West-Central Mountain Lion Ecoregion Population Monitoring Report, 2021-2023

Montana Fish, Wildlife and Parks

Final Report: September 14, 2023

Photo Credit: Cody and LeRee Hensen

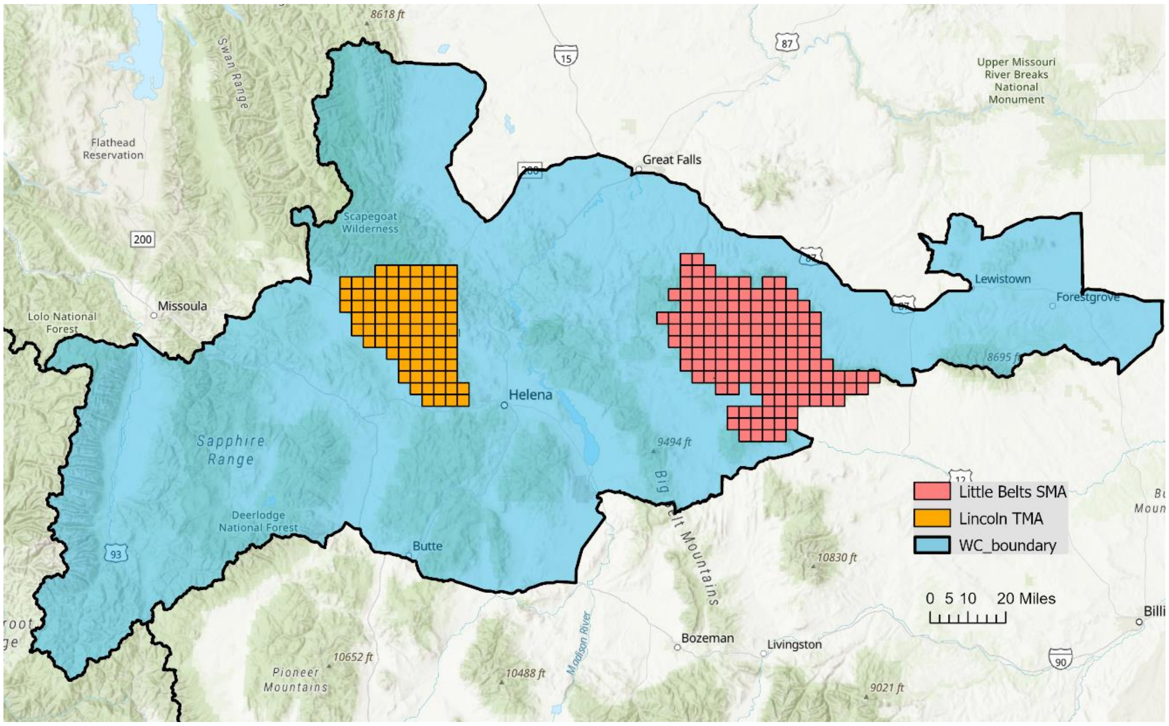
West-Central Ecoregion Mountain Lion Population Estimate 2023

SUMMARY: Based on spatial capture-recapture population estimates and lion density-habitat quality relationships estimated in the 2021-2022 trend monitoring area and the 2022-2023 supplemental monitoring area, the estimated population of the West-central ecoregion was 2,574 lions (90% credible interval: 554-15,069) or 5.6 lions per 100 km^2 (90% credible interval: 0.7-38.0). Due to high uncertainty, especially for density estimates at higher habitat quality values, we also calculated the population estimate capped by the maximum estimated density found in the Northwest ecoregion and estimated 1,402 lions (90% credible interval: 540-7,503) or 2.5 lions per 100 km^2 (90% credible intervals: 0.7 – 17.7). We also calculated the West-central ecoregional lion population using the lion density-habitat quality relationships estimated in the Northwest ecoregion, finding an estimated 1,170 lions (90% credible interval: 479-3,489) or 1.9 lions per 100 km^2 (90% credible intervals: 0.5 – 6.9).

Introduction

The Montana Mountain Lion Monitoring and Management Strategy (MTFWP 2019) describes the monitoring program currently underway for the state's mountain lion populations. In brief, the state is divided into 4 ecoregions for which population objectives are set, and monitoring of population density will take place in the western 3 ecoregions. For each of the 3 western ecoregions, population estimates are produced every 6 years based on 2 winters of field data collection across 2 monitoring areas (Figure 1). In each region the trend monitoring area (TMA) will be repeatedly surveyed each rotation through the ecoregions, and the supplemental monitoring area (SMA) may change location when ecoregions are resurveyed. The field data allow for direct population size estimation in the monitoring areas via a spatial capture-recapture (SCR) methodology. The SCR method also estimates the relationship between habitat quality and lion density. This relationship is used to extrapolate lion density from the TMA and SMA to the full ecoregion utilizing a model of habitat quality (known as a resource selection function [RSF]; Robinson et al. 2015 [revised in 2016]). The ecoregional population estimate is then used as an input to an integrated population model (IPM) which helps FWP estimate the impact of past and future lion harvests. In addition to the periodic ecoregion population estimates, the IPM uses lion demographic rates obtained from past research in Montana (MTFWP 2019) and a population reconstruction method based on harvest data. Combining these 3 sources of information, the IPM estimates lion population size in years between ecoregional estimates. Critically, the IPM provides a tool for FWP staff to estimate harvest prescriptions necessary to achieve population objectives in each ecoregion, which are recommended by citizen working groups composed of diverse stakeholders and set by the Fish & Wildlife Commission.

Figure 1. *The West-central ecoregion boundary (blue polygon) and Lincoln (gold grid) and Little Belt (red grid) trend and supplemental monitoring areas (TMA and SMA) sampled during the winters of 2021-2022 and 2022-2023, respectively.*



Method for ecoregion density extrapolation

The SCR method used for estimating lion abundance in each monitoring area is described in the later sections of this report and in the Mountain Lion Monitoring and Management Strategy (MTFWP 2019). The relationship between lion density and habitat quality (indexed via resource selection function [RSF]) within the West-central monitoring areas were unique to the TMA and SMA in the West-central ecoregion and were different from those found in the Northwest ecoregion (Figure 2). The West-central ecoregion estimates contain a large amount of uncertainty.

To estimate lion population across the ecoregion we first estimated the population in each TMA and SMA grid and surrounding statespace using the SCR method for the TMA and SMA individually. The SCR method combines information about the search effort in each grid cell, the average RSF value of the grid cells, and the lion observations. A statespace in the SCR methodology refers to the sampled grid cells in each monitoring area and a surrounding 10 km buffer area which crews do not search, but from which lions may occasionally enter the searched area. The SCR model estimates density not only in the grid cells of the trend area, but also in the surrounding buffer area.

To estimate the population in the remaining area of the West-central ecoregion we combined the lion density to RSF relationship found in the TMA and SMA and extrapolated that across the remaining area of the ecoregion. We summed the SMA and TMA population estimates with the extrapolated area to estimate the population size for the whole ecoregion. The averaged relationship had high levels of uncertainty for lion density estimates, especially where the relationship was extrapolated beyond the observed RSF values in the TMA and SMA.

For comparison, we used the estimated relationship of lion density and habitat quality estimated in the Northwest ecoregion (MTFWP 2022) and extrapolated the relationship across the West-central region, excluding the TMAs. The Northwest ecoregion had greater RSF values on average (mean RSF value = 0.82; MTFWP 2022) than the West-central ecoregion (mean RSF value = 0.69). The relationship between lion density and habitat quality from the Northwest ecoregion provided smaller density estimates in high quality habitat than the West-central ecoregion relationships. We can reasonably assume that the upper end of the density to habitat quality relationship in the West-central TMA and SMA are inaccurately high due to data with few recaptures and fewer observed grid cells with large RSF values. To improve the model, we decided to combine the information from the West-central and the Northwest ecoregions. We set an upper limit on lion density in the West-central model at the maximum estimated lion density in the Northwest ecoregion (Figure 3). The Northwest ecoregion provides a reasonable 'cap' of lion densities with greater RSF values on average than the West-central region and less uncertainty around density estimates in high quality habitat than the West-central region (MTFWP 2022).

Results

The combined TMA and SMA statespaces encompassed 29% of the total West-central ecoregion area and extended outside of the West-central ecoregion. Habitat quality was similar on average in the ecoregion (mean RSF value = 0.69), compared to the TMA and SMA statespaces (mean RSF value = 0.70). For the Lincoln TMA and statespace the estimated population was 126 lions (90% CrI: 88-222) or a density of 2.0 lions/100 km^2 (90% CrI: 1.4-3.6). For the Little Belt SMA and statespace the estimate was 327 lions (90% CrI: 189-680) or a density of 2.8 lions/100 km^2 (90% CrI: 1.6-5.7).

The ecoregion population estimate (TMA and SMA plus extrapolated area) without a cap was 2,574 (90% CrI: 554-15,069) or 5.6 lions per 100 km$_2$ (90% CrI: 0.7-38.0). The population estimate was strongly impacted by the lion density estimates on the edges of the modeled relationship and was therefore unrealistically high. When we capped the density to RSF relationship at the maximum estimated in the Northwest ecoregion the ecoregional population estimate was 1,402 lions (90% CrI 540-7,503) or 2.5 lions per 100 km^2 (90% CrI 0.7-17.7). When we extrapolated the density to RSF relationship found in the Northwest ecoregion to the West-central ecoregion, we estimated 1,170 lions (90% CrI: 479-3,489), or 1.9 lions per 100 km^2 (90% CrI 0.5-6.9). These estimated densities were lower than the Northwest TMA (4.9 lions/100 km^2; 90% CrI: 3.5–7.3), and the Middle Clark Fork SMA (3.6 lions/100 km^2; 90% CrI: 2.3–7.7; MTFWP 2022). The uncorrected estimate based on the West-central ecoregion TMA and SMA was unrealistically high and had extremely high uncertainty compared to other density estimates generated using these methods in Montana (Figure 4). The estimates generated by capping the West-central ecoregion density to RSF relationship at the maximum density observed in the Northwest ecoregion and by extrapolating the Northwest ecoregional density to RSF relationship are more comparable to other areas with similar habitats, though uncertainty is still high (Figure 4).The West-central TMA and SMA estimates are described in detail in sections below.

Figure 2. *The SCR-estimated relationship between lion density and habitat quality (indexed via resource selection function [RSF]) for both winters of monitoring in the West-central ecoregion and the estimated relationship from the Northwest ecoregion (blue).*

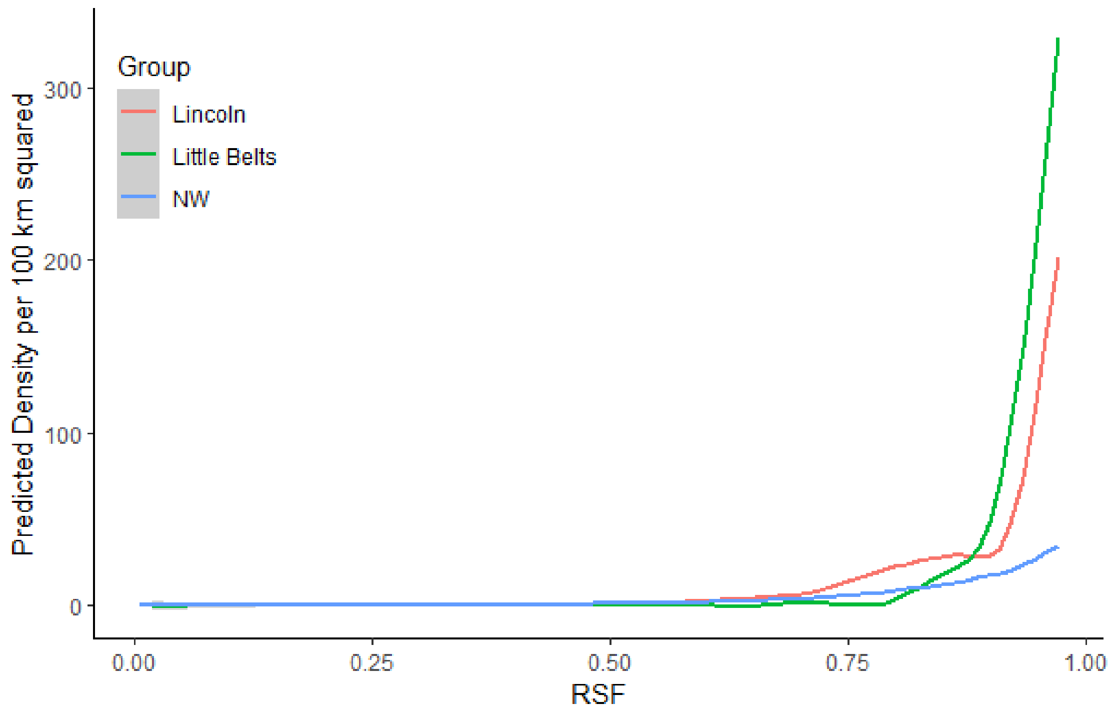


Figure 3. *The SCR-estimated relationship between lion density and habitat quality (indexed via resource selection function [RSF]) averaged across monitoring areas in the West-central ecoregion (black) and the same relationship capped at the maximum estimated lion density in the Northwest ecoregion (blue).*

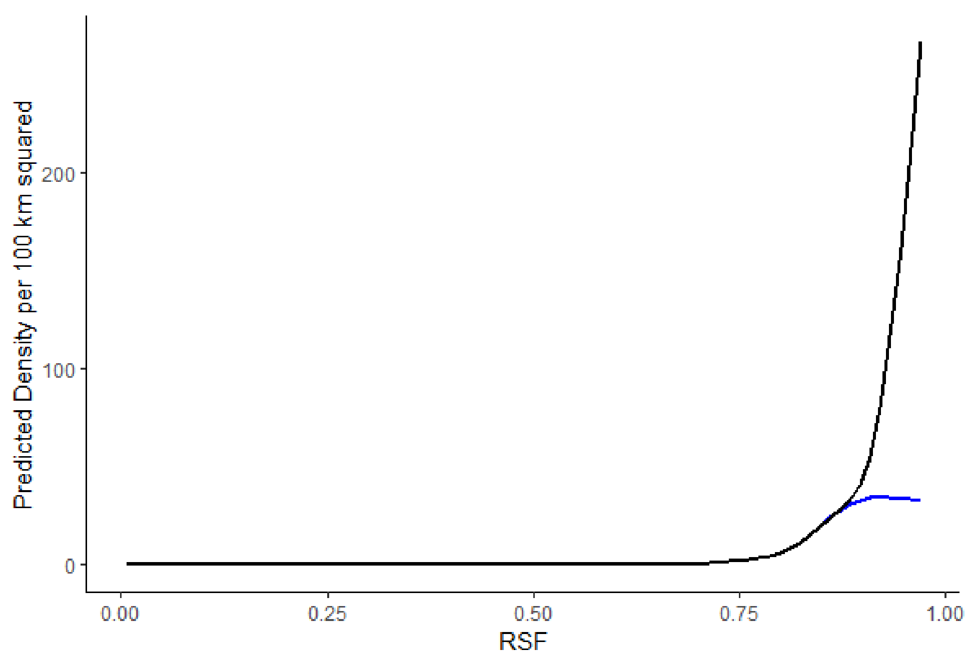
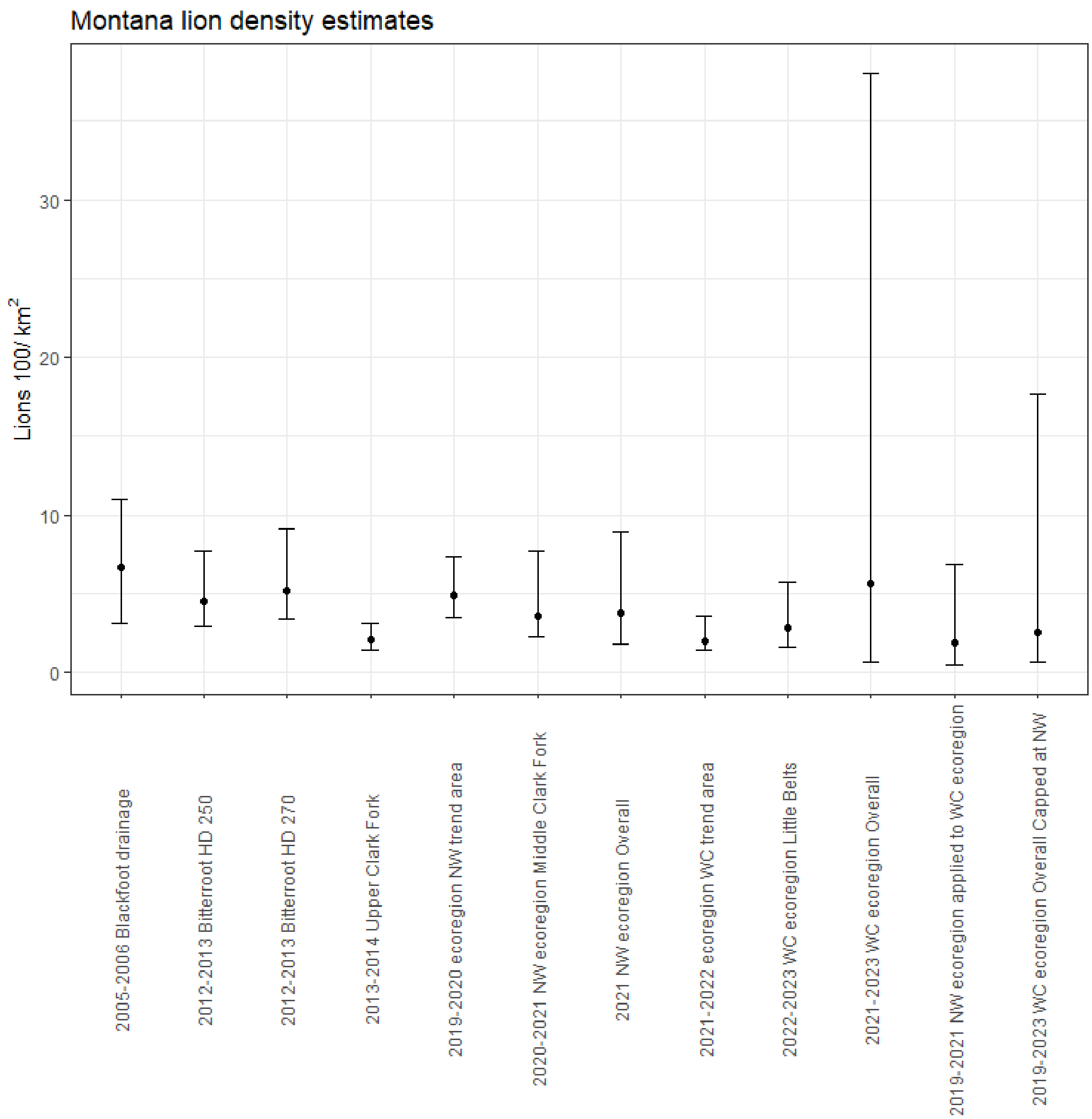


Figure 4. *Mountain lion density estimates and 95% credible intervals from all spatial capture-recapture studies in Montana, which used similar methodologies and detection models, 2005–2021. Blackfoot drainage (Russell et al. 2012), Bitterroot and Upper Clark Fork (Proffitt et al. 2015, Proffitt et al. 2020), and Northwest and West-central ecoregion estimates (MTFWP 2022).*



Winter 2021-2022 West-central Trend Monitoring area mountain Lion Density

Lincoln Area

Prepared Sept 27, 2022 by Molly Parks and Dave Messmer

SUMMARY: Based on 63 DNA samples from 34 individual lions, we estimated a density of 2.0 lions/100km² (90% Credible interval: 1.4–3.1) in the West-central Trend Monitoring Area during the winter of 2021-2022.

Field season summary

Montana Fish, Wildlife, and Parks completed a third season of mountain lion population monitoring with field efforts focused in the West-central ecoregion. Hound handler crews searched and sampled lions in the permanent Trend Monitoring Area (TMA) between Lincoln and Avon from December 6, 2021– March 23, 2022. The winter conditions improved this season compared to last winter, with extensive snow cover for most of the study period. The 2021-2022 season produced the most consistent snow and tracking/trailing conditions to date and required snowmobiles for access most of the winter. While early March started with good conditions, warming temperatures led to extensive bare ground in lower elevation portions of the study area by mid-March. Access became increasingly difficult for both snowmobiles and trucks, and ultimately ended lion monitoring efforts March 23. The crew collected 19 samples in December (16 tissue samples from treed lions, 1 hair, and 2 scat), 22 samples in January (20 tissue and 2 scat), 17 samples in February (13 tissue, 2 hair, 2 scat), and 12 samples in March (11 tissue, 1 hair). Note, some of the aforementioned samples included repeated samples of the same individuals. The crew encountered less wolf activity this winter than in previous seasons, and most sets of wolf tracks encountered were in smaller groups of 2-4 wolves. With improved snow tracking/trailing conditions and less concern for wolf-hound conflicts, hound handlers were able to thoroughly search and sample most of the monitoring area.

The biggest challenge for the season was access. Several large ranches with high quality lion habitat denied hound handlers permission to search and sample lions on their property, limiting efforts around Lincoln and west of Highway 279. The West-central TMA also contained a number of inaccessible grid cells that consisted of high elevation areas accessible only by trail (particularly along the Continental Divide), further limiting search effort. An additional note was a shared observation of several hound handlers. While searching throughout the winter, the crew noted the monitoring area appeared to have several "holes" where lion sign was rarely detected, despite high RSF values and expected lion detections. While this coincided with scarce ungulate presence in the same locations, hound handlers were surprised by lack of activity in these seemingly high-quality habitat areas.

Spatial capture-recapture model results

Winter habitat suitability in West-central trend area was generally high with 75% of grid cells having mean RSF > 0.86 (range = 0.61–0.95; Figure 5b). We searched a total of 39,754 km in the 88 grid cells from Dec–Apr (Figure 5c). Of the 70 successfully amplified DNA samples collected by crews, 55 were usable in analysis, because they represented unique encounters of independent-aged individuals for a given grid cell during each monthly sampling occasion (Table 1, Figure 5d, Figure 6). An additional 8 samples were obtained from lions harvested inside the study area, or from lions harvested outside the study area, but previously encountered inside. Of the 63 total usable samples, 34 were from unique individuals (13 males and 21 females) and the remaining 29 were recaptures or dead recoveries of those individuals in other grid cells or sampling occasions (Table 2). Based on these samples, we estimated a median density of 2.0 lions/100km^2 (90% CrI: 1.4–3.1) with 68% female (90% CrI: 47–85%) in the West-central trend area during the winter of 2021-2022 (Table 3) – this equates to 126 (90% CrI: 89–195) total lions with activity centers in the state space and 44 with activity centers falling under the 88 study area grid cells. Therefore, the overall detection rate for lions with any activity center in the statespace was 27% (90% CrI: 17–38%). Of the 34 unique lions detected, 18 were first detected in December, 10 in January, 5 in February, and 1 in March–April (Figure 7).

Figure 5) *a) location of study area (blue fill) and statespace (grey fill around study area) with West-central ecoregion boundary, b) average resource selection function (RSF) values for each study area grid cell – scaled 0 to 1 with 1 being highest suitability, c) total kilometers of search effort by houndsmen, d) total captures in each grid cell.*

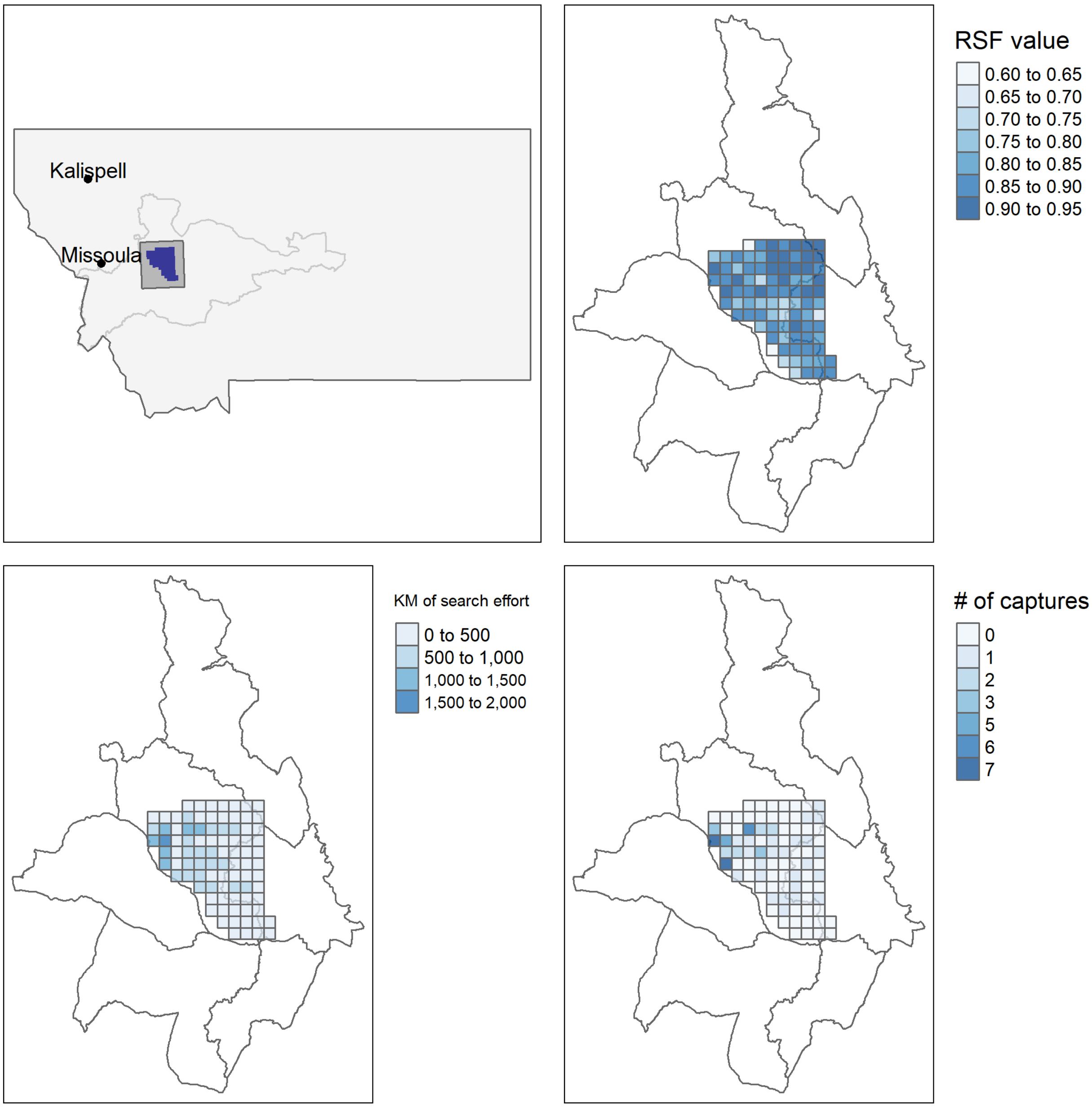


Figure 6. *Locations of captures in West-central trend area, winter 2021-2022. Trapping grid cells (5 x 5 km, n = 88) are shown in light purple. Yellow dots are successfully amplified DNA from live captured lions or samples of their hair or scat. Purple dots are samples from harvested animals.*

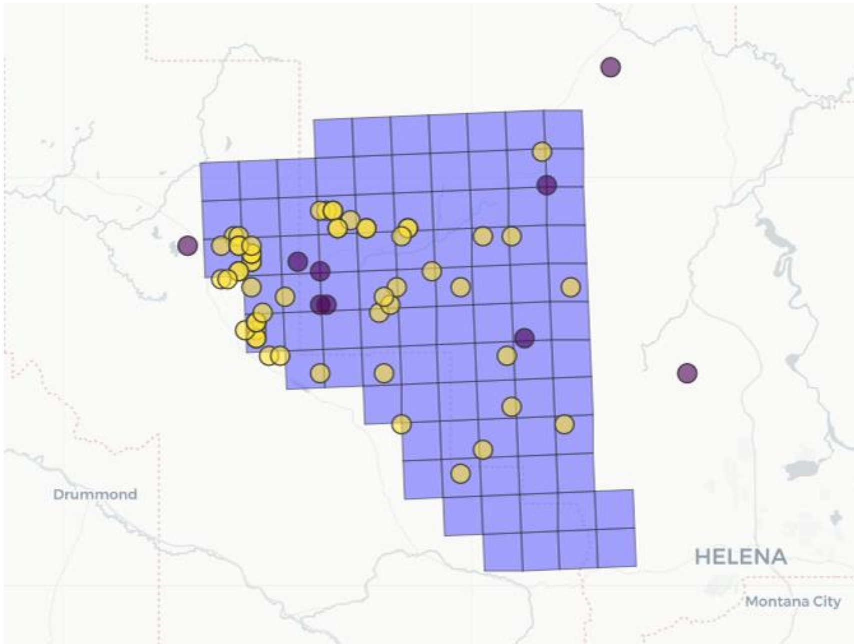


Figure 7. *Cumulative unique lion detections over the duration of the study in the West-central trend area, winter 2021-2022.*

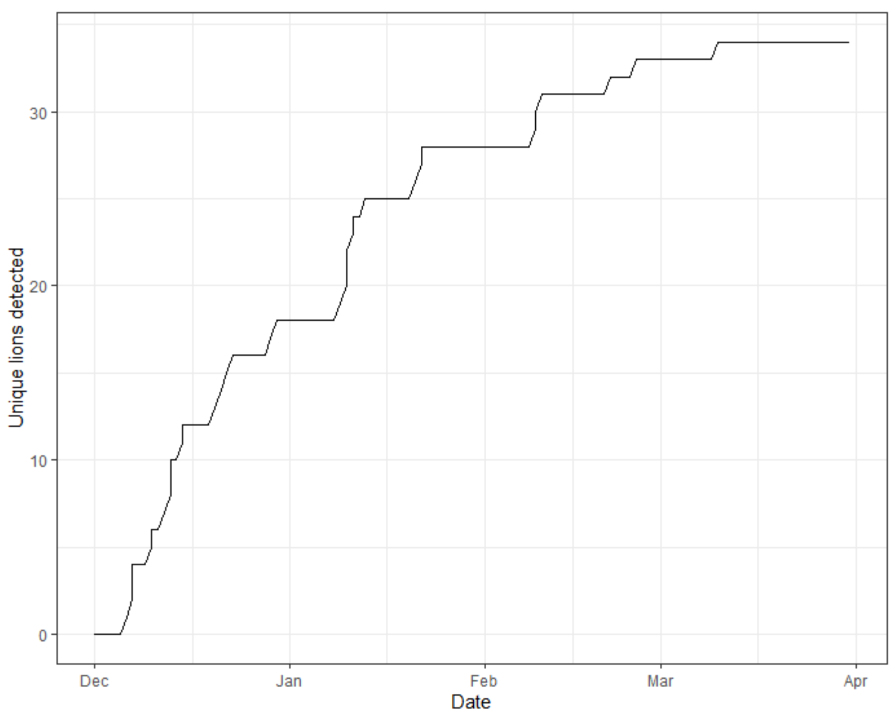


Table 1. *Summary of DNA sample types used in density estimation for winter 2021-2022 in the West-central trend area, winter 2021-2022.*

Type	***n***
Tissue (live)	53
Hair	2
Scat	0
Tissue (Harvest)	8
Total	63

Table 2. *Frequency of capture for 34 individuals detected during winter 2021-2022 in the West-central trend area, winter 2021-2022.*

Times captured	***n* individuals**
1	16
2	9
3	7
4	2

Table 3. *Density estimate from analysis of spatially explicit capture-recapture data for the winter 2021-2022 in the West-central trend area. The model incorporating search effort and sex as covariates for the detection probability model and allowed home range size to vary by sex. The model for density of lion activity centers used resource selection function (RSF) values as covariates.*

Model	**Median density (per 100km^2)**	**90% CI**
$\boldsymbol{Effort + RSF + Sex + \sigma_{sex}}$	2.6	1.4–3.1

Methods

We followed the spatial capture recapture (SCR) data collection and analysis methods described by Proffitt et al. (2015) and the MTFWP Mountain Lion Monitoring and Management Strategy (2019). These methods estimate the density of independent-aged (i.e., legally harvestable) mountain lions in the study area (including transient lions). The detection model included covariates for search effort and sex and it allowed expected home range size to differ by sex. The model for the density of activity centers included a covariate for habitat quality, indexed by the resource selection function developed with radio-collar data (MTFWP Mountain Lion Monitoring and Management Strategy [2019]). We fit the model using the R package 'SCRbayes' (Royle et al. 2013). We ran 1 Markov-chain Monte Carlo chain run for 130,000 iterations with the first 13,000 iterations discarded as burn-in.

WINTER 2022-2023 WEST-CENTRAL SUPPLEMENTAL MONITORING AREA MOUNTAIN LION DENSITY

Little Belt and Castle Mountains

Prepared August 13, 2023 by Alix Godar and Alissa Anderson

SUMMARY: Based on 53 DNA samples from 44 individual lions, we estimated a density of 2.8 lions/100km² (90% Credible interval: 1.6–5.7) in the West-central Supplemental Monitoring Area during the winter of 2022-2023.

Field season summary

During the winter of 2022-2023 Montana Fish, Wildlife and Parks completed the fourth season of mountain lion monitoring, and the second year of monitoring in the West-central ecoregion. Contracted hound handlers conducted field sampling in a supplemental monitoring area (SMA) located in the Little Belt and Castle Mountains in central Montana from (Figure 8). Between December 12 – March 24, six contracted houndsmen and women contributed to a total of 183 field days. Sample collection started out slow in December with about half the average search effort as other months and only 2 samples collected. Collection picked up in January (14 samples) and samples continued to trickle in the rest of the season culminating in 39 tissue, 4 scat, and 7 hair samples (50 samples) collected in the field. In addition to field samples, 12 hunter harvested lions were sampled within the study area and included in analysis, resulting in 62 samples collected in total.

This season saw some of the most continuous snow coverage of the study so far. By the end of March all 5 snow monitoring sites in the Little Belts were in the range of 110-149% above average snow water equivalent with 2 of the sites at the record highest or second highest readings ever recorded (MSLS 2023). There were a few areas that melted out off and on, but if anything, deep unconsolidated snow and drifts became the largest hurdle in February and March, limiting search effort in several places. Areas we were unable to search later in the season were mostly high elevation areas unlikely to support lions, but travel became more difficult even in lower elevation high quality habitat making search effort less efficient. By the second half of the season there was so much snow that it seemed game and lions had moved out of many parts of the study area where we had been finding them earlier in the season.

One of the largest challenges was the size of the study area. It was a large area to cover and crews had to shuffle between White Sulphur Springs and the Judith WMA housing to cover the whole SMA. Use of the bunkhouse in White Sulphur Springs proved invaluable to the project and we are grateful to the U.S. Forest Service for letting us use their facilities. There was also more cliff habitat in the Little Belts than previous study areas and we had several races where lions outran hounds in cliffs and could not be treed. Particularly on the east side of the study area, it seemed that capture rates were lower due to difficult terrain where lions had the upper paw over hounds. in addition, there were large roadless sections of the study area where we were unable to search for lions.

Permission from private landowners was invaluable to the study this year; 22% of samples were collected only because we had permission to access private lands and many other samples were easier to collect thanks to access. We greatly appreciate landowners allowing us access to these important private lands for research purposes.

Spatial capture-recapture model results

Winter habitat suitability in the west-central SMA was slightly lower than previous monitoring areas with 75% of grid cells having mean RSF > 0.73 (range = 0.56–0.93; Figure 8b). We searched a total of 46,628.710 km from December–March (Figure 8c). The entire study area was 152 cells in size, but due to large roadless areas we only targeted 119 cells. Of 62 samples collected, 59 were successfully amplified in the lab to individual and sex. Of these, 53 were usable in analysis as they represented unique encounters of independent-aged individuals for a given grid cell during each monthly sampling occasion (Table 4, Figure 8d, Figure 9). Samples were censored from analysis if the same individual was caught in the same cell during the same sampling occasion, or when non-independent aged subadults were captured with a related adult female. Of the 53 total usable samples, 44 were from unique individuals (21 males and 23 females) and the remaining 9 were recaptures (live or harvested) in other grid cells or sampling occasions (Table 5). Based on these samples, we estimated a median density of 2.8 lions/100km^2 (90% CrI: 1.6–5.7) with 51% female (90% CrI: 27–71%) in the SMA during the winter of 2022-2023 (Table 6), this equates to 327 (90% CrI: 189–680) total lions with activity centers in the state space. The overall detection rate for lions with any activity center in the statespace was 13% (90% CrI:

6.5–23%). Of the 44 unique lions detected, 3 were first detected in December, 18 in January, 13 in February, and 10 in March (Figure 10).

Figure 8) *a) location of study area (blue fill) and statespace (grey fill around study area) with West-central ecoregion boundary, b) average resource selection function (RSF) values for each study area grid cell – scaled 0 to 1 with 1 being highest suitability, c) total kilometers of search effort by houndsmen, and d) total captures in each grid cell.*

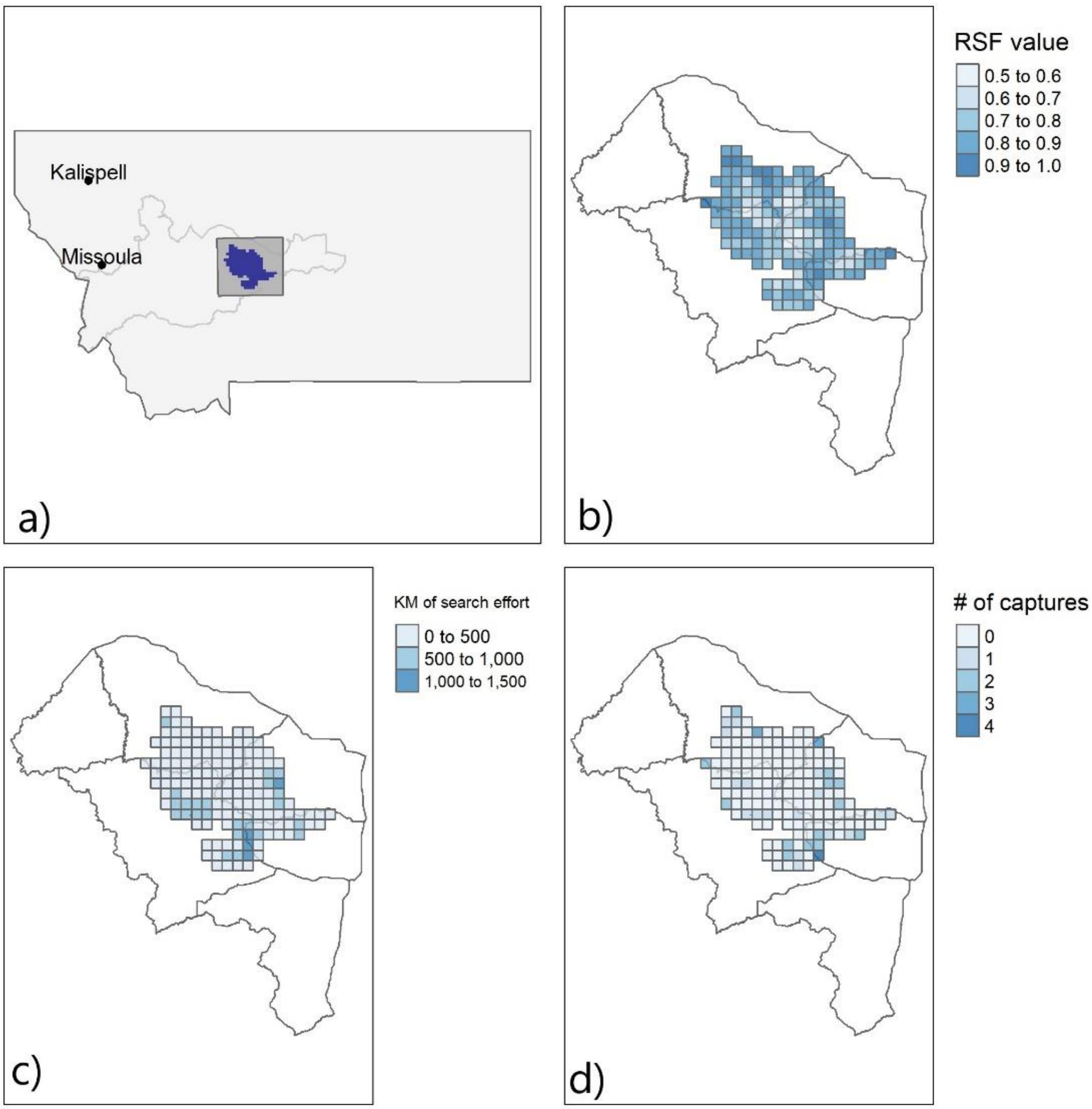


Figure 2. *Locations of captures in West-central supplemental monitoring area, winter 2022-2023. Trapping grid cells (5 x 5 km, n = 152) are shown in light purple. Yellow dots are successfully amplified DNA from live captured lions or hair or scat samples. Purple dots are samples from harvested animals.*

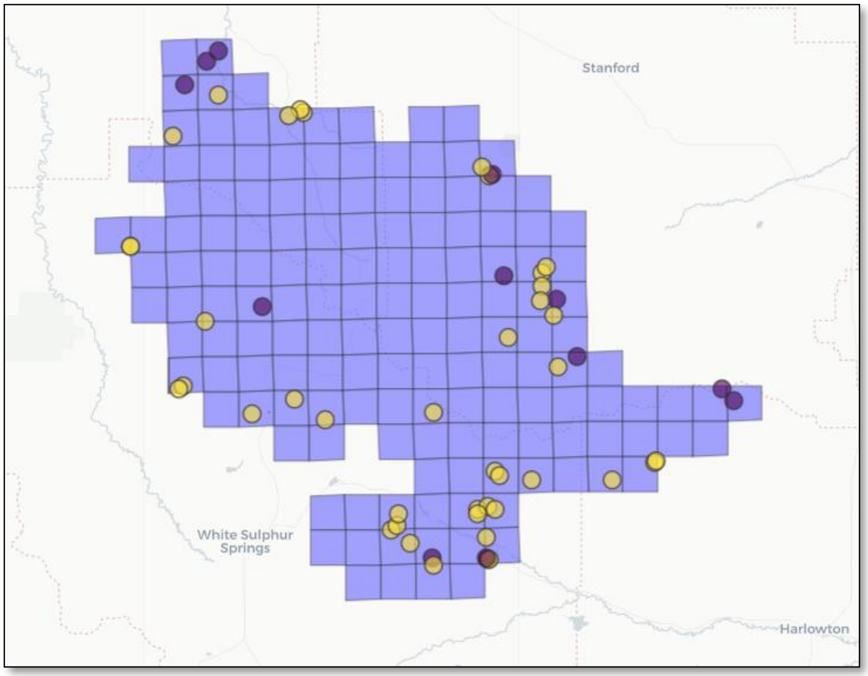


Figure 3. *Cumulative unique lion detections over the duration of the study in the West-central supplemental monitoring area, winter December 12- March 24 2022-2023.*

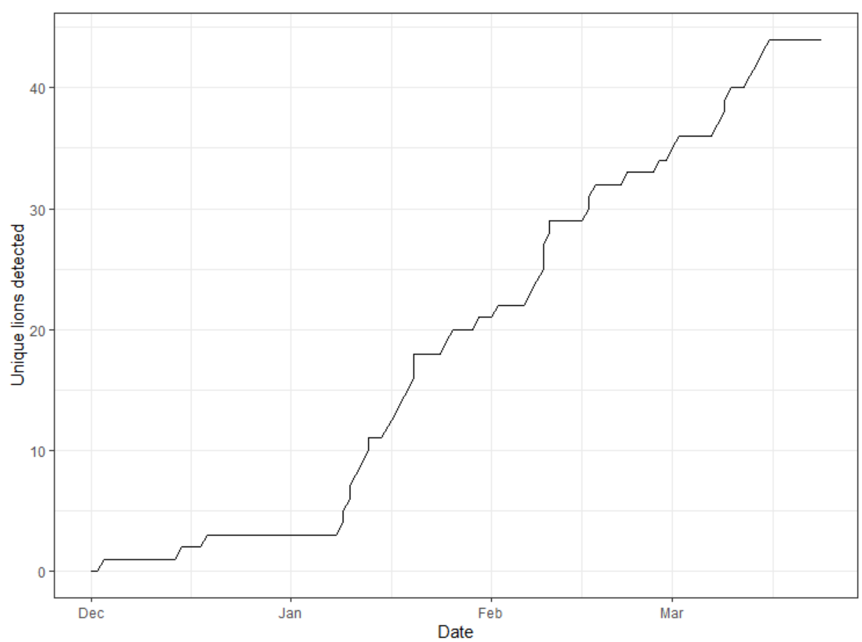


Table 1. *Summary of DNA sample types used in density estimation for winter 2022-2023 in the West-central supplemental monitoring area.*

Type	*n*
Tissue (live)	35
Hair	3
Scat	3
Tissue (Harvest)	12
Total	53

Table 2. *Frequency of capture for 44 individuals detected during winter 2022-2023 in the West-central supplemental monitoring area.*

Times captured	*n* individuals
1	39
2	3
3	0
4	2

Table 3. *Density estimate from analysis of spatially explicit capture-recapture data for the winter 2022-2023 in the West-central supplemental area. The model incorporating search effort and sex as covariates for the detection probability model and allowed home range size to vary by sex. The model for density of lion activity centers used resource selection function (RSF) values as covariates.*

Model	Median density (per 100km^2)	90% CI
$\boldsymbol{Effort + RSF + Sex + \sigma_{sex}}$	2.8	1.6–5.7

Methods

We followed the spatial capture recapture (SCR) data collection and analysis methods described by Proffitt et al. (2015) and the Mountain Lion Monitoring and Management Strategy (MTFWP 2019). These methods estimate the density of independent-aged (i.e., legally harvestable) mountain lions in the study area (including transient lions). The detection model included covariates for search effort and sex and it allowed expected home range size to differ by sex. The model for the density of activity centers included a covariate for habitat quality, indexed by the resource selection function developed with radio-collar data (MTFWP 2019). We fit the model using script from the R package 'SCRbayes' (Royle et al. 2013) modified by Kelly Proffitt. We ran 1 Markov-chain Monte Carlo chain run for 200,000 iterations with the first 50,000 iterations discarded as burn-in.

Acknowledgements

We would like to thank all the private landowners and ranch managers who were so generous to work with us over the winter and allow access crucial to completing this study. Thank you! We are also grateful to the Helena – Lewis and Clark National Forest for their collaboration, particularly to the kind folks at the White Sulphur Springs Ranger Station (Helen Smith and Jordan Kibbee in particular) for letting us stay at their bunkhouse over the winter. Thanks to all our hard-working houndsmen and women; Casey Stutzman, Ryan Castle, Cody and LeRee Hensen, Dustin Huffaker, Scott Cargill, Josh Shively, and all the hounds! Finally, thanks to Jay Kolbe and all the FWP bios and wardens who assisted with our work.

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