Pronghorn Monitoring in the Pinedale Anticline Project Area: 2010 Annual Report

Prepared For:

Pinedale Anticline Project Office (PAPO)
P.O. Box 768
Pinedale, WY 82941

Prepared By:

Ryan M. Nielson and Hall Sawyer
Western EcoSystems Technology (WEST), Inc.
200 S. Second St., Suite B
Laramie, WY 82070

June 13, 2011

TABLE OF CONTENTS

Page

Overview…… 3

Methods……... 4

Results…… 9

Discussion……..…….. 22

Literature Cited…… 24

Appendix A…….. 26

Suggested Citation:

Nielson, R. M., and H. Sawyer. 2011. Pronghorn monitoring in the Pinedale Anticline Project Area: 2010 Annual Report. Report for the Bureau of Land Management Pinedale Anticline Project Office. By Western EcoSystems Technology, Inc.

OVERVIEW

As part of the record of decision for gas 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 (Table 1; BLM 2008). For pronghorn (*Antilocapra Americana*), the matrix was intended to identify monitoring parameters that allow for a quantitative assessment of changes in pronghorn abundance and avoidance of infrastructure. Additionally, data from pronghorn fitted with global positioning system (GPS) collars can be used for developing resource selection models, along with estimating annual survival rates and migration routes. In 2009, Western EcoSystems Technology (WEST), Inc. was contracted by the Pinedale Anticline Project Office (PAPO) to conduct pronghorn monitoring to meet the objectives of the WMMM during the winter of 2009-10. This report describes the monitoring methods and results for the 2009-10 study period.

Table 1. Wildlife monitoring and mitigation matrix (WMMM) developed by the Bureau of Land Management (BLM 2008).

Criteria	Method	Changes that will be monitored	Specific change requiring mitigation
Change in Anticline antelope numbers	Present WCS antelope study; Present TRC project and use of WGFD data	Change in antelope numbers in any year, or a cumulative change over all years, initially compared to first year of available antelope data	15% decline in any year, or cumulatively over all years, compared to reference area (Sublette antelope herd unit or other, mutually agreeable area)
Size of habitat fragments used		Use by antelope in any year, initially compared to first year of available antelope habitat use data, and a concurrent change in antelope numbers compared to first year of available antelope data	10% decline in habitat availability for one year, and a concurrent 15% change in antelope numbers for that year, compared to reference area (Sublette antelope herd unit or other mutually agreeable area).

METHODS

Capture and Collaring

We captured 30 adult female pronghorn on December 7, 2009 and equipped them with store-on-board GPS collars (Generation 4; Telonics, Inc., Mesa, AZ) that were programmed to collect locations every 3.5 hours and drop off November 1, 2010. Capture efforts were split between the Pinedale Anticline Project Area (PAPA; $n = 15$) and Cottonwood Creek area ($n = 15$). We attempted to sample pronghorn in proportion to their relative abundance across both winter ranges. The locations of sampled pronghorn captured and fitted with GPS collars are shown in Figure 1.

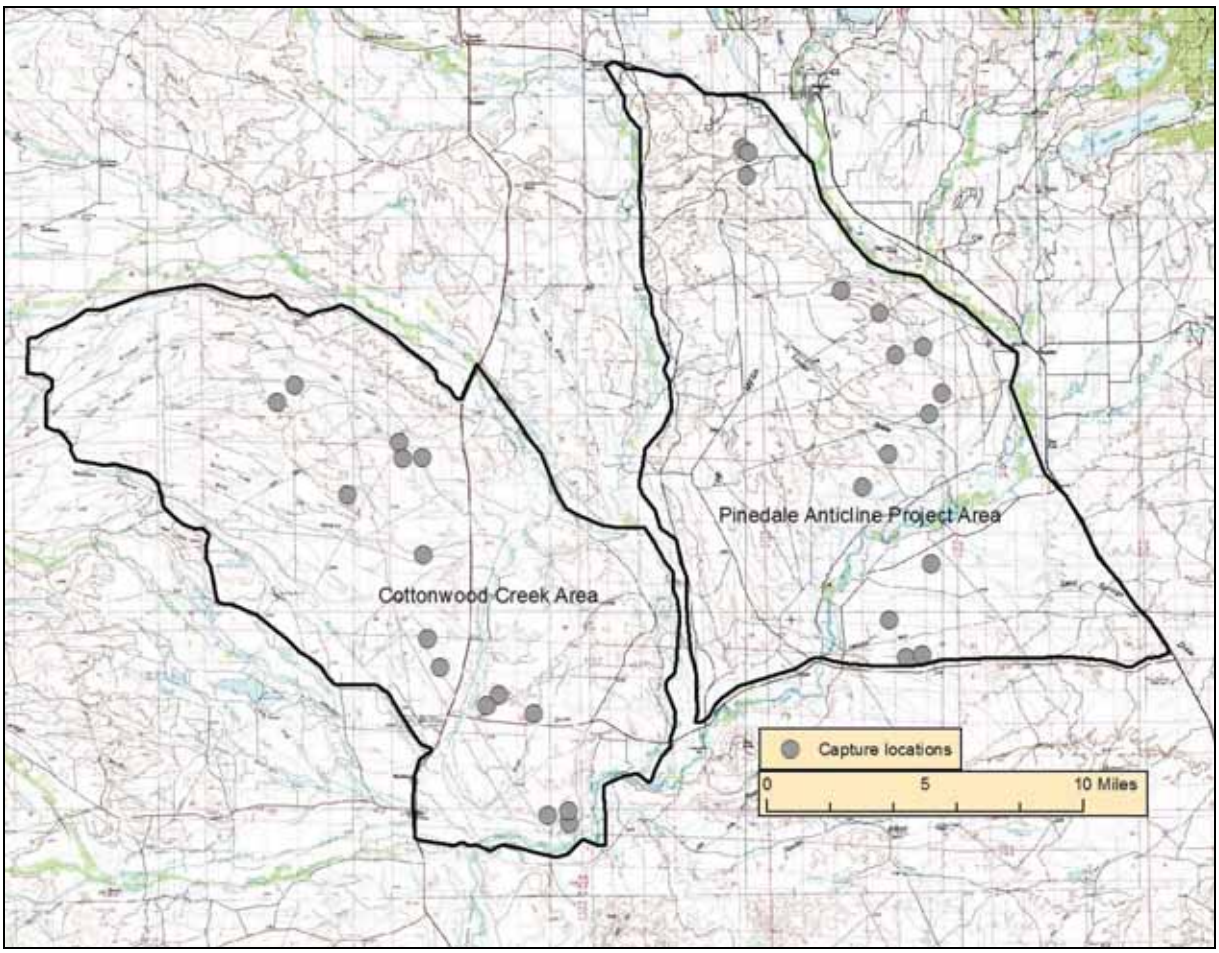

Figure 1. Capture locations of pronghorn in the Pinedale Anticline Project Area (PAPA) and Cottonwood Creek area, December 2009..

Relocation flights were conducted on five occasions between the capture date and when collars dropped off to monitor changes in distribution and identify mortalities. These reconnaissance flights occurred on 2/24, 3/12, 4/24, 6/30 and 8/26. An additional flight was conducted on November 1, 2010 to locate dropped GPS collars so they could be retrieved.

Abundance

We attempted to estimate pronghorn abundance in the PAPA and Cottonwood Creek area in January and February 2010 using aerial line transects surveys. Line transects were spaced approximately ½-mile apart and were flown in an east-west orientation using fixed-wing aircraft flying at 300 – 400 feet above ground level (AGL). Locations of all detected pronghorn groups were recorded using a GPS, and all group sizes were visually counted. Groups with >50 animals were recorded with a hand-held video recorder. The January surveys (1/15 and 1/16) were conducted using only one observer with a high-definition video recorder (Contour HD). However, this video recorder was inadequate in low-light situations produced by heavy cloud cover. In addition, we determined that two observers were necessary to ensure complete coverage of the study area and proper data recording. Accordingly, we used two observers and tested a new video recorder (Sony HD Handycam HDR-CX100) in the February surveys over the Cottonwood Creek area and the PAPA on 2/26 and 2/27, respectively.

The goal of the surveys was to obtain a complete count of pronghorn abundance. Thus, we assumed that few, if any pronghorn were not detected or incorrectly counted. The survey of each area was completed within one day, and both areas were flown a minimum of one day apart to avoid double counting. Originally, we intended to survey both PAPA and Cottonwood Creek area three times in 2010 (January – March; minimum of 25 days between flights). However, many pronghorn began migrating early this year because of low snowpack levels, so the 3rd (March) survey was cancelled

In addition to completing the survey for each area within a single day, and surveying the two adjacent areas at least one day apart, the following procedures were used to reduce the chances of double-counting groups: 1) all surveys began on the northern end of the survey area and were completed from north to south, 2) groups were circled by the aircraft at an altitude of 300 – 400 feet AGL during counting in an attempt to avoid disturbing the animals and causing movement of the group, and 3) groups that did move in response to the aircraft were carefully monitored.

Video images were analyzed in the lab by two independent observers. When a video clip could be reduced to one still image containing the entire group, the two observers reviewed the image collectively and came to a consensus on the total count of pronghorn in the group (see Figures 2 and 3). When a video clip could not be reduced to a single image containing the entire group, we used the average of the two counts from each observer as an estimate of the group size. The sum totals of observed group sizes were considered estimates of the total number of pronghorn occupying the PAPA and Cottonwood Creek area during the surveys. As requested by Pinedale Anticline Planning Office (PAPO), we also compared abundance estimates in the PAPA with those estimated by the Wyoming Game and Fish Department (WGFD) for the entire Sublette herd unit.

Figure 2. Example of a video clip containing a group of pronghorn observed during an aerial survey.

Figure 3. Example of a pronghorn group count $(n = 165)$ based on a video clip from an aerial survey.

Sex and Age Classifications

Ground surveys were conducted within 24 hours of each aerial survey. The goal of the ground surveys was to estimate the number of juveniles and males per 100 does. The PAPA and Cottonwood Creek area were surveyed on consecutive days. We attempted to classify a minimum of 400 animals in each area during each ground survey. Ninety-percent confidence intervals (CIs) were calculated for each estimate using a bootstrap procedure (Manly 2006). The bootstrap process involved taking 200 simple random samples with replacement of individual groups observed during the ground surveys, and re-calculating the age/sex ratios to produce 200 new estimates. We calculated CIs based on the central 90% of the bootstrap distribution (the "Percentile Method") for each estimate.

Resource Selection

We developed a resource (habitat) selection model for pronghorn in the PAPA during the winter of 2009-10 (December 9th – March 31st). Average GPS fix success was high (>99%), so our approach to resource selection analysis followed that of Sawyer et al. (2006, 2009*a, b*), where the animal is treated as the experimental, or primary sampling unit (Thomas and Taylor 2006), and probability of use is estimated for each animal as a function of habitat variables. This approach consisted of 5 basic steps where we: 1) measured habitat variables at 4,353 randomly selected circular sampling units with 100 m-radii, 2) counted the number of pronghorn locations in the sampling units for each GPS-collared pronghorn, 3) used the relative number of pronghorn locations (i.e., relative frequency of use) as the response variable in a multiple regression analysis to model the probability of use as a function of habitat variables, 4) averaged the coefficients of individual models to develop a population-level model, and then 5) mapped predictions of the population-level model.

We considered the following variables in the resource selection analysis: slope (%), elevation (m), distance (km) to well pad, distance (km) to infrastructure (well pad, road or other infrastructure), and aspect. Additionally, we considered two vegetation variables, including the proportion of low-density (< 25% canopy cover) Wyoming big sagebrush and the proportion of high-density (>25% canopy cover) Wyoming big sagebrush. The proportion of low-density and high-density sagebrush within each circular sampling unit was based upon a vegetation layer developed by Thomas (2010). This vegetation layer did not cover the entire PAPA so we limited our resource selection analysis to the extent of the vegetation layer within the PAPA boundary. All other variables were based on the center point values of each of the circular sampling units (e.g., elevation at the center of the 100 m-radius circle). We considered south and east facing slopes to be preferred by pronghorn in winter, so we combined these two aspects into one category and considered other aspects as the Cottonwood Creek area level in the resource selection model.

Before modeling resource selection, we conducted a Pearson's pairwise correlation analysis to identify possible multicollinearity issues and determine whether we should exclude any variables from our modeling $(|r| \geq 0.60)$. Not surprisingly, distance to well pad and distance to infrastructure were highly correlated $(r = 0.76)$. Due to the redundancy in these two variables, we did not allow both to be in the same model. In addition, proportions of low-density and high-density sagebrush were correlated $(r = -0.60)$. Due to this correlation, we chose to drop

proportion of high-density sagebrush from the analysis because we believed, *a priori*, that pronghorn were more likely associated with areas containing low-density sagebrush.

We developed an *a priori* list of resource selection models (Table 2). Each model was fit using the location data from each GPS-collared pronghorn and Akaike's Information Criterion (AIC; Burnham and Anderson 2002) was used to rank the models for each individual animal. A model with a rank of 1 had the lowest AIC value and a model with a rank of 5 had the largest AIC value. We then summed the model ranks across animals and selected the model with the lowest sum as our final resource selection model. Another approach could have been to sum the AIC values for each model. However, some models may have had extremely low (or high) AIC values when fit to data from a particular animal, and thus that animal would have exhibited more influence on the model ranking process compared to another animal. Our approach of summing model rankings gave equal weight to each GPS-collared animal. Resource selection models were fit using R v2.12.2 (R Development Core Team 2011).

Table 2. List of *a priori* pronghorn winter resource selection models.

Model	Variables
1	elevation + elevation^2 + slope + slope^2 + % low-density sagebrush + aspect (S & E)
2	Model (1) + distance to well
3	Model (1) + distance to well + distance to well^2
4	Model (1) + distance to infrastructure
5	Model (1) + distance to infrastructure + distance to infrastructure^2

Migration

We used the Brownian bridge movement model (BBMM; Horne et al. 2007) to estimate population-level migration routes for pronghorn sampled from the PAPA and Cottonwood Creek area. Estimation of the BBMM was conducted using the R contributed package BBMM (Nielson et al. 2011). Following the methods of Sawyer et al. (2009), we also identified route segments used as stopover sites versus those used primarily for movement. The BBMM can also be used to prioritize routes based on their proportional levels of use (Sawyer et al. 2009). However, because of the relatively small sample sizes ($n = 9$ in each area) we did not complete this analysis. We expect sample sizes to be adequate for prioritizing routes following an additional year of GPS data collection.

Habitat Loss

We used 10 m resolution SPOT satellite imagery to calculate habitat loss from construction of well pads, roads and other infrastructure in the PAPA. Infrastructure was hand-digitized from the image using ArcGIS (v10). We used a grid-based method similar to that described in Beckmann et al. (2008). The PAPA was covered with a grid comprised of 300 m x 300 m cells, and the proportion of the total area within each grid cell covered by the hand-digitized layer of well pads, roads and other infrastructure was then calculated.

RESULTS

We recovered 14 of the 15 GPS collars placed on pronghorn in the PAPA (Table 3). The single un-recovered collar (frequency 149.18) was last detected during a reconnaissance flight on August 8, 2010 and the fate of this animal is unknown. All of the remaining 14 pronghorn survived the winter of 2009-10, and 13 survived to November 1, 2010 when their collars dropped. One pronghorn died on October 2, 2010, presumably from wounding-loss. Based on the sample of 14 pronghorn, survival was 92.8% from December 7, 2009 to November 1, 2010.

We recovered 13 of the 15 GPS collars placed on pronghorn in the Cottonwood Creek area (Table 3). One collar (frequency 149.01) failed to drop on the scheduled release date. This collar was later detected on private property, but will not be recovered until the spring of 2011. The missing collar with frequency 149.24 was last detected in the Cottonwood Creek area during the reconnaissance flight on August 8th, but the fate of this animal is unknown. All of the remaining 13 pronghorn from the Cottonwood Creek area survived the winter of 2009-10, and 10 survived through November 1, 2010 when their collars dropped. Two of the mortalities (frequencies 149.04 and 149.17) were attributed to wounding-loss and the third was harvested on October 15, 2010. Based on the sample of 14 pronghorn with known fates (i.e., not including frequency 149.24) survival was 78.6% from December 7, 2009 to November 1, 2010.

A map of all pronghorn locations recorded from December 7th, 2009 through October 31st, 2010 is provided in Appendix A.

Table 3. Summary of GPS collars placed on pronghorn December 7, 2009. The summary includes the collar frequency, the area it was deployed, whether the collar was recovered, whether the animal migrated out of the PAPA or Cottonwood Creek area for the summer and the fate of the animal (if known) up to November 1, 2010.

Frequency	Area	Recovery	Migratory	Survival
149.05	PAPA	Yes	Yes	Alive
149.06	PAPA	Yes	No	Alive
149.07	PAPA	Yes	No	Alive
149.08	PAPA	Yes	Yes	Alive
149.12	PAPA	Yes	No	Died 10/02/10 (wounding-loss)
149.14	PAPA	Yes	Yes	Alive
149.15	PAPA	Yes	Yes	Alive
149.18	PAPA	Not Found	NA	Unknown
149.21	PAPA	Yes	Yes	Alive
149.26	PAPA	Yes	Yes	Alive
149.27	PAPA	Yes	Yes	Alive
149.28	PAPA	Yes	No	Alive
149.31	PAPA	Yes	Yes	Alive
149.33	PAPA	Yes	No	Alive
149.35	PAPA	Yes	Yes	Alive
149.01	Cottonwood Creek area	No	NA	Alive
149.02	Cottonwood Creek area	Yes	Yes	Alive
149.04	Cottonwood Creek area	Yes	No	Died 10/19/10 (wounding-loss)
149.09	Cottonwood Creek area	Yes	Yes	Alive
149.10	Cottonwood Creek area	Yes	No	Alive
149.11	Cottonwood Creek area	Yes	Yes	Alive
149.13	Cottonwood Creek area	Yes	Yes	Alive
149.17	Cottonwood Creek area	Yes	Yes	Died 9/24/10 (wounding-loss)
149.20	Cottonwood Creek area	Yes	No	Alive
149.22	Cottonwood Creek area	Yes	Yes	Alive
149.23	Cottonwood Creek area	Yes	Yes	Alive
149.24	Cottonwood Creek area	Not Found	NA	Unknown
149.25	Cottonwood Creek area	Yes	Yes	Died 10/15/10 (harvested)
149.29	Cottonwood Creek area	Yes	No	Alive
149.37	Cottonwood Creek area	Yes	Yes	Alive

Abundance

Pronghorn abundance in the PAPA area was highly variable. We counted 775 pronghorn in 14 groups on January 15th, and 2,291 pronghorn in 24 groups on February 27th (Figure 4). In contrast, pronghorn abundance was relatively consistent in the Cottonwood Creek area, as we counted 2,683 pronghorn in 26 groups in on January 16th, and 2,802 pronghorn in 28 groups on February 26th (Figure 5). WGFD population estimates for the entire Sublette herd unit were: 57,000. We note that the WGFD estimates were modeled from POPII software and have no confidence intervals associated with them.

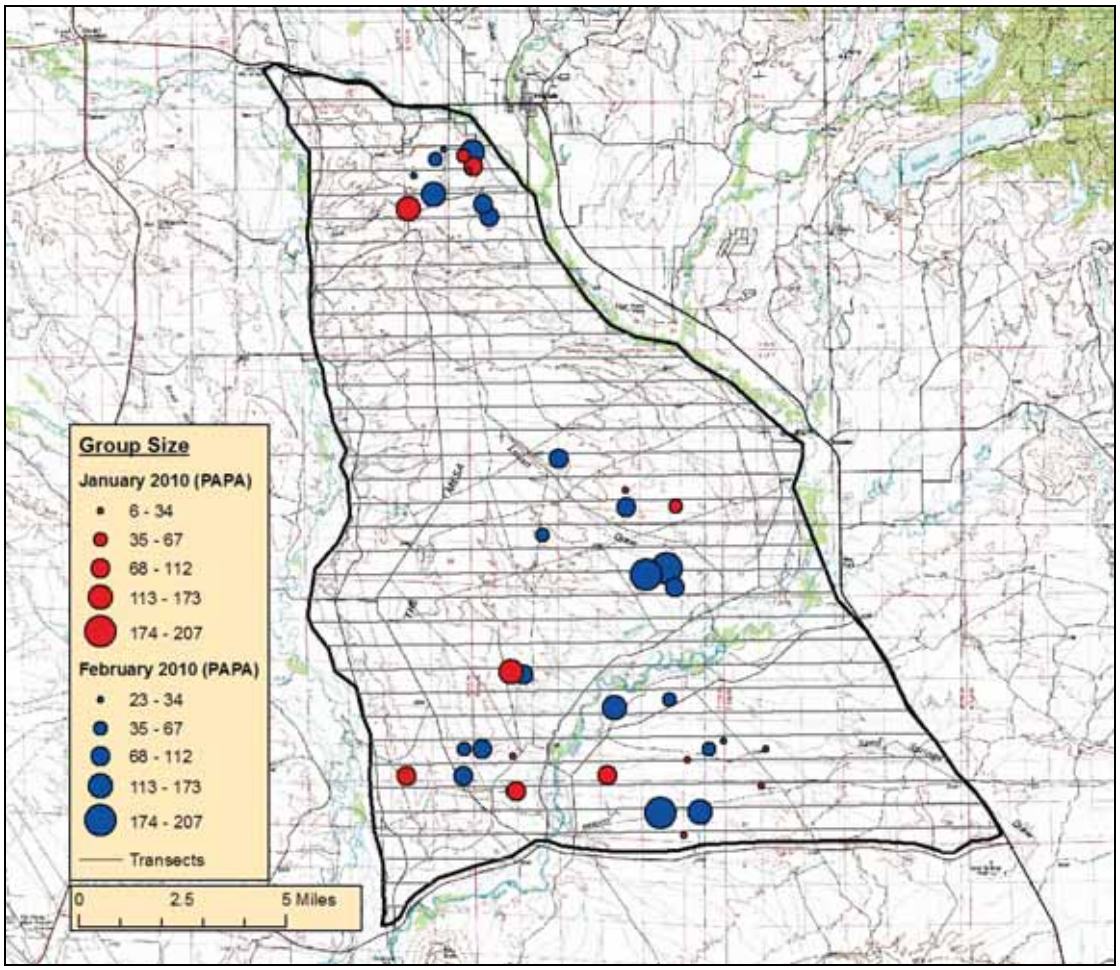

Figure 4. Location and relative size of pronghorn groups observed during aerial surveys in the Pinedale Anticline Project Area (PAPA).

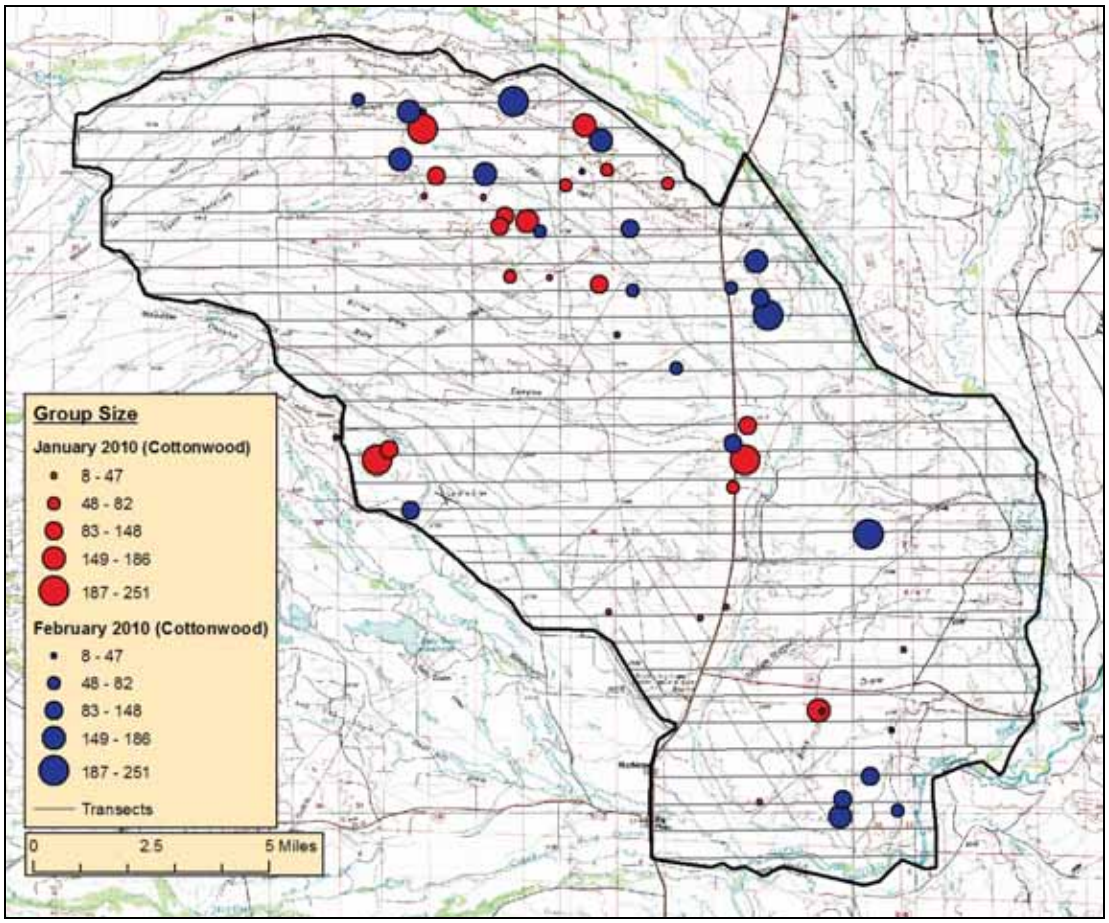

Figure 5. Location and relative size of pronghorn groups observed during aerial surveys in the Cottonwood Creek area.

Sex and Age Classifications

The number of juveniles and males per 100 does did not differ between the PAPA and Cottonwood Creek area areas. Age and sex ratios (and 90% CIs) observed during each survey are provided in Tables 4 and 5.

Table 4. The number of juveniles observed per 100 does, along with 90% confidence intervals, for the Pinedale Anticline Project Area (PAPA) and the Cottonwood Creek area (CC).

Area (Period)	# Groups	Juveniles per 100 Females	90% Confidence Interval Lower Limit	90% Confidence Interval Upper Limit
PAPA (Jan)	7	24.4	20.4	28.6
PAPA (Feb)	4	29.2	22.0	39.8
PAPA (Jan & Feb)	11	26.7	22.1	32.6
CC (Jan)	6	20.8	16.6	24.1
CC (Feb)	8	31.5	25.1	44.8
CC (Jan & Feb)	14	25.4	22.2	30.4
PAPA and CC (Jan)	13	22.5	20.6	25.4
PAPA and CC (Feb)	12	30.2	24.6	37.0
PAPA and CC (Jan & Feb)	25	26.1	23.2	30.2

Table 5. The number of males observed per 100 does, along with 90% confidence intervals, for the Pinedale Anticline Project Area (PAPA) and the Cottonwood Creek area (CC).

Area (Period)	# Groups	Males per 100 Does	90% Confidence Interval Lower Limit	90% Confidence Interval Upper Limit
PAPA (Jan)	7	40.6	29.9	46.4
PAPA (Feb)	4	53.8	42.5	69.4
PAPA (Jan & Feb)	11	47.0	37.6	56.2
CC (Jan)	6	42.8	38.1	55.9
CC (Feb)	8	52.6	36.5	68.6
CC (Jan & Feb)	14	47.0	40.1	57.3
PAPA and CC (Jan)	13	41.7	38.2	46.7
PAPA and CC (Feb)	12	53.2	43.1	64.8
PAPA and CC (Jan & Feb)	25	47.0	41.8	54.7

Resource Selection: Winter 2009-10

We used 9,470 locations collected from 13 GPS-collared pronghorn to estimate individual and population-level models for the winter of 2009-10. One GPS-collared pronghorn (frequency 149.15) was excluded because most locations were outside the resource selection modeling area. The model containing elevation, elevation^2, slope, slope^2, aspect (S & E),

proportion of low-density sagebrush, distance to well pad and distance to well pad^2 was the top model for 9 of the 13 pronghorn and had the lowest sum of AIC rankings (Table 6).

Table 6. Resource selection model rankings based on AIC values for each pronghorn, and the total sum of rankings for each model.

	Pronghorn													Sum
Model	1	2	3	4	5	6	7	8	9	10	11	12	13	of Ranks
1	5	5	5	5	5	5	5	5	5	5	5	3	5	63
2	4	1	4	4	2	4	2	2	2	4	4	5	2	40
3	3	3	3	3	3	2	3	3	4	2	3	4	4	40
4	2	4	2	1	4	1	4	4	3	3	1	2	3	34
5	1	2	1	2	1	3	1	1	1	1	2	1	1	18

Estimated coefficients for each individual pronghorn, based on the final model, are presented in Table 7. Coefficients from the population-level model (average values; Table 7) suggest that pronghorn selected for areas with a high proportion of low-density sagebrush at moderate elevations, with moderate slopes facing south or east, and closer to well pads. Plots in Figure 6, show how predicted levels of use vary in relation to each variable, assuming all other variables are held constant at their respective medians,

Areas with the highest predicted level of use (i.e., dark blue areas in Figure 7) had an average elevation of 2,222 m, 2.56% slope, 60.52% low-density sagebrush, and were 0.51 km from well pads (Table 8). In addition, 68.3% of the areas with the highest predicted level of use had south or east facing slopes. The predictive map indicated that pronghorn use was highest in areas relatively close to well pads (Figure 7).

Table 7. Coefficients for individual pronghorn and the population-level model (*Average* values) during the 2009-10 winter.

Pronghorn	Intercept	Elevation	Elevation^2	Slope	Slope^2	% Low-density Sagebrush	Aspect (S & E)	Dist. to Well Pad	Dist. to Well Pad^2
1	-2941.61	2.6199	-0.0006	0.8103	-0.0768	0.0028	0.5293	4.5308	-2.4659
2	-776.61	0.6917	-0.0002	-0.0353	-0.0040	0.0085	0.1605	-1.0671	0.0221
3	-3348.90	2.9940	-0.0007	0.6424	-0.0546	0.0004	0.1008	3.1598	-2.0471
4	-6401.84	5.7573	-0.0013	-0.0232	-0.0080	0.0003	0.0345	1.9138	-2.3920
5	-1613.68	1.4336	-0.0003	0.0934	-0.0108	0.0102	-0.1410	-2.4722	0.4048
6	-2874.11	2.5555	-0.0006	0.3859	-0.0287	0.0035	0.6087	1.5579	-0.6537
7	-1154.71	1.0357	-0.0002	0.1203	-0.0184	0.0058	0.3271	-1.6588	0.1363
8	-585.44	0.5604	-0.0001	-0.1081	0.0083	0.0144	0.0878	-0.3727	-0.4654
9	-1872.05	1.6995	-0.0004	0.1765	-0.0145	0.0078	0.3894	-3.2711	0.5192
10	-820.53	0.7390	-0.0002	0.1217	-0.0095	0.0065	0.6034	-1.7207	0.3208
11	-4947.74	4.4372	-0.0010	0.6107	-0.0526	-0.0109	0.3880	5.9051	-4.4357
12	1392.58	-1.2608	0.0003	-0.2026	0.0123	0.0268	0.3450	1.4724	-0.5929
13	-1062.15	0.9449	-0.0002	-0.0835	0.0033	0.0074	0.2951	-0.5549	-0.4615
Average	-2077.45	1.8622	-0.0004	0.1930	-0.0195	0.0064	0.2868	0.5709	-0.9316
SE	563.96	0.5061	0.0001	0.0891	0.0074	0.0024	0.0633	0.7742	0.4094
CI Upper	-3082.58	0.9602	-0.0006	0.0342	-0.0328	0.0021	0.1740	-0.8090	-1.6613
CI Lower	-1072.31	2.7641	-0.0002	0.3517	-0.0063	0.0107	0.3997	1.9508	-0.2019

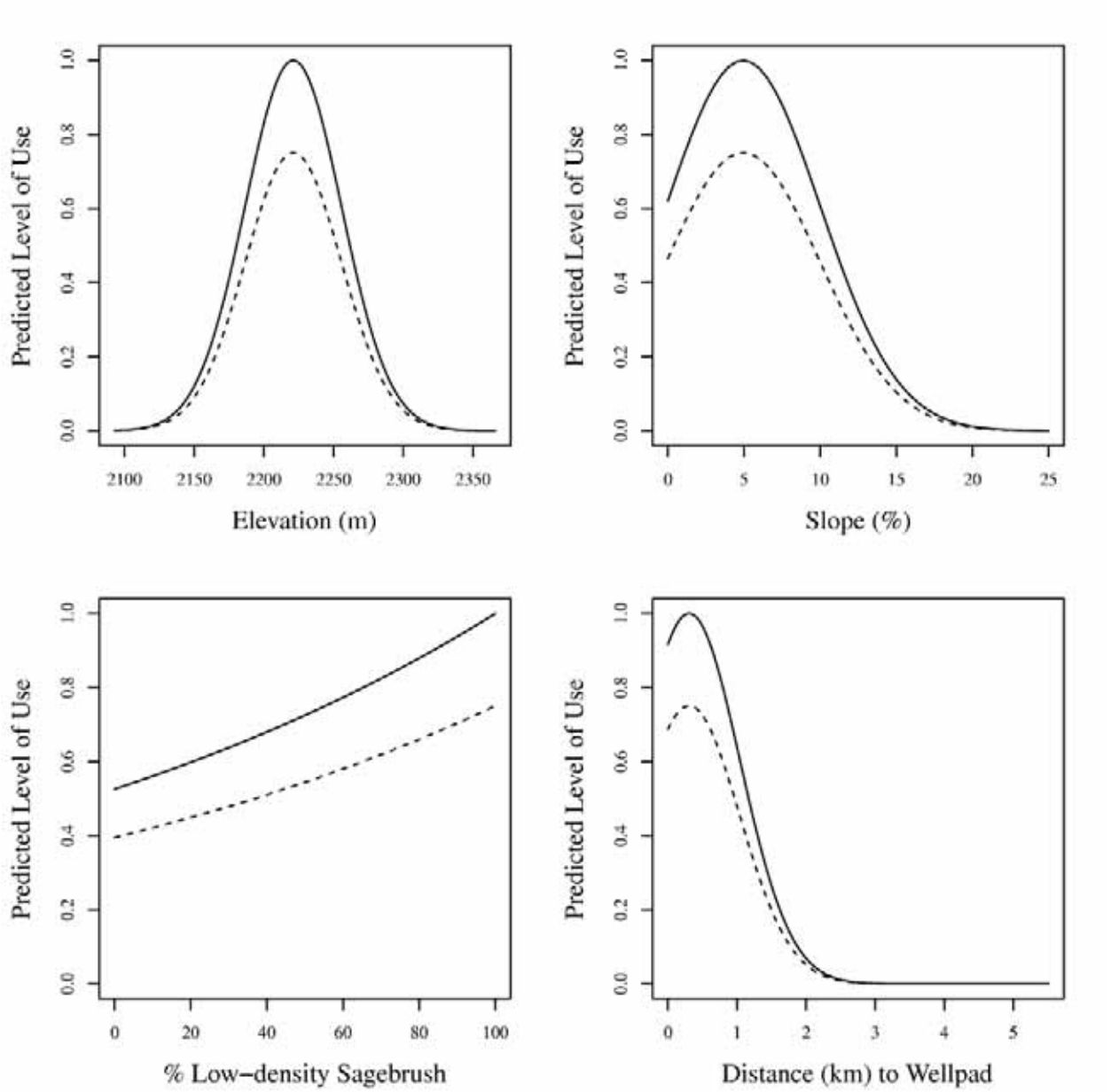

Figure 6. Predicted levels of use by pronghorn in the Pinedale Anticline Project Area (PAPA) area during the winter of 2009-10, as a function of variables in the top resource selection model. Predictions in each panel were scaled to have a maximum value of 1.0. Solid lines represent predictions for south and east facing slopes and dashed lines represent predictions for areas facing north or west. Levels of variables not plotted were held constant at their median values.

Table 8. Average values of model variables in low, medium-low, medium-high and high use pronghorn categories during the winter of 2009-10.

	Predicted Pronghorn Use			
Model Variables	High	Medium-high	Medium-low	Low
Elevation (m)	2222	2200	2172	2178
Slope (%)	2.56	2.75	3.32	3.37
% Low-density Sagebrush	60.52	59.70	59.67	49.23
Distance (km) to Well Pad	0.51	0.84	1.31	2.68
Aspect of South or East	68.3*	55.9*	51.9*	51.8*

*Values represent percent of landscape with south or east facing slopes.

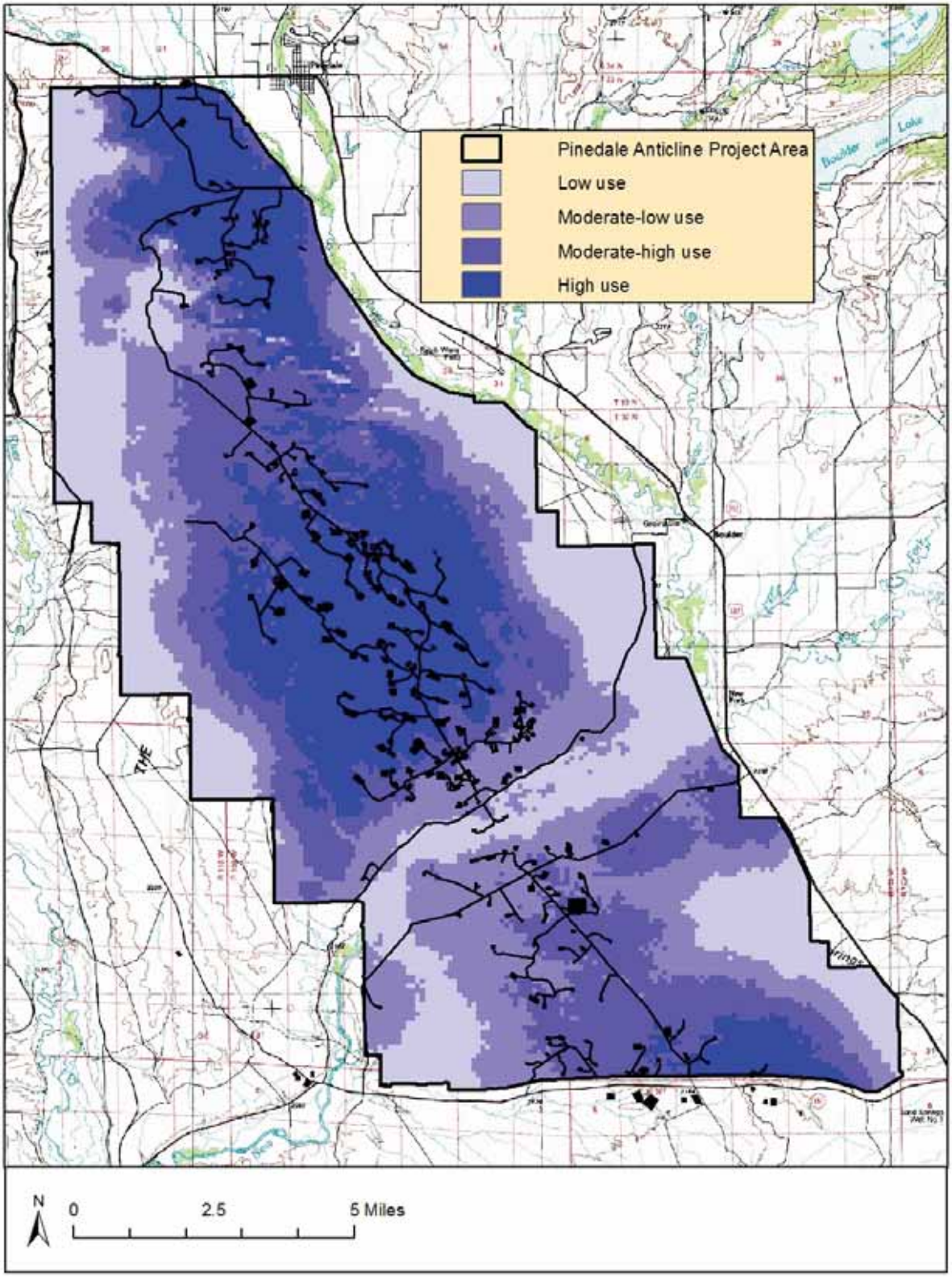

Figure 7. Predicted level of pronghorn habitat use in the Pinedale Anticline Project Area (PAPA) during the winter of 2009-10

Migration

Of the 30 GPS-collared pronghorn, we recovered 27 collars. Of those, 18 displayed clear seasonal migrations, including 9 from the PAPA area and 9 from the Cottonwood Creek area. The other 9 pronghorn were either non-migratory or nomadic. From the 18 migratory animals, 18 spring and 9 fall migrations were adequate to analyze. We combined the routes of animals with both spring and fall migrations, such that each animal only contributed one route to the population-level route. We estimated population-level migration routes for both PAPA and Cottonwood Creek area (Figure 8). Pronghorn from the PAPA area migrated 10 to 70 miles north. Pronghorn moved north off the Mesa through Trapper's Point or just west of Pinedale, near the WYDOT and BLM offices. Some pronghorn summered west of Cora, while others occupied areas along Willow Creek to the east of Cora. Other pronghorn migrated further north towards Black Butte, along the Upper Green River, and as far as Piñon Ridge. Pronghorn from the Cottonwood Creek area migrated 10 to 60 miles north and west. A portion migrated northwest along Muddy Creek and Billy Canyon to summer west of Ryegrass Junction. Others migrated north through the Soapholes, westerly through the Grindstone and Ryegrass, then north to Beaver Ridge. Some pronghorn summered along Beaver Ridge, but others continued north to the South Hoback Rim and as far north as Dell Creek.

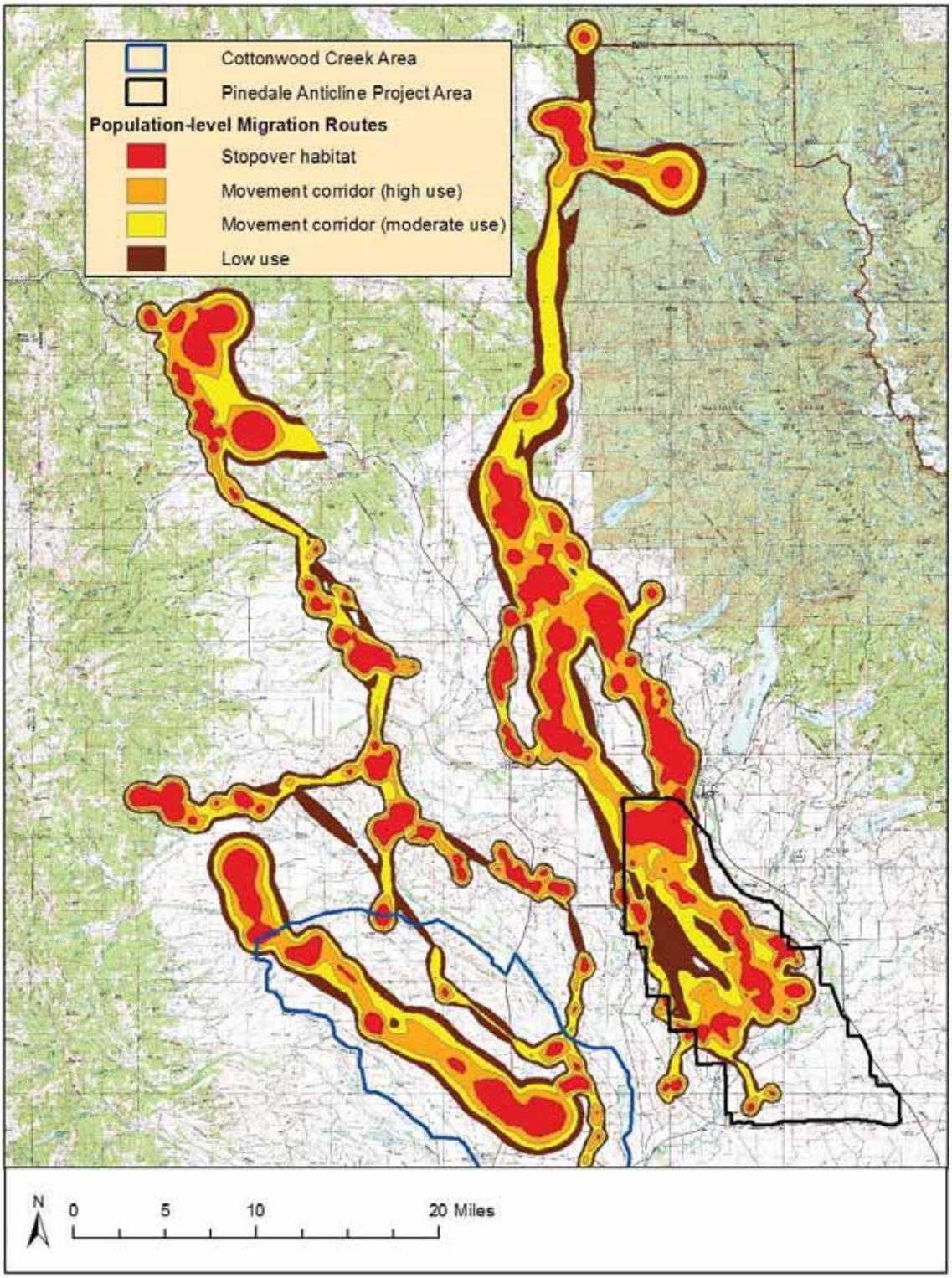

Figure 8. Population-level migration routes of pronghorn from the Pinedale Anticline Project Area and Cottonwood Creek area during spring and fall migrations of 2010.

Habitat Loss

We estimated a total of 10.76 km^2 of habitat has been lost in the PAPA area due to construction of roads, well pads and buildings. Past estimates of habitat loss presented in Beckmann et al. (2008) are not comparable due to differences in study area boundaries. Percent habitat loss in each 300 m x 300 m grid cell is shown in Figure 9.

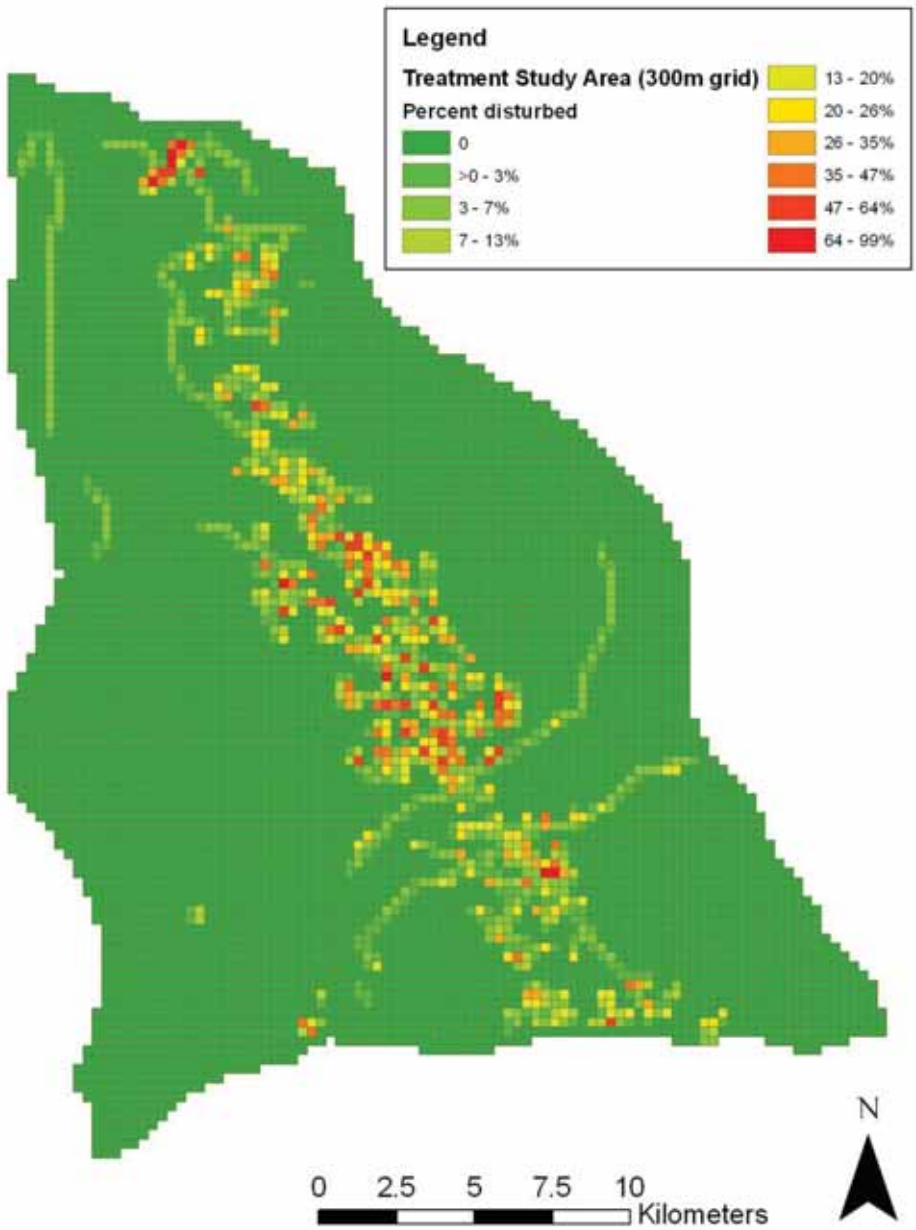

Figure 9. Percent habitat loss (disturbance) as of 2009-10 for each 300 m grid cell across the Pinedale Anticline Project Area (PAPA).

DISCUSSION

As outlined in the BLM's Wildlife Monitoring and Mitigation Matrix (WMMM; BLM 2008), our primary tasks were to: 1) estimate pronghorn abundance in PAPA and Cottonwood Creek area, and 2) evaluate pronghorn avoidance of infrastructure and habitat loss. We discuss each below.

Pronghorn Abundance

The winter of 2009-10 was the first attempt to estimate pronghorn abundance in the PAPA and Cottonwood Creek area. Thus, no comparison to past estimates can be made at this time. Our approach used HD video camera technology and tightly spaced aerial transects to provide complete survey coverage of the study areas. A key assumption is that few, if any pronghorn groups are missed or incorrectly counted. It is important to note that the 2009-10 winter was unusually mild and the patchy snow cover made pronghorn more difficult to detect and count compared to normal winter conditions

The current methodology for estimating pronghorn abundance does not adhere to common line transect distance methodology (Buckland et al. 2001), but instead is based on a 'complete count' technique (Seber 1982). Current application of the complete count technique involves flying a dense sample of line transects (spaced ½-mile apart), attempting to locate every group of pronghorn in the study area(s), and using high-definition video images to determine group size. The problem with traditional line transect distance methodology (Buckland et al. 2001), is the assumption that animals do not move in response to observers. Obviously, pronghorn are very mobile and react quickly to nearby aircraft, which would likely violate this assumption and result in observers detecting groups after movement and further from the transect line.

At this time, we believe the 'complete count' approach is the preferred method and that surveying line transects ½ mile apart using HD video to determine group size is likely the most efficient and reliable method of estimating pronghorn abundance. However, it should be recognized that this technique can only produce an index, and not a complete count, unless we are confident that all pronghorn were detected and none were double-counted. Regardless of whether the estimate is considered a complete count or an index of abundance, this approach provides a reliable means to monitor trends in pronghorn abundance through time.

The WMMM specifies that mitigation measures will be triggered if a 15% decline in pronghorn abundance is detected in any year compared to the first year of abundance monitoring (2009-10 winter), or a cumulative change over all years since the first year, relative to a Cottonwood Creek area. However, as the independent review of WMMM (Bissonette et al. 2010) noted, the current methodology is unlikely to detect a change of 15% or less between annual abundance estimates of two populations. Their power analysis indicated that changes would need to be 35% or greater to have at least 80% confidence in detection. Generally, a more rigorous method for assessing population trend is to consider all years of data collection and examine the long-term trend using regression analysis (e.g., the PAPO mule deer analysis). Although a simple comparison can be made between two years of population estimates, a regression analysis requires a minimum of three estimates and so will not be feasible until after the third year of monitoring.

The distribution and movement of pronghorn during the winter is influenced by snow depth. However, as stated above, snow depth was low or non-existent in areas across the study

area for much of the winter. Snow depth data provided by the PAPO measured at monitoring stations in and around the PAPA and Cottonwood Creek area had a maximum average around February 23rd and 24th. This average value was 6.09 inches with a standard deviation of ~0.47. Thus, relationships between pronghorn group locations and snow depth was not investigated.

Because we have only one year of abundance estimates for the PAPA and Cottonwood Creek area, a comparison of trends or changes in numbers between the study areas and the Sublette herd unit is not possible.

Pronghorn Avoidance

Consistent with previous big game monitoring on the Mesa (Sawyer and Nielson 2010, Sawyer et al. 2009*a*, Beckmann et al. 2008), data from GPS-collared pronghorn were used in a resource selection analysis to determine how or if gas field infrastructure affected pronghorn distribution in the PAPA. Consistent with Beckmann et al. (2008), we found that pronghorn used areas close to well pads. This is in sharp contrast to mule deer that avoid well pads in the same study area (Sawyer et al. 2009b, Sawyer and Nielson 2010). Our data suggest pronghorn distribution during the winter of 2009-10 was not negatively affected by gas field infrastructure. Although pronghorn did not avoid infrastructure, it is possible that their vigilance and foraging was affected (Gavin and Komers 2006), but measuring that level of behavioral response was beyond the scope of this study. Pronghorn and other herding animals may alleviate the effects of disturbance or perceived risk by aggregating in large groups (Lima 1995, Gavin and Komers 2006), so it is possible that the large group sizes observed in the PAPA allow pronghorn to effectively utilize areas close to infrastructure.

The WMMM specifies that mitigation measures may be triggered if "availability" of habitat declines by 10% in any one year (concurrent with 15% population decline). An independent review panel concluded that these criteria were not adequately explained and the terms "size of habitat fragment", "use", and "availability" were not adequately defined (Byers et al. 2010). Accordingly, the panel recommended that changes in probability of use be estimated similar to Sawyer et al. (2006). We agree with this recommendation and believe this approach would be especially powerful if all pronghorn data from the Shell funded study (Beckman et al. 2008) were made available, such that comparisons with earlier years could be made.

Mitigation Triggers

Mitigation triggers defined in the WWMM require at least two years of data for comparison. Because this report represents the first year of data collection we cannot assess whether abundance or avoidance thresholds have been exceeded at this time.

Future Monitoring

The Adaptive Management Review Team has recommended changes to the Wildlife Monitoring and Mitigation Matrix (WMMM; BLM 2008). These changes largely represent clarifications to the original MM, but include dropping analysis of habitat loss and fragmentation. Pronghorn abundance in the PAPA will still be monitored using aerial surveys, and the distribution of pronghorn will be modeled annually from sample of GPS collared adult females.

LITERATURE CITED

Beckmann, J. P., K. M. Berger, J. K. Young, and J. Berger. 2008. Wildlife and energy development: pronghorn of the Upper Green River Basin – year 3 summary. Wildlife Conservation Society.

Bissonette, J. A., G. C. White, and P. R. Krausman. 2010. Review: Mule deer monitoring, Pinedale Anticline. Mule deer monitoring plan review committee. Pinedale Anticline Planning Office, Pinedale, Wyoming.

Bureau of Land Management [BLM]. 2008. Record of Decision: Final Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Pinedale Field Office, Wyoming.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference. Second edition. Springer – Verlag, New York, USA.

Byers, J., S. Creel, and J. Millspaugh. 2010. Review of Pronghorn Monitoring Plan in the Pinedale Anticline Project Area Sublette County, Wyoming. Pinedale Anticline Planning Office, Pinedale, Wyoming.

Freddy, D. J., G. C. White, M. C. Kneeland, R. H. Kahn, J. W. Unsworth, W. J. deVergie, V. K. Graham, J. H. Ellenberger, and C. H. Wagner. 2004. How many mule deer are there? Challenges of credibility in Colorado. Wildlife Society Bulletin 32:916–927.

Gavin, S. D., and P. E. Komers. 2006. Do pronghorn perceive roads as predation risk? Canadian Journal of Zoology 84:1775-1780.

Lima, S. L. 1995. Back to the basics of anti-predatory vigilance: the group-size effect. Animal Behavior 49:11-20.

Manly, B. F. J. 2006. Randomization, bootstrap and Monte Carlo methods in biology. Third edition. Chapman and Hall/CRC, Boca Raton, Florida, United States.

Millspaugh, J. J., R. M. Nielson, L. McDonald, J. M. Marzluff, R. A. Gitzen, C. D. Rittenhouse, M. W. Hubbard, and S. L. Sheriff. 2006. Analysis of resource selection using utilization distributions. Journal of Wildlife Management 70:384–395.

Nielson, R. M., H. Sawyer and T. L. McDonald. BBMM: Brownian bridge movement model for estimating the movement path of an animal using discrete location data. http://CRAN.R-project.org/package=BBMM.

R Development Core Team. 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Samuel, M. D., E. O. Garton, M. W. Schlegel, and R. G. Carson. 1987. Visibility bias during aerial surveys of elk in northcentral Idaho. Journal of Wildlife Management 51:622–630.

Sawyer, H. and F. Lindzey. 2000. Jackson Hole Pronghorn Study. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming. 57 pp.

Sawyer, H., R. M. Nielson, F. Lindzey, and L. L. McDonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. Journal of Wildlife Management 70:396-403.

Sawyer, H., R. Neilson, and D. Strickland. 2009*a*. Sublette Mule Deer Study (Phase II): Final Report 2007 - long-term monitoring plan to assess potential impacts of energy development on mule deer in the Pinedale Anticline Project Area. Western Ecosystems Technology, Inc. Cheyenne, Wyoming.

Sawyer, H., M. J. Kauffman, and R. M. Nielson. 2009*b*. Influence of well pad activity on the winter habitat selection patterns of mule deer. Journal of Wildlife Management 73:1052-1061.

Sawyer, H. and R. M. Nielson. 2010. Mule deer monitoring in the Pinedale Anticline Project Area: 2010 Annual Report. Western Ecosystems Technology, Inc., Laramie, Wyoming.

Seber, G. A. F. 1982. The Estimation of Animal Abundance and Related Parameters. Second edition. Blackburn Press, Caldwell, New Jersey, United States.

Thomas, D. 2010. Final vegetation and wildlife habitat inventory and landscape analysis, Pinedale Anticline Habitat Study Area, Sublette County, Wyoming. TRC Environmental Corporation, Laramie, Wyoming

Thomas, D. L., and E. J. Taylor. 2006. Study designs and tests for comparing resource use and availability II. Journal of Wildlife Management 70:324–336.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring Vertebrate Populations. Academic Press, San Diego, California, USA.

APPENDIX A

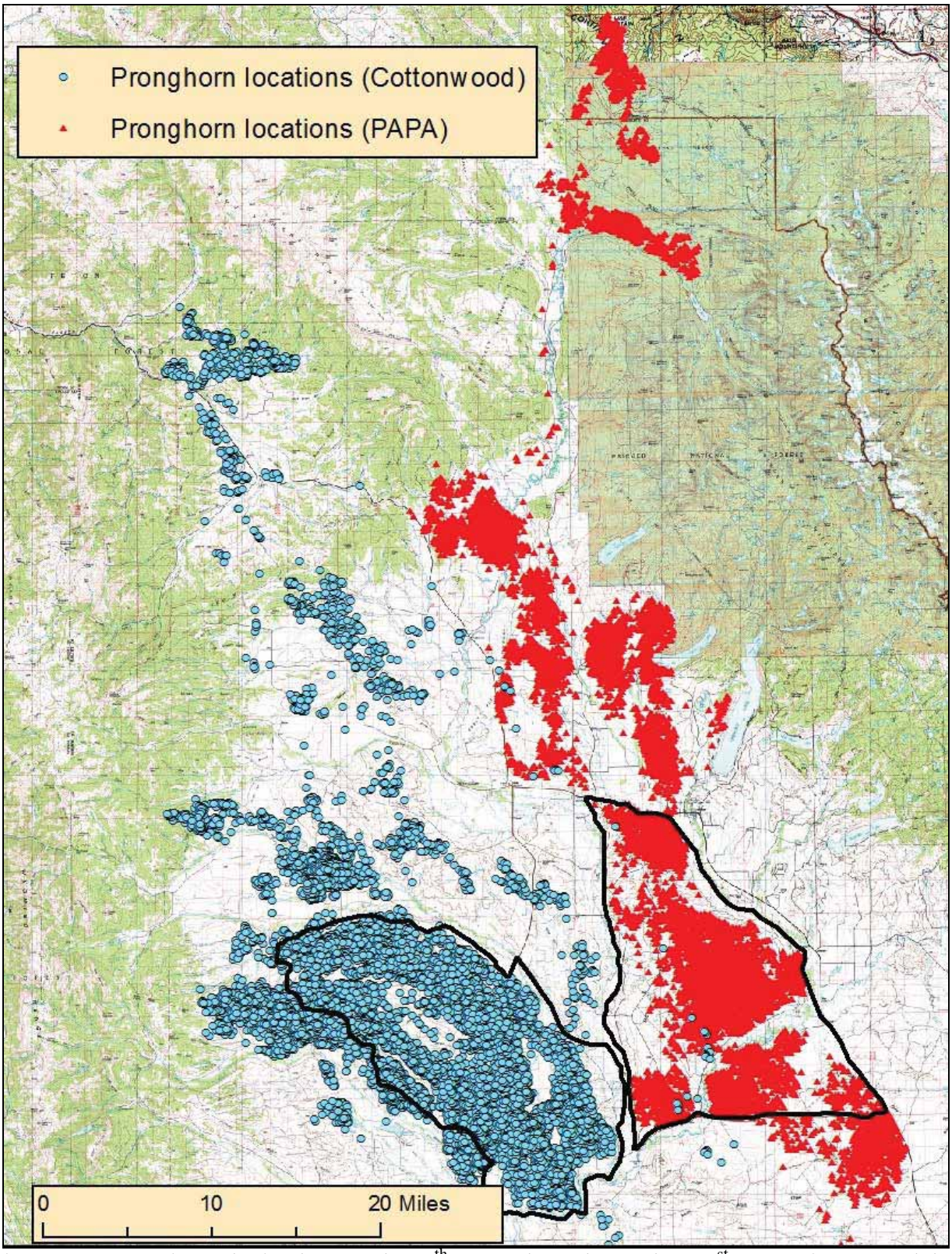

Figure A.1. Locations obtained December 7th, 2009 through October 31st, 2010, from 27 Global Positioning System collars fitted to sampled pronghorn.