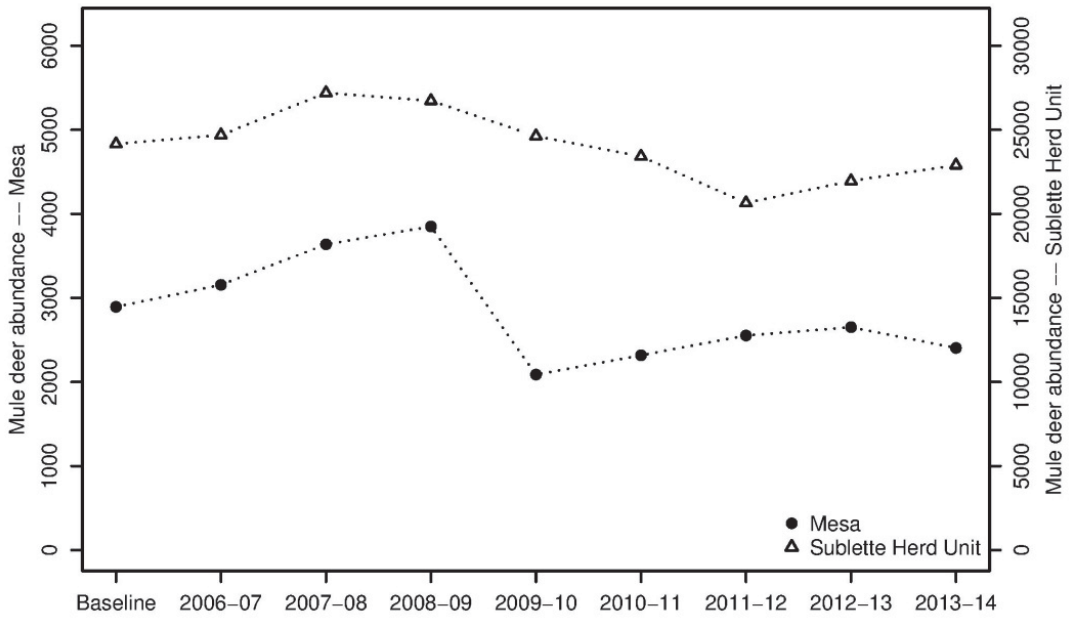
Mule Deer Monitoring in the Pinedale Anticline Project Area

2014 Annual Report Update



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NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

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SUGGESTED CITATION

Sawyer, H. and R. Nielson. 2014. Mule deer monitoring in the Pinedale Anticline Project Area: 2014 Annual Report Update. Western Ecosystems Technology, Inc., Laramie, WY.

SECTION I: Wildlife monitoring and mitigation matrix

OVERVIEW

As part of the record of decision for natural gas exploration and development in the Pinedale Anticline Project Area (PAPA), the Bureau of Land Management (BLM) developed a Wildlife Monitoring and Mitigation Matrix (WMMM) that provides direction for development-phase wildlife monitoring (BLM 2008). For mule deer, the WMMM was intended to identify monitoring parameters that allow changes in mule deer abundance to be quantitatively assessed. Monitoring was intended to be consistent with previous efforts that began in 2001 (Sawyer et al. 2009*a*), such that comparisons across years could be made. The WMMM specifies that mitigation measures will be triggered if a 15% decline in mule deer abundance is detected in any year relative to the Sublette herd unit, using the average of population estimates from winter's 2004-05 and 2005-06 as the baseline (BLM 2008). Here, we report monitoring results for the winter of 2013-14, where population estimates indicate the Mesa portion of the herd unit has declined more than the Sublette herd unit as a whole, since the baseline.

METHODS

Abundance

We estimated abundance in the Mesa portion of the PAPA using aerial counts similar to Freddy et al. (2004). The sampling frame was 68 mi^2 and reflected the relative size of the winter range (Fig. 1). We systematically sampled 46 1-mi^2 quadrat units and then surveyed those units by helicopter. In past years, 50% (n=34) of the quadrats were flown, however beginning in 2010, the number of sampled quadrats increased to 46 in an effort to increase precision of abundance estimates. The same 46 quadrats have been flown every winter since 2010. A real-time flight path was traced into the on-board global positioning system (GPS) and once the perimeter of the quadrat was established, all mule deer within the quadrat were counted. Although group size and vegetative cover may influence probability of detection (Samuel et al. 1987), we did not correct for potential visibility bias because the study area did not contain forest vegetation; rather it was characterized by homogenous sagebrush stands and snow cover. Further, when survey areas contain large numbers of animals that are widely distributed, recognition of individual groups may be nearly impossible, and thus attempting to determine visibility correction factors for groups is not feasible in these situations (Samuel et al. 1987). Regardless, consistency in surveying the same quadrats using the same methods and observer since 2001 strengthens our ability to detect trends in abundance. We used equations from Thompson et al. (1998) to calculate abundance and variance estimates.

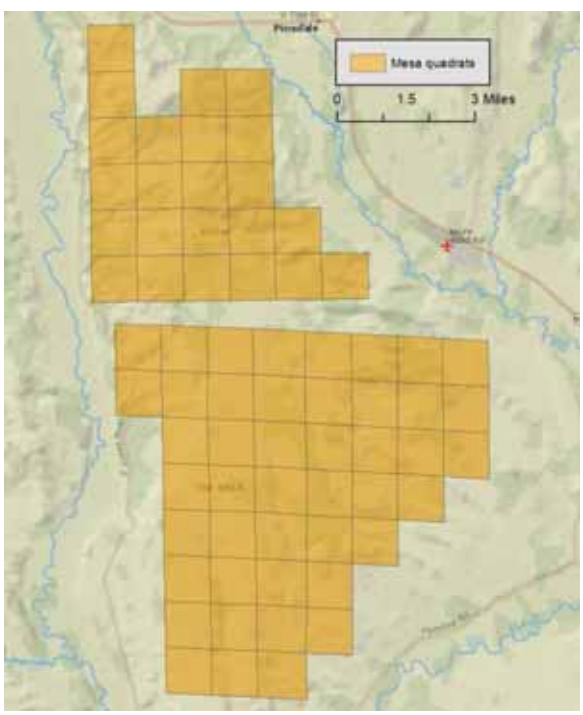

Figure 1. Location of 1-mi^2 quadrats in Mesa study area (*n*=68).

As requested by PAPO, we compared abundance estimates in the Mesa with those estimated by the Wyoming Game and Fish Department (WGFD) for the entire Sublette herd unit. We note that using the herd unit as a reference area is of limited value because the reference area should not contain the treatment area (PAPA), as the treatment will affect what is observed in the reference. Thus, the comparison does not allow potential treatment effects (e.g., gas development) to be discerned from the reference area. Additionally, the WGFD herd estimates were based on models and not actual counts.

RESULTS

Abundance

The WMMM considers changes in mule deer abundance on the Mesa using a baseline of 2,856, derived by averaging the winters of 2004-05 (2,818) and 2005-06 (2,894). The baseline for the reference area (Sublette herd unit) was identified as 27,254 in the WMMM (BLM 2008). To determine whether the mitigation threshold (15%) was exceeded, we calculated the observed population change in the Mesa from the baseline to present, and compared that to the population change observed in the reference area during the same time period (Table 1). Between the baseline winter and 2013-14, mule deer abundance on the Mesa declined 16%, whereas the Sublette herd unit declined by 5%.

Table 1. Mule deer abundance estimates, standard errors (SE), and percent change for the Mesa and Sublette herd unit, baseline winter through 2013-14.

Winter	Mesa			Sublette Herd Unit			Threshold Exceeded?
	Estimate	SE	% Change	Estimate	SE	% Change	
baseline*	2,856*	n/a	baseline*	24,165	n/a	baseline	baseline
2006-07	3,156	470	10%	24,699	n/a	2%	NO
2007-08	3,638	424	27%	27,200	n/a	13%	NO
2008-09	3,850	322	35%	26,732	n/a	11%	NO
2009-10	2,088	325	-27%	24,630	n/a	2%	YES
2010-11	2,318	212	-19%	23,426	n/a	-3%	YES
2011-12	2,553	210	-11%	20,652	n/a	-15%	NO
2012-13	2,652	220	-7%	21,969	n/a	-9%	NO
2013-14	2,405	243	-16%	22,900	n/a	-5%	NO

* Note: the record of decision (ROD; BLM 2008) uses 2,856 as the baseline and was derived from the average of 2004-05 and 2005-06 estimates.

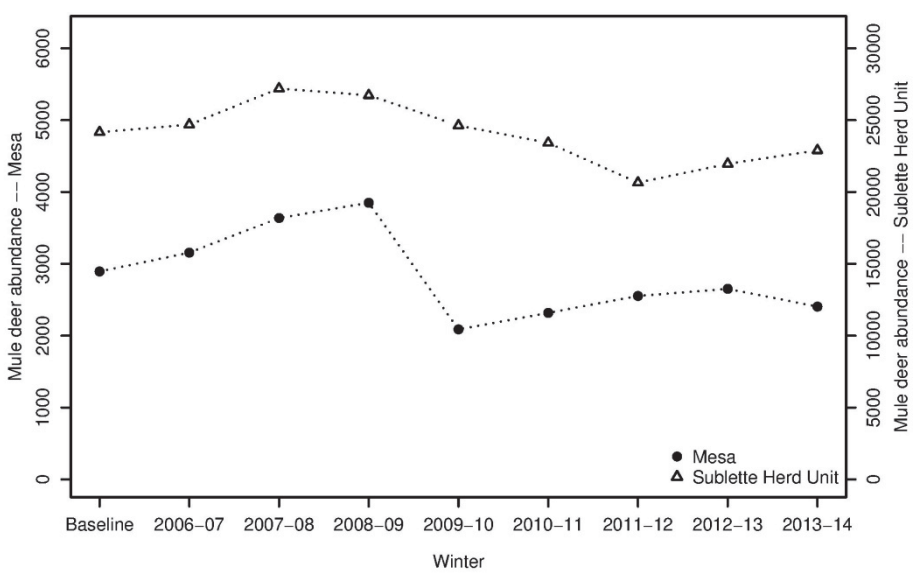

Figure 2. Mule deer abundance estimates for the Mesa and Sublette herd unit, baseline winter through 2013-14.

SECTION II: Habitat use

OVERVIEW

While not part of the WMMM, but in support of the mule deer monitoring effort, we attempt to maintain a sample (~30 animals) of GPS-collared deer in both the Mesa and Ryegrass-Soapholes areas to document movements and help ensure abundance estimates are not influenced by movements of animals between the two areas (i.e., marked animals occupy their respective winter ranges when we conduct counts). The GPS data provide additional opportunity to examine winter habitat use patterns and update migration routes for the Mesa and Ryegrass-Soapholes sub-populations, which have been reported annually since the WMMM was implemented. However, in an effort to reduce costs and take advantage of improved GPS technology, the GPS collars now remain on animals 2.5 years, rather than dropping off after only 1 year of deployment. Accordingly, the habitat-use analysis will be updated every 3 years. Here, we present the Mesa habitat use analysis for winters 2011-12, 2012-13, and 2013-14. The habitat use models and predictive maps help document and display how habitat variables (e.g., elevation, terrain roughness, distance to well pad) influence deer use across the entire study area.

METHODS

Capture and Collaring

We captured 19 adult female mule deer on the Mesa in January 2012 and equipped them with store-on-board GPS collars. Another 7 deer were captured in December 2012, 3 in February 2013, and 4 in December 2013. Consistent with previous years, we attempted to sample deer in proportion to their relative abundance across the Mesa winter range. Collars were programmed to collect locations every 2 hours during non-summer months and every 5 hours during summer (June 15 – September 15). Collars were equipped with release mechanisms designed to drop the collar off the animal on April 1, 2014. However, in an effort to monitor the same individual animals through time, we recaptured animals in March 2014 (prior to collars dropping) and replaced old collars with new ones.

Habitat use

We developed habitat use models for the winters of 2011-12, 2012-13, and 2013-14 using GPS locations collected from marked animals between December 01 and March 31. We followed the approach of Nielson and Sawyer (2013), where a generalized linear model was used to estimate probability of use as a function of habitat variables (e.g., slope, elevation, etc.), with an error term following a negative binomial distribution. This approach combines data from all GPS-collared animals to estimate a population-level model and then bootstraps individual animals to estimate standard errors (SEs) and 90% confidence intervals (CIs) for model coefficients. Key advantages of this approach are that it weights the location data (i.e., number of locations per animal) from each animal appropriately (Thomas and Taylor 2006), treats the animal as the primary sampling unit (Thomas and Taylor 2006), and allows for information-theoretic approaches to model selection (Burnham and Anderson 2002).

We used the same study area as defined in earlier work on the PAPA (Sawyer et al. 2006, 2009), which we refer to as the Mesa. We then measured habitat variables at 10,000 randomly selected circular sampling units with 100-m radii. We considered a suite of habitat variables, including: elevation, slope, aspect, a terrain roughness index, and distance to well pad, distance to road, road density, and percent disturbance. Elevation, slope, aspect, and roughness were calculated from 10-m digital

elevation models. Aspect was transformed into continuous variable (0 to 1) using the TRASP function (Roberts and Cooper 1989) from the Geomorphometric and Gradient Metrics Toolbox (GGMT) in ARCGIS, where values near 1 correspond to land with north-northeast orientation and values near 0 reflect south-southwest orientation. Terrain roughness was also calculated from the GGMT (Blaszcyznski 1997, Riley et al. 1999). Roads and well pad locations were digitized from SPOT imagery with 10-m resolution. Prior to modeling, we conducted a Pearson's pairwise correlation analysis to identify possible multicollinearity issues and determine whether any variables should be excluded from the model ($|r| \geq 0.60$). Next, we counted the number of mule deer locations in each of the 10,000 sampling units and used those counts as the response variable in a multiple regression analysis to estimate the probability of use as a function of habitat variables. We used a stepwise model selection process and Akaike's Information Criterion (AIC) to determine the best model. Once the top model was identified, we then bootstrapped the individual animals to estimate SEs and 90% CIs for the model coefficients. Our final step was to then map predictions of the habitat use model. We note that average GPS fix success was >99%, so habitat-induced fix-rate bias (Frair et al. 2004, Nielson et al. 2009) was not a concern.

RESULTS

We used 17,927 locations collected from 22 GPS-collared deer, 20,569 locations from 23 deer, and 13,806 locations from 17 deer to estimate a population-level habitat use models and predictive maps for the Mesa during winters 2011-12, 2012-13, and 2013-14, respectively (Figs. 3-6). Based on AIC values, the top model included 3 habitat variables: elevation, terrain roughness, and distance to well pad (Table 2). The 90% CIs for elevation coefficients overlapped with zero 2 of 3 winters, which suggests there was considerable variation in the elevations that individual deer utilized. The same pattern was true for distance to well pad variable in winters 2011-12 and 2012-13. The 90% CIs for terrain roughness never overlapped zero, indicative of consistent use among individual animals. Among all the various disturbance metrics considered (e.g., road density, well percent disturbance, distance to well pad), the model with distance to well pad had the lowest AIC value. In general, deer selected for areas with moderate to high elevations, rough terrain, and away from well pads (Fig. 7). The high-use areas depicted in the predictive maps (Figs. 13-14) identified the northern part of the Mesa and surrounding "flanks" as high use habitat, whereas most of the areas with intensive drilling were lower use.

Table 2. Estimated coefficients and 90% confidence intervals for habitat use models, winters 2011-12, 2012-13, and 2013-14 on the Mesa study area.

Variable	Winter 2011-12 coefficients	Winter 2012-13 coefficients	Winter 2013-14 coefficients	90% CI overlap with 0
Intercept	-0.060600	-0.014350	-0.801000	n/a
Elevation	0.521500	0.104200	0.042570	no, yes, yes*
Elevation^2	-0.000114	-0.000020	-0.000005	no, yes, yes
Roughness	0.461900	0.771700	0.653800	no, no, no
Distance to well pad	0.113200	0.424700	0.291800	yes, yes, no
Distance to well pad^2	0.028160	-0.028000	n/a	yes, yes, n/a

*Cis that do not overlap with zero indicate statistical significance and consistent use among individual animals

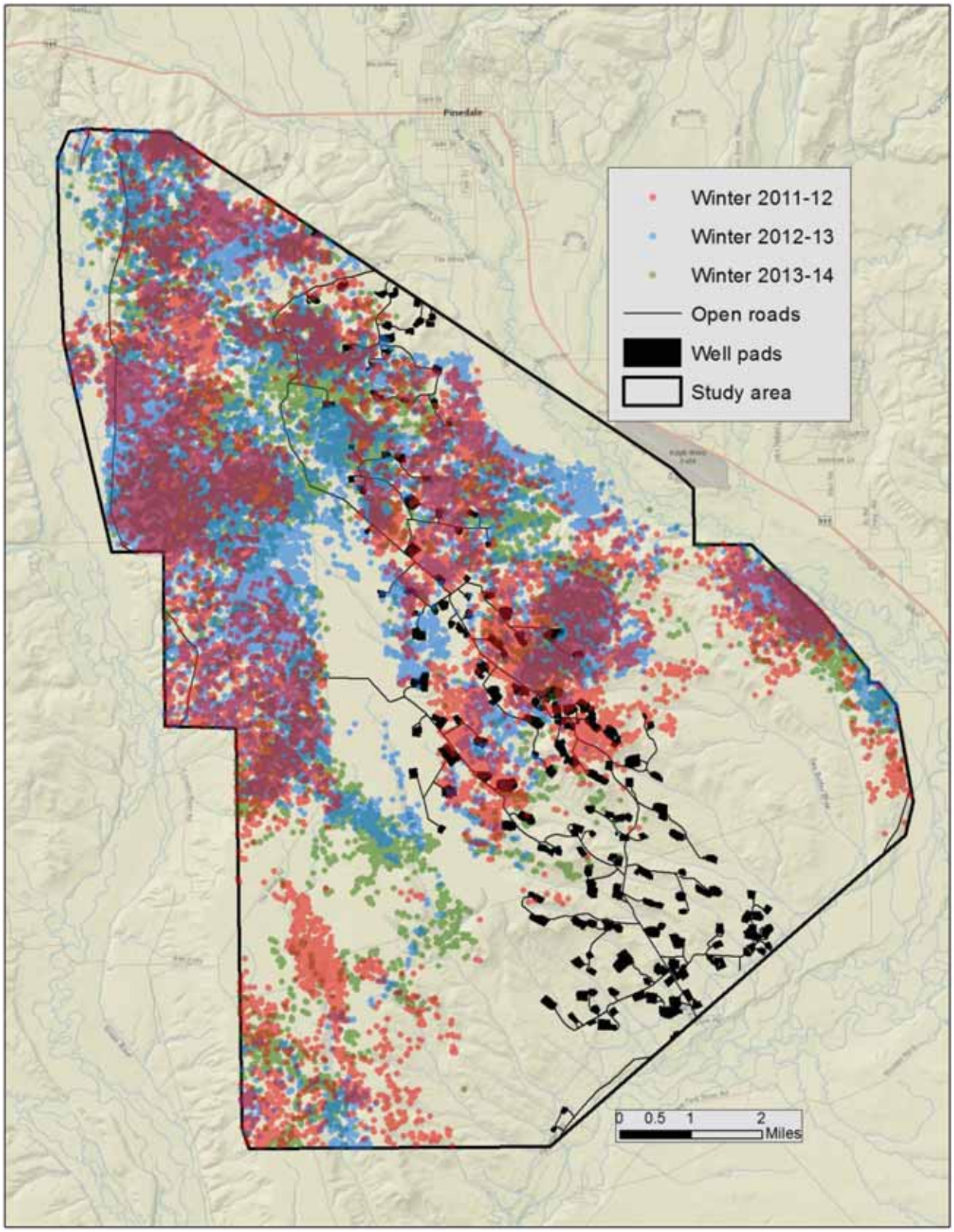

Figure 3. GPS locations collected during winters 2011-12 (*n*=17,927), 2012-13 (*n*=20,569), and 2013-14 (*n*=13,806) in Mesa habitat use study area.

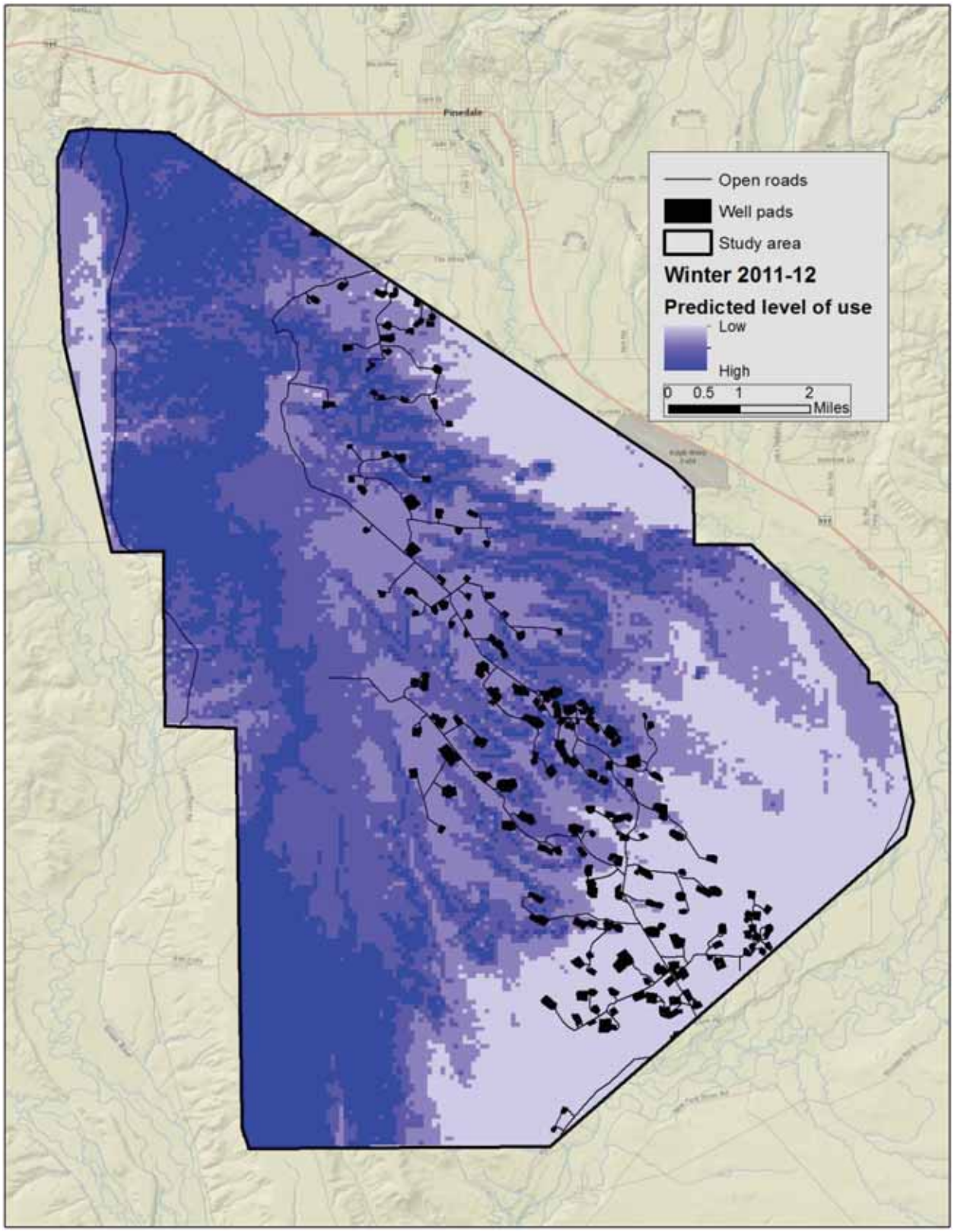

Figure 4. Predicted level of mule deer use in the Mesa study area during the 2011-12 winter.

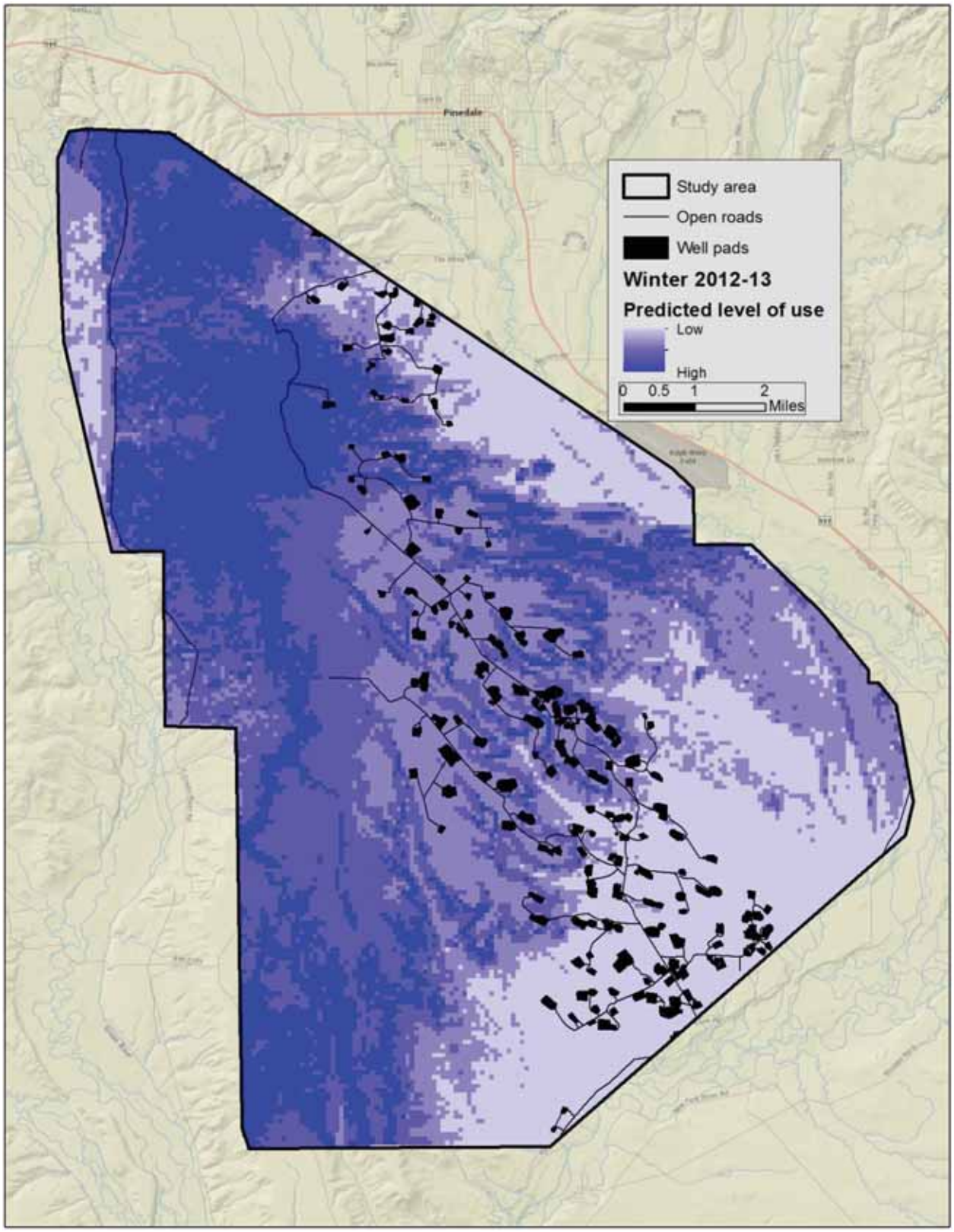

Figure 5. Predicted level of mule deer use in the Mesa study area during the 2012-13 winter.

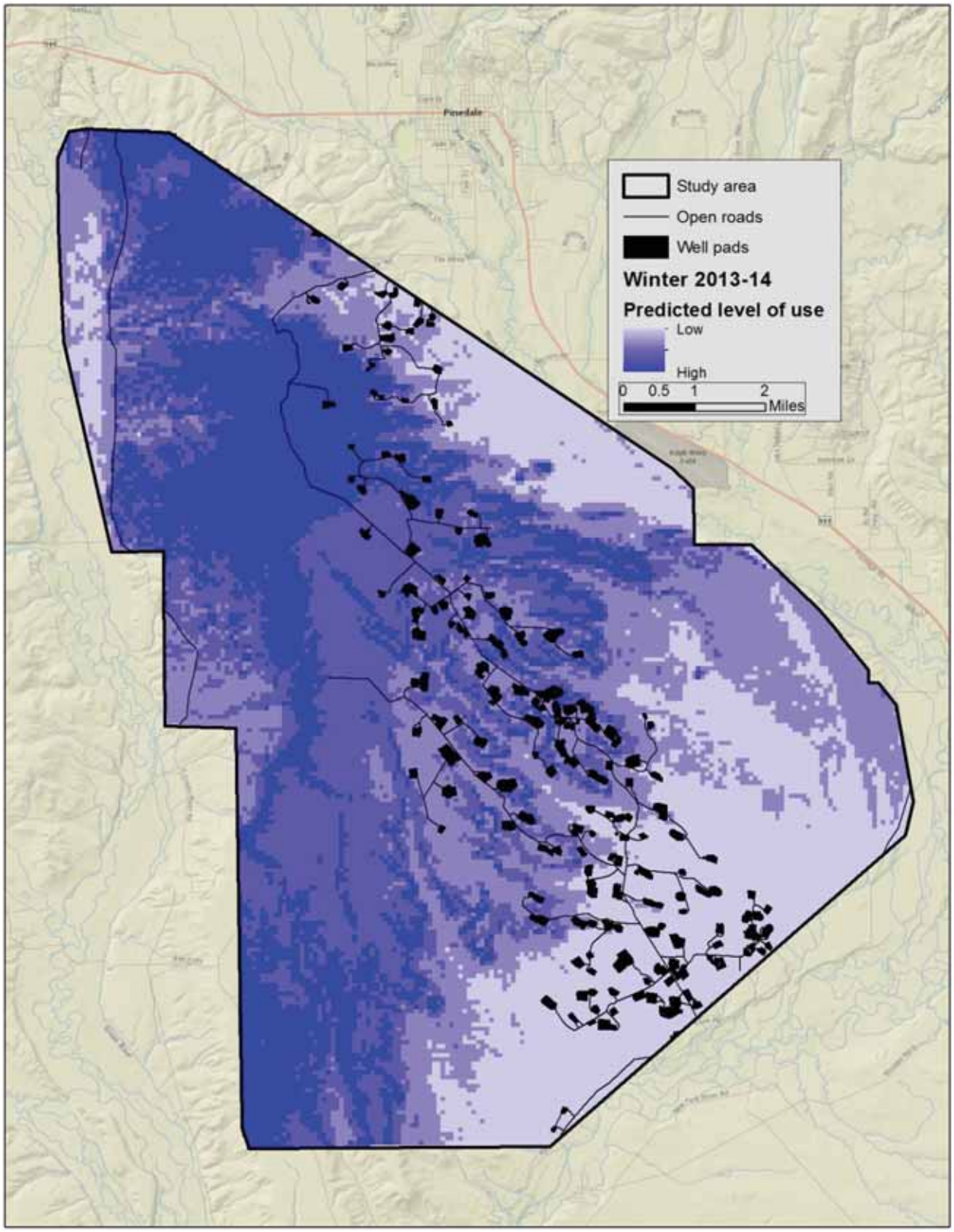

Figure 6. Predicted level of mule deer use in the Mesa study area during the 2013-14 winter.

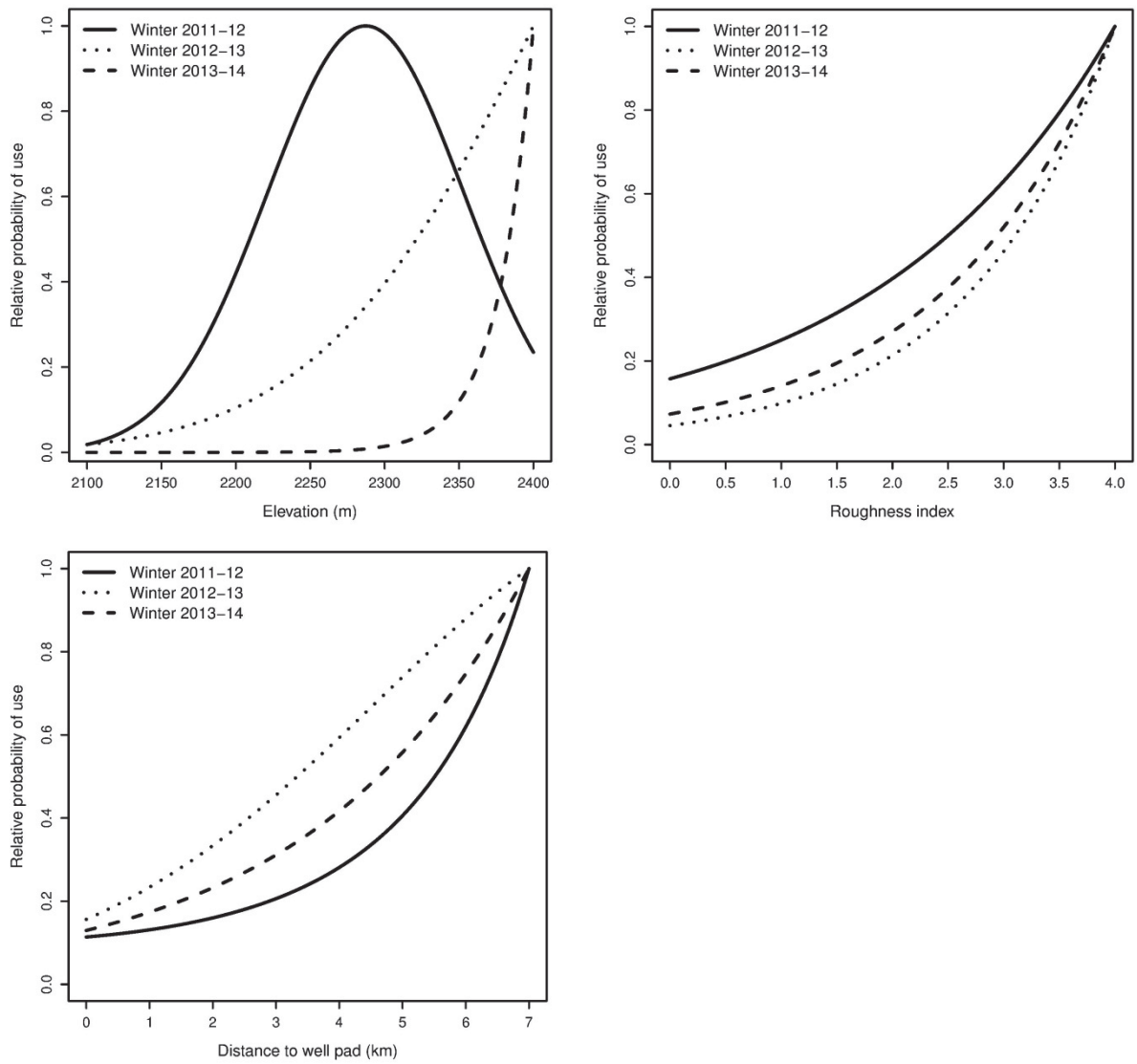

Figure 7. Influence of elevation, terrain roughness, and distance to well pad on the relative probability of deer use during the winters of 2011-12, 2012-13, and 2013-14. Mule deer selected for areas with higher elevations (top left), rough terrain (top right), and away from well pads (lower left).

SECTION III: Long-term mule deer trends in Pinedale Anticline and Ryegrass-Soapholes

OVERVIEW

As part of the record of decision for natural gas exploration and development in the Pinedale Anticline Project Area (PAPA), the Bureau of Land Management (BLM) developed a Wildlife Monitoring and Mitigation Matrix (WMMM) that provides direction for development-phase wildlife monitoring (BLM 2008). For mule deer, the WMMM was intended to identify monitoring parameters that allow changes in mule deer abundance since 2006 to be quantitatively assessed. However, mule deer monitoring began in 2001 (Sawyer et al. 2009), following the original record of decision (BLM 2000). While not a component of the WMMM, here we report the long-term trends in mule deer abundance in the PAPA, as they are important for understanding the population dynamics of the Sublette deer herd in relation to gas development. Long-term trends indicate that mule deer have declined at higher rates in the Mesa portion of the PAPA compared to the larger Sublette herd unit and nearby Ryegrass-Soapholes area.

METHODS

Abundance

We estimated abundance in the Mesa portion of the PAPA using aerial counts similar to Freddy et al. (2004). The sampling frame was 68 mi^2 and reflected the relative size of the winter range (Fig. 1). We systematically sampled 46 1-mi^2 quadrat units and then surveyed those units by helicopter. In past years, 50% (*n*=34) of the quadrats were flown, however beginning in 2010, the number of sampled quadrats increased to 46 in an effort to increase precision of abundance estimates. The same 46 quadrats have been flown every winter since 2010. A real-time flight path was traced into the on-board global positioning system (GPS) and once the perimeter of the quadrat was established, all mule deer within the quadrat were counted. Although group size and vegetative cover may influence probability of detection (Samuel et al. 1987), we did not correct for potential visibility bias because the study area did not contain forest vegetation; rather it was characterized by homogenous sagebrush stands and snow cover. Further, when survey areas contain large numbers of animals that are widely distributed, recognition of individual groups may be nearly impossible, and thus attempting to determine visibility correction factors for groups is not feasible in these situations (Samuel et al. 1987). Regardless, consistency in surveying the same quadrats using the same methods and observer since 2001 strengthens our ability to detect trends in abundance. We used equations from Thompson et al. (1998) to calculate abundance and variance estimates.

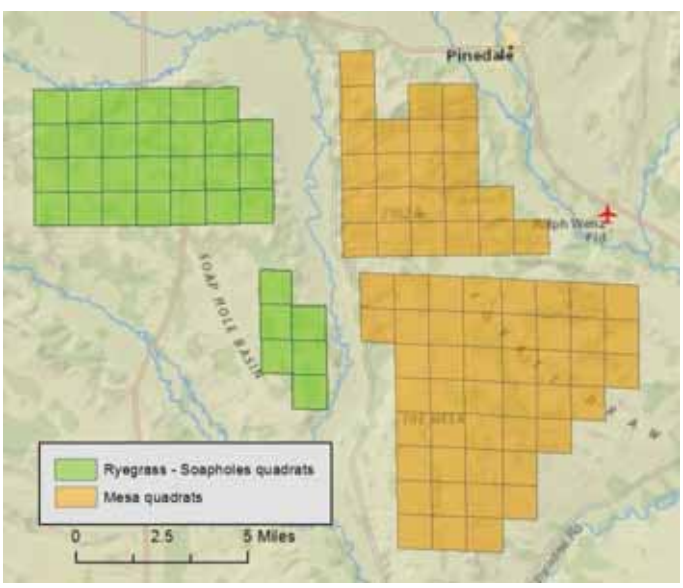

Figure 8. Location of 1-mi^2 quadrats in Mesa (*n*=68) and Ryegrass-Soapholes (*n*=33).

In contrast to the WMMM in Section I, where population estimates from one year were compared to another year, here we used regression analysis to examine population trends through time. This type of analysis is more likely to reflect true changes in population because it is not as sensitive to natural year-to-year variation in abundance. We used a weighted linear regression to account for differences in annual variation in the estimates of abundance.

RESULTS

Abundance

Mesa: We conducted aerial surveys in the Mesa during the winters of 2001-02 through 2013-14 (Table 3). A weighted regression analysis revealed a negative trend over the 13-year period (*Abundance in the Mesa* = 4164 – 147[*year*], $P = 0.007$) with an average decline of 147 deer per year (Fig. 9). Based on the 13-year weighted regression trend, deer abundance declined 44% from 2001 to 2013.

Sublette Herd Unit: During the same time period, WGFD population estimates for the larger Sublette herd unit suggest deer numbers declined less than those observed in the Mesa (Table 3 and Fig. 10). Regression analysis indicated a negative trend over the 13-year period (*Abundance in Sublette herd unit* = 30257 - 684[*year*], $P = <0.001$), with an average decrease of 684 deer per year. The 13-year regression trend indicates deer abundance declined by 27% (Fig. 10).

Ryegrass-Soapholes: As another comparison, we conducted aerial surveys west of the Mesa in the Ryegrass-Soapholes area, beginning in 2006 (Table 3). Consistent with other average and mild winters, GPS data to date indicate that Ryegrass-Soapholes mule deer rarely intermix with Mesa deer. The weighted regression analysis revealed no positive or negative trend across the 8-year period (*Abundance in Ryegrass-Soapholes* = 1382 + 13[*year*], $P = 0.85$; Fig. 11).

Table 3. Mule deer abundance estimates and standard errors (SE) for the Mesa, Sublette Herd Unit, and Ryegrass-Soapholes, winters 2001-02 through 2011-12.

Winter	Mesa		Sublette Herd Unit		Ryegrass - Soapholes	
	Estimate	SE	Estimate	SE	Estimate	SE
2001-02	5,228	820	32,011	n/a	--	--
2002-03	4,676	614	28,881	n/a	--	--
2003-04	3,564	395	29,670	n/a	--	--
2004-05	2,818	325	24,115	n/a	--	--
2005-06	2,894	311	24,215	n/a	--	--
2006-07	3,156	470	24,699	n/a	986	237
2007-08	3,638	424	27,200	n/a	1,106	260
2008-09	3,850	322	26,732	n/a	1,862	249
2009-10	2,088	325	24,630	n/a	2,223	201
2010-11	2,318	212	23,426	n/a	1,109	180
2011-12	2,553	210	20,652	n/a	1,727	165
2012-13	2,652	220	21,969	n/a	1,210	92
2013-14	2,405	243	22,900	n/a	1,547	138

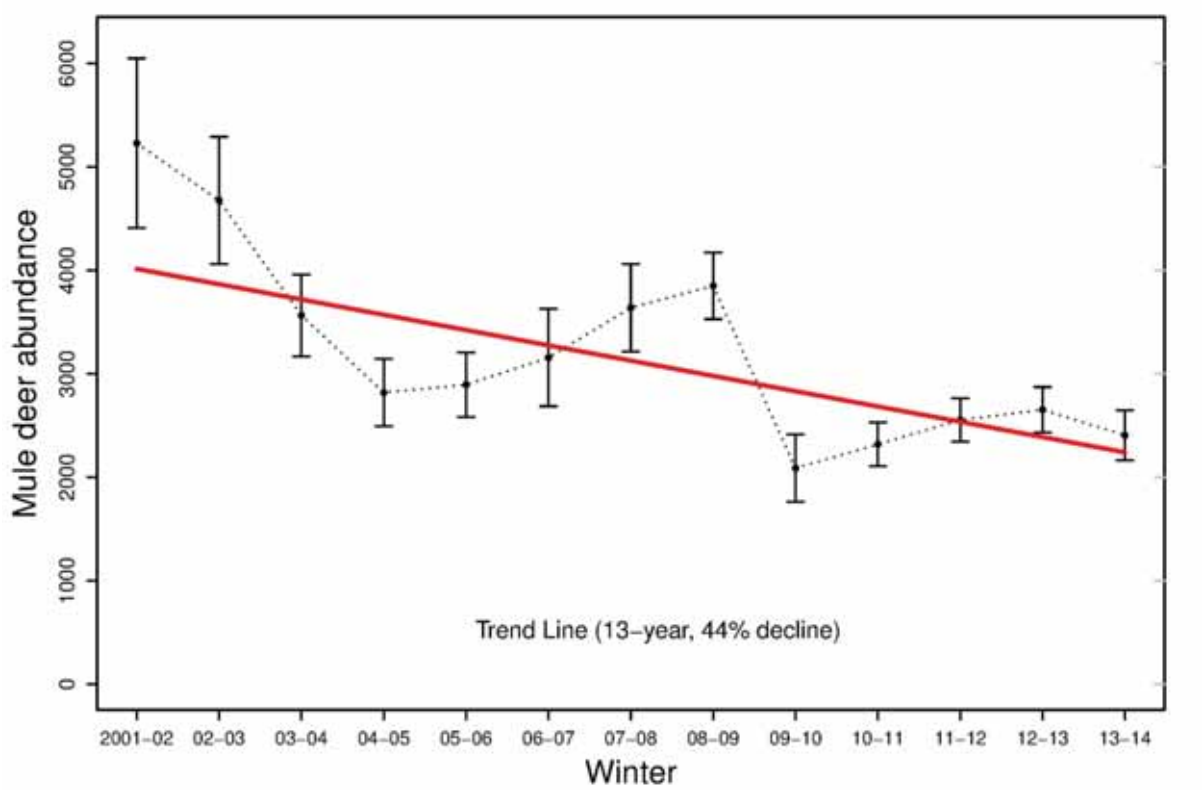

Figure 9. Mule deer abundance estimates (± SE) and 13-year negative trend (-44%) for the Mesa.

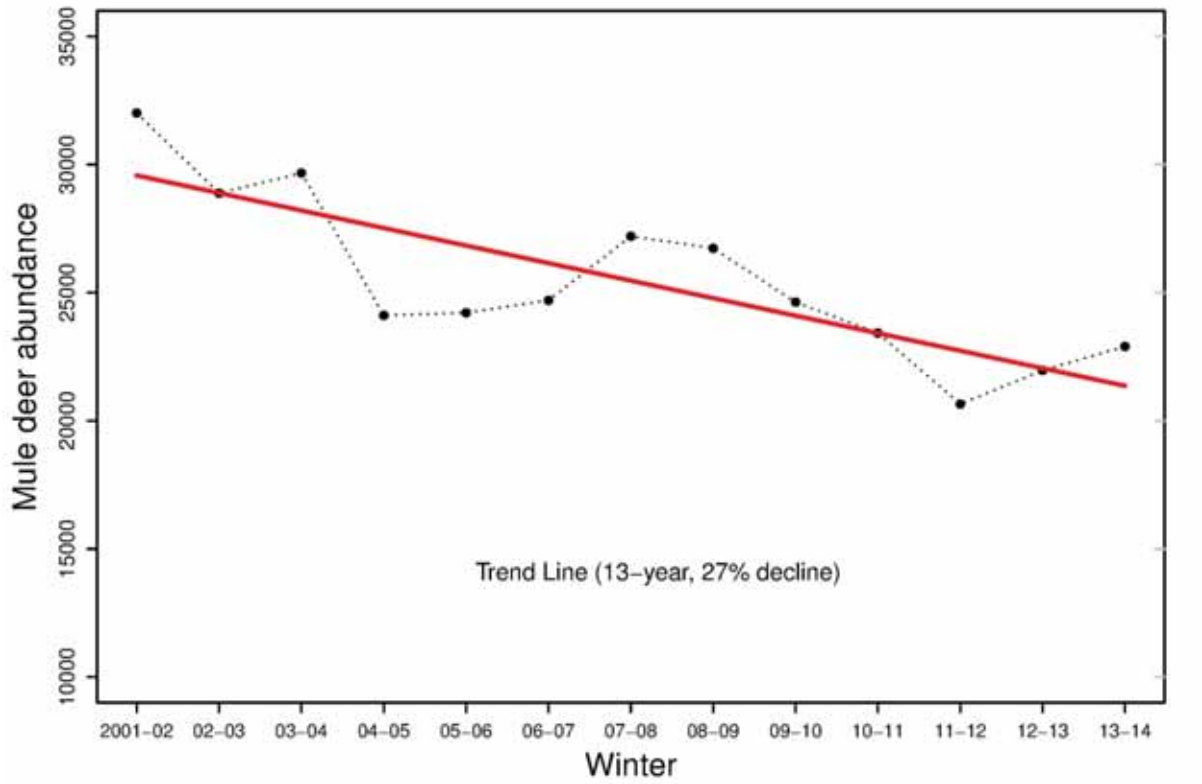

Figure 10. Mule deer abundance estimates and 13-year negative trend (-27%) for the Sublette herd unit.

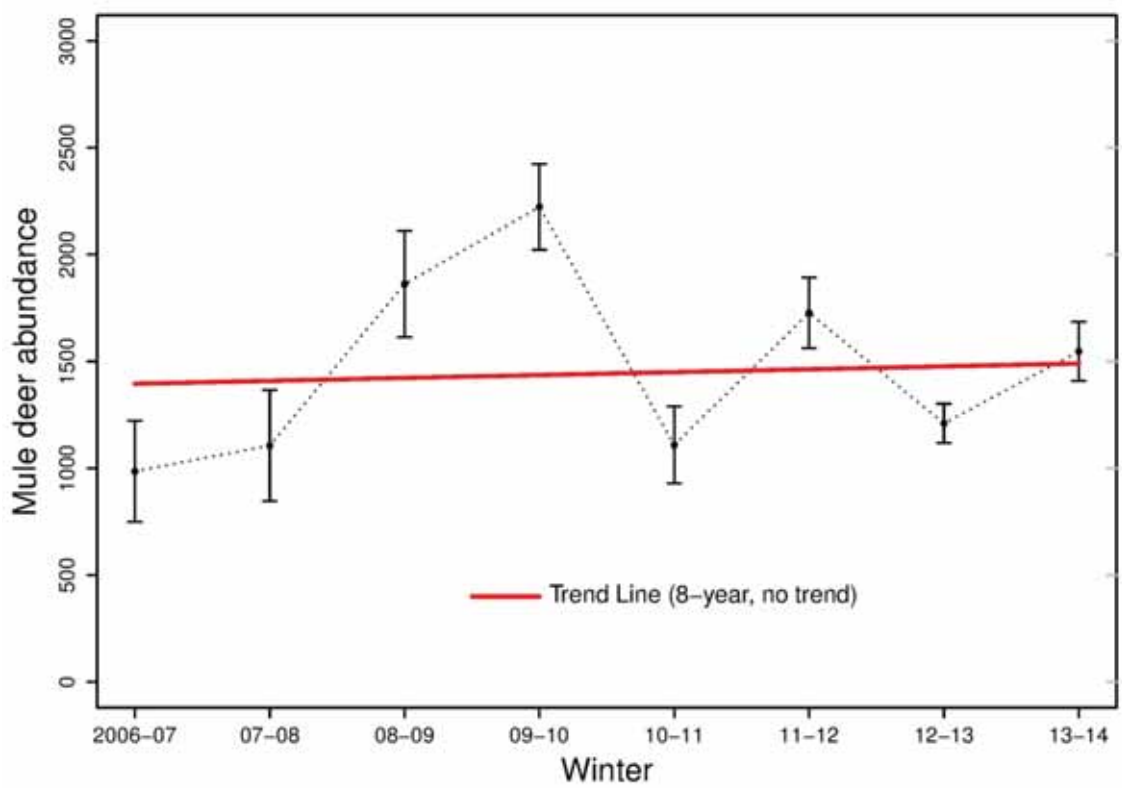

Figure 11. Mule deer abundance estimates (± SE) and 8-year trend line for the Ryegrass -Soapholes area. Although the trend line indicates a slight increase, the positive trend was not statistically significant.

DISCUSSION

Our task was to estimate mule deer abundance in the Mesa and compare population changes with those observed in the larger Sublette herd unit and an adjacent winter range with no gas development (i.e., Ryegrass-Soapholes area). Since large-scale gas development began (BLM 2000), the 13-year (2001-2013) trend in mule deer abundance on the Mesa shows an overall decline of 44%. This decline was concurrent with documented behavioral changes of mule deer avoiding well pads (Sawyer et al. 2006, 2009*a*, *b*). Of interest here is whether mule deer numbers declined at a similar rate in other portions of the Sublette herd unit. The PAPO requested that abundance in the Mesa be compared to population estimates modeled by the WGFD for the entire Sublette herd unit. The 13-year (2001-2013) trend in mule deer abundance for the entire herd unit indicated an overall decline of 27%. Because there was no variance estimate associated with the WGFD numbers, the precision of year to year variation in herd unit numbers is unknown. Nonetheless if we assume the herd estimates are reliable, then mule deer in the Mesa have declined at a higher rate compared to the larger herd unit. However, it is important to note that the Sublette herd unit contains the Mesa, so population trends in the Mesa can significantly influence those observed in the larger herd unit. Thus, comparing the Mesa with the larger Sublette herd does not allow potential treatment effects (e.g., gas development) to be discerned.

As an additional comparison, the Ryegrass-Soapholes area was identified as a potential study area in 2006 because GPS data suggests minimal deer movement between the two areas when winter surveys are conducted. Comparison with the Ryegrass-Soapholes is advantageous because the same abundance estimations methods (quadrat counts) are used there, and because of their close proximity, the two areas experience similar winter conditions. The 8-year population trend in the Ryegrass-

Soapholes has been stable, whereas the long-term abundance trend in the Mesa has declined. Using both the herd unit and Ryegrass-Soapholes as a comparison, there is no evidence that deer in the region have declined at rates observed in the Mesa.

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