Elk Monitoring for Performance Standard #5 in the Fortification Creek Planning Area: Fidelity to Seasonal Ranges

2014 Annual Report

Prepared for:

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June 18, 2015

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NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

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INTRODUCTION

The Resource Management Plan Amendment approved by the Bureau of Land Management (BLM) for managing minerals in the Fortification Creek Planning Area (FCPA; FCPAMP 2011) outlines a performance-based approach to ensure adequate vegetation reclamation and the protection of elk (Appendix B of the FCPAMP). For elk, the performance standards identify 7 parameters (also referred to as Objectives; FCPAMP 2011) that are measured each year and intended to help monitor potential impacts to elk from energy development. Here, we focus on Objective 5 (Seasonal and Range Fidelity) which evaluates the fidelity of elk to their seasonal ranges. Specifically, Objective 5 states that, "*Fidelity to the seasonal ranges (yearlong, calving, and crucial winter) remains greater than 80% of current levels. This means that if currently 80% of the collared elk locations (pre-CBNG [coal bed methane gas]) are within the yearlong range for the entire year, then following drilling 64% of the collared elk locations should remain within the yearlong range for the entire year (64% is 80% of 80%). The seasonal crucial range fidelity metric will evaluate the collared elk use within the seasonal ranges (calving and crucial winter) during the crucial seasons. Calving range fidelity will be evaluated for the period from May 15 through June 15. Crucial winter range fidelity will be evaluated for the period from December 1 through April 30*." Using 172,785 global positioning system (GPS) locations collected from March 26, 2008 to May 14, 2012 on a sample of 92 elk, we 1) calculated baseline (pre-development) estimates for the proportion of elk locations occurring in existing seasonal ranges, and 2) estimated resource selection functions (RSF; Manly et al. 2002) for each season (winter, parturition, yearlong). As outlined in Objective 5, the proportion of elk locations in each range can be monitored over time to determine whether 80% of locations remain in their respective ranges. In addition, the RSF analyses provide a quantitative and complimentary metric that identifies high-use elk habitat and associated habitat characteristics (e.g., distance to road, distance to cover). Similar to the proportion of elk locations in each range, the RSF analyses can be used to measure changes in habitat use or fidelity across years.

This report presents analyses that compare two years of post-baseline elk location data to baseline elk location data. Specifically, 1) the proportions of elk locations occurring in existing seasonal ranges from May 15, 2012 to June 15, 2013 and May 16, 2013 to June15, 2014 are compared to the proportions of baseline elk locations in the various seasonal ranges; and 2) RSFs are estimated for each season (winter, parturition, and yearlong) using the GPS location data collected from May 15, 2012 to June 15, 2014 and the resulting RSFs analyses are evaluated to provide a measure of changes in habitat use or fidelity compared to the baseline RSF analyses.

METHODS

Elk Fidelity

We estimated elk fidelity to seasonal ranges by comparing the number of collared elk locations in each seasonal range to the number of GPS elk locations in the FCPA. The seasonal ranges were defined as yearlong, parturition (May 15 through June 15), and winter (December 1 through April 30; Figure 1). Because the yearlong range comprised 78% of the FCPA, we included all elk locations (i.e., inside and outside of FCPA) to estimate the proportion of locations within the yearlong range within the FCPA. To calculate the baseline proportions of elk locations in each range, we used 172,785 GPS locations collected from 92 elk, between March 2008 and May 14, 2012. Ninety-percent confidence intervals (CIs) for estimated proportions were calculated by treating the individual elk as the primary sampling units (Thomas and Taylor 2006) and bootstrapping (Manly 2007) the elk 200 times. This bootstrapping process, which randomly samples individual elk with replacement in each year and re-estimates the proportion of locations in each seasonal range, accounted for the individual variation (e.g., differing number of individual locations per elk and year) among collared elk. Lower and upper CI limits were based on the 5th and 95th percentiles of the 200 estimates. After the proportion of locations in each range was estimated, we then determined the minimum performance standard by calculating 80% of the baseline value for each seasonal range. In addition to the methods described above, at the request of the BLM, we also calculated the proportions of locations contained within the seasonal ranges within the FCPA out of all the locations contained within the herd unit.

Proportions (along with associated confidence intervals) of elk locations from May 15, 2012 through June 15, 2014 were calculated using the same methods used to calculate the baseline proportions. These proportions were compared to the baseline proportions and specifically, whether or not the proportions were within the pre-defined performance standards (fidelity to the seasonal ranges remains at 80% of baseline levels).

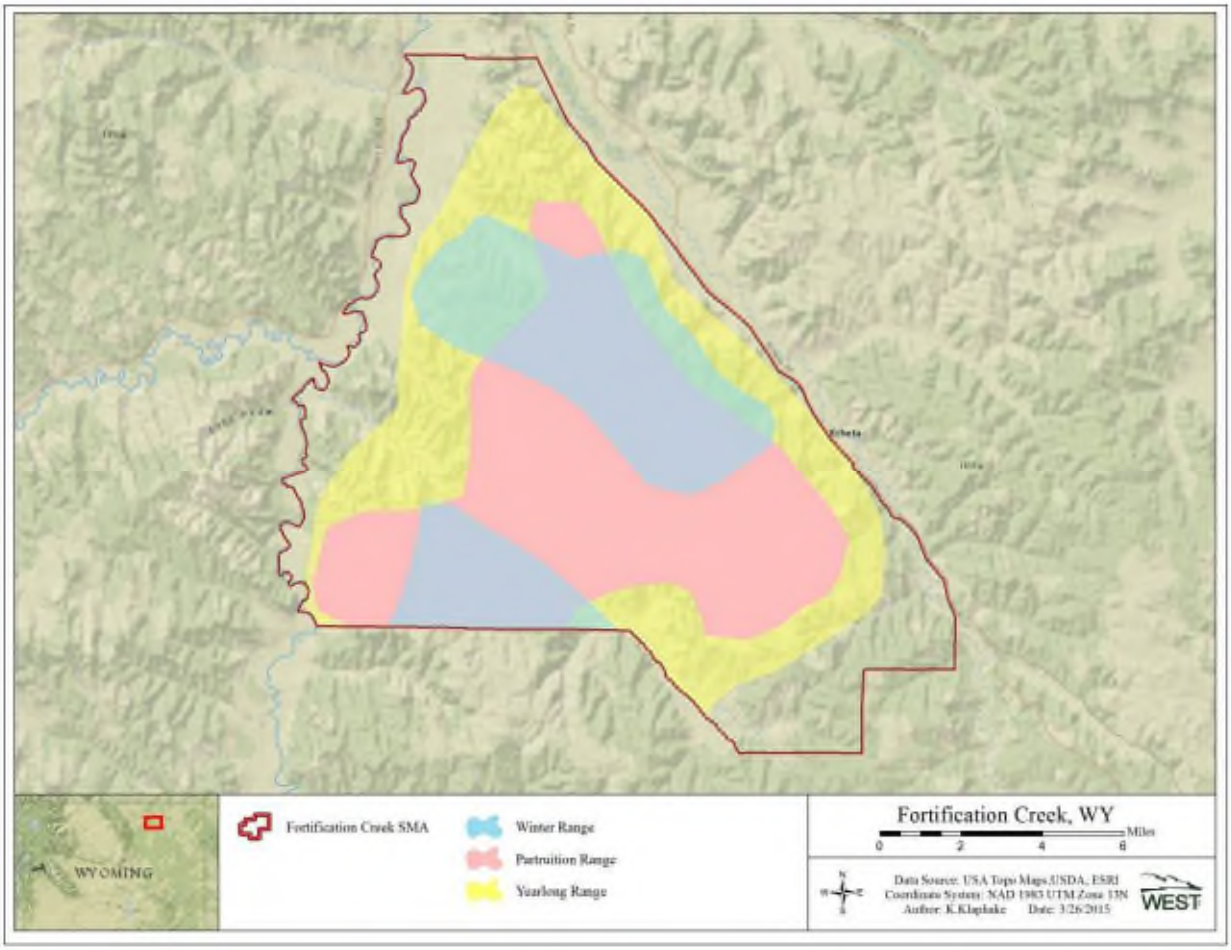

Figure 1. Elk seasonal ranges including winter, parturition, and yearlong within the Fortification Creek Planning Area.

Resource Selection

Our approach to the resource selection analysis followed the methods described by Nielson and Sawyer (2013), which was similar to that of Sawyer et al. (2006; 2009), where the animal is treated as the experimental unit and probability of use is estimated using negative binomial regression (Hilbe 2008) as a function of habitat variables. We estimated seasonal RSFs using GPS locations recorded within the FCPA during the parturition (May 15 through June 15), winter (December 1 through April 30), and yearlong crucial periods. Consistent with other elk models (Wisdom et al. 1986; Sawyer et al. 2007; Skovlin et al. 2002; Barbknecht et al. 2011), the habitat variables included slope, elevation, distance to road (km), distance to cover (km), and terrain ruggedness. Slope, elevation, and terrain ruggedness were estimated from a 30 meter (m) digital elevation model (DEM) (Sappington et al. 2009; ESRI 2012). We considered the quadratic term for slope and ruggedness because elk may select moderate, rather than extreme, slopes and ruggedness habitats. We obtained a road layer from the Bureau of Land Management (BLM) to calculate the distance to nearest road. We defined cover as juniper-

pinyon pine vegetation classified from the 30 m 2006 National Landcover Dataset. We restricted our distance-to-cover calculations to cover patches greater than 2 acres (8,093 m^2).

Estimating the RSF consisted of 6 basic steps where we: 1) measured habitat variables at 10,000 randomly selected circular sampling units with 200-m radii, 2) counted the number of elk locations within each of the sampling units, 3) used the number of elk locations (i.e. 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) identified the best approximating model from 8 *a* priori models (see Table 3 in the Resource Selection section below) by comparing the Akaike's information criterion (AIC; Burnham and Anderson 2002) values for each model, 5) accounted for individual variation by bootstrapping individual animals to estimated standard errors for RSF coefficients, and then 6) predictions of the best RSF for each season were classified into 5 equal-area bins (low, medium-low, medium, medium-high, and high use) using percentiles and mapped within the FCPA. Again, 90% CIs were calculated using the percentile method. Importantly, this method treats the animal as the experimental unit and accounts for unequal number of GPS locations among individuals. Post development models were developed with data from multiple post-development years

RESULTS

Elk Fidelity

Yearlong: We used 172,785 locations collected from 92 GPS-collared elk from March 26, 2008 to May 14, 2012 to estimate the baseline yearlong site fidelity. Of all the 172,785 baseline locations, 71% (90% CI: 60–82%) occurred in the yearlong range within the FCPA. According to the performance standards, 80% of 71%, or 57% (90% CI: 48–66%), of future elk locations must remain within the yearlong range (Table 1a, Appendix A). We also estimated baseline fidelity to the FCPA yearlong range based on the total number of locations in the herd unit (Table 1b). There were a total of 157,536 baseline locations in the herd unit and 78% (90% CI: 68–88%) occurred in the FCPA yearlong range. Eighty percent of 78% is 62% (Table 1b).

From May 15, 2012 to May 14, 2013, 17,249 elk locations were collected from 33 GPS-collared elk. Of these, 77% (90% CI: 64–90%; Table 1a) were located in the FCPA, which exceeds the baseline performance standard and exceeds the baseline yearlong proportion (Table 1a, Appendix A). For the same time period, fidelity to the yearlong range based on the total number of locations in the herd unit also exceeded the fidelity estimated from the baseline study period (Table 2b). There were a total of 17,026 locations in the herd unit and 78% (90% CI: 65-91%) occurred in the yearlong range.

From May 15, 2013 to May 14, 2014, 35,060 elk locations were collected from 51 GPS-collared elk. Of these, 67% (90% CI: 56–78%; Table 1a) were located in the FCPA, which exceeds the minimum baseline performance standard (57%) but, is lower than the baseline yearlong proportion (71%; Table 1a; Appendix A). For the same time period, fidelity to the yearlong range based on the total number of locations in the herd unit (67%) was also below the fidelity

estimated from the baseline study period (78%; Table 2b). There were a total of 34,807 locations in the herd unit and 67% (90% CI: 56-78%) occurred in the yearlong range.

Parturition: We used 11,804 elk locations within the FCPA during the parturition period from 69 GPS-collard elk to determine the baseline proportion of locations in designated parturition range. Of the 11,804 baseline elk locations within the FCPA, 10,332 (88%; 90% CI: 79–96%) occurred in parturition range. Thus, the minimum performance standard for the parturition period is 70% (90% CI: 63–77%; Table 1a). We also estimated baseline fidelity to the FCPA parturition range based on the total number of locations in the herd unit (Table 1b). There were a total of 14,960 baseline locations in the herd unit during parturition of these locations, 69% (90% CI: 58–80%) occurred in the FCPA parturition range. Eighty percent of 69% is 55% (Table 1b).

In the 2012 and 2013 parturition period, the proportion of elk locations in the pre-defined parturition range out of all elk locations within the FCPA were higher than the baseline proportions. During the parturition period in 2012, there were 2,131 elk locations within the FCPA from 26 collared elk and 93% (90% CI: 86–101%) were within the parturition range (Table 1a; Appendix A). In 2013, there were 770 elk locations from 12 collared elk within the FCPA during the parturition season and 96% (90% CI: 93–100%) were located within the pre-defined parturition range (Table 1a; Appendix A). In 2012, fidelity to the parturition range within the FCPA based on the total number of locations in the herd unit also exceeded the fidelity estimated from the baseline study period (Table 2b). There were a total of 2,400 locations in the herd unit and 83% (90% CI: 71-95%) occurred in the parturition range within the FCPA. Estimated fidelity to the parturition range within the FCPA based on the total number of locations within the herd unit during parturition in 2013 was lower than the fidelity estimated using the same approach during the baseline study. There were a total of 1,224 locations in the herd unit during parturition in 2013 and of these locations, 61% were recorded in the parturition range within the FCPA. However, sixty-one percent is higher than 55%, which is 80% of the fidelity estimated using the same approach during the baseline study period (Tables 1b and 1b). During the 2014 parturition period, the proportions of elk locations in the pre-defined parturition range were lower than the baseline proportions but above the performance standard (Table 1a). There were 4,916 elk locations within the FCPA from 33 collared elk and 87% (90% CI: 78–96%) were within the parturition range (Table 1a; Appendix A). In 2014, fidelity to the parturition range within the FCPA based on the total number of locations in the herd unit was similar to 2013 and was below the fidelity estimated from the baseline study period (Table 1b). There were a total of 7,183 locations in the herd unit and 60% (90% CI: 49-71%) occurred in the parturition range within the FCPA.

Winter: We used 46,036 elk locations within the FCPA from 72 GPS-collared elk during the winter period to determine the proportion of baseline locations in designated winter range. Overall 52% (90% CI: 41–63%) of these locations occurred in winter range. Thus, the minimum performance standard for the winter period is 42% (90% CI: 33–50%; Table 1a; Appendix A). We also estimated fidelity to the winter range based on the total number of locations in the herd unit (Table 1b). There were a total of 60,326 baseline locations in the herd unit during winter

and 40% (90% CI: 31–49%) of these locations occurred in the winter range within the FCPA. Eighty percent of 40% is 32% (Table 1b).

During the winter season of 2012-2013, 3,779 elk locations from 21 collared elk were collected and of these 2,475 elk locations were within the pre-defined winter range (65%; 90%CI: 55–76%; Table 1a; Appendix A). During the winter season of 2012-2013, the proportion of the FCPA elk locations located within the pre-defined winter range was greater than the baseline winter proportions. For the same time period, fidelity to the winter range within the FCPA based on the total number of locations in the herd unit also exceeded the fidelity estimated using the same approach from the baseline study period (Table 1b). There were a total of 5,418 locations in the herd unit and 46% (90% CI: 32-59%) occurred in the winter range within the FCPA.

During the winter season of 2013-2014, 17,441 elk locations from 43 collared elk were collected and of these 8,773 elk locations were within the pre-defined winter range (50%; 90%CI: 43–57%; Table 1a; Appendix A). During the winter season of 2013-2014, the proportion of the FCPA elk locations located within the pre-defined winter range was lower than the baseline winter proportions but, above the performance standard. For the same time period, fidelity to the winter range within the FCPA based on the total number of locations in the herd unit (35%) was below the fidelity estimated but, was above the minimum performance standard using the same approach from the baseline study period (Table 1b). There were a total of 24,784 locations in the herd unit and 35% (90% CI: 27-43%) occurred in the winter range within the FCPA.

Table 1a. Elk proportions estimated from the number of elk locations within the seasonal ranges within the Fortification Creek Planning Area and the total number of elk locations located within Fortification Creek Planning Area.

Period	Season	Date Range	# of Elk	# Locations within FCPA	# Locations within Range	Fidelity (%)	90% Confidence Intervals (%)		80% of Baseline Proportion (%)	Performance Standard (±/-%)
							Lower	Upper		
Baseline	Yearlong	03-26-08 to 05-14-12	92	172,785*	122,483	71	60	82	57	--
2012-2013	Yearlong	05-15-12 to 05-14-13	33	17,249	13,328	77	64	90	NA	+20
2013-2014	Yearlong	05-15-13 to 05-14-14	51	35,060	23,488	67	56	78	NA	+10
Baseline	Winter	12-01-08 to 04-30-12	72	46,036	24,044	52	41	63	42	--
2012-2013	Winter	12-01-12 to 04-30-13	21	3,779	2,475	65	55	76	NA	+23
2013-2014	Winter	12-01-13 to 04-30-14	43	17,441	8,773	50	43	57	NA	+8
Baseline	Parturition	05-15-08 to 06-15-11	69	11,804	10,332	88	79	96	70	--
2012	Parturition	05-15-12 to 06-15-12	26	2,131	1,992	93	86	101	NA	+23
2013	Parturition	05-15-13 to 06-15-13	12	770	743	96	93	100	NA	+26
2014	Parturition	05-15-14 to 06-15-14	33	4,916	4,279	87	78	96	NA	+17

*Includes all locations from GPS-collared elk (e.g., not restricted to the FCPA).

Table 1b. Elk proportions estimated from the number of elk locations within the seasonal ranges within the Fortification Creek Planning Area and the total number of elk locations located the Herd Unit.

Period	Season	Date Range	# of Elk	# Locations within Herd Unit	# Locations within Range	Fidelity (%)	90% Confidence Intervals (%)		80% of Baseline Proportion (%)	Performance Standard (±/-%)
							Lower	Upper		
Baseline	Yearlong	03-26-08 to 05-14-12	92	157,536	122,483	78	68	88	62	--
2012-2013	Yearlong	05-15-12 to 05-14-13	33	17,026	13,328	78	65	91	NA	+16
2013-2014	Yearlong	05-15-13 to 05-14-14	51	34,807	23,488	67	56	78	NA	+5
Baseline	Winter	12-01-08 to 04-30-12	74	60,326	24,044	40	31	49	32	--
2012-2013	Winter	12-01-12 to 04-30-13	21	5,418	2,475	46	32	59	NA	+14
2013-2014	Winter	12-01-13 to 04-30-14	43	24,784	8,773	35	27	43	NA	+3
Baseline	Parturition	05-15-08 to 06-15-11	83	14,960	10,332	69	58	80	55	--
2012	Parturition	05-15-12 to 06-15-12	32	2,400	1,992	83	71	95	NA	+28
2013	Parturition	05-15-13 to 06-15-13	16	1,224	743	61	39	83	NA	+6
2014	Parturition	05-15-14 to 06-15-14	40	7,183	4,279	60	49	71	NA	+5

Resource Selection

We used 124,192 locations collected from 90 GPS-collared elk within the FCPA from March 26, 2008 to May 14, 2012 to estimate a yearlong baseline RSF. For the parturition baseline RSF we used 11,804 locations collected from 69 GPS-collared elk. Lastly, we used 46,036 locations collected from 72 GPS-collared elk to estimate a winter baseline RSF. The top model for each season contained elevation, the slope, terrain ruggedness, distance to road, and distance to cover (Table 2). Coefficients from each RSF suggest that elk selected for habitats with higher elevations, moderate to steep slopes, rugged terrain, away from roads, and close to cover. In addition, selection patterns of RSF coefficients were similar among seasons (Figure 2a-c). Predicted levels of elk use show an avoidance to roads during all 3 seasons (Figure 2a-c).

The top models estimated from the baseline data for each season were used to estimate RSF's for the data collected during post-development to identify changes in resource selection patterns. We used 37,029 locations from 83 GPS-collared elk from May 15, 2012 to May 14, 2014 to estimate a yearlong post RSF. We used 7,817 locations from 71 elk during the 2012, 2013, and 2014 post parturition periods. For the post winter periods (2012-2013 and 2013-2014), we used 21,220 locations from 64 elk. Coefficients from each RSF in the post-baseline analysis showed similar effects as in the baseline RSF analysis (Figure 2a-c). However, there was a shift in use from the baseline to post-baseline among the three seasons.

During the yearlong period, the effect of elevation appears to be slightly higher in the post-baseline period than the baseline period. For example, the relative probability of elk resource selection increased by 0.16% for every 1 m increase in elevation during the baseline period and 0.54% during the post-baseline period. The effect of distance to road was similar during the pre- and post-baseline periods as resource selection increased by 56% for every 1 km increase in distance to road during the baseline period and 54% during the post-baseline period (Figure 2a-c and 3a-c; Appendix B). Resource selection decreased by 12 and 21% for every 1 km increase in Distance to cover during the pre- and post-baseline periods, respectively. Change in use of these covariates (higher magnitude elevation and distance to cover) and ruggedness (decreased magnitude) likely influenced the shift in selection from the northwestern portion of the study area to the southeast portion of the study area (Figure 3a-c; Appendix B).

A shift in resource selection was also detected from the baseline to the post-baseline parturition study periods. Elevation and distance to road had similar effects on resource selection but the magnitude changed between periods. Resource selection increased by 0.33% and 56% for every 1 m and 1 km increase in elevation and distance to road during the baseline parturition period, respectively. The magnitude of the distance to road covariate decreased from the baseline to post-baseline period (27%) but the elevation covariate increased to 0.53% (Figure 2a-c). Similar to the yearlong period, resource selection decreased by 10 and 25% for every 1 km increase in distance to cover during the baseline and post-baseline periods. There appears to some variability in the selection of the ruggedness covariate between the baseline and the first post-baseline and the second post-baseline period as the relative probability of selection decreased in habitats with greater slope and ruggedness. Percent slope and ruggedness were

not significant during the second year post-baseline parturition models. Additional years of monitoring should help to better understand the influence of these variables on resource selection by elk within the study area during parturition.

Similar to the yearlong and parturition period, a shift in resource selection was detected from the baseline to the post baseline winter period. Similar to the yearlong period, elevation and distance to road had similar effects on winter resource selection but the magnitude of these effects changed. Resource selection increased by 0.31 and 67% for every 1 m and 1 km increase in elevation and distance to road during the winter baseline period, respectively. Selection for elevation increased to 0.63% during the post-baseline period and distance to road was similar to baseline levels (60%). The changes in magnitude of elevation and slope resulted in an increase of use from the baseline to the post-baseline period within the southeastern portion of the study area (Figure 3a-c; Appendix B).

Table 2. Candidate set models to describe seasonal baseline resource selection of GPS-collared elk within the Fortification Creek Planning Area.

Model Number	Model	AIC	ΔAIC	Model Rank
	Yearlong			
2	elevation+slope+slope^2+rugged+dis_road+dis_cover	83236.58	0.00	1
1	elevation+slope+rugged+dis_road+dis_cover	83236.98	0.40	2
5	slope+rugged+dis_road+dis_cover	83296.15	59.58	3
3	elevation+slope+slope^2+rugged+rugged^2+dis_road+dis_cover	83364.38	127.80	4
4	elevation+rugged+dis_road+dis_cover	83831.22	594.64	5
7	rugged+dis_road+dis_cover	83891.08	654.50	6
6	dis_road+dis_cover	84353.93	1117.35	7
8	elevation+slope+dis_cover	88428.9	5192.32	8
	Parturition			
2	elevation+slope+slope^2+rugged+dis_road+dis_cover	42809.39	0.00	1
3	elevation+slope+slope^2+rugged+rugged^2+dis_road+dis_cover	42809.73	0.33	2
1	elevation+slope+rugged+dis_road+dis_cover	42816.73	7.34	3
4	elevation+rugged+dis_road+dis_cover	42912.89	103.49	4
5	slope+rugged+dis_road+dis_cover	43418.58	609.18	5
7	rugged+dis_road+dis_cover	43495.92	686.53	6
6	dis_road+dis_cover	43612.55	803.15	7
8	elevation+slope+dis_cover	46485.27	3675.87	8
	Winter			
2	elevation+slope+slope^2+rugged+dis_road+dis_cover	59329.03	0.00	1
1	elevation+slope+rugged+dis_road+dis_cover	59335.56	6.54	2
3	elevation+slope+slope^2+rugged+rugged^2+dis_road+dis_cover	59342.02	13.00	3
5	slope+rugged+dis_road+dis_cover	59505.69	176.66	4
4	elevation+rugged+dis_road+dis_cover	60330.17	1001.14	5
7	rugged+dis_road+dis_cover	60460.27	1131.25	6
6	dis_road+dis_cover	61039.78	1710.75	7
8	elevation+slope+dis_cover	65864.39	6535.36	8

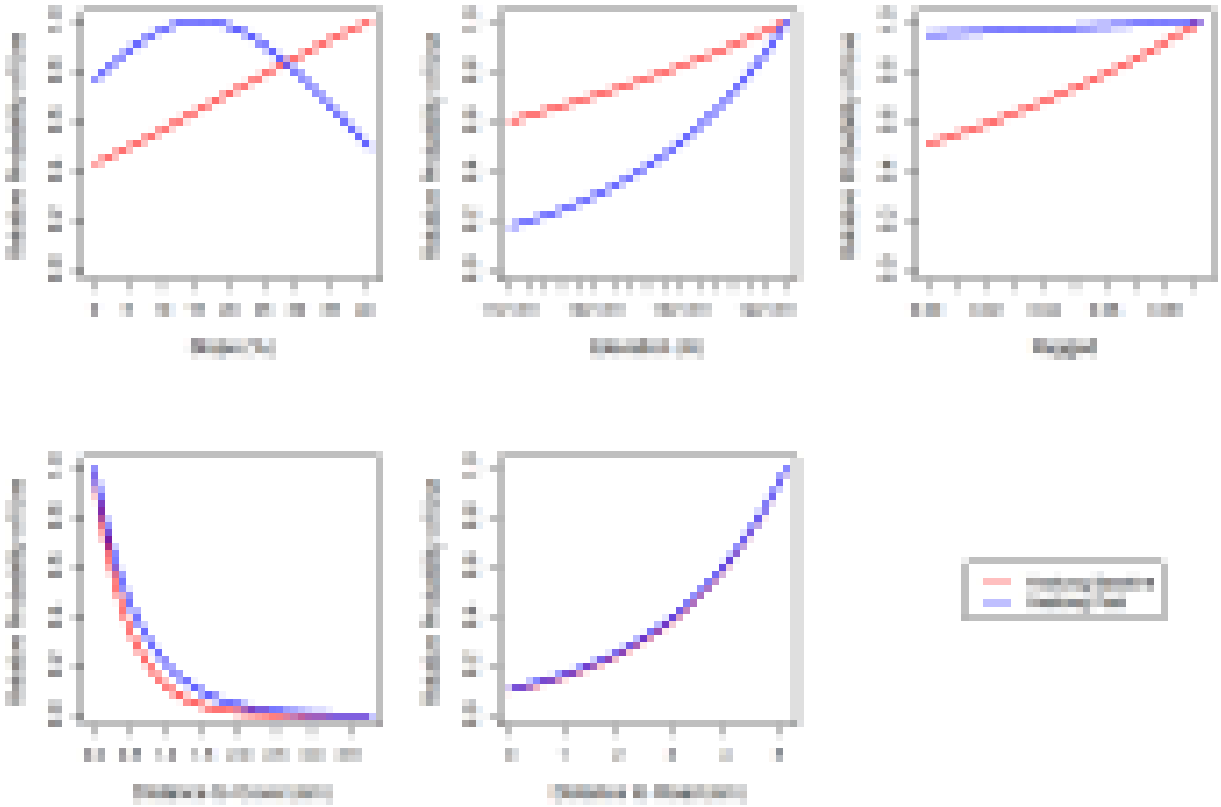

Figure 2a. Predicted level of elk use according to the final resource selection functions for each of three periods within the Fortification Creek Planning Area. Predictions were scaled so the maximum value was equal to 1. Variables not in a figure were held constant at their median values.

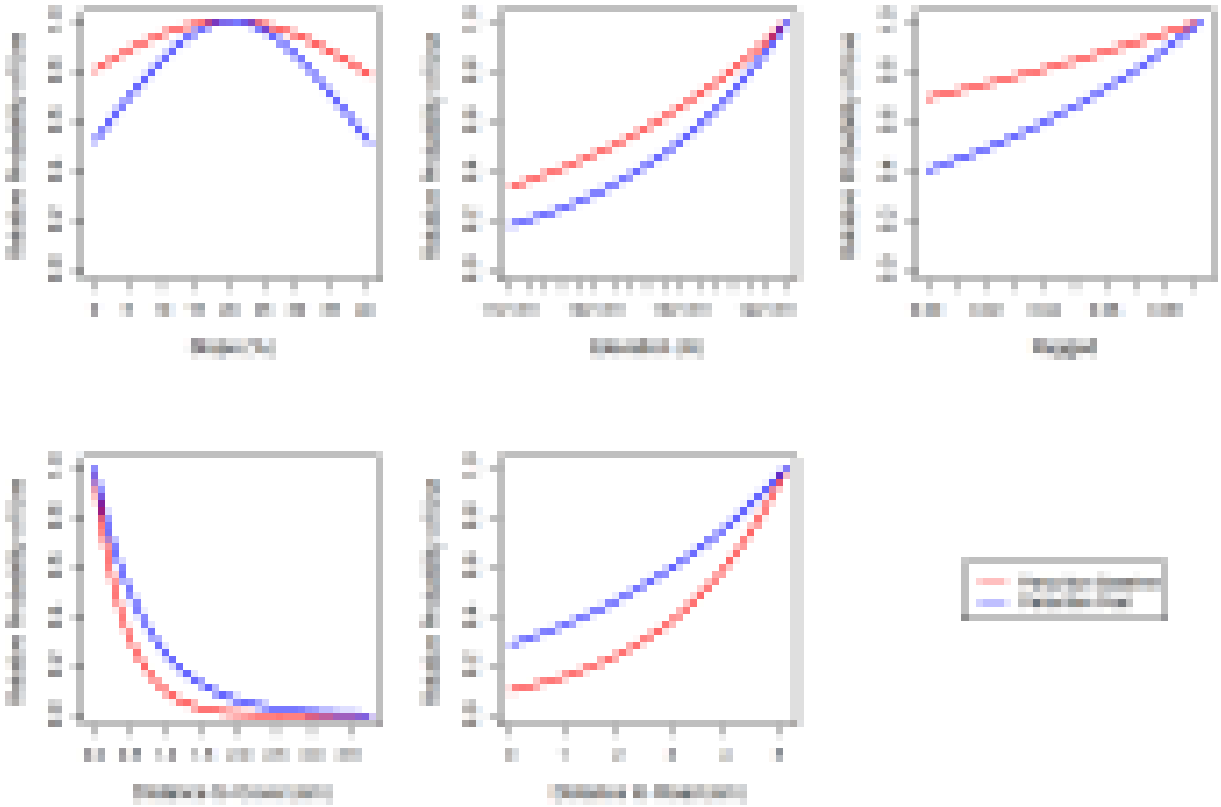

Figure 2b. Predicted level of elk use according to the final resource selection functions for each of three periods within the Fortification Creek Planning Area. Predictions were scaled so the maximum value was equal to 1. Variables not in a figure were held constant at their median values.

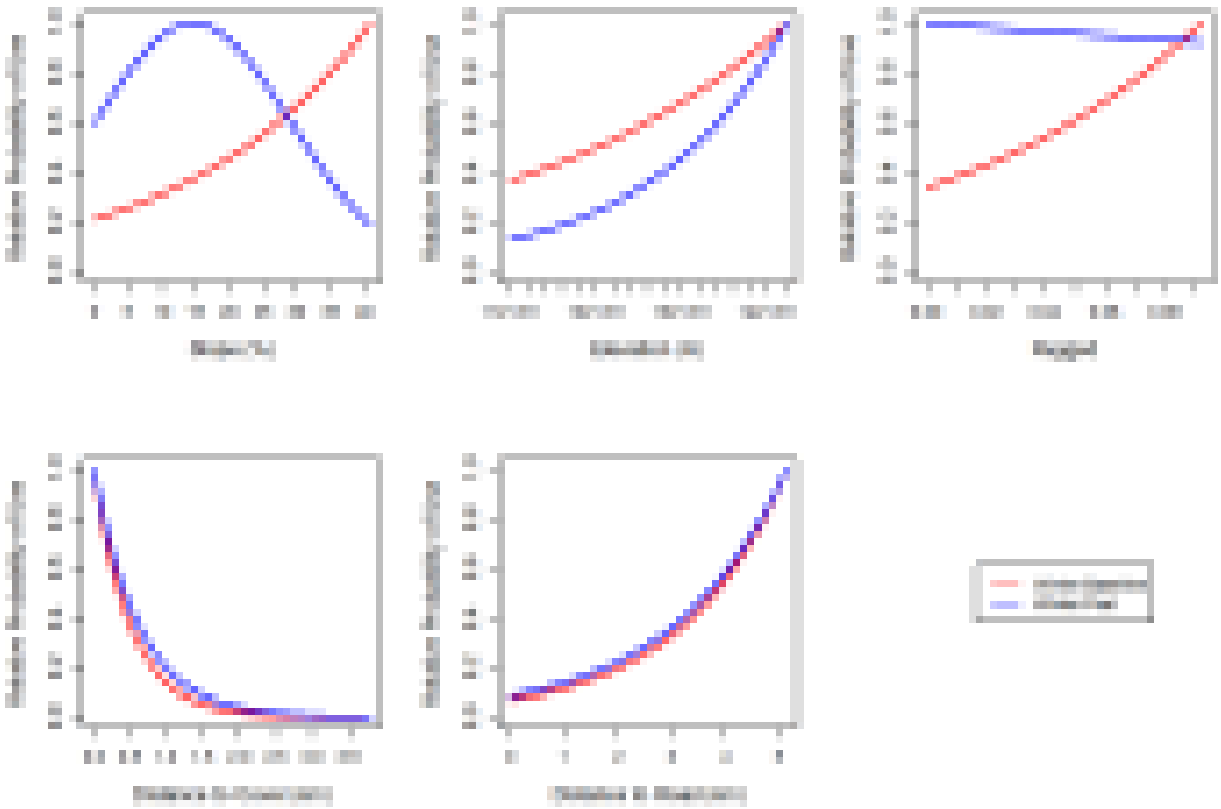

Figure 2c. Predicted level of elk use according to the final resource selection functions for each of three periods within the Fortification Creek Planning Area. Predictions were scale so the maximum value was equal to 1. Variables not in a figure were held constant at their median values.

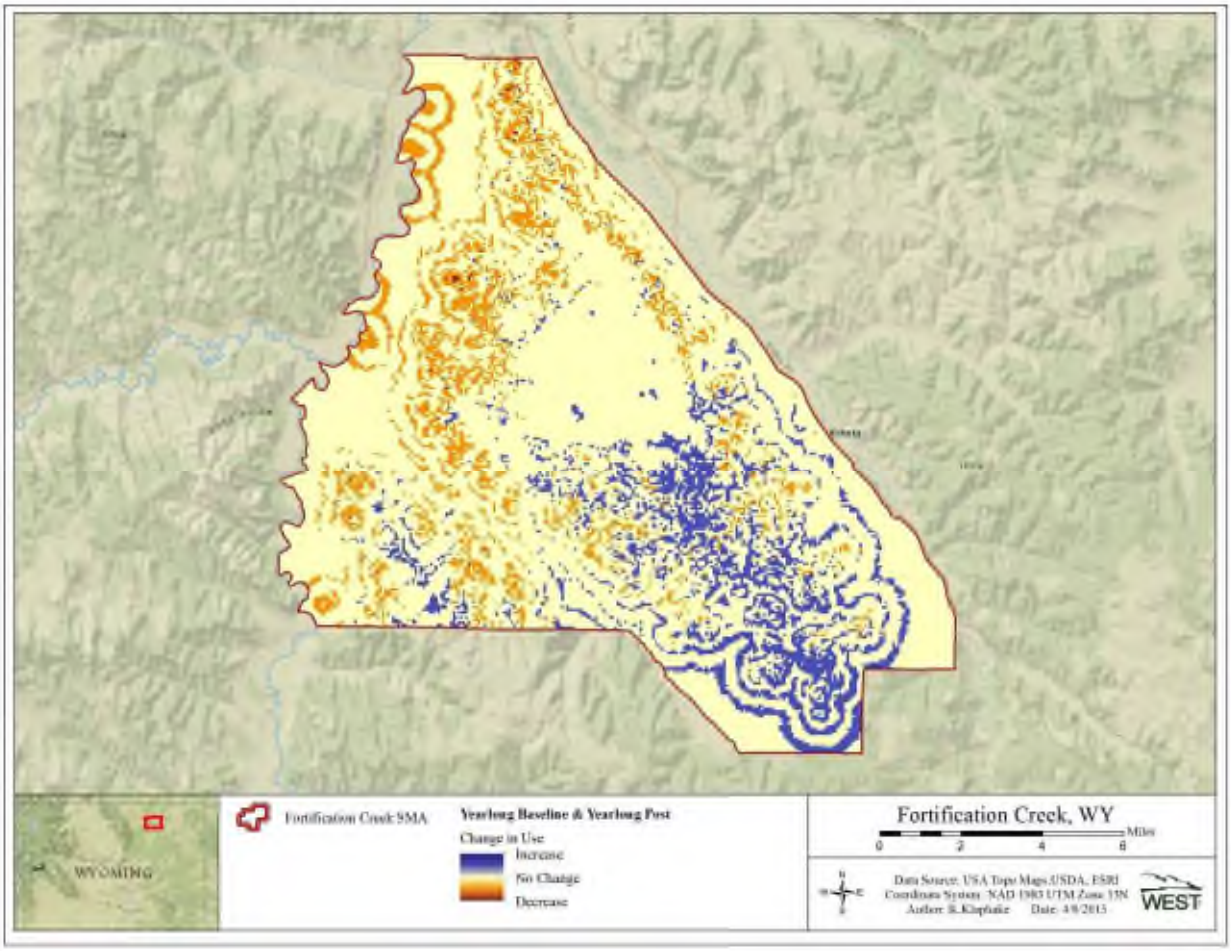

Figure 3a. Change in predicted levels of elk use from yearlong baseline to yearlong during the first year post-baseline 2013-2014 within the Fortification Creek Planning Area.

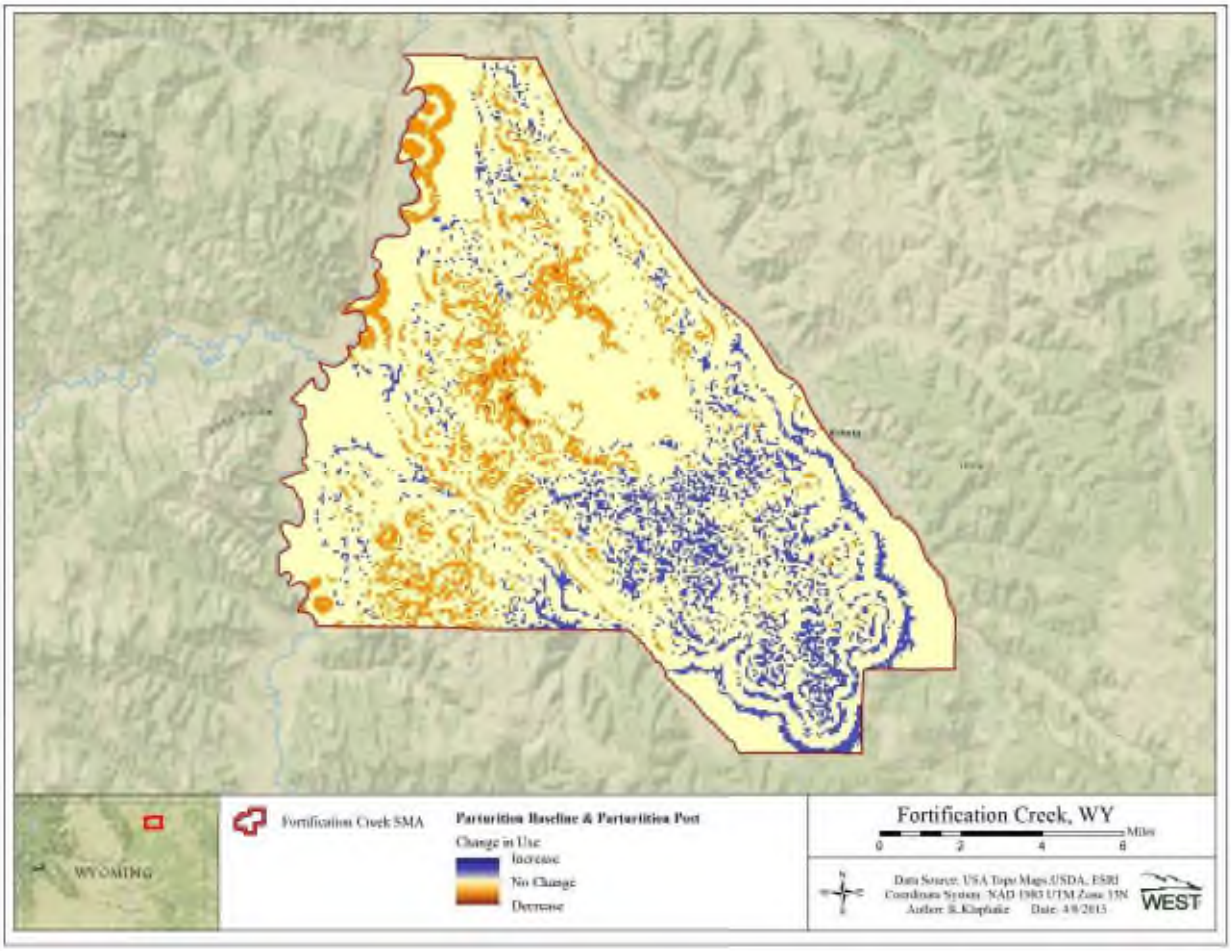

Figure 3b. Change in predicted levels of elk use from parturition baseline to the first two parturition seasons post-baseline 2013 and 2014 within the Fortification Creek Planning Area.

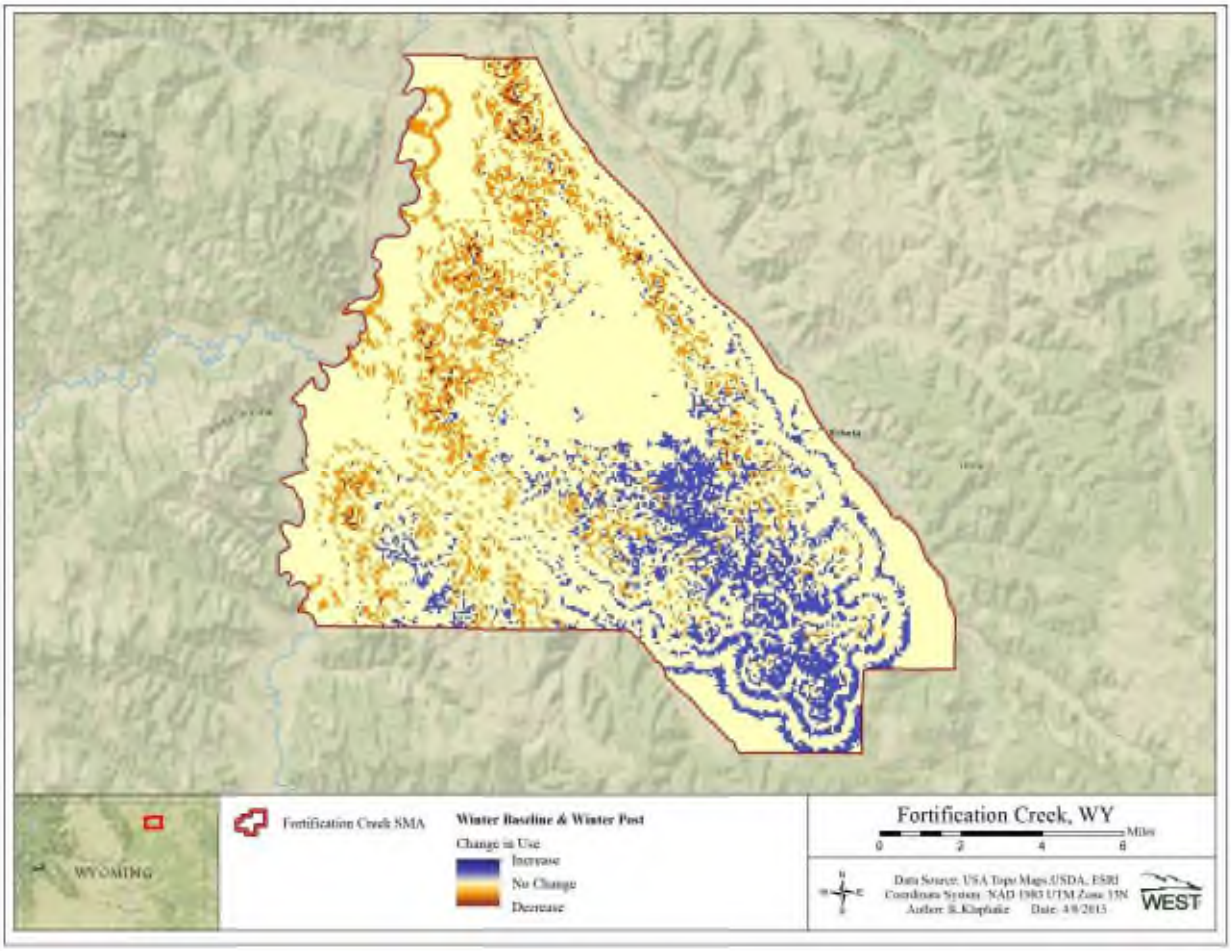

Figure 3c. Change in predicted levels of elk use from winter baseline to the first winter season post-baseline in 2013-2014 within the Fortification Creek Planning Area.

DISCUSSION

Our task was to compare the first and second year of post-baseline elk locations collected in (2012-2013 and 2013-2014) to the seasonal (parturition, winter, and yearlong) baseline elk fidelity standards. GPS fix success was assumed to be high or unrelated to habitat use and the data were used as provided by the BLM. The proportions of elk locations collected during the first and second year post-baseline exceeded the minimum proportion standards across all seasons. In addition, we also compared the seasonal baseline RSFs to RSFs developed using the location data from the post-baseline years (2012-2014) to predict levels of elk use throughout the FCPA.

The RSFs can be used as an additional tool to evaluate changes in elk fidelity or habitat use through time (e.g., Sawyer et al. 2006). We applied the baseline RSF models to the 2012-2014 location data to detect changes in use within the FCPA during all three periods. Use during the post-baseline period was slightly different than use during the baseline period. There appears to

be a greater shift in resource selection in the southeastern portion of the FCPA (positively) and western portions of the FCPA (negatively). If there were no changes in selection patterns from baseline to post-baseline then we would expect the majority of the FCPA to be neutral in color. A relatively minor amount of new roads (1.8 miles) were added to the southeast portion of FCPA during the summer of 2013 (Figure 4). Given the relatively minor amount of new roads and the small area impacted by the construction of new roads in 2013 (relative to the entire FCPA), it is unlikely that the new roads would have a big influence on overall elk resource selection within the FCPA. This was also evident by the small changes in magnitude in the distance to road covariate for all seasons. The elk also selected areas of higher elevation in the post-baseline period than during the baseline period for all seasons (Figure 5). It is unknown why the elk resource selection patterns slightly changed from the baseline to post-baseline; however, changes in yearly weather regimes could have influenced the changes in selection patterns. For example, elk may select habitats at lower elevations compared to higher elevations during mild winters. Further investigation into weather patterns during the baseline and post-baseline periods may provide insight into the changes of use within the FCPA.

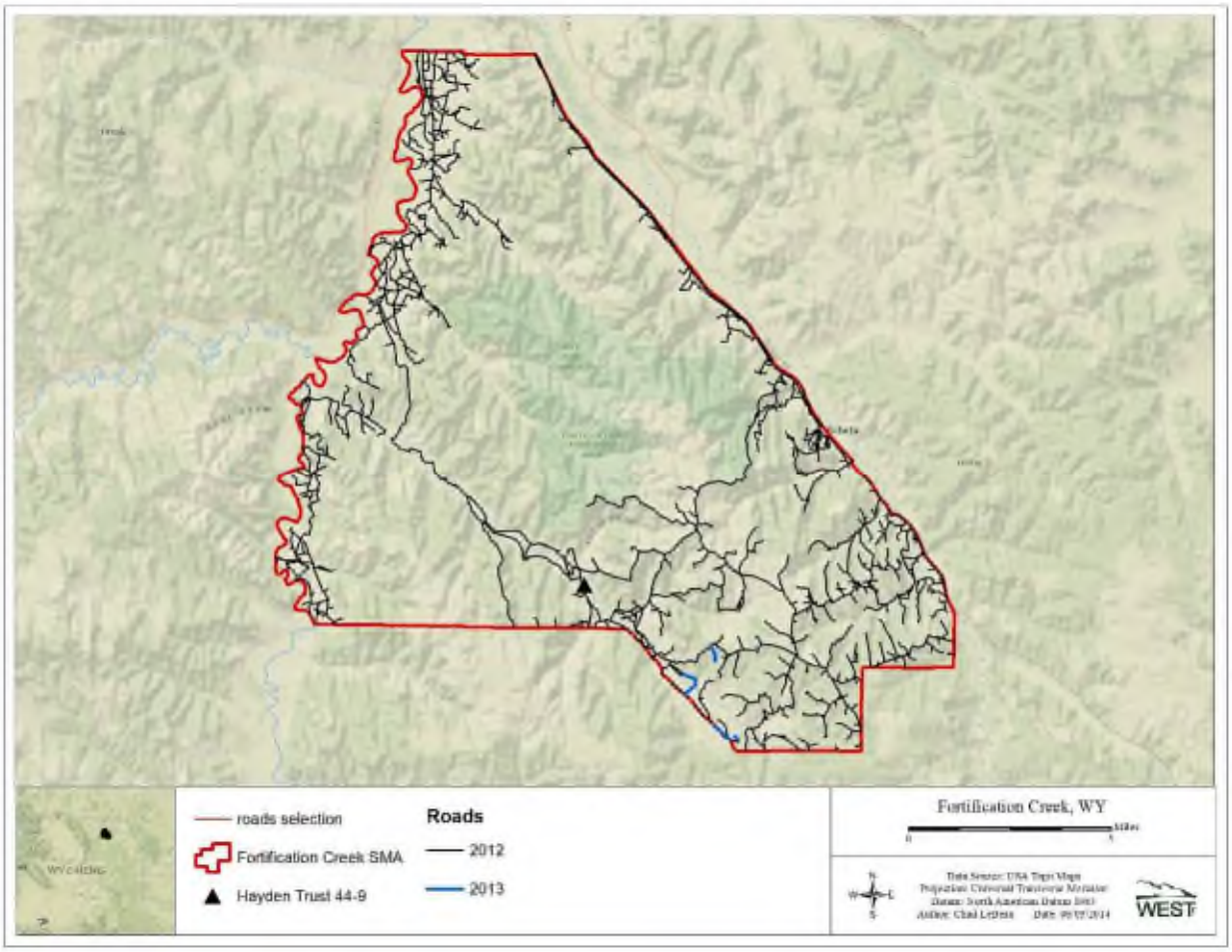

Figure 4. Location of roads included in analysis within the Fortification Creek Planning Area. The new roads constructed during the summer of 2013 are identified in blue.

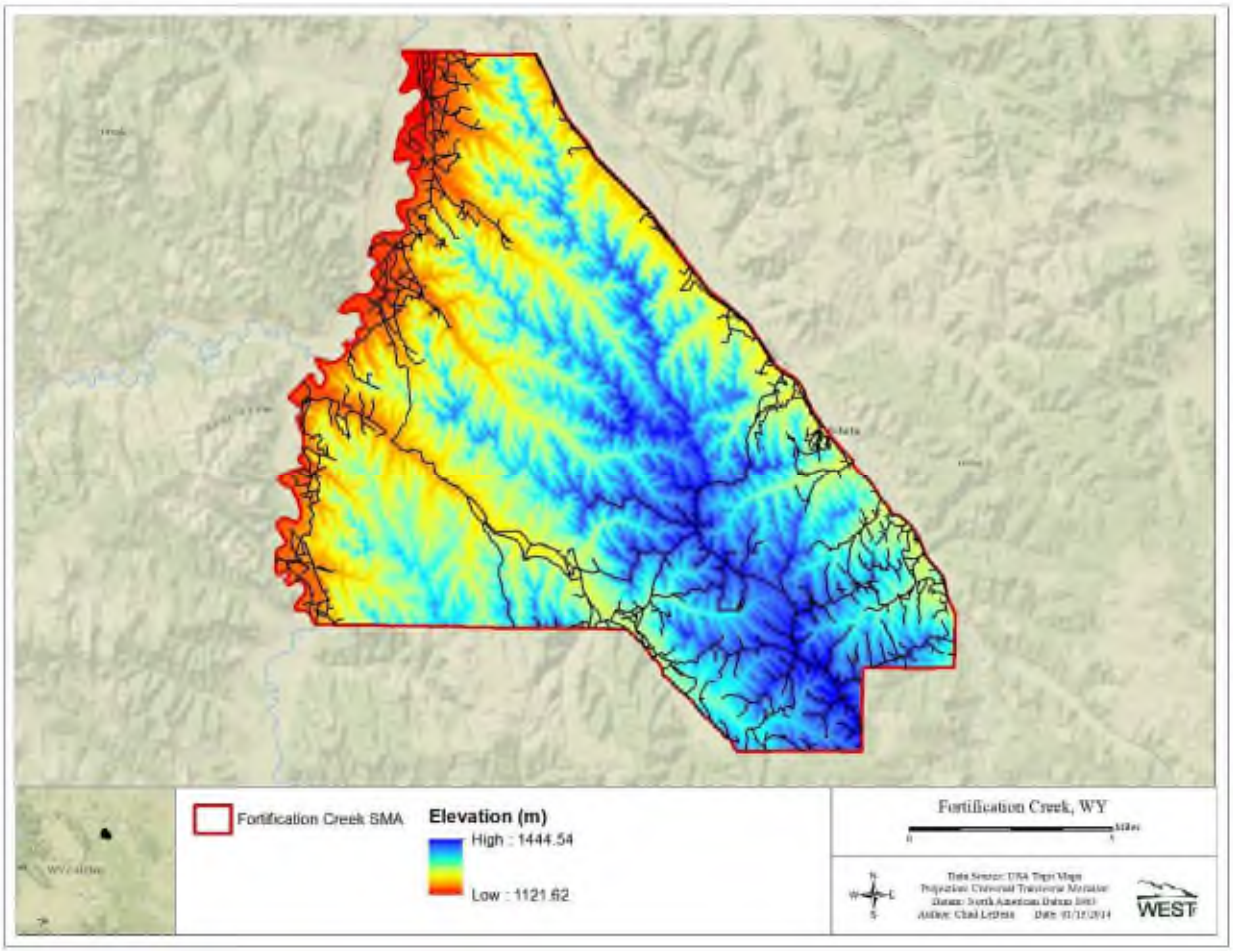

Figure 5. Figure depicting elevation within the Fortification Creek study area.

In addition to total elk use of each range, we investigated elk use patterns within the parturition and winter ranges. More specifically, we investigated weekly use of the winter and daily use of the parturition range by individual elk during the winter and parturition periods to identify movement patterns (e.g., movements in and out of seasonal ranges) and range fidelity behavior exhibited by the elk. The winter range comprised of 38% of the total FCA so we would expect elk to use this area approximately 38% of the time if no selection of this area was occurring. Elk appear to be selecting habitat within the winter range during the 2008-2009 winter especially from week 1 (early Dec.) through week 16 (mid-March) where elk had high fidelity towards the winter range (Figure 6). There was a steady decline in number of locations within the winter range from week 7 (mid Jan.) to week 17 (mid-March) before increasing again in week 18 (Figure 6). The proportion of elk locations within the winter range during the 2009-2010 and 2011-2012 winters were slightly higher than expected at random but there is little evidence to suggest elk are selecting for or against the habitats within the winter range. The proportions during the 2009-2010 and 2011-2012 winters remained relatively constant between 30 and 60% suggesting the elk using the winter range during this period spent the majority of their time

within the range (Figure 6). During the 2010-2011 winter, elk within the FCA appear to be selecting against habitats within the winter range during weeks 7 (mid Jan) through 14 (early March) compared to the 2008-2009 winter. However, selection increased from week 17 (mid March) to week 21 (mid April; Figure 6).

During the first post-baseline year, elk appear to be selecting for the winter range throughout the winter season with a peak during week 10 (end of January; Figure 6) when over 90% of the collared elk locations within the FCPA were within the pre-defined winter range. The second post-baseline year peaked around week 6 (approximately 85%) before declining to around 50% in week 11.

If elk had high site fidelity to the winter range during the winter period then we would expect to see large proportions of locations within the range. During the baseline, we only observed high proportions during the 2008-2009 winter, suggesting the collared elk within FCPA did not use the winter range during the entire winter period during the baseline period. However, we did see high proportions of elk locations in the winter range during the winters of 2012-2013 and 2013-2014. The source of the patterns observed in the proportion of locations within the winter range (e.g., peaks and valleys) is not known; however, these peaks and valleys could be attributable to mild or extreme winter weather conditions, major storm events, and/or anthropogenic influences.

The parturition range is larger than the winter range and comprises of 59% of the overall study area. Similar to the winter range selection patterns, we would expect approximately 59% of elk parturition locations to occur within the parturition range if no selection for habitats within the parturition range was occurring. Elk appear to be selecting for the parturition range during the parturition time period for all study years especially during the 2013 parturition season (2008-2013; Figure 7). Elk appear to have left the parturition range earlier in 2008-2010 than in 2011-2013 (Figure 7). There is also evidence of stronger fidelity to the parturition range in 2011, 2012, and especially in 2013 indicated by the small range in proportions (0.85 to 1.00; Figure 7). Similarly to other post-baseline years, 2014 experienced similar fidelity patterns to the parturition range but the overall proportion was lower than the other two post-baseline years. In contrast, increased daily variation in the proportion of locations within the parturition range (0.68 to 0.93) from 2008-2010 indicates increased movements in and out of the range (Figure 7).

Unlike the winter range, we observed high fidelity by elk to the parturition range during the parturition time period. The parturition range appears to capture the majority of elk locations within the FCPA during this time period; however, there appears to be some movements in and out of the range. Similar to the patterns observed in the winter range, we are unsure as to the source of these patterns observed during the parturition period.

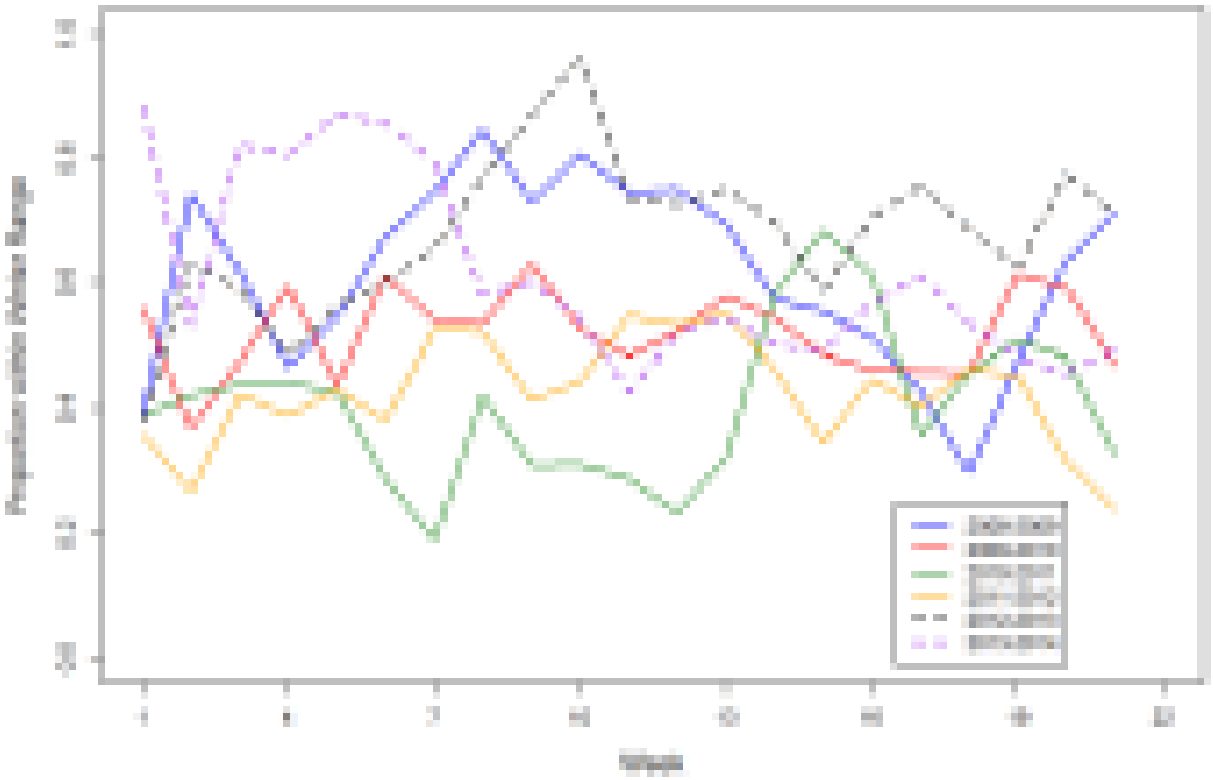

Figure 6. The weekly proportion of elk locations within the winter range during the winter period (December 1 to April 30) in the Fortification Creek Area.

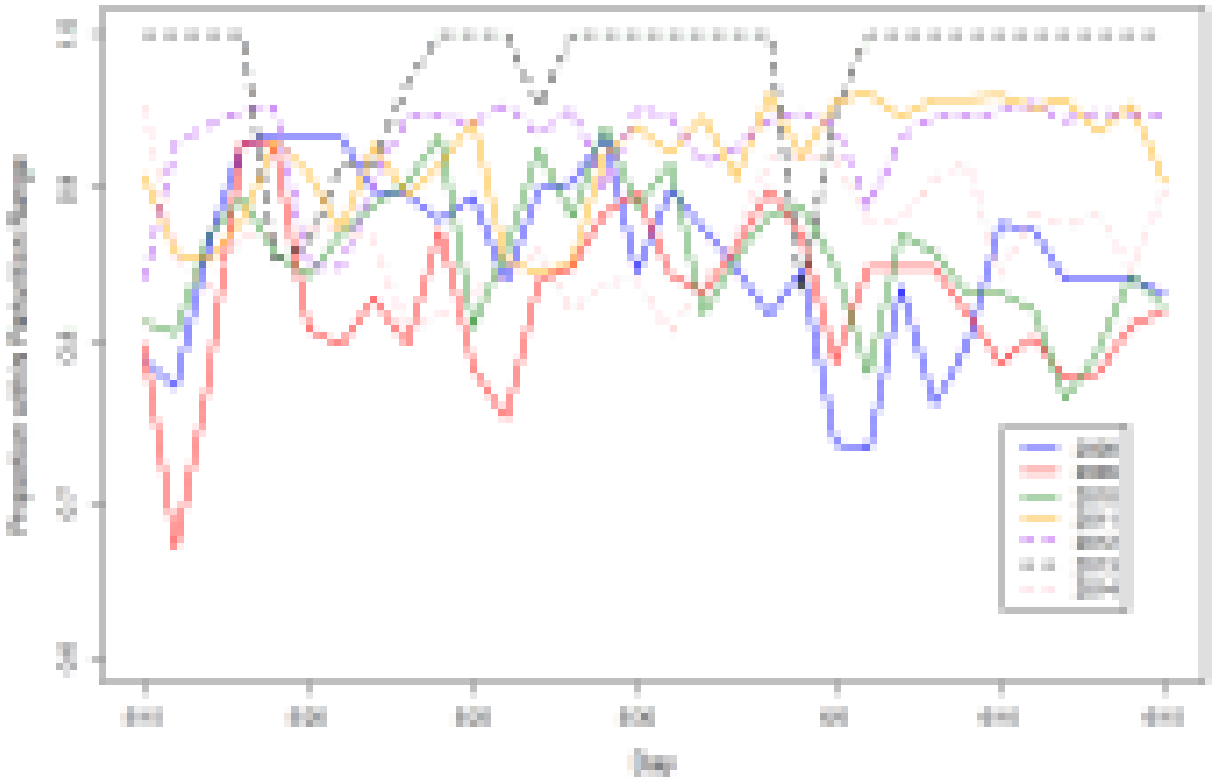

Figure 7. The daily proportion of elk locations within the parturition range during the parturition period (May 15 to June 15) in the Fortification Creek Area.

In addition to the relatively minor road construction (1.8 miles) that occurred in the summer of 2013, a deep non-federal oil well was drilled in early 2013 located off Fortification Road near Fortification Creek at: T51N R76W S9 SE SE. At the request of the BLM, we evaluated the average distance of elk locations within varying distance bands (e. g., 300, 500, 700, 1000, 1500, 3000 m) relative to the well location for both the baseline and post-baseline periods to detect any possible avoidance. The response (if any) of elk to this well pad may be different for elk that utilize habitat in close proximity to the well versus elk that utilize habitats located at greater distances. Because of this possible avoidance gradient we compared the average distances within each distance band between the baseline and post-baseline periods. The average distance of locations observed within 500 m of the well during the yearlong baseline period (period prior to development) was 323 m (90% CI: 308-339 m). One well was drilled January 2013 and elk use within 500 m during the post–baseline period (period following development; January 2013-March 2014) was 441 m (90% CI: 400 – 483 m). A second well was drilled March 28, 2014 and use did not occur within 1,000 m of the well during the post-baseline period following development. On average use within 1,500 m and 3,000 m of the well during the post-baseline period was higher than average use within these distance bands during the pre-baseline period.

The observed results could be the result of a number of factors such as the specific elk that were marked during the different time periods and habitat or weather conditions during the time

periods evaluated. In an attempt to minimize some of potential unknowns associated with the elk behavior relative to the well, we investigated elk use within a year of the well development rather than including multiple baseline periods to identify possible behavior changes at a smaller time scale. Similar to results that included all baseline years, the distance of average elk locations within 1,500 m of the well increased significantly from one year pre-development to the post development period suggesting some possible avoidance. However, continued monitoring of collared elk over time should help to better understand the potential influence the well has on elk use and habitat selection within the area.

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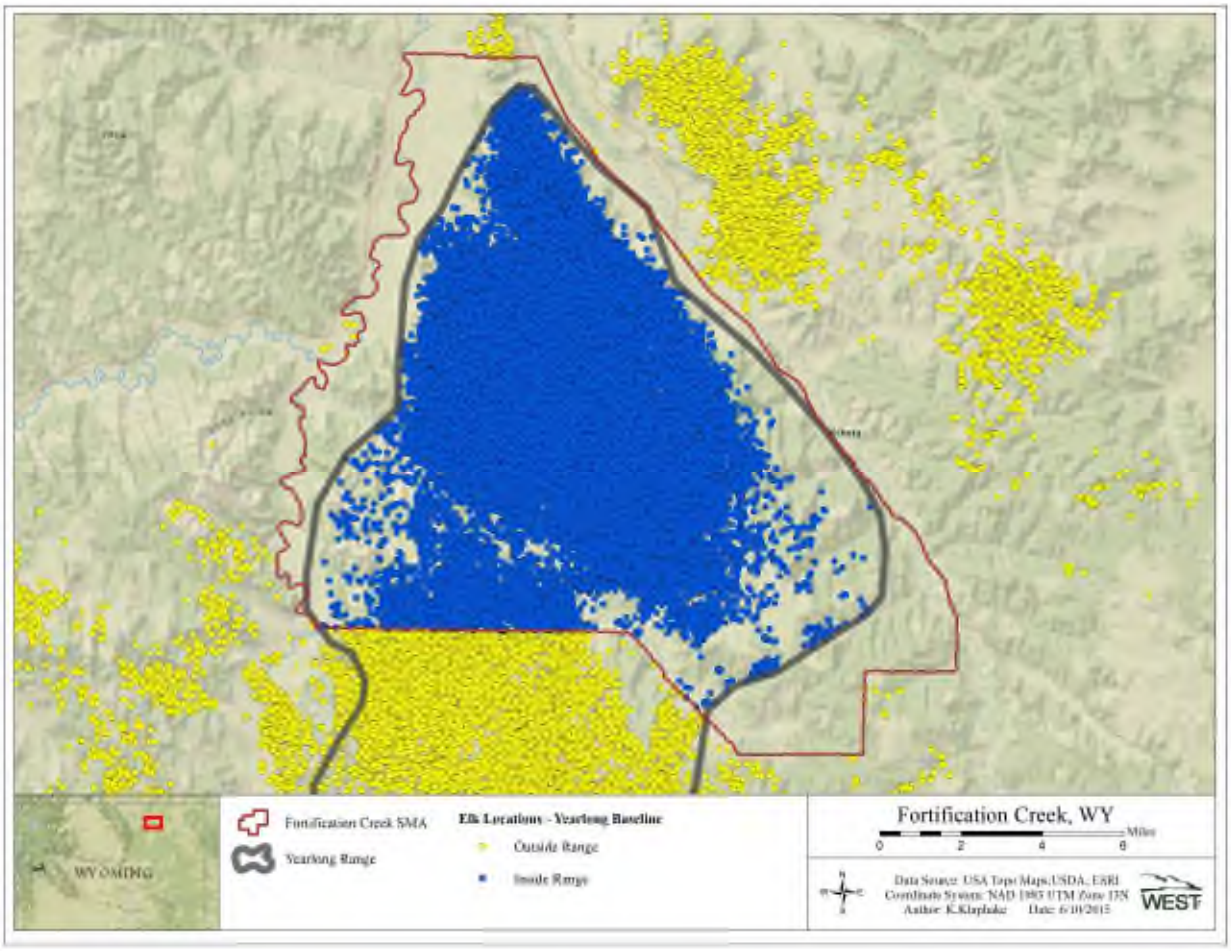
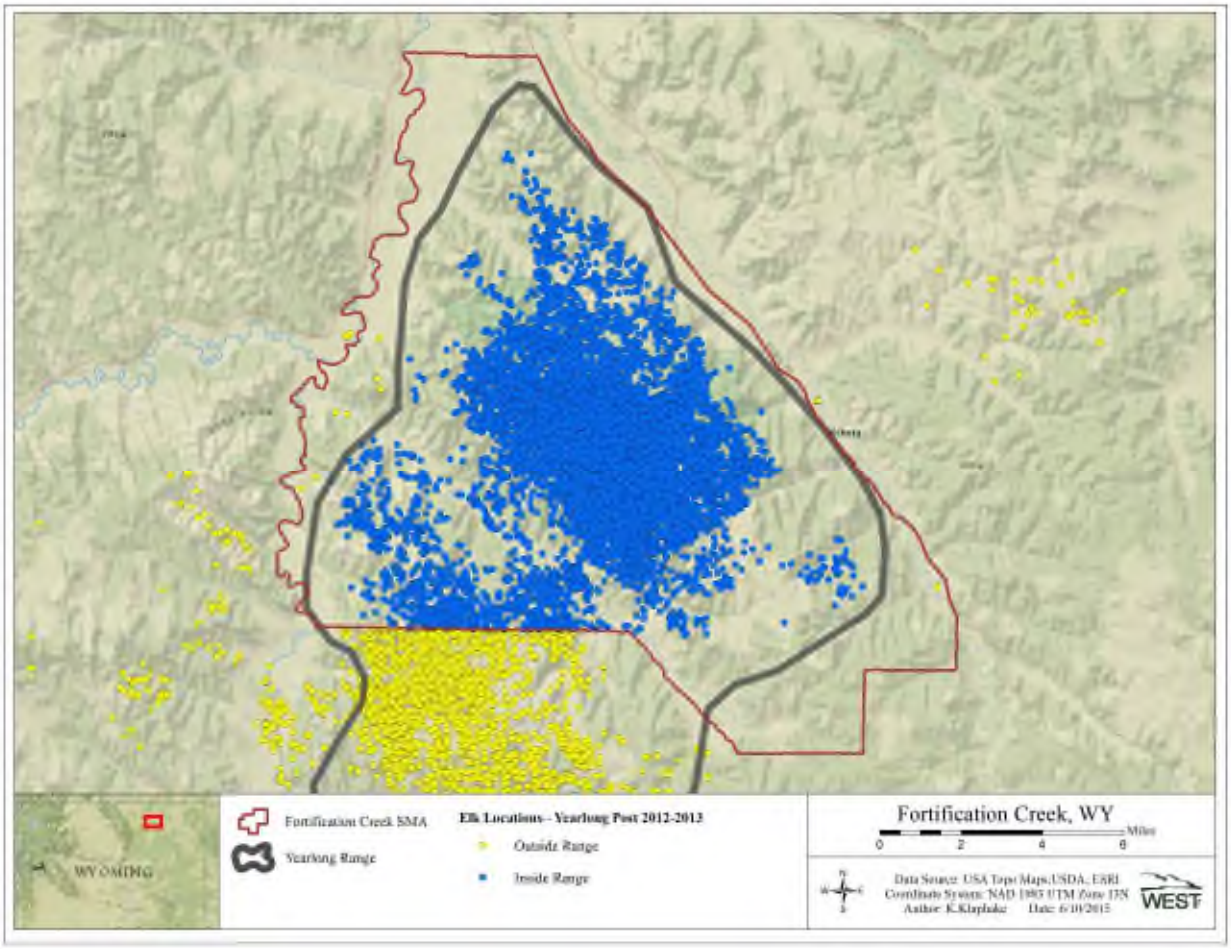
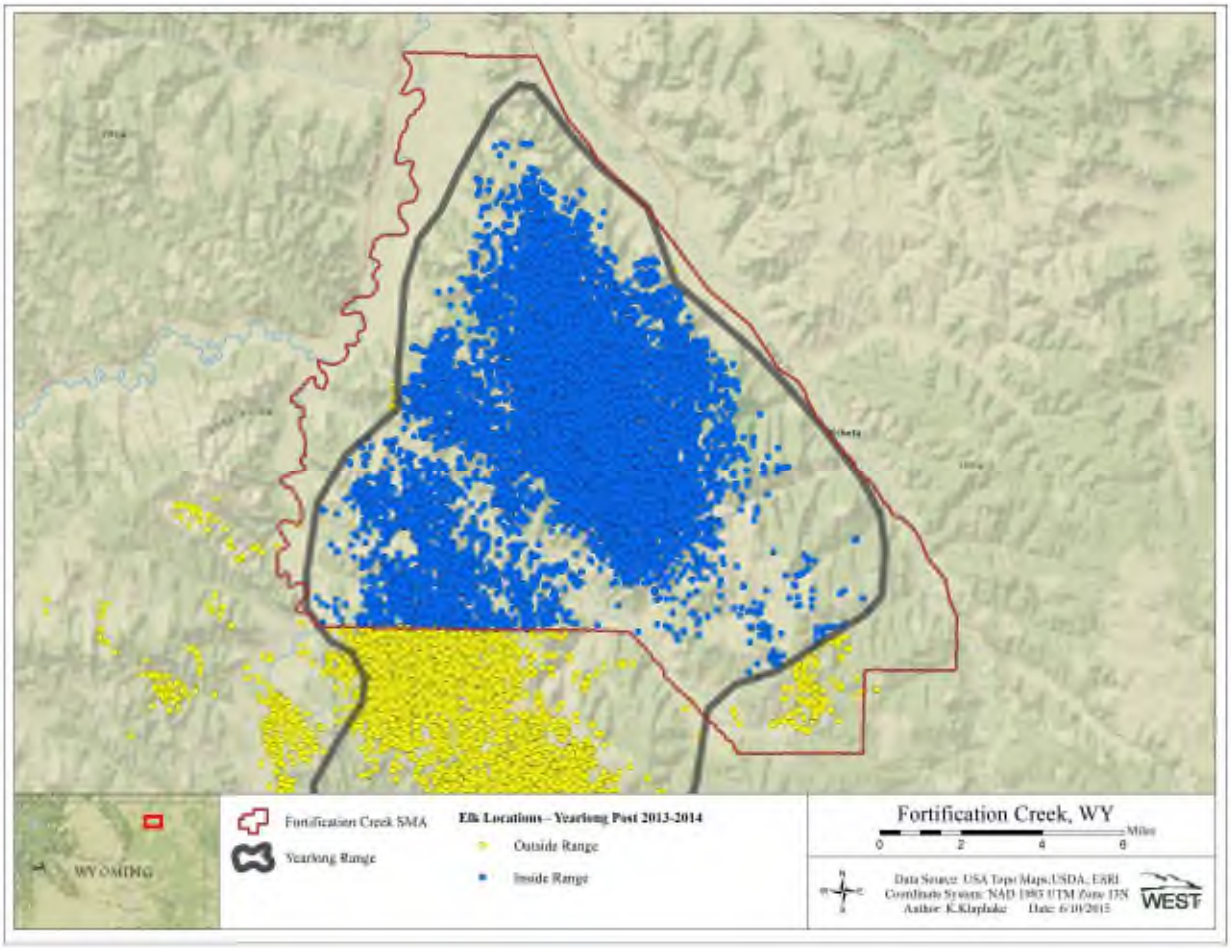
Appendix A. Figures depicting baseline and post-construction GPS elk locations within the Fortification Creek Planning Area during the Yearlong, Parturition, and Winter Periods



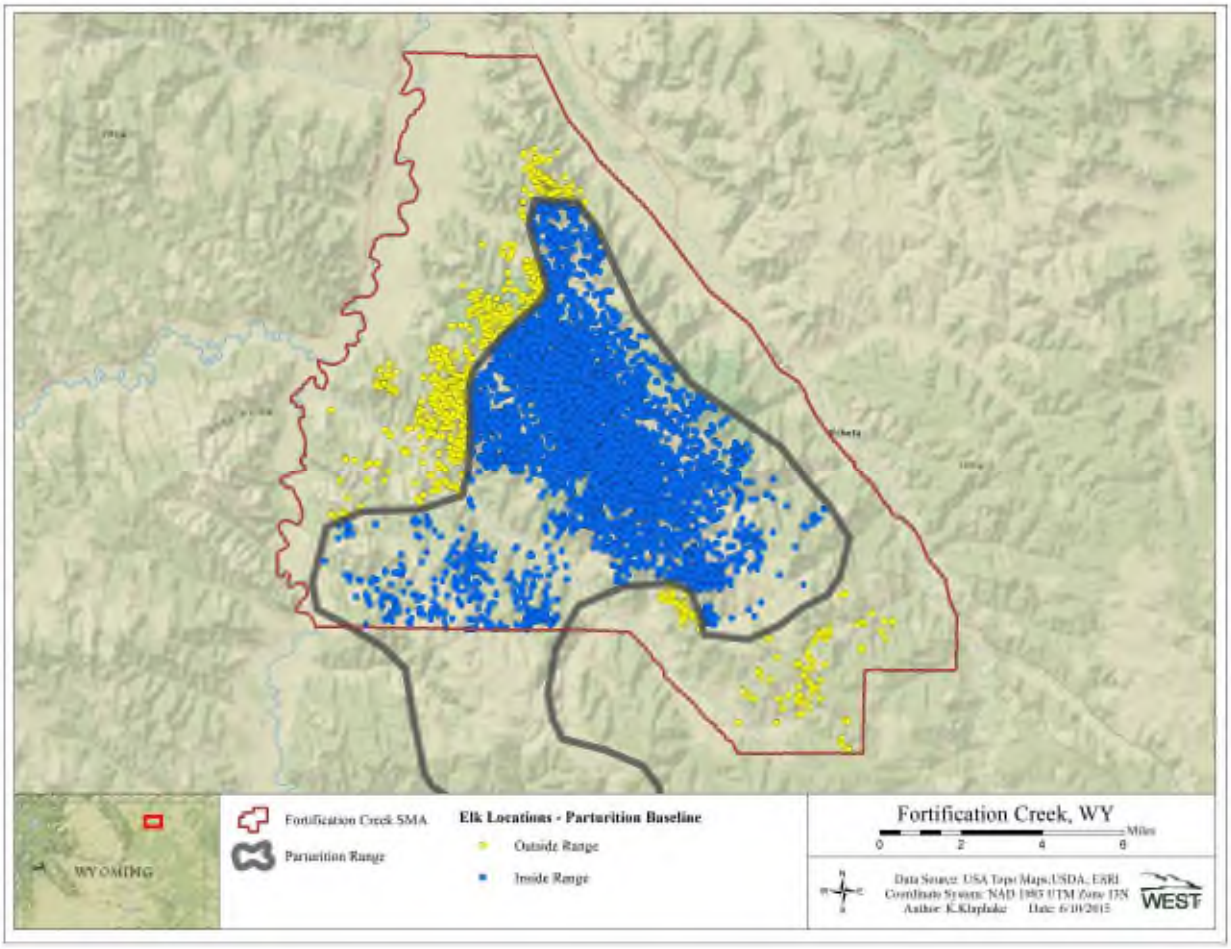
Elk locations from GPS-collared elk during the yearlong baseline period within Fortification Creek Planning Area.



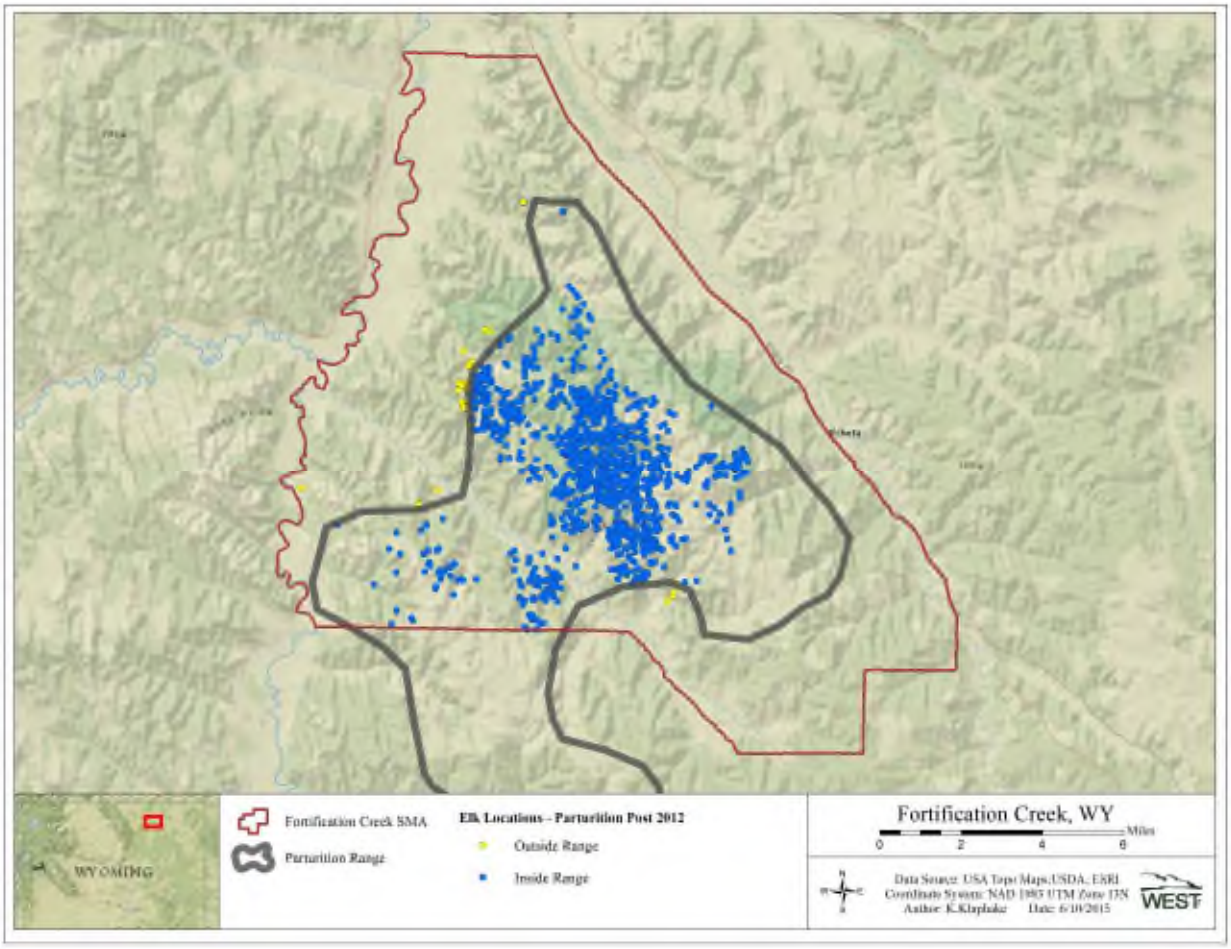
Elk locations from GPS-collared elk during the yearlong 2012-2013 post-construction period within Fortification Creek Planning Area.



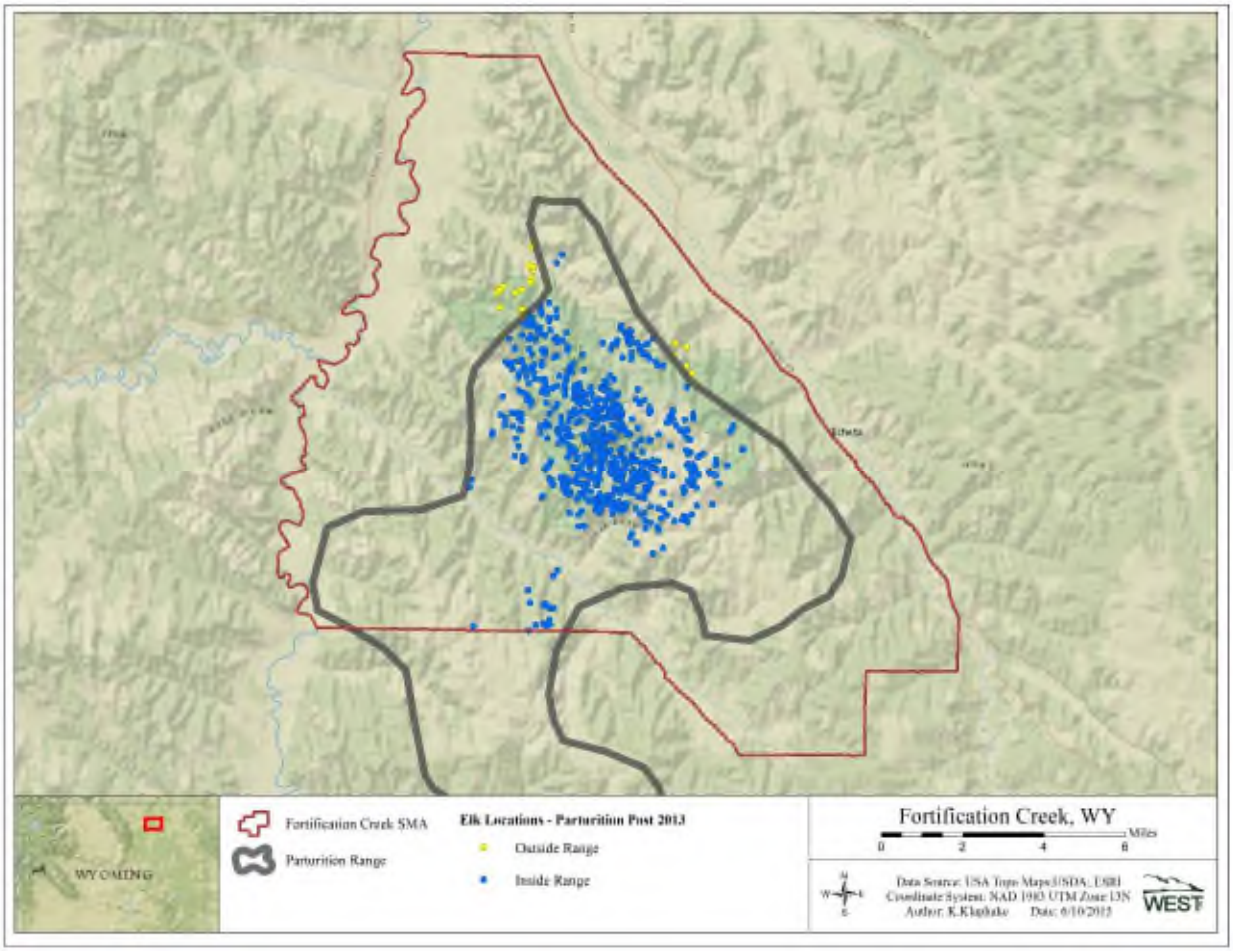
Elk locations from GPS-collared elk during the yearlong 2013-2014 post-construction period within Fortification Creek Planning Area.



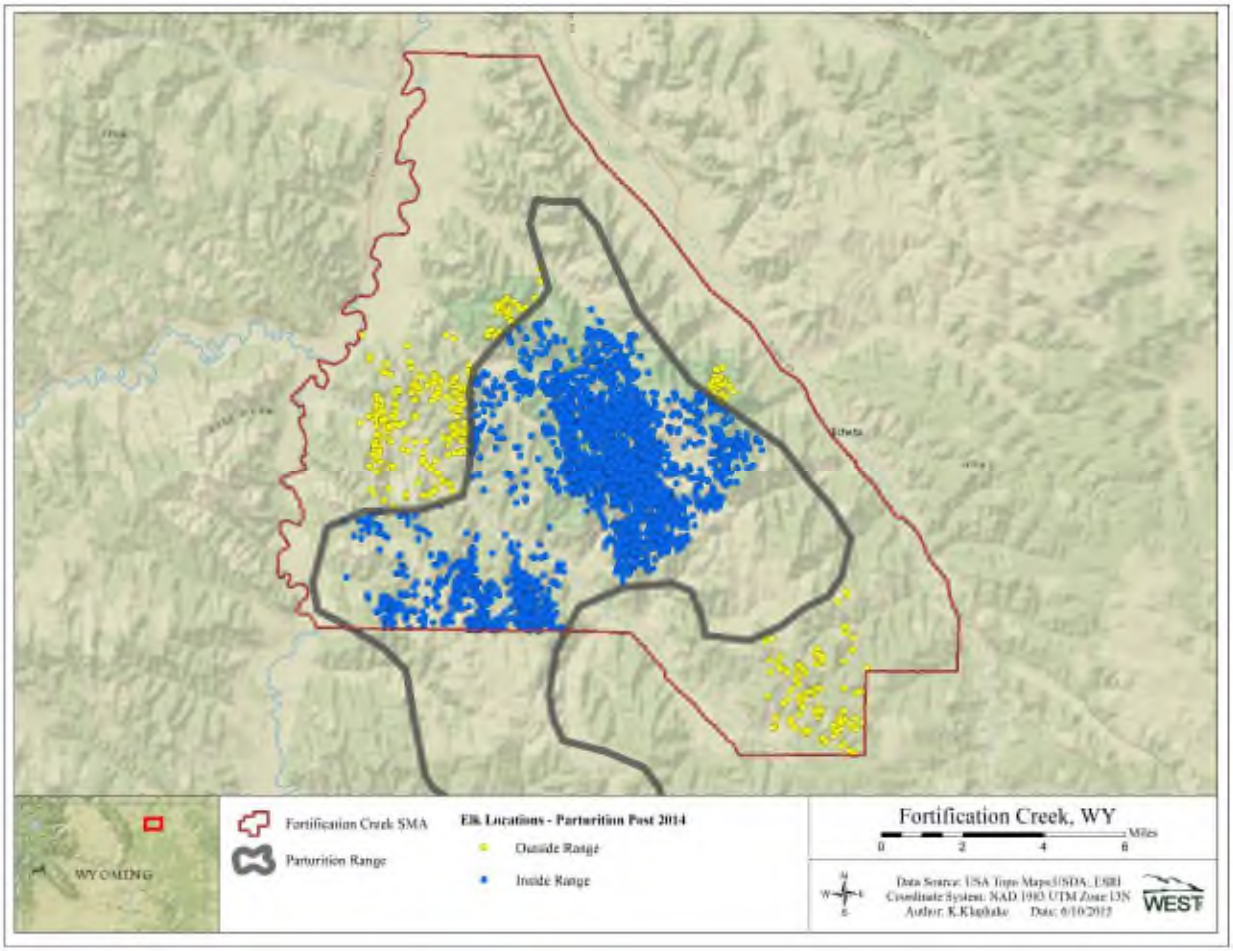
Elk locations from GPS-collared elk during the baseline parturition period within Fortification Creek Planning Area.



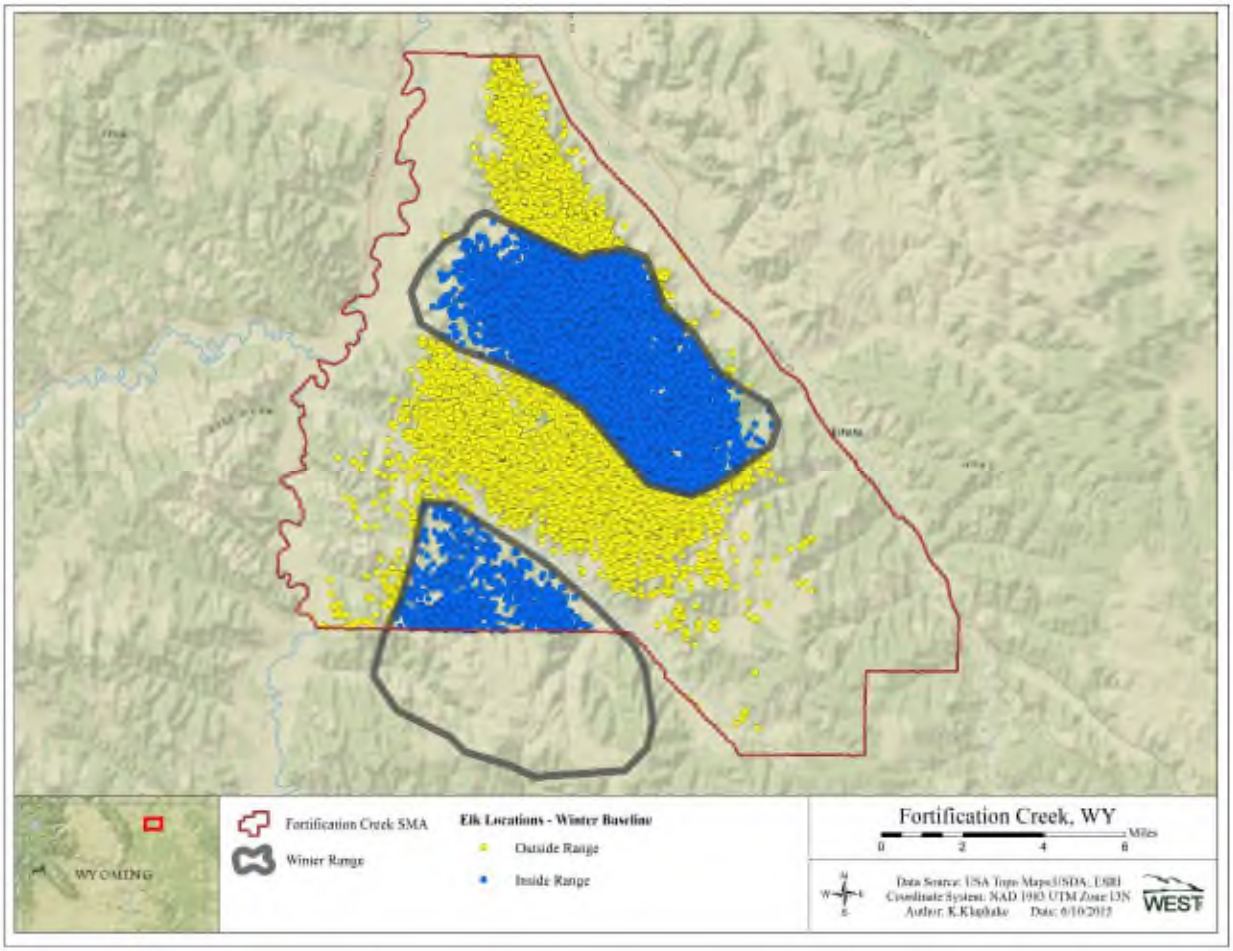
Elk locations from GPS-collared elk during the 2012 post-construction parturition period within Fortification Creek Planning Area.



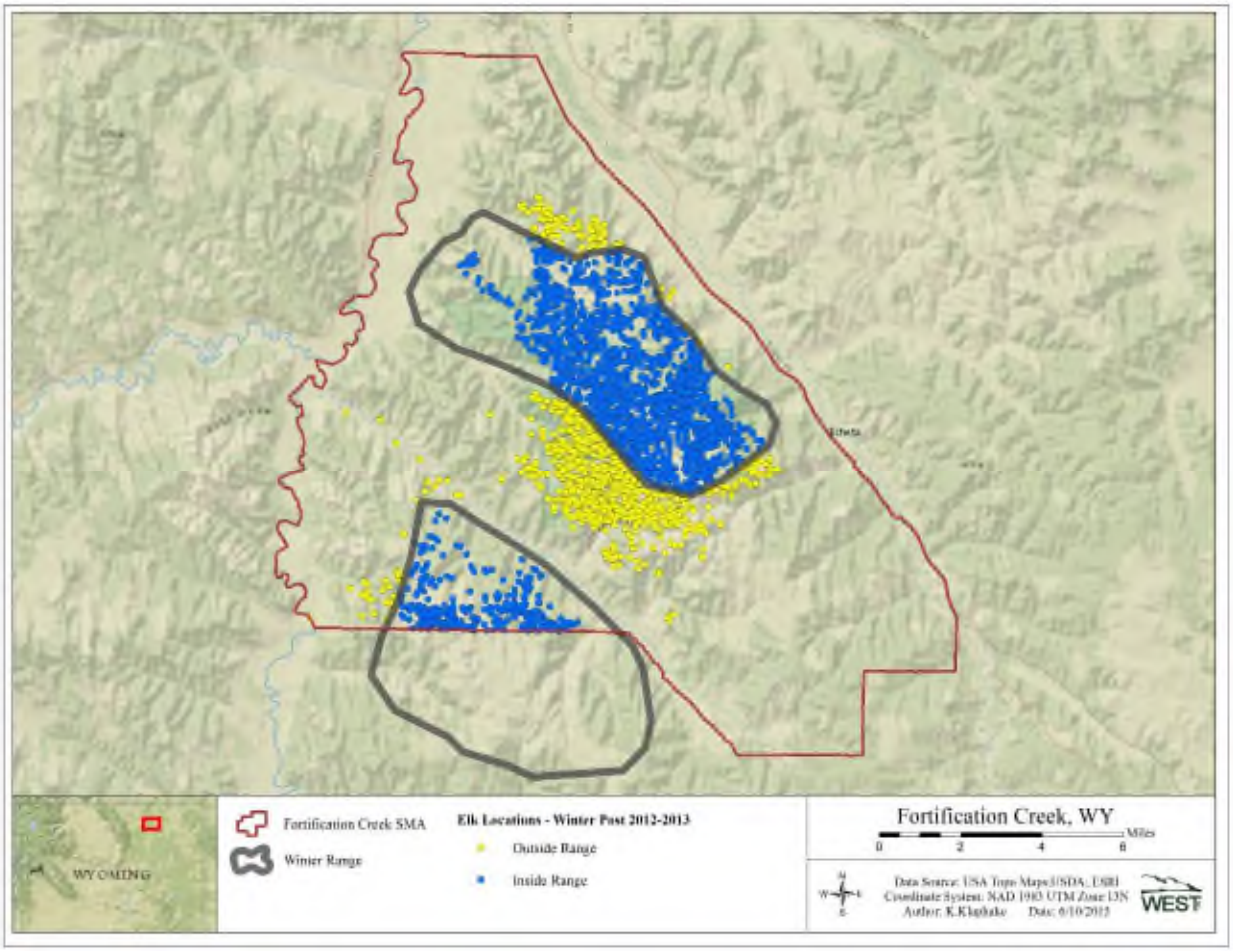
Elk locations from GPS-collared elk during the 2013 post-construction parturition period within Fortification Creek Planning Area.



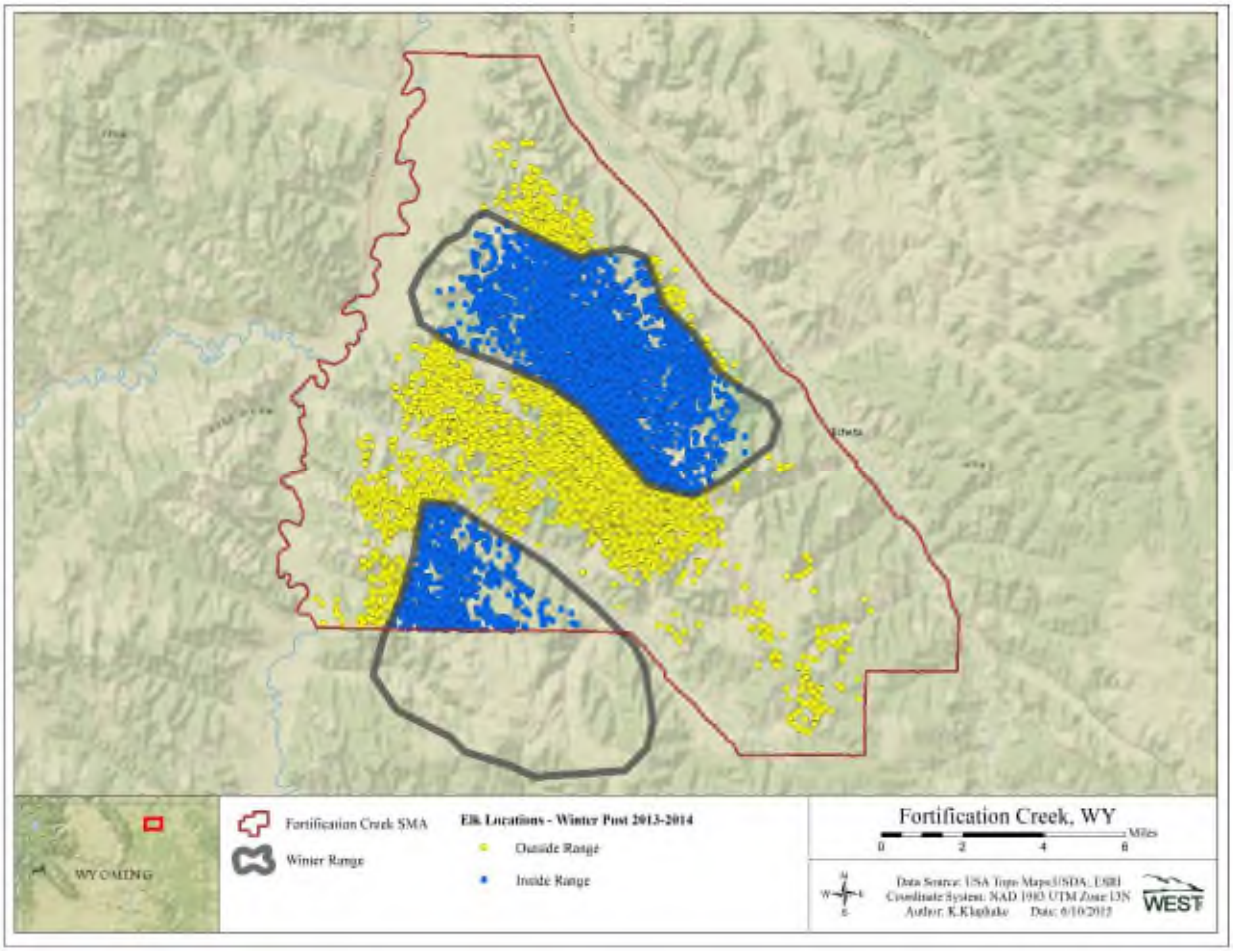
Elk locations from GPS-collared elk during the 2014 post-construction parturition period within Fortification Creek Planning Area.



Elk locations from GPS-collared elk during the winter baseline period within Fortification Creek Planning Area.

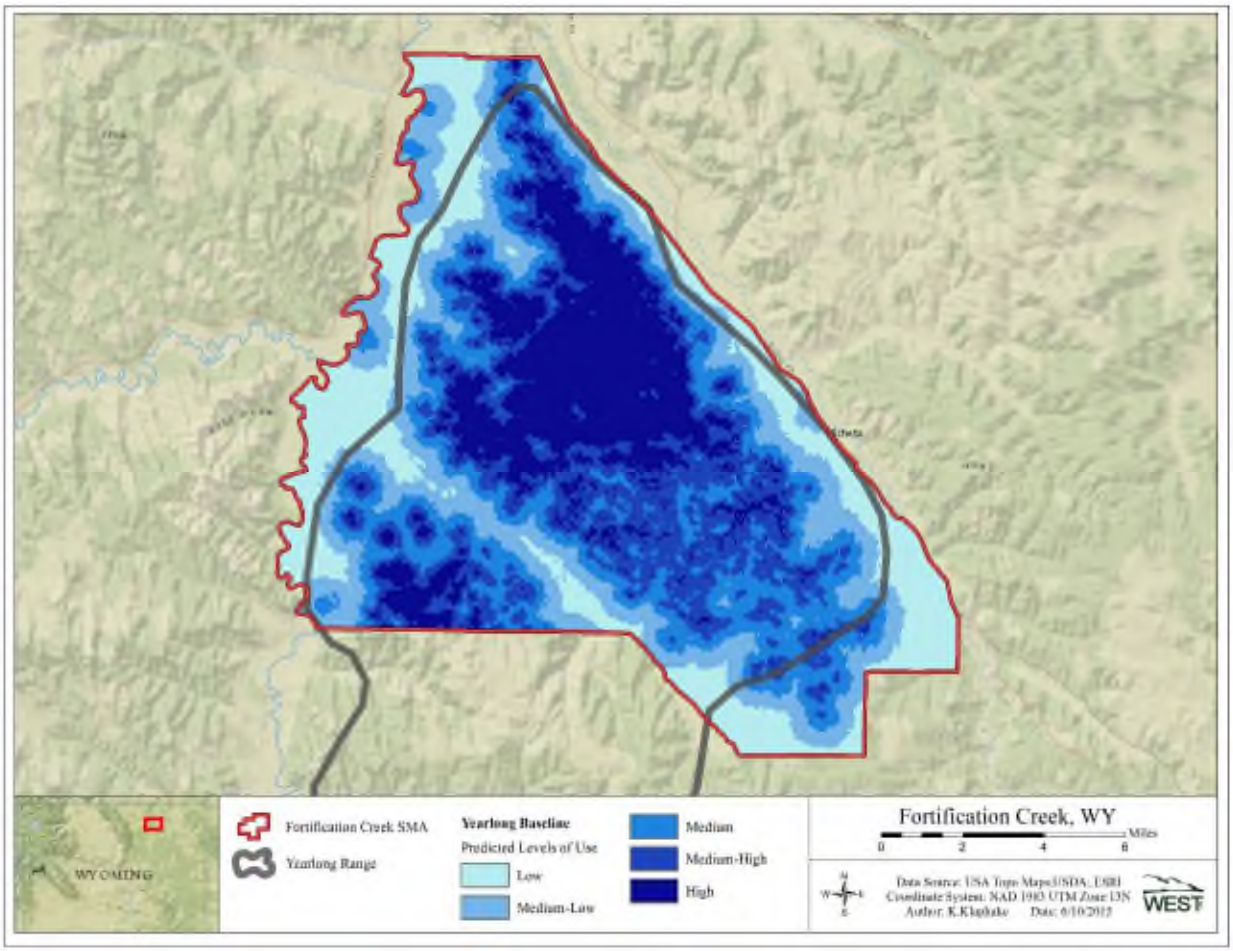


Elk locations from GPS-collared elk during the 2012-2013 post-construction winter period within Fortification Creek Planning Area.

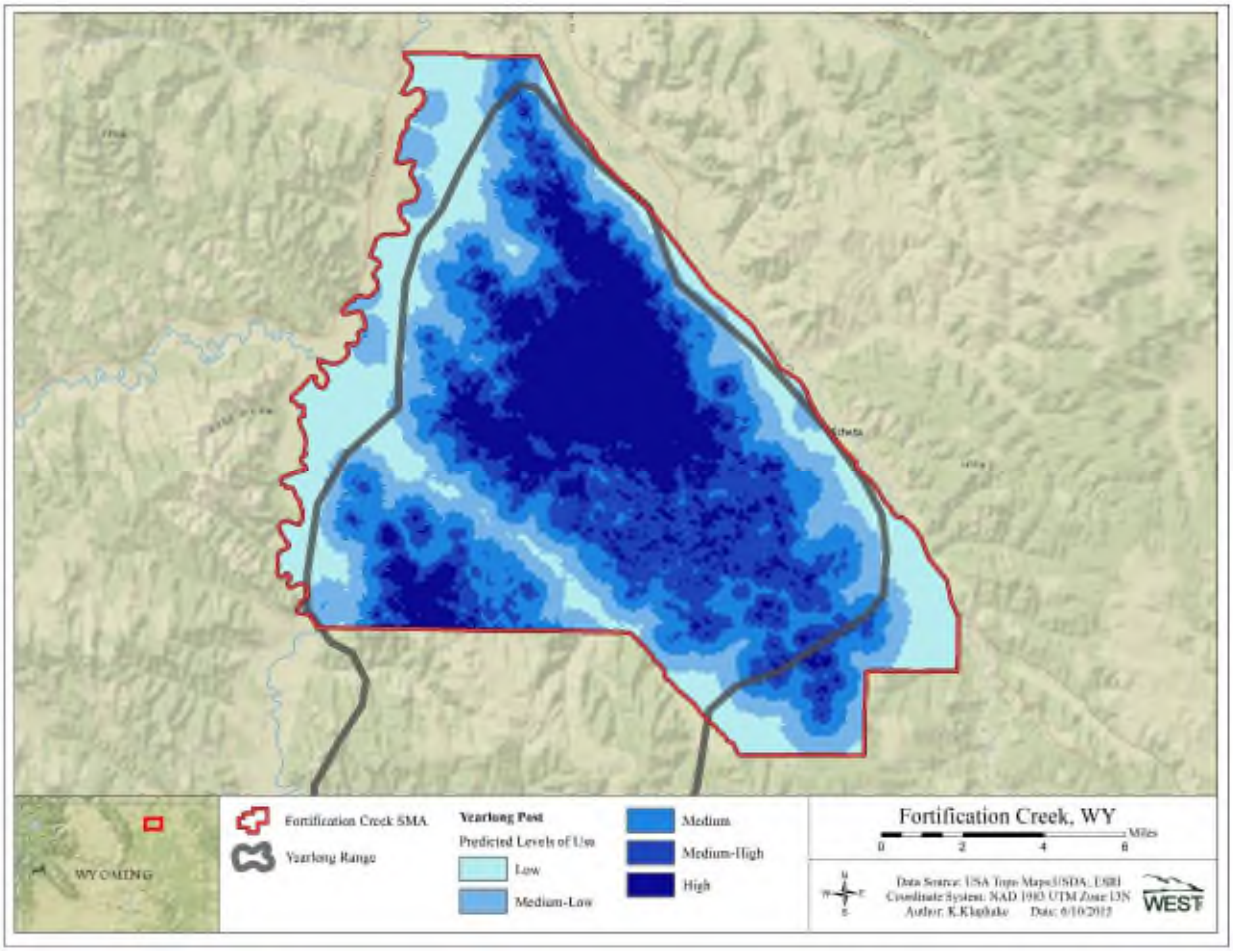


Elk locations from GPS-collared elk during the 2013-2014 post-construction winter period within Fortification Creek Planning Area.

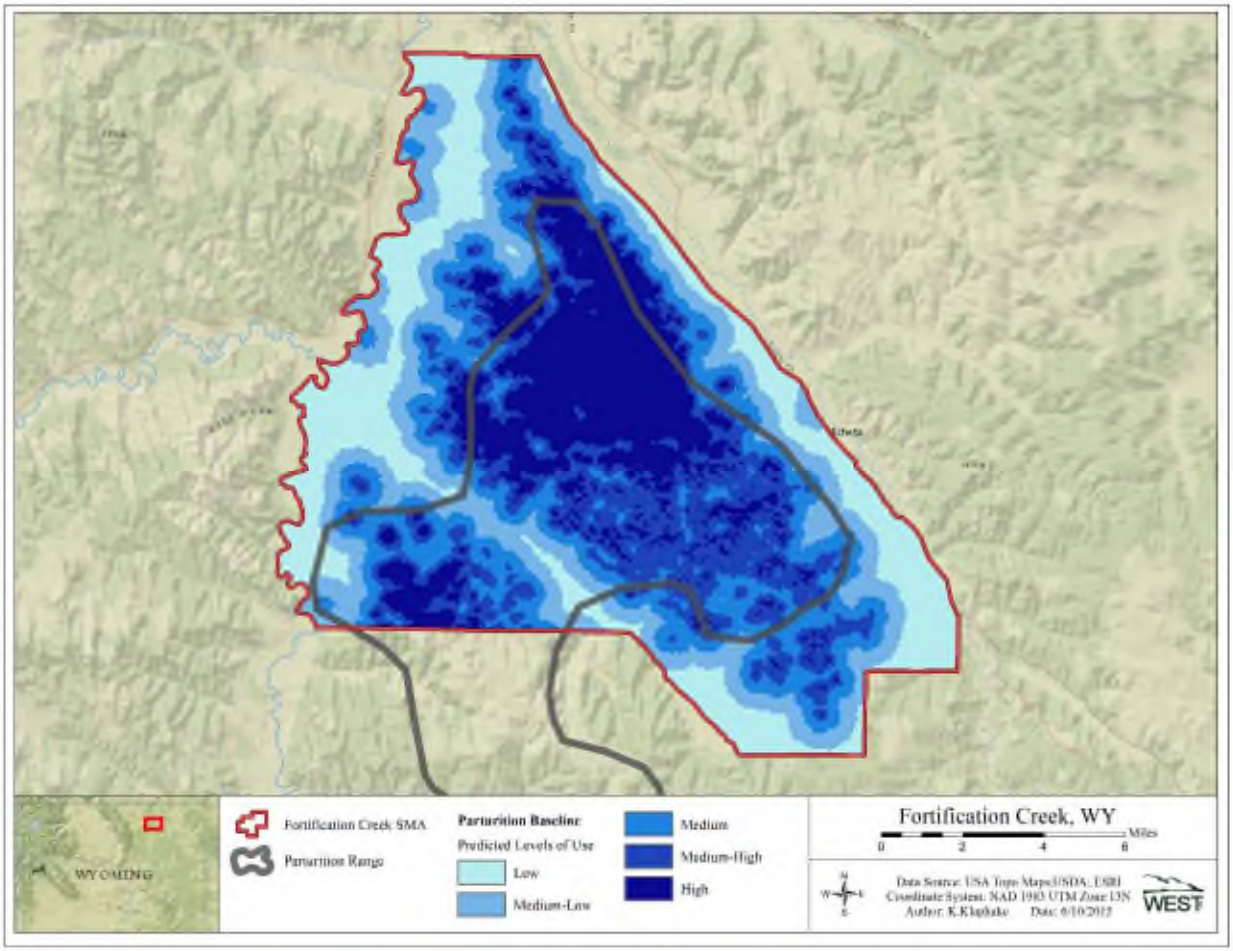
Appendix B. Figures depicting Predicted Levels of Elk Use for the Yearlong, Parturition, and Winter Periods during the Baseline and Post-Construction Periods within the Fortification Creek Planning Area



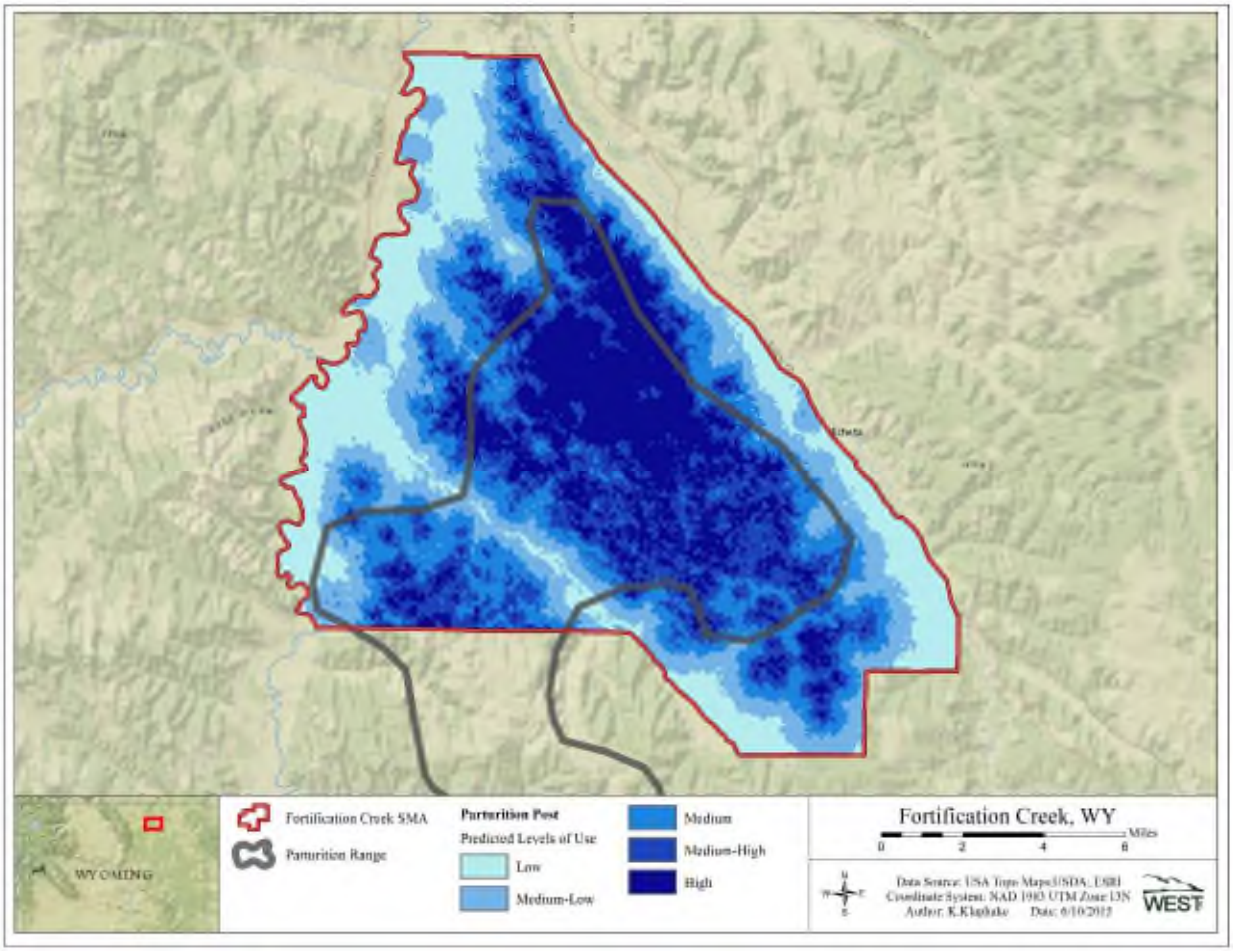
Predicted levels of baseline yearlong elk use within the Fortification Creek Planning Area.



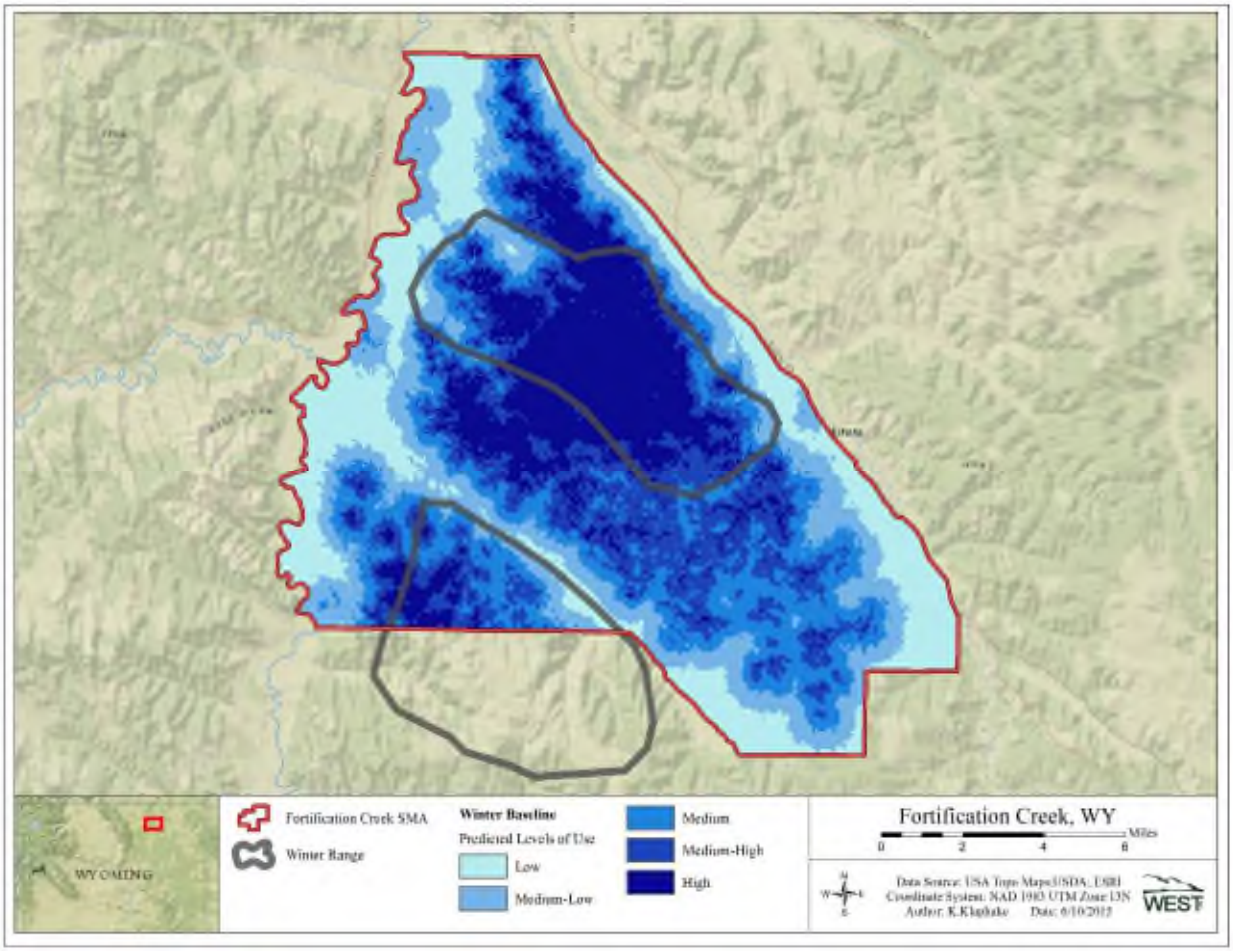
Predicted levels of post-construction yearlong elk use within the Fortification Creek Planning Area.



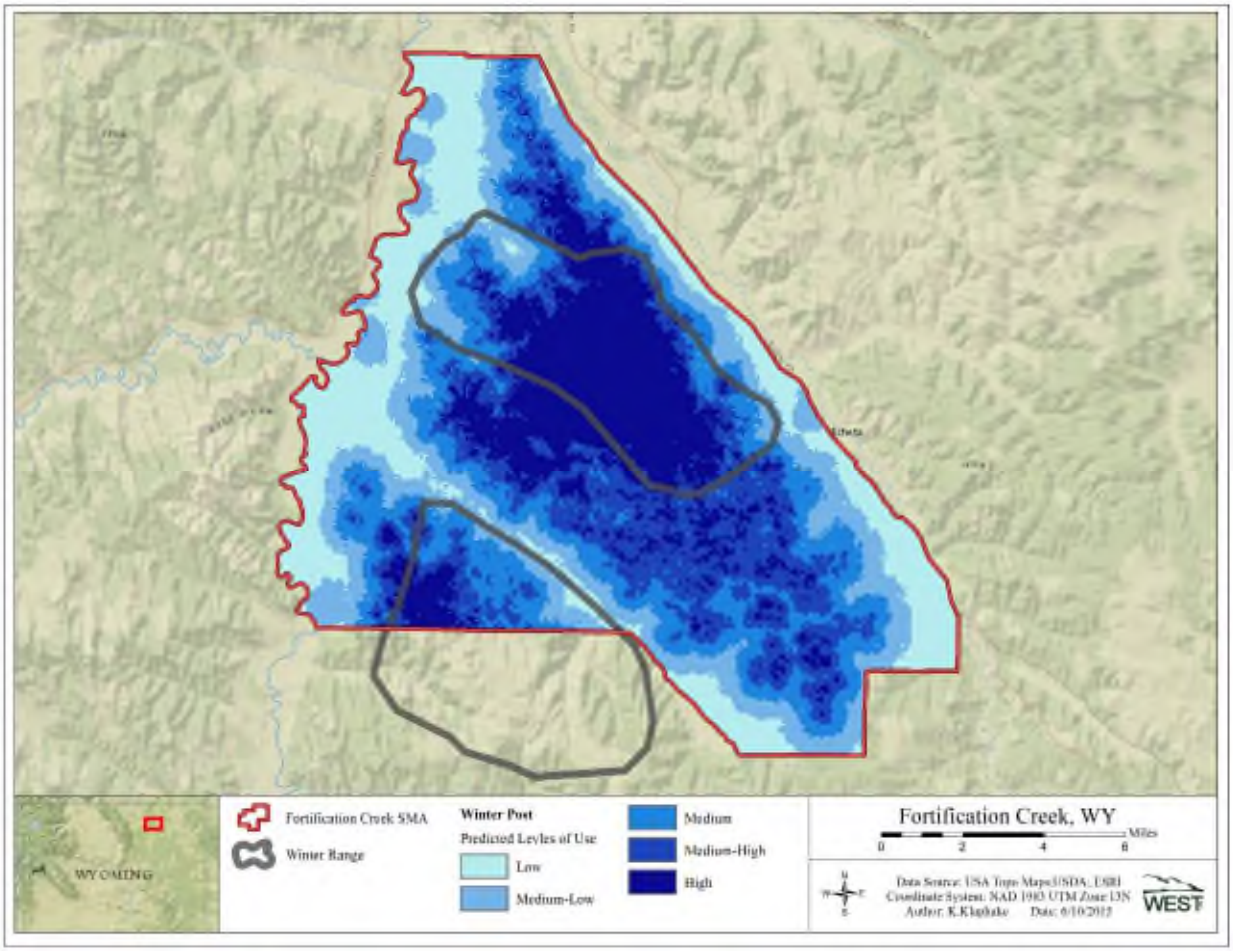
Predicted levels of baseline elk use within the Fortification Creek Planning Area during the parturition season.



Predicted levels of post-construction elk use within the Fortification Creek Planning Area during the parturition season.



Predicted levels of baseline elk use within the Fortification Creek Planning Area during the winter season.



Predicted levels of post-construction elk use within the Fortification Creek Planning Area during the winter season.