Migration Patterns of Adult Female Mule Deer in Response to Energy Development

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Introduction

Migration is an adaptive strategy that enables animals to enhance resource availability and reduce risk of predation at a broad geographic scale. Ungulate migrations generally occur along traditional routes, many of which have been disrupted by anthropogenic disturbances. Spring migration in ungulates is of particular importance for conservation planning because it is closely coupled with timing of parturition. The degree to which oil and gas development affects migratory patterns, and whether ungulate migration is sufficiently prepared to compensate for such changes, has recently been investigated in Colorado and Wyoming (Lendrum et al. 2012, 2013; Sawyer et al. 2012).

Lendrum et al. (2012, 2013) and Sawyer et al. (2012) address mule deer (*Odocoileus hemionus*) migration patterns in relation to energy development from northwest Colorado and south-central Wyoming, respectively. We address results from the Colorado and Wyoming studies and then compare similarities and differences. Management and conservation implications are proposed for consideration and future investigation.

Piceance Basin Mule Deer Migration

Lendrum et al. (2012, 2013) investigated spring migration patterns of adult female mule deer in the Piceance Basin of northwest Colorado from 2008 to 2010. They used Global Positioning System (GPS) collars (five location attempts per day) to address habitat use patterns and factors influencing timing and synchrony of spring migration by comparing areas with ongoing natural gas development activity to areas with little to no development (Lendrum et al. 2012, n = 167; Lendrum et al. 2013, n = 205). Mean migration distances among study areas varied from 36 to 53 kilometers (distance traveled; n = 4 winter range study areas), averaging 36 kilometers between seasonal ranges (linear distance; study area range: 32–40 km). Piceance Basin mule deer demonstrated rapid spring migration exhibiting median durations of three to eight days among areas. Stopover use (areas used to increase energy reserves during migration) along migration paths was rare for Piceance Basin mule deer. Well pad densities along migration paths within the two developed study areas were 1.5 to 2.0 pads per square kilometer.

Mule deer migrated more quickly through the most developed areas compared with deer in less developed areas. Additionally, deer migrating through the most developed study areas tended to select habitat types that provided greater amounts of concealment cover, whereas deer from the least developed areas tended to select habitats that increased access to forage and cover. Deer selected habitats closer to well pads and avoided roads in all instances except along the most highly developed migratory routes, where road densities may have been too high for deer to avoid roads without deviating substantially from established migration routes.

Environmental factors influencing timing and synchrony of spring migration included snow depth and emerging vegetation, which varied among years but was highly synchronous among study areas within years. Migration timing was also influenced by development disturbance, rate of travel, distance traveled, and late-winter body condition. Rates of travel were more rapid over shorter migration distances in areas of high natural gas development resulting in delayed departure—but early arrival for females.

These results indicate that behavioral tendencies to avoid anthropogenic disturbance can be overridden during migration by the strong fidelity mule deer demonstrate towards migration routes. If avoidance is feasible, then deer may select areas further from development, whereas in highly developed areas, deer may simply increase their rate of travel along established migration routes.

Atlantic Rim Mule Deer Migration

Sawyer et al. (2012) used GPS data (location attempts every 2.5 hours) collected from two subpopulations of mule deer (n = 97) in the Atlantic Rim region of Wyoming to evaluate how different densities of gas development (coal-bed methane) influenced migratory behavior, including movement rates and stopover use at the individual level and intensity of use and width of migration route at the population level. They characterized the functional landscape of migration routes as either stopover habitat or movement corridors and examined how the observed behavioral changes affected the functionality of the migration route in terms of stopover use. Atlantic Rim mule deer exhibited relatively longer migration duration averaging about three weeks, with distances averaging 40 kilometers between seasonal ranges, and common stopover use along migration paths. Well pad densities were more concentrated and higher than in the Piceance Basin increasing from 0.8 to 2.8 pads per square kilometer in the most developed study area.

Sawyer et al. (2012) found migratory behavior to vary with development intensity. They suggest that mule deer can migrate through moderate levels of development without any noticeable effects on migratory behavior. However, in areas with more intensive development, animals often detoured from established routes, increased their rate of movement, and reduced stopover use, while the overall use and width of migration routes decreased.

In contrast to impermeable barriers that impede animal movement, semipermeable barriers allow animals to maintain connectivity between their seasonal ranges. Their results identify the mechanisms (e.g., detouring, increased movement rates, reduced stopover use) by which semipermeable barriers affect the functionality of ungulate migration routes and emphasize that the management of semipermeable barriers may play a key role in the conservation of migratory ungulate populations.

Discussion

Environmental conditions were similar between study areas, whereas development intensity and migratory behavior differed in some respects (Table 1). Migration distances, elevation gradients, and general habitat types were similar (Table 1), but overstory cover was typically higher in the Piceance Basin where migratory mule deer took advantage of security cover to avoid development activity, without detectable deviation from migration paths. Migratory mule deer in both areas traveled more quickly through developed landscapes, but permeability of migration routes was only inhibited at the more concentrated development intensity evident in Atlantic Rim, Wyoming. Nonetheless, increased movement rates through developed areas can discourage use of stopover habitat and reduce the ability of animals to optimally forage and track vegetation phenology. Whether such behavioral changes have demographic consequences is unknown, but given the importance of summer nutrition for body condition and reproduction, any lost foraging opportunities during migration have the potential to incur energetic and demographic costs and the resulting effect may act as de facto habitat loss. Increased energetic costs associated with strong deviations in traditional migration routes, and reduced energy intake resulting from poor timing of arrival on summer range relative to forage conditions, could compromise long-term fitness of migratory mule deer populations. Thus, conservation measures may be warranted in areas where expansive and concentrated development activities occur or are planned within the range of long-distance migratory ungulates.

Interesting differences between the two migratory mule deer populations, which likely was not related to energy development activities, included the relatively rapid migration duration and reduced stopover use exhibited by Piceance Basin, Colorado, mule deer (Table 1). The reason for these differences is unclear, but could be related to forage conditions and mule deer body condition prior to migration. Lendrum et al. (2013) noted that mule deer in relatively good condition migrated earlier than deer in poor condition, which required improved body condition prior to long-distance movements, and it is intuitive (although speculative) that individuals with improved energy reserves could migrate more quickly without stopping along the way to "refuel." It may also be that stopover use in Wyoming reflected an optimal foraging strategy relative to the timing of green-up as deer progressed in elevation. Where stopover use is common, identifying and incorporating stopover sites into energy development planning is critical to sustaining migratory ungulate populations (Sawyer et al. 2012).

Implications

The interactions between migratory mule deer and energy development identified by Lendrum et al. (2012, 2013) and Sawyer et al. (2012) suggest mule deer may benefit from energy development planning by considering thresholds of development that may alter migratory behavior. It appears that migration rate, migration routes, and stopover use, if present, may be altered at high development intensities. In addition, migratory mule deer may benefit by maintaining security cover along migration paths, and improved habitat conditions may facilitate more direct and rapid migration requiring less energy to complete migration. Enhancing permeability along migration routes by applying dispersed development plans (<2 well pads/km^2) and minimizing disturbance to vegetation types by maintaining security cover should reduce impacts to migratory mule deer as well as other migratory ungulates. Where feasible, habitat improvement projects on winter range and possibly stopover sites would also enhance migratory mule deer populations by enhancing energy reserves for long-distance movements and parturition shortly after summer range arrival. Where possible, directional drilling could be used to extract energy resources from underneath migration routes while maintaining no surface occupancy. Lastly, we emphasize that GPS studies now allow managers to accurately map migration routes for entire populations and identify relatively narrow corridors that are most heavily used thus allowing for the identification of the most important corridors for migrating ungulates. Where available, we encourage agencies to incorporate such migration corridors into land-use plans (e.g., resource management plans) and National Environmental Policy Act documents.

References

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Table 1. Comparison of two migratory mule deer populations from Piceance Basin, Colorado (Lendrum et al. 2012, 2013), and Atlantic Rim, Wyoming (Sawyer et al. 2012), in relation to environmental conditions, migration behavior, and well pad density of developed landscapes along migration paths.

	Piceance Basin, CO	Atlantic Rim, WY
Mean dist. between seasonal ranges	36 km	40 km
Range in elevation	1,980–2,400 m	2,065–2,385 m
General habitat types	PJ woodland, mtn. shrub, Aspen/conifer	Sparse PJ/sage, sage, Aspen/sage
Stopover use	Rare	Common
Well pad density[a]	1.5–2.0/km^2	0.8–2.8/km^2

[a]Well pad densities in the Piceance Basin, Colorado, were averaged along entire migration paths of the two developed study areas (Lendrum et al. 2012). Well pad densities in Atlantic Rim, Wyoming, represent phased development over a five-year period within a concentrated area along the migration corridor of the most developed study area (Sawyer et al. 2012).