Ungulate Migrations of the Western United States, Volume 6

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Acknowledgments

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Figures

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations

>	greater than
BBMM	Brownian bridge movement model
BLM	Bureau of Land Management
BMV	Brownian motion variance
CDOT	Colorado Department of Transportation
CMT	Corridor Mapping Team
CPW	Colorado Parks and Wildlife
CWD	chronic wasting disease
DAU	Data Analysis Unit
FS	U.S. Department of Agriculture Forest Service
GPS	global positioning system
NDOW	Nevada Department of Wildlife
NSD	Net Squared Displacement
ssp.	subspecies
UD	utilization distribution
UDWR	Utah Division of Wildlife Resources
USGS	U.S. Geological Survey
WGFD	Wyoming Game and Fish Department
WMU	Wildlife Management Unit
WVC	wildlife-vehicle collision

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Abstract

This report, volume 6 in the "Ungulate Migrations of the Western United States" report series, showcases the migrations of 23 ungulate herds in the Western United States. The report series is produced by the Corridor Mapping Team (CMT). Led by the U.S. Geological Survey, the CMT is a collaboration among 11 State agencies, as well as regional and Federal partners, and an expanding number of Tribal wildlife agencies. The CMT was initiated in response to the U.S. Department of the Interior Secretarial Order 3362, which was signed in 2018 and provided Federal support to expand existing research efforts to study ungulate populations and conserve their migrations throughout the Western United States. Including this volume, the report series has detailed the migrations of 237 unique ungulate herds throughout the Western United States and continues to serve as a valuable resource to guide local and regional management, policy, and on-the-ground work necessary to maintain intact and functional ungulate migrations. This report highlights several guiding principles of the CMT that facilitate collaboration among the diverse set of partners and contribute to the program's continued successes. Notably, raw global positioning system data are not shared among participating agencies and the U.S. Geological Survey, delineating migration corridors and seasonal ranges relies on empirical data, the CMT provides flexible approaches to participating State and Tribal partners, and regular CMT meetings create a framework for open communication among agency partners that supports transboundary mapping of migrations. The 237 ungulate migrations that have been included in the report series are an expanding inventory, which can help maintain ungulate migrations in perpetuity.

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[10]Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Department of Fisheries, Wildlife, and Conservation Sciences.

[11]Utah Division of Wildlife Resources.

[12]Navajo Nation Department of Fish and Wildlife.

[13]Wyoming Migration Initiative.

[14]Western Wildlife Research Collective, LLC.

[15]California Department of Fish and Wildlife.

[16]Wyoming Game and Fish Department.

[17]Native American Fish and Wildlife Society.

[18]U.S. Fish and Wildlife Service.

[19]Southern Ute Indian Tribe, Wildlife Resource Management Division.

[20]Shoshone & Arapaho Tribes Fish & Game.

[21]Nevada Department of Wildlife.

[22]Colorado State University, Cooperative Institute for Research in the Atmosphere and Graduate Degree Program in Ecology.

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[24]Western EcoSystems Technology, Inc.

[25]Oregon Department of Fish and Wildlife.

Introduction

Migration is a common strategy for many taxa, where animals move seasonally between distinct ranges to track spatially and temporally variable resources and conditions or avoid predation and other threats (Fryxell and Sinclair, 1988). Globally, the connectedness of animal migration is being affected by roads, fences, and other types of human development, which impede and threaten the long-term persistence of ungulate (hooved mammal) populations that rely on seasonal migrations (Kauffman and others, 2021). Recognizing the importance of migrations to sustain ungulate populations and the increasing number of threats that negatively impact migratory routes, the Secretary of the Interior signed Secretarial Order 3362 in 2018 (U.S. Department of the Interior, 2018). Secretarial Order 3362 called on the U.S. Geological Survey (USGS) to work with State wildlife management agencies to develop maps and mapping tools related to ungulate migrations and seasonal ranges. In support of this directive, the USGS created the Corridor Mapping Team (CMT), which is a partnership among State agencies, regional and Federal partners, and an expanding number of Tribal nations that work collaboratively to implement a unified mapping approach for ungulate migrations throughout the Western United States.

Led by the USGS, the CMT produces the USGS "Ungulate Migrations of the Western United States" report series, which is published annually (Kauffman and others, 2020a, 2022a, c, 2024a, 2025a). This report, volume 6 in the series, includes migrations and seasonal ranges from 23 herds, of which 19 herds are new to the report series and 4 herds are updates from previous volumes (Kauffman and others, 2022a, c, 2025a). In total, the report series has detailed the migrations of 237 unique ungulate herds throughout the Western United States and continues to serve as a valuable resource to guide local and regional management, policy, and conservation regarding ungulate migrations. Many of the maps within the report series and the associated map layers are available from Kauffman and others (2020b, 2022b, d, 2024b, 2025b).

The successes of the CMT build on several principles that help to maintain productivity and facilitate collaboration among a diverse set of partners. Since the 1970s, when the Craighead brothers first collared a single female *Cervus canadensis* (elk) within Yellowstone National Park (Craighead and others, 1972), tracking wildlife has been a hallmark of effective wildlife management. Especially for ungulate populations, animal tracking can identify critical seasonal habitats and key migratory or dispersal movements (Tomkiewicz and others, 2010). Although expensive and logistically challenging to deploy, global positioning system (GPS) collars can help managers fundamentally understand the habitat needs of wildlife. Given the long history of State, Tribal, and Federal agencies deploying GPS collars, the agencies are most often the curators of existing

tracking datasets and have a wealth of natural history information from their on-the-ground observations of animal movements and behavior.

Wildlife movement data are commonly collected as part of research and management projects, although numerous constraints, such as data sharing policies, can hinder the sharing of data among agencies or universities. Consequently, to encourage collaborations among agency partners, a key component of the CMT is that GPS data stay with the data provider, typically State or Tribal wildlife management agencies. Rather than providing GPS location data to the USGS, the spatial analyses that produce corridors and seasonal ranges are conducted by the respective data owners who provide the derived mapping layers of migration lines or polygons, or seasonal range polygons, that are included in the report series. This workflow helps to recognize the State and Tribal agencies as the primary data contributors and facilitates collaboration through exchanging derived products rather than GPS location. Additionally, because the data owners are leading the analysis, this process also helps to ensure that the final products best represent agency priorities and protocols with respect to mapping ungulate migrations.

The CMT relies on empirical GPS data collected from collared individuals. In contrast to more general connectivity models that are based on simulation or movement metrics (Dickson and others, 2019), the Brownian bridge movement model (BBMM; Horne and others, 2007), Fixed Motion Variance (McKee and others, 2024) or more recent line buffer (Merkle and others, 2023) modeling approaches do not extrapolate a corridor model beyond the movement paths collected from collared individuals and always represent the underlying GPS data. This approach is different from connectivity models (Keeley and others, 2021) that model how habitat patches are connected across large landscapes. Although there are many varieties of connectivity models, many are "species agnostic," meaning that the habitat connections they quantify are not specific to a particular species, but instead are driven by general animal movement capacities. The approaches used by the CMT are built on the assumption that the collared animals reveal the migration routes that they use to move between seasonal ranges. Moreover, the GPS data provide additional information on other migration metrics, such as timing, duration, and migration distance. The use of GPS-collared animal movements is a widely accepted method to map ungulate migrations and provides an intuitive approach to identify areas to prioritize for conservation (Middleton and others, 2020).

Since its inception in 2018, the CMT has maintained a community of practice focused on supporting State, Federal, and Tribal partners by providing analytical tools for curating and analyzing data and flexible approaches for improving agency engagement and collaboration with the CMT. Each participating agency has different policies that guide their mapping efforts; therefore, the tools developed by the CMT

provide multiple analytical options within a standardized framework to support State and Tribal agencies in meeting their goals for mapping ungulate migrations. For example, the Migration Mapper application was developed through the CMT and has become a standard and widely used tool to curate and analyze GPS data when mapping migrations (Merkle and others, 2022). Within the application, users can clean and view GPS data and identify migration start and end dates using established methods, such as Net Squared Displacement (NSD; Bunnefeld and others, 2011). Migration Mapper also generates population-level migration corridors and seasonal ranges using user-selected methods, such as the BBMM and related variants (Horne and others, 2007; McKee and others, 2024), continuous-time movement models (Calabrese and others, 2016), and the line buffer approach (Merkle and others, 2023). The different analytical methods available in Migration Mapper allow wildlife managers to account for species differences in migration patterns, sample size differences among herds, and State or Tribal policies when designing individual herd maps. The "Herd Summaries" section in the report series includes maps of low, medium, and high use corridor polygons; singular corridor footprints; line features representing individual migration routes; and year-round ranges showing annual distributions (fig. 1). Wintering areas are also included in the maps for many herds because of the importance of winter ranges to ungulates. The multiple analytical methods and tools provided by the CMT offer State and Tribal partners flexibility to adhere to their local policies and procedures.

Many agency partners choose to make the migration and seasonal range products (for example, lines of migration routes or polygons of migration corridors and seasonal ranges) available to the public, although it is not a prerequisite for participating in the CMT or the "Ungulate Migrations of the Western United States" report series. Lines of migration routes or polygons of migration corridors and seasonal ranges are made publicly available by the respective State or Tribal agency upon request. GPS locations are not made publicly available through agency involvement in the report series. Sometimes, participating States have State-led repositories where the migration and seasonal range products are publicly available. A rigid approach in requiring a singular analytical method or necessary data sharing would ultimately limit our ability to map ungulate migrations.

The CMT's highly collaborative approach and regular meetings help further foster a community of practice and maintain an open dialog among the many partners. Regular communication has helped facilitate transboundary mapping of ungulate migrations. For example, volume 5 (Kauffman and others, 2025a) of the report series included three elk herds with winter ranges in Idaho and summer ranges to the south in Nevada. The Nevada Department of Wildlife (NDOW) and Idaho Department of Fish and Game had collected separate datasets by collaring elk in their respective States. In part,

through the interstate communication of the CMT, the two State agencies combined their datasets and generated corridors for the three elk herds that spanned the Idaho and Nevada border (fig. 2; Kauffman and others, 2025a). Similarly, this report details the migrations of three *Antilocapra americana* (pronghorn) herds using the tristate border area of Oregon, Nevada, and California, that were jointly mapped with a combined dataset (refer to the "Sheldon-Hart Mountain Pronghorn," "Central Washoe Pronghorn," and "Surprise Valley Pronghorn" sections of this report). Many other herds in this report also show transboundary movements. Before the creation of the CMT, the few ungulate migration maps that existed often stopped at State or Tribal boundaries. However, migratory animals do not recognize jurisdictional boundaries, so maps using combined datasets can help identify and advance the management of the connected habitats upon which comanaged herds rely.

Migration was likely more common before the American West was settled, although the historical record is sparse. Early records of trappers and hunters suggest ungulate herds were abundant and migratory (Whittlesey and others, 2017), and archeological data provide evidence of early humans hunting and ambushing ungulates along their migration routes. For example, an archeological site along the Path of the Pronghorn in Wyoming revealed a pronghorn "kill site" that included clear signs of butchering (Miller and others, 1999). The site also included the bones of fetal pronghorn, which indicated that animals were killed in the spring, most likely during migration. Carbon dating places those pronghorn along the modern-day migration corridor 5,000–8,000 years ago (Miller and others, 1999). State, Federal, and Tribal collaborators have made great progress toward a complete map of the migratory herds that currently (2025) exist in the Western United States. However, there is still a poor understanding of migrations that may have been lost because of human settlement and development before the broad use of tracking technology. Additionally, some of today's (2025) migrations may look different from the seasonal movement patterns presettlement because of population bottlenecks, reintroductions, and human-avoidance behavior that are common to many wildlife species. Nevertheless, the 237 ungulate migrations in the report series are the beginning of a broader inventory of all migrations that exist across the Western United States. Although incomplete, the published maps are useful for guiding on-the-ground conservation efforts necessary to maintain intact and functional migrations. Compiling a more robust inventory of western migrations could be aided by tracking additional animals on the landscapes where ungulate migrations are expected, but where tracking data are currently (2025) lacking. Analyses of additional animals may inform where new tracking projects could best contribute to existing knowledge gaps.
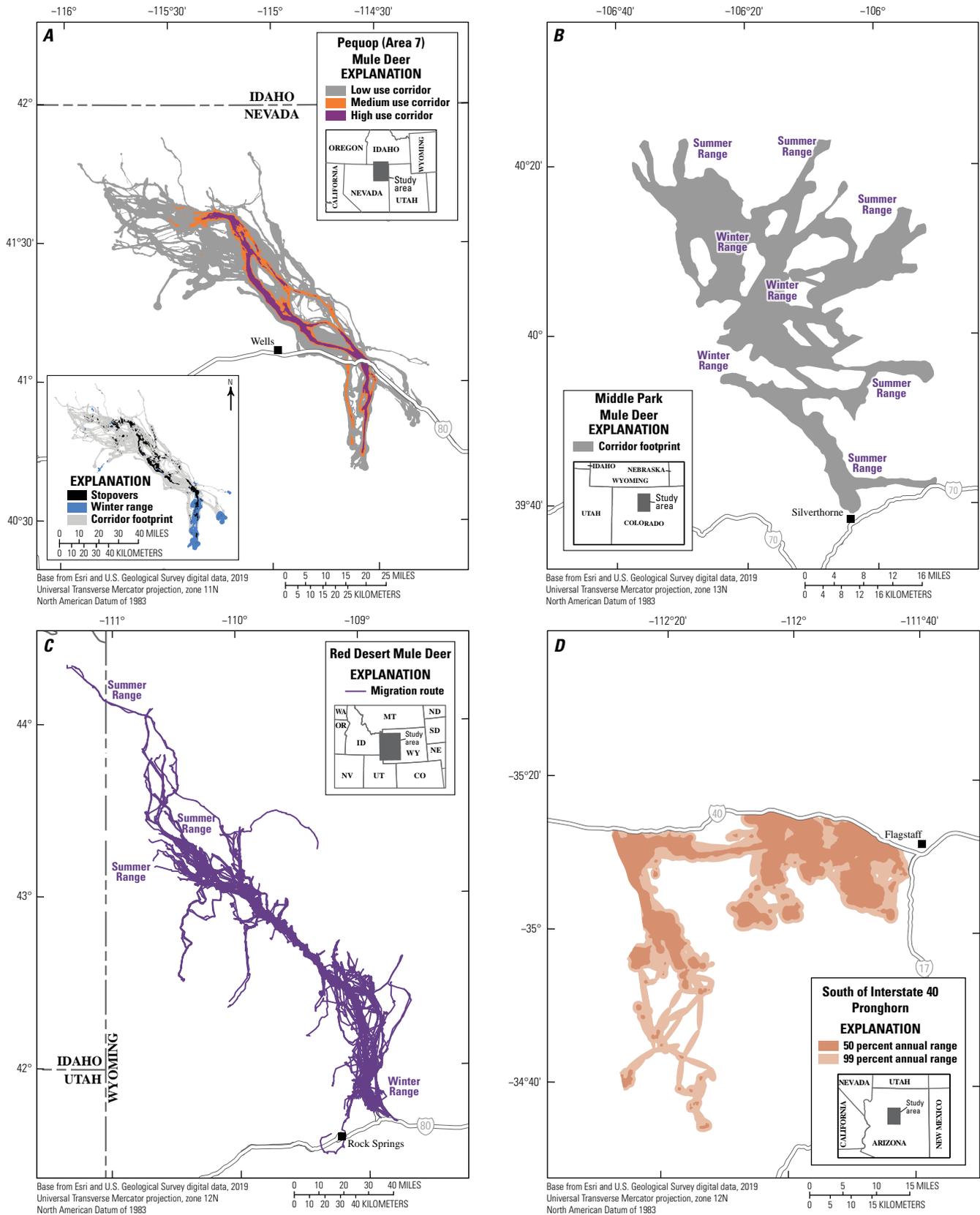
Figure 1.   Example maps showing the flexibility in mapping approaches used by partners contributing to the "Ungulate Migrations of the Western United States" report series (modified from Kauffman and others, 2020a, 2022a, c, 2024a, 2025a). Maps of *A*, low, medium, and high use corridors; *B*, singular corridor footprints; *C*, line features representing individual migration routes; and *D*, year-round ranges showing annual ranges (distributions) have all been used to highlight important areas used by migrating ungulates.
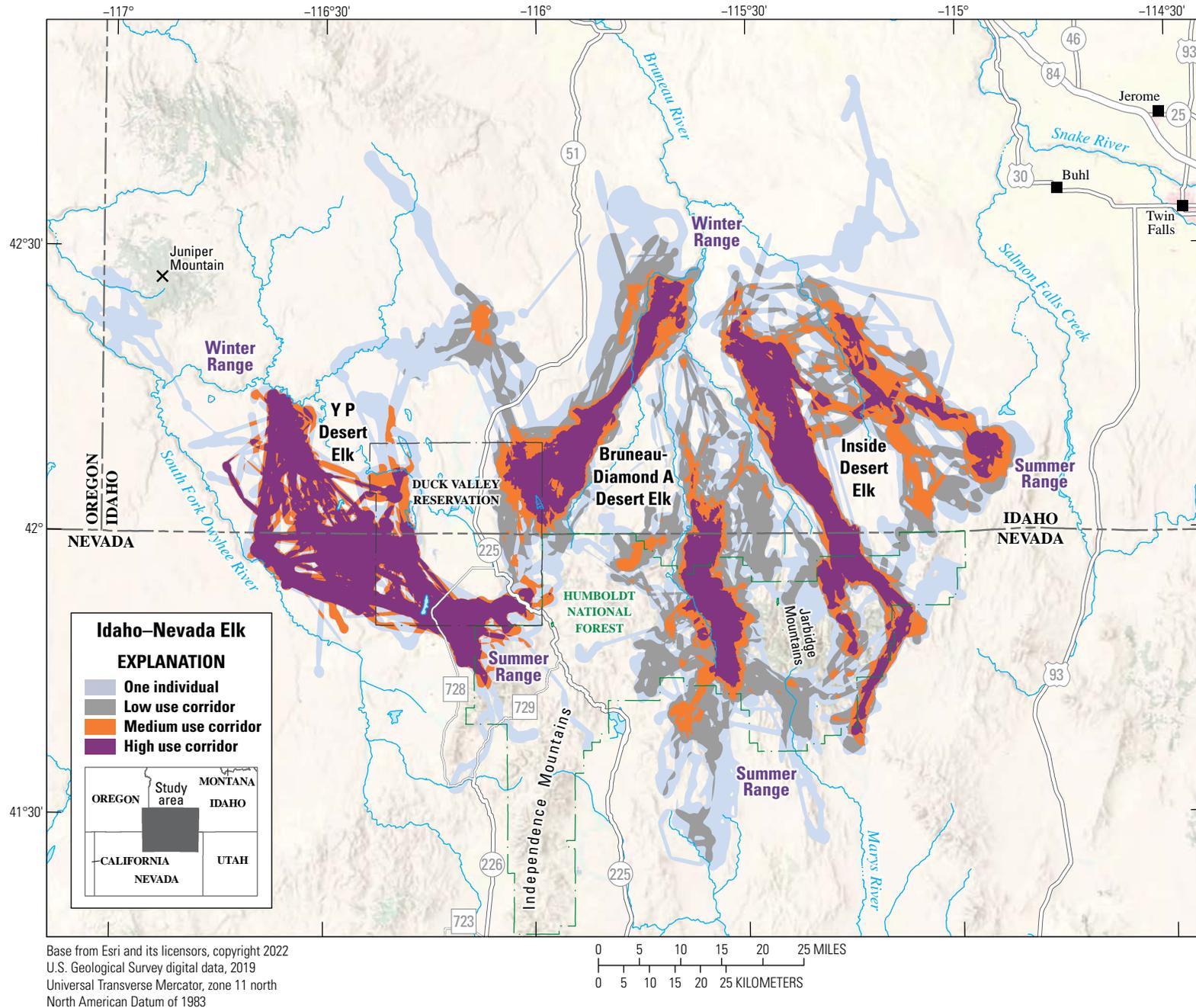
Figure 2. The Y P Desert, Bruneau-Diamond A Desert, and Inside Desert elk herds were jointly mapped by Idaho Department of Fish and Game and Nevada Department of Wildlife and included in volume 5 of the "Ungulate Migrations of the Western United States" report series (modified from Kauffman and others, 2025a). The elk winter in southern Idaho and migrate south in the spring to northern Nevada, where they summer.

Herd Summaries

The herd-specific maps and associated summary text make up the core content of the USGS "Ungulate Migrations of the Western United States" report series. This section includes maps documenting the migrations and seasonal ranges for 23 *Odocoileus hemionus* (mule deer), elk, and pronghorn herds from most Western United States and select Tribal lands. The maps in this report were produced in close collaboration with participating State or Tribal agencies that collected and analyzed the GPS-collar data to delineate the migration corridors and seasonal ranges. The specific methods, space-use classifications (for example low, medium, or high use corridors), and data layers (for example, migration routes shown as lines and migration corridors, stopovers, winter ranges, or annual ranges shown as polygons) vary across herds in the report to adhere to agency-specific policies and procedures.

In addition to the herd maps, this section includes project and analytical details, summary statistics for the underlying data, and relevant contacts and reports for each herd. The general workflow for each herd's data analysis consisted of the following steps: (1) selecting migration dates for each animal year using the Migration Mapper application (Merkle and others, 2022; app. 1), (2) using a BBMM to estimate a utilization distribution (UD) for each migration sequence (Horne and others, 2007; app. 1), (3) averaging the UDs for a given individual's migration sequences for all years, and (4) stacking the averaged individual UDs for a given herd and defining different levels of migration-corridor use on the basis of the number of individuals using a given pixel or defined area of space. In general, we define "low use" as areas traversed by at least 1 collared individual during migration, "medium use" as areas used by 10–20 percent of collared individuals in the herd, and "high use" as areas used by greater than (>) 20 percent of collared individuals in the herd. Complete descriptions of the methods and herd-specific modifications are included in appendix 1. The data layers for many of the herd maps in this report are also publicly available in the associated USGS data release (Kauffman and others, 2026).

Photograph from Patrick Rodgers, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming.
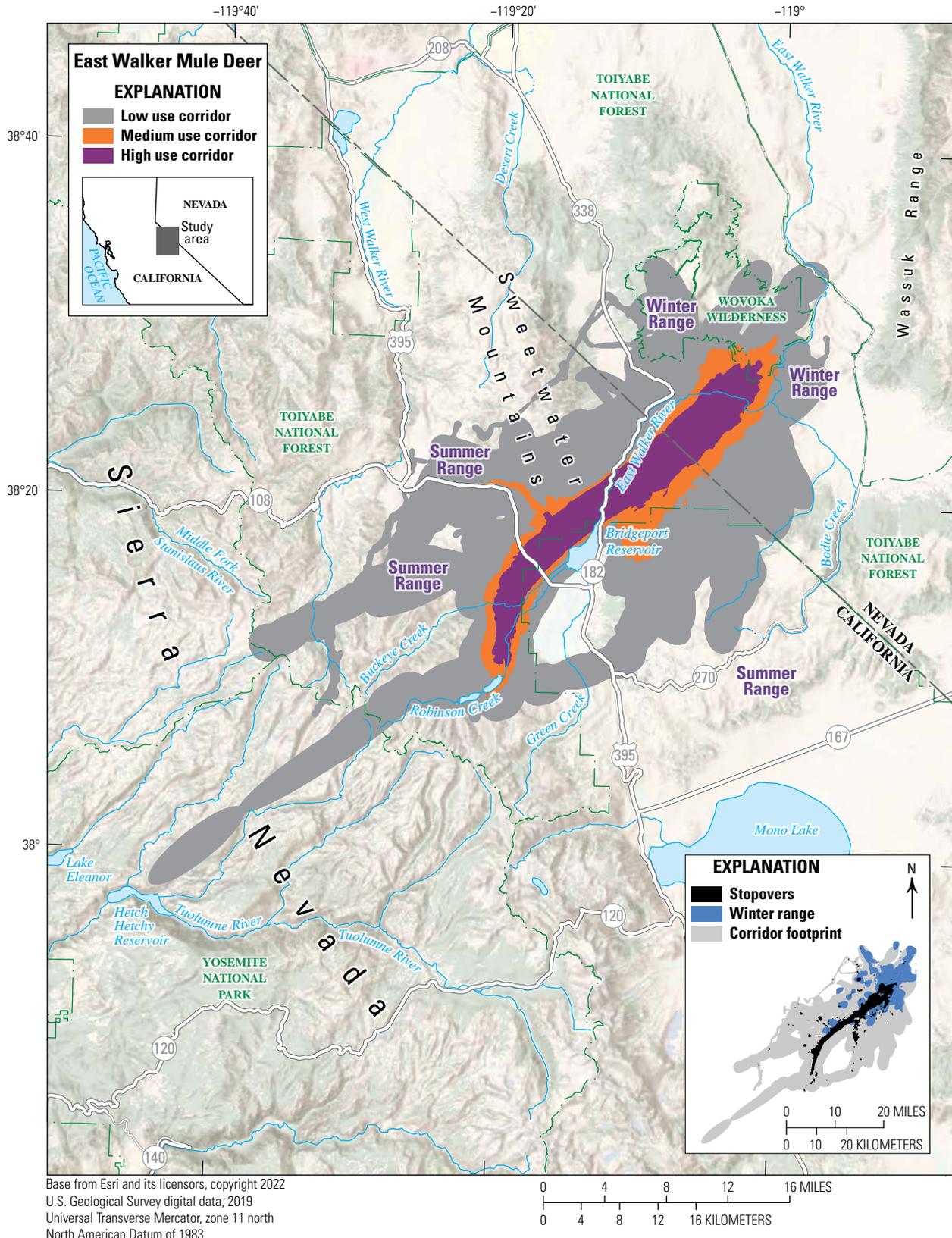
Figure 3.   Map showing migration corridors, stopovers, and winter ranges of the East Walker mule deer herd.

California | Mule Deer

East Walker Mule Deer

East Walker mule deer are mostly traditional migrants that migrate between distinct seasonal ranges in central California near the Nevada border. Their winter range comprises *Pinus* spp. (pinyon)-*Juniperus* spp. (juniper) and spans Wovoka Wilderness in Nevada and an area east of State Route 338 in Nevada and State Route 182 in California. In 2019, the herd contained 1,279 mule deer (Tom Stephenson, California Department of Fish and Wildlife, written commun., 2025). In the spring, individuals move west into California using several corridors; however, a concentrated migration corridor parallels the East Walker River, crossing State Route 182 and into the Sweetwater Mountains to the north of Bridgeport Reservoir, ending in the Sierra Nevada (fig. 3). Most deer do not cross into Yosemite National Park, instead summering in the Toiyabe National Forest (part of the Humboldt-Toiyabe National Forest) or Bureau of Land Management (BLM) lands. Migration corridors varied from short (3.96 miles [mi]; 6.38 kilometers [km]) to long (41.54 mi [66.85 km]) distances and migration start dates were variable within and among years.

Animal Capture and Data Collection

Sample size: 125 adult female mule deer
Relocation frequency: Approximately 1−24 hours
Project duration: 2017–present (data through August 2024 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Fixed Motion Variance (McKee and others, 2024; app. 1)
Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 267 sequences from 91 individuals (177 spring sequences, 90 fall sequences)
- Winter: 190 sequences from 94 individuals

Migration use classifications:
- Low: Used by at least one individual
- Medium: Used by 10–20 percent of the individuals
- High: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 22 to May 5
- Fall: November 8 to November 16

Number of days migrating (mean):
- Spring: 13 days
- Fall: 9 days

Migration corridor length:
- Minimum: 3.96 mi (6.37 km)
- Mean: 18.24 mi (29.35 km)
- Maximum: 41.54 mi (66.71 km)

Migration corridor area:
- Low use: 353,640 acres (143,113 hectares [ha])
- Medium use: 69,179 acres (27,996 ha)
- High use: 39,310 acres (15,908 ha)

Stopover area: 32,782 acres (13,266 ha)

Winter Range Summary

Winter start and end dates (median):
- March 23 to April 23
- Winter length (mean): 68 days
- Winter range (50 percent contour) area: 72,467 acres (29,326 ha)

Other Information

Project contacts:
- Tom Stephenson (tom.stephenson@wildlife.ca.gov), Senior Environmental Scientist, California Department of Fish and Wildlife

Data analyst:
- Evan Greenspan, Project Manager—Ecological Modeler, California Department of Fish and Wildlife

Photograph from Tom Stephenson, California Department of Fish and Wildlife.
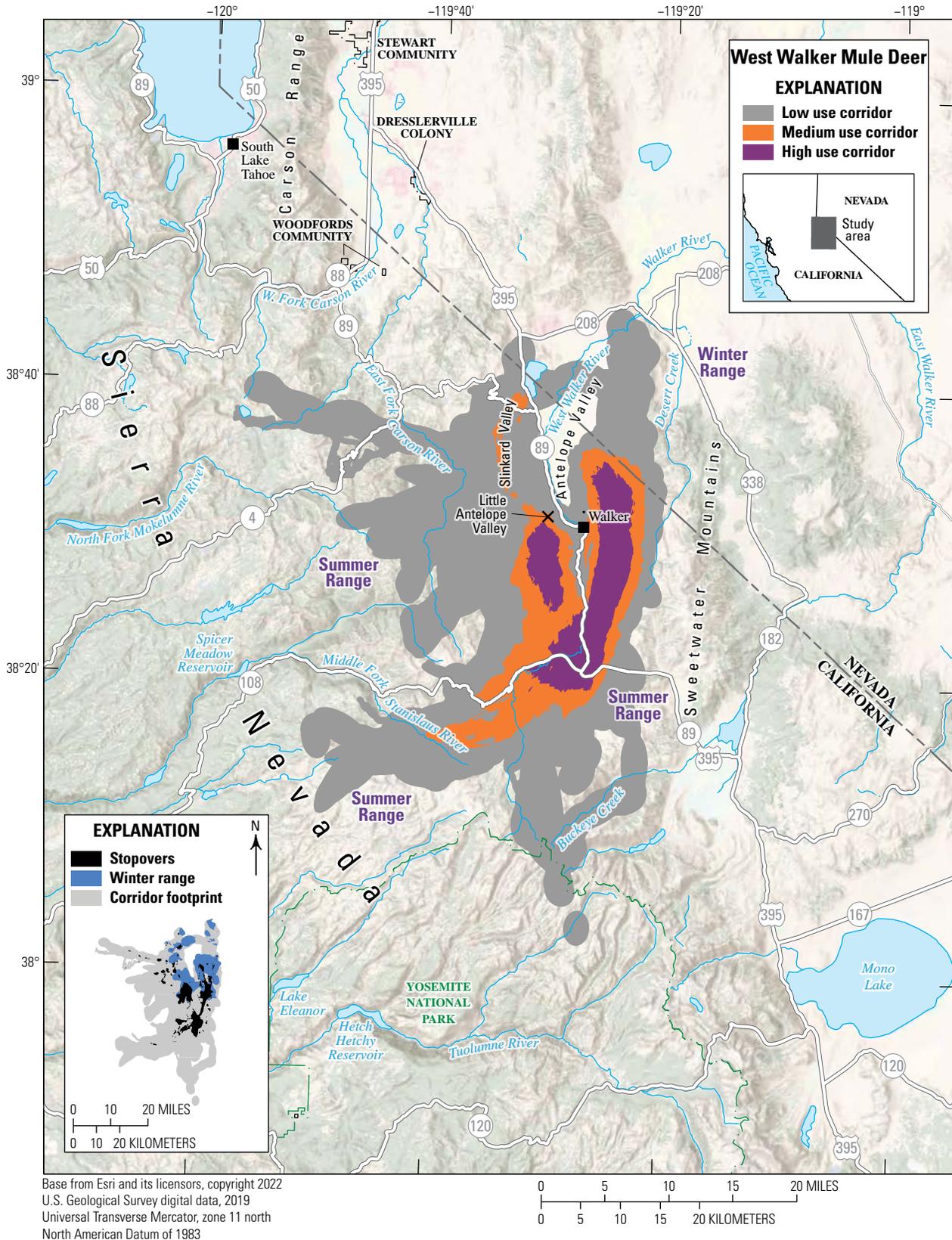
Figure 4.   Map showing migration corridors, stopovers, and winter ranges of the West Walker mule deer herd.

California | Mule Deer

West Walker Mule Deer

West Walker mule deer are mostly traditional migrants in east-central California, near the Nevada border. Their winter range spans Antelope Valley in California and Nevada and stretches across State Route 395 into Slinkard Valley and Little Antelope Valley near Walker, California. In 2019, the herd contained an estimated 3,589 mule deer (Tom Stephenson, California Department of Fish and Wildlife, written commun., 2025). In the spring, individuals move south and west into higher elevations in California using several corridors; however, a concentrated migration corridor parallels the West Walker River, straddling State Routes 395 and 108 to the west of the Sweetwater Mountains and ending in the Sierra Nevada (fig. 4). Most deer do not cross into Yosemite National Park, instead summering in montane forests of Stanislaus and Toiyabe National Forests (part of the Humboldt-Toiyabe National Forest). Some mule deer are multirange migrants, moving among two or more distinct ranges in a single season.

Animal Capture and Data Collection

Sample size: 171 adult female mule deer
Relocation frequency: Approximately 1−24 hours
Project duration: 2017–present (data through August 2024 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:
- Migration: 392 sequences from 119 individuals (230 spring sequences, 162 fall sequences)
- Winter: 328 sequences from 126 individuals

Migration use classifications:
- Low: Used by at least one individual
- Medium: Used by 10–20 percent of the individuals
- High: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 28 to May 23
- Fall: October 21 to October 29

Number of days migrating (mean):
- Spring: 22 days
- Fall: 10 days

Migration corridor length:
- Minimum: 2.06 mi (3.32 km)
- Mean: 17.34 mi (27.91 km)
- Maximum: 41.52 mi (66.82 km)

Migration corridor area:
- Low use: 468,271 acres (189,503 ha)
- Medium use: 104,917 acres (42,458 ha)
- High use: 42,820 acres (17,329 ha)
- Stopover area: 42,927 acres (17,372 ha)

Winter Range Summary

Winter start and end dates (median):
- October 15 to April 27
- Winter length (mean): 109 days
- Winter range (50 percent contour) area: 80,874 acres (32,729 ha)

Other Information

Project contacts:
- Tom Stephenson (tom.stephenson@wildlife.ca.gov), Senior Environmental Scientist, California Department of Fish and Wildlife

Data analyst:
- Evan Greenspan, Project Manager—Ecological Modeler, California Department of Fish and Wildlife

Photograph from Tom Stephenson, California Department of Fish and Wildlife.
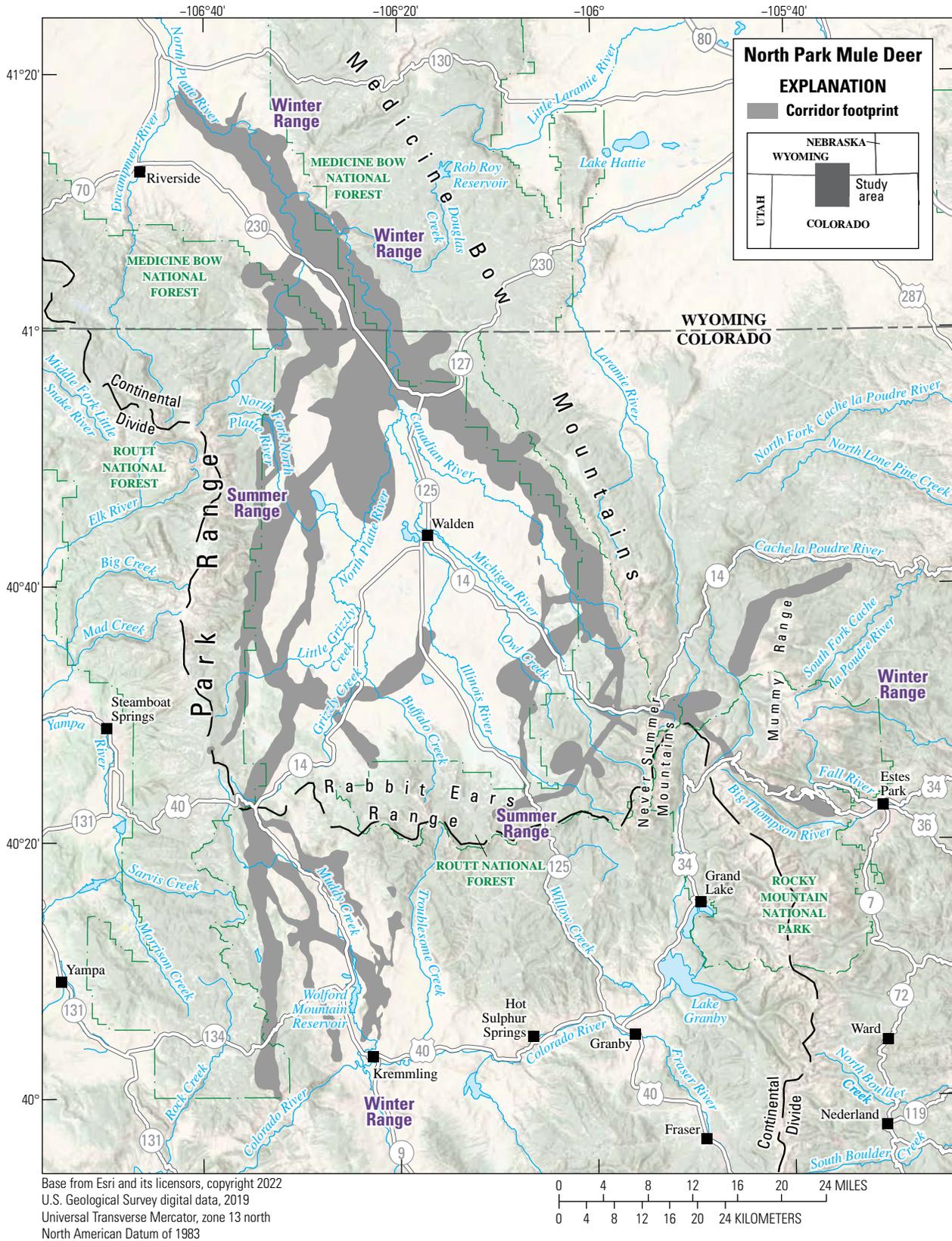
Figure 5.   Map showing the migration footprint used by at least one individual of the North Park mule deer herd.

Colorado | Mule Deer

North Park Mule Deer

The North Park mule deer herd (Data Analysis Unit [DAU] D3) inhabits North Park, an intermountain basin on the east side of the Continental Divide in Jackson County, Colorado (fig. 5). Elevations within the DAU range from approximately 7,800 to 13,000 feet (ft; 2,377 to 3962 meters [m]). North Park is bound to the north by the Wyoming border, to the east by the Medicine Bow Mountains and Never Summer Mountains, to the south by the Rabbit Ears Range, and to the west by the Park Range. North Park serves as the headwaters of the North Platte River and contains many drainages, including the Illinois River, Michigan River, Canadian River, and the North Fork of the North Platte River. The North Park basin spans 1.04 million acres (420,873 ha) and features diverse landownership, including 12 percent State, 36 percent private, and 52 percent Federal land (BLM, U.S. Department of Agriculture Forest Service [FS], and U.S. Fish and Wildlife Service).

During the summer, North Park mule deer are dispersed across the entire DAU; higher deer densities are in forested and alpine habitats more than 8,500 ft (2,591 m). Population estimates have historically fluctuated, peaking at 10,000–12,000 deer in the 1950s (Don Gore, Colorado Division of Wildlife, written commun., 2025), though more recent estimates indicate approximately 4,500–6,000 deer (the 2023 posthunt estimate was 5,400 deer; Eric VanNatta, Colorado Parks and Wildlife [CPW], written commun., 2025). Historically, North Park supported a large wintering deer population within the DAU. However, in the early 2000s, CPW staff observed a shift in wintering deer patterns; most deer now migrate from North Park to adjacent winter ranges to the north, east, and south of the DAU. Despite only moderate land-use changes, including the conversion of some *Artemisia* spp. (sagebrush) habitat to grassland for livestock grazing, North Park still retains quality mule deer winter range, although few, if any, deer now use it. CPW staff hypothesize this shift in winter deer distribution may be a result of past management decisions implemented during the mid-1900s, when a combination of relatively liberal hunting quotas and late-season hunting permitted years of heavy, targeted harvest of deer on local winter range. Because of this management regime, a smaller migratory subset of deer that were less affected by hunter harvest may have experienced higher survival and may have led to migratory behavior becoming more dominant.

The predominance of this migratory behavior poses challenges for managing a stable population. For example, CPW classification survey flights, done annually in late December or early January, coincide with winter conditions that drive deer, elk, and *Alces alces* (moose) into areas with greater sightability. Surveys from the 1960s to 1970s reported 2,000–3,000 mule deer per year. However, an average of only 250 deer per year have been counted during the past decade (CPW, 2023), likely because most mule deer have already left North Park or are near

staging areas along suspected migration routes during the typical survey period. These small sample sizes complicate population modeling, limiting CPW's ability to accurately estimate population size and detect subtle demographic changes. This challenge has spurred recent research, funded by Secretarial Order 3362, into understanding North Park mule deer migration characteristics.

Animal Capture and Data Collection

Sample size: 50 adult female mule deer
Relocation frequency: 4 hours
Project duration: 2021–24 (data from August 2021 through January 2024 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Fixed Motion Variance (McKee and others, 2024; app. 1)
Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 104 sequences from 45 individuals (42 spring sequences, 62 fall sequences)

Migration use classifications:
- Migration footprint: Any migration area used by at least one individual

Corridor Summary

Migration start and end dates (median):
- Spring: April 21 to May 24
- Fall: November 3 to December 12

Number of days migrating (mean):
- Spring: 33 days
- Fall: 39 days

Migration corridor length:
- Minimum: 10.7 mi (17.22 km)
- Mean: 40.3 mi (64.86 km)
- Maximum: 76.9 mi (123.76 km)

Migration corridor area:
- Migration footprint: 368,649 acres (149,187 ha)

Other Information

Project contacts:
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- Michelle Cowardin (michelle.cowardin@state.co.us), Wildlife Movement Coordinator, Colorado Parks and Wildlife

Data analyst:
- Eric VanNatta, Wildlife Biologist, Colorado Parks and Wildlife

Photograph from Jacob Way, Colorado Parks and Wildlife.
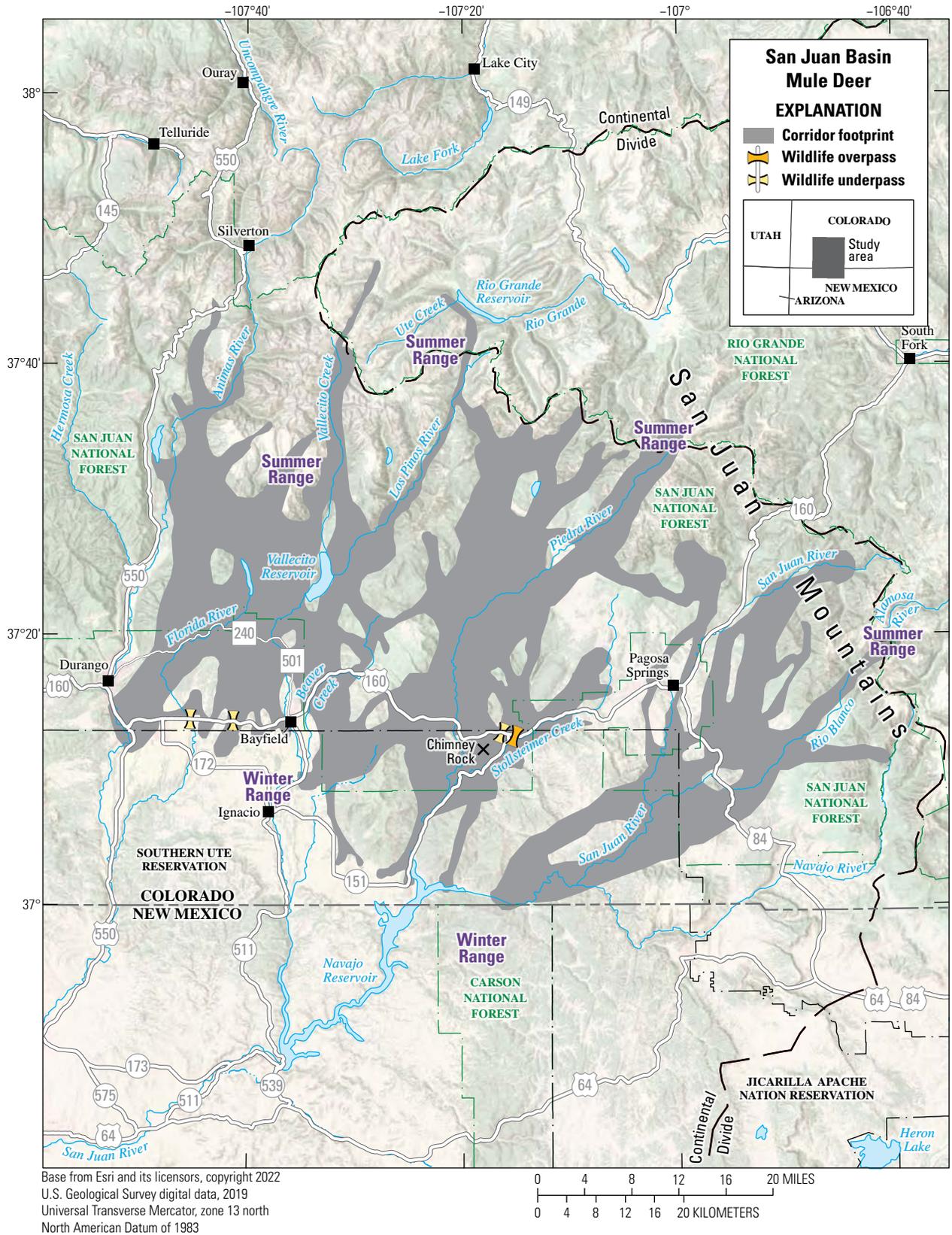
Figure 6.   Migration footprint used by two or more individuals in the San Juan Basin mule deer herd.

Colorado | Mule Deer

San Juan Basin Mule Deer

The San Juan Basin mule deer herd (DAU D30) inhabits a 2,800-square mile (mi²; 7,252-square kilometer [km²]) area in the southwest corner of Colorado (fig. 6). It is bounded to the north and east by the Continental Divide, to the south by the Colorado and New Mexico border, and to the west by the Animas River. Elevations range from 5,000 ft (1,524 m) to more than 14,000 ft (4,267 m). The DAU encompasses Durango, Bayfield, Ignacio, and Pagosa Springs, Colorado, and landownership is a mix of 30 percent private, 12 percent Southern Ute Indian Tribe of the Southern Ute Reservation, Colorado (hereafter Southern Ute Indian Tribe), 2 percent BLM lands, and 56 percent FS lands.

The San Juan Basin mule deer herd includes migratory and nonmigratory individuals. Deer generally summer at higher elevations in the northern and eastern part of the DAU and winter at lower elevations to the south. The timing of deer migration is consistent annually; peak spring migration occurs approximately during the second week of May, and the peak fall migration occurs approximately during the third week of October. In the fall, males generally migrate 1–2 weeks later than females. Part of the deer herd's migration corridor and winter range extends onto Southern Ute Indian Tribal lands and into New Mexico. Resident deer remain year round at the lower elevations that are often associated with agriculture fields.

The main threats to the San Juan Basin mule deer herd include human development and associated infrastructure. Energy and recreational development occur on a large part of important habitat for the San Juan mule deer herd and jeopardize their available resources. Development concerns are a region-wide issue, but they pose a greater problem near Durango, Bayfield, and Pagosa Springs, Colorado.

Additionally, the San Juan mule deer herd inhabits an area with some of the highest recorded wildlife-vehicle collisions (WVCs) in the State. Several highways bisect mule deer migration corridors and winter range, including U.S. Highways 160, 84, and 550, and Colorado State Highways 172, 151, 240, and 501. GPS-collar data from female mule deer have helped identify locations where mule deer cross roadways. These data, along with WVC data, have been instrumental in prioritizing where to build wildlife-crossing structures to ease mule deer movement across busy roads. In 2022, the Colorado Department of Transportation (CDOT), the Southern Ute Indian Tribe, CPW, and other partners helped to fund the construction of a wildlife overpass and underpass on a 1.9-mi (3.1-km) section of U.S. Highway 160 near Chimney Rock and the intersection of Colorado State Highway 151. In 2023, a network of camera traps was established to determine the effectiveness of wildlife-crossing structure installations to reduce WVCs and maintain wildlife movement permeability. Within the first 8 months of monitoring (October 2023 through June 2024), mule deer, elk, *Ursus americanus* (black bears), *Puma concolor* (mountain lions), and many smaller mammal species successfully used the crossing structures (Cramer, 2024). The CDOT has plans for additional crossing structures as funding becomes available.

Animal Capture and Data Collection

Sample size: 194 adult female mule deer
Relocation frequency: Approximately 1–5 hours
Project duration: 2004–22

Data Analysis

Corridor footprint: Brownian bridge movement models (Sawyer and others, 2009)
Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011; app. 1)
Models derived from:
- Migration: 414 sequences from 143 individuals (230 spring sequences, 184 fall sequences)

Migration use classifications:
- Migration footprint: Any migration area used by two or more individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: May 3 to June 1
- Fall: October 8 to October 28

Number of days migrating (mean):
- Spring: 31 days
- Fall: 22 days

Migration corridor length:
- Minimum: 3.44 mi (5.54 km)
- Mean: 28.68 mi (46.16 km)
- Maximum: 55.95 mi (90.04 km)

Migration corridor area:
- Migration footprint: 150,653 acres (60,967 ha)

Other Information

Project contacts:
- Brad Weinmeister (brad.weinmeister@state.co.us), Terrestrial Biologist, Colorado Parks and Wildlife
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- Michelle Cowardin (michelle.cowardin@state.co.us), Wildlife Movement Coordinator, Colorado Parks and Wildlife

Data analysts:
- Nick Jaffe, Spatial Ecologist, Colorado Parks and Wildlife
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Photograph from Brad Weinmeister, Colorado Parks and Wildlife.
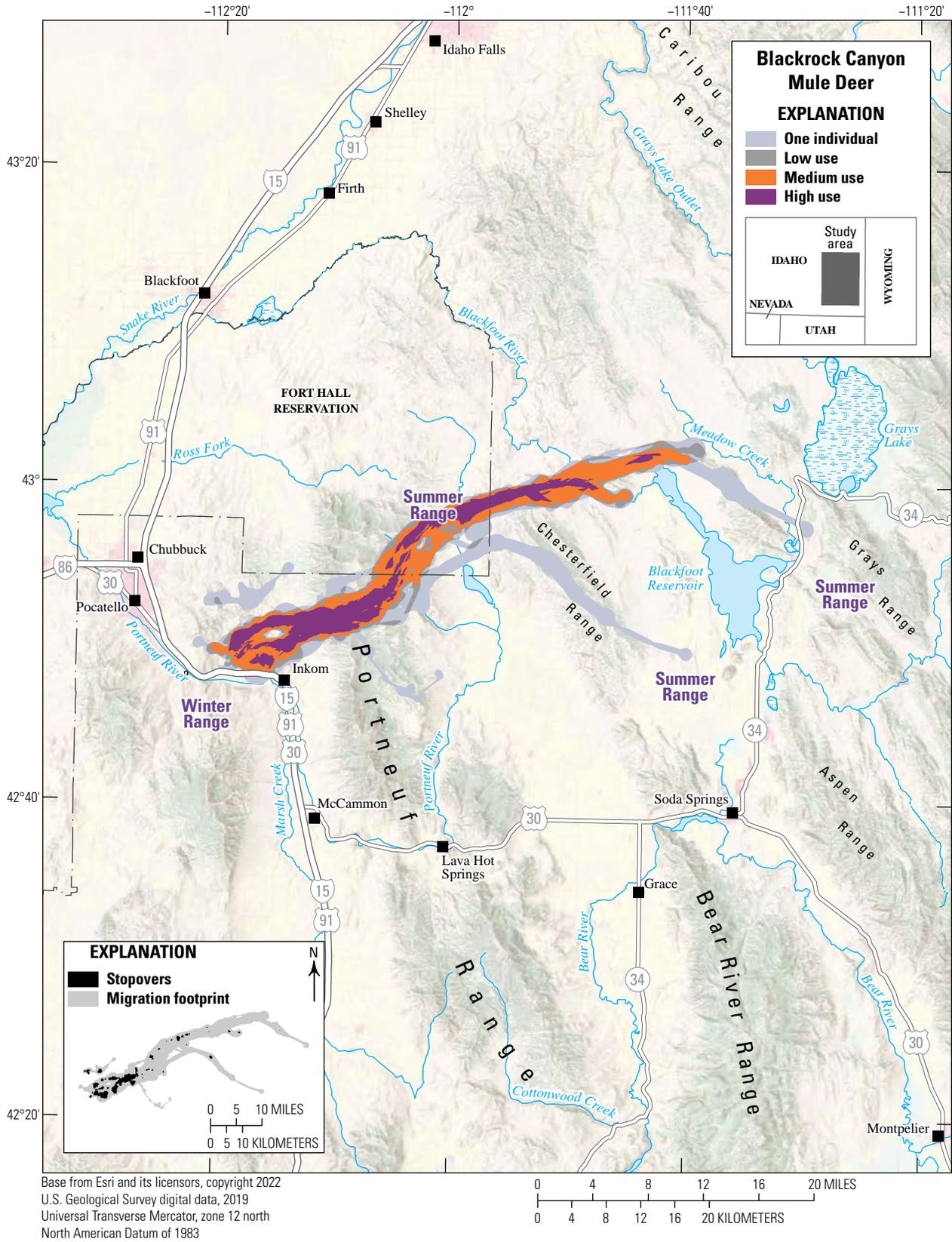
Figure 7.   Map showing migration routes and stopovers of the Blackrock Canyon mule deer herd.

Idaho | Mule Deer

Blackrock Canyon Mule Deer

The Blackrock Canyon mule deer herd winters near Pocatello, Idaho. During very severe winters, most deer live within 0.5 mi (1 km) of the Interstate 15 corridor from Inkom, Idaho, to the southeast extent of the Pocatello city limits (fig. 7). During milder winters, deer shift southeast of Pocatello and use a broader winter range covering approximately 27 mi^2 (70 km^2). Recent aerial abundance surveys indicated that 1,500–2,500 mule deer winter to the southeast of Pocatello. The Interstate 15 corridor is fenced with wildlife-exclusionary fencing from Inkom to Pocatello, and very little movement currently (2025) occurs between the Blackrock Canyon mule deer herd and deer south of the highway. Before 2020, the Blackrock Canyon mule deer winter range was considered part of the Bannock mule deer herd to the southwest. However, as more GPS-collar data were collected, it became clear that the winter range of this herd had little connectivity to those southwestern areas and, instead, was integrally connected to summer ranges to the north and east. Blackrock Canyon mule deer travel to the east–northeast through the Fort Hall Reservation to the Portneuf Range, Chesterfield Range, the foothills of the Grays Range, and near the Blackfoot Reservoir. In the winter range, wildfire has degraded the lowest-elevation areas, and nonnative, invasive annual grasses have flourished. Fencing, WVCs, urban sprawl, and connectivity are also concerns for this herd. In the summer range, resource extraction and *Populus tremuloides* (quaking aspen) stand invasion by *Pseudotsuga menziesii* (Douglas fir) continue to challenge and degrade nutrient-rich summer habitats.

Animal Capture and Data Collection

Sample size: 26 adult female mule deer
Relocation frequency: Approximately 4 hours
Project duration: 2023−24

Data Analysis

Migration route and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) with an 8-hour time lag
Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 45 sequences from 26 individuals (26 spring sequences, 19 fall sequences)

Migration use classifications:
- One individual: Used by one individual
- Low: Used by two individuals to 10 percent of the individuals
- Medium: Used by 10–20 percent of the individuals
- High: Used by >20 percent of the individuals

Migration Route and Stopover Summary

Migration start and end dates (median):
- Spring: April 21 to May 12
- Fall: October 17 to October 24

Number of days migrating (mean):
- Spring: 14 days
- Fall: 7 days

Migration route length:
- Minimum: 6.37 mi (10.25 km)
- Median: 28.38 mi (45.67 km)
- Maximum: 48.62 mi (78.25 km)

Migration route area:
- One individual: 104,968 acres (42,479 ha)
- Low use: 62,905 acres (25,457 ha)
- Medium use: 51,803 acres (20,964 ha)
- High use: 23,309 acres (9,433 ha)
- Stopover area: 10,829 acres (4,382 ha)

Other Information

Idaho migration routes are updated and viewable by Idaho Department of Fish and Game (Idaho Department of Fish and Game, 2024). Mapping layers shown for this herd are sensitive but may be made available to researchers upon request by contacting Idaho Department of Fish and Game (idfgdatarequests@idfg.idaho.gov).

Project contacts:
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- Zach Lockyer (zach.lockyer@idfg.idaho.gov), Regional Wildlife Populations Manager, Idaho Department of Fish and Game
- Eric Freeman (eric.freeman@idfg.idaho.gov), Regional Wildlife Populations Biologist, Idaho Department of Fish and Game

Data analysts:
- Scott Bergen, Senior Wildlife Research Biologist, Idaho Department of Fish and Game
- Robert Ritson, Associate Research Scientist, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming

Reports and Publications:
- Meints, D., Ward, R., Knetter, J., Miyasaki, H., Oelrich, K., Mosby, C., Ellstrom, M., Roche, E., Elmer, M., Crea, S., Smith, D., Hribik, D., Hickey, C., Berkley, R., McDonald, M., Lockyer, Z., Hendricks, C., Painter, G., and Newman, D., 2020, F19AF00858 statewide surveys and inventory final performance report: Boise, Idaho, Idaho Department of Fish and Game, 20 p. [Also available at https://idfg.idaho.gov/data/request.]
- Roberts, S., and Mumma, M., 2023, F22AF03552 statewide wildlife research final performance report: Boise, Idaho, Idaho Department of Fish and Game, 48 p.

Figure 8.   Map showing migration routes and stopovers of the Hells Canyon mule deer herd.

Idaho | Mule Deer

Hells Canyon Mule Deer

The Hells Canyon mule deer herd consists of 3,000–5,000 deer that winter primarily in sagebrush-steppe habitat adjacent to the Snake River and near the Brownlee and Oxbow dams (fig. 8). The area is dominated by steep canyons with grasslands and sagebrush-steppe habitat at lower elevations and on south-facing slopes and pine at higher elevations. Most of this herd summers at high elevations in the management unit, to the northwest of Cambridge and west of Council, Idaho. However, a large part of this herd winters farther east, south of New Meadows, Idaho, where it overlaps with the Weiser mule deer herd and migrants from areas around Riggins, Idaho. Additionally, several Hells Canyon mule deer cross the Snake River between Oregon and Idaho during their seasonal migrations. Hells Canyon mule deer face multiple challenges along their migration routes, including crossing State Highway 95, Idaho's primary north–south highway, increased energy and mining development, and navigating a matrix of private and public lands. Frequent, large wildfires degrade winter range quality and promote the establishment of invasive annual grasses on winter and summer ranges.

Animal Capture and Data Collection

Sample size: 74 female mule deer
Relocation frequency: 4–12.5 hours
Project duration: 2015–24

Data Analysis

Migration route and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) with an 8-hour time lag for 61 migration sequences, Fixed Motion Variance (11,840 square feet [ft^2]; 1,100 square meters [m^2]; McKee and others, 2024) with a 14-hour time lag for 59 migration sequences, and Fixed Motion Variance (11,840 ft^2 [1,100 m^2]; McKee and others, 2024) with a 27-hour time lag for 9 migration sequences (app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:
- Migration: 129 sequences from 74 individuals (86 spring sequences, 43 fall sequences)

Migration use classifications:
- One individual: Used by one individual
- Low: Used by two individuals to 10 percent of the individuals
- Medium: Used by 10–20 percent of the individuals
- High: Used by >20 percent of the individuals

Migration route and Stopover Summary

Migration start and end dates (median):
- Spring: April 17 to April 28
- Fall: November 5 to November 25

Number of days migrating (mean):
- Spring: 13 days
- Fall: 13 days

Migration corridor length:
- Minimum: 3.61 mi (5.81 km)
- Median: 17.38 mi (27.97 km)
- Maximum: 84.73 mi (136.36 km)

Migration route area:
- One individual: 371,565 acres (150,367 ha)
- Low use: 185,622 acres (75,119 ha)
- Medium use: 32,124 acres (13,000 ha)
- High use: 14,404 acres (5,829 ha)
- Stopover area: 37,595 acres (15,214 ha)

Other Information

Idaho migration routes are updated and viewable by Idaho Department of Fish and Game (Idaho Department of Fish and Game, 2024). Mapping layers shown for this herd are sensitive but may be made available to researchers upon request by contacting Idaho Department of Fish and Game (idfgdatarequests@idfg.idaho.gov).

Project contacts:
- Matt Mumma (matt.mumma@idfg.idaho.gov), Wildlife Research Manager, Idaho Department of Fish and Game
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Data analysts:
- Scott Bergen, Senior Wildlife Research Biologist, Idaho Department of Fish and Game
- Robert Ritson, Associate Research Scientist, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming

Reports and Publications:
- Meints, D., Ward, R., Knetter, J., Miyasaki, H., Oelrich, K., Mosby, C., Ellstrom, M., Roche, E., Elmer, M., Crea, S., Smith, D., Hribik, D., Hickey, C., Berkley, R., McDonald, M., Lockyer, Z., Hendricks, C., Painter, G., and Newman, D., 2020, F19AF00858 statewide surveys and inventory final performance report: Boise, Idaho, Idaho Department of Fish and Game, 20 p. [Also available at https://collaboration.idfg.idaho.gov/WildlifeTechnicalReports/F19AF00858%20Statewide%20Surveys%20%20Inventory%20Final%20Report%20FY20.pdf.]
- Roberts, S., and Mumma, M., 2023, F22AF03552 statewide wildlife research final performance report: Boise, Idaho, Idaho Department of Fish and Game, 48 p.

Figure 9.   Map showing migration corridors, stopovers, and winter ranges of the Canyon de Chelly mule deer herd.

Navajo Nation | Mule Deer

Canyon de Chelly Mule Deer

The Canyon de Chelly mule deer herd is one of several herds that winter in the foothills of the Chuska Mountains, an 80-mile (129-km) long range within the southeastern Colorado Plateau in Navajo Nation, Arizona, New Mexico, & Utah (hereafter Navajo Nation). Initially included in Kauffman and others (2022a), this herd has been updated for this report with data from additional years. The winter ranges and migration corridors of the Canyon de Chelly herd are just 7 mi (11 km) south of the Ram Pasture herd (refer to the "Ram Pasture Mule Deer" section of this report) but are separated geographically by Canyon del Muerto and Black Rock Canyon (fig. 9). These canyons are part of the larger Canyon de Chelly National Monument. Unlike other federally managed parks, the monument is comanaged with a Native American Tribe, whereas all parklands remain Navajo Nation Tribal trust land (National Park Service, 2025). Members of the Navajo Nation continue to reside in and around the canyons, maintaining livestock and cultivating crops. Although the canyon has accessible routes and perennial streams, GPS-collared mule deer primarily winter on the canyon mesas. Windmills installed by the Navajo Nation Department of Water Resources for livestock also provide a critical water source for mule deer in winter. During spring and fall migrations, the Canyon de Chelly herd crosses Indian Route 12, a heavily traveled rural highway along the Arizona and New Mexico border. The primary challenges the herd faces during migration include vehicular collisions, urban development, and overgrazing by feral horses and unregulated livestock.

Animal Capture and Data Collection

Sample size: 8 adult female mule deer
Relocation frequency: Approximately 1–4 hours
Project duration: 2018–24

Data Analysis

Corridor and winter range analysis: Fixed Motion Variance (McKee and others, 2024; app. 1)
Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 35 sequences from 8 individuals (18 spring sequences, 17 fall sequences)
- Winter: 10 sequences from 4 individuals

Migration use classifications:
- Low: Used by at least one individual
- Medium: Used by at least two individuals
- High: Used by >30 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 22 to April 25
- Fall: October 29 to October 30

Number of days migrating (mean):
- Spring: 3 days
- Fall: 3 days

Migration corridor length:
- Minimum: 7.20 mi (11.59 km)
- Mean: 14.74 mi (23.72 km)
- Maximum: 23.99 mi (38.61 km)

Migration corridor area:
- Low use: 63,292 acres (25,613 ha)
- Medium use: 22,517 acres (9,112 ha)
- High use: 6,958 acres (2,816 ha)
- Stopover area: 4,619 acres (1,869 ha)

Winter Range Summary

Winter start and end dates (median):
- October 30 to April 24
- Winter length (mean): 181 days
- Winter range (50 percent contour) area: 14,775 acres (5,979 ha)

Other Information

Project contacts:
- Jess Fort (jfort@nndfw.org), Wildlife Biologist, Navajo Nation Department of Fish and Wildlife
- Tatjana Woody (twoody@nndfw.org), Wildlife Biologist, Navajo Nation Department of Fish and Wildlife

Data analyst:
- Tatjana Woody, Wildlife Biologist, Navajo Nation Department of Fish and Wildlife

Photograph from Sydney Smolla (https://www.sydneysmolla.art/), used with permission.
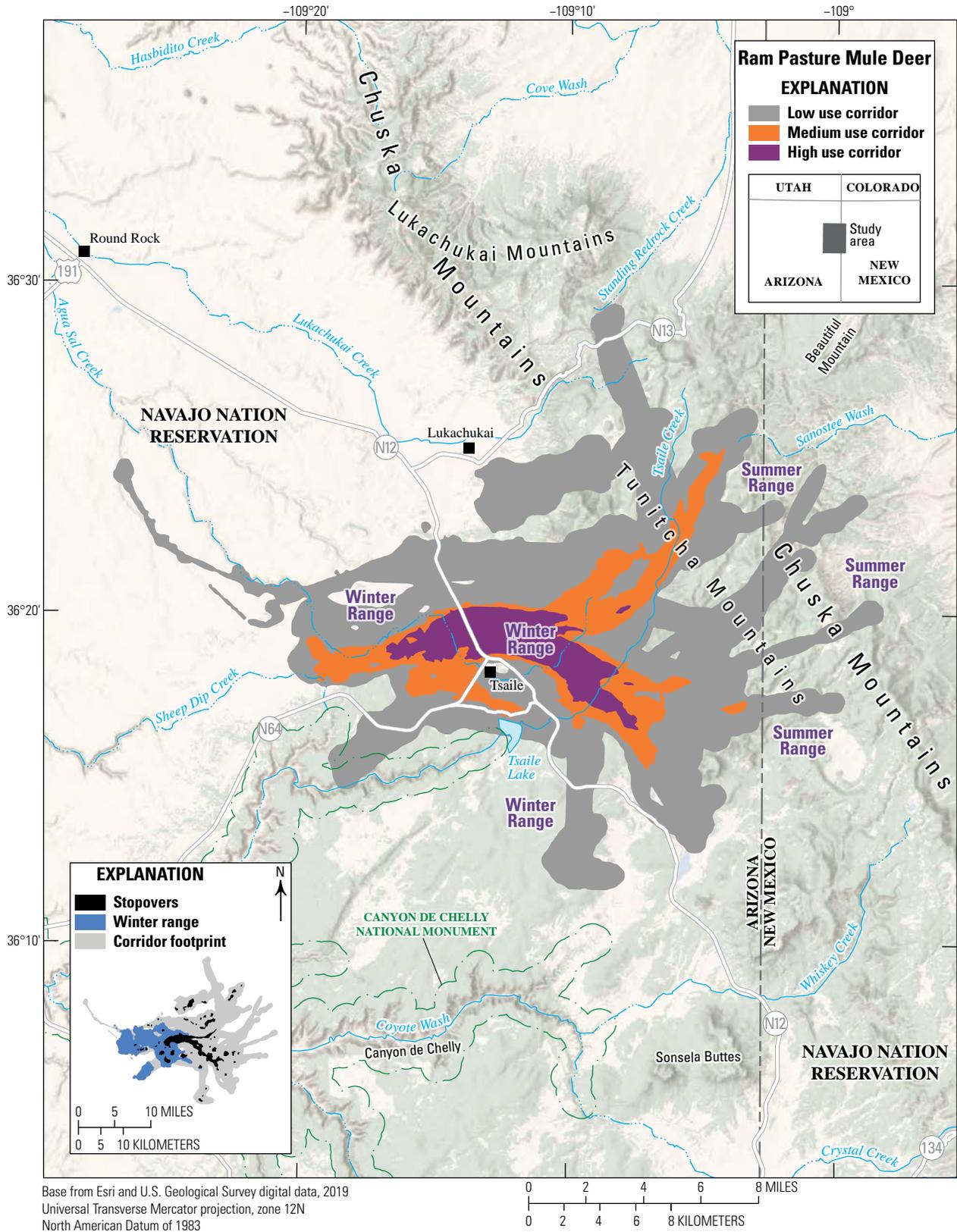
Figure 10.   Map showing migration corridors, stopovers, and winter ranges of the Ram Pasture mule deer herd.

Navajo Nation | Mule Deer

Ram Pasture Mule Deer

The Ram Pasture mule deer herd is one of several herds that winter in the foothills of the 80-mi (129-km) long Chuska Mountains in Navajo Nation (fig. 10). This herd was originally included in Kauffman and others (2022a) and has been updated for this report to include new data from additional years and mule deer (12 new adults; Kauffman and others, 2022a). These mule deer winter in pinyon-juniper and sagebrush foothills; migrate to the east to higher elevations in the spring; and summer in habitats comprised of mixed conifer, aspen, high alpine meadows, and *Pinus ponderosa* (ponderosa pine). Winter and summer ranges remain entirely within Tribal trust lands managed by the Navajo Nation Department of Fish and Wildlife. Similar to the Canyon de Chelly mule deer herd (refer to the "Canyon de Chelly Mule Deer" section of this report), every spring and fall, the Ram Pasture herd must cross Indian Route 12, a busy rural highway along the Arizona and New Mexico border. During migration seasons, WVCs are a continuous problem in these areas. In 2023, aerial surveys estimated 1,030 mule deer as the minimum number of known alive deer throughout their winter ranges in the Chuska Mountains, which is a decline from the 2020 estimate of 1,583 mule deer (Kauffman and others, 2022a). The limiting factors for this herd include low-quality habitat caused by overgrazing and resource competition with feral horses and unregulated livestock (Davies and Boyd, 2019; Wallace and others, 2021). Furthermore, extended drought and habitat fragmentation driven by urban development have accelerated the decline of habitat suitability (Redsteer and others, 2018; Nania and others, 2014).

Animal Capture and Data Collection

Sample size: 44 adult mule deer (20 males, 24 females)
Relocation frequency: Approximately 1–4 hours
Project duration: 2018–24

Data Analysis

Corridor and winter range analysis: corridor analysis used Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:
- Migration: 150 sequences from 41 individuals (78 spring sequences, 72 fall sequences)
- Winter: 55 sequences from 23 individuals

Migration use classifications:
- Low: Used by at least one individual
- Medium: Used by 10–20 percent of the individuals
- High: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 26 to April 29
- Fall: October 29 to November 1

Number of days migrating (mean):
- Spring: 5 days
- Fall: 4 days

Migration corridor length:
- Minimum: 3.77 mi (6.07 km)
- Mean: 10.08 mi (16.22 km)
- Maximum: 17.29 mi (27.83 km)

Migration corridor area:
- Low use: 103,118 acres (41,730 ha)
- Medium use: 23,129 acres (9,360 ha)
- High use: 7,934 acres (3,211 ha)
- Stopover area: 10,295 acres (4,166 ha)

Winter Range Summary

Winter start and end dates (median):
- November 1 to April 26
- Winter length (mean): 171 days
- Winter range (50 percent contour) area: 25,512 acres (10,324 ha)

Other Information

Project contacts:
- Jess Fort (jfort@nndfw.org), Wildlife Biologist, Navajo Nation Department of Fish and Wildlife
- Tatjana Woody (twoody@nndfw.org), Wildlife Biologist, Navajo Nation Department of Fish and Wildlife

Data analyst:
- Jess Fort, Wildlife Biologist, Navajo Nation Department of Fish and Wildlife

Photograph from Jess Fort, Navajo Nation Department of Fish and Wildlife.
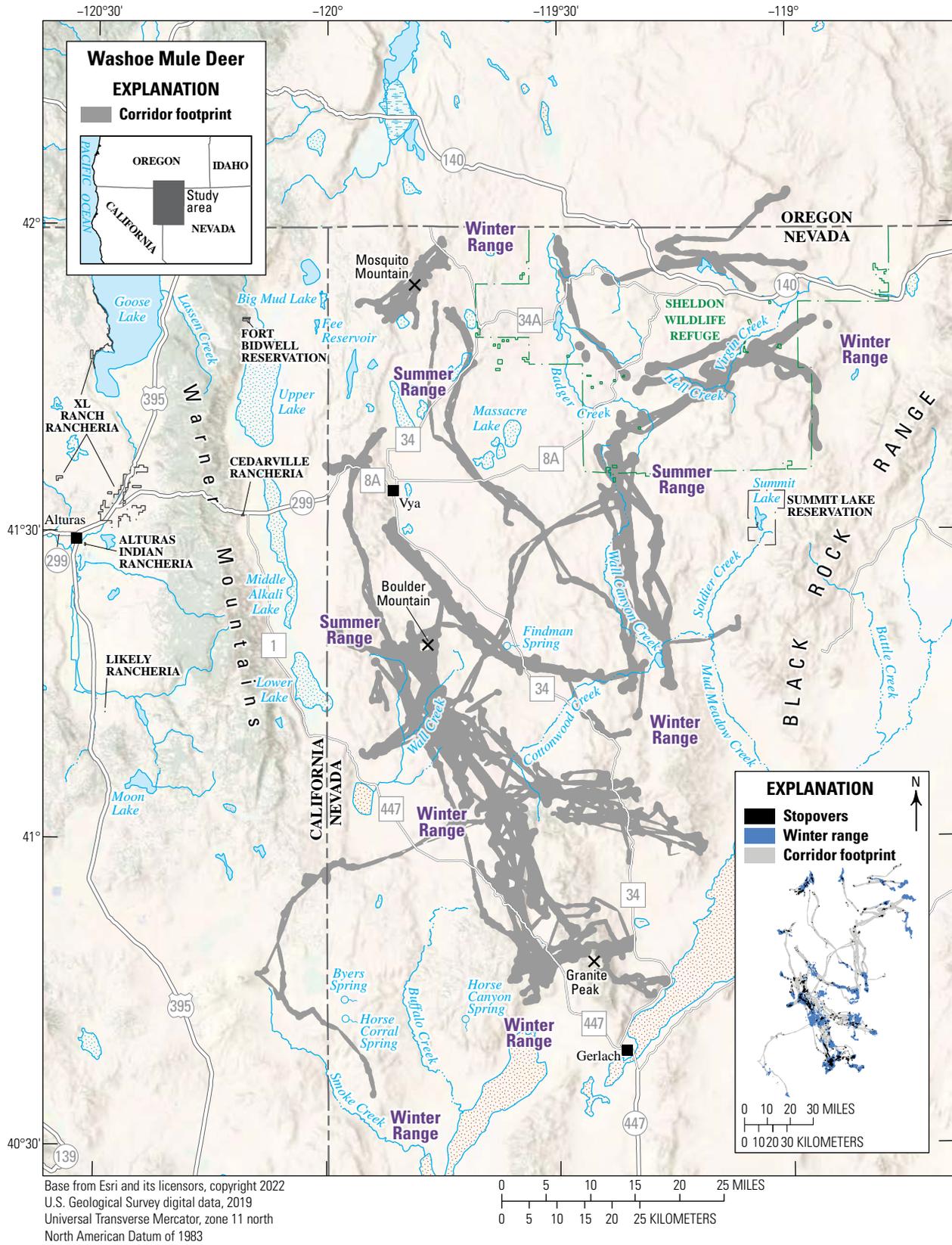
Figure 11. Map showing migration corridors, stopovers, and winter ranges of the Washoe mule deer herd.

Nevada | Mule Deer

Washoe Mule Deer

The Washoe mule deer herd inhabits the northwest corner of Nevada, northeastern California, and southern Oregon (fig. 11). The Washoe mule deer herd spans seven of Nevada Department of Wildlife (NDOW)'s Hunt Units (011–015, 032–033) and consists of long-distance and short-distance migrants; some deer travel more than 62 mi (100 km), and other deer travel less than 0.5 mi (1 km) downslope to lower elevations during the winter. The Washoe mule deer herd comprises several subherds, including the Mosquito Mountain, Sheldon National Wildlife Refuge, Vya, Boulder Mountain, and Granite Peak mule deer. Over the past 10 years, the Washoe mule deer herd has declined drastically, largely because of the long-term effects of drought. Other threats this herd faces include fencing, habitat loss from wildfires, the conversion of shrublands to annual grasses, and competition with feral horses for forage and water. Several habitat projects have been initiated to help manage these mule deer subherds, including spring protection projects in Hunt Unit 013 near Findman Spring and Horse Canyon Spring, and in Hunt Unit 015 near Horse Corral and Byers Springs. Additionally, approximately 7.5 mi. (12 km) of fencing improvements have been made along the California border near Big Mud Lake and Fee Reservoir (NDOW, 2024).

Animal Capture and Data Collection

Sample size: 89 adult mule deer (9 males, 80 females)
Relocation frequency: Approximately 3.5−8 hours
Project duration: 2008−09 and 2018−present (data through June 2024 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Brownian bridge movement models (Sawyer and others, 2009) and Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:

- Migration: 234 sequences from 68 individuals (103 spring sequences, 131 fall sequences)
- Winter: 99 sequences from 58 individuals

Migration use classifications:

- Corridor footprint: Used by at least one individual

Corridor and Stopover Summary

Migration start and end dates (median):

- Spring: April 29 to May 4
- Fall: December 25 to January 7

Number of days migrating (mean):

- Spring: 6 days
- Fall: 6 days

Migration corridor length:

- Minimum: 1.27 mi (2.04 km)
- Mean: 14.50 mi (23.34 km)
- Maximum: 62.58 mi (100.71 km)

Migration corridor area:

- Corridor footprint: 560,413 acres (226,791 ha)
- Stopover area: 63,716 acres (25,785 ha)

Winter Range Summary

Winter start and end dates (median):

- February 19 to April 28
- Winter length (mean): 101 days
- Winter range (50 percent contour) area: 223,067 acres (90,272 ha)

Other Information

Project contacts:

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Reports and Publications:

- Nevada Department of Wildlife, 2024, Nevada State action plan—Implementation of Department of Interior [sic] Secretarial Order 3362—Improving habitat quality in western big-game winter range and migration corridors: Western Association of Fish and Wildlife Agencies, 26 p. [Also available at https://wafwa.org/wp-content/uploads/2024/10/NV-State-Action-Plan-for-SO-3362.pdf.]
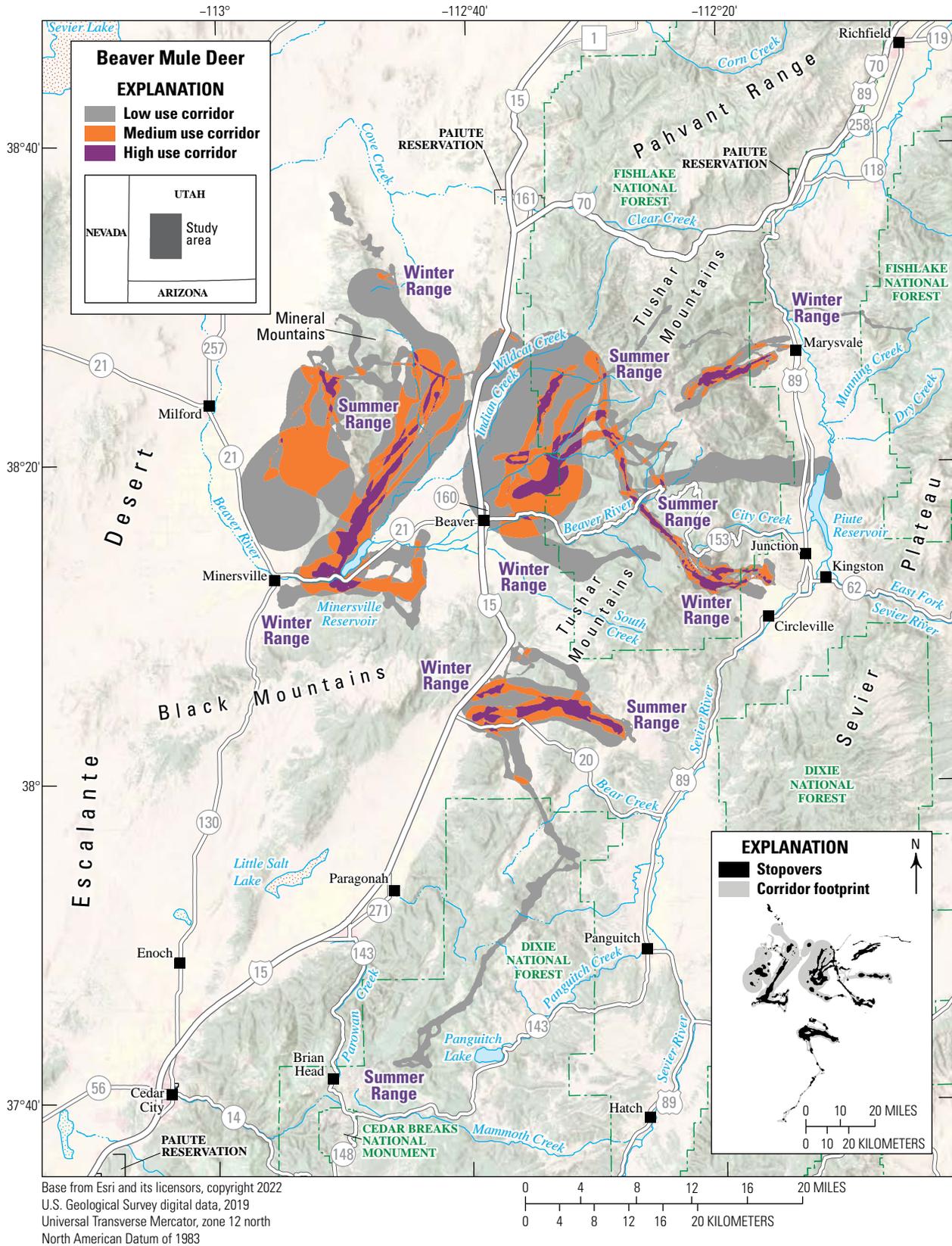
Figure 12.   Map showing migration corridors and stopovers of the Beaver mule deer herd.

Utah | Mule Deer

Beaver Mule Deer

The Beaver mule deer herd inhabits the Beaver Wildlife Management Unit (WMU) in southern Utah and includes three mountain ranges: the Tushar Mountains in the east and the Mineral and Black Mountains in the west (fig. 12). The WMU encompasses more than 885,000 acres (358,147 ha) of mule deer range and has approximately 12,000 mule deer (Utah Division of Wildlife Resources [UDWR], 2020b). The area is mostly rural, and landownership consists mainly of BLM and FS lands (UDWR, 2020b). The Beaver mule deer herd is migratory; most deer summer in high elevations on the Tushar Mountains, but some use limited summer range on the Mineral and Black Mountains. Mule deer winter in the lower-elevation slopes of all three mountain ranges. Most mule deer habitat in this WMU is made up of pinyon-juniper woodland (38 percent) and sagebrush-steppe and shrublands (27 percent; Payne and others, 2023). However, widespread encroachment of pinyon and juniper into sagebrush shrublands has decreased available food sources for Beaver mule deer.

Other challenges this herd faces include drought conditions, which much of the Beaver WMU has experienced for 68 percent of the time since 1993 (Payne and others, 2023). Several major roads with high traffic densities pass through this WMU, resulting in concentrated WVCs along sections of Interstate 15, State Route 20, and State Route 21 (Payne and others, 2023). Several mitigation measures have been installed in these areas, including five wildlife crossings and mesh wire exclusionary fencing along Interstate 15 and Interstate 70, which have begun to reduce these WVC effects (Payne and others, 2023). The UDWR uses the GPS data of this herd to describe migration corridors and determine crucial habitats.

Animal Capture and Data Collection

Sample size: 46 adult mule deer (1 male, 44 females, 1 unknown)
Relocation frequency: Approximately 2–13 hours
Project duration: 2016–21

Data Analysis

Corridor and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) and Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 95 sequences from 46 individuals (69 spring sequences, 26 fall sequences)

Migration use classifications:
- Low: Used by 0–25 percent of the individuals
- Medium: Used by 25–75 percent of the individuals
- High: Used by >75 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: May 14 to May 26
- Fall: October 31 to December 20

Number of days migrating (mean):
- Spring: 20 days
- Fall: 29 days

Migration corridor length:
- Minimum: 4.73 mi (7.61 km)
- Mean: 11.24 mi (18.09 km)
- Maximum: 25.77 mi (41.47 km)

Migration corridor area:
- Low use: 302,901 acres (122,580 ha)
- Medium use: 101,767 acres (41,184 ha)
- High use: 27,516 acres (11,135 ha)
- Stopover area: 90,254 acres (36,524 ha)

Other Information

Utah mule deer migration corridors are viewable and available for download at the Utah Division of Wildlife Resources Wildlife Migration Initiative web page (UDWR, 2025). Data used in this report may be made available upon request by contacting Utah Division of Wildlife Resources.
Project contacts:
- Makeda Hanson (makedatrujillo@utah.gov), Wildlife Migration Initiative Coordinator, Utah Division of Wildlife Resources

Data analyst:
- Amy Ehrhart, Wildlife Migration Data Specialist, Utah Division of Wildlife Resources

Photograph from Scott Gibson, Utah Division of Wildlife Resources.
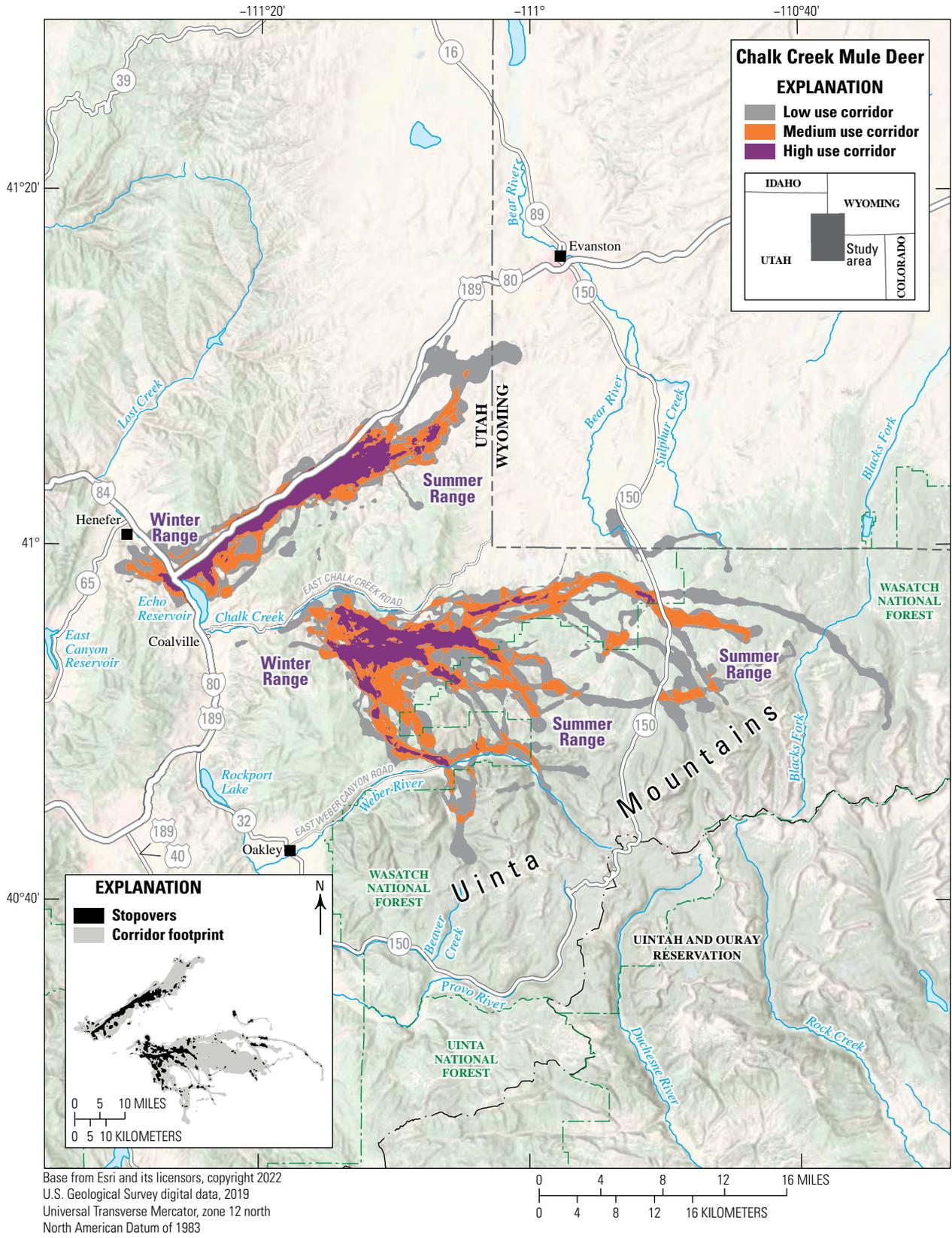
Figure 13.   Map showing migration corridors and stopovers of the Chalk Creek mule deer herd.

Utah | Mule Deer

Chalk Creek Mule Deer

The Chalk Creek mule deer herd inhabits the Chalk Creek WMU in northern Utah, northeast of Salt Lake City, Utah, and abuts the Wyoming border (fig. 13). The WMU is bordered to the east by the Uinta Mountains and to the west by the Weber River and two State park reservoirs, Echo Reservoir and Rockport Lake. It encompasses 380,608 acres (154,027 ha) of mule deer range and has approximately 11,250 mule deer (UDWR, 2023b). Landownership is primarily private (88 percent summer range, 96 percent winter range), which makes management of critical mule deer habitat challenging for UDWR (UDWR, 2023b). The Chalk Creek mule deer herd is migratory; deer use high-elevation habitat on private and FS lands in the summer, and limited low-elevation habitats on mostly private lands in the winter. Habitat vegetation types in this WMU include sagebrush–grass, *Quercus gambelii* (oak brush), and juniper, and 43 percent of the WMU consists of shrubland cover (Payne and others, 2021).

Winter range is limited and threatened by development, agriculture, oil and gas infrastructure, juniper encroachment, and overuse by large elk herds (Payne and others, 2021; UDWR, 2023b). Additionally, Echo Reservoir and Rockport Lake hinder mule deer movement on the west side of the herd's range. A high number of WVCs occur along Interstate 80 near the reservoirs, particularly along Echo Reservoir where a high use migration corridor intersects Interstate 80 (Payne and others, 2021). The UDWR works closely with the Utah Department of Transportation to prevent WVCs in this unit through fence installation, construction of wildlife escape ramps, and inclusion of wildlife underpasses (UDWR, 2023b). The UDWR uses the GPS data of this herd to describe migration corridors and identify crucial habitats.

Animal Capture and Data Collection

Sample size: 65 adult mule deer (18 males, 47 females)
Relocation frequency: Approximately 2 hours
Project duration: 2016–22

Data Analysis

Corridor and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) and Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 208 sequences from 65 individuals (118 spring sequences, 90 fall sequences)

Migration use classifications:
- Low: Used 0–25 percent of the individuals
- Medium: Used by 25–75 percent of the individuals
- High: Used by >75 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: May 6 to May 15
- Fall: November 15 to December 18

Number of days migrating (mean):
- Spring: 15 days
- Fall: 25 days

Migration corridor length:
- Minimum: 1.26 mi (2.02 km)
- Mean: 14.02 mi (22.56 km)
- Maximum: 35.09 mi (56.47 km)

Migration corridor area:
- Low use: 169,274 acres (68,505 ha)
- Medium use: 80,646 acres (32,636 ha)
- High use: 31,148 acres (12,605 ha)
- Stopover area: 38,495 acres (15,578 ha)

Other Information

Utah mule deer migration corridors are viewable and available for dvownload at the Utah Division of Wildlife Resources Wildlife Migration Initiative web page (UDWR, 2025). Data used in this report may be made available upon request by contacting Utah Division of Wildlife Resources.
Project contacts:
- Makeda Hanson (makedatrujillo@utah.gov), Wildlife Migration Initiative Coordinator, Utah Division of Wildlife Resources

Data analyst:
- Amy Ehrhart, Wildlife Migration Data Specialist, Utah Division of Wildlife Resources

Photograph from Rusty Robinson, Utah Division of Wildlife Resources.
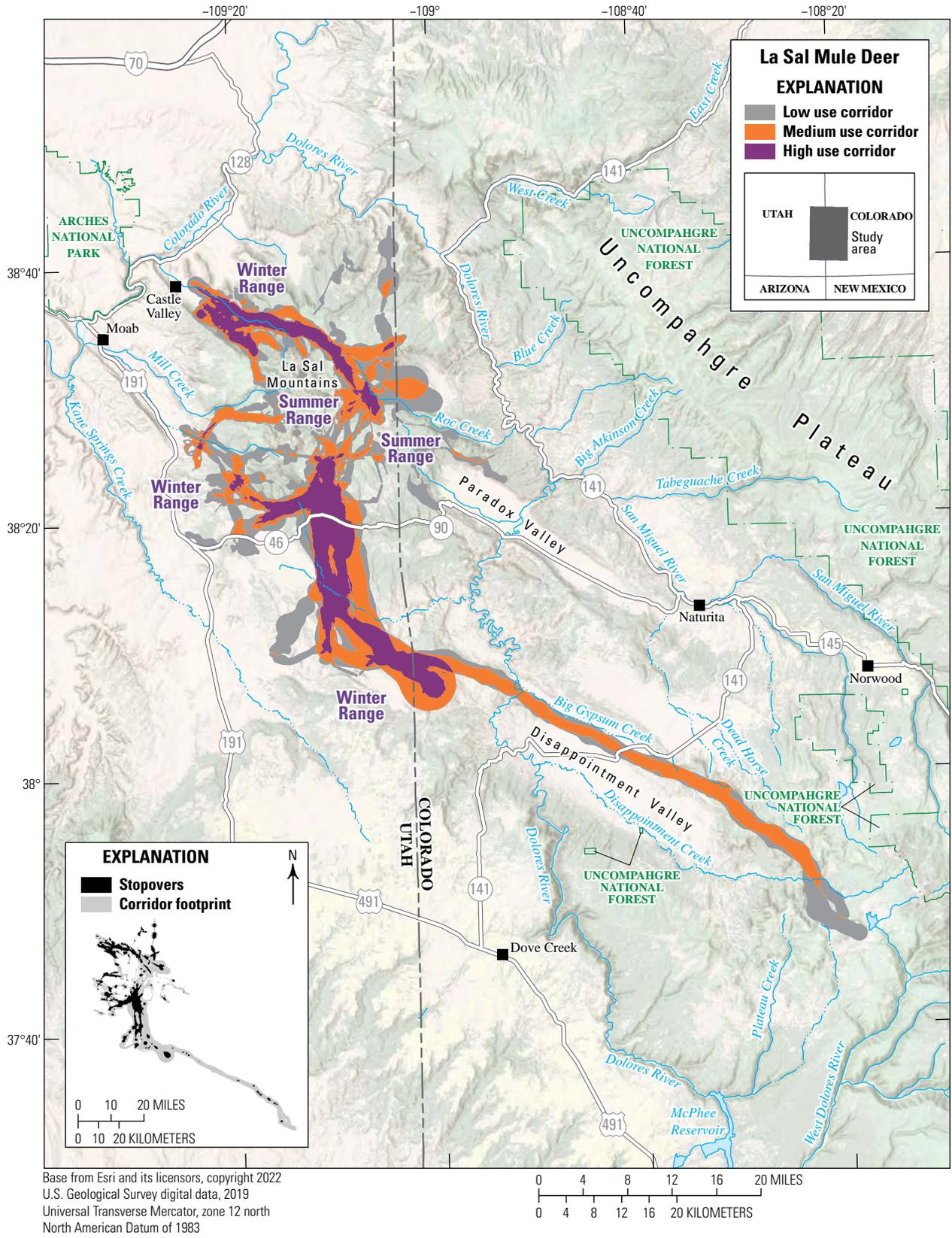
Figure 14.   Map showing migration corridors and stopovers of the La Sal mule deer herd.

Utah | Mule Deer

La Sal Mule Deer

The La Sal mule deer herd inhabits the La Sal WMU in southeastern Utah, abutting the Colorado border (fig. 14). Southeastern Utah has varied geography, including a section of the Disappointment Valley, the Colorado River, La Sal Mountains, Arches National Park, and part of Uncompahgre National Forest in western Colorado. The elevation ranges from 4,000 ft (1,219 m) at the lowest point to 12,721 ft (3,877 m) at the highest point (Payne and others, 2019). It encompasses 507,156 acres (205,239 ha) of mule deer range, mostly on and around La Sal Mountains, and has approximately 5,100 mule deer (UDWR, 2020a). Land is primarily managed by the BLM in the winter range (73 percent) and FS in the summer range (57 percent). The annual range is made up of National Park Service lands (41 percent) and BLM lands (46 percent; UDWR, 2020a). The La Sal mule deer herd is migratory; animals use high-elevation slopes in La Sal Mountains in the summer and mesas at 8,000 ft (2,438 m) or lower in the winter, which are all on the east side of the WMU. About 60 percent of the unit comprises shrublands, including *Coleogyne ramosissima* (blackbrush), a key browse species for mule deer, but most of these areas are not considered mule deer habitat (Payne and others, 2019). The herd faces several challenges, including habitat quality and quantity, pinyon-juniper encroachment, and wildlife-unfriendly fences and crossings that reduce ranges (Payne and others, 2019). The La Sal WMU has the highest prevalence of chronic wasting disease (CWD) in the State; CWD increased in prevalence from 7.9 percent to 14.1 percent between 2015 and 2020 (UDWR, 2020a). The UDWR uses the GPS data of this herd to describe migration corridors, identify crucial habitats, and determine CWD transmission risk.

Animal Capture and Data Collection

Sample size: 57 adult mule deer (12 males, 45 females)
Relocation frequency: Approximately 2–22 hours
Project duration: 2020–21

Data Analysis

Corridor and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) and Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
   Models derived from:
   - Migration: 147 sequences from 57 individuals (95 spring sequences, 52 fall sequences)

   Migration use classifications:
   - Low: Used 0–25 percent of the individuals
   - Medium: Used by 25–75 percent of the individuals
   - High: Used by >75 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 21 to May 5
- Fall: October 26 to October 31

Number of days migrating (mean):
- Spring: 22 days
- Fall: 14 days

Migration corridor length:
- Minimum: 2.36 mi (3.80 km)
- Mean: 15.32 mi (24.66 km)
- Maximum: 55.09 mi (88.66 km)

Migration corridor area:
- Low use: 278,226 acres (112,594 ha)
- Medium use: 164,397 acres (66,529 ha)
- High use: 64,808 acres (26,227 ha)
- Stopover area: 74,745 acres (30,248 ha)

Other Information

Utah mule deer migration corridors are viewable and available for download at the Utah Division of Wildlife Resources Wildlife Migration Initiative web page (UDWR, 2025). Data used in this report may be made available upon request by contacting Utah Division of Wildlife Resources.
   Project contacts:
   - Makeda Hanson (makedatrujillo@utah.gov), Wildlife Migration Initiative Coordinator, Utah Division of Wildlife Resources

   Data analyst:
   - Amy Ehrhart, Wildlife Migration Data Specialist, Utah Division of Wildlife Resources

Photograph from Scott Gibson, Utah Division of Wildlife Resources.
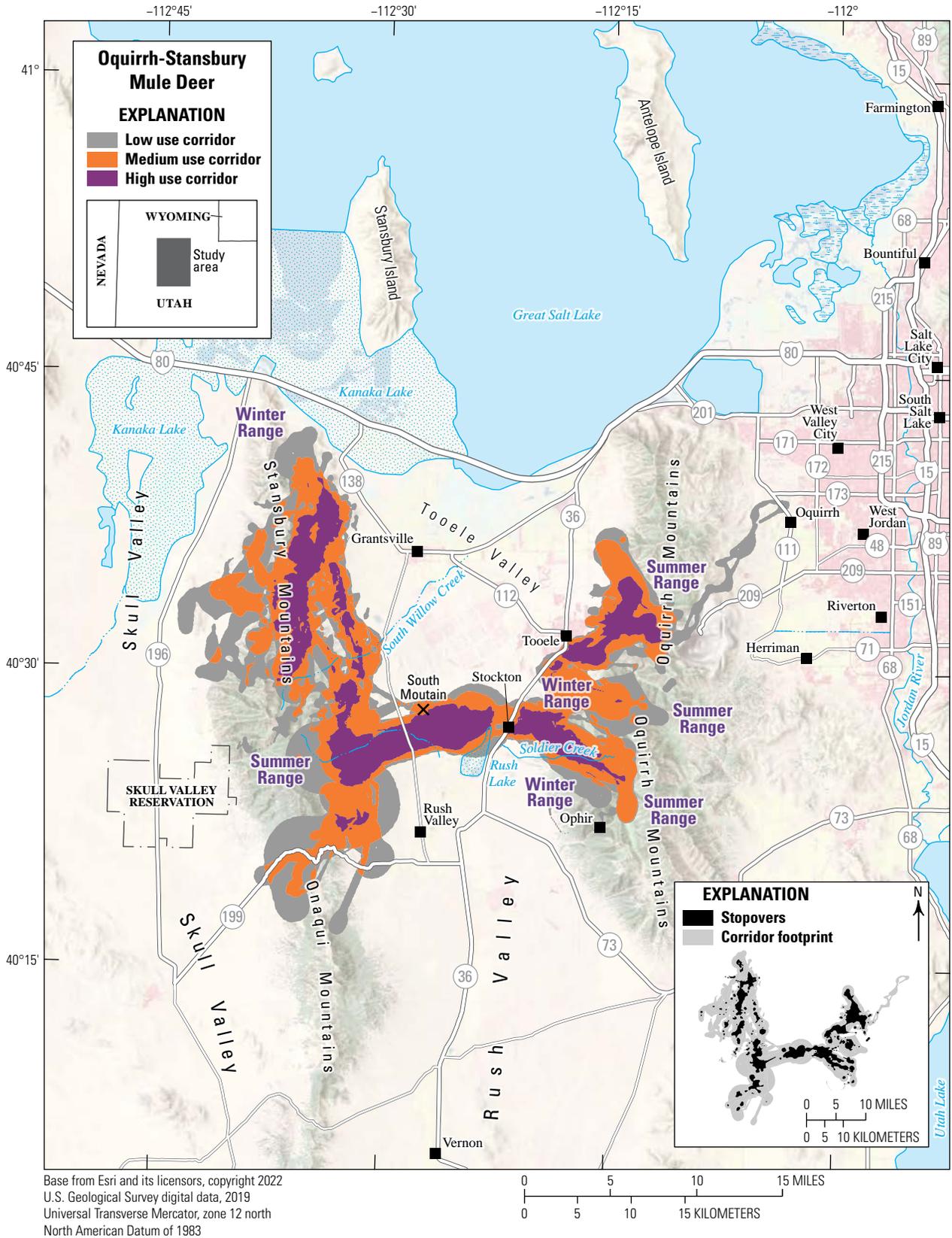
Figure 15.   Map showing migration corridors and stopovers of the Oquirrh-Stansbury mule deer herd.

Utah | Mule Deer

Oquirrh-Stansbury Mule Deer

The Oquirrh-Stansbury mule deer herd inhabits the Oquirrh-Stansbury WMU in north-central Utah, south of the Great Salt Lake (fig. 15). The WMU includes parts of Salt Lake City, Tooele, Grantsville, and Stockton, Utah, and two mountain ranges: the Stansbury Mountains to the west and the Oquirrh Mountains to the east. It encompasses 449,582 acres (181,939 ha) of mule deer range and has approximately 9,900 mule deer (UDWR, 2023a). Landownership is a mix of private (38.2 percent summer range, 38.6 percent winter range), BLM (27.3 percent summer range, 31.3 percent winter range), and FS (28.8 percent summer range, 7.2 percent winter range) lands (UDWR, 2023a). In the fall, deer migrate from high-elevation summer ranges to low-elevation winter ranges surrounding the Stansbury and Oquirrh Mountains. A small part of the winter habitat and migration corridors overlap with developed areas in the WMU. On the west side of the unit, habitat consists primarily of shrubland (36 percent) and a mix of mostly developed, agricultural, open water, and sparsely vegetated areas (24 percent; Payne and others, 2021). On the east side of the WMU, only 23 percent of the habitat is shrubland, and 57 percent is a mix of developed, agricultural, open water, and sparsely vegetated areas (Payne and others, 2021). The herd faces several challenges, including winter range habitat conditions and habitat degradation and loss due to housing development, mining, and pinyon-juniper encroachment on sagebrush rangelands (Payne and others, 2021). Additionally, deer fences and crossings may limit deer ranges, emphasizing the importance of agency collaborations to ensure habitat access for deer and human safety (Payne and others, 2021). The UDWR uses the GPS collar data of this population to monitor mule deer survival, describe migration corridors, and identify crucial habitats.

Animal Capture and Data Collection

Sample size: 90 adult mule deer (22 males, 68 females)
Relocation frequency: Approximately 2–24 hours
Project duration: 2016–21

Data Analysis

Corridor and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) and Fixed Motion Variance (McKee and others, 2024; app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 239 sequences from 90 individuals (126 spring sequences, 113 fall sequences)

Migration use classifications:
- Low: Used 0–25 percent of the individuals
- Medium: Used by 25–75 percent of the individuals
- High: Used by >75 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 23 to May 2
- Fall: December 19 to January 7

Number of days migrating (mean):
- Spring: 12 days
- Fall: 15 days

Migration corridor length:
- Minimum: 1.31 mi (2.11 km)
- Mean: 7.32 mi (11.78 km)
- Maximum: 17.11 mi (27.54 km)

Migration corridor area:
- Low use: 176,345 acres (71,364 ha)
- Medium use: 110,787 acres (44,834 ha)
- High use: 40,029 acres (16,199 ha)
- Stopover area: 43,485 acres (17,598 ha)

Other Information

Utah mule deer migration corridors are viewable and available for download at the Utah Division of Wildlife Resources Wildlife Migration Initiative web page (UDWR, 2025). Data used in this report may be made available upon request by contacting Utah Division of Wildlife Resources.
Project contacts:
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Data analyst:
- Amy Ehrhart, Wildlife Migration Data Specialist, Utah Division of Wildlife Resources


Photograph from Makeda Hanson, Utah Division of Wildlife Resources.
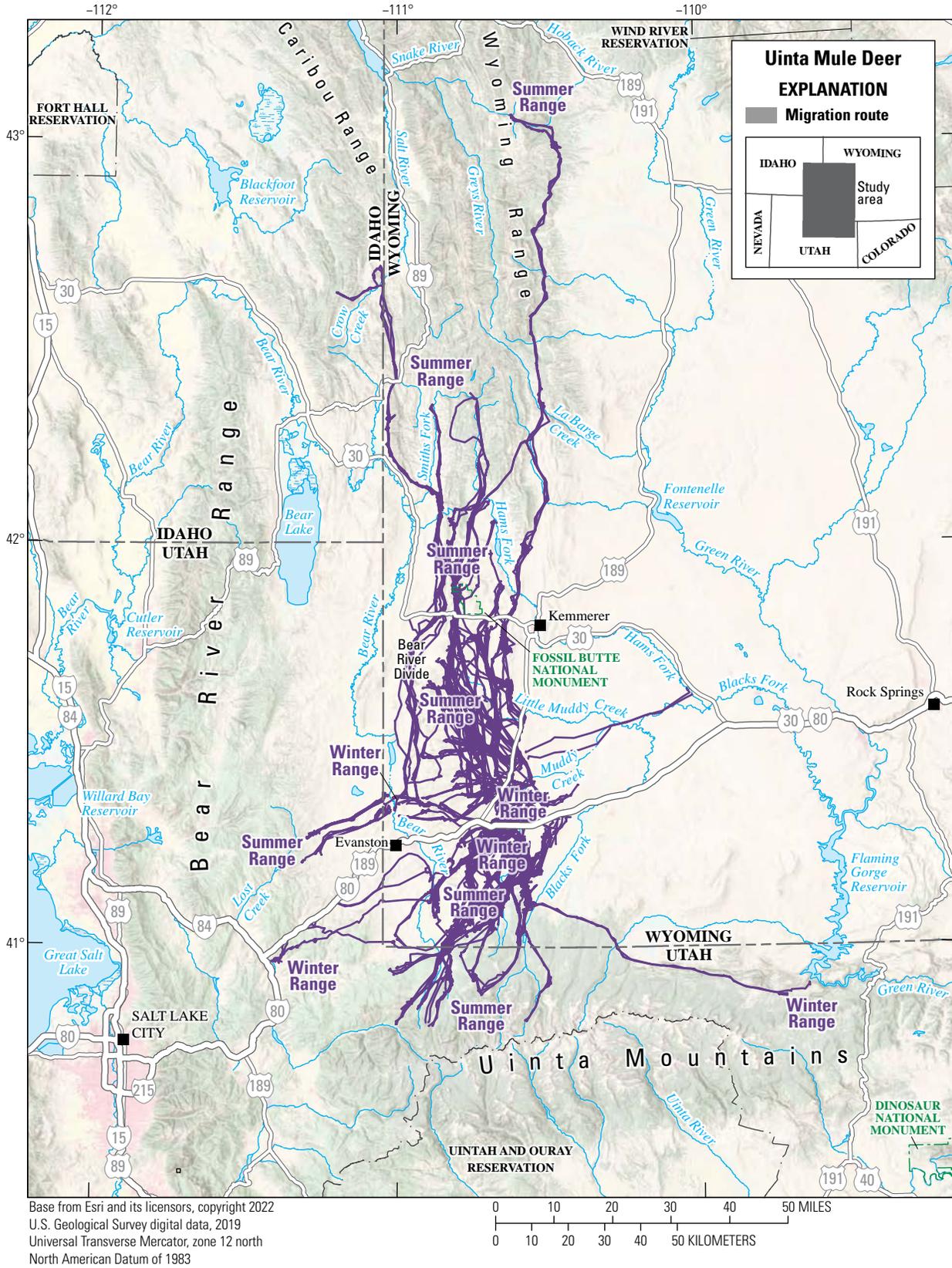
Figure 16.   Map showing migration routes of the Uinta mule deer herd.

Wyoming | Mule Deer

Uinta Mule Deer

Between 2021 and 2024, the Wyoming Cooperative Fish and Wildlife Research Unit at the University of Wyoming and the Wyoming Game and Fish Department (WGFD) conducted a GPS-collaring study to further understand the movement patterns and habitat use of mule deer near Evanston, Wyoming (fig. 16). To gain additional insight into the potential effects of U.S. Highway 189 and Interstate 80 on deer movements, wildlife cameras were used to monitor crossing structures along these highways. Almost 7,000 deer crossings were documented during the winter of 2021–22. New underpasses and a potential overpass to mitigate WVCs are planned for the section of U.S. Highway 189 north of its intersection with Interstate 80. The GPS-collar data collected from this study will likely be used to help the Wyoming Department of Transportation and other agency partners appropriately site these crossing structures to conserve mule deer migrations and reduce WVCs.

Most of the mule deer in the Uinta herd winter in the flats and hills to the north, east, and south of the intersection of U.S. Highway 189 and Interstate 80. Winter range is characterized by *Juniperus osteosperma* (Utah juniper) and sagebrush species, including *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush) that occupies most upland sites, *Artemisia tridentata* ssp. *tridentata* (basin big sagebrush) in ephemeral drainages and terraces adjacent to riparian areas, *Artemisia arbuscula* ssp. *longiloba* (early sagebrush) in upland sites with clay soils, and *Artemisia nova* (black sagebrush) on shallow soil and gravelly sites. Migrations of these mule deer extend from their winter ranges north into the Wyoming Range, west into the foothills of northeastern Utah, and south into the foothills of the Uinta Mountains. During migration, mule deer must navigate linear barriers such as Interstate 80, U.S. Highway 189, and Wyoming State Highway 89, which can lead to WVCs. Mule deer summer ranges along the Bear River Divide, foothills of the Uinta Mountains, and lower elevations of the Wyoming Range comprise mixed mountain shrubs and aspen habitat. Mountain shrub species consist of *Artemisia tridentata* ssp. *vaseyana* (mountain big sagebrush), *Purshia tridentata* (antelope bitterbrush), *Amelanchier alnifolia* (western serviceberry), *Cercocarpus montanus* (true mountain mahogany), and *Symphoricarpos albus* (common snowberry). Healthy aspen understories include species such as *Geranium viscosissimum* (sticky geranium), *Ligusticum porteri* (Porter's licorice-root), *Elymus glaucus* (blue wildrye),

and *Bromus marginatus* (mountain brome). High-elevation summer ranges comprise conifer stands as well as tall forb and alpine meadow communities.

Animal Capture and Data Collection

Sample size: 116 adult female mule deer
Relocation frequency: Approximately 2 hours
Project duration: 2021–24

Data Analysis

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011; app. 1)
Models derived from:
- Migration: 336 sequences from 97 individuals (173 spring sequences, 163 fall sequences)

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 30 to May 8

- Fall: November 13 to December 3

Number of days migrating (mean):
- Spring: 10 days

- Fall: 11 days

Migration corridor length:
- Minimum: 4.52 mi (7.27 km)
- Mean: 21.95 mi (35.33 km)
- Maximum: 109.68 mi (176.51 km)

Other Information

Project contacts:
- Matthew Kauffman (mkauffm1@uwyo.edu), U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming

- Sean Yancey (sean.yancey@wyo.gov), Wildlife Management Coordinator, Wyoming Game and Fish Department

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- Bill Rudd (billrudd2@gmail.com), Project Manager and Cofounder, Wyoming Migration Initiative

Data analyst:
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Photograph from Gregory Nickerson, Wyoming Migration Initiative.
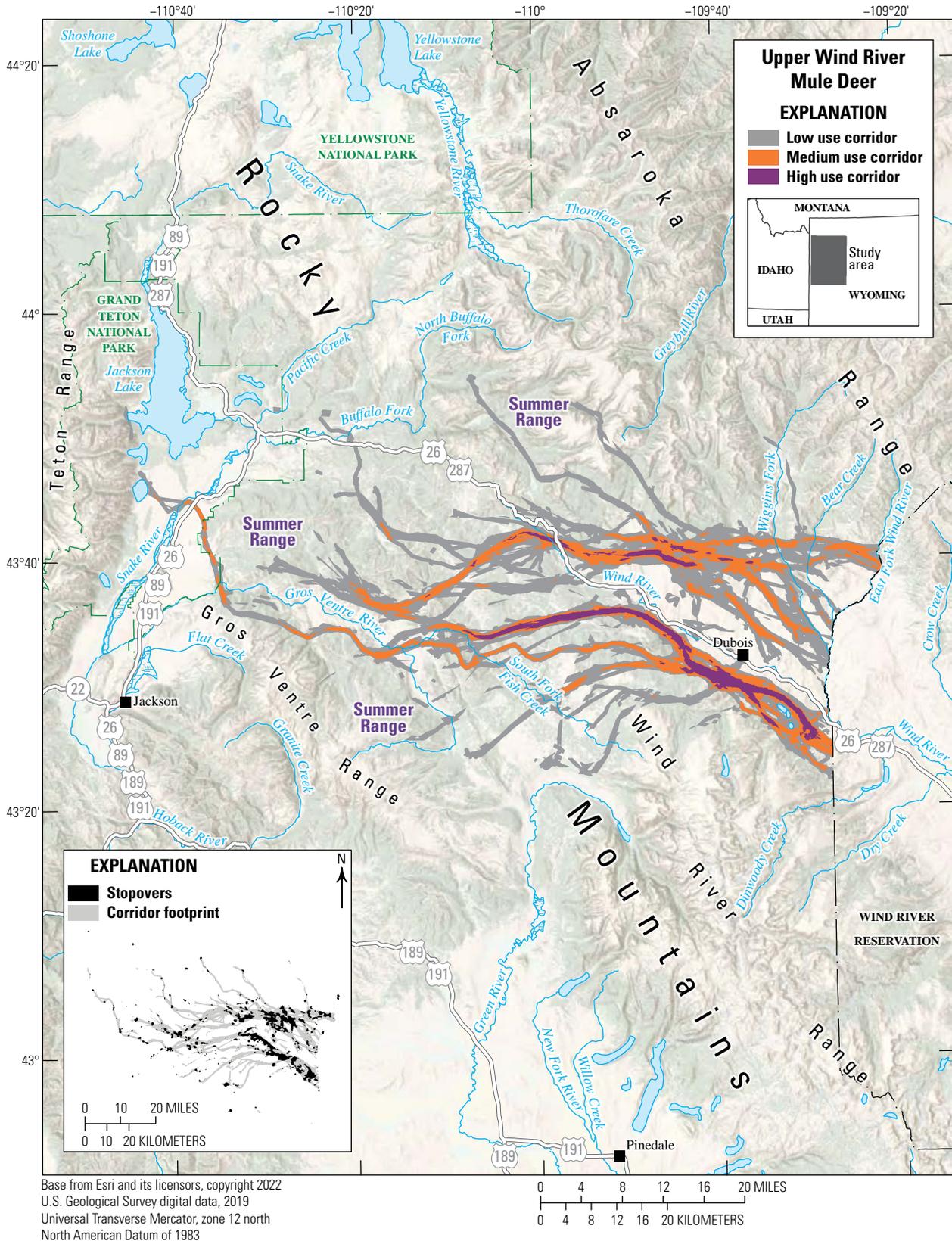
Figure 17. Map showing Wyoming Game and Fish Department's identified migration corridor of the Upper Wind River mule deer. The identified corridor ends at the reservation boundary to respect the sovereignty of the Eastern Shoshone Tribe of the Wind River Reservation, Wyoming, and Northern Arapaho Tribe of the Wind River Reservation, Wyoming.

Wyoming | Mule Deer

Upper Wind River Mule Deer

The Upper Wind River mule deer herd is a larger aggregate of the Dubois, Wind River, and Owl Creek herds, which were included in previous volumes of the report series (Kauffman and others, 2020a, 2022a). Upper Wind River deer migrate varying distances, ranging from 5 to 90 mi (8 to 144 km) between their winter and summer ranges. Short-distance migrations are largely elevational from winter ranges on the lowlands along the Wind River to summer ranges in the Wind River Range (fig. 17). Many deer migrate longer distances into the heart of the Greater Yellowstone Ecosystem, including Yellowstone and Grand Teton National Parks. Mule deer in this migration corridor winter on habitats in the upper Wind River valley under the jurisdiction and sovereignty of the Eastern Shoshone Tribe of the Wind River Reservation, Wyoming, and Northern Arapaho Tribe of the Wind River Reservation, Wyoming (hereafter Wind River Reservation) and surrounding State, Federal, and private lands. Winter ranges are a mix of shrubs, herbaceous grasslands, riparian habitats, and mixed vegetation types associated with agriculture. Summer ranges on the surrounding national forests and national parks are predominantly *Pinus contorta* (lodgepole pine) montane forests with smaller areas of open herbaceous sagebrush–grasslands, and subalpine forests and grasslands at higher elevations in the Teton Range.

Though the herd has declined, it is one of the few mule deer herds in the State that has not experienced a large decline in recent decades. This relative stability of the herd may be partly because the herd continues to use intact migration routes and winter ranges each year, as it has for generations. Winter ranges and the migrations of this herd often cross U.S. Highway 26/287, which is the highest priority area in Wyoming for reducing WVCs (Wyoming Wildlife and Roadways Initiative, 2019). Additionally, part of the larger herd moves through residential subdivisions near Dubois, Wyoming, including undeveloped private lands. Recognizing the value of this migration, regional partners have collaborated to collect GPS data and track the herd's movements. In 2024, the WGFD identified the migration corridor as part of Governor Gordon's Migration Corridor Executive Order 2020–1 (State of Wyoming, 2020). Although the Wind River Reservation provides critical winter, migratory, and stopover habitat, the WGFD's identified corridor ends at the reservation boundary to respect the sovereignty of the Tribes. Volumes 1 and 2 of the report series (Kauffman and others, 2020a, 2022a) detail the full migration routes of the three separate herds, including the routes through the Wind River Reservation.

Animal Capture and Data Collection

Sample size: 147 adult mule deer
Relocation frequency: Approximately 2 hours
Project duration: 2014–23

Data Analysis

Corridor analysis: Line buffer method using 984 ft (300 m) buffer (Merkle and others, 2023)
Stopover analysis: Brownian bridge movement models (Sawyer and others, 2009)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011; app. 1)
Models derived from:
- Migration: 494 sequences from 147 individuals (265 spring sequences, 229 fall sequences)

Migration use classifications:
- Low: Used by at least two individuals
- Medium: Used by 10–20 percent of the individuals
- High: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: May 22 to June 7
- Fall: October 15 to November 5

Number of days migrating (mean):
- Spring: 19 days
- Fall: 23 days

Migration corridor length:
- Minimum: 5.00 mi (8.05 km)
- Mean: 33.78 mi (54.36 km)
- Maximum: 91.03 mi (146.50 km)

Migration corridor area:
- Low use: 312,866 acres (126,612 ha)
- Medium use: 92,099 acres (37,271 ha)
- High use: 20,484 acres (8,290 ha)
- Stopover area: 81,047 acres (32,799 ha)

Other Information

Project contacts:
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Data analyst:
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Photograph from Gregory Nickerson, Wyoming Migration Initiative.

Reports and Publications:

- Wyoming Game and Fish Department, 2024, Wyoming Game and Fish Department migration corridor threat evaluation worksheet—Upper Wind River mule deer: Cheyenne, Wyo., Wyoming Game and Fish Department, 8 p. [Also available at https://wgfd.wyo.gov/sites/default/files/2024-06/ThreatEvaluation_UpperWindRiverMD_FinalDraft.pdf.]

Photograph from Patrick Rodgers, Wyoming Migration Initiative.
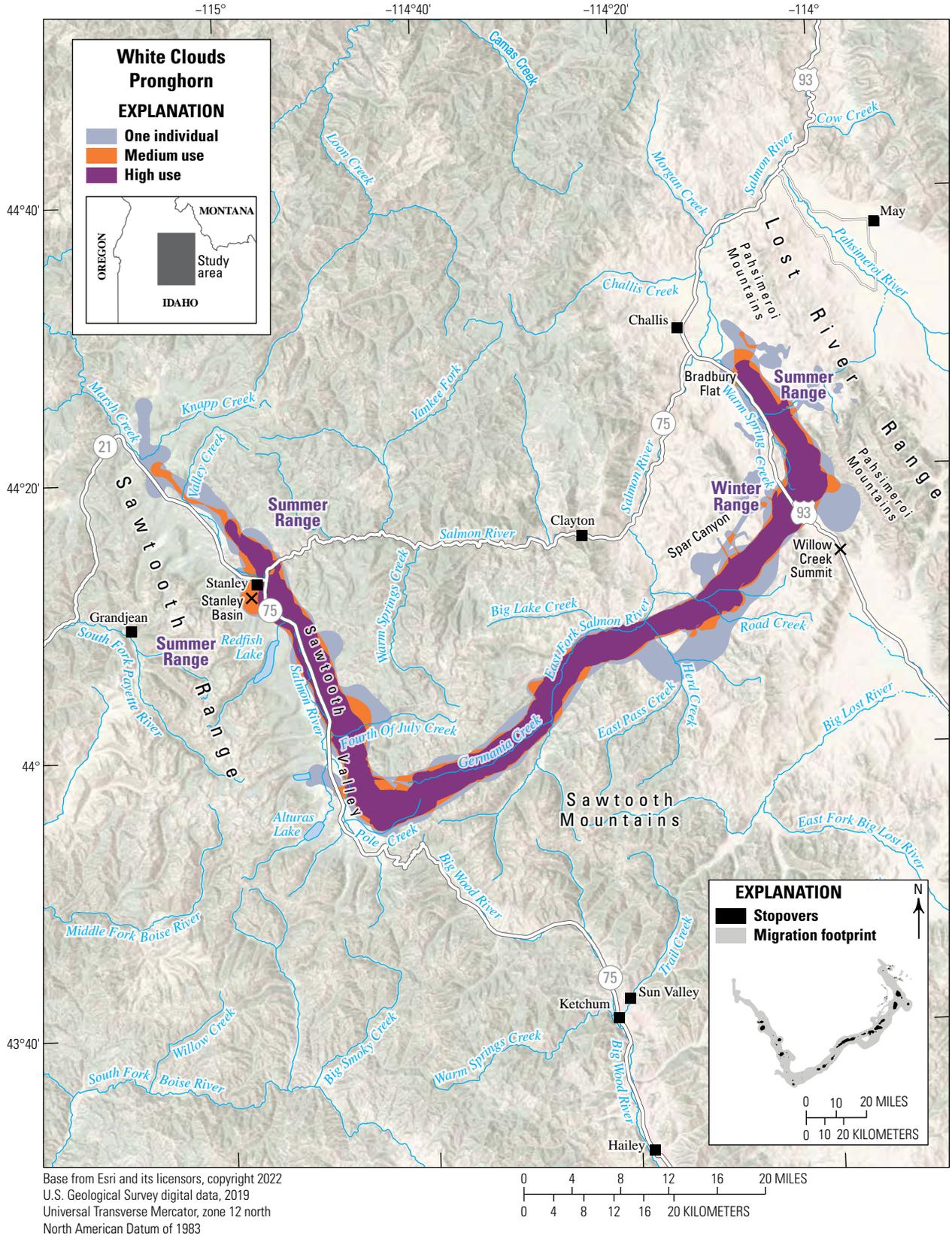
Figure 18.   Map showing migration routes and stopovers of the White Clouds pronghorn herd.

Idaho | Pronghorn

White Clouds Pronghorn

The White Clouds pronghorn herd winter range runs from Willow Creek Summit to Bradbury Flat and extends to the south to Spar Canyon. Pronghorn concentrate on both sides of U.S. Highway 93 between Willow Creek Summit and Bradbury Flat in winter (fig. 18). This area is mostly public land (BLM) with some private properties along U.S. Highways 93 and 75. The winter range comprises broad, flat sagebrush-steppe at lower elevations and rolling, sagebrush-covered hills from Bradbury Flat to Road Creek. Snow accumulation is light during most winters with occasional short periods of deeper snow, generally later in winter (late January–February). Pronghorn concentrations vary depending on snow depth and winter severity. White Clouds pronghorn have two main migration styles. Most pronghorn wintering here migrate to the west along a narrow corridor following the East Fork Salmon River, Germania Creek, and Pole Creek to the Sawtooth Valley south of Stanley, Idaho. Once in the Stanley Basin, an unknown number of individuals stay south of Stanley, whereas others continue northwest into Valley Creek and upper Marsh Creek. This migration is likely the highest elevation pronghorn migration in North America (8,480 ft [2,585 m]). The summer range in the Sawtooth Valley, Valley Creek, and Marsh Creek receives abundant precipitation and comprises meadows and sagebrush-steppe with high-quality forage. The other, much shorter, migration routes are either limited elevational migrations to the northeast to the Lost River Range or to the southwest to the Road and Herd Creeks area. Barriers to this migration include wildlife-unfriendly fencing along the route and a long stretch of heavily forested habitat that pronghorn pass through, which increases the risk of predation by mountain lions, black bears, *Canis lupus* (gray wolves), and *Canis latrans* (coyotes). The White Clouds pronghorn herd faces unique challenges throughout the year. On summer range, increased development in the Sawtooth Valley and a concurrent increase in fences impede movements and access to forage; on the eastern part of the migration route, an increase in nonnative annual grasses (*Bromus tectorum* [cheatgrass]) reduces forage quality; and on winter range, an increasing feral horse population competes for forage and water resources.

Animal Capture and Data Collection

Sample size: 13 adult female pronghorn
Relocation frequency: 4 hours
Project duration: 2020–24

Data Analysis

Migration route and stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) with an 8-hour time lag
Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)
Models derived from:
- Migration: 22 sequences from 13 individuals

(5 spring sequences, 17 fall sequences)

Migration use classifications:
- One individual: Used by one individual
- Medium: Used by 2 individuals to 20 percent of the individuals
- High: Used by >20 percent of the individuals

Migration route and Stopover Summary

Migration start and end dates (median):
- Spring: March 30 to April 25
- Fall: October 10 to October 19
Number of days migrating (mean):
- Spring: 31 days
- Fall: 13 days
Migration route length:
- Minimum: 13.81 mi (22.23 km)
- Median: 57.08 mi (91.86 km)
- Maximum: 105.05 mi (169.06 km)
Migration route area:
- One individual: 238,809 acres (96,643 ha)
- Medium use: 149,957 acres (60,686 ha)
- High use: 122,405 acres (49,536 ha)
- Stopover area: 19,308 acres (7,814 ha)

Other Information

Idaho migration routes are updated and viewable by Idaho Department of Fish and Game (Idaho Department of Fish and Game, 2024). Mapping layers shown for this herd are sensitive but may be made available to researchers upon request by contacting Idaho Department of Fish and Game (idfgdatarequests@idfg.idaho.gov).
Project contacts:
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Photograph from Idaho Department of Fish and Game.
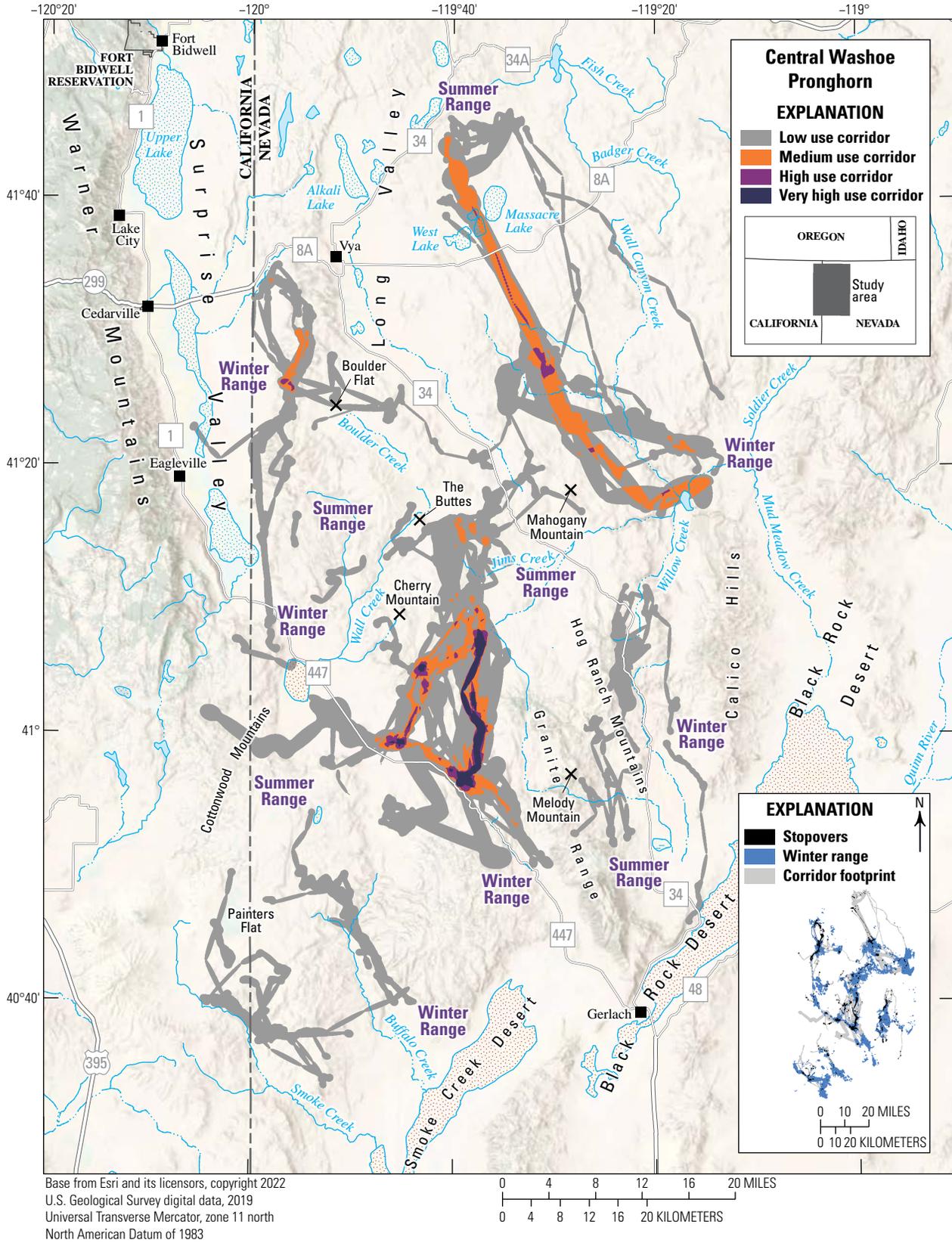
Figure 19.   Map showing migration corridors, stopovers, and winter ranges of the Central Washoe pronghorn herd.

Nevada | Pronghorn

Central Washoe Pronghorn

Central Washoe pronghorn use a network of interconnected migration corridors and seasonal ranges (fig. 19). Pronghorn summering east of Long Valley migrate south to winter ranges on Mahogany Mountain and the Calico Hills, where they overlap with pronghorn that summer near The Buttes. Pronghorn summering by Cherry Mountain also use Mahogany Mountain and areas near Nevada Route 447 during winter; some pronghorn travel long distances to use both locations during the same season. One pronghorn dispersed from the Calico Hills to Melody Mountain in early 2020, overlapping with other wintering pronghorn that summer near Granite Range and Hog Ranch Mountain. Pronghorn wintering by Boulder Flat have summer ranges to the southwest of Long Valley and near Surprise Valley, California. Other pronghorn wintering north of Nevada Route 447 migrate south to summer near the Cottonwood Mountains in California, temporarily overlapping with pronghorn that winter near the Smoke Creek Desert, and use additional summer ranges surrounding Painters Flat, California. Habitat primarily consists of shrub-steppe intermixed with grassland. Big sagebrush and basin big sagebrush dominate low altitudes, transitioning to Wyoming big sagebrush, followed by *A. arbuscula* (low sagebrush) and mountain big sagebrush as elevation increases.

Challenges to this herd include invasive annual grasses and *Juniperus occidentalis* (western juniper) encroachment, potential competition with feral horses, unpermitted livestock grazing on some BLM allotments, and livestock fences that inhibit efficient movement. Several habitat improvement projects have been implemented in Central Washoe County, Nevada. The Horse Canyon Spring protection project installed pipe-rail fencing to protect more than 8.75 acres (3.54 ha) of degraded springs and the Cherry Spring protection project preserved 20 acres (8.09 ha) of riparian habitat along a prominent pronghorn migration route on private land (NDOW, 2024). Additionally, the NDOW cooperated with the Winnemucca BLM Field Office to treat approximately 7,755 acres (3,138 ha) of burned native rangeland from the 2020 Poodle fire using an aerial herbicide application to reduce annual grass invasion and promote native vegetation growth.

Animal Capture and Data Collection

Sample size: 42 adult female pronghorn
Relocation frequency: Approximately 2–17 hours
Project duration: 2019–present (data through September 2023 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Brownian bridge movement models (Sawyer and others, 2009); corridor analysis used Fixed Motion Variance (11,840 ft^2 [1,100 m^2]; McKee and others, 2024) with a 48-hour time lag (app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:

- Migration: 150 sequences from 40 individuals (78 spring sequences, 72 fall sequences)
- Winter: 106 sequences from 42 individuals

Migration use classifications:

- Low: Used by at least one individual
- Medium: Used by 10–15 percent of the individuals
- High: Used by 15–20 percent of the individuals
- Very high: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):

- Spring: April 8 to April 12
- Fall: November 28 to December 2

Number of days migrating (mean):

- Spring: 6 days
- Fall: 5 days

Migration corridor length:

- Minimum: 1.68 mi (2.70 km)
- Mean: 13.05 mi (21.00 km)
- Maximum: 36.82 mi (59.26 km)

Migration corridor area:

- Low use: 418,307 acres (169,283 ha)
- Medium use: 61,278 acres (24,798 ha)
- High use: 14,280 acres (5,779 ha)
- Very high use: 6,802 acres (2,753 ha)
- Stopover area: 49,475 acres (20,022 ha)

Winter Range Summary

Winter start and end dates (median):

- December 3 to April 2
- Winter length (mean): 122 days
- Winter range (50 percent contour) area: 321,478 acres (130,098 ha)

Other Information

Project contacts:

- Don Whittaker (don.whittaker@odfw.oregon.gov), Ungulate Management Coordinator, Oregon Department of Fish and Wildlife
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- Cody Schroeder (cschroeder@ndow.org), Wildlife Staff Specialist, Nevada Department of Wildlife

Data analyst:

- Valerie Hinojoza-Rood, Faculty Research Assistant, Oregon State University

Reports and Publications:

- Collins, G.H., 2016, Seasonal distribution and routes of pronghorn in the northern Great Basin: Western North American Naturalist, v. 76, no. 1, p. 101–112. [Also available at https://scholarsarchive.byu.edu/wnan/vol76/iss1/10.]

Figure 20.   Map showing migration corridors, stopovers, and winter ranges of the Paulina pronghorn herd.

Oregon | Pronghorn

Paulina Pronghorn

Most of the Paulina pronghorn herd winter either near U.S. Highway 20 or Browns Valley; additional winter ranges are near Christmas Lake Valley and Alfalfa, Oregon (fig. 20). During spring, pronghorn use a complex network of migration corridors to reach summer ranges near West Butte, Mahogany Butte, Trail Butte, Bronco Butte, Stookey Flat, and the base of the Maury Mountains. The seasonal ranges of different pronghorn frequently overlapped, often with the same area used as either summer or winter range, depending on the individual. One pronghorn dispersed north almost 60 mi (97 km) to new seasonal ranges near Waterman Flat during the spring of 2018, crossing the Ochoco Mountains and U.S. Highway 26. In 2019, another pronghorn traveled south from winter range in Browns Valley until finally turning back at Oregon Route 140 and crossing U.S. Highway 395 twice in a 76-mi (122-km) round-trip movement.

Summer and winter ranges were dominated by shrubland with common species, including low sagebrush, big sagebrush, mountain big sagebrush, and Wyoming big sagebrush. Winter ranges contained more farmland and Columbia Basin grassland, and summer ranges contained more western juniper and ponderosa pine. U.S. Highway 20 bisects a major migration corridor and multiple seasonal ranges, which increases the risk of WVCs. One particularly high-use area occurs where the highway separates two fields of *Medicago sativa* (alfalfa) pivots near Hampton, Oregon. Paulina pronghorn were present in alfalfa pivots throughout the year, and individuals often incorporated the same pivot into summer and winter ranges. Paulina pronghorn occupy an area containing more than 995 mi (1,601 km) of known BLM fencing because of their range's proximity to residential and agricultural regions. On average, the straight-line paths of pronghorn intersected fences almost 148 times per animal per year. However, this value only incorporates mapped BLM fences and ignores instances where pronghorn approached fences but did not attempt to cross, likely underestimating the true effect on pronghorn behavior.

Animal Capture and Data Collection

Sample size: 53 adult female pronghorn
Relocation frequency: Approximately 5−13 hours

Project duration: 2017–23 (data through December 2023 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Brownian bridge movement models (Sawyer and others, 2009); corridor analysis used Fixed Motion Variance (11,840 ft^2 [1,100 m^2]; McKee and others, 2024) with a 48-hour time lag (app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:

- Migration: 178 sequences from 53 individuals (101 spring sequences, 77 fall sequences)

- Winter: 189 sequences from 53 individuals

Migration use classifications:

- Low: Used by at least one individual
- Medium: Used by 10–15 percent of the individuals
- High: Used by 15–20 percent of the individuals
- Very high: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):

- Spring: April 1 to April 9
- Fall: October 20 to October 24

Number of days migrating (mean):

- Spring: 7 days
- Fall: 5 days

Migration corridor length:

- Minimum: 1.14 mi (1.83 km)
- Mean: 12.34 mi (19.86 km)
- Maximum: 76.38 mi (122.92 km)

Migration corridor area:

- Low use: 900,150 acres (364,278 ha)
- Medium use: 47,767 acres (19,331 ha)
- High use: 11,704 acres (4,736 ha)
- Very high use: 2,226 acres (901 ha)
- Stopover area: 101,124 acres (40,923 ha)

Winter Range Summary

Winter start and end dates (median):

- October 25 to March 31
- Winter length (mean): 163 days
- Winter range (50 percent contour) area: 411,716 acres (166,616 ha)

Other Information

Project contacts:

- Don Whittaker (don.whittaker@odfw.oregon.gov), Ungulate Management Coordinator, Oregon Department of Fish and Wildlife

Data analyst:

- Valerie Hinojoza-Rood, Faculty Research Assistant, Oregon State University

Reports and Publications:

- Walch, A.J., Heath, C., Harju, S., and Whittaker, D.G., 2022, Seasonal resource selection by pronghorn in central Oregon, *in* Western States and Provinces Pronghorn Workshop, 29th, Deadwood, South Dakota, August 22–25, 2022, Proceedings: Western Association of Fish and Wildlife Agencies, p. 51–63. [Also available at https://wafwa.org/wp-content/uploads/2024/04/WAFWA-Pronghorn_Workshop_Proceedings_2022.pdf.]

Figure 21.   Map showing migration corridors, stopovers, and winter ranges of the Sheldon-Hart Mountain pronghorn herd.

Oregon and Nevada | Pronghorn

Sheldon-Hart Mountain Pronghorn

Sheldon-Hart Mountain pronghorn traverse northwest Nevada and southeast Oregon (fig. 21). First published in Kauffman and others (2022a), this updated analysis includes 8 years of additional GPS data from 51 pronghorn. Winter ranges are as far north as Catlow Valley, Oregon, and as far south as the Black Rock Desert, Nevada. Winter range use depends on winter conditions, and almost half the Sheldon-Hart Mountain pronghorn travel to additional winter ranges in more severe winters. The highest use midwinter migration corridors occur between Sage Hen Flats and Big Spring Table, and the highest use spring and fall migration corridors occur between Sage Hen Flats and Little Juniper Mountain. Core summer ranges are near Duhaime Flat, Hart Mountain, Little Juniper Mountain, and Catnip Mountain. One pronghorn traveled 86.5 mi (139 km) to a new range during summer in 2016 before returning to its previous location within the same season. This herd is affected by invasive grasses, habitat loss, juniper encroachment, severe droughts, fences, and WVCs along Oregon/Nevada Route 140. Wildfires in summer range, such as the 2019 Poker fire and the 2024 Warner Peak fire, also spread invasive grasses in areas without sufficient shrub cover.

Animal Capture and Data Collection

Sample size: 82 adult female pronghorn
Relocation frequency: Approximately 2−17 hours
Project duration: 2011–13, 2015–17, and 2019–23 (data through September 2023 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Brownian bridge movement models (Sawyer and others, 2009); corridor analysis used Fixed Motion Variance (11,840 ft^2 [1,100 m^2]; McKee and others, 2024) with a 48-hour time lag (app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:
- Migration (midwinter): 85 sequences from 36 individuals (53 early midwinter sequences, 32 late midwinter sequences)
- Migration (spring and fall): 236 sequences from 75 individuals (123 spring sequences, 113 fall sequences)
- Winter: 272 sequences from 80 individuals

Migration use classifications:
- One individual: used by at least one individual
- Low: used by two individuals to less than 5 percent of the individuals
- Medium: used by 5–10 percent of the individuals
- High: used by 10–20 percent of the individuals
- Very high: Used by >20 percent of the individuals

Corridor and Stopover Summary (Midwinter)

Migration start and end dates (median):
- Early midwinter: December 22 to December 29
- Late midwinter: February 14 to February 24

Number of days migrating (mean):
- Early midwinter: 8 days
- Late midwinter: 5 days

Migration corridor length:
- Minimum: 2.38 mi (3.83 km)
- Mean: 22.13 mi (35.61 km)
- Maximum: 80.72 mi (129.91 km)

Corridor and Stopover Summary (Spring and Fall)

Migration start and end dates (median):
- Spring: March 25 to March 31
- Fall: November 2 to November 4

Number of days migrating (mean):
- Spring: 6 days
- Fall: 6 days

Migration corridor length:
- Minimum: 1.23 mi (1.98 km)
- Mean: 8.98 mi (14.45 km)
- Maximum: 36.71 mi (59.08 km)

Migration corridor area (combined):
- One individual: 1,588,528 acres (642,854 ha)
- Low use: 834,506 acres (337,713 ha)
- Medium use: 390,203 acres (157,910 ha)
- High use: 120,352 acres (48,705 ha)
- Very high use: 9,849 acres (3,986 ha)
- Stopover area: 175,662 acres (71,088 ha)

Winter Range Summary

Winter start and end dates (median):
- November 5 to March 21
- Winter length (mean): 138 days
- Winter range (50 percent contour) area: 679,828 acres (275,117 ha)

Other Information

Project contacts:
- Don Whittaker (don.whittaker@odfw.oregon.gov), Ungulate Management Coordinator, Oregon Department of Fish and Wildlife
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Data analyst:
- Valerie Hinojoza-Rood, Faculty Research Assistant, Oregon State University

Photograph from Charlotte Ganskopp, Oregon Department of Fish and Wildlife.

Reports and Publications:

- Collins, G.H., 2016, Seasonal distribution and routes of pronghorn in the northern Great Basin: Western North American Naturalist, v. 76, no. 1, p. 101–112. [Also available at https://scholarsarchive.byu.edu/wnan/vol76/iss1/10.]
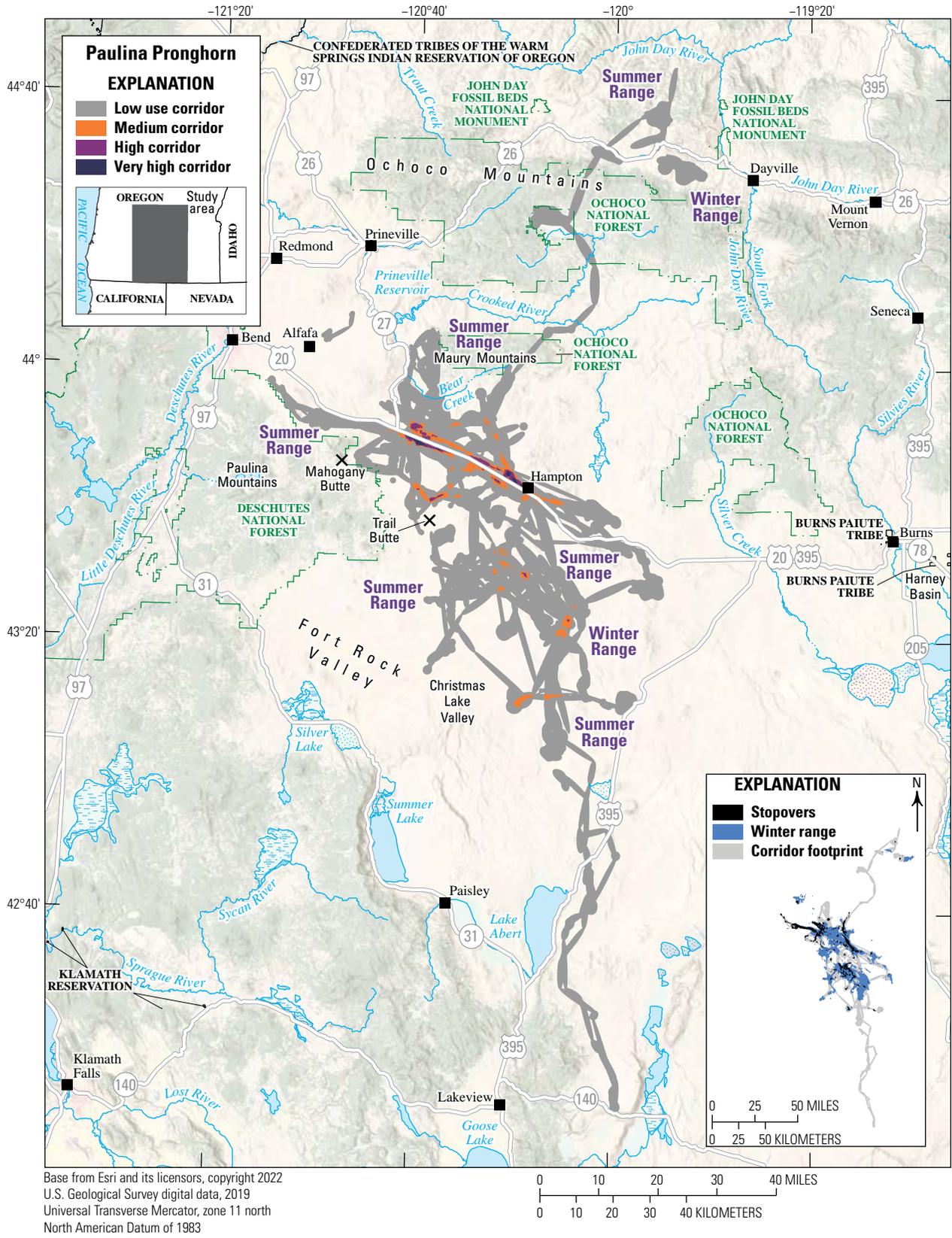
- Larkins, A., Harju, S., and Whittaker, D.G., 2019, Pronghorn migration and survival—A statistical analysis of a southeastern Oregon population, *in* Wakeling, B.F., and Schroeder, C., eds., Learning from the past—Adapting for the future, v. 28 *of* Western United States and Provinces Biennial Pronghorn Workshop, 28th, Reno, Nev., 2018, [Proceedings]: Western Association of Fish and Wildlife Agencies, p. 19–28. [Also available at https://wafwa.org/wp-content/uploads/2020/09/Pronghorn-Proceedings-Final-2019.pdf.]
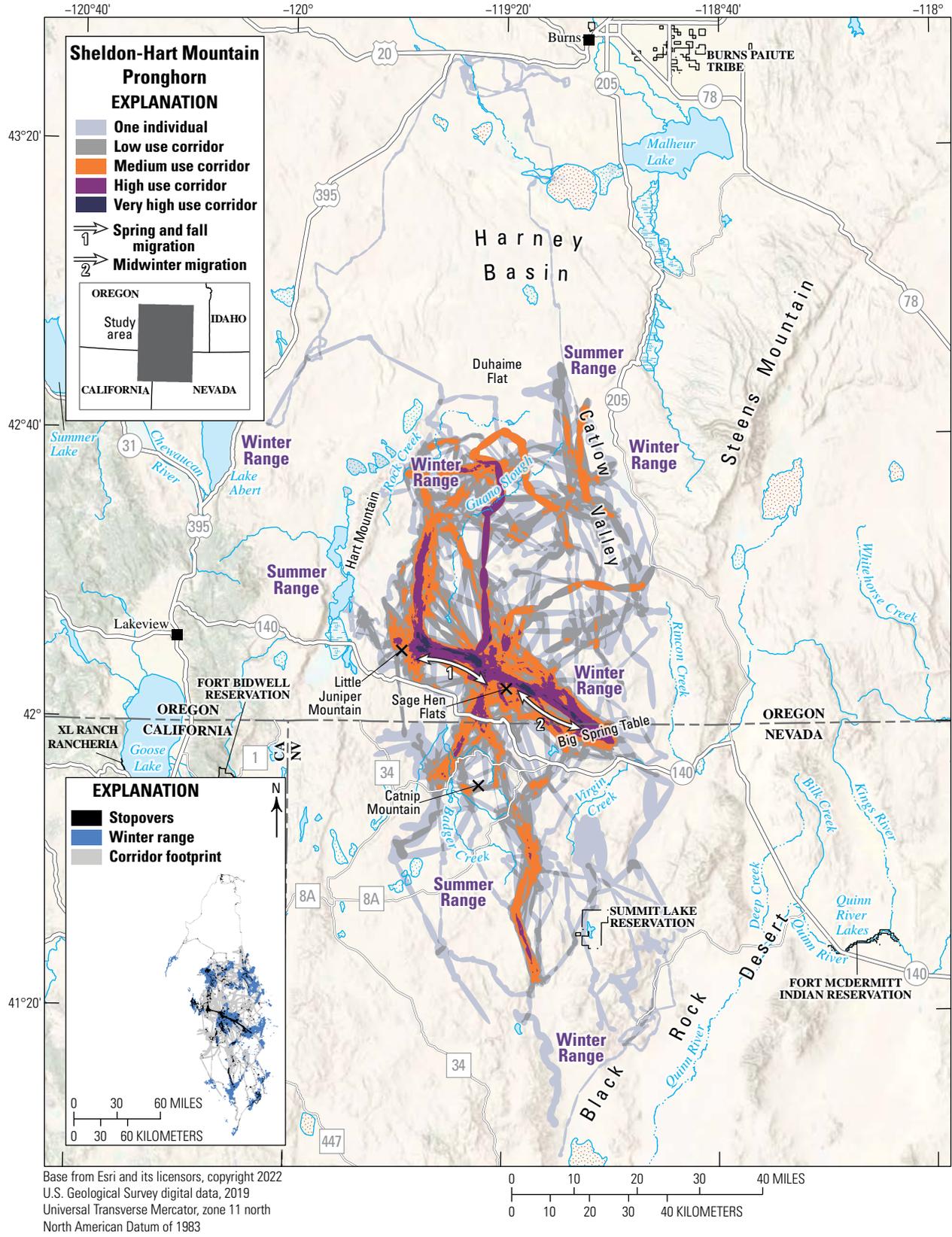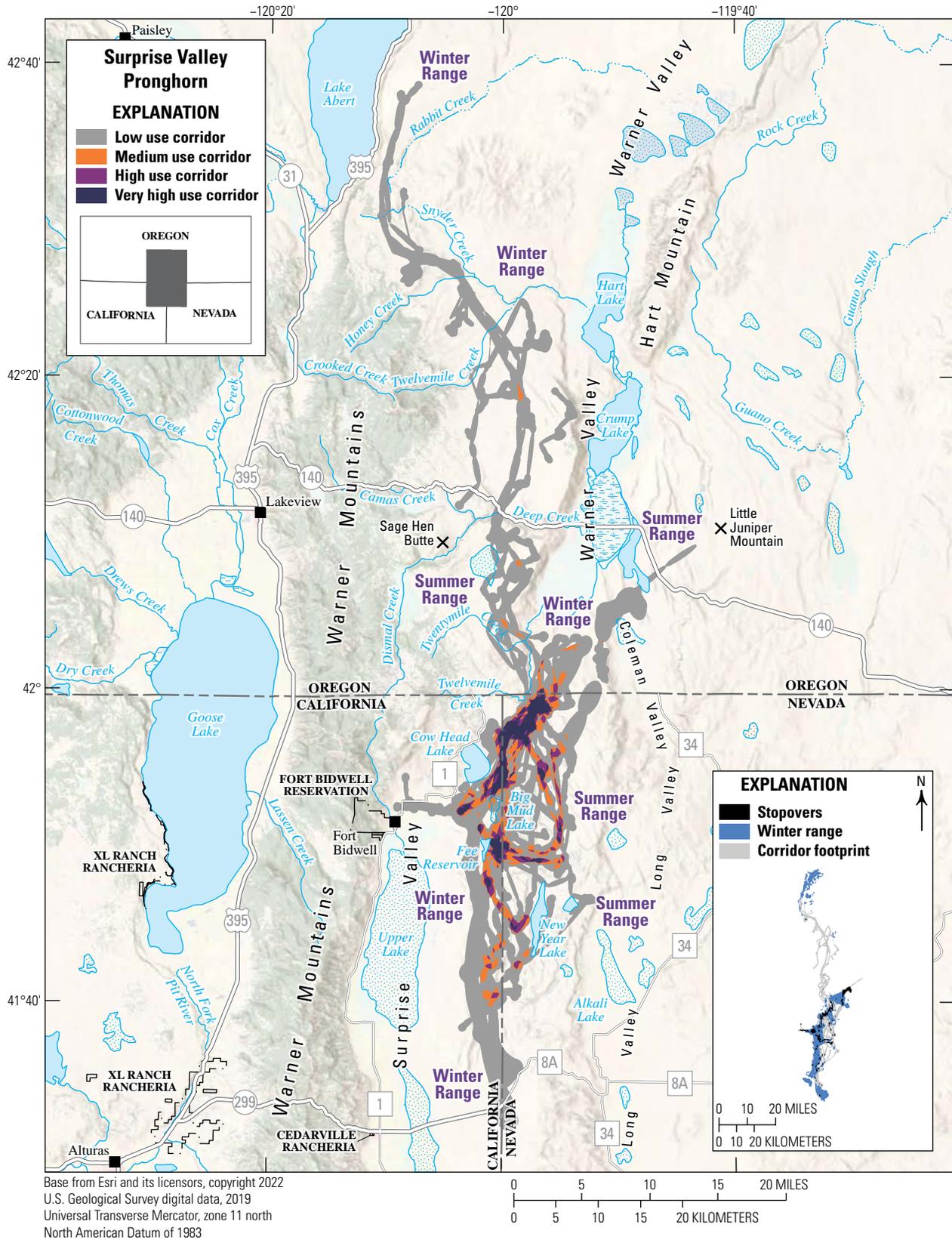
Figure 22. Map showing migration corridors, stopovers, and winter ranges of the Surprise Valley pronghorn herd.

Oregon, Nevada, and California | Pronghorn

Surprise Valley Pronghorn

The Surprise Valley pronghorn herd crosses Oregon, Nevada, and California, primarily occupying shrub-steppe communities containing low sagebrush, big sagebrush, and mountain big sagebrush with mixed-conifer forests at some higher elevations. Most pronghorn use winter ranges near Lake Abert and Warner Valley in Oregon and the northeast edge of Surprise Valley in California (fig. 22). Individual seasonal ranges often extend over large areas; some pronghorn travel along Surprise Valley or move between Surprise Valley and Warner Valley during the winter. Summer ranges are near Oregon Route 140, Coleman Valley, Sage Hen Butte, the northwestern rim of Long Valley, and Fort Bidwell, California. In comparison to winter ranges, summer ranges include more mountain big sagebrush and wetland habitats. Summer ranges in higher elevations also contain sections of encroaching western juniper and several low-elevation seasonal ranges around Surprise Valley and Coleman Valley that overlap agricultural areas. Multiple pronghorn migrate across, or have summer ranges adjacent to, Oregon Route 140, which increases the risk of WVCs.

In Oregon, the Surprise Valley herd inhabits the Warner WMU, which has benefited from multiple habitat mitigation projects. Since 2010, more than 49,940 acres (20,210 ha) of western juniper were removed, 13,568 acres (5,491 ha) were treated to eliminate invasive plants, 13,002 acres (5,262 ha) of prescribed burns were completed, and 1,702 acres (689 ha) were reseeded with shrubs and grasses (Oregon Department of Fish and Wildlife, 2015, 2020). In 2023, the NDOW cooperated with the BLM Applegate Field Office to complete a 5.7-mi (9.2-km) fence improvement project that benefitted pronghorn migrating across the Nevada and California State boundary fence near Big Mud Lake and Fee Reservoir (NDOW, 2024). The transboundary nature of this herd will potentially require cooperation among Oregon, Nevada, and California State agencies and stakeholders to ensure migration corridors are unimpeded and seasonal ranges are protected.

Animal Capture and Data Collection

Sample size: 27 adult female pronghorn
Relocation frequency: Approximately 2−13 hours
Project duration: 2015–17 and 2019–23 (data through September 2023 analyzed for this report)

Data Analysis

Corridor, stopover, and winter range analysis: Brownian bridge movement models (Sawyer and others, 2009); corridor analysis used Fixed Motion Variance (11,840 ft^2 [1,100 m^2]; McKee and others, 2024) with a 48-hour time lag (app. 1)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:
- Migration: 90 sequences from 24 individuals (53 spring sequences, 37 fall sequences)
- Winter: 83 sequences from 27 individuals

Migration use classifications:

- Low: Used by at least one individual
- Medium: Used by 10–15 percent of the individuals
- High: Used by 15–20 percent of the individuals
- Very high: Used by >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: April 11 to April 13
- Fall: October 25 to October 26

Number of days migrating (mean):
- Spring: 2 days
- Fall: 4 days

Migration corridor length:
- Minimum: 1.23 mi (1.98 km)
- Mean: 8.98 mi (14.45 km)
- Maximum: 36.71 mi (59.08 km)

Migration corridor area:
- Low use: 163,932 acres (66,341 ha)
- Medium use: 26,751 acres (10,826 ha)
- High use: 14,284 acres (5,781 ha)
- Very high use: 7,376 acres (2,985 ha)
- Stopover area: 18,868 acres (7,636 ha)

Winter Range Summary

Winter start and end dates (median):
- October 27 to April 11
- Winter length (mean): 146 days
- Winter range (50 percent contour) area: 108,176 acres (43,777 ha)

Other Information

Project contacts:
- Don Whittaker (don.whitaker@odfw.oregon.gov), Ungulate Management Coordinator, Oregon Department of Fish and Wildlife
- Cody McKee (cmckee@ndow.org), Wildlife Staff Specialist, Nevada Department of Wildlife
- Cody Schroeder (cschroeder@ndow.org), Wildlife Staff Specialist, Nevada Department of Wildlife

Data analyst:
- Valerie Hinojoza-Rood, Faculty Research Assistant, Oregon State University

Reports and Publications
- Collins, G.H., 2016, Seasonal distribution and routes of pronghorn in the northern Great Basin: Western North American Naturalist, v. 76, no. 1, p. 101–112. [Also available at https://scholarsarchive.byu.edu/wnan/vol76/iss1/10.]

Photograph from Charlotte Ganskopp, Oregon Department of Fish and Wildlife.

Figure 23.   Map showing migration routes of the Gillette pronghorn herd.

Wyoming | Pronghorn

Gillette Pronghorn

The Gillette pronghorn herd comprises the North Black Hills and Gillette Herd Units that are separated by State Route 59. In general, pronghorn populations in northeastern Wyoming are understudied, and this work represents the first GPS study to document detailed movement and distribution patterns of pronghorn in this region. This initial study of 35 pronghorn revealed clear interstate movements and migrations of 30–50 mi (48–80 km) between Wyoming and Montana, including occasional facultative winter migrations of Montana pronghorn into Wyoming, and more consistent seasonal migrations of Wyoming pronghorn to summer ranges in Montana. Regardless of the migratory type or State origin, all pronghorn migrations paralleled the Little Powder River, and the heaviest use was on the river's east side (fig. 23). Pronghorn movements to the south were limited by Interstate 90 in Wyoming and blocked to the north by U.S. Highway 212 in Montana. East and west movements across the Little Powder River and State Route 59 were rare and only documented at the southern extent of the migrations. The region largely comprises private lands interspersed with parcels managed by the BLM. Roadways, fencing, energy development, invasive species, and disease are the primary management concerns for pronghorn herds in this region. This project was initiated by the WGFD, and all animals were captured on winter ranges in Wyoming. Although many of the animals moved north into Montana, Montana Fish, Wildlife & Parks was not directly involved in the project or the resulting maps produced in this report.

Animal Capture and Data Collection

Sample size: 35 adult female pronghorn
Relocation frequency: Approximately 2 hours
Project duration: 2022–24

Data Analysis

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011; app. 1)
Models derived from:
- Migration: 46 sequences from 20 individuals (20 spring sequences, 18 fall sequences, 7 winter, 1 summer)

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: March 8 to March 31
- Fall: October 23 to November 2

Number of days migrating (mean):
- Spring: 22 days
- Fall: 11 days

Migration corridor length:
- Minimum: 16.25 mi (26.15 km)
- Mean: 35.90 mi (57.78 km)
- Maximum: 72.85 mi (117.24 km)

Other Information

Project contacts:
- Erika Peckham (Erika.Peckham@wyo.gov), Wildlife Biologist, Wyoming Game and Fish Department
- Hall Sawyer (hsawyer@west-inc.com), Research Biologist, Western EcoSystems Technology, Inc.

Data analyst:
- Hall Sawyer, Research Biologist, Western EcoSystems Technology, Inc.

Reports and Publications:
- Sawyer, H., 2025, Gillette pronghorn study—Phase I summary: Laramie, Wyo., Western EcoSystems Technology, Inc., 11 p.

Photograph from Patrick Rodgers, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming.

Figure 24.   Map showing migration corridors and stopovers of the Sublette Pronghorn herd.

Wyoming | Pronghorn

Sublette Pronghorn

The Sublette pronghorn herd was originally included in the second volume of the report series (Kauffman and others, 2022a) and is one of the largest pronghorn populations in North America. The management population objective for this herd is 48,000 individuals (WGFD, 2023). During the early 2000s, modeled population size—estimated using aerial line-transect abundance surveys—fluctuated between 31,000 and 62,000 pronghorn. The 5-year average herd size was estimated at 33,700 individuals in 2024, although the herd's posthunting season population size in 2024 was 26,800 individuals (WGFD, 2024).

Sublette pronghorn winter in the more southern areas of the upper Green River Basin in Wyoming (fig. 24). Depending on winter severity, individual pronghorn winter between Pinedale, Wyoming, in the north, to Rock Springs, Wyoming, in the south, and on the west side of the Red Desert. Winter ranges include a mix of grassland, desert shrub, sagebrush-dominated mesas, and rolling hills. The herd uses a variety of summer ranges, which generally consist of higher-elevation grasslands and sagebrush habitats intermixed with mesic meadows.

Sublette pronghorn have mixed movement strategies: 75 percent of pronghorn tracked with GPS collars (469 females) show migratory behavior with distinct seasonal ranges, and the remaining 25 percent show more nomadic or resident strategies. Sublette pronghorn migrate an average one-way distance of nearly 42 miles (68 km), and some individuals migrate more than 150 miles (241 km). This herd includes some of the longest-distance migrating pronghorn; one pronghorn migrated 200 mi (322 km) from the southern reaches of the range to Grand Teton National Park following Bridger-Teton National Forest Path of the Pronghorn, the first federally designated migration corridor (Berger and Cain, 2014). Others migrate to summer ranges in the Hoback River valley, the Gros Ventre Range, and along the east slope of the Wyoming Range and west slope of the Wind River Range.

Many pronghorn within this herd migrate or winter near energy development, mainly oil and gas development in the Pinedale Anticline, Jonah, and Calpet natural gas fields. Previous research shows pronghorn spend less time in areas after development (Sawyer and others, 2025), and sometimes, pronghorn abandon traditional winter ranges altogether (Reinking and others, 2019). Additional gas wells are permitted in the center of the Sublette pronghorn herd range, and pressures are increasing from renewable energy sources, such as wind and solar developments along the Interstate 80 corridor in the southern reaches of the herd's range. However, in 2012–13, Sublette pronghorn benefitted from wildlife overpasses constructed over U.S. Highway 191 at the Trapper's Point and Boroff Hill sites in high-use parts of the migration route, and an arch crossing structure was constructed to facilitate pronghorn movement across U.S. Highway 189 to the south of Big Piney, Wyoming. In 2024, the Wyoming Game and Fish Department identified the migration corridor as part of Governor Gordon's Migration Corridor Executive Order 2020–1 (State of Wyoming, 2020), and the process of designating the corridor is currently (2025) ongoing.

Photograph from Mark Gocke, Wyoming Game and Fish Department.

Animal Capture and Data Collection

Sample size: 469 adult female pronghorn
Relocation frequency: Approximately 2–5 hours
Project duration: 2002–25

Data Analysis

Corridor analysis: Line buffer method using 300 m buffer (Merkle and others, 2023)

Stopover analysis: Brownian bridge movement models (Sawyer and others, 2009) with a 5 percent volume contour.

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011; app. 1)

Models derived from:
- Migration: 923 sequences from 469 individuals (549 spring sequences, 374 fall sequences)

Migration use classifications:
- Low: Used by at least two individuals
- Medium: Used by at least 10 percent of the individuals
- High: Used by at least >20 percent of the individuals

Corridor and Stopover Summary

Migration start and end dates (median):
- Spring: March 23 to May 3
- Fall: October 11 to October 29

Number of days migrating (mean):
- Spring: 40 days
- Fall: 24 days

Migration corridor length:
- Minimum: 6.00 mi (9.66 km)
- Mean: 41.96 mi (67.53 km)
- Maximum: 165.00 mi (265.54 km)

Migration corridor area:
- Low use: 1,966,403 acres (795,776 ha)
- Medium use: 409,662 acres (165,784 ha)
- High use: 136,500 acres (55,240 ha)
- Stopover area: 312,996 acres (126,665 ha)

Other Information

Project contacts:
- Brandon Scurlock (brandon.scurlock@wyo.gov), Wildlife Coordinator, Wyoming Game and Fish Department
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  Grand Teton National Park

Data analyst:

- Jerod A. Merkle, Associate Professor, Department of
  Zoology and Physiology, University of Wyoming

Reports and Publications:

- Beckmann, J.P., Murray, K., Seidler, R.G., and Berger,
  J., 2012, Human-mediated shifts in animal habitat use—
  Sequential changes in pronghorn use of a natural gas
  field in Greater Yellowstone: Biological Conservation, v.
  147, no. 1, p. 222–233. [Also available at https://doi.org/
  10.1016/j.biocon.2012.01.003.]

- Reinking, A.K., Smith, K.T., Mong, T.W., Read, M.J.,
  and Beck, J.L., 2019, Across scales, pronghorn select
  sagebrush, avoid fences, and show negative responses to
  anthropogenic features in winter: Ecosphere, v. 10, no.
  5, art. e02722, 17 p. [Also available at https://doi.org/
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- Reinking, A.K., Smith, K.T., Monteith, K.L., Mong,
  T.W., Read, M.J., and Beck, J.L., 2018, Intrinsic,
  environmental, and anthropogenic factors related to
  pronghorn summer mortality: The Journal of Wildlife
  Management, v. 82, no. 3, p. 608–617. [Also available at
  https://doi.org/10.1002/jwmg.21414.]

- Sawyer, H., Beckmann, J.P., Seidler, R.G., and Berger,
  J., 2019, Long-term effects of energy development
  on winter distribution and residency of pronghorn in
  the Greater Yellowstone Ecosystem: Conservation
  Science and Practice, v. 1, no. 9, 11 p. [Also available at
  https://doi.org/10.1111/csp2.83.]

- Sawyer, H., Lindzey, F., and McWhirter, D., 2005, Mule
  deer and pronghorn migration in western Wyoming:
  Wildlife Society Bulletin, v. 33, no. 4, p. 1266–1273.
  [Also available at https://doi.org/10.2193/0091-76
  48(2005)33[1266:MDAPMI]2.0.CO;2.]

- Wyoming Game and Fish Department [WGFD], 2024,
  Wyoming Game and Fish Department migration corridor
  threat evaluation—Sublette pronghorn: Laramie, Wyo.,
  Wyoming Game and Fish Department, 17 p. [Also
  available at https://wgfd.wyo.gov/sites/default/files/2024-
  04/ThreatEvaluation_SublettePronghorn_FINAL.pdf.]

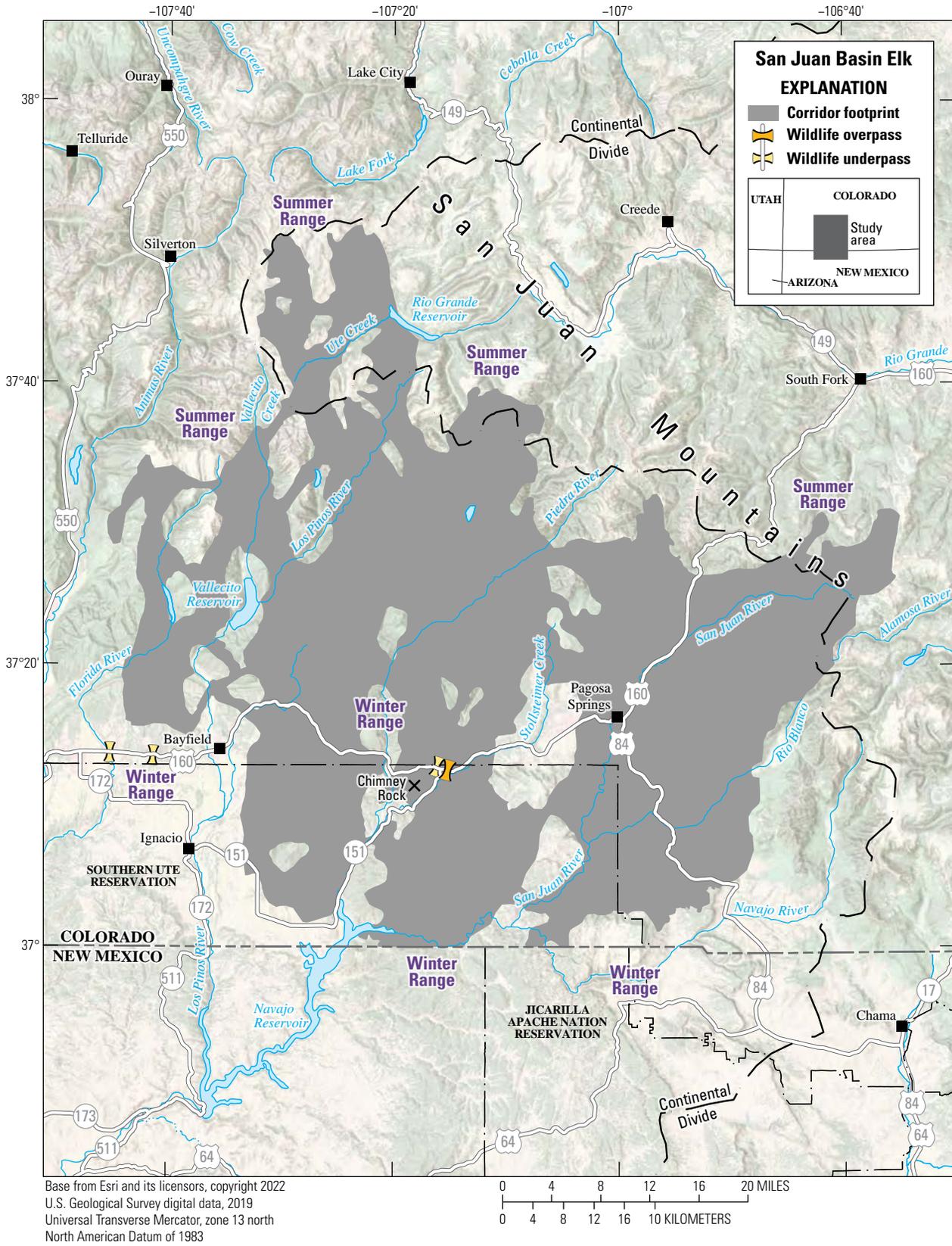Photograph from Patrick Rodgers, Wyoming Migration Initiative.

Figure 25.   Migration footprint used by two or more individuals in the San Juan Basin elk herd.

Colorado | Elk

San Juan Basin Elk

The San Juan Basin elk herd (DAU E31) is in the southwest corner of Colorado (fig. 25). The DAU is 2,800 mi² (7252 km²) and is bound to the north and east by the Continental Divide, to the south by the New Mexico border, and to the west by the Animas River. Elevations range from 5,000 ft (1,524 m) to more than 14,000 ft (4,267 m). The DAU encompasses Durango, Bayfield, Ignacio, and Pagosa Springs, Colorado, and landownership is a mix of 30 percent private, 12 percent Southern Ute Indian Tribe, 2 percent BLM, and 56 percent FS. Elk generally summer at higher elevations at the northern and eastern part of the DAU and regularly cross the Continental Divide. Elk winter at lower elevations in the southern part of the DAU and into Southern Ute Indian Tribal lands and New Mexico.

Public lands attract multitudes of outdoor recreationists to southwest Colorado, which causes urban, exurban, and recreational development to occur on a large part of critical elk habitat. Development affects the entire DAU, but it is a considerably larger problem near Durango, Bayfield, and Pagosa Springs, Colorado. In addition, one of the largest natural gas fields in the United States overlaps part of the winter range. Several highways, including U.S. Highways 160, 84, and 550, and Colorado State Highways 172 and 151, bisect elk habitat. These roadways affect migrating elk and elk on winter range and increase WVCs. The Southern Ute Indian Tribe and CPW have used GPS-collared data from elk to identify priority habitat, migration routes, timing of migrations, and highway crossing locations. These data and WVC data are used to identify locations for building wildlife-crossing structures.

In 2022, CDOT, the Southern Ute Indian Tribe, CPW, and other partners helped to fund the construction of a wildlife overpass and underpass on a 1.9-mi (3.1-km) section of U.S. Highway 160 near Chimney Rock and the intersection of Colorado State Highway 151. These structures connected an important area of winter range containing high concentrations of elk and mule deer to summer habitats to the north. A multiyear monitoring study was started in 2023 (refer to the "San Juan Basin Mule Deer" section in this report) to determine the effectiveness of the project to reduce WVCs and maintain wildlife movement permeability. Preliminary data analysis (from data collected in October 2023 through June 2024) revealed that the underpass and overpass provide for safe crossings and habitat connectivity for elk and many other wildlife species and increase safer traveling for residents and visitors using the highway (Cramer, 2024).

Animal Capture and Data Collection

Sample size: 117 adult female elk

Relocation frequency: Approximately 2–3 hours

Project duration: 2013–22

Data Analysis

Corridor footprint analysis: Brownian bridge movement models (Sawyer and others, 2009)

Delineation of migration periods: Net Squared Displacement (Bunnefeld and others, 2011)

Models derived from:

- Migration: 306 sequences from 108 individuals (176 spring sequences, 130 fall sequences)

Migration use classifications:

- Corridor footprint: Any area used by two or more individuals during migration

Corridor and Stopover Summary

Migration start and end dates (median):

- Spring: March 27 to May 30
- Fall: October 12 to December 19

Number of days migrating (mean):

- Spring: 61 days
- Fall: 71 days

Migration corridor length:

- Minimum: 5.97 mi (9.61 km)
- Mean: 33.24 mi (53.49 km)
- Maximum: 64.86 mi (104.38 km)

Migration corridor area:

- Migration footprint: 1,073,513 acres (434,435 ha)

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Photograph from Jerry Neal, Colorado Parks and Wildlife.

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Appendix 1.   Methods

The methods used for all reports in the "Ungulate Migrations of the Western United States" series are from Kauffman and others (2020). This and other volumes build on the initial methods, much of which are reproduced herein. However, where required, we have modified previous methods to reflect changes in the analytical approach or added new sections to describe methods that were not used in previous report volumes.

Extracting and Mapping Migration Sequences

To identify spring and fall migration start and end dates for each individual in a given year, we visually inspected the Net Squared Displacement (NSD) curve (Bunnefeld and others, 2011; Bastille-Rousseau and others, 2016) alongside digital maps of the individual's movement trajectory in the Migration Mapper application (Merkle and others, 2022). The NSD curve represents the square of the straight-line distance between any global positioning system (GPS) location of an animal's movement trajectory and a location in the animal's winter or summer range. Users defined this location separately for each herd on the basis of the start of a biological year, which ranged between January 1 and March 31.

When an animal stays in a defined home range, the NSD varies little during the year. However, when an animal migrates away from its winter range, the NSD of each successive location increases until the animal settles in its summer range (fig. 1.1*A*, *B*, *C*). The days with clear breakpoints in the NSD curves represent the start and end dates for migration and were used to identify the sequential GPS locations for spring and fall migration (in other words, the migration sequences). Migration routes were mapped by joining successive GPS locations with a straight line in each migration sequence.

Calculating Probability of Use with Brownian Bridge Movement Models

Once migration sequences were extracted for each individual in a given year, we used a Brownian bridge movement model (BBMM; Horne and others, 2007) to estimate a utilization distribution (UD) representing the probability of use during migration. The UD produced from the BBMM provides a probability surface, or heat map, of the area used in each migration sequence. Additionally, the outer bounds of the UD provide estimated widths of the movement path around the straight line between an animal's two successive locations. Together, the heat map and boundary of the UD can be used to identify migration corridors (Sawyer and others, 2009) and the stopover sites where animals spend extended time foraging along their migration route (Sawyer and Kauffman, 2011).

To generate the heat map for each migration sequence, we used the BBMM to estimate a UD with a grid resolution of 164 feet (50 meters). When GPS collars failed to record a location at a given time and breaks in the sequential data exceeded an 8–14-hour time lag, we did not build a bridge between the two locations encompassing the break. A key parameter of the BBMM is the Brownian motion variance (BMV), which provides an index of the mobility of the animal under observation (Horne and others, 2007). An empirical estimate of the BMV was obtained for each migration sequence using the methods of Horne and others (2007). We did not include migration sequences with a BMV greater than or equal to 1.98 acres (8,013 square meters [m^2]) because large BMV values poorly represented the observed migration trajectory.

Variations of the Brownian Bridge Movement Model Method—Sparse Data and Fixed Motion Variance

When location data are sparse (in other words, when there is a long time interval between GPS locations), the BBMM performs poorly because of the increased uncertainty in the movement path between two successive GPS locations. Such uncertainty tends to overestimate the corridor width and area (Horne and others, 2007; Benhamou, 2011). To facilitate corridor analyses of migration sequences collected with low relocation rates (in other words, fix rates), we used the alternative Fixed Motion Variance method, in which we set the BMV at specific levels when estimating the UDs for each migration sequence (Kauffman and others, 2020; McKee and others, 2024). For herds with sparse sampling data, we set the BMV between 0.15 and 0.40 acres (607 and 1,619 m^2, respectively) for *Cervus canadensis* (elk) and *Antilocapra americana* (pronghorn) and between 0.10 and 0.30 acres (405 and 1,214 m^2, respectively) for *Odocoileus hemionus* (mule deer; McKee and others, 2024).

For most analyses, traditional BBMM methods were used to estimate corridors and stopovers. However, when there were large amounts of missing data in the migration sequences, corridors were calculated using Fixed Motion Variance if they improved delineation as observed through a visual comparison of maps from the two methods. When fix rates were highly variable among individuals in a herd, BBMM and Fixed Motion Variance methods were used to construct individual UDs. In general, by bridging gaps in the probability surface created by missing GPS locations, Fixed Motion Variance provided a modeled corridor that more closely matched data with frequent relocations (for example, a 2-hour fix rate; McKee and others, 2024). In most of these analyses, a 14-hour time lag was allowed; a 27-hour or 48-hour time lag was allowed only when it provided more complete migration corridors compared to using a 14-hour time lag.
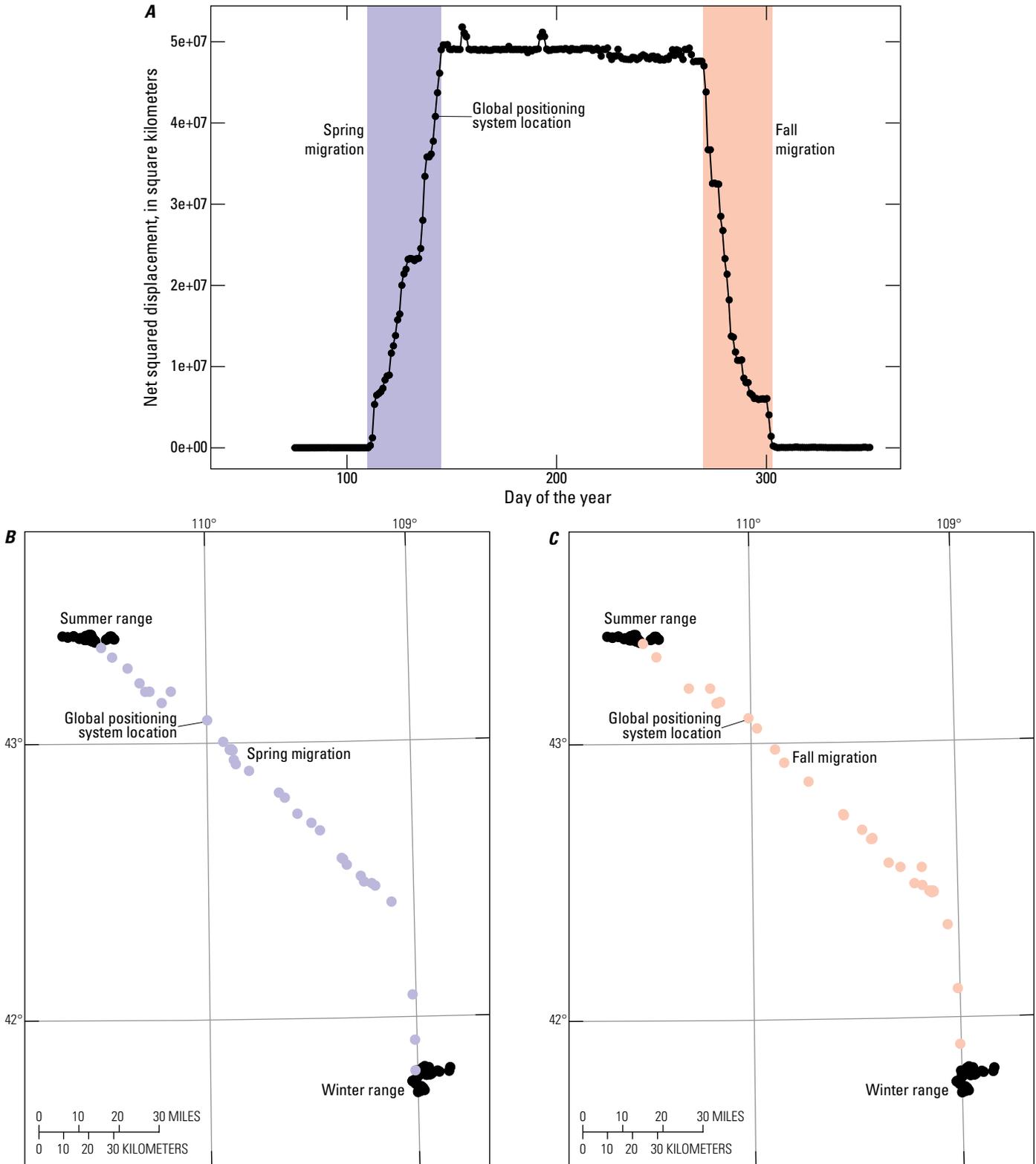
Figure 1.1.   Example of Net Squared Displacement (NSD) analysis to identify migration sequences (from Kauffman and others, 2020). *A,* breakpoints in the NSD curve provide the start and end dates for the spring migration, when an animal migrates from the winter range to the summer range, and the fall migration, when an animal leaves its summer range to return to the winter range; *B,* the corresponding global positioning system (GPS) locations are highlighted on the map insets for the spring migration; *C,* the GPS locations are highlighted on the map insets for the fall migration. For ease of readability, only one GPS location per day is shown. [e+, e-notation]

Calculating Population-Level Corridors and Stopovers

We applied a three-step process to calculate population-level corridors and to identify stopovers; the process generally followed the methods developed by Sawyer and others (2009). First, we averaged the UDs for a given individual's spring and fall migration sequences across all years to produce a single, individual-level migration UD. We rescaled this mean UD to sum to one. Second, we defined a migration footprint for each individual as the 99-percent isopleth of its UD. We then stacked all the individual footprints for a given population, which provided a raster representing the number of animals that used each grid cell during migration. Next, we defined different levels of corridor use on the basis of the proportion of the collared migrants in the population for a given grid cell. For most herds, we then defined low use corridors as areas traversed by at least one collared individual during migration, medium use corridors as areas used by 10–20 percent of the collared individuals, and high use corridors as areas used by more than 20 percent of the collared individuals in the population. These corridors were converted from a grid-based format to a polygon format, and then isolated-use polygons of less than 4.94 acres (19,991 m^2) were removed. Finally, to calculate stopover use, we averaged all the individual-level UDs to produce a single population-level UD, rescaled to sum to one. Stopovers were defined as the areas representing the highest 10 percent of use from the mean population-level UD. We then converted stopovers from a grid-based format to a polygon format, like the corridors, and removed isolated-use polygons of less than 4.94 acres (19,991 m^2). The resulting population-level corridors are referred to as "corridors," "routes," or "footprints," depending on the preference of individual States and Tribes.

Variations of the Method to Calculate Population-Level Corridors

The simplest method for delineating migratory corridors was the line buffer approach (Merkle and others, 2023). For this method, we simply buffered the migration lines (lines connecting sequential GPS locations) by a specified distance (for example, 820 feet [250 meters]) and then used the general methods in the "Calculating Population-Level Corridors and Stopovers" section to determine low, medium, and high use areas. The line buffer method serves as a useful alternative to the BBMM methods because it (1) ensures individual routes are the same width and do not vary extensively, (2) ensures population-level routes have full connectivity between seasonal ranges (in other words, no broken segments or overly large areas are produced), (3) easily accommodates variable GPS fix rates, and (4) requires little computing power.

Most maps in this report display low, medium, and high use corridors or routes. However, some individual State and Tribal contributors adapted methods to best suit their management purposes or accommodate the limitations posed by varying sample sizes among herds. The "Data Analysis" section of the page-pair text accompanying each herd provides additional herd-specific details when analysts deviated from the general methods presented herein, for example, when different definitions were used to define the migration corridor or route use levels.

Estimating a Population's Winter Range

To estimate a population's winter range, we generally followed the same methods used to calculate migration stopover sites but had some exceptions. First, instead of migration sequences, we isolated winter sequences of GPS locations. For each year, we calculated a standard date for the start and end of winter, and based on the preference of individual States and Tribes, we applied one of three options to calculate winter range dates: (1) for each year, we calculated the start of winter as the 95th percent quantile of the end dates of all fall migrations and the end of winter as the 5th percent quantile of the start dates of all spring migrations, (2) we defined winter as the dates between the end of fall migration and the start of spring migration for each individual, or (3) we defined a fixed date range using local expert knowledge for a given herd (for example, December 15–March 15). We discarded winter sequences that spanned fewer than 30 days. Using the same methods for calculating migration stopovers, we calculated a population-level UD of winter use and identified the core winter range using the 50-percent isopleth. The "Data Analysis" section for the corresponding herd summaries in this report provided additional herd-specific details regarding winter ranges.

Estimating a Population's Annual Range

To estimate a population's annual range, we generally followed the same methods used to calculate migration stopover sites or winter range but had some exceptions. First, we isolated annual movement sequences for each individual. These movement sequences were defined as movements longer than 275 days (200 days for California) in a calendar year and began at the time of GPS collar deployment. Start dates were similar because GPS collars were deployed in batches around the same dates. End dates varied depending on individual mortalities. Using the methods for migration corridors, we calculated a population-level UD of annual use and identified the core annual range using isopleth values (for example, 50 and 90 percent contours) selected on the basis of local expert knowledge for a given herd. The "Data Analysis" section for the corresponding herd summaries in this report provided additional herd-specific details regarding annual ranges.

Herd Summary Statistics

In addition to the map for each herd, several summary statistics described the project and associated data. In the "Animal Capture and Data Collection" section for the corresponding herd summaries in this report, sample size was defined as the number of collared individuals (inclusive of residents and migrants), relocation frequency was determined by local researchers and varied within and among herds, and the project duration was defined using the year of the first and last GPS location included in the analyses. In the "Data Analysis" section for the corresponding herd summaries in this report, we provided the number of migration sequences and individuals used in the respective analysis. These numbers accounted for sequences that failed to fit a BBMM and were not included in the delineation of the migration corridor or seasonal range. In the "Corridor and Stopover Summary" section for the corresponding herd summaries in this report, we included the median start and end dates for the spring and fall migrations and the average duration of each migration period in days. Additionally, we defined the migration length as the maximum distance between any two points in a spring or fall migration sequence. These methods helped to avoid overestimating migration distances, which can be inflated when calculated as the sum of all step lengths in a sequence because distances traveled when foraging at a stopover are included. The "Corridor and Stopover Summary" section for the corresponding herd summaries in this report also includes the areas of migration corridors and stopovers.

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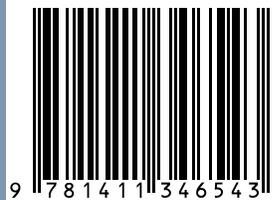Sawyer, H., and Kauffman, M.J., 2011, Stopover ecology of a migratory ungulate: Journal of Animal Ecology, v. 80, no. 5, p. 1078–1087. [Also available at https://doi.org/10.1111/j.1365-2656.2011.01845.x.]

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