Evaluating the cumulative effects of oil and gas development on elk and mule deer in the middle reaches of the Colorado River watershed near Silt, Colorado

A report by Western Watersheds Project and Redstone GIS
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Executive Summary

Elk and mule deer are sensitive to both habitat fragmentation and disturbance from human activity, which can result from oil and gas development as well as rural roads and settlement. Ungulate responses to the imposition of networks of roads, pipelines, powerlines, and wellsites most commonly take the form of avoidance within buffer areas around infrastructure, as well as stress and/or metabolic cists when traversing habitats within close proximity of roads and other infrastructure. In addition, road networks contribute to direct mortality through vehicle collisions as well as increasing motorized access and vulnerability of wildlife to hunting in roaded habitats. For elk, avoidance of roads and infrastructure ranges from a 0.4 to 2.5 km distance extending from the site of disturbance. For mule deer, avoidance of roads and infrastructure ranges from a 0.2 to 7.5 km distance extending from the site of disturbance. Avoidance distances, describing the distance of expected loss of habitat effectiveness, tends to be greater in open habitats than in woodlands, but significant avoidance occurs in both settings. Neither elk nor mule show a propensity to adapt to disturbance over time and reduce their avoidance of developed sites or roadways. In addition, oil and gas wellfield development can impair habitat quality along migration routes and in some cases even block or interrupt seasonal migrations. It is essential to consider the cumulative impacts of both oil and gas infrastructure and the underlying road, residence, and highway infrastructure when assessing the impacts of human-caused disturbance on elk and mule deer. We mapped oil and gas infrastructure in the Bureau of Land Management's Colorado River Valley Field Office, together with underlying infrastructure and developments from residential and agricultural land uses, using GIS mapping with buffers of 0.4 to 2.5 km for elk and buffers of 0.2 to 2.7 km for mule deer. We found, using various metrics of disturbance, that in the region of interest, at least 98.1% of identified winter ranges and 95.4%of parturition areas for elk, and at least 75.6% of winter ranges and 99.4% of parturition areas for mule deer, are already impacted by the cumulative levels of development found in the region. We conclude that these sensitive habitats, for both species (along with migration corridors) should be closed to future oil and gas leasing, and future wellsites and other infrastructure should be co-located withy existing infrastructure impacts to prevent adding additional impacts to an already over-stressed ecosystem.

Introduction

Oil and gas development is projected to have a continuing negative impact on a number of species, including mule deer, in coming years as the footprint of oil and gas wellfield development continues to expand (Copeland et al. 2009). Over time, with directional drilling and multiple wells on single wellpads, wellpad size is increasing. Sawyer et al. (2020) reported an average pad size of 0.6 ha in 2013 versus 3.6 ha (a sixfold increase) by 2020. Oil and gas field development comes with a network of access roads and pipelines, which contribute direct elimination of habitat, habitat fragmentation, and disturbance and displacement of animals from nearby habitats. Roads can have population-level effects on wildlife, related to roadkill, barriers to movement and migration, and displacement from adjacent habitats (Forman and Alexander 1998, Trombulak and Frissell 2000).

Examining the indirect effects of development, i.e. the displacement and disturbance of ungulates in habitats near roads or wellpads, is key to a sound cumulative impacts analysis (Hebblewhite 2011). According to Sawyer et al. (2017:7), "Our findings contradict many NEPA documents (e.g. Environmental Impact Statements, Environmental Assessments) that guide federal land use on millions of acres in the western USA and consider natural gas development a short-term impact to which animals can readily habituate once drilling activities are complete (e.g. BLM, 2005, 2006, 2012). We understand that a paucity of data on the long-term impacts of development likely led to this type of conclusion in the NEPA process. However, our long-term dataset comprising multiple generations of animals indicates that avoidance of energy infrastructure is a long-term effect that can be associated with significant population declines."

The scope of this report includes all land ownerships within the Colorado River Valley Field office (including, importantly, Forest Service lands in the Grand Mesa-Uncompahgre-Gunnison National Forest), For mule deer, key herd areas include the Rifle Creek population Deer Analysis Unit, or "DAU," D-42), North Grand Mesa (DAU D-12), Sweetwater Creek (DAU D-43), State Bridge (DAU D-8), Middle Park (DAU D-9), Red Table Mountain (DAU D-14), Basalt (DAU D-53), and Maroon Bells (DAU D-13). As of 2020, the mule deer population was below habitat objectives for North Grand Mesa, Maroon Bells, Red Table Mountain, and Basalt, but within population objectives for Rifle Creek, Sweetwater Creek, State Bridge, while Middle Park is above objective (CPW 2020). Statewide, mule deer populations declined from 600,000 deer in 2006 to 433,000 in 2018 (CPW 2020). For elk, key herd areas include White River (DAU E-6), Gore Pass (DAU E-7), Troublesome Creek (DAU E-8), Piney River (DAU E-12), Williams Fork River (DAU E-13), Grand Mesa (DAU E-14), Avalanche Creek (DAU E-15), and Frying Pan River (DAU E-16). As of 2020, the elk population was below habitat objectives for Grand Mesa, but within population objectives for Piney River, Avalanche Creek, and Frying Pan River, while White River, Gore Pass, Troublesome Creek, Williams Fork River, are above objective (CPW 2020). Statewide, elk populations declined from 305,000 elk in 2001 to 287,000 in 2018 (CPW 2020).

Elk Sensitivity to Disturbance

Human-caused disturbance of elk is similar in its effects to predation risk (Frid and Dill 2002). Disturbance from industrial activity is comparable to predation risk in its effect on large herbivores (Sawyer et al. 2009, Lendrum et al. 2012). Predation risk has been shown to be a sufficiently strong influence on cervid behavior that it can lead to evolutionary changes (e.g., Molvar and Bowyer 1994).

Increasing levels of human disturbance to wildlife result in decreasing survival and reproduction for wildlife, and elevations of glucocorticoids, a metabolite associated with stress (Busch and Hayward 2009). Glucocorticoids have been found to be associated with vehicle traffic along roads during summer (Millspaugh and Washburn 2004). Jachowski et al. (2015) found that elk fecal glucocorticoids were elevated in response to human disturbance on winter ranges subjected to human disturbance, and also found that human disturbance was the single most important correlate with these stress-related metabolites.

On winter ranges, elk are highly susceptible to disturbance. They are so sensitive to human disturbance that even cross-country skiers can cause significant stress to wintering animals (Cassirer et al. 1992). Ferguson and Keith (1982)

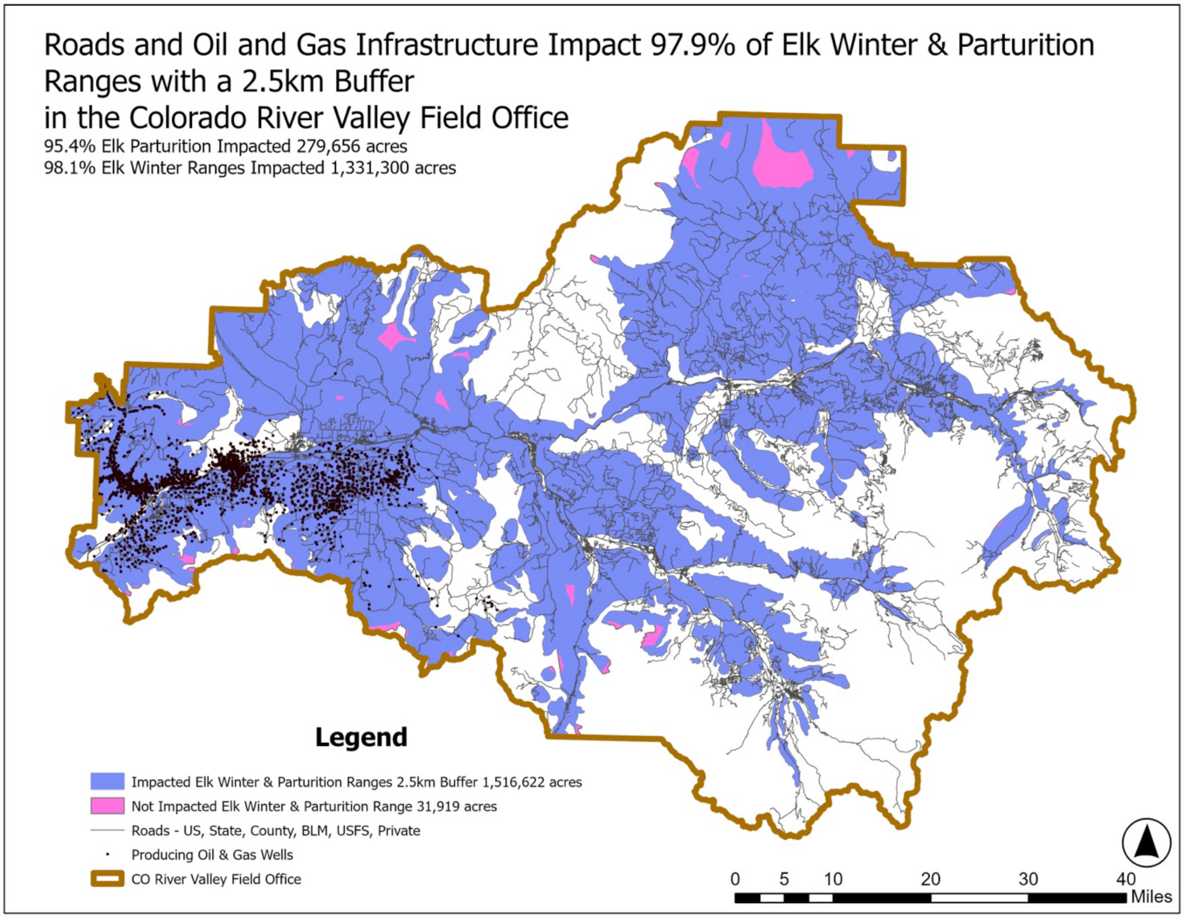

Figure 1. Elk winter and parturition ranges within 2.5 km of road and oil and gas infrastructure.

found that while cross-country skiers did not influence overall elk distribution on the landscape, elk avoided heavily-used ski trails. Disturbance during this time of year can be particularly costly, since the metabolic costs of locomotion are up to five times as great when snows are deep (Parker et al. 1984). Both snowmobiles and cross-country skiers are known to cause wintering ungulates to flee (Richens and Lavigne 1978, Eckstein et al. 1979, Aune 1981, Freddy et al. 1986). Because flight response may be particularly costly to wintering ungulates (Parker et al. 1984), disturbance on winter ranges should be avoided at all costs. Furthermore, Thomas et al. (1988) asserted that winter logging on elk winter range is disruptive to elk.

There may be some habitat partitioning between elk and mule deer on winter ranges. According to Oedekoven and Lindzey (1987), wintering mule deer in southwestern Wyoming favored draws, flats, and ridgelines, while wintering elk selected ridges, hilltops, and steep topography. In this study, mule deer used lower elevation sagebrush grasslands preferentially, while elk preferred to remain at high elevations until deep snows pushed them down. Thomas et al. (1988) asserted that hiding and thermal cover are critical components of elk winter range, and that patches of cover greater than 200m wide are more effective than smaller blocks. Thus, habitat fragmentation from roads and wellsites reduces the habitat effectiveness of elk winter range.

A number of studies have shown that elk avoid open roads (Grover and Thompson 1986, Rowland et al. 2000, Ager et al. 2003, Sawyer et al. 2007, Stewart et al. 2010, Roberts et al 2017, Rowland et al. 2018). Edge and Marcum (1991) found that elk use was reduced within 1.5 km of roads, except where there was topographic cover. Rowland et al. (2000) found that elk response to open roads fell

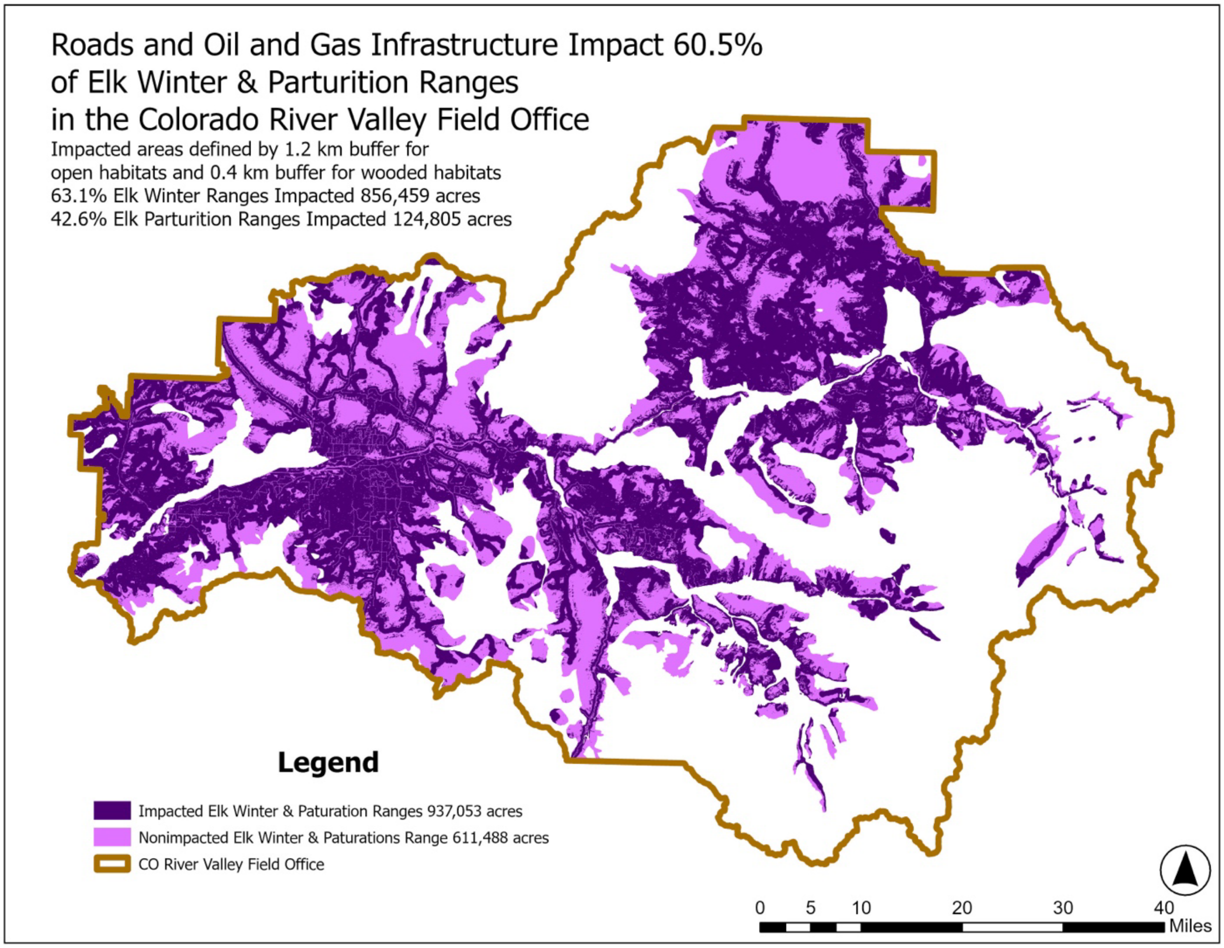

Figure 2. Elk winter and parturition habitats within 0.4 km of roads and oil and gas infrastructure (wooded habitats) and within 1.2 km of roads and oil and gas infrastructure (open habitats).

off rapidly at 1.8 km distance from the road. In open sagebrush habitats, Sawyer et al. (2007) found that elk use was greatest farther than 1.2 km from roads. In heavily forested habitats, Storlie (2006) found that Roosevelt elk preferred habitats 0.4 km from gravel roads and 0.6 km from paved roads during the hunting season. Gratson and Whitman (2000) found that hunter success was higher in roadless areas than in heavily roaded areas, and that closing roads increased hunter success rates. Buchanan et al. (2014) found that elk avoid wellfield roads by 2.5 km, and that the onset of gas development increased elk avoidance of roads by 1.3 – 1.5 km from prior conditions. On the Black Hills, elk chose their day bedding sites to avoid tertiary roads and even horse trails (Cooper and Millspaugh 1999). Prokopenko et al. (2017) found that elk both avoid roads and avoid crossing them, making roads a permeable barrier to elk movements, and they recommended minimizing open roads in elk winter range areas.

Cole et al. (1997) found that reducing open road densities led to smaller elk home ranges, fewer movements, and higher survival rates. Road densities less than one linear mile of road per square mile are optimal for elk (Lyon 1983, Thomas et al. 1988). Sawyer et al. (1997) found an even lower road-density tolerance for elk on the Bighorn National Forest of Wyoming, finding that elk selected lands with road density less than 0.5 linear mile per square mile. The reduction of road densities on the winter ranges as a whole and the maintenance of low road densities in important habitat areas would aid in maintaining healthy elk populations. Benefits to elk of reduced open-road density include reduced energy expenditure, increases in diet quality, and increases in effective habitat (Rowland et al. 2005). Watkins (2023)

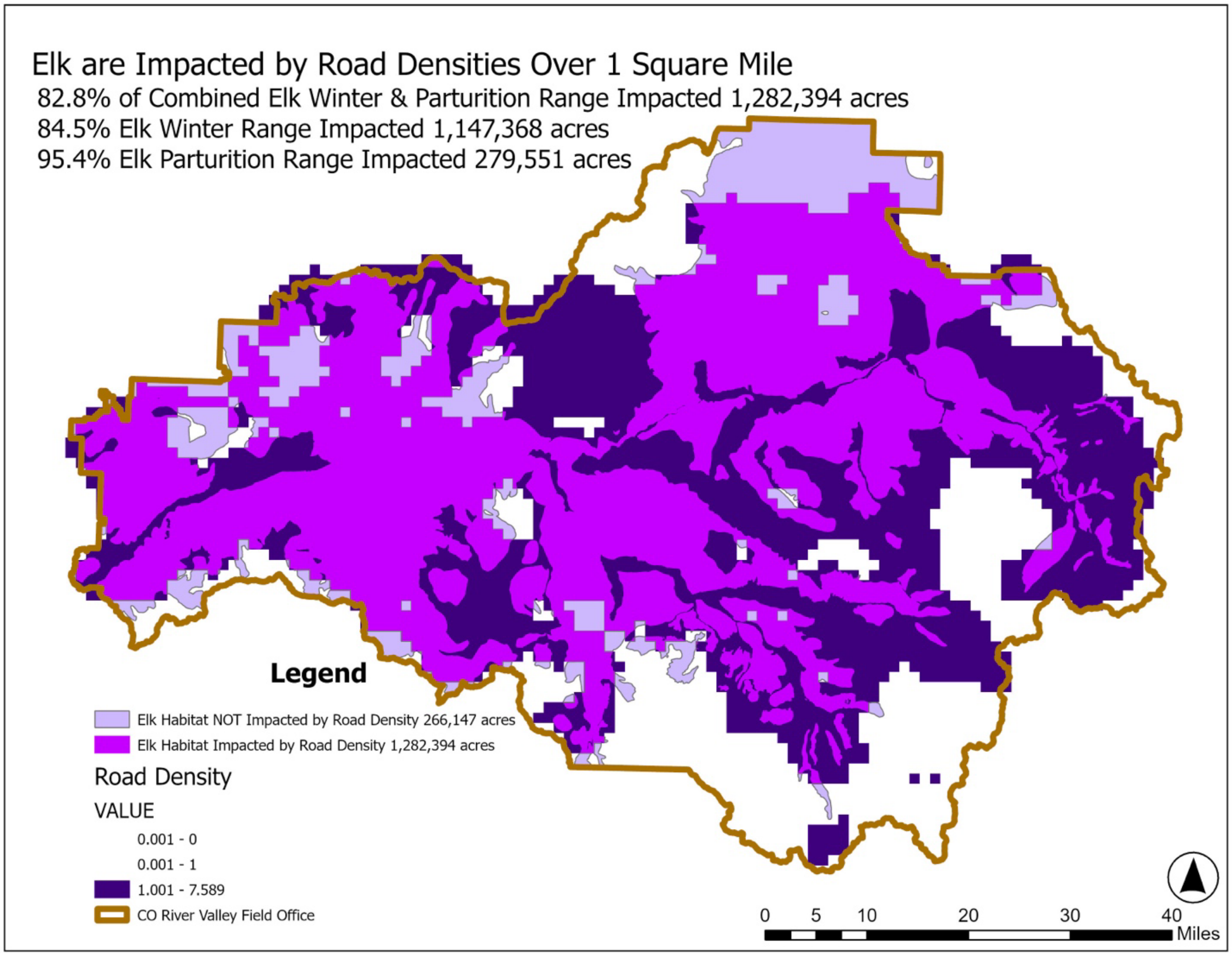

Figure 3. Elk winter and parturition habitats affected by road densities exceeding one linear mile per square mile.

found that high-traffic (>1,000 vehicles/day) or high-speed (> 65 mph) roads pose significant movement barriers to elk.

Elk select calving ranges on the basis of higher forage availability, regardless of predation risk (Rearden et al. 2011, Berg et al. 2021). Human activity can displace elk from calving ranges (e.g., Storlie 2006), and such displacement can result in reductions in calf survivorship and recruitment (Phillips and Alldredge 2000). Several studies have shown that elk abandon calving and winter ranges in response to oilfield development. In mountainous habitats, the construction of a small number of oil or gas wells has caused elk to abandon substantial portions of their traditional winter range (Johnson and Wollrab 1987, Van Dyke and Klein 1996). Drilling in the mountains of western Wyoming displaced elk from their traditional calving range (Johnson and Lockman 1979, Johnson and Wollrab 1987). Powell and Lindzey (2001) found that elk avoid lands within 1.5 kilometers of oilfield roads and well sites in sagebrush habitats of the Red Desert.

Migration corridors may in some cases be equally important to large mammals and are susceptible to impacts from oil and gas development (Sawyer et al., in press). Elk time their fall and spring migrations based of forage depletion on the present range and snow conditions on the next seasonal range; the timing can vary up to 50 days based on weather (and therefore snow and forage condition) variation from year to year (Rickbeil et al. 2019). Rickbeil et al. (2019) found evidence for "green-wave surfing" in elk as well. Mumme et al. (2023) found that human disturbance exerted an even greater effect on elk movements than did natural factors like slope or vegetation productivity.

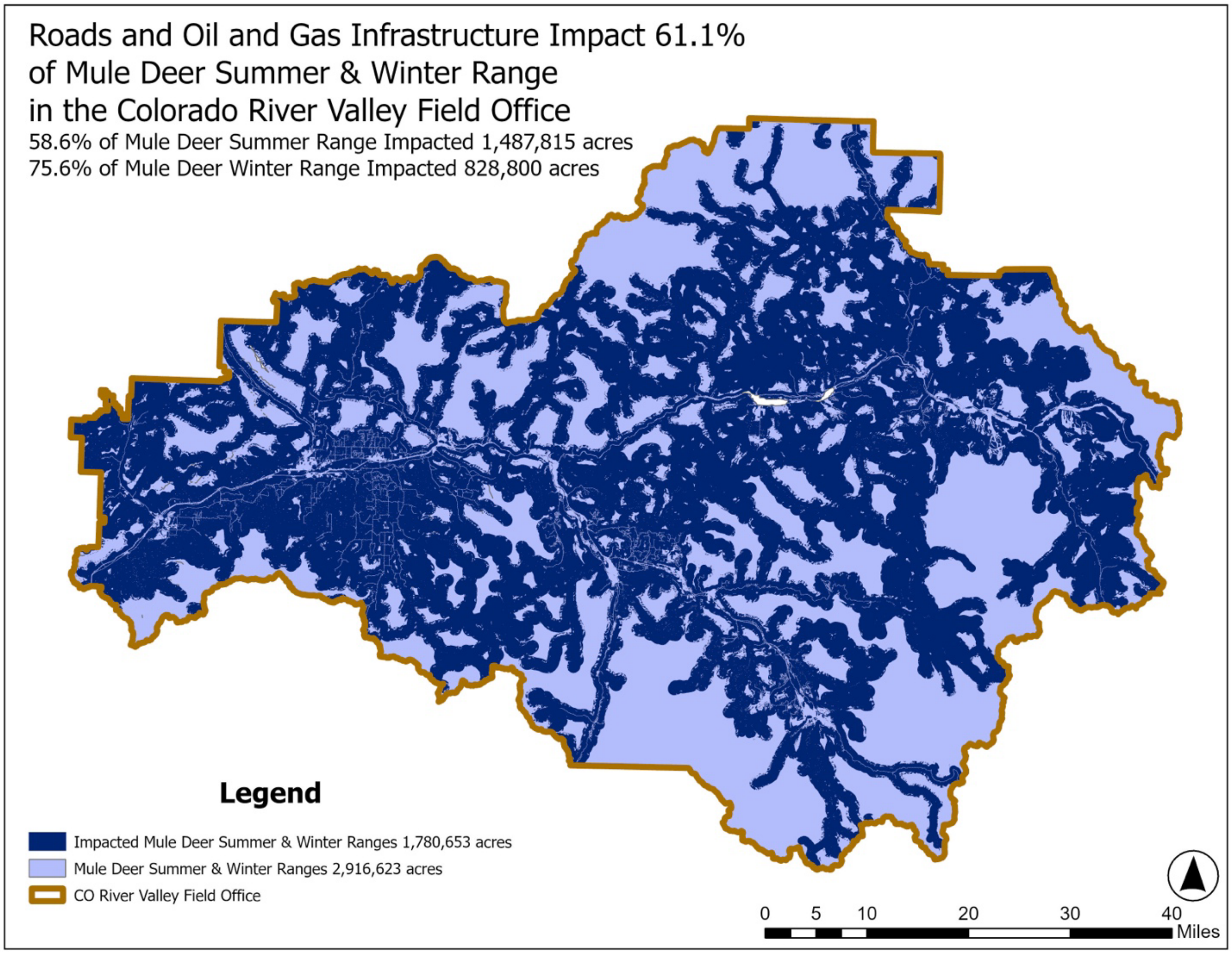

Figure 4. Mule deer impacted wintering and summer habitats within 1.0 mile of roads (in wooded habitats) or within 0.6 km of roads (open habitats).

Dzialek et al. (2011) found that female elk with calves strongly avoided lands with oil and gas development in daylight hours, but showed no selection bias at night. Webb et al. (2011) found that female elk avoided areas of oil and gas development, particularly with increasing well density, and shifted concentrated use to areas with minimal development. Van Dyke et al. (2012) demonstrated use of elk in clearcut areas adjacent to natural gas wellpads, but did not quantify selection or avoidance of these areas. Buchanan et al. (2014) documented displacement of elk to more rugged, wooded terrain, displacing them from preferred summer and winter ranges by 43.1% and 50.2%, respectively.

In winter, female elk showed strong variation in resource selection patterns among years, tended to avoid roads and natural gas wells and consistently showed stronger selection for security cover, steeper slopes and greater distance to edge habitats within the gas field relative to outside of the gas field (Harju et al. 2011).

Buchanan et al. (2014) found that gasfield development caused major shifts in elk seasonal range use. Similarly, in the LaBarge Creek area, satellite collar data showed that elk south of the creek migrated out into the sagebrush flats of the Green River Basin in winter, while elk to the north of the creek (where the LaBarge oilfield occupies the sagebrush flats) wintered in the foothills and did not venture into the flats (Fred W. Lindzey, pers. comm.). These results suggest that the LaBarge oilfield effectively blocks elk migrations to the north of LaBarge Creek, preventing the elk from wintering in sagebrush lowlands.

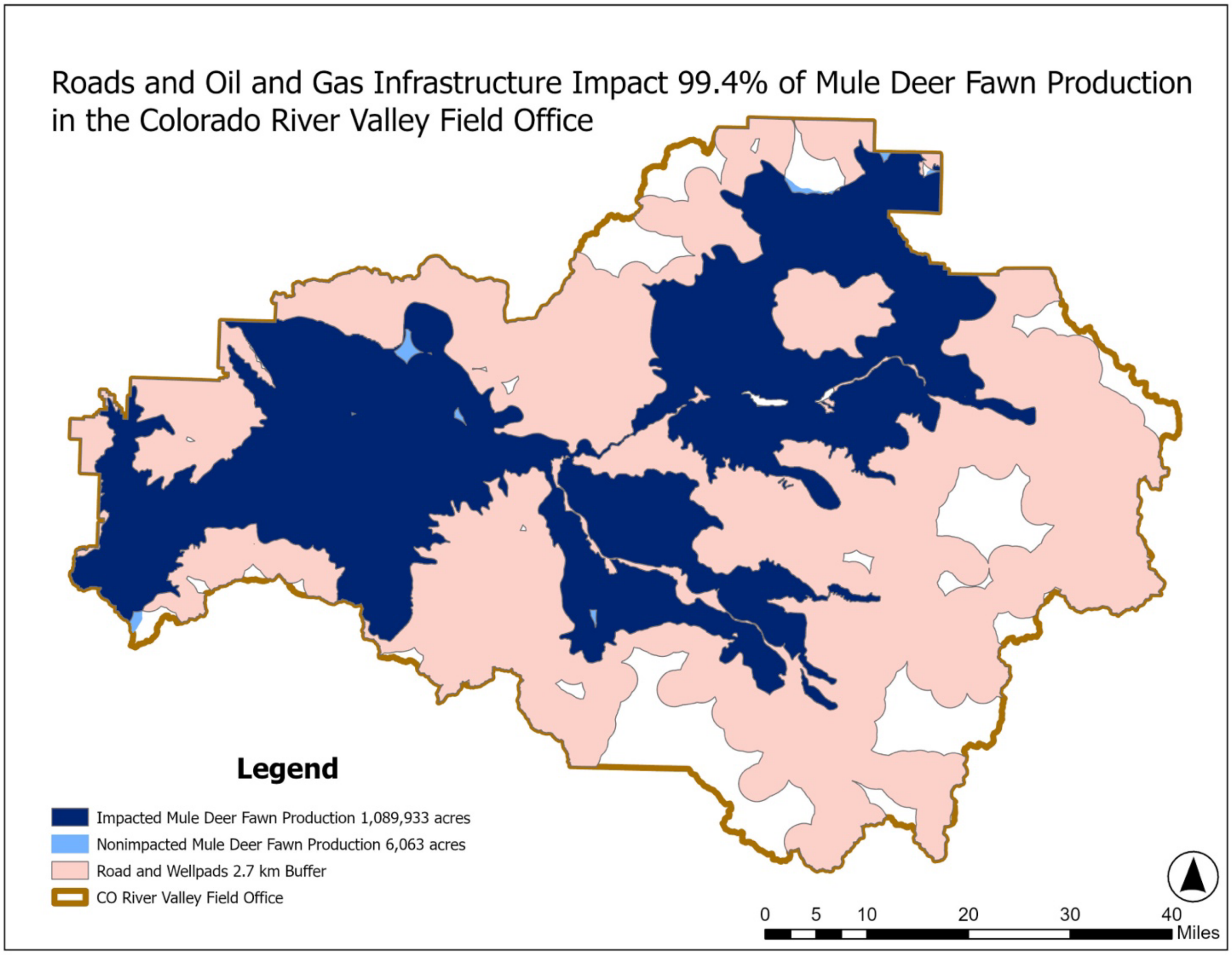

Figure 5. Mule deer fawn production habitats within 2.7 km of roads.

Gas field development fragments habitat, resulting in more edge habitat and less distance from roads or other human infrastructure (Harju et al. 2011). Liquid gathering systems (i.e., pipelining, rather than trucking, of wastewater and condensate) reduces the frequency of vehicle trips to each wellpad by roughly half (Sawyer et al. 2009).

Mule Deer Sensitivity to Disturbance

Sawyer et al. (2017) found that oil and gas development can result in long-lasting behavioral shifts in mule deer, as well as long-term population reductions. Johnson et al. (2017) conducted an analysis of both residential and energy development on mule deer habitats in Colorado, and found that an increasing proportion of habitats is being impacted over time.

The ability of mule deer to forage effectively on winter ranges in a stress-free environment is the key to maintaining viable populations in this region. Winter mortality has claimed up to 80% of the adult mule deer population of southeastern Wyoming, and also depresses fawn production during the following spring (Strickland 1975). On winter ranges, mule deer are easily disturbed by snowmobile traffic and even nonmotorized visitors (Freddy et al. 1986). This can be a critical factor, because metabolic costs of locomotion in snow can be five times as great as normal locomotion costs for mule deer (Parker et al. 1984). Johnson et al. (2017) found that energy development, particularly on winter ranges, has a negative effect on fawn recruitment, suggesting one possible mechanism for demographic shifts resulting from energy development. The 2.7 km buffer was the only buffer correlated with fawn recruitment (id.). Due to the sensitivity of mule deer to disturbance on

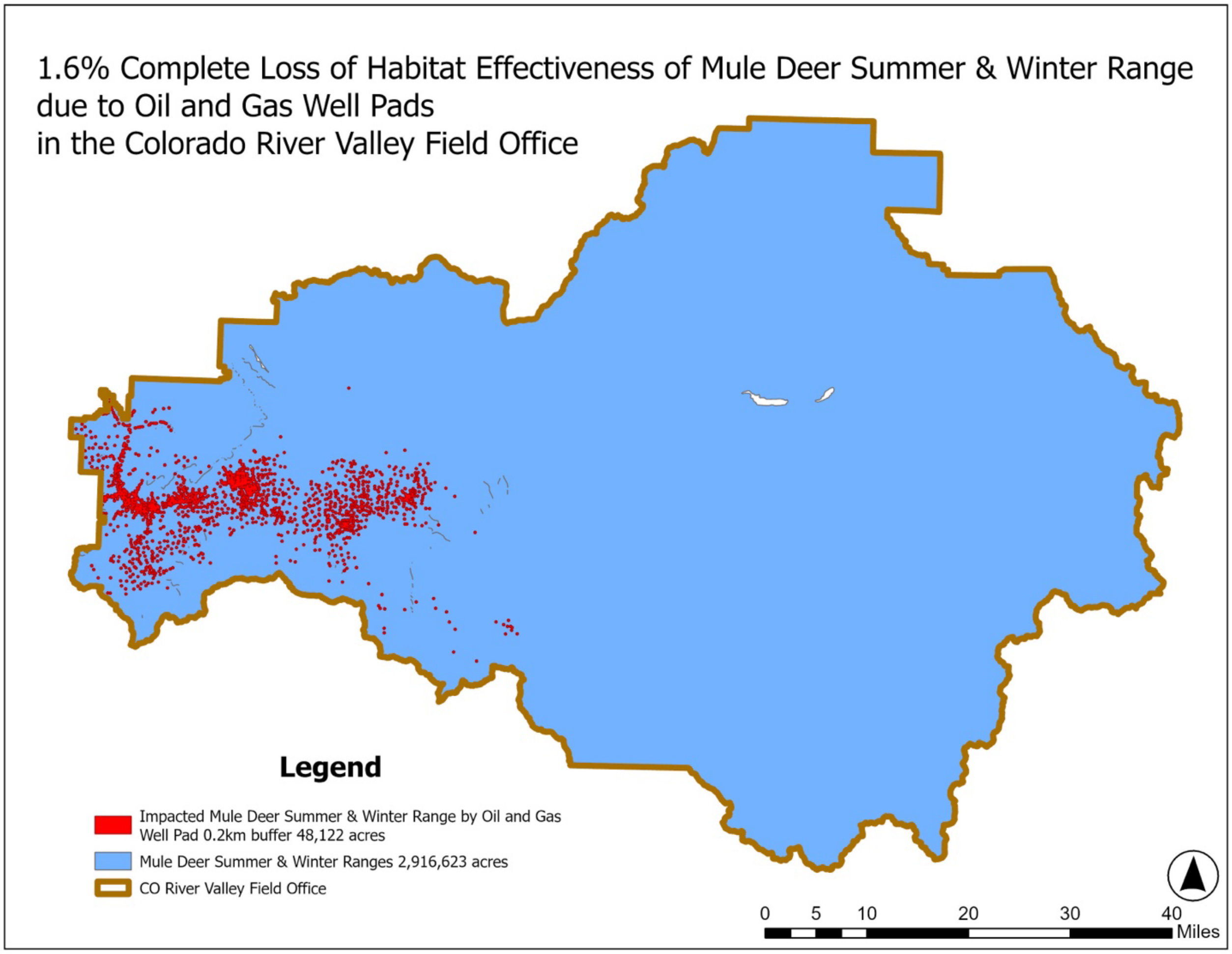

Figure 6. Mule deer summer and winter ranges within 0.2 km of infrastructure.

winter ranges and the crucial nature of winter range performance to maintaining healthy deer populations, further oil and gas development, which would increase the level of human disturbance on these winter ranges, should be minimized.

Mule deer synchronize their spring migrations with seasonal greenup timing, or "surf the green wave" (Aikens et al. 2017). Sawyer et al. (2013) found that mule deer can migrate through moderate densities (4.8 wells per square mile) of oil and gas development without difficulty, but migrations are impaired, and stopover feeding is reduced, when development reaches high densities (7.3 wells per square mile). Aikens et al. (2022) found that oil and gas development can interfere with green-wave surfing for mule deer, delaying migrations and causing them to get out-of-sync with spring greenup. Conversely, Lendrum et al. (2013) found that mule deer may speed up migrations through developed areas, arriving on parturition ranges earlier than spring greenup. This results in "jumping," rather than "surfing," the green wave (Lendrum et al. 2014).

Lendrum et al. (2012) hypothesized that oil and gas development may disturb mule deer more than residential development, because while residential development reaches a relatively static state, wellfields and their activity are constantly changing. In western Wyoming, Sawyer et al. (2017) found that mule deer failed to habituate to the impacts of oil and gas development over the 15-year course of their study, and that mule deer avoided wellpads by an average of 913m. According to Sawyer et al. (2017: 7), "Population turnover, combined with long-term behavioral responses, indicates an inability of individuals, across generations, to habituate to gas

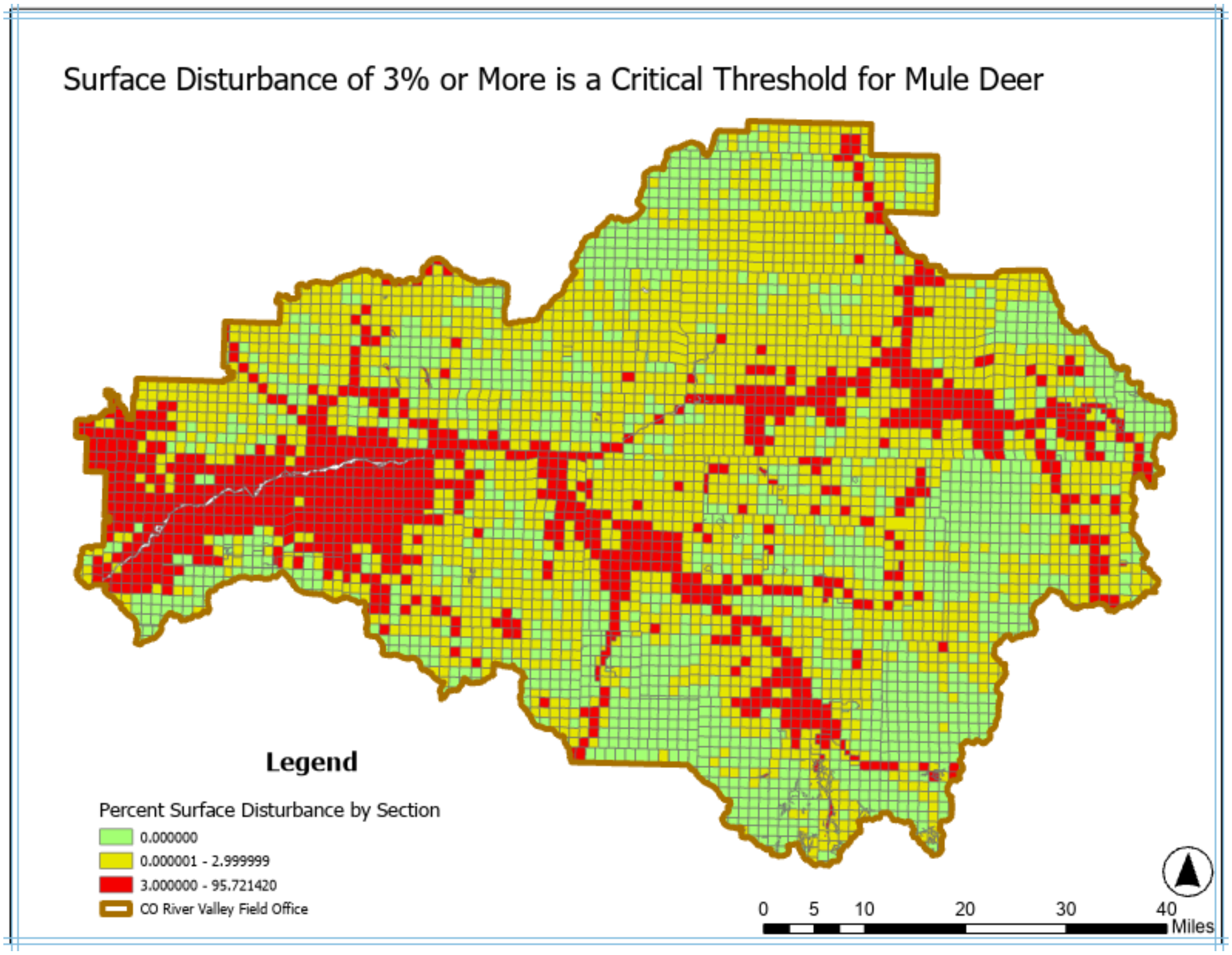

Figure 7. Mule deer summer and winter ranges exceeding 3% surface disturbance threshold.

development even if they have been exposed to infrastructure their entire lives." Aversion to wellpads increased as winter severity increased (id.). According to Sawyer et al. (2017: 5-6), "Even during the last 3 years of development when most wells were in production and well pads were in various states of reclamation, we found no evidence of habituation. Instead, mule deer used areas that averaged nearly 1 km further from well pads compared with animals before development occurred."

Sawyer et al. (2006) found that energy development displaced mule deer from high-use habitats to low-use (less preferred, less suitable) habitats. Even with the use of directional drilling and liquid-gathering systems to reduce truck traffic, mule deer populations decreased by 36% following oil and gas development in a western Wyoming study (Sawyer et al. 2017).

Sawyer et al. (2006) found that mule deer habitat use declined within 2.7 km of a wellpad. Sawyer et al. (2009) found that the avoidance distance for wellpads using liquid gathering systems (2.6 km) was less than the avoidance distance for conventional wellpads (4.3 km); avoidance of active drilling extended outward to 7.5 km. Northrup et al. (2015) found that mule deer avoided wellpads with active drilling by 800m, and avoided post-drilling, producing wellpads by 600m. Mule deer displayed 100% avoidance of habitats within 200m of wellpads (Northrup et al. 2015). Lendrum et al. (2012) found no avoidance of wellsites by migrating mule deer in western Colorado, but did document habitat selection shifts and accelerated migration times, and hypothesized that deer have strong fidelity to established migration routes that overcomes the tendency toward avoidance documented by other studies.

Lendrum et al. (2012) found that mule deer avoided roads during their migrations at moderate levels of oil and gas development, but as development densities increased, road avoidance was no longer possible and deer showed no pattern of avoidance. This finding could have a knock-on population effect, as deer in highly developed wellfields with more roads and displaying less behavioral avoidance of roads would likely experience greater collision mortality from vehicle traffic. Stewart et al. (2010) found that mule deer in southeastern Idaho selected habitats closer to roads, but attributed this to avoidance of elk, which selected habitats farther from roads. Ager et al. (2003) found that mule deer avoided roads, but still used habitats closer to roads (400-600m distant) than did elk (600 to 900m distant).

Northrup et al (2015) reported that based on their avoidance buffers, about half of winter range was impacted by day, and 25% was impacted by night.

Oil and gas development creates a semi-permeable barrier to mule deer migration (Sawyer et al. 2013). Mule deer fidelity to traditional migration routes is quite strong, even in the face of oil and gas development (Wyckoff et al. 2018). Rather than detouring around energy development, mule deer speed up their migrations when traversing developed oil and gas wellfields (Lendrum et al. 2012, 2013, Sawyer et al. 2013, Wyckoff et al. 2018). In the face of oil and gas development, mule deer shift toward habitats with more cover while migrating, and use more open habitats during migration where oil and gas development is absent (Lendrum et al. 2012). During migrations, mule deer use of stopover habitats, essential to maintain body condition, decrease in the face of oil and gas development relative to undeveloped habitats (Wyckoff et al. 2018). When migration routes become obstructed, mule deer populations can experience major declines (e.g., Bertram and Remple 1977). Sawyer et al. (2020) determined that habitat use by migrating mule deer sharply declined where total surface disturbance exceeded 3% measured at the scale of 0.68 mi^2 circular units.

Methods

For our analyses, we projected mapped development against mapped key habitats for elk and mule deer using Geographic Information System (GIS) software. For elk, we used Colorado Parks and Wildlife Department map layers for elk production range, elk winter range, elk severe winter range, and elk winter concentration areas For mule deer, we used CPW mule deer summer range, mule deer winter range, mule deer severe winter range, and mule deer winter concentration are, projecting them over map layers of roads and wellpads. We pooled winter range, mule severe winter range, and winter concentration for each species are to describe total mule deer winter habitats. Well (COGCC) and road data (Eagle County, Mesa County, Garfield County, Garfield County, Pitkin County, Forest Service, and Bureau of Land Management. To determine open habitats and wooded habitats, we used the National Land Cover Database (NLCD). satellite imagery were procured from National Agricultural Imagery Program (NAIP) to determine area of ungulate habitat falling within critical disturbance zones or exceeding density criteria, in order to determine the proportion of habitats that have presently been disturbed for both mule deer and elk populations in the Upper Colorado River Field Office. We also digitized newer roads from the most recent NAIP to supplement older spatial data. CPW provides "production range" for elk, to describe habitats used for parturition. For mule deer, summer range was a surrogate for parturition range. All maps and analyses are clipped to the BLM's Colorado River Valley Field Office boundary.

GIS Mapping Results for the Colorado River Field Office

Crucial seasonal habitats for native ungulates in the Colorado River Valley Field Office have already been impacted to a heavy degree. For elk, when projecting a 2.5 km buffer for the disturbance of roads and wellpads, which in this area is driven primarily by oil and gas development, 97.9% of elk winter and parturition ranges already are impacted (95.4% of parturition habitats or "production areas," and 98.1% of winter ranges), and subject to avoidance and/or elevated stress by elk. See Figure 1. Using the more conservative buffers of 1.2 km for open habitats and 0.4 km for wooded habitats, some 60.5% of elk winter ranges and parturition habitats already have been impacted by roads and development. Figure 2. Using the same combination of buffers for open and wooded habitats, 63.1% of winter ranges and 42.6% of parturition habitats/production areas are subject to elk avoidance. When considering road densities per square mile, rather than buffer distances from existing roads, some 82.8% percent of elk winter and parturition habitats are presently impacted by road densities exceeding 1 mile per square mile. Figure 3. Some 84.5% of elk winter ranges and 95.4% of parturition habitats are affected by road densities exceeding one mile per square mile.

Considering mule deer summer and winter ranges, when buffering existing roads and wellpads by 1 km for open habitats and 0.6 km for wooded habitats, 61.1% of mule deer habitats are already impacted by the present network of roads and wellsites. Figure 4. Within these overlapping habitats, 58.6% of summer habitats are impacted, while 75.6 % of winter habitats are impacted. Considering mule deer fawn production, which declines when roads are sited within 2.7 km, some 99.4% of mule deer fawning habitats fall within 2.7 km of a road. Figure 5. At present, 1.6% of mule deer summer and winter ranges fall within 0.2 km of roads and wellpads, indication total loss of habitat effectiveness. Figure 6. Considering the critical surface disturbance of 3% per square mile for mule deer, 21.1% of the Field Office is past this critical threshold for mule deer summer habitats and winter ranges combined. Figure 7. Over the same geography, 38.2% of winter ranges exceed the 3% disturbance threshold, while 12.7% of summer ranges are past this threshold.

Conclusions

The combined residential and industrial development footprint in the Upper Colorado River Field Office is already quite heavy, with overwhelming majority of key seasonal habitats for both elk and mule deer already within the zone of disturbance for these animals. The likely outcome is that for both elk and deer, insufficient undisturbed habitat presently exists in the Upper Colorado River F.O. to maintain optimal survival and reproduction for these species. The Grand Mesa elk population, and North Grand Mesa, Maroon Bells, Red Table Mountain, and Basalt mule deer populations, are at particular risk due to being below habitat objectives. Due to the scarcity of undisturbed habitats, the overwhelming likelihood is that both elk and deer in this region are constrained to use habitats that are subject to levels of human disturbance and activity that result in increased stress, inability to optimally use appropriate seasonal habitats (and their forage resources), hurried or interrupted seasonal migrations resulting in lowered body condition, and ultimately population-level effects including increased mortality and decreased recruitment of young animals to the population.

We recommend closing all elk and mule deer winter and parturition habitats to future oil and gas development. In addition, lands not currently exceeding key thresholds (either road/disturbance density, or within buffer distances for avoidance, should be buffered by 2.5 miles to account for the scientifically-demonstrated avoidance criteria, and also withdrawn from future oil and gas leasing. For existing leases, additional conditions of approval must be applied at the application for permit to drill stage. Mule deer and elk migration corridors must be identified and buffered by a minimum of 2.5 km, and the same stringent development criteria should apply to these areas as well. These reforms can (and should) be formalized through designation of Areas of Critical Environmental Concern and Forest Service Research Natural Areas through the planning process, and in the interim federal agencies can (and should) exercise their broad administrative discretion to opt not to approve additional industrial impacts in sensitive habitats used by elk and mule deer. New wellsites should be prohibited in sensitive elk and mule deer habitats, adding to the already-excessive levels of disturbance faced by these species. Directional drilling technologies have been in place allowing the achievement of 8-mile horizontal displacement, and allowing multiple wells, in large numbers, to be drilled from a single wellsite (Molvar 2003).

This report also highlights the fact that the cumulative impacts of oil and gas development together with residential development and the pre-existing network of logging roads has so fragmented elk and deer habitats that their ability to use critical habitats and migration corridors is severely hampered, subjecting individuals to stress and displacement to suboptimal habitats, and contributing to population-level declines. In light of these results, federal agencies can no longer pretend that individual oil and gas projects and well siting decisions do not have a significant environmental impact on elk and mule deer populations. Instead, agencies (from the county to the state to the federal levels) must conduct serious and credible cumulative effects analyses prior to approving additional energy development or other road and residential developments in important ungulate habitats.

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