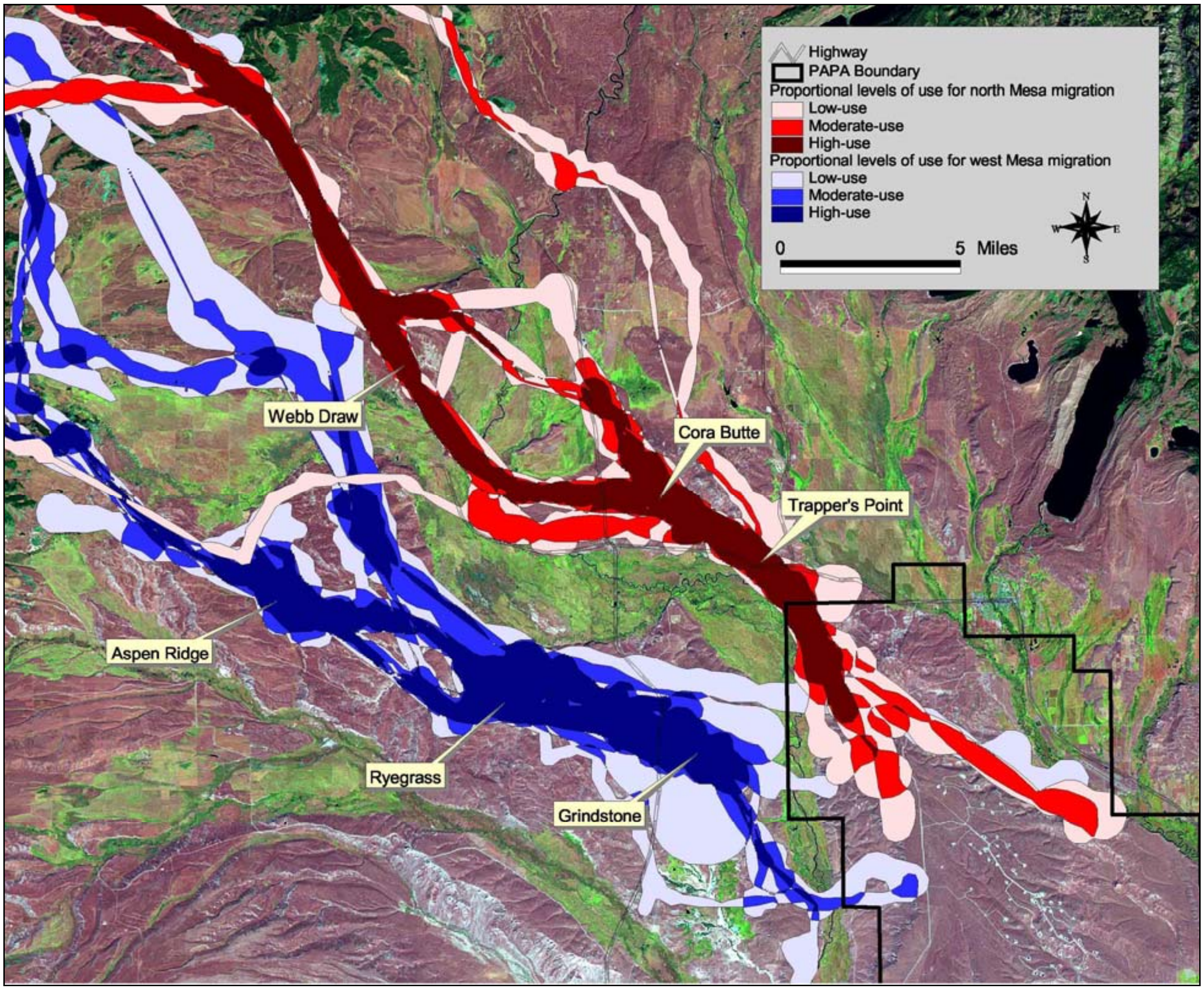

Figure 8. Population-level migration route for mule deer that migrate north (red) and west (blue) from the Pinedale Anticline Project Area (PAPA).

Acknowledgements

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