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Pronghorn Movement and Population Ecology

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Executive Summary

The Montana Pronghorn Movement and Population Ecology Project was initiated in 2020 to collect information on pronghorn movements, seasonal habitat use, and demographics in 7 study areas across Montana that included the Big Hole, Paradise, Musselshell, Fergus-Petroleum, South Philips, Garfield-Rosebud, and Powder River-Carter study areas. An ongoing pronghorn study collecting identical information in the Madison that began in 2019 is being included in this study and reporting. The primary objectives of the project are to: 1) delineate seasonal range and movement corridors of pronghorn in the study areas; 2) distribute maps of seasonal range and movement areas for pronghorn widely to conservation partners and landowners via a web-based platform; 3) use seasonal range and movement data to identify potential barriers to movements, inform management decisions, and prioritize locations for habitat improvement projects; 4) develop a population model to identify important vital rates affecting population growth rates and describe important demographic differences between pronghorn populations that are growing or stable, versus those that are limited in their population performance, and 5) evaluate the effect of vegetation and other landscape features on resource selection and movement of migratory and non-migratory pronghorn.

In February 2021, we captured and instrumented with GPS collars a total of 168 adult female pronghorn to augment the sample of animals captured in winter 2020 and maintain approximately 60 animals with active collars in each study area. This capture effort included a total of 13 animals in the Fergus-Petroleum, 16 in the South Philips, 18 in the Garfield-Rosebud, 19 animals in the Musselshell, 22 in each of the Powder River-Carter, Madison, and Paradise, and 31 in the Big Hole. In total, across all study areas from 2019 to 2021, we have captured and collared 598 animals. To date, across all study areas, a total of 30 collars have malfunctioned, 159 animals have died, and 409 collars remain active and will continue to be monitored. We have collected 4,653,004 locations from 598 individuals.

Movement patterns of individuals were diverse within and across study areas with population-level seasonal ranges generally reflecting greater contraction from summer to winter in the montane-valley populations of southwest Montana as compared to the prairie populations of central and eastern Montana. Estimates of movement corridors will be finalized at the end of location data collection. On a monthly basis, we generate study area-specific summary reports of collared pronghorn movements and mortality information and distribute these reports widely to state and federal agency biologists, non-profit conservation organizations, and private landowners. We have developed a web interface that allows biologists to view pronghorn movement trajectories and identify areas that may be barriers to pronghorn movements. FWP leadership will determine how additional web-based data sharing will proceed. Fence mapping projects have been initiated in all study areas and are being aggregated into a single spatial layer for mapping, movement barrier identification, and evaluation of the influence of fences on pronghorn movements and behaviors. We plan to use the collar location data in combination with the fence spatial data to develop a set of tools to identify and quantify pronghorn behavioral

responses to different types of fences during winter, summer, and migratory periods. This information will be used to identify problematic barriers to pronghorn movement and prioritize remediation efforts.

We have begun considering several questions and factors affecting the development of the integrated population model (IPM). We have also begun compiling priors that will be used in the IPM. These important considerations will be fully addressed by fall 2021 and model formulation will occur. The IPM will be developed and applied in the next reporting period. We will use the population model to 1) identify important vital rates affecting population growth rate, 2) contrast important vital rates among populations, and 3) develop hypotheses to explain why some pronghorn populations experience limitations on population growth rate.

From mid-March to current, we have collected vegetation data at 238 locations, including 121 at known locations of collared pronghorn and 117 at available locations randomly distributed in proportion to landcover type across three study areas (Musselshell, Fergus-Petroleum, and South Philips). In addition, we have collected 35 fecal samples from across the 3 study areas for diet analysis. Combined with diet information, the vegetation data will be used to understand how seasonal changes in forage resources affect pronghorn resource selection and movements. Sampling efforts for this portion of the project will continue to the end of July for this year's field season and will additionally include March to July of 2022.

Project Background

Pronghorn (*Antilocapra americana*) provide important ecosystem functions and recreational opportunities in Montana, which hosts the 2nd largest population and harvest of pronghorn across their range. Ecologically, pronghorn may serve as an umbrella species for conserving sagebrush-grasslands and maintaining landscape connectivity of these systems (Rowland et al. 2006, Gates et al. 2012). Because of the important ecosystem functions and recreational opportunities pronghorn provide, conserving and managing pronghorn and their habitats is a priority for Montana Fish, Wildlife & Parks (FWP), land management agencies, private landowners, non-governmental organizations (NGOs), and numerous additional stakeholders.

Recently, there has been a focus in the western United States to identify and protect big game migration corridors and winter ranges, highlighted in the 2018 Department of Interior Secretarial Order (SO) 3362. The purpose of SO 3362 is to foster collaboration between the federal government, states, NGOs, and private landowners to identify, improve, and conserve winter range and migration corridors for mule deer, elk, and pronghorn. In response to SO 3362, FWP drafted a State Action Plan which identifies five priority conservation areas in Montana. Collaborations between landowners and state and federal wildlife, land management, and transportation agencies have since formed to design cooperative habitat or transportation projects to improve landscape connectivity and conserve big game populations.

In Montana, there are limited data available regarding pronghorn movements and population dynamics. Therefore, additional information is needed regarding pronghorn seasonal habitat use and migratory movements to inform and prioritize these important habitat and conservation efforts. In addition to collecting movement data, understanding population demography is needed to promote effective management strategies. Given widespread pronghorn population declines in portions of central and eastern Montana in recent decades, biologists need information regarding survival and demography to identify and understand potential issues limiting pronghorn population recovery.

Pronghorn populations were abundant and at or above regional population objectives/long-term averages (LTAs) throughout their range in Montana during the mid-2000s with harvest totaling 33,500 at the latest peak in 2007. Following widespread blue-tongue virus (BTV) outbreaks in the subsequent two years, then the record cold and snowy winter in 2010-2011, harvest fell to a low of 8,200 in 2013 (Montana Fish Wildlife and Parks 2020a). Pronghorn populations typically rebound quickly with favorable weather conditions, yet numbers of pronghorn in many of Montana's central and eastern populations are < 50% of population objective despite multiple years of favorable weather and minimal harvest. Meanwhile, mule deer and elk populations are exceeding objective levels over much of the region (Montana Fish Wildlife and Parks 2020b, 2020c)

The factors currently limiting pronghorn population recovery across central and eastern Montana are unknown. Stochastic events including severe winter weather may cause significant mortality events, leading to high variability in overwinter pronghorn survival rates (Martinka 1967, Pyrah 1987, O'Gara 2004). Accordingly, survival of adult female pronghorn is lower or more variable than for other northern temperate ungulates, ranging from 0.29 to 0.87 in Montana (Boccadori 2002, Dunn and Byers 2008, Barnowe-Meyer et al. 2009, Jakes 2015). During winter 2010-2011, abnormally high snow depths in central and eastern Montana concentrated pronghorn on winter range, resulting in rapid exhaustion of browse, over exposure, and altered pronghorn distributions (Jakes et al. 2018a). In the Fort Peck Reservoir area of central Montana, flooding exacerbated the effects of the 2011 severe winters, as more than 2,000 pronghorn attempting to return north to fawning and summer ranges were stranded on the south side of the reservoir by unusually high floodwaters and were presumed to have died after exhausting nearby forage. Fences and roads may also act as barriers to movements within or between seasonal ranges, potentially affecting seasonal range selection and reducing habitat availability (Jakes et al. 2018b, Jones et al. 2019).

Pronghorn pregnancy and birth rates are generally high; however, these vital rates may also be affected by habitat or weather conditions and have the potential to limit pronghorn population recovery. Dunn and Byers (2008) recorded pronghorn reproductive failures on the National Bison Range (NBR), Montana, following severe drought in 2003 and none of the marked females that weaned fawns in 2003 gave birth in 2004. During this same period, annual counts of other ungulates on the NBR did not indicate exceptionally low survival or fecundity rates potentially because other ungulate species fall lower on the maternal energy-expenditure spectrum than pronghorn (Dunn and Byers 2008). Additionally, severe weather such as drought or harsh winters may have carryover effects on future reproductive success or survival (Webster et al. 2002). Although habitat or weather-related factors generally have a greater effect on pronghorn populations than predation, predation may limit recruitment and have important effects on population growth (O'Gara and Shaw 2004). Overall fawn mortality across 18 studies averaged 71%, with 76% of all mortalities being due to predation from coyotes (O'Gara and Shaw 2004). We expect that coyote predation is the main proximate cause of mortality of pronghorn fawns in central and eastern Montana, but its extent may vary due to habitat conditions (weather and land-use influences on vegetation), the abundance of alternate prey species (Hamlin and Mackie 1989, Berger et al. 2008, Berger and Conner 2008), or coyote control operations (Harrington and Conover 2007, Brown and Conover 2011).

In addition to the potential limiting effects of habitat, weather and predation on pronghorn survival and recruitment, disease events like BTV or epizootic hemorrhagic disease (EHD) can also impact pronghorn populations via direct mortality or negative effects on reproduction (Thorne et al. 1988, Dubay et al. 2006, Gray 2013). In July 2007, a BTV outbreak occurred across portions of central and eastern Montana and precipitated the decade-long decline in pronghorn populations (Montana Fish Wildlife and Parks 2012). Disentangling the effects of

BTV and other diseases on pronghorn reproductive rates will require serologic assays and pregnancy tests or other measures of productivity in years with and without disease outbreaks, and data from pronghorn in this study will begin to inform us on the influences of disease on pronghorn populations in Montana.

Several hypotheses exist concerning factors potentially limiting pronghorn population recovery. For example, 1) adult female survival and/or recruitment, as influenced by weather, habitat conditions, predation, and/or a combination of these factors, may be too low and therefore limiting the population, 2) carryover effects of past disease events or current infection may impact adult female survival and reproduction, and/or 3) potential barriers restricting seasonal movements of pronghorn may impact vital rates. We will develop an integrated population model using adult female survival data combined with population abundance and production estimates from survey and harvest data. This population model will 1) identify important vital rates affecting population growth rate, 2) contrast important vital rates between populations that are considered productive vs. limited in performance, and 3) develop hypotheses to explain why some pronghorn populations experience limitations on population growth rate. The population model will provide information towards developing more focused investigations into ecological and/or anthropogenic factors limiting pronghorn population recovery in central Montana and future population monitoring strategies.

The overall purpose of this project is to identify seasonal ranges and movement corridors and provide demographic data for pronghorn populations in 8 study areas across Montana (Figure 1). These areas have been selected based on local needs identified by FWP area biologists and where considerable community, conservation partner, and agency interest exists in mapping anthropogenic impediments or other habitat features that influence habitat/migratory pathway selection or fitness. Our specific objectives include:

1. Delineate seasonal range and movement corridors of pronghorn in the study areas.
2. Distribute maps of seasonal range and movement areas for pronghorn widely to conservation partners and landowners via a web-based platform.
3. Use seasonal range and movement data to identify potential barriers to movements, inform management decisions, and prioritize locations for habitat improvement projects.
4. Develop a population model to identify important vital rates affecting population growth rates and describe important demographic differences between pronghorn populations that are growing or stable, versus those that are limited in their population performance.
5. Evaluate the effect of vegetation and other landscape features on resource selection and movement of migratory and non-migratory pronghorn.

Study Location

The 8 study areas are located in the southwestern, central, and southeastern regions of Montana (Figure 1) and include the Big Hole, Madison, Paradise, Musselshell, Fergus-Petroleum, South Philips, Garfield-Rosebud, and Powder River-Carter.

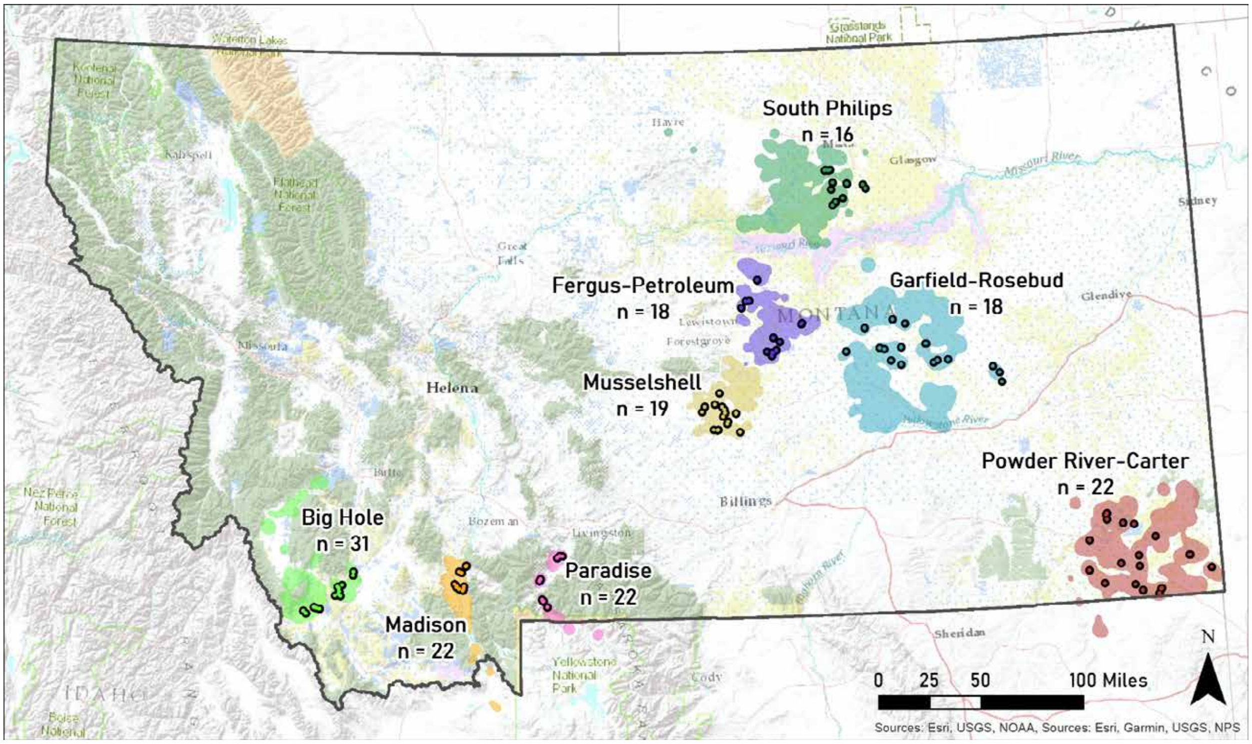


Figure 1. Capture locations and number of animals captured in the 8 study areas for the Montana Pronghorn Movement and Population Ecology Project during winter 2021 overlaid on annual ranges based on collar locations collected 2019 - 2021.

Objective #1: Delineate seasonal range and movement corridors of pronghorn in the study areas

1.1 Pronghorn capture, collaring, and sampling

In February 2021, we captured and instrumented with GPS collars a total of 168 adult female pronghorn to augment the sample of animals captured in winter 2020 and maintain approximately 60 animals with active collars in each study area (Figure 1). This capture effort included a total of 13 animals in the Fergus-Petroleum, 16 in the South Philips, 18 in the Garfield-Rosebud, 19 animals in the Musselshell, 22 in each of the Powder River-Carter, Madison, and Paradise, and 31 in the Big Hole study areas. In total, across all study areas from 2019 to 2021, we have captured and collared 598 animals. We outfitted each animal with a Lotek LiteTrack Iridium 420 collar programmed to collect locations every hour for three years, transmit a VHF signal during daylight periods, and transmit a mortality alert and signal if the device is stationary for >5 hours. These collars upload locations via Iridium satellites to a web platform for viewing and downloading near-real-time data. To date, across all study areas and years, a total of 30 collars have malfunctioned, 159 animals have died (see Section 1.2 for survival monitoring and analyses), and 409 collars remain active and will continue to be monitored.

In addition, we collected blood serum for disease testing from each animal in the Big Hole and Paradise to provide broader disease surveillance for these study areas due to limited sampling completed during 2020. Blood serum samples were assayed for evidence of exposure to pathogens including *Anaplasma* bacteria, bovine herpesvirus, bovine respiratory syncytial virus, bluetongue virus, bovine viral diarrhea type 1, bovine viral diarrhea type 2, epizootic hemorrhagic disease, *Leptospira canicola*, *L. grippo*, *L. hardjo*, *L. ictero*, *L. pomona*, and parainfluenza-3. These pathogens were selected for screening because of either their known potential impact to individual or herd health (e.g., bluetongue virus and epizootic hemorrhagic disease) and/or because of their known association with livestock or wildlife health (e.g., *Leptospra* serovars, *Anaplasma*, bovine viral syncytial virus, and parainfluenza-3). All assays were conducted by the Montana Veterinary Diagnostic Laboratory (Bozeman, Montana), except for epizootic hemorrhagic disease, which was conducted by the Washington Animal Disease Diagnostic Lab (Pullman, Washington). We combined these results with the 2020 sampling results (Table 1).

We found no serological evidence of exposure for bovine herpesvirus, bluetongue virus, bovine diarrhea type 1, epizootic hemorrhagic disease, or *L. hardjo*. We found evidence of exposure in both the Big Hole and Paradise for *Anaplasma* (16 and 75% seroprevalence, respectively), bovine respiratory syncytial virus (8 and 9% seroprevalence, respectively), *L. ictero* (9 and 17% seroprevalence, respectively), and parainfluenza-3 (75 and 90% seroprevalence, respectively). In addition, we found evidence of exposure for *L. grippo* (1% seroprevalence) and *L. pomona* (1% seroprevalence) in the Big Hole, and for bovine viral diarrhea type 2 (2% seroprevalence) and *L. canicola* (2% seroprevalence) in the Paradise. Although we found evidence of exposure to these diseases, the results are not expected to impact individual or herd health and are within the range of normal exposure rates in pronghorn (Barrett and Chalmers 1975, Stauber et al. 1980, O'Gara 2004).

Table 1. Seroprevalence for anaplasmosis (ANPLSM), bovine herpesvirus (BHV), bovine respiratory syncytial virus (BRSV), bluetongue virus (BTV), bovine viral diarrhea type 1 (BVD1), bovine viral diarrhea type 2 (BVD2), epizootic hemorrhagic disease (EHD), *Leptospira canicola* (L. CAN), *L. grippo* (L. GRI), *L. hardjo* (L. HAR), *L. ictero* (L. ICT), *L. pomona* (L. POM), and parainfluenza-3 (PI3) based on serological screening of adult female pronghorn in the Big Hole and Paradise study areas sampled during winter 2020 and 2021 for the Montana Pronghorn Movement and Population Ecology Project.

Herd	Statistic	ANPLSM	BHV	BRSV	BTV	BVD1	BVD2	EHD	L. CAN	L. GRI	L. HAR	L. ICT	L. POM	PI3
Big Hole	# Sampled	76	76	76	76	76	76	75	76	76	76	76	76	76
	# Exposed	12	0	6	0	0	0	0	0	1	0	7	1	57
	% Exposed	16	0	8	0	0	0	0	0	1	0	9	1	75
Paradise	# Sampled	47	47	47	47	47	47	34	47	47	47	47	47	47
	# Exposed	40	0	4	0	0	1	0	1	0	0	8	0	42
	% Exposed	75	0	9	0	0	2	0	2	0	0	17	0	90

1.2 Survival monitoring and analysis

Of the 598 animals captured and collared to date, a total of 159 (26.6%) animals have died, ranging 12 – 27 (22.1 – 32.9%) animals in each study area, and 30 (0.5%) collars have malfunctioned (Figure 2). Mortality investigations were completed as soon as possible after receiving the morality alerts. Mortalities associated with both 2020 and 2021 winter capture operations (capture myopathy or injury) totaled 29, ranging 0 – 9 (4.2 – 52.9%) mortalities in each study area (Figure 3). The remaining mortalities were classified as predation (n = 44), unknown (n = 37), natural (n = 31), disease (n = 8), legal harvest (n = 7), illegal take (n = 4), human-related (n = 4), and injury/starvation (n = 2). We classified mortalities as natural when a carcass was found intact with no evidence of predation, injury/starvation, human-related injuries, or lab-confirmed disease or the mortality was likely due to old age or birth complications. A total of 409 collared animals are currently being monitored.

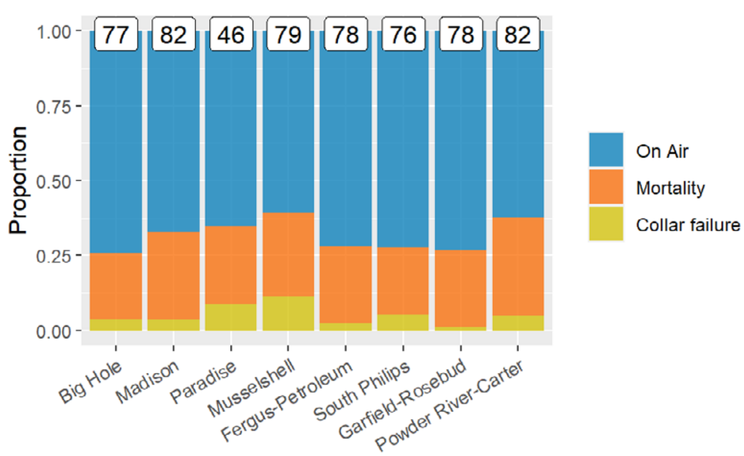


Figure 2. Proportion of collared adult female pronghorn remaining on air, dead, or with a malfunctioned collar in each study area in the Montana Pronghorn Movement and Population Ecology Project as of June 30, 2021. The total number of collared animals in each study area is labeled at the top of each bar.

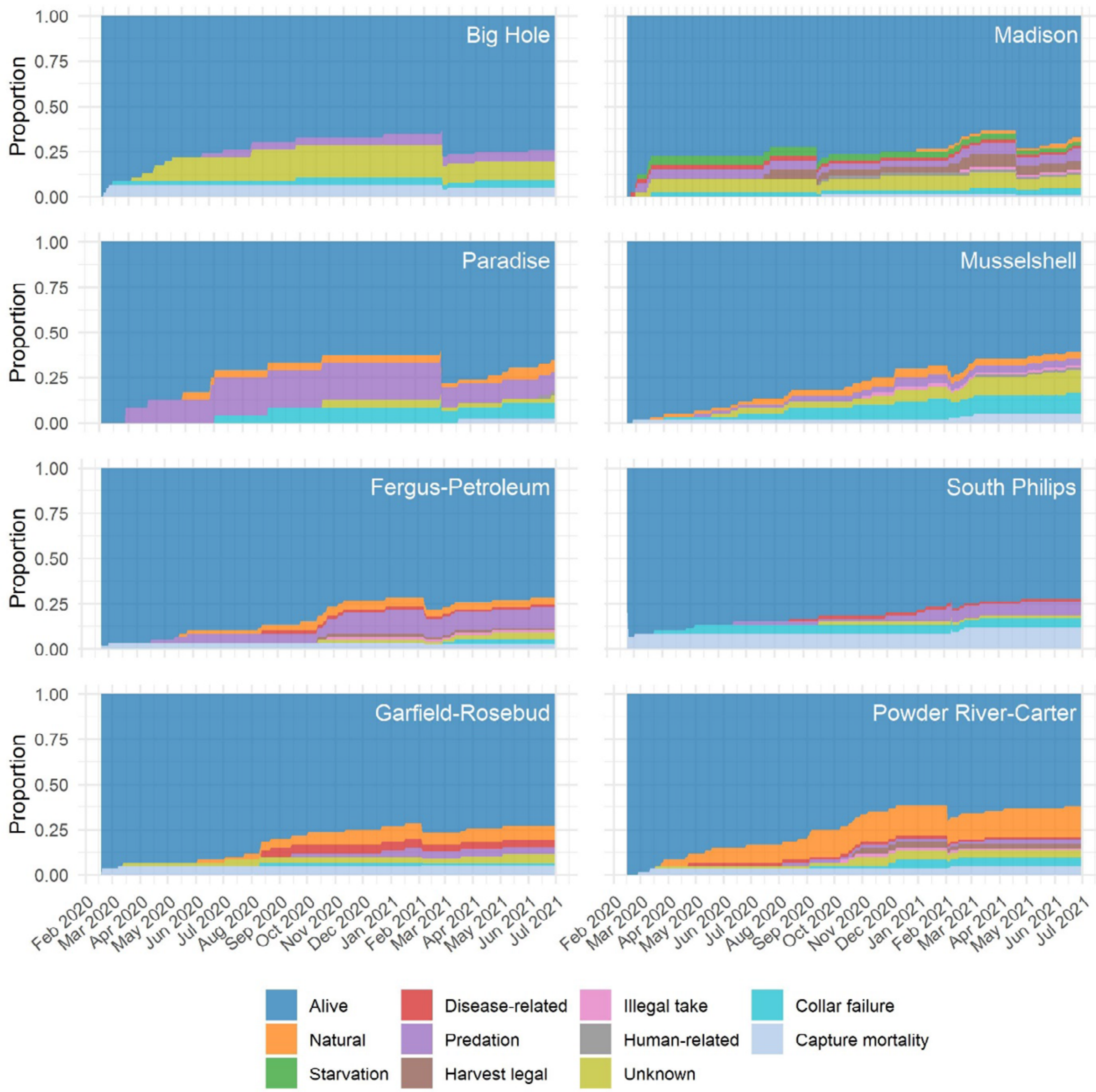


Figure 3. Proportion of collared adult female pronghorn remaining alive, dead, or with a malfunctioned collar in each study area in the Montana Pronghorn Movement and Population Ecology Project through June 30, 2021. Cause of death was determined by field investigations.

Based on the known fate information from the collared pronghorn, we estimated survival by month across populations (Figure 4) and by population (Table 2) using a multi-state survival model with known-detection (with GPS collar data, perfect detection is assumed) in a Bayesian framework. Multi-state survival models are a class of survival models that can incorporate covariates easily by measuring covariates at the scale of the sampling occasion (i.e., at the monthly scale). Multi-state survival models are also flexible to a range of recapture period lengths (occasion lengths) and can integrate the influence of individual states and transition between states on survival rates. We built the model using an encounter history of length = 12

(12 months in a year) for each animal-year, and we removed from the analysis animals that were classified as harvest or illegal take to represent “baseline-survival” (Brodie et al. 2013). The estimated survival is the probability that an animal alive at the start of one occasion (i.e., a month) will survive to the start of the next occasion (the next month). From these data, the survival model can estimate mean monthly survival (Figure 4) as well as calculate apparent annual survival by taking the product of all months’ survival probabilities within each population (Table 2). Monthly survival probabilities across study populations varied between approximately 0.95 – 1.0, with the lowest occurring in September and the highest occurring in June. Annual survival probability across all populations was 0.77, and ranged from 0.66 in the Garfield-Rosebud population to 0.88 in the Madison population.

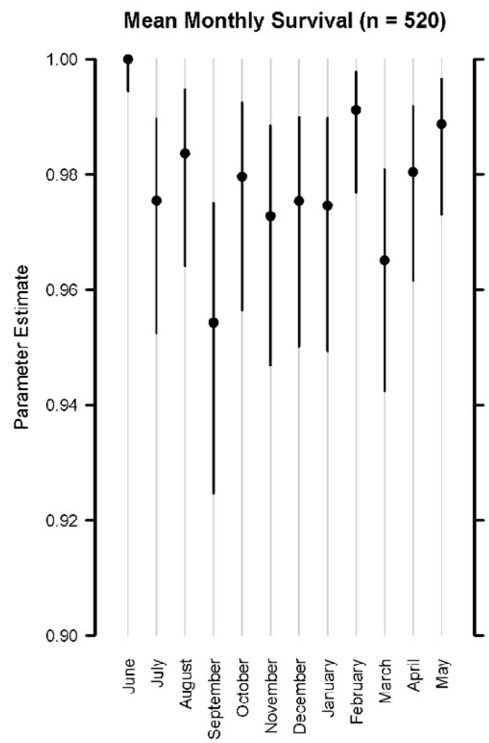


Figure 4. Mean monthly survival probabilities (and 95% credible intervals) estimated from known fate information of collared adult female pronghorn across all study populations in the Montana Pronghorn Movement and Population Ecology Project as of June 30, 2021. The estimated probabilities represent the probability that an animal alive in one month will survive to the next month.

Table 2. Apparent annual survival probabilities (and 95% credible intervals) estimated from known fate information of collared adult female pronghorn for each study population and across study populations (the "Total Annual Survival" row) in the Montana Pronghorn Movement and Population Ecology Project as of June 30, 2021. The estimated probabilities are the product of all months' survival probabilities for each study area.

Survival by Population		95% Credible Interval	
	Annual Survival	2.5 %	97.5 %
Big Hole (n=65)	0.843	0.723	0.932
Madison (n=64)	0.880	0.776	0.953
Paradise (n=41)	0.725	0.536	0.877
Musselshell (n=72)	0.783	0.673	0.875
Fergus-Petroleum (n=70)	0.756	0.642	0.853
South Philips (n=66)	0.813	0.705	0.900
Garfield-Rosebud (n=73)	0.664	0.546	0.775
Powder River-Carter (n=69)	0.700	0.576	0.813
Total Annual Survival (n=520)	**0.766**	**0.726**	**0.805**

1.3 Delineation of pronghorn seasonal ranges and movement corridors

To date, we have collected 4,653,004 locations from 598 individuals, averaging 7,940 (range: 7 – 21,423) locations per individual. Movement patterns of individuals were diverse within and across study areas (Figure 5 – 19). To calculate seasonal ranges (Figure 6 - 20), we randomly sampled 4 locations per day per individual and estimated a 95% kernel utilization distribution (KUD) for each season using all the locations from each individual within each study area (i.e., population-level). The 95% KUD represent the area in which the probability of relocating an animal is equal to 0.95. We defined spring as April 1 – June 30, summer as July 1 – Aug 31, fall as September 1 – November 30, and winter as December 1 – March 31. Estimates of seasonal ranges and movement corridors shown in this report are preliminary and will be finalized at the end of location data collection. Estimates of movement corridors will be finalized at the end of location data collection.

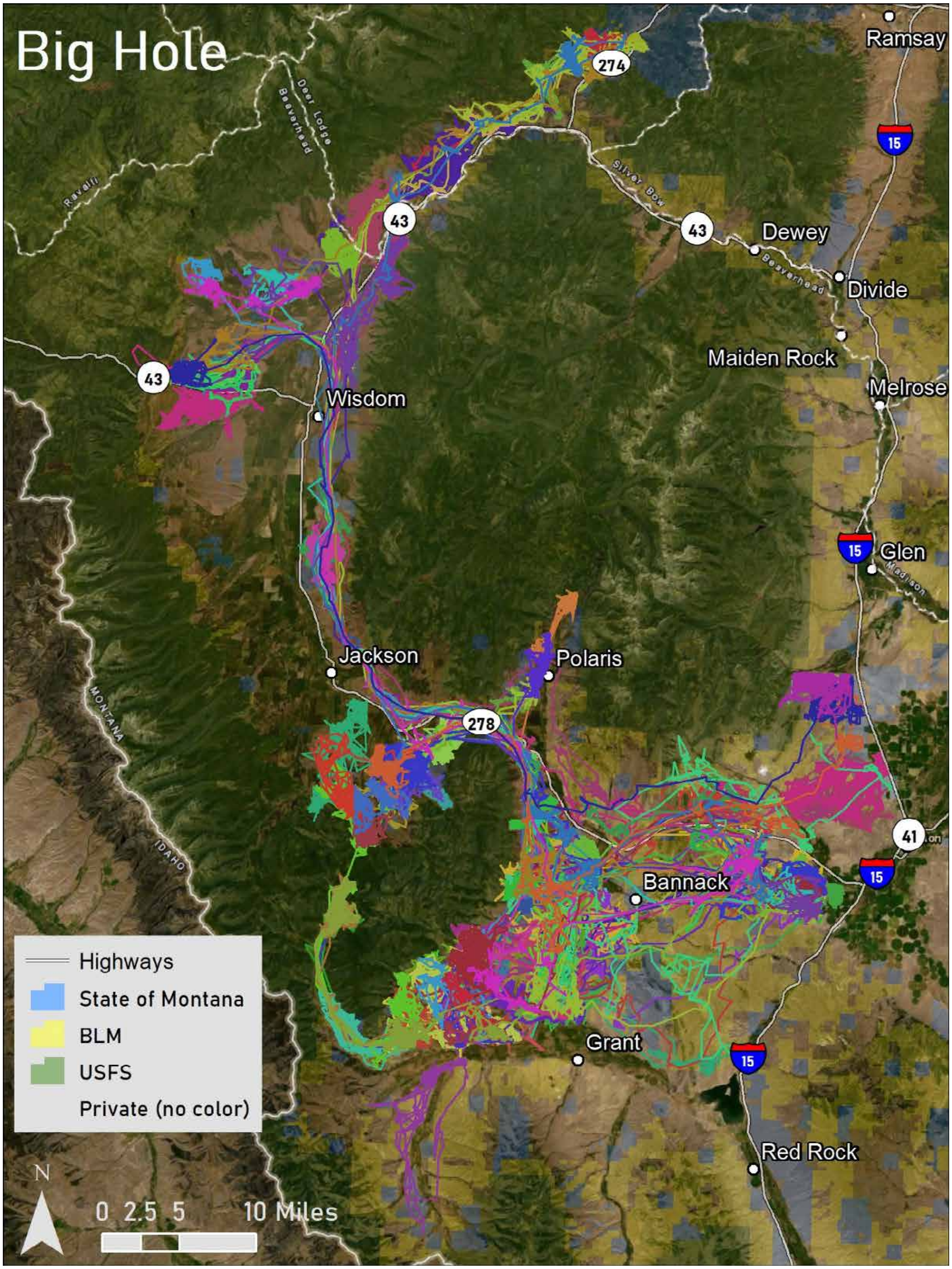


Figure 5. Movements of collared adult female pronghorn (colored by individual) in the Big Hole study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

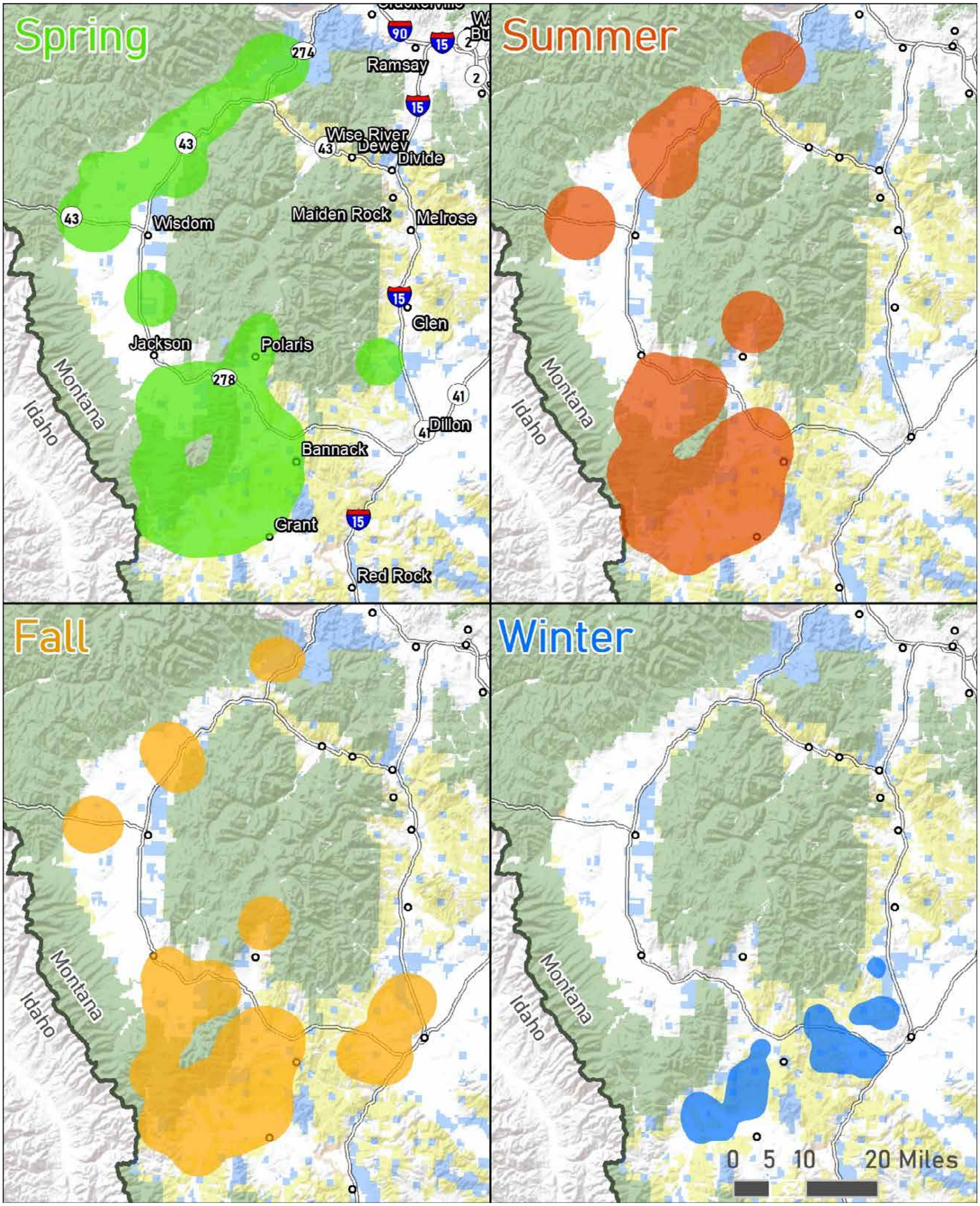


Figure 6. Seasonal ranges of collared adult female pronghorn in the Big Hole study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

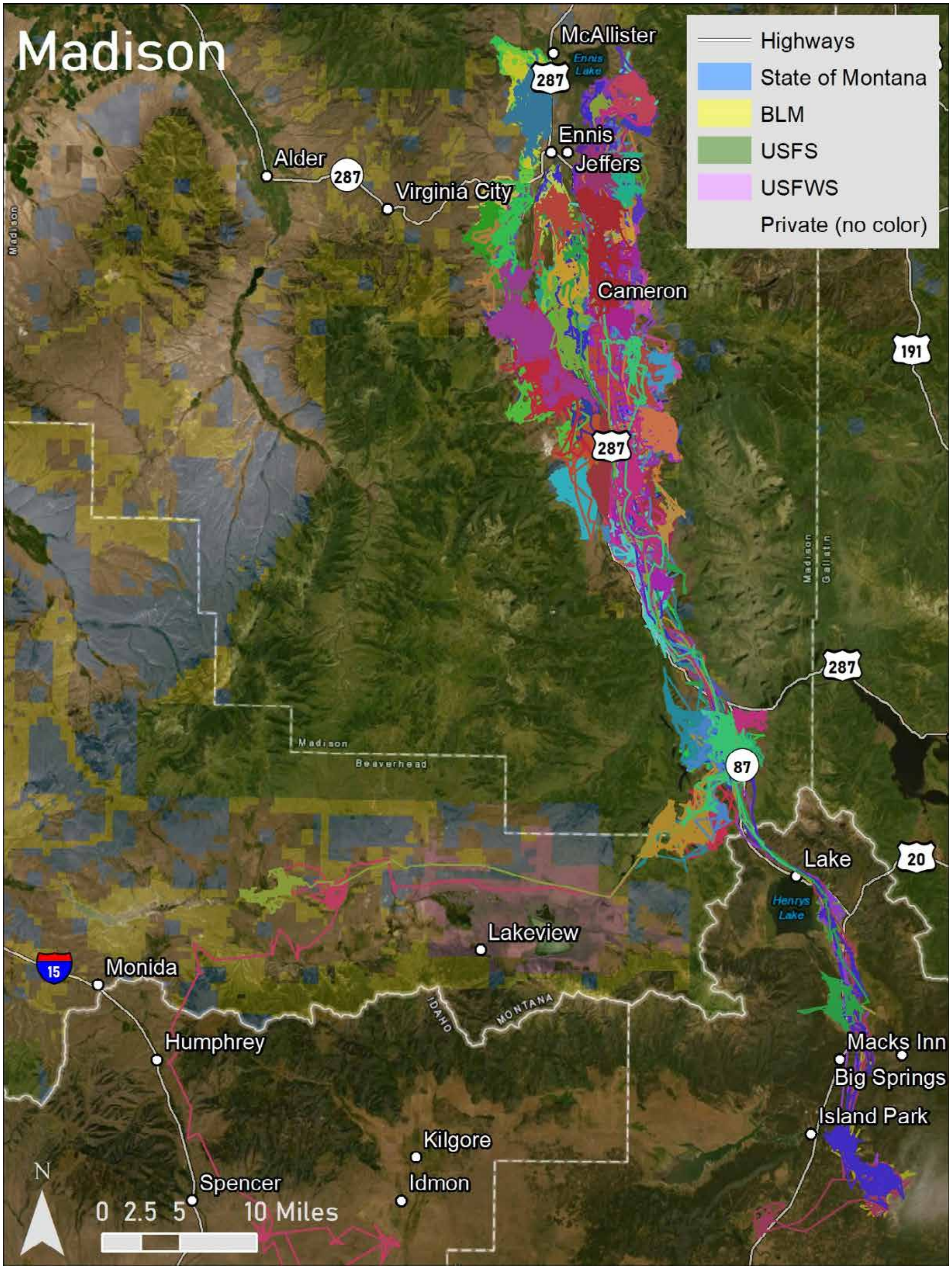


Figure 7. Movements of collared adult female pronghorn (colored by individual) in the Madison study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

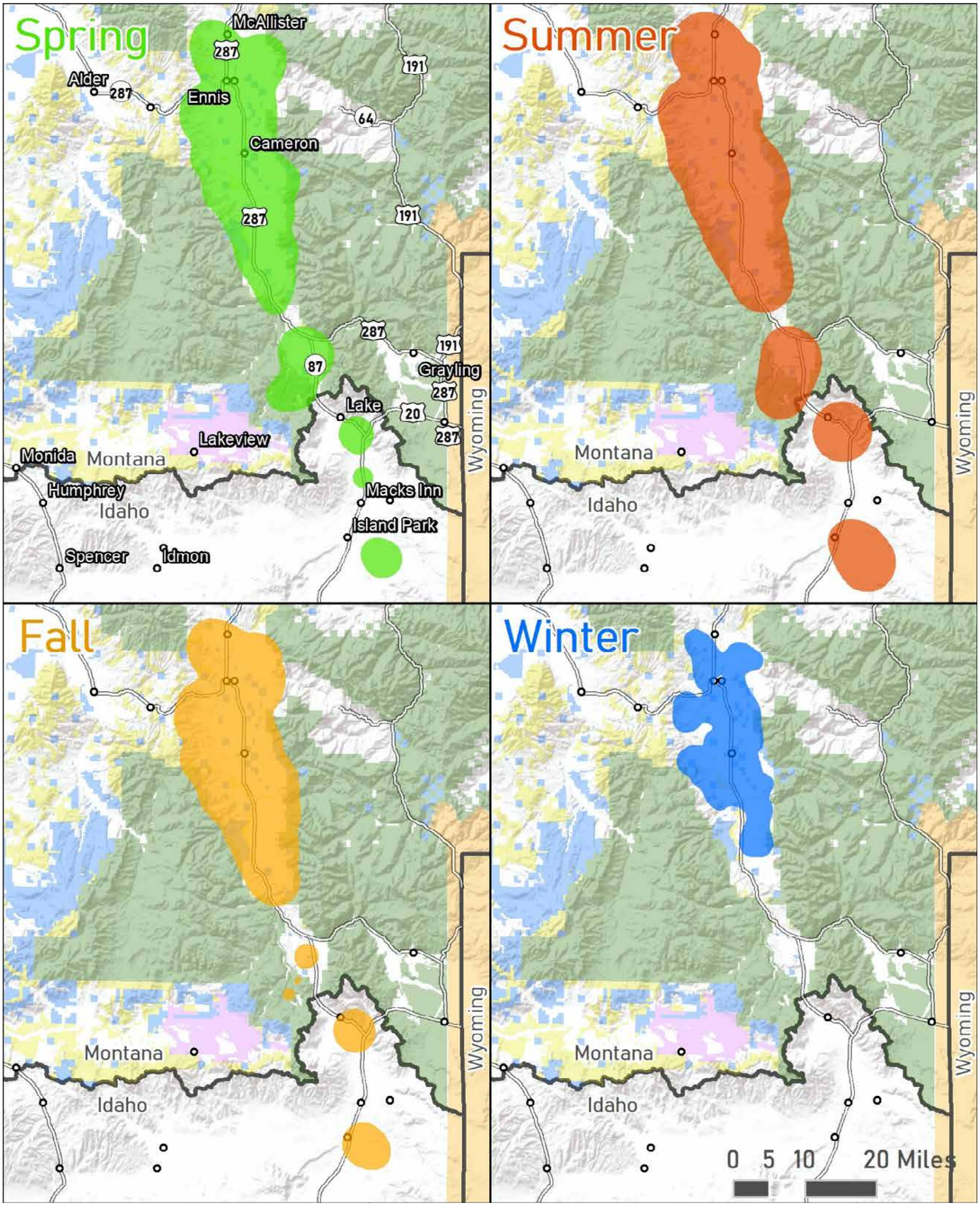


Figure 8. Seasonal ranges of collared adult female pronghorn in the Madison study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

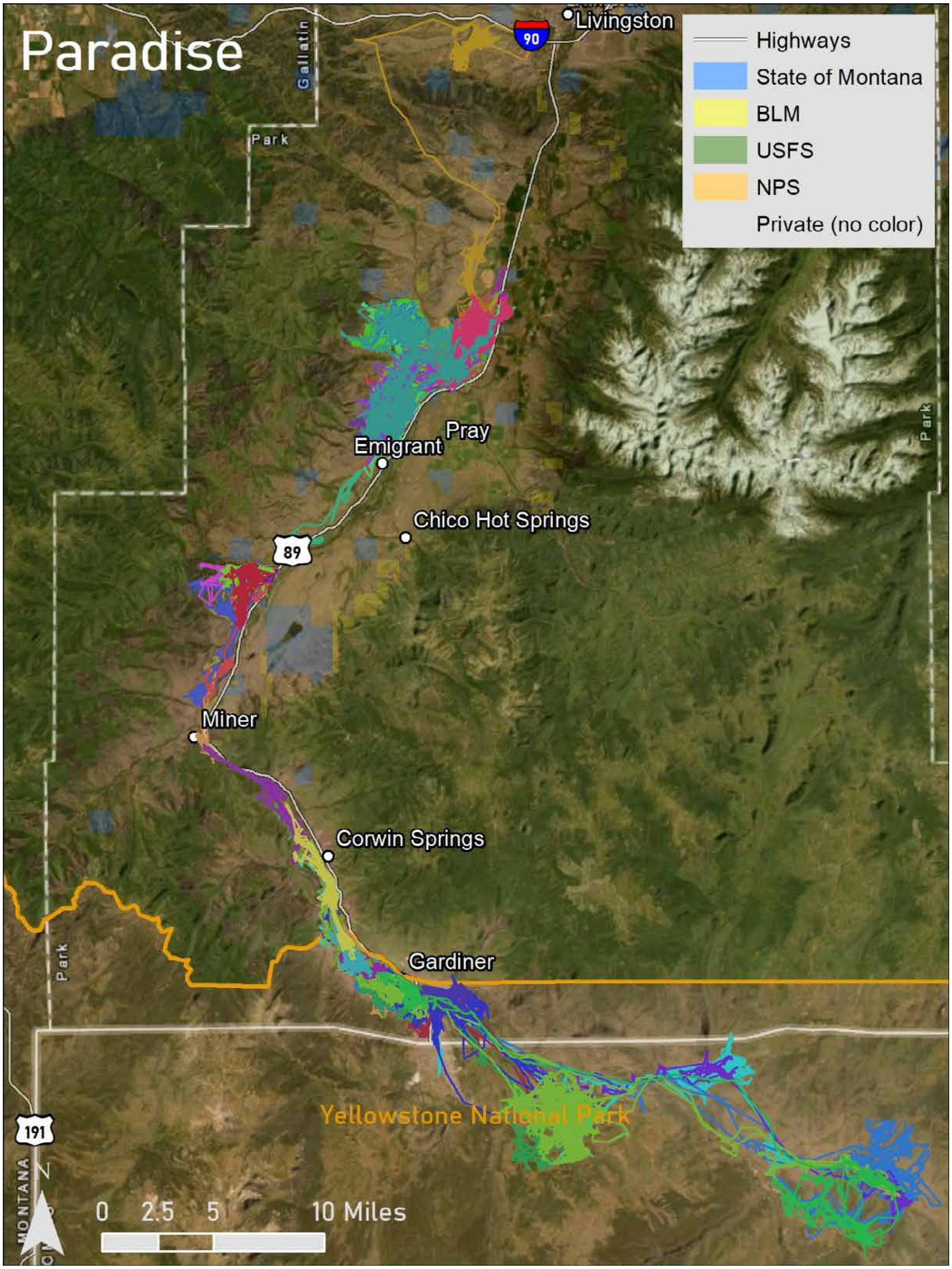


Figure 9. Movements of collared adult female pronghorn (colored by individual) in the Paradise study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

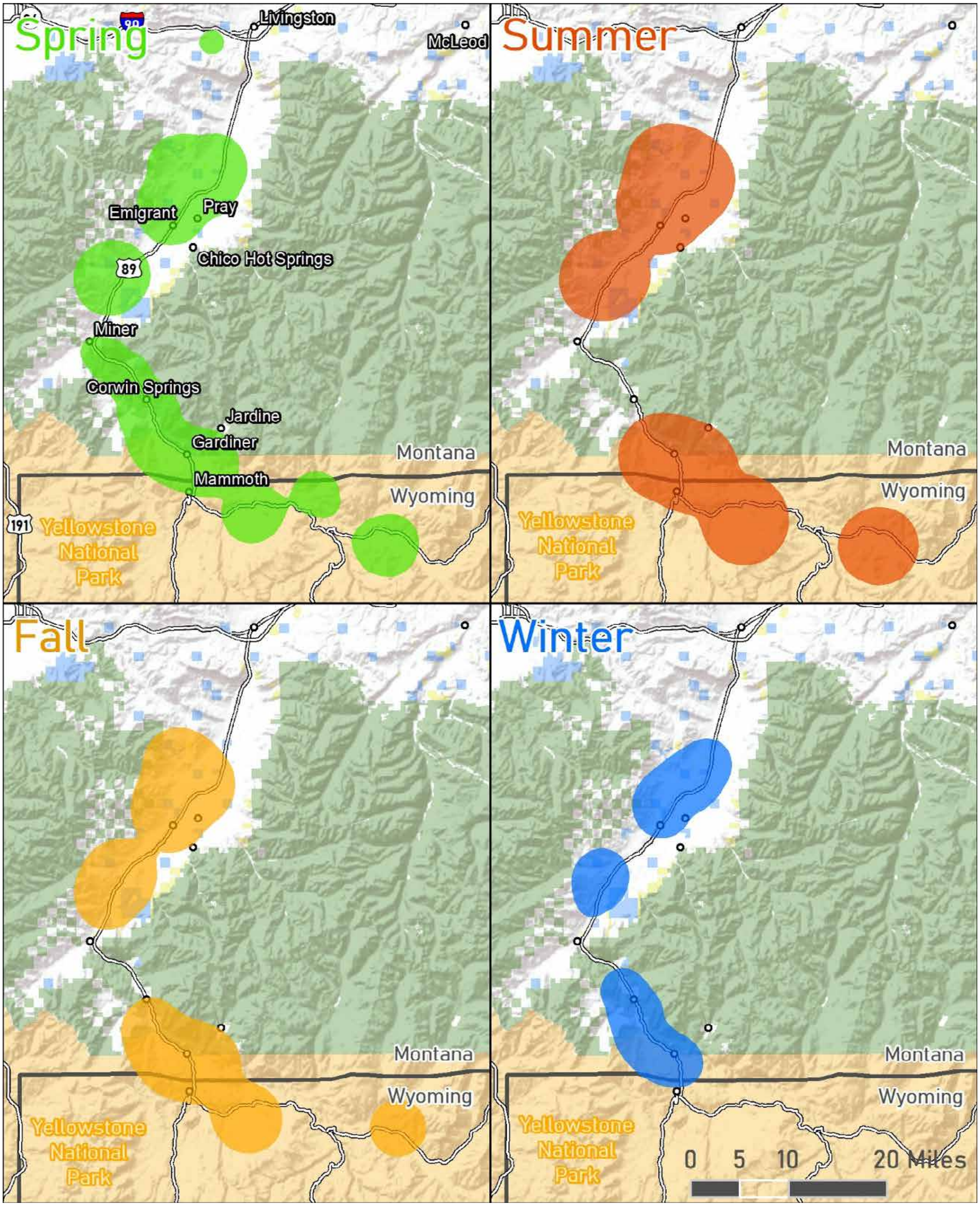


Figure 10. Seasonal ranges of collared adult female pronghorn in the Madison study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

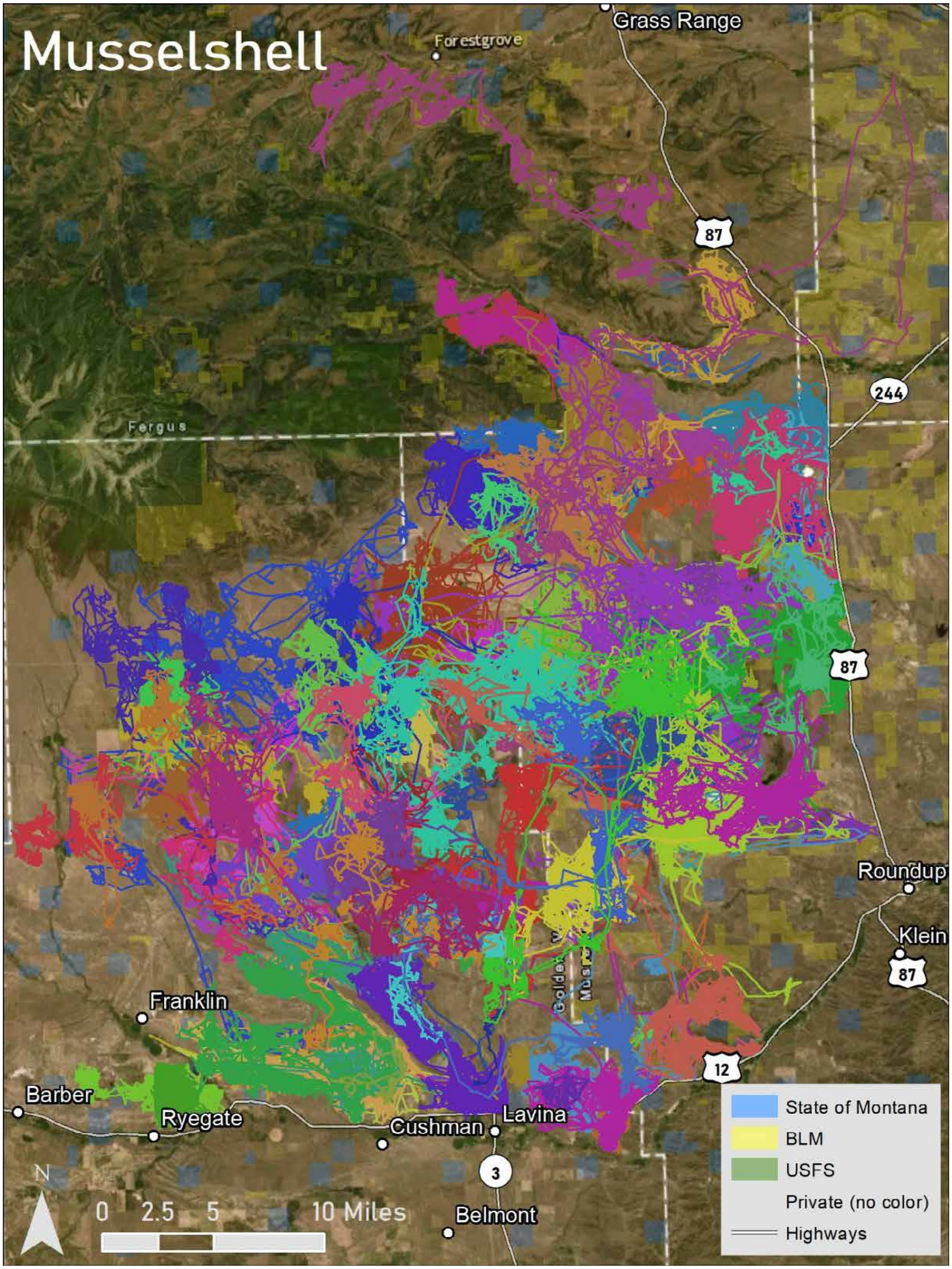


Figure 11. Movements of collared adult female pronghorn (colored by individual) in the Musselshell study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

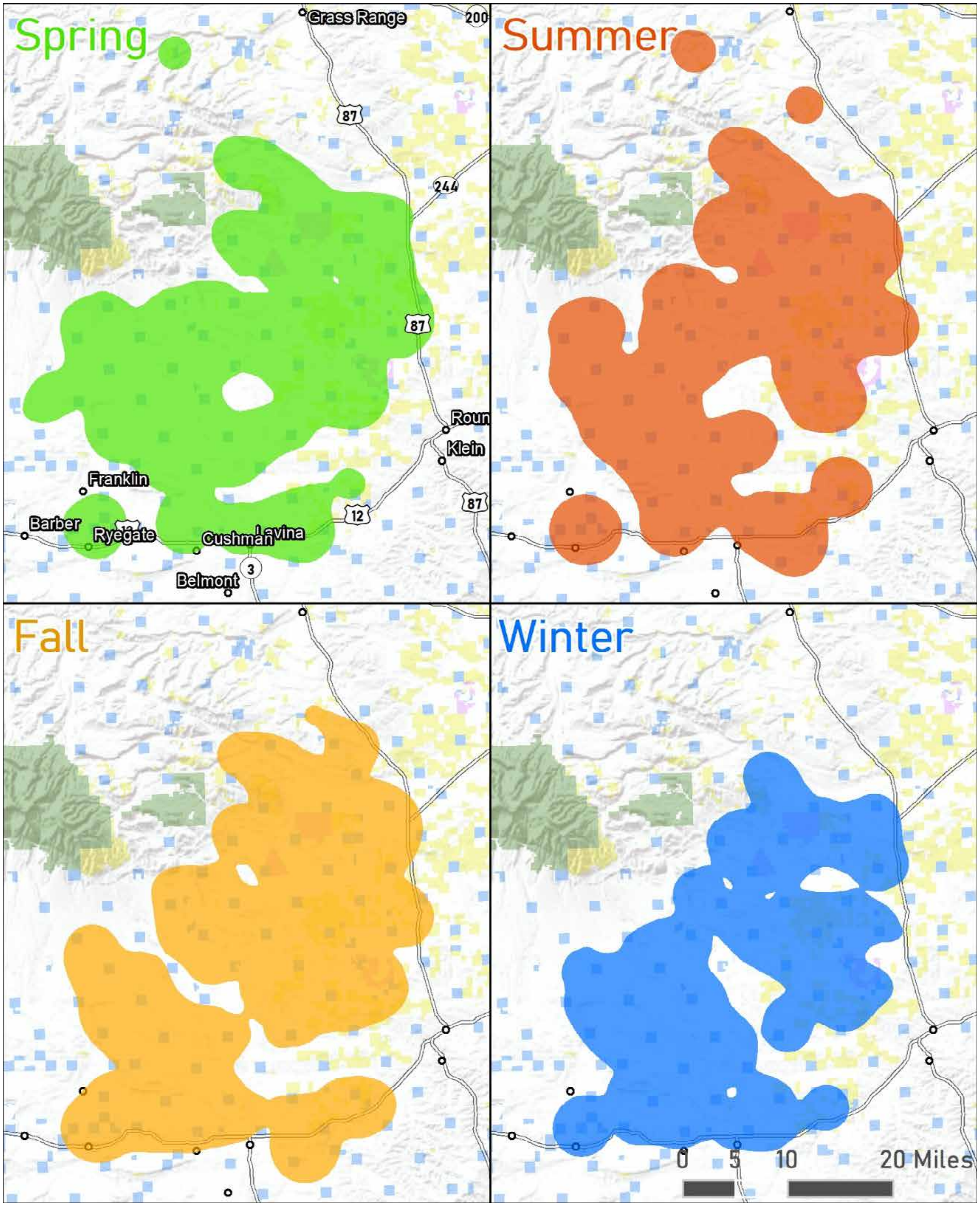


Figure 12. Seasonal ranges of collared adult female pronghorn in the Musselshell study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

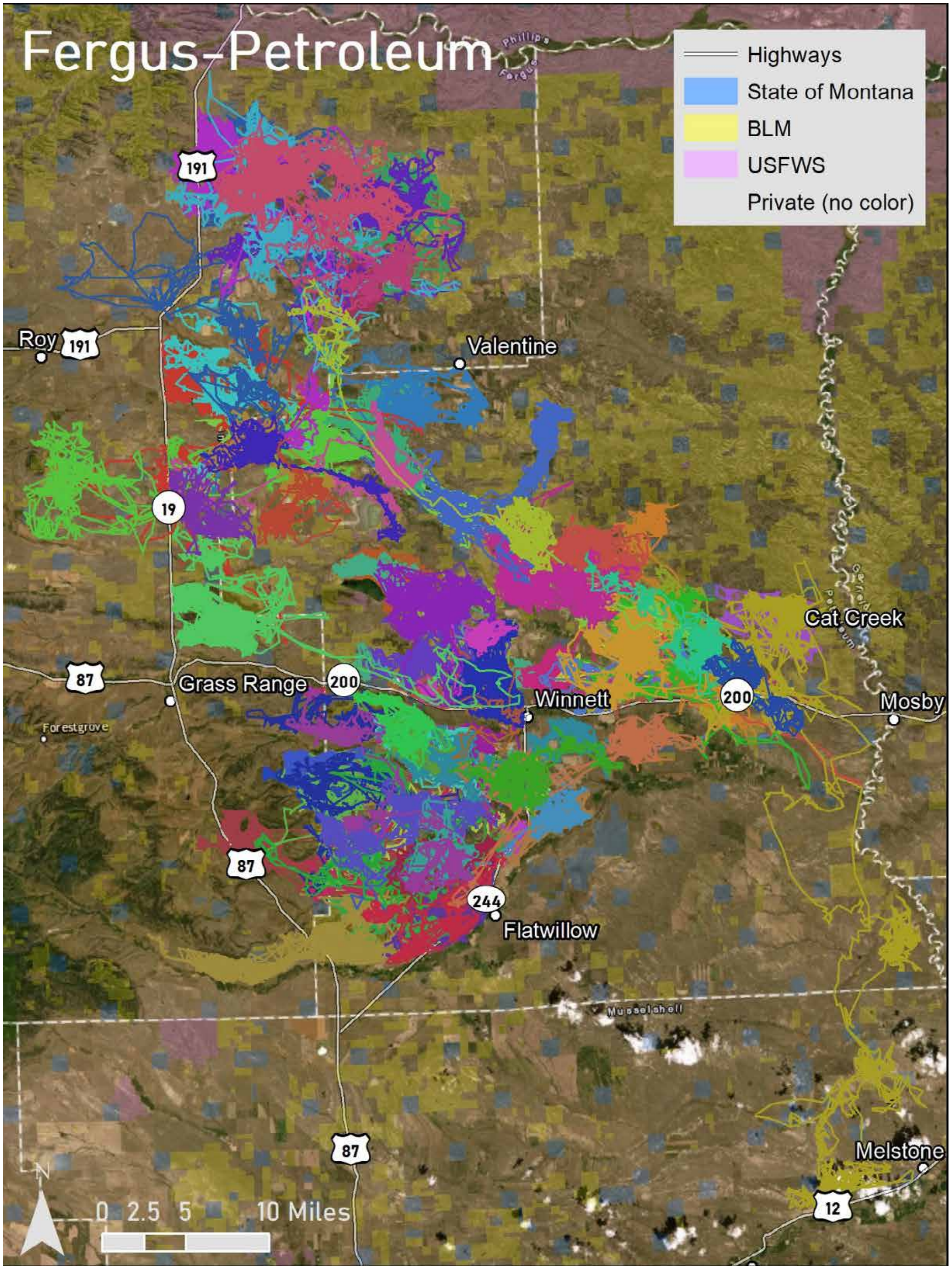


Figure 13. Movements of collared adult female pronghorn (colored by individual) in the Fergus-Petroleum study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

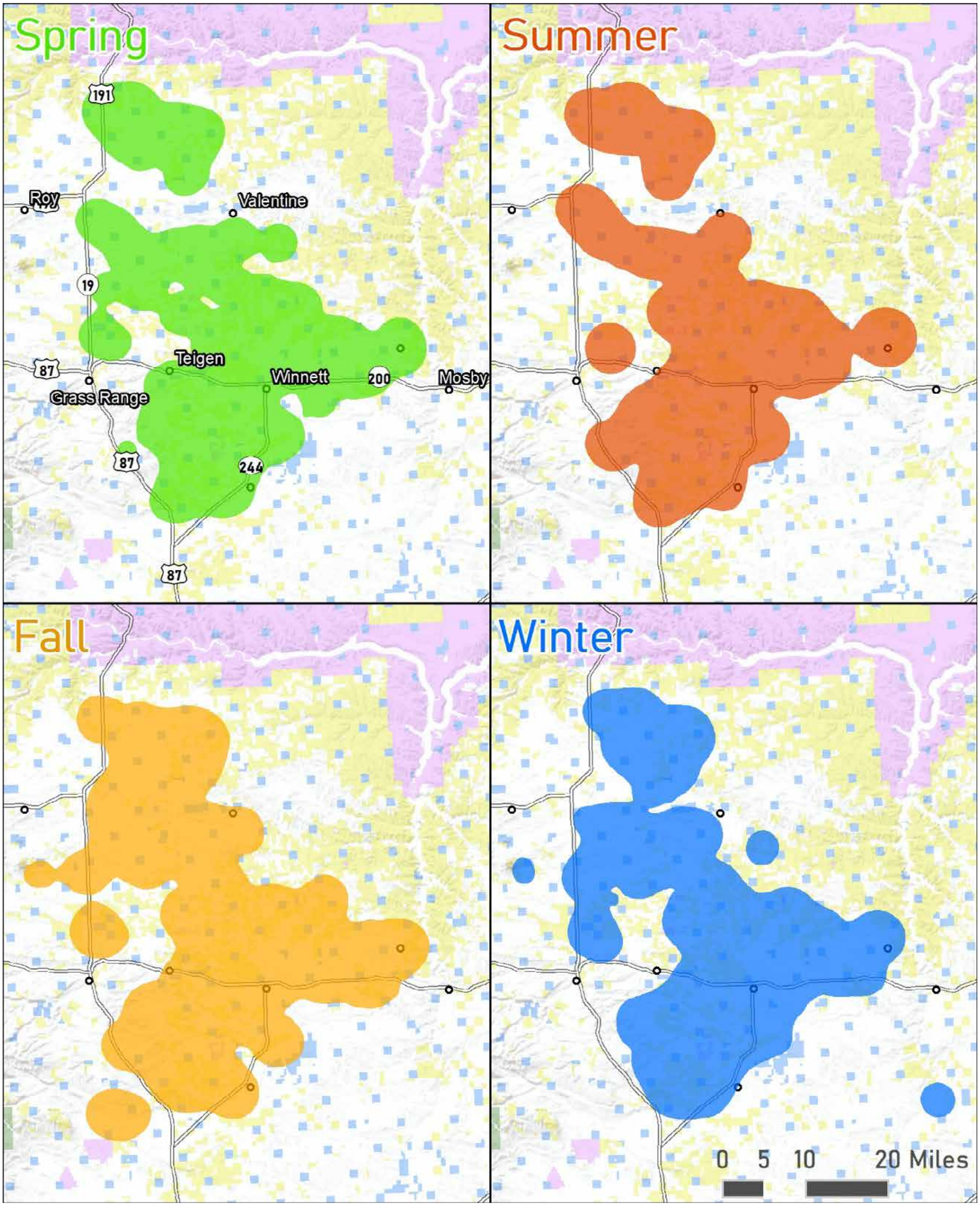


Figure 14. Seasonal ranges of collared adult female pronghorn in the Fergus-Petroleum area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

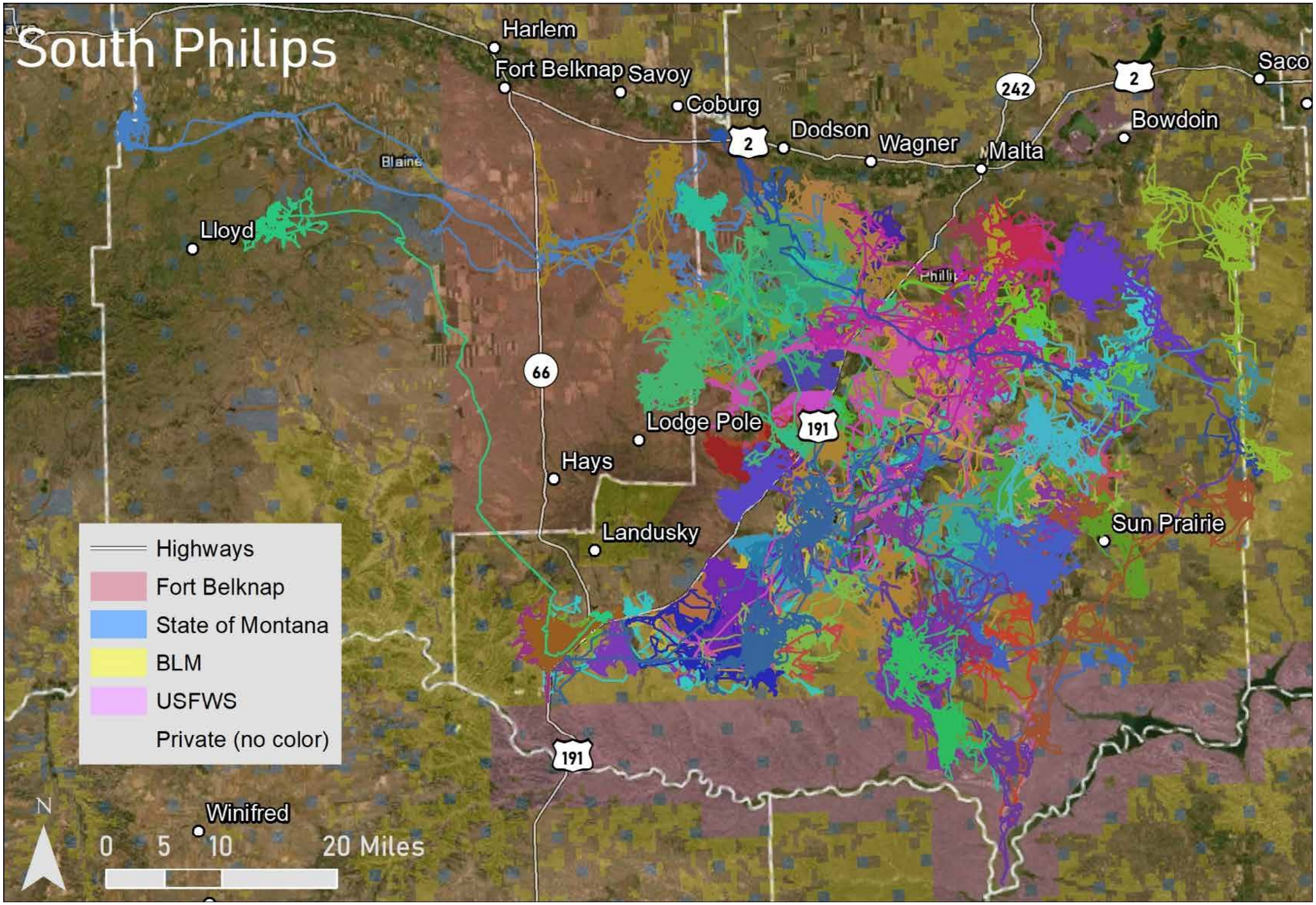


Figure 15. Movements of collared adult female pronghorn (colored by individual) in the South Philips study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

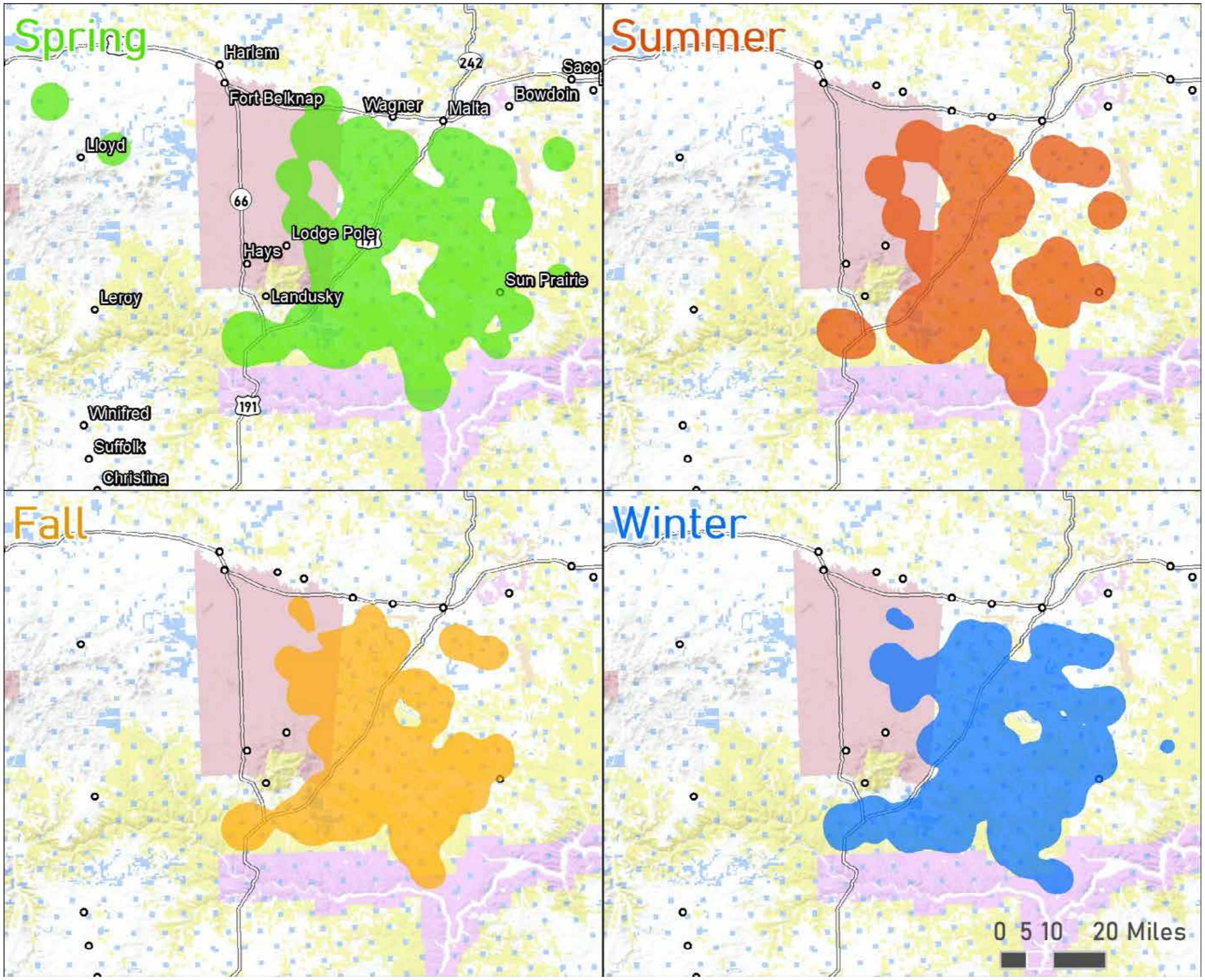


Figure 16. Seasonal ranges of collared adult female pronghorn in the South Philips area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

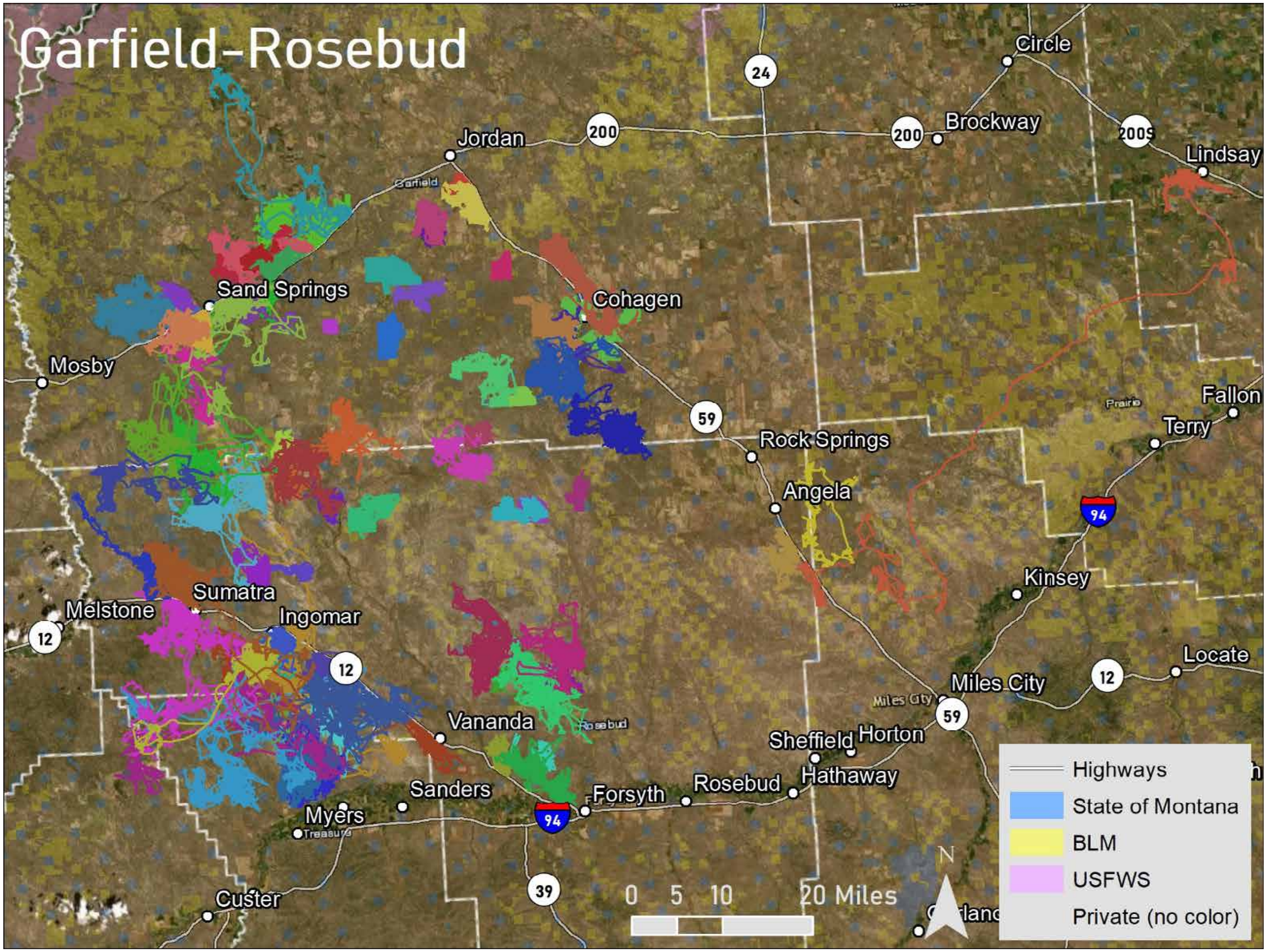


Figure 17. Movements of collared adult female pronghorn (colored by individual) in the Garfield-Rosebud study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

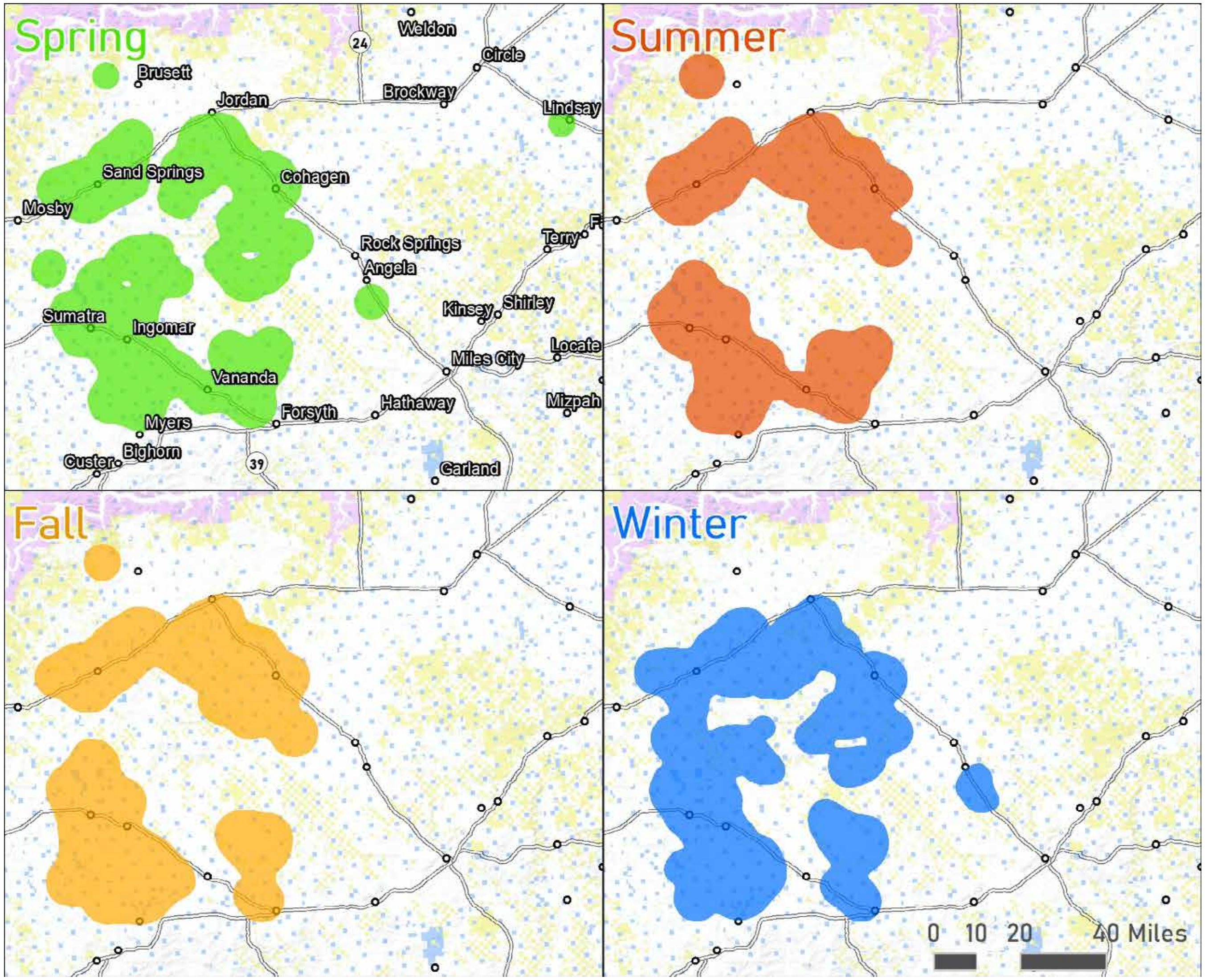


Figure 18. Seasonal ranges of collared adult female pronghorn in the Garfield-Rosebud area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

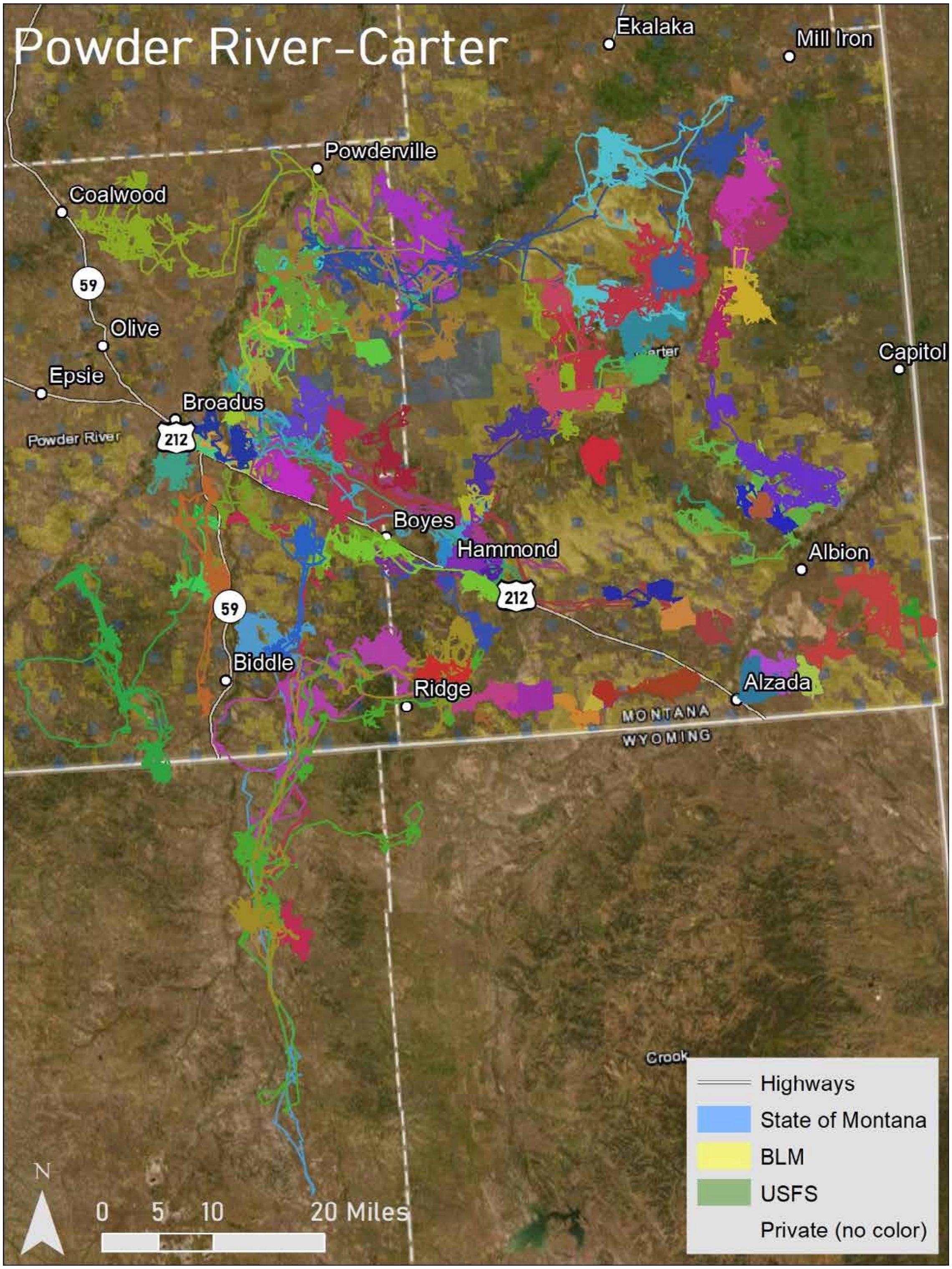


Figure 19. Movements of collared adult female pronghorn (colored by individual) in the Powder River-Carter study area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020.

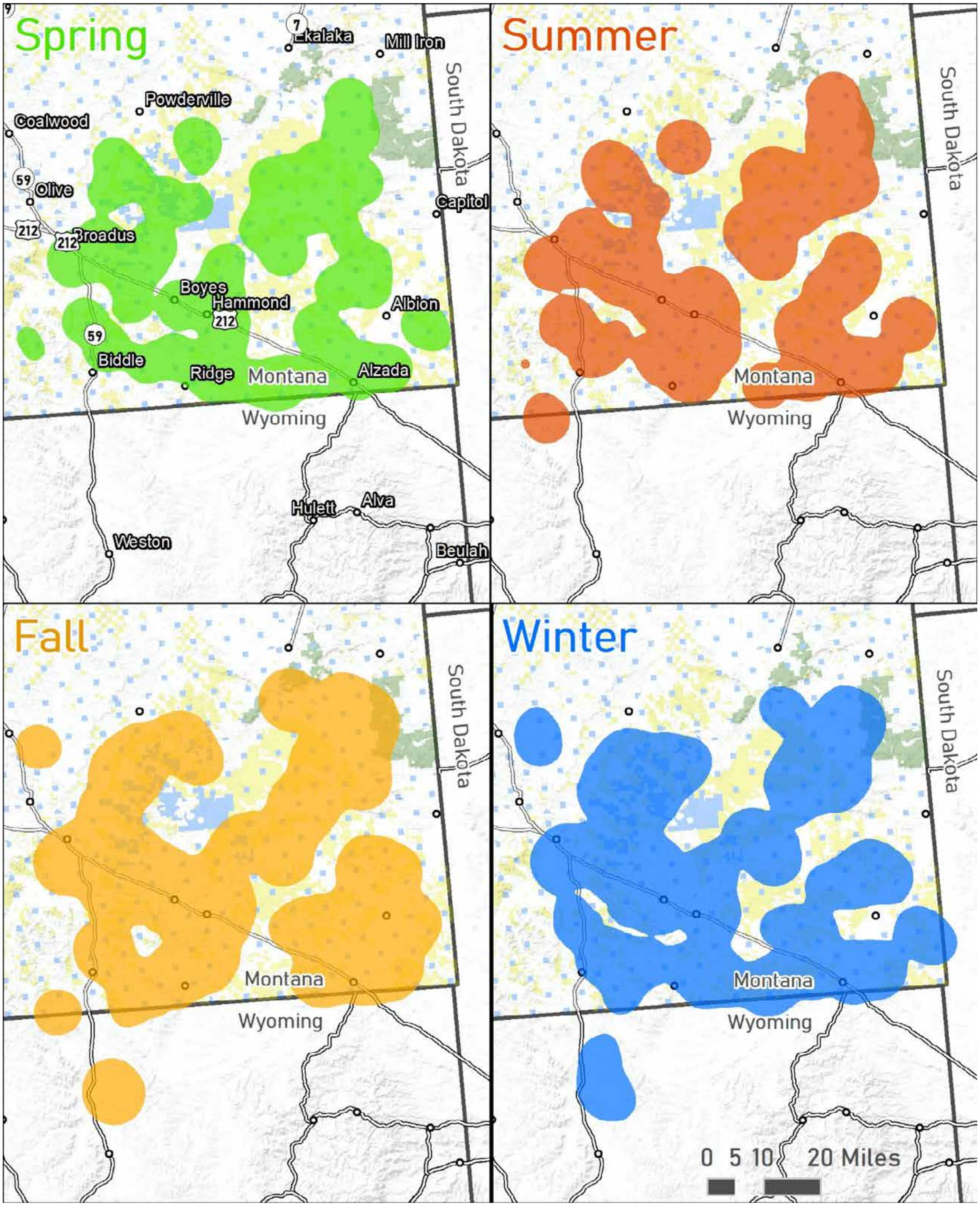
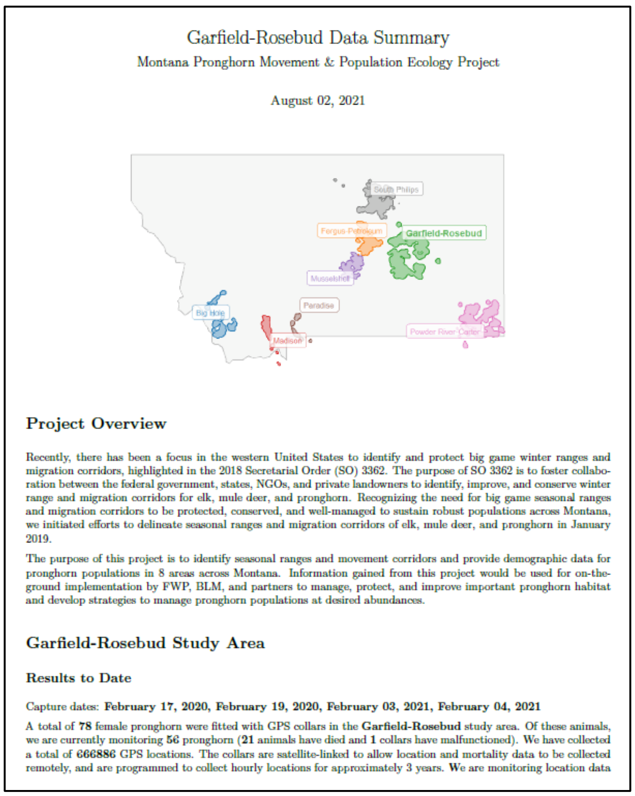


Figure 20. Seasonal ranges of collared adult female pronghorn in the Powder River-Carter area for the Montana Pronghorn Movement and Population Ecology Project, as of August 1, 2020. Spring: Apr 1 – Jun 30; Summer: Jul 1 – Aug 31; Fall: Sep 1 – Nov 30; Winter: Dec 1 – Mar 31.

Objective #2: Distribute maps of seasonal range and movement areas for pronghorn widely to conservation partners and landowners via a web-based platform

2.1 Generation and distribution of maps

Since the initiation of the location data collection, we have generated monthly summary reports of animal distributions and movements specific to each study area (Figure 21). These reports include population- and individual-level maps, with individual-level maps showing seasonal movements. On a monthly basis, we distribute these reports widely to state and federal agency biologists, non-profit conservation organizations, and private landowners. We generate these reports in lieu of a web-based platform, but do make location data available to FWP area biologists associated with each study area on the ArcGIS Online platform (see Objective #3). All animal movement data sharing associated with this project is aligned with FWP policy and directions for data sharing.



Garfield-Rosebud Data Summary

Montana Pronghorn Movement & Population Ecology Project

August 02, 2021

Project Overview

Recently, there has been a focus in the western United States to identify and protect big game winter ranges and migration corridors, highlighted in the 2018 Secretarial Order (SO) 3362. The purpose of SO 3362 is to foster collaboration between the federal government, states, NGOs, and private landowners to identify, improve, and conserve winter range and migration corridors for elk, mule deer, and pronghorn. Recognizing the need for big game seasonal ranges and migration corridors to be protected, conserved, and well-managed to sustain robust populations across Montana, we initiated efforts to delineate seasonal ranges and migration corridors of elk, mule deer, and pronghorn in January 2019.

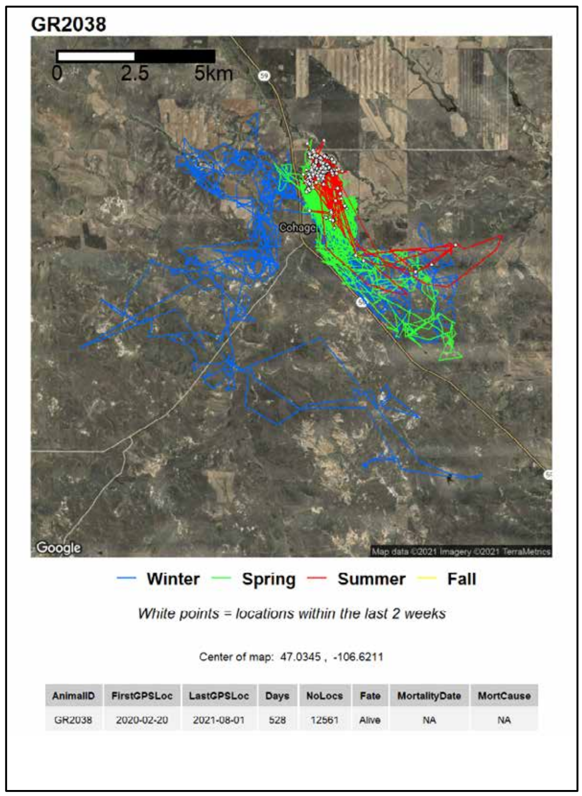
The purpose of this project is to identify seasonal ranges and movement corridors and provide demographic data for pronghorn populations in 8 areas across Montana. Information gained from this project would be used for on-the-ground implementation by FWP, BLM, and partners to manage, protect, and improve important pronghorn habitat and develop strategies to manage pronghorn populations at desired abundances.

Garfield-Rosebud Study Area

Results to Date

Capture dates: **February 17, 2020, February 19, 2020, February 03, 2021, February 04, 2021**

A total of **78** female pronghorn were fitted with GPS collars in the **Garfield-Rosebud** study area. Of these animals, we are currently monitoring **56** pronghorn (**21** animals have died and **1** collars have malfunctioned). We have collected a total of **666886** GPS locations. The collars are satellite-linked to allow location and mortality data to be collected remotely, and are programmed to collect hourly locations for approximately 3 years. We are monitoring location data



AnimalID	FirstGPSLoc	LastGPSLoc	Days	NoLocs	Fate	MortalityDate	MortCause
GR2038	2020-02-20	2021-08-01	528	12561	Alive	NA	NA

Figure 21. Examples pages from the Garfield-Rosebud monthly summary report generated for distribution to agency biologists and collaborators. Reports are updated and distributed monthly for each of the 8 study areas of the Montana Pronghorn Movement and Population Ecology Project.

Objective #3: Use seasonal range and movement data to identify potential barriers to movements, inform management decisions, and prioritize locations for habitat improvement projects

3.1 Identification of potential barriers to movements

The monthly reports summarizing pronghorn movement information (Section #2) have been used by area biologists to identify movement barriers and prioritize fence removal and modification projects for improving landscape permeability for pronghorn. Some projects have been completed or are scheduled for completion within the next year. To further facilitate the identification of potential barriers to pronghorn movements, we have developed an online platform based in ArcGIS Online that allows biologists to visualize pronghorn movements and record information on potential barriers (Figure 22).

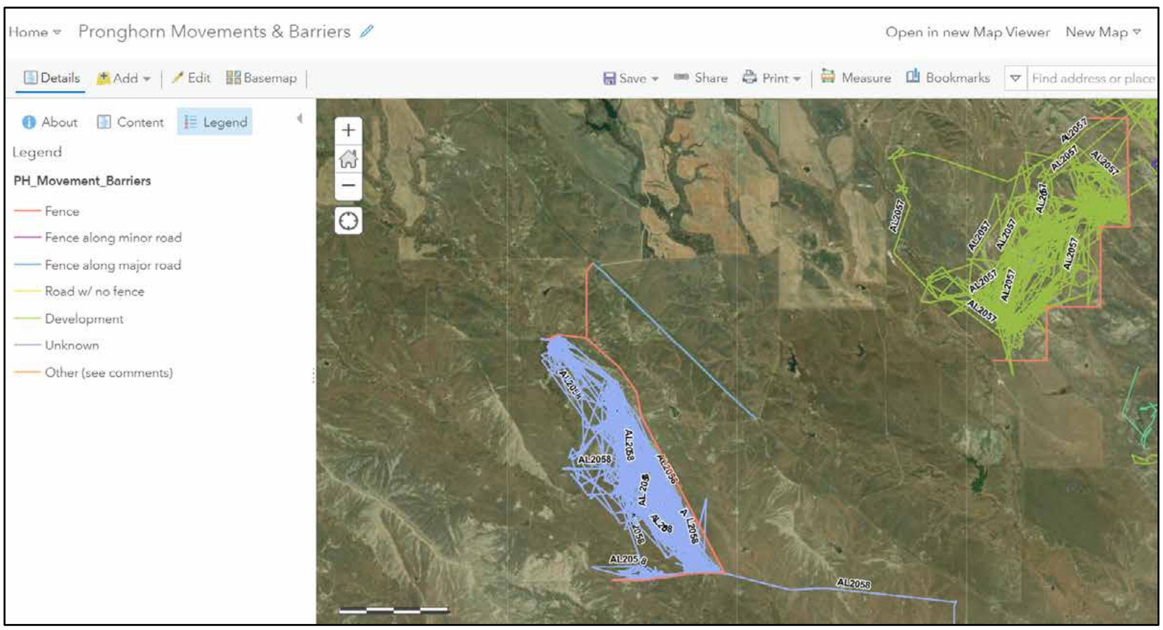


Figure 22. Example of potential movement barriers (orange and light blue lines) identified from adult female pronghorn collar location data (lines colored and labeled by individual) using the online platform on ArcGIS Online as part of the Montana Pronghorn Movement and Population Ecology Project.

In addition, fence mapping projects have been initiated in all study areas (Figure 23). In the Garfield-Rosebud, Power River-Carter, South Philips, Musselshell, and Fergus-Petroleum study areas, management biologists and technicians have mapped and collected information on fence characteristics (e.g., fence type, lowest wire height, highest wire height, etc.) for approximately 1,700 km of fences. In these study areas as well as all remaining study areas, technicians will continue to map the spatial position of all fences visible on high resolution imagery and within the annual ranges of each population using an ArcGIS Online platform. All spatial information and attributes of fences will be aggregated into a single GIS layer that will be used for mapping projects, movement barrier identification, and further evaluations of the influence of fences on pronghorn movements and behaviors.

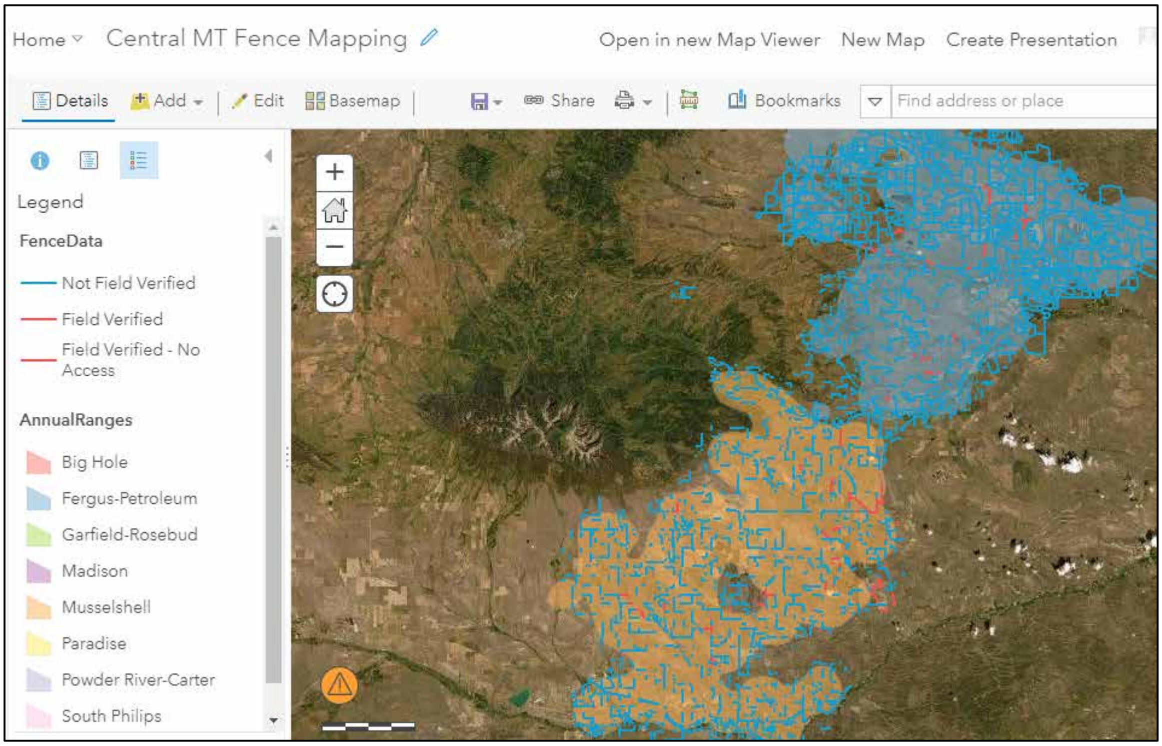


Figure 23. Example of fence spatial data recorded in the field within annual ranges of each population using the online platform on ArcGIS Online as part of the Montana Pronghorn Movement and Population Ecology Project. Red and blue lines represent mapped fences with and without fence characteristics measured in the field.

Using these fence data and the collar locations, we have begun developing methods to identify and quantify pronghorn behavioral responses to fences. These methods include the use of the Barrier Behavior Analysis (Xu et al. 2021) to categorize pronghorn responses to fences and the use of model-based analyses to estimate how different fence types, such as woven wire, barbed, or modified fences, and location attributes, such as terrain ruggedness or snow depth, influence pronghorn responses to fencing. Additional methodologies may be used to quantify pronghorn responses to fences, including estimating step lengths before and after the crossing, estimating movement rates in proximity to different fences, etc. Better understanding of how fence style and configurations affect pronghorn movements will inform wildlife-friendly fencing strategies and conservation efforts aimed at improving landscape permeability. After evaluating pronghorn responses to difference fence types, our goal will be to rank fences by occurrence/frequency of behavior types in order to identify the most "problematic" styles of fences that may impede animal movements. This will allow for prioritization of remediation efforts across the study areas. We are currently in the development stages of identifying and evaluating movement barriers and behavioral responses, and we will continue to work on this as additional movement and barrier data become available.

Objective #4: Develop a population model to identify important vital rates affecting population growth rates and describe important demographic differences between populations that are growing or stable, versus those that are limited in their population performance

Integrated population models (IPMs) can integrate known-fate survival from marked adults, recruitment and abundance data from count and classification surveys, and harvest data to provide estimates of vital rates and improve inferences into the underlying driers of variation of these vital rates (Kéry and Schaub 2011, Schaub and Abadi 2011). Management decisions can be improved by the use of IPMs in several ways that include: sensitivity and elasticity analyses for determining the vital rate most important in driving population abundance and targeting management actions specific to that vital rate (Johnson et al. 2010a, Eacker et al. 2017); retrospective analyses for estimating vital rates (Proffitt et al. 2021) and population abundances and assessing the factors influencing annual variability in vital rates (Paterson et al. 2021), and prospective analyses for projecting population abundances under different management scenarios under consideration (e.g., what harvest rates increase or decrease populations by how much and over what amount of time; Johnson et al. 2010b, Mitchell et al. 2018). Integrated population models, therefore, can be a powerful learning tool that may help resource managers to understand the mechanisms driving population performance and to adapt management strategies accordingly.

Our objective is to develop a pronghorn IPM based on abundance and production estimates from survival data from collared females, surveys, and harvest data collected for each study population. We will use this model to 1) identify important vital rates affecting population growth rate, 2) contrast important vital rates between populations that are considered productive vs. limited in performance, and 3) develop hypotheses to explain why some pronghorn populations experience limitations on population growth rate. The population model will provide information towards developing more focused investigations into ecological and/or anthropogenic factors limiting pronghorn population recovery in central Montana and future population monitoring strategies.

We have begun considering several questions and factors affecting model development including how to formulate the reproductive process, the number of age classes to use, whether to use population reconstruction methods as a secondary source of abundance information, how count data should be treated (i.e., as abundance estimates or minimum counts), whether harvest mortality should be expressed as an additive form of mortality, how data should be organized spatially, and, if aggregation is desirable, how units should be aggregated, and how priors should be created. We are currently compiling priors. These important considerations will be fully addressed by fall 2021 when model formulation will occur. After working through these questions related to IPM development in fall 2021, we envision rapid iteration and routine meetings to facilitate communication and ensure the project is progressing in a timely manner. The IPM will be developed and applied in the next reporting period.

Objective #5: Evaluate the effect of vegetation and other landscape features on resource selection and movement of migratory and non-migratory pronghorn

5.1 Pronghorn resource selection and vegetation data collection

Pronghorn resource selection is important for the management of the species and their associated habitat. The growing season, ranging from mid-March through July, is an important period for pronghorn as it encompasses the biological period of late gestation and early lactation, which is energetically expensive and important for annual reproductive output. The primary objectives of this portion of the project are to determine what resources pronghorn select for seasonally, as well as the distribution of those resources and other important landscape features across the study areas. By evaluating vegetative resources and other landscape features that influence pronghorn resource selection and movement, we can better understand how pronghorn move through and use the surrounding environment.

From mid-March through the end of July 2021, we collected fine-scale vegetation data in the Musselshell, Fergus-Petroleum, and South Philips study areas. Vegetation data were collected at known locations of collared pronghorn as well as at randomly assigned available locations throughout the study areas. At each location a variety of attributes were recorded, including species-specific % cover, species-specific phenology, biomass of shrubs/forbs/grasses, and shrub/herbaceous plant height. At each location, we collected forage samples consisting of the earliest two available phenological stages. These samples will be sent to the lab and analyzed to determine forage quality, measured as digestible energy. In addition to vegetation samples, we collected fecal samples at known pronghorn locations and/or opportunistically. These samples will be sent to the lab and will allow us to determine what plant species pronghorn are eating throughout the growing season.

As of June 30, 2021, we sampled vegetation at 238 locations, including 117 available locations and 121 used locations. The 117 available locations were spread in proportion to available landcover type within the annual range (Figure 25 and 26). At these sites, we identified nearly 200 different plant species. The most common species were Artemisia species (n = 317), common dandelion (*Taraxacum officinale*, n = 234), Western wheat grass (*Pascopyrum smithii*, n = 173), prairie Junegrass (*Koeleria macrantha*, n = 162), and common yarrow (*Achillea millefolium*, n = 80). To evaluate pronghorn diets, we collected 35 fecal samples from across the three study areas, which is on track with our 2021 field season goals. Sampling efforts will continue through the end of July for this year's field season. For the 2022 field season, we hope to accomplish vegetation sampling at approximately 300 locations and collect an additional 45 fecal samples from mid-May through July. With the two years of data collection, we should have sufficient sample sizes for statistical analysis of our results.

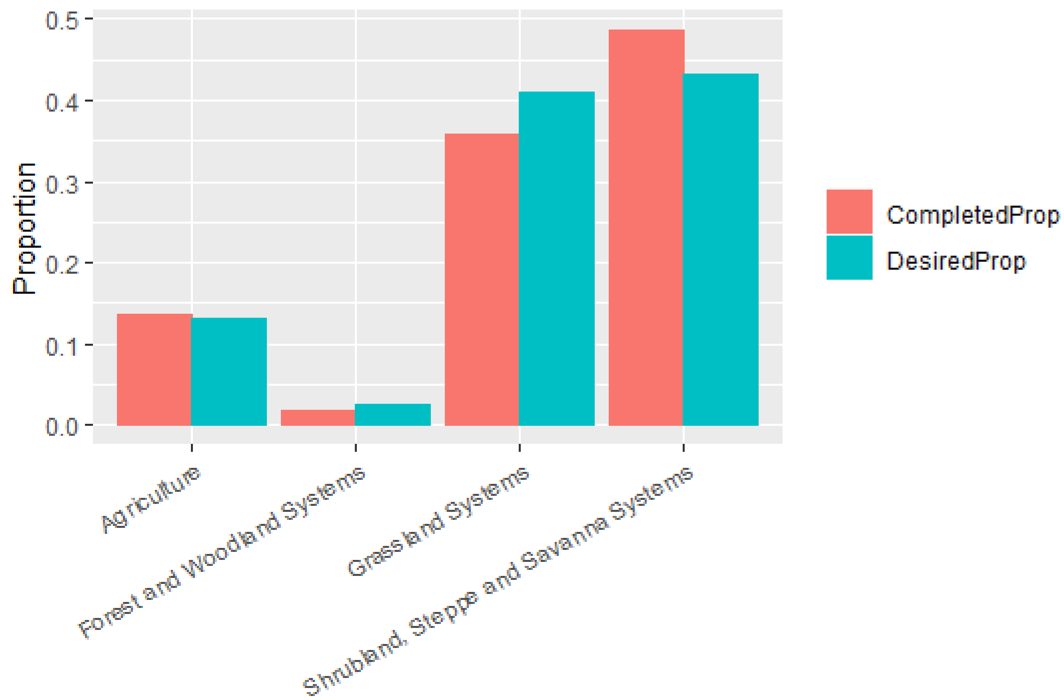


Figure 25. Proportion of available locations completed and desired (i.e., the objective proportion) in each landcover type in the Musselshell, Fergus-Petroleum, and South Philips study areas.

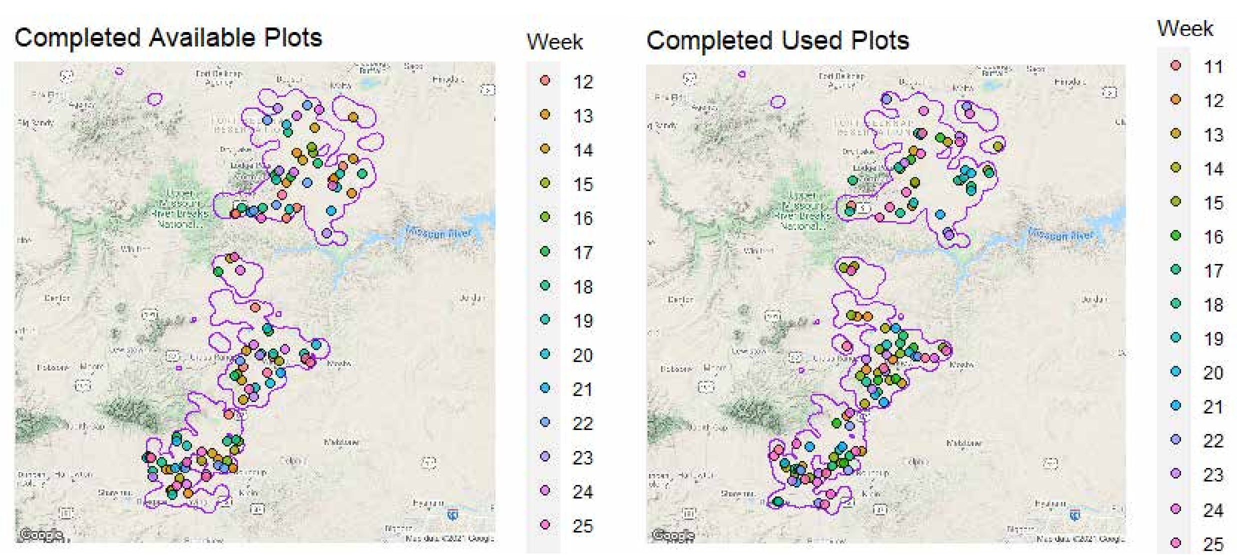


Figure 26. Map of available (left) and used (right) vegetation sampling locations completed in the Musselshell, Fergus-Petroleum, and South Philips study areas, grouped by week of the year.

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