DEER MANAGEMENT
NEW MEXICO DEPARTMENT OF GAME AND FISH

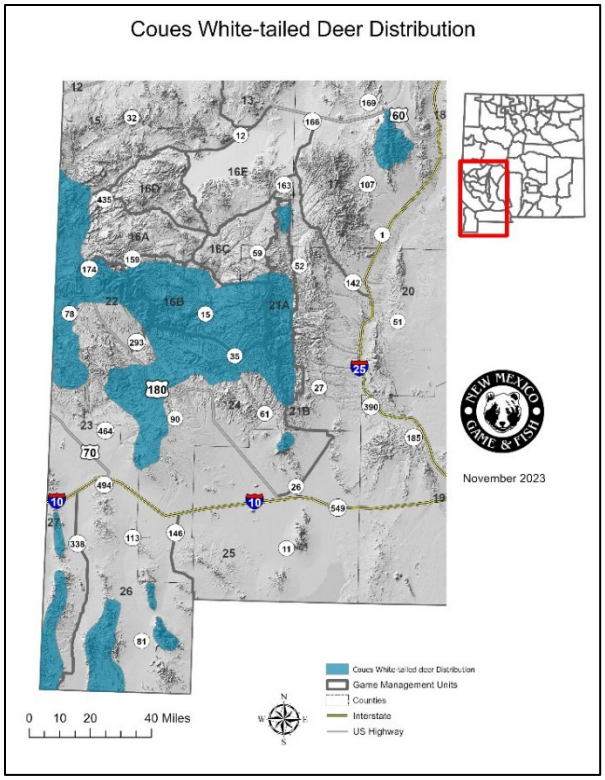
Prepared by Orrin Duvuvuei, Deer program Manager
Updated May 2025

INTRODUCTION

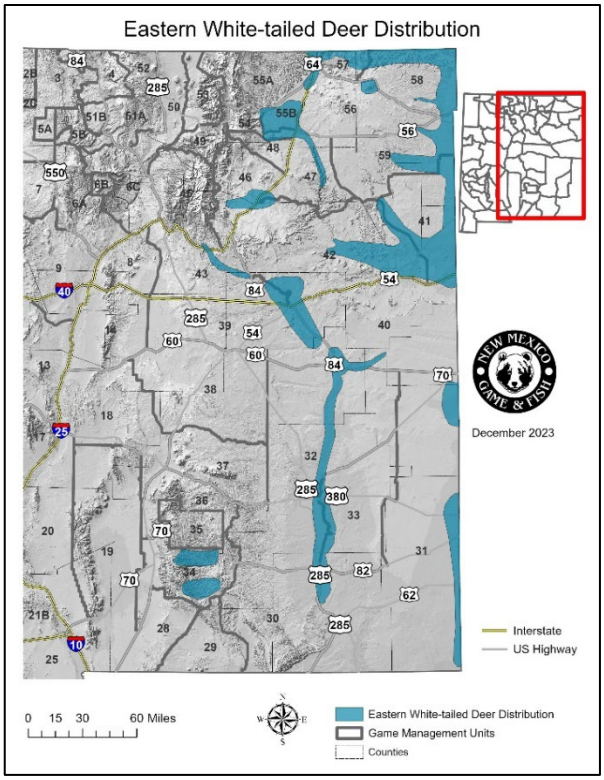
Deer are valued by New Mexico's outdoor recreation community because of the hunting and wildlife viewing opportunities they provide. In addition to being a food source, deer are a coveted species among hunters. In fact, deer are one of New Mexico's most popular game animals in the state with over 36,000 hunters pursuing deer annually and an annual harvest of approximately 9,000-11,000.

New Mexico has 2 species of deer: mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*; whitetails), with mule deer being the most common. Within each species there are two subspecies; for mule deer NM has Rocky Mountain and desert mule deer, and for white-tailed deer NM has eastern white-tailed and Coues white-tailed deer. Mule deer can be found in all areas and habitat types ranging from desert floors to high alpine environments. Rocky Mountain mule deer are found in the northern 2/3 of New Mexico while desert mule deer inhabit the southern 1/3 of the state. Eastern white-tailed deer are found in isolated pockets in the eastern ½ of New Mexico while Coues white-tailed deer occupy mountain ranges in the southwestern portion of the state.

While many mule deer herds in New Mexico use the same habitats year-round, others are migratory. Deer in the north central part of the state may migrate 30-40 miles between summer ranges at higher elevations or in Colorado to lower elevation winter ranges in New Mexico. Other herds may make smaller movements to take advantage of sporadic seasonal precipitation. Because of these different requirements for deer throughout the state, it is important to maintain productive, connected habitats on the landscape.



Coues white-tailed deer distribution in New Mexico.

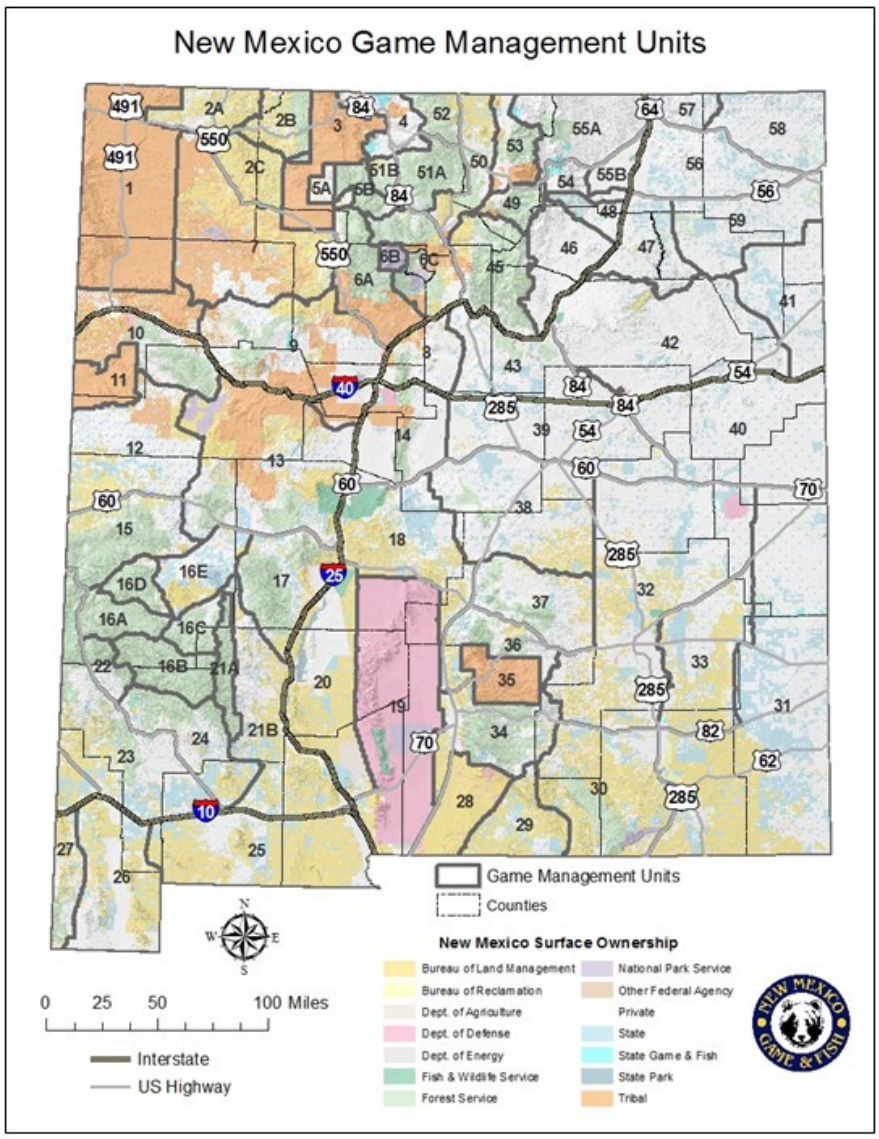


Eastern white-tailed deer distribution in New Mexico.

Landownership

Approximately eleven percent of the land mass in New Mexico is tribally owned. Of the remaining land mass, approximately 50% is public land while the other 50% is privately owned. Public lands available to hunt deer in New Mexico include both state and federally owned and managed lands. Each jurisdiction has different rules for access and recreation.

Additional information about rules for each landownership type can be found on the Department's website or by accessing the links below.



Map of Department GMUs and New Mexico surface ownership.

MULE DEER BIOLOGY

Deer populations naturally fluctuate between high and low densities over time, and these fluctuations can be dramatic. Deer population trajectories are driven by adult female and fawn survival; both adult female and fawn survival rates need to be adequate for stable populations. Deer have a polygamous breeding strategy where a single male will breed many females within a season. Because of this breeding strategy, almost all (>95%) breeding age females become pregnant each year even though there are generally fewer males than females in a population. In fact, there can be far fewer males than females with no impact to pregnancy rates. Studies have shown that when the number of bucks stays above 10 bucks per 100 does, pregnancy rates are consistent and high. As such, buck mortality, including mortality from harvest, does not

negatively impact population growth because females carry pregnancies and almost all of them are pregnant each year.

Adult doe survival is relatively consistent across the mule deer range with only minor variability. Conversely, fawn survival varies by region and across years and is heavily influenced by precipitation patterns and resulting habitat conditions. Weather, disease, predation and human induced mortality can all impact adult female and fawn survival; however, availability of quality forbs, shrubs, and concealment cover can lessen or intensify the effect of these individual factors.

For more information on issues impacting mule deer populations, visit the Mule Deer Working Group website.

Breeding and timing.


Photo by D. Poeble

The timing of breeding is regulated by changes in daylength (photoperiod) interacting with genetics to determine when females come into estrus. The nutritional status and body condition of individual females in the months leading up to breeding may also influence timing. Although weather and temperature do not directly affect the physiological readiness of breeders, cooler temperatures may trigger more deer movement in general, whereas warm temperatures may suppress it.

The breeding period for deer in the Southwest Deserts is typically later in the year and longer lasting than in northern ecoregions (Heffelfinger 2006). In New Mexico, the timing of the rut varies by area. In the north, the peak rut typically occurs during the last week of November. In the central and southeastern parts of the state, the rut occurs during the first week of December. In southwestern New Mexico, deer tend to rut between the end of December and beginning of January.

Fawns in desert habitats rarely attain breeding condition by their first breeding season, so it is uncommon to see yearling (1.5 yr) females with fawns. In other parts of mule deer range outside of the Southwest Deserts, particularly those with extensive agricultural areas, up to half of the female fawns will breed during their first fall (Heffelfinger 2006). As such, in New Mexico, multiple consecutive years of timely seasonal rains are necessary to see significant deer population growth.

Factors that Impact Mule Deer Populations

Fundamentally, all population growth is influenced by births, deaths, immigration, and emigration (Mills and Johnson 2013). Forage availability, weather, and predation are common factors that influence birth and death rates, although others could be important (e.g., malnutrition, disease; Forrester and Wittmer 2013), and the interrelated causative mechanisms are not perfectly understood (Lawrence et al. 2004). Precipitation with resulting impacts on forage and direct predation on deer often interact as leading factors influencing population fluctuations in the Southwestern US (Lawrence et al. 2004), although other factors may affect population growth rates (e.g., habitat condition, human encroachment).

Weather Patterns

Weather is a major driver of population fluctuations in the Southwest because it drives plant growth and vegetation biomass, which correlates to deer body condition, hiding cover, survival, recruitment, and population density (Smith and LeCount 1979, Marshal et al. 2002, Haskell et al. 2017). When drought is prolonged, or when seasonal precipitation does not come at optimal times, deer will have reduced body condition and recruitment will be lower. This can result in higher mortality rates from all causes. Three consecutive years of above-average rainfall are often needed for mule deer populations to experience significant growth in this ecoregion (Heffelfinger 2006).

Habitat Condition and Availability

Habitat availability and condition is one of the biggest factors impacting New Mexico's deer populations, and the number of deer the landscape can support. Specifically forage availability and cover often determine the number of deer that inhabit an area. Access to a variety of habitats is crucial to providing adequate nutrition and hiding cover during different seasons.

Anthropogenic changes, fire suppression, and excessive herbivory can significantly change plant community composition, structure, nutritional values, and disturbance processes on the landscape that are important for mule deer population growth (Lutz et al. 2003, Richardson 2003). These combined factors have generally resulted in decreased nutritional quality and lost or fragmented habitat, which poses issues for robust mule deer populations (Lutz et al. 2003, Heffelfinger et al. 2006). These impacts can be long-lasting and are often difficult to address on the scale that is meaningful to a large deer population.

Deer habitat in New Mexico is highly variable and complex. It is also subject to degradation and fragmentation from land use practices which sometimes result in effects that are detrimental to deer. Degradation and habitat loss can prohibit deer from reaching and utilizing important habitats in seasonal areas. Advancing succession of forage species, due to fire suppression, along with management practices that favor grass production for cattle grazing rather than browse, continue to change habitat suitability for deer. These changes have likely reduced habitat quality for deer in New Mexico. For mule deer to thrive in the state, habitats must be maintained and improved to provide a mosaic landscape. To complicate this, because of low rainfall in New Mexico, habitats do not recover as quickly from disturbances, and it may take decades for degraded habitat to return to historical conditions.

Barriers to Movement & Habitat Fragmentation

Major changes are occurring throughout much of mule deer range in the west due to growing human populations. This population growth can lead to habitat fragmentation which can negatively affect deer populations by making it difficult for individuals to disperse, migrate, and forage (Fischer and Lindenmayer 2006).

Habitat fragmentation can be caused by roadways, fences, canals, housing developments, wind, solar, gas, and oil energy developments, transmission lines, mines, railways, roads, and others. Fences are among the more common movement barriers in the western United States because they are frequently used to control and distribute livestock. When built improperly, fences can substantially hinder deer movement and cause mortality (Howard 1991, Harrington

and Conover 2006). The Department has been actively involved in helping convert livestock fencing to wildlife friendly in various locations across the state.

Predation

In areas where deer populations are depressed due to other factors, predation can maintain populations at low levels. However, active predator removal does not generally increase populations unless these other limiting factors are addressed and very specific predator removal practices are enacted. Predator removal programs designed to benefit deer are ineffective unless it is focused, intense, and timed to coincide with the most crucial period for that population. For example, to effectively help deer populations, coyote numbers would have to be reduced by 50 percent annually (Andelt 1996). Predator control may help improve deer populations only when the following conditions are met:

1) Predation is identified as a limiting factor,
2) Predator management is implemented when deer populations are below habitat carrying capacity,
3) Predator management efforts reduce predator populations sufficiently across the landscape to yield results,
4) Predator management efforts are timed to be most effective (just prior to predator or prey reproduction),
5) Predator management occurs at a focused scale (generally <250 mi^2).

For more information on mule deer and their predators, see this fact sheet developed by the WAFWA Mule Deer Working Group.

Diseases and Parasites

In most cases, disease by itself does not generally determine deer abundance, but stressors such as drought can exacerbate the impact of diseases in a population. When diseases are present in a population, they rarely cause large-scale deer die-offs; mortality events are typically smaller scale or productivity is reduced.

Chronic Wasting Disease (CWD) is the biggest disease concern for New Mexico's deer populations. CWD is a fatal neurological disease that affects deer, elk, and other members of the deer family (Family *Cervidae*). Because CWD is always fatal, it can negatively impact population growth when prevalence rates are high. CWD has been detected in GMUs 19, 28, 29, and 34, special restrictions apply for deer and elk harvested in these units. The Department continues to expand CWD testing throughout the state. For more information see this fact sheet on CWD developed by the WAFWA Mule Deer Working Group.

Mule Deer Population Trends in New Mexico

Mule deer have always been common in New Mexico, but not extremely abundant. Historically, they were not uniformly abundant or distributed in all areas (Stewart 1967). Similar to other big game populations nationwide, market and sustenance hunting drove New Mexico populations to all-time lows around the early 1900s.

Because of declining wildlife populations, harvest regulations were established in the early 1900s and deer numbers improved. In the 1920's and 1930's, predator control programs were implemented, allowing deer populations to continue to grow, largely uninhibited (Stewart

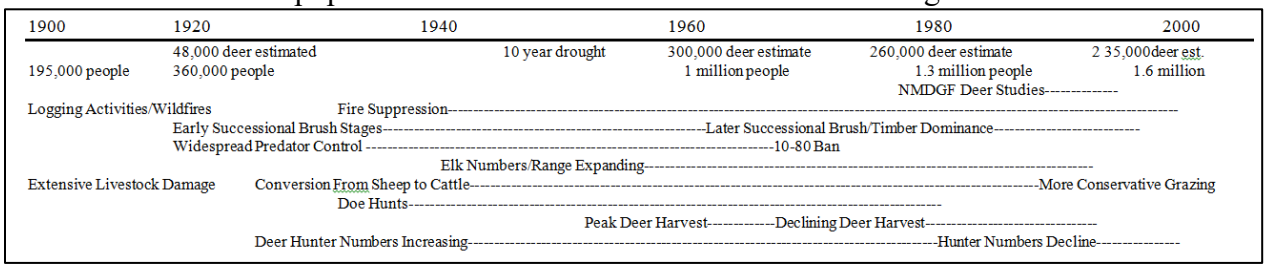
1962). The first published estimate indicates that New Mexico's mule deer population was approximately 97,000 in 1928 (Ames 1967). Around the same time scientists suggested that the herbivores on the landscape, including deer and livestock, exceeded what the habitat could sustain (Leopold et al. 1947). Field surveys conducted between 1929 and 1932 found deer that died of starvation, confirming that indeed herbivores were overutilizing forage on the landscape.

Widespread logging and forest thinning from the 1930s through the 1950s changed habitat conditions and increased deer forage quantity and availability on the landscape. These improved habitat conditions, coupled with intensive predator eradication efforts, resulted in a deer "irruption" that saw herds swell throughout New Mexico and the intermountain West states of Nevada, Utah, Idaho, Montana and Wyoming (Gruell 1986). Together, these factors resulted in a three-fold increase in mule deer by the 1960s. The state's mule deer population grew from approximately 97,000 deer in 1928 to 301,000 deer in 1964 (Ames 1967). This estimate stands as the highest population size the state has seen in modern times and is consistent with trends reported from other western states. Many western mule deer hunters that were around during the 1960s fondly call this period the "Good Old Days" of mule deer hunting. However, land and wildlife use practices may have allowed deer populations to be artificially inflated compared to what can naturally occur on the landscape.

Shortly after this peak in the 1960s, logging slowed and fire suppression increased. These landscape scale changes allowed allowed the forests to mature to old growth states that are less beneficial to mule deer, and declines were noticeable. By the 1990s and the early-2000s, these less productive forests coupled with long-term drought further suppressed deer numbers compared to historical estimates. Although it is unlikely that New Mexico's mule deer numbers will ever be as high as those reported in the 1960s, mule deer populations are stable today with some local herds experiencing growth while others experience declines.

For more information on historical and current mule deer abundance, see this fact sheet developed by the WAFWA Mule Deer Working Group.

Timeline of mule deer population levels in New Mexico and contributing factors



Surveys

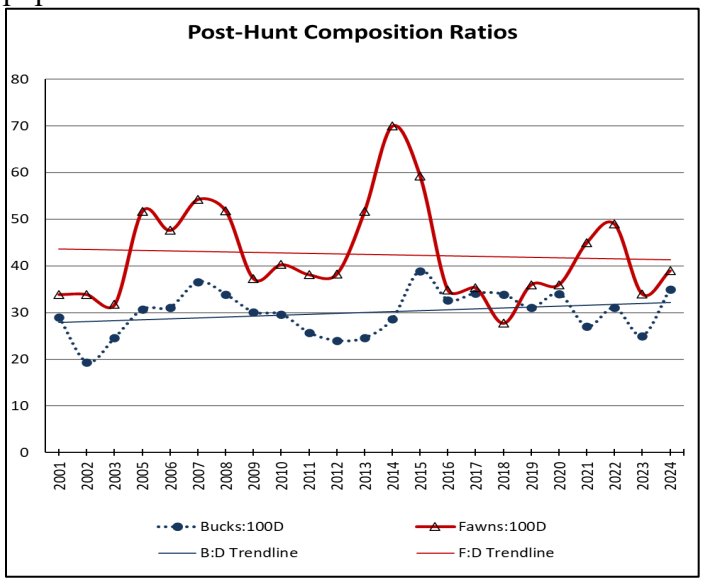
To effectively manage deer populations, biologists must accurately quantify factors affecting population growth (birth rates, death rates, and natural movement into and out of the population). It is often not possible to precisely estimate these demographic parameters without intensive research; however, the Department quantifies indices of populations using hunter harvest metrics and post-hunt aerial surveys. Mandatory harvest reporting provides an estimate of total harvest for each unit, a measure of hunter effort, and an index of population trends. Post-hunt aerial surveys are conducted each winter to quantify sex [buck to doe (B:D)] and age [fawn

to doe (F:D)] ratios and monitor population trends. These surveys provide an index of post-hunt buck availability and population productivity and allow biologists to assess whether population objectives are met. For more information on aerial surveys throughout the western US, see this WAFWA fact sheet on aerial survey inventories developed by the Mule Deer Working Group.

These composition estimates have been obtained since the early 2000's, allowing comparisons to be made over time. Surveys primarily focus on collecting data for mule deer, but white-tailed deer are also observed and noted as incidental sightings. These surveys are used in conjunction with hunter harvest metrics to generate management recommendations.

Over the years, the Department has tried implementing new survey techniques designed to obtain mule deer density and population estimates. While these methods are used with success in other areas, they require large sample sizes that are not achievable in New Mexico without a substantial increase in helicopter survey resources. A recent technique [Integrated Population Models (IPMs)] shows promise for estimating mule deer populations. Beginning in 2024, the Department started a collaborative project with a statistical consulting firm aimed at generating deer population estimates. IPMs utilize multiple sources of data to generate population estimates, including composition ratios, harvest, survival, and population productivity. Importantly, IPMs are capable of handling small sample sizes to obtain population estimates.

The long-term statewide post-hunt composition ratio averages are 40 fawns:100 does and 30 bucks:100 does. A minimum of 40 fawns per 100 does is required in New Mexico for stable populations. These ratios, coupled with statewide harvest trends, indicate that the statewide population is stable in most areas.



Statewide post hunt composition ratios

Harvest Management

The Department allocates licenses to meet stakeholder desires without adversely impacting populations and their habitats. New Mexico predominately targets bucks when allocating hunting licenses. There is a misconception that limiting buck harvest, or even closing a unit to buck harvest completely, increases the deer population. This is not true; as described

above, buck harvest does not limit population growth because the breeding strategy of deer assures that all does in estrus become pregnant during the breeding season. Prior attempts to increase the number of bucks in New Mexico through reducing male harvest have often failed to produce a higher B:D ratios or improved success rate. Rather, in nutritionally stressed populations, slightly increasing B:D ratios can result in a decrease in F:D ratios. This likely occurs because a buck will consume more resources, per capita, than a smaller bodied female or fawn. And when resources are limited, fewer bucks may result in more resources for fawns and does. The Department implements female harvest only under certain circumstances when deer populations are over social objectives, such as near human population centers or when small population segments can withstand limited female harvest by youth hunters.

Harvest reporting is mandatory for all deer hunters. Approximately 88% of deer license holders report their harvest each year giving the Department a reasonable estimate of the number of deer harvested throughout the state. Additionally, harvest reports provide information on success, satisfaction ratings, and the number of days hunters spend afield. Trends in success rates and hunter satisfaction are used as another index of population performance and deer licenses may be adjusted based on these trends and stakeholder desires. Success rates for hunts can vary across weapon types and GMU, but the long-term overall success rate for deer hunts across areas and weapon types is approximately 32%.

License Allocations

The Department is tasked with optimizing hunting opportunities with diverse opinions of what that means. Many hunters only desire the chance to go hunting, while others measure the success of a hunt by number or size of bucks that are seen. To meet these diverse desires, the Department provides different hunting opportunities and hunt structures across the state through "Standard" (also defined as "Opportunity") hunts and "Quality" hunts.

Opportunity Hunt Units

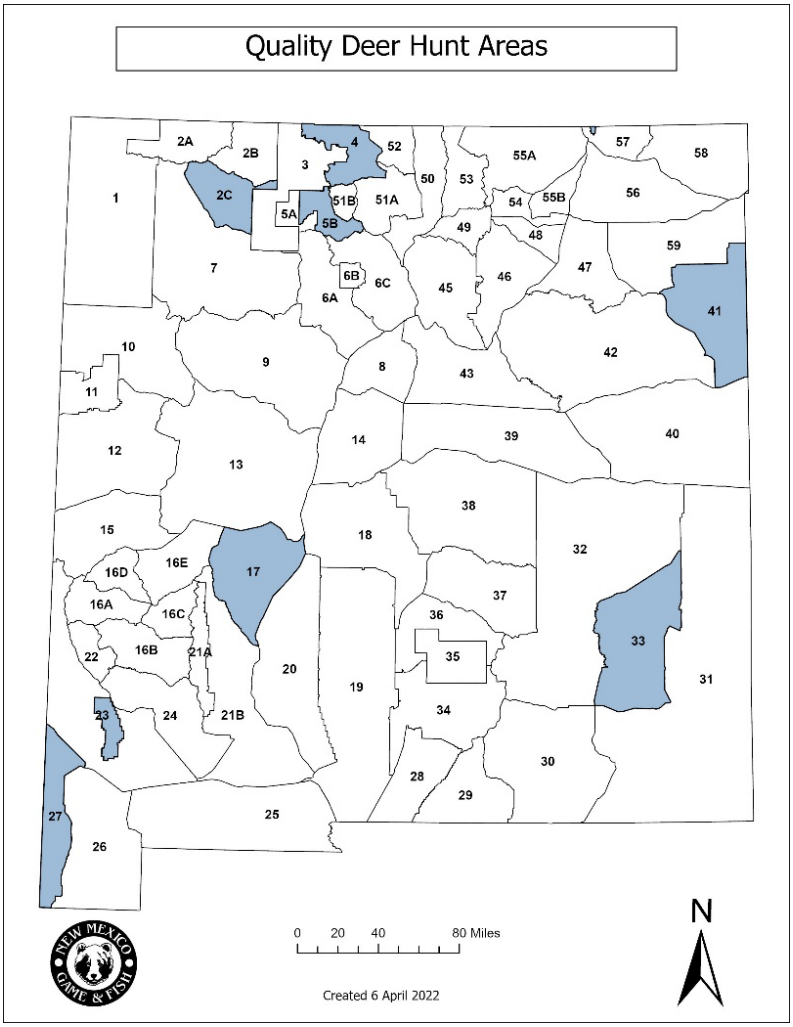
Standard hunts (also defined as Opportunity Hunts) are designed to provide applicants with a higher chance of drawing a deer hunting license. Opportunity Hunt Units These units are managed to maximize annual hunter opportunity without significant negative impacts to overall population health. Hunting opportunities in these units are less restrictive.

A minimum of 15 bucks:100 does is desired in Opportunity GMUs. The age class of bucks in opportunity units is typically younger than that in Quality units. Hunter density in these areas is typically higher, and success rates may be lower as a result. Most of the state is managed for opportunity except for in the Quality Hunt Units detailed below.

Quality Hunt Units

Quality hunts are designed to provide hunters with some combination of lower hunter density per hunt, an increased opportunity for success, an ability to select from a wider selection of legal animals, and/or season structures (timing and length) that provide a more pleasurable hunting experience. Quality hunts/units are designated by the Commission and license allocation is more restrictive.

For more information on managing hunting for opportunity or mature bucks in the context of Western States, see this fact sheet developed by the WAFWA Mule Deer Working Group.



Quality deer hunt units in New Mexico.

Guidelines to allocate hunting licenses based on hunt type.

	Parameter	Decrease	Maintain	Increase
Opportunity	Fawn:Doe[a]	<35	35 - 45	-
	Buck:Doe[a]	<15	15 - 25	>25
	Rifle and Muzzleloader Success[b]	<20%	20% - 35%	>35%
	Archery Success[b]	<10%	10 - 25%	>25%
	Hunter Density (mi^2)[c]	>1	0.5 - 1	<0.5
Quality	Fawn:Doe[a]	<35	35 - 45	-
	Buck:Doe[a]	<30	30 - 40	>40
	Rifle and Muzzleloader Success[b]	<40%	40 - 55%	>55%
	Archery Success[b]	<20%	20 - 35%	>35%
	Hunter Density (mi^2)[c]	>0.3	0.1 - 0.3	<0.1
	Population Trend[d]	Decreasing	Stable	Increasing
	Hunter Satisfaction	<3.0	3.0 – 3.5	>3.5
	Hunter Satisfaction Trend	Decreasing	Constant	Increasing

[a] The 3-year average of the composition ratios will be used as the basis for setting license quotas.
[b] The 3-year average of harvest success will be used as the basis for setting license quotas
[c] Calculated by dividing the number of hunters by the legally accessible public land (mi^2) within a GMU. This metric does not consider the quality of habitat.
[d] Situations might arise where hunt modifications do not follow this guideline. Examples include areas of high disease risk, areas with low social tolerance of deer, or areas where constituents desire different hunting opportunities.

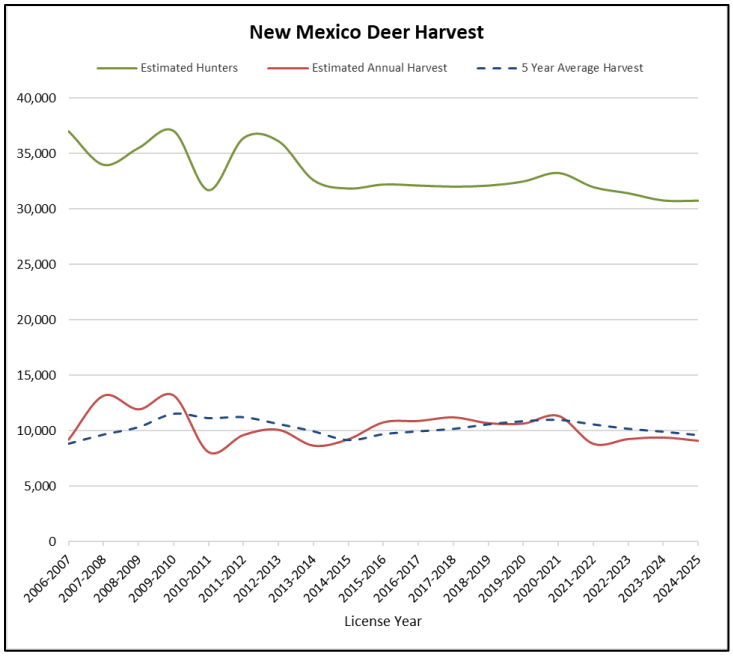
White-tailed Deer

The behavior of Coues white-tailed deer is such that success is typically lower. License allocation recommendations for Coues white-tailed deer are made with emphasis on hunter satisfaction and supplemented with local population knowledge.

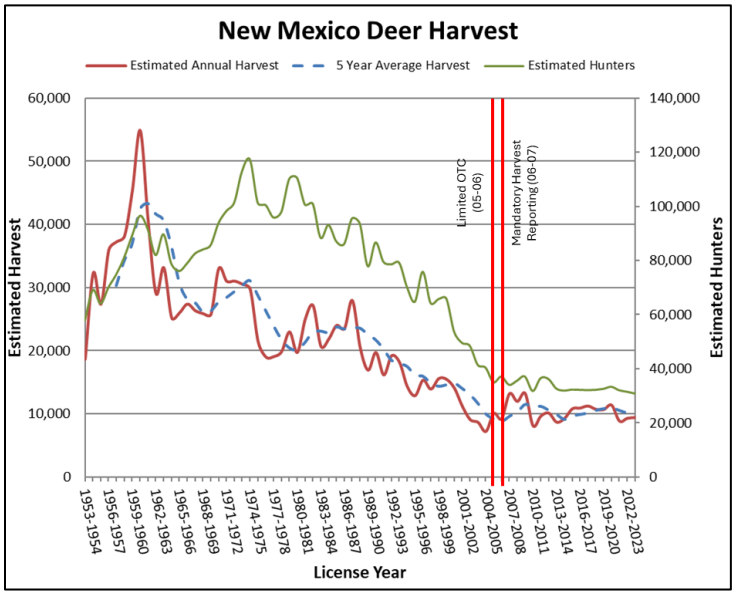
Success rates for Texas white-tailed deer on the eastern portion of the state are consistently low. These hunts are intended to provide hunters with an opportunity to go hunting.

Private Land Deer Hunting

For most of the state, private-land only deer licenses are available over the counter. The exception is in units 2A, 2B, 2C, 4, and 5A. In these units the Department restricts the licenses that are available for private-land deer hunting. To hunt deer in these units, hunters must obtain an authorization code and a hunt code from the landowner and must apply through the regular public draw.



Estimated deer hunters, deer harvest, and 5-year average deer harvest in New Mexico for 2006-2024 hunting seasons.



Estimated deer hunters, deer harvest, and 5-year average deer harvest in New Mexico for 1953-2024 hunting seasons. Vertical lines denote when licenses became limited and when mandatory harvest reporting began.

Deer Rule Development

The Department's Deer Rule outlines season dates and license numbers and opens every 4 years, allowing the Department to make management recommendations to the State Game Commission (Commission) based on changes in deer populations and hunter desires. Recommendations are based on biological data, hunter harvest data, and management objectives. The Department solicits public input on these recommendations and adjusts where necessary. The following is a breakdown of how hunting rules are set in New Mexico and ways in which the public can be involved.

1) The Department proposes initial recommendations to the public and Commission based on biological, survey, and harvest data.
2) These initial recommendations are presented at public meetings, typically in each region of the state.
3) The Department solicits and compiles formal written and emailed comments about proposals from all stakeholders.
4) Based on this input, the Department may modify the recommendations if the majority of stakeholders desire a particular change (or no change) as long as it does not negatively impact a population or management objective.
5) The Department makes final recommendations to the Commission who then votes to adopt the rule based on biological data and public input submitted during the open rule period.

The Deer Rule for the 2027-2030 hunting seasons will open for public comment in 2026. The Department appreciates feedback and encourages public engagement. For a list of proposals that the Commission may be currently considering, please visit this webpage: http://www.wildlife.state.nm.us/commission/proposals-under-consideration/

Alternative Deer Hunting Programs

Private Land Deer Incentive Program

The Private Land Deer Incentive Program (PLDIP) was created to incentivize landowners to improve habitat on their property through alternate deer hunting opportunities. Participating landowners must demonstrate a commitment to managing their property in a manner that offers protection to deer habitat and/or implements long-term habitat improvements designed to restore natural vegetation composition and structure desirable to deer. There are approximately 80 ranches enrolled in this program as of 2025.

Urban Deer Hunts

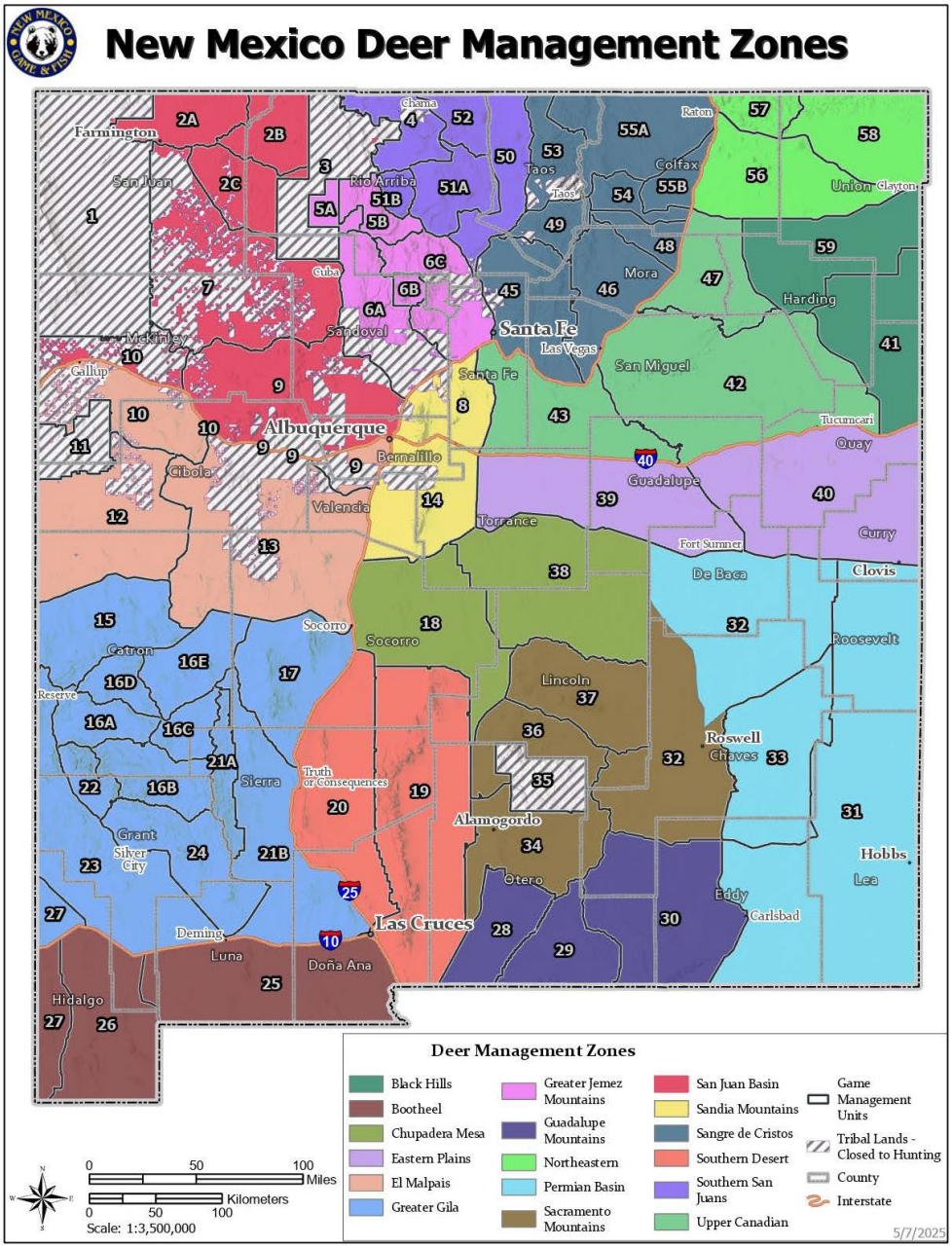
The Department aims to minimize deer nuisance or safety issues when they arise, typically around population centers. Oftentimes in these situations, conflicting social values of residents of the municipalities make it difficult to manage deer populations in these areas. Some residents find the deer endearing and enjoy watching them, while others consider the deer a nuisance because of the damage they can do to landscaping. In addition to the damage, increased vehicle strikes or aggression toward humans can result in safety concerns.

Silver City, Ruidoso, and Raton currently have deer overpopulation issues that the cities and NMDGF managers are trying to address. A deer management hunt area was created in Silver

City, and antlerless hunts began in 2014. Approximately 40 females are harvested on this hunt each year.

DEER MANAGEMENT ZONES

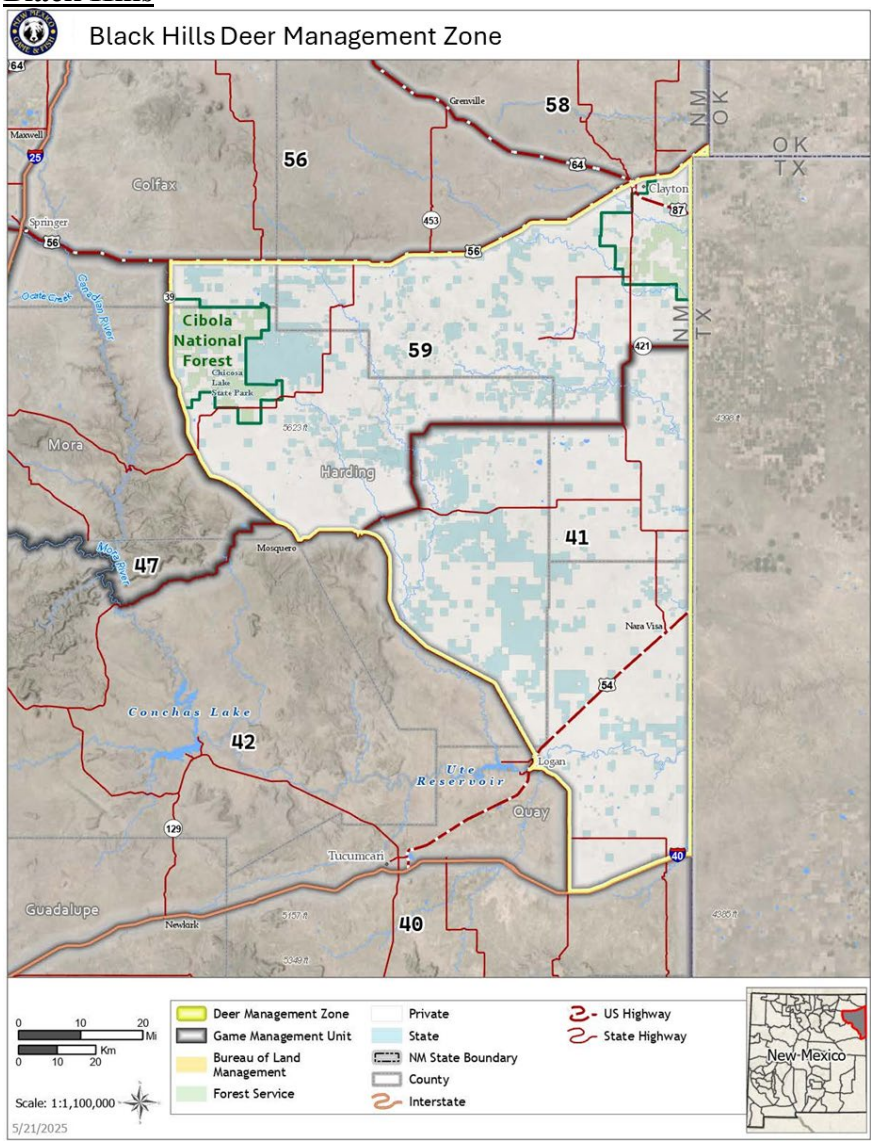
Deer Management Zones (DMZ) are ecoregions where relatively distinct deer populations inhabit the landscape. These zones span several GMU's, each containing specific annual harvest regulations and license allotments. As the new survey technique is developed and new information becomes available, these DMZs might be adjusted.



Deer Management Zones for New Mexico Department of Game and Fish.

Deer Management Zone Descriptions and Hunting Information

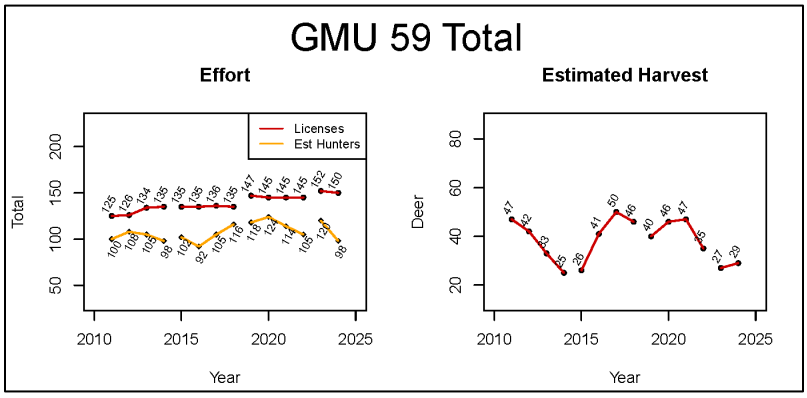
Black Hills

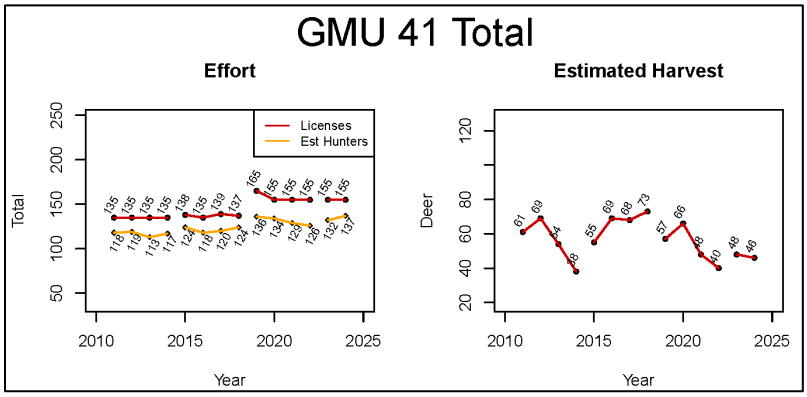


BIOLOGY – Deer in this DMZ are largely resident; they may make short seasonal movements in response to weather patterns or water and food distributions. If deer make seasonal movements, they will return to their home ranges when conditions become favorable. Aerial surveys are not conducted regularly in this DMZ. Thus, population trajectories are monitored using hunter harvest data. The Black Hills deer herd is considered stable. CWD has been detected a few miles from GMU 41 in Texas.

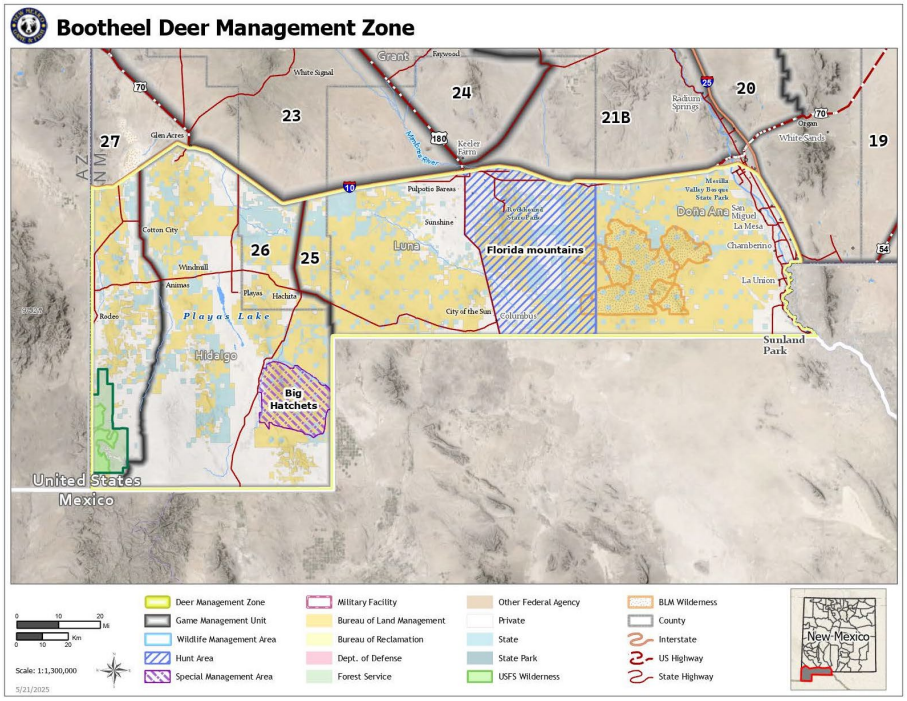
HUNTING – Both mule deer and white-tailed deer can be found throughout the Black Hills. The Black Hills are characterized by sandy flats that are broken up with caprock escarpments and mesas. Mesquite and grasslands dominate the sandy flats at lower elevations and oakbrush and

pinyon-juniper (PJ) habitat are found on the escarpments and mesas. Good mule deer numbers can be found in pockets throughout this DMZ, and white-tailed deer are found along river bottoms and in the grasslands on the eastern side of this DMZ. GMU 41 is managed as a Quality hunt unit while GMU 59 is managed for opportunity. Hunting access is limited to the patchwork of State Land Office (SLO) parcels. Trends in harvest for each GMU can be found in the graphs below.





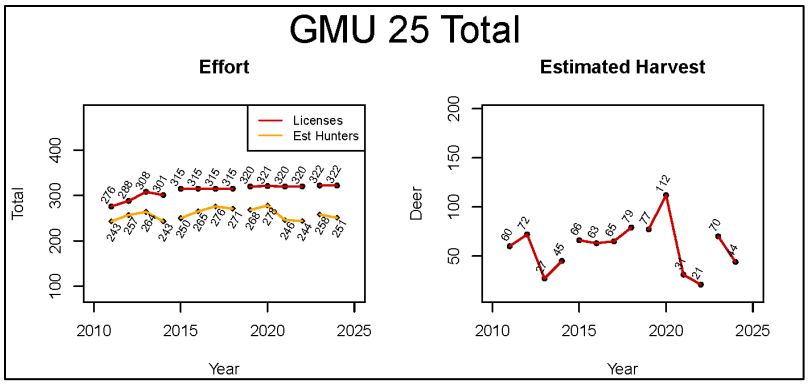
Bootheel

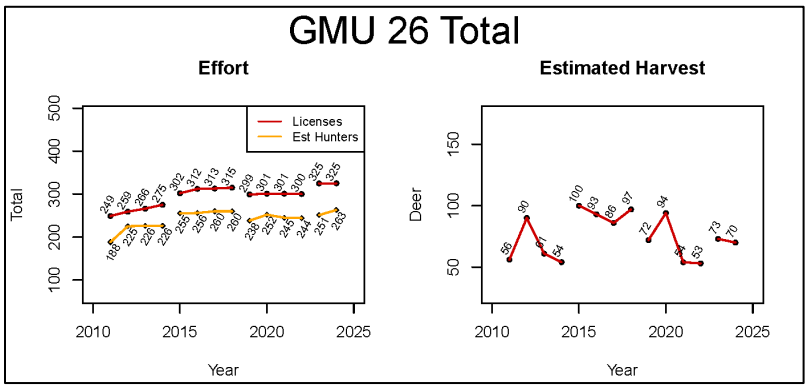


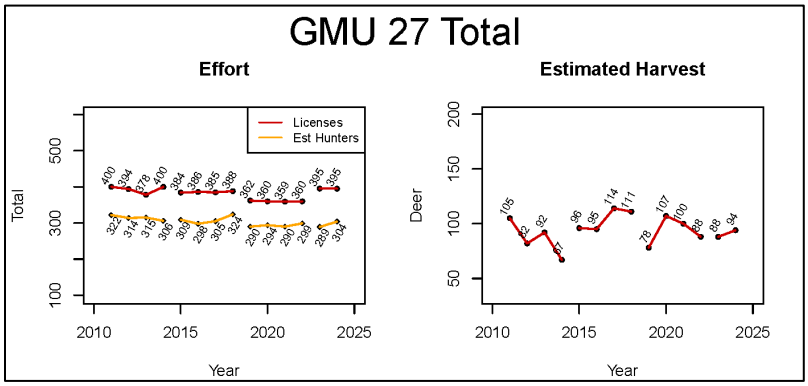
BIOLOGY – Deer in the Bootheel are year-round residents. However, they may make seasonal movements in response to monsoonal rain patterns, livestock use, or breeding behavior. Some of these movements might be substantial to escape unfavorable conditions, such as when water sources dry up. They typically return to their known ranges when conditions become favorable. Deer numbers in this area are largely influenced by the timing and amount of rainfall. As such, deer densities can be sporadic in these desert habitats, but good numbers can be found in pockets. Deer densities in the Peloncillo Mountains are typically higher than the rest of the DMZ. Because of extended drought, the deer populations in GMUs 25 and 26 are lower in recent years; the deer population in GMU 27 remains stable.

HUNTING – Mule deer dominate this DMZ, but GMU 27 contains a robust Coues white-tailed deer herd. The Bootheel is dominated by the Chihuahuan Desert, characterized by arid landscapes and distinct rugged mountain ranges. The vegetation is characterized by Yucca, creosote, buffalo gourd, and mesquite. The Peloncillo Mountains, which are part of the Madrean Sky Islands, are situated on the western side of this DMZ and contain interesting pine-oak woodlands.

In dry years, deer will typically be within 1.5 miles of water sources. Public hunting access is obtained through the vast Bureau of Land Management (BLM) and United States Forest Service (USFS) land found throughout. GMU 27 is managed as a Quality Hunt Unit; the remaining GMUs are managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.







RESEARCH – GMU 27: Peloncillo Mountains

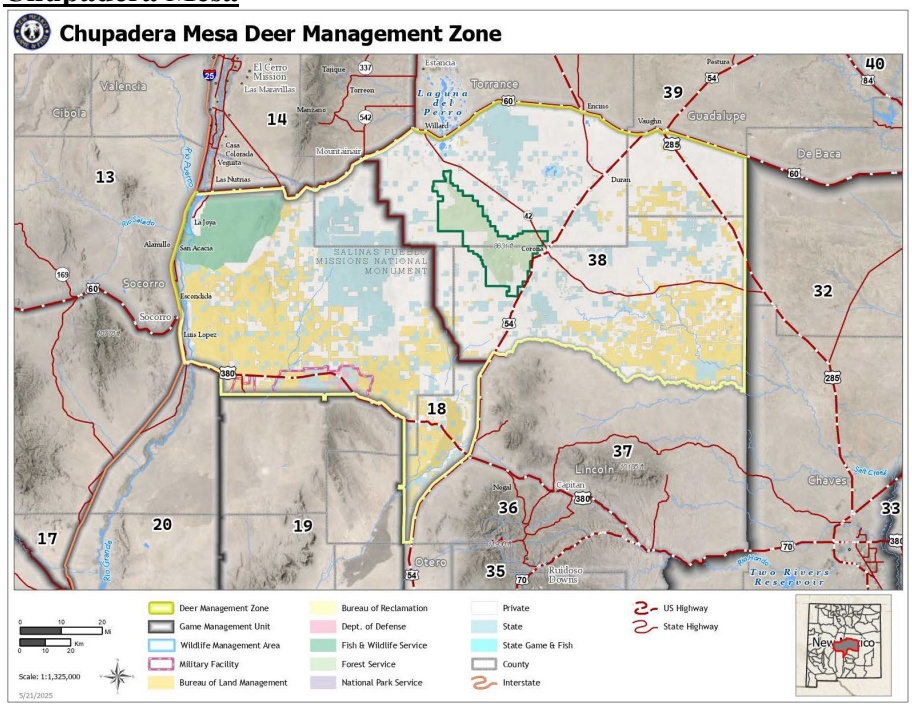
Survival and cause-specific mortality of translocated female mule deer in southern, NM, USA. Journal of Wildlife Management. 2018.

James W. Cain III[1], Jana B. Ashling[1], Stewart G. Liley[2]

[1]Department of Fish, Wildlife and Conservation Ecology, New Mexico State University
[2]New Mexico Department of Game and Fish

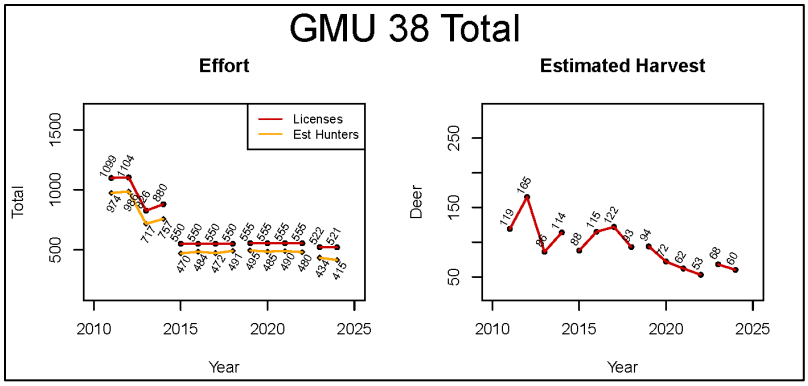
ABSTRACT – Many mule deer (*Odocoileus hemionus*) populations in New Mexico have failed to recover from previous population declines, while some populations near urban areas have increased, resulting in more frequent human–wildlife conflicts. Translocations were used in an effort to simultaneously reduce an urban mule deer population and augment two low-density populations in south-western New Mexico, USA. Because of insufficient monitoring, the efficacy of many ungulate translocations is unknown. Our goal was to monitor cause-specific mortality and 1 year post-release survival of mule deer translocated during 2013 and 2014. We compared survival rates of mule deer released with a hard- versus soft-release during the 2014 translocation. We translocated 218 mule deer in 2013 and 2014 into the Peloncillo Mountains (PM) and San Francisco River Valley (SFRV); 106 adult female mule deer were fitted with telemetry collars to determine cause-specific mortality and estimate survival 1 year post-release. All deer were hard-released in 2013. In 2014, translocated mule deer were either held in a soft-release pen (0.81 ha) for approximately 3 weeks or hard-released into their new environment. We used a Kaplan–Meier approach to estimate survival of translocated mule deer at each release area and to compare survival of mule deer translocated using each release method (i.e. hard- versus soft-release). In 2013–14, survival of hard-released deer in the PM was 0.627 (s.e. = 0.09), compared with 0.327 (s.e. = 0.10) in the SFRV. In 2014–15, survival of hard–released deer in the PM was 0.727 (s.e. = 0.13) and survival of soft-released deer was 0.786 (s.e. = 0.11). In the SFRV, survival of hard- and soft-released deer was 0.656 (s.e. = 0.14) and 0.50 (s.e. = 0.16), respectively. Causes of mortality were predation (51%), potential disease (9%; blue tongue or epizootic haemorrhagic disease), accident (5%), poaching (5%) and unknown (20%). Translocations can be an effective management tool to augment populations of mule deer while reducing overabundant urban populations. Soft-released mule deer did not have higher survival than hard-released mule deer, although the length and conditions of the acclimation period were limited in our study. Overabundant mule deer populations in urban areas may serve as sources of animals to bolster declining populations. Soft-release pens of smaller size and short period of acclimation did not influence survival.

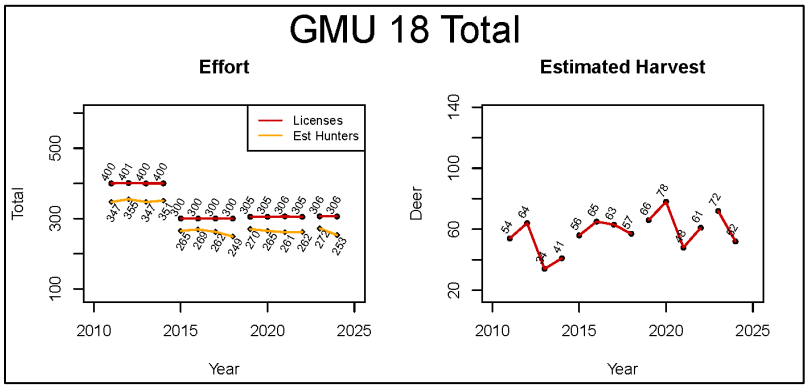
Chupadera Mesa



BIOLOGY – Deer in this DMZ are largely resident; they may make short seasonal movements in response to weather patterns or water and food distributions. If deer make seasonal movements, they will return to their home ranges when conditions become favorable. The deer population in this DMZ is considered stable with the highest deer densities found on and around the Gallinas Mountain.

HUNTING – The majority of Chupadera Mesa is relatively flat with rolling PJ grasslands. Numerous moderate canyon complexes break off the mesa tops. The Gallinas Mountain is the exception to the flat nature of this DMZ. The Gallinas Mountain is a mixed-conifer mountain in GMU 38, and it reaches approximately 8,600 feet. Deer numbers in this range are good; a stand replacing wildfire in 2001 has recovered and provides ample shrub cover and early successional plants that are beneficial to deer. Deer use and numbers are higher in the burned areas than in the unburned areas. Public hunting access is obtained through the vast BLM and USFS land found throughout. The Chupadera Mesa DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.





RESEARCH – GMU 38: Gallinas Mountains

Mule deer resource selection: trade-offs between forage and predation risk. Frontiers in Ecology and Evolution. 2024.

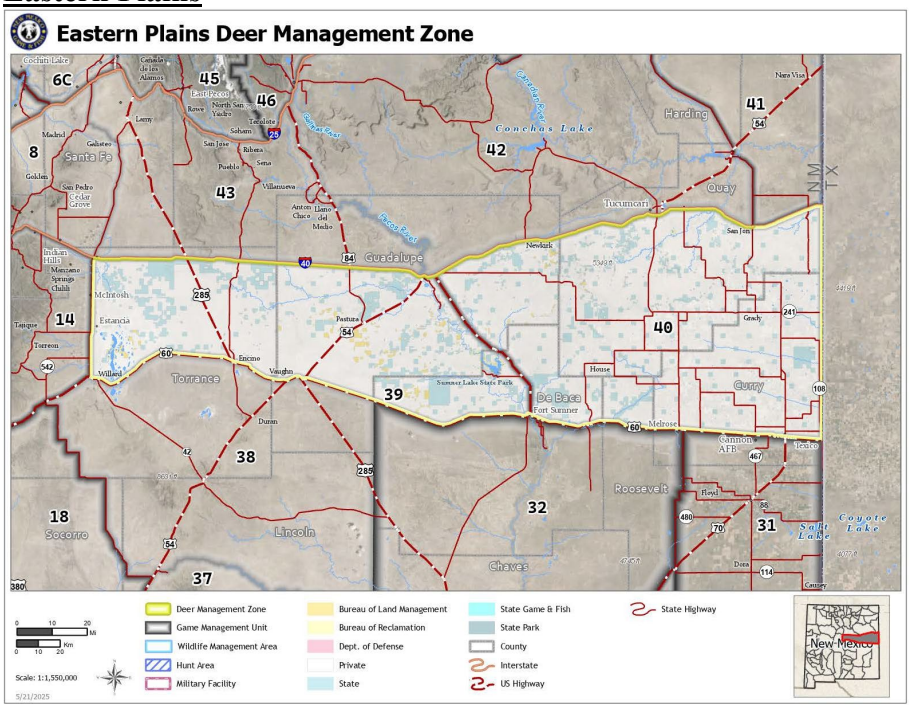
James W. Cain III[1], Jacob H. Kay[1], Stewart G. Liley[2], Jay V. Gedir[1]

[1]Department of Fish, Wildlife and Conservation Ecology, New Mexico State University
[2]New Mexico Department of Game and Fish

ABSTRACT – Ungulates commonly select habitat with higher forage biomass and or nutritional quality to improve body condition and fitness. However, predation risk can alter ungulate habitat selection and foraging behavior and may affect their nutritional condition. Ungulates often choose areas with lower predation risk, sometimes sacrificing higher quality forage. This forage–predation risk trade-off can be important for life history strategies and influences individual nutritional condition and population vital rates. We used GPS collar data from adult female mule deer (*Odocoileus hemionus*) and mountain lions (*Puma concolor*) to model mule deer habitat selection in relation to forage conditions, stalking cover and predation risk from mountain lions to determine if a forage-predation risk trade-off existed for mule deer in central New Mexico. We also examined mountain lion kill sites and mule deer foraging locations to assess trade-offs at a finer scale. Forage biomass and protein content were inversely correlated with horizontal

visibility, hence associated with higher stalking cover for mountain lions, suggesting a forage-predation risk trade-off for mule deer. Mule deer habitat selection was influenced by forage biomass and protein content at the landscape and within home range spatial scales, with forage protein being related to habitat selection during spring and summer and forage biomass during winter. However, mule deer selection for areas with better foraging conditions was constrained by landscape-scale encounter risk for mountain lions, such that increasing encounter risk was associated with diminished selection for areas with better foraging conditions. Mule deer also selected for areas with higher visibility when mountain lion predation risk was higher. Mountain lion kill sites were best explained by decreasing horizontal visibility and available forage protein, suggesting that deer may be selecting for forage quality at the cost of predation risk. A site was 1.5 times more likely to be a kill site with each 1-meter decrease in visibility (i.e., increased stalking cover). Mule deer selection of foraging sites was related to increased forage biomass, further supporting the potential for a trade-off scenario. Mule deer utilized spatio-temporal strategies and risk-conditional behavior to reduce predation risk, and at times selected suboptimal foraging areas with lower predation risk

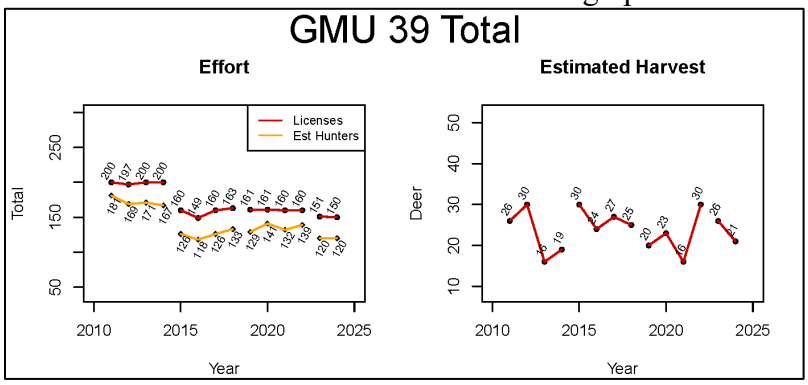
Eastern Plains

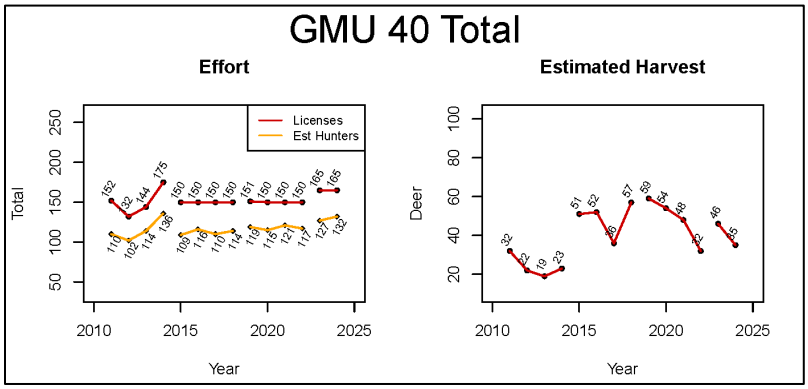


BIOLOGY – Deer in the Eastern Plains are year-round residents. On the eastern side of this DMZ, some deer live their entire lives around the vast crop fields that dominate this area. On the western side of the Eastern Plains, deer are a little more mobile as they move throughout the PJ-grassland habitats to obtain necessary resources. The deer population in this DMZ is considered stable.

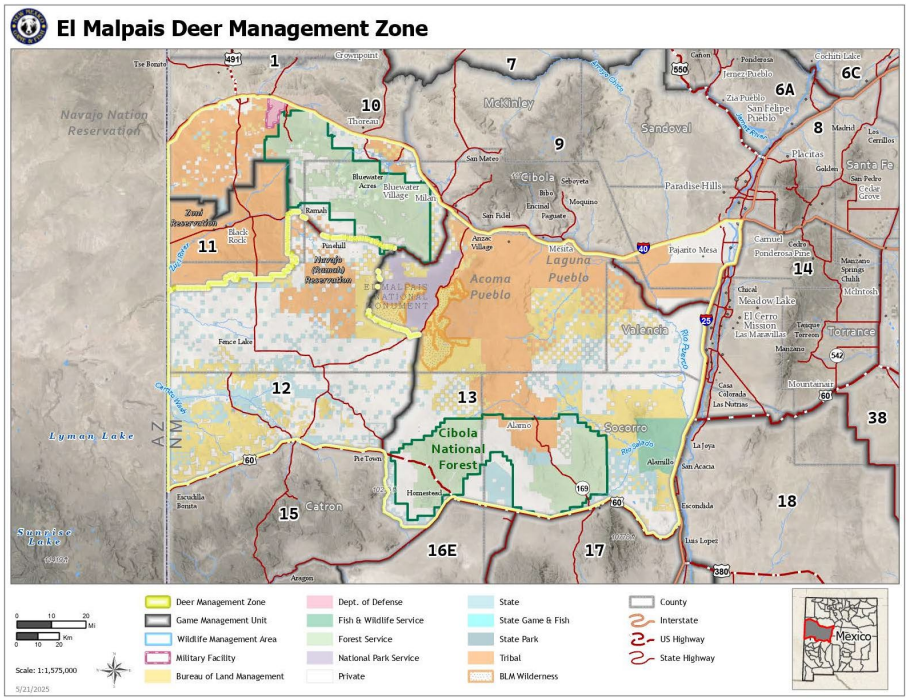
HUNTING – The Eastern Plains is better known for the pronghorn hunting that it affords, but good deer hunting can still be found in pockets. Plains and rolling hills dominate this area with

some rimrock escarpments scattered throughout. The eastern portion of this DMZ is dominated by private agricultural lands while the western portion is characterized by rolling PJ-grassland habitats. Successful hunters will find deer in the open grasslands and agricultural lands as well as along escarpments or where there is a mosaic of habitat types. Public hunting access is obtained through the scattered SLO parcels. The Eastern Plains DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.



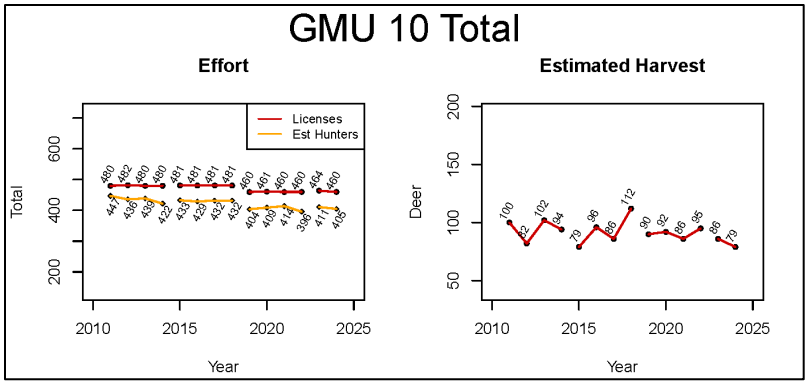


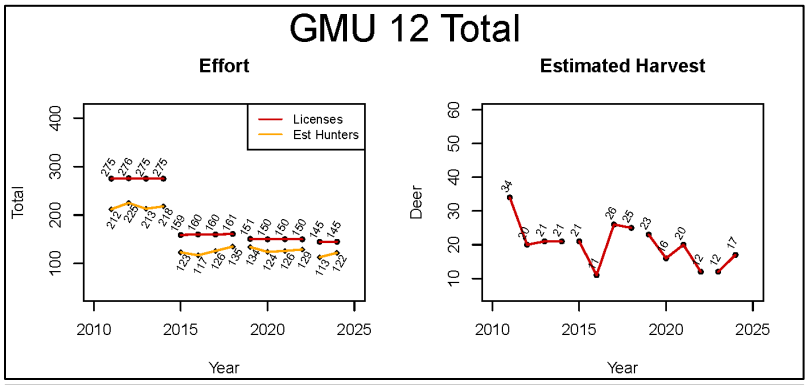
El Malpais

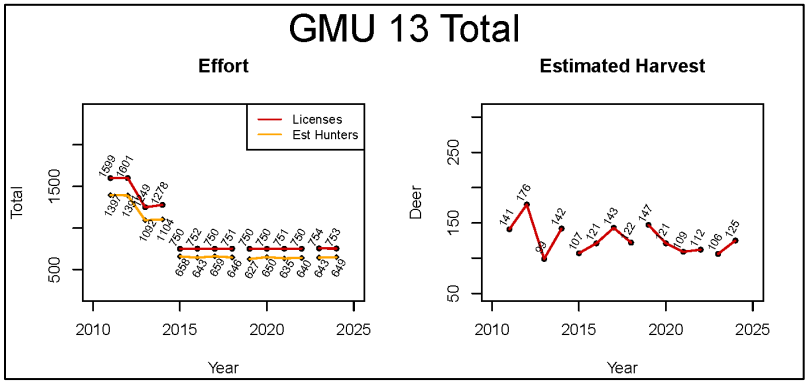


BIOLOGY – Deer in El Malpais are year-round residents, but they might make short movements to take advantage of favorable conditions in this arid landscape. This deer herd is not surveyed, so hunter harvest data provides an index of population productivity. Deer densities and the resulting population size in El Malpais are considered low.

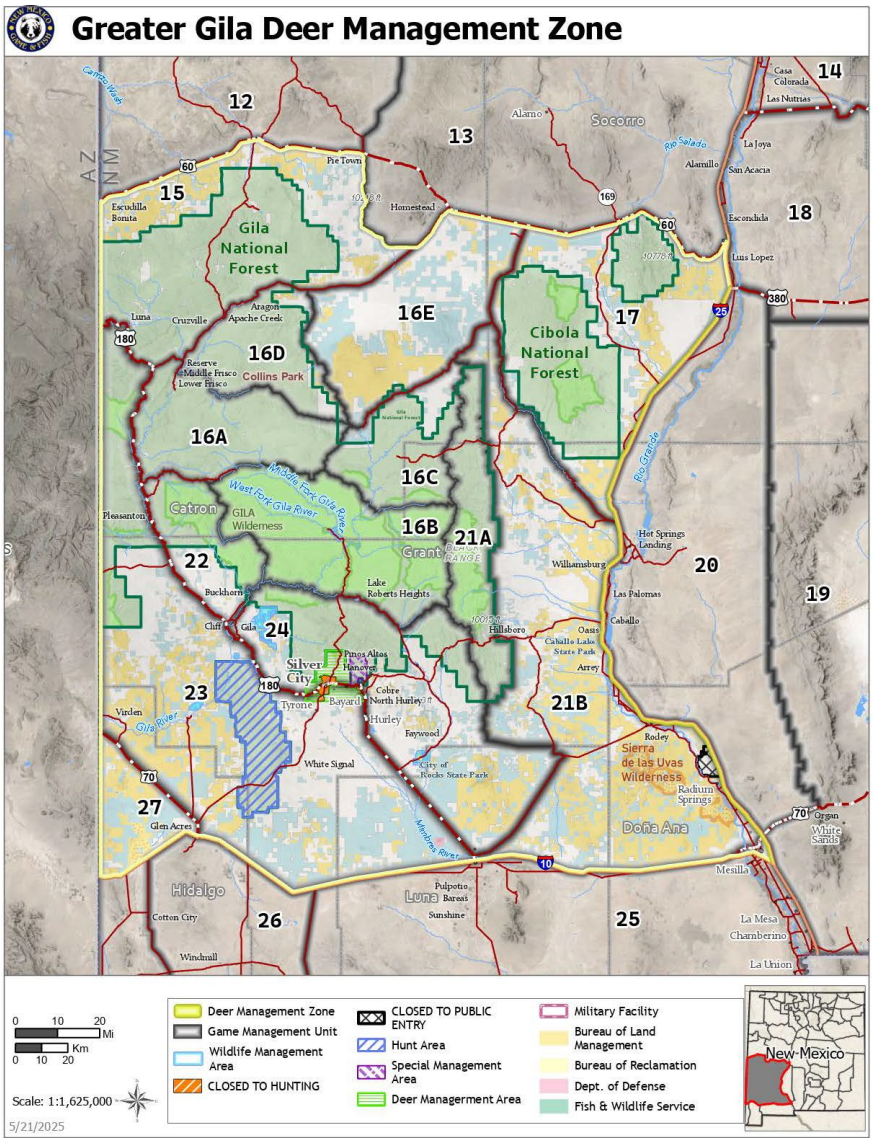
HUNTING – Although this area is better known for pronghorn and elk hunting, some large antlered bucks are harvested in this DMZ each year. This diverse volcanic landscape is characterized by rolling grasslands, isolated sandstone and basalt mesas, lava flows, cinder cones, and pressure ridges. Because of the volcanic influences, hiking here can be difficult. Vegetation consists of grasslands, PJ woodlands, and scrub oak. Deer can be found in localized pockets throughout this DMZ. Water can be scarce, so hunting within 1.5 miles of water sources is recommended. Public hunting access can be obtained through abundant BLM, SLO, and USFS lands. Several tribal reservations are found in this DMZ and are close to public hunting. The El Malpais DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.







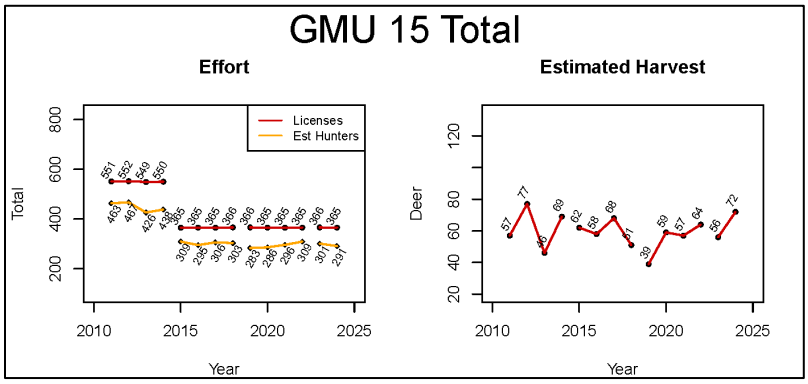
Greater Gila

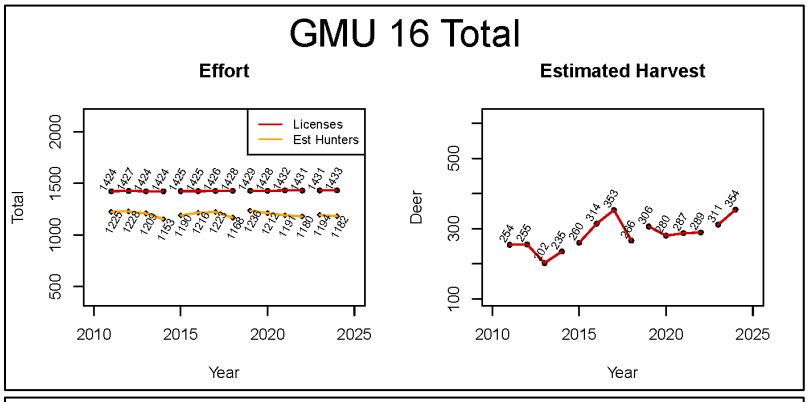


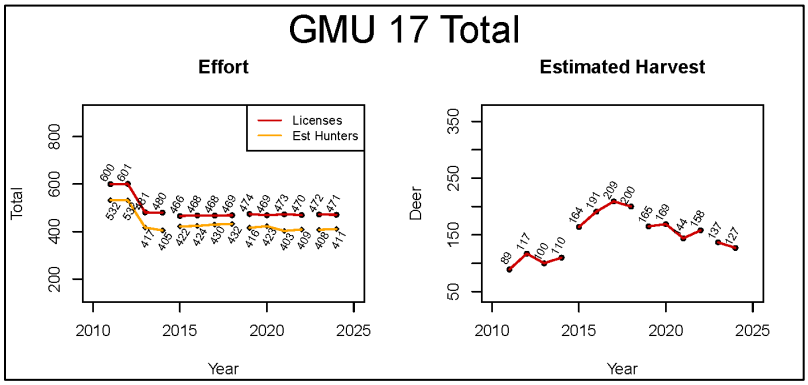
BIOLOGY – Deer in portions of the Greater Gila DMZ are year-round residents while others might make temporary seasonal movements to find more favorable conditions. In the mountainous portion of the Greater Gila, some deer might migrate out of the high elevations when the snowpack is deep. Due to long-term drought, deer numbers in this area are lower than historically reported. Despite this, the population is considered stable in recent years.

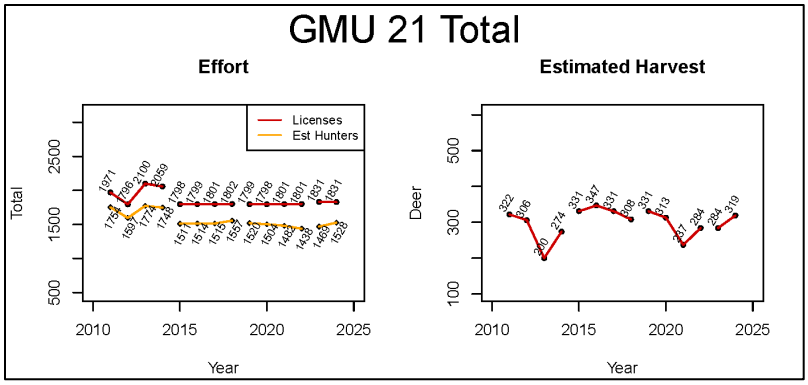
HUNTING – Mule deer are found throughout the Greater Gila and Coues white-tailed deer are found throughout most of this DMZ. The Burro Mountains and GMU 17 are managed as Quality Hunt units. The remaining portions of the Greater Gila are managed as opportunity units. Both mule deer and Coues white-tailed deer can be found throughout this DMZ. The Greater Gila is large with habitats ranging from desert floors to mixed conifer and aspen woodlands. The mixed-conifer woodlands have a grassland understory and shrub cover can be found on the slopes. The desert areas are dominated by prickly pear uplands and creosote flats. The deer are not evenly

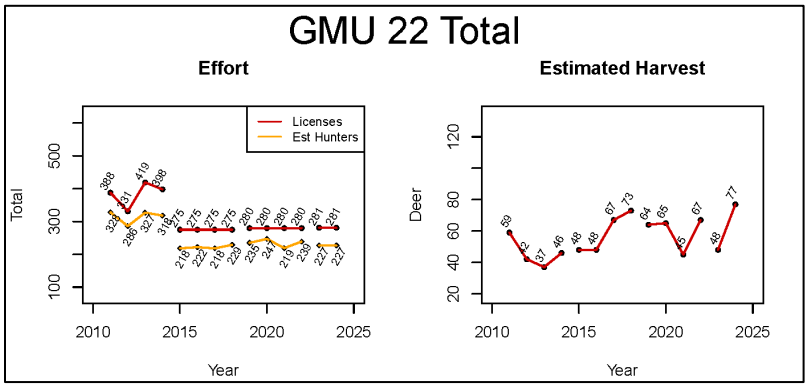
distributed in this DMZ; wildfire is a common occurrence in the Gila National Forest and these areas will hold deer throughout the year. GMUs 23 and 24 are well known for Coues bucks. Public hunting access in the Greater Gila is through the extensive USFS, BLM, and SLO lands. The Greater Gila DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.

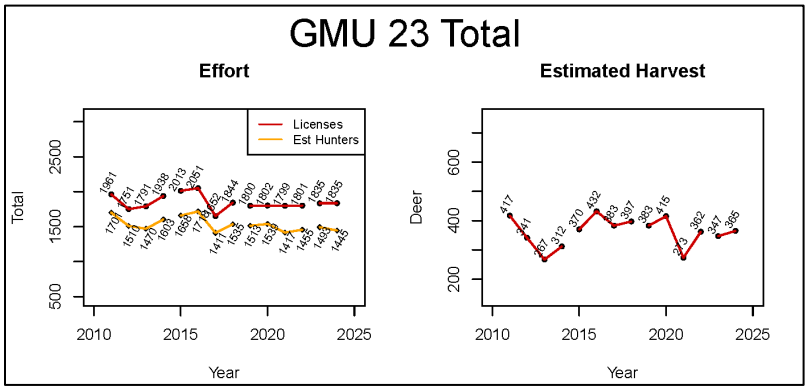


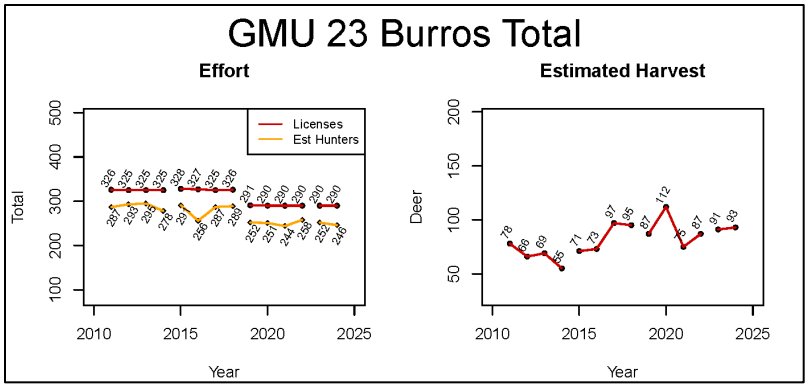


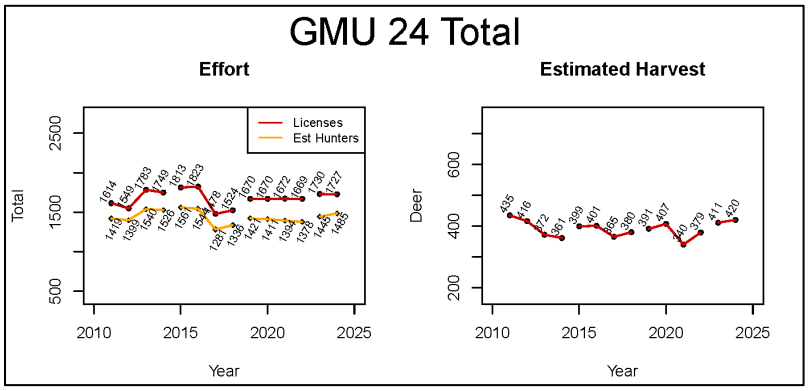



GMU 21 Total
Effort
Licenses
Est Hunters
Total
Year
Estimated Harvest
Deer
Year


GMU 22 Total
Effort
Licenses
Est Hunters
Total
Year
Estimated Harvest
Deer
Year


GMU 23 Total
Effort
Licenses
Est Hunters
Total
Year
Estimated Harvest
Deer
Year





RESEARCH – GMU 23: San Francisco River Valley

Survival and cause-specific mortality of translocated female mule deer in southern, NM, USA. Journal of Wildlife Management. 2018.

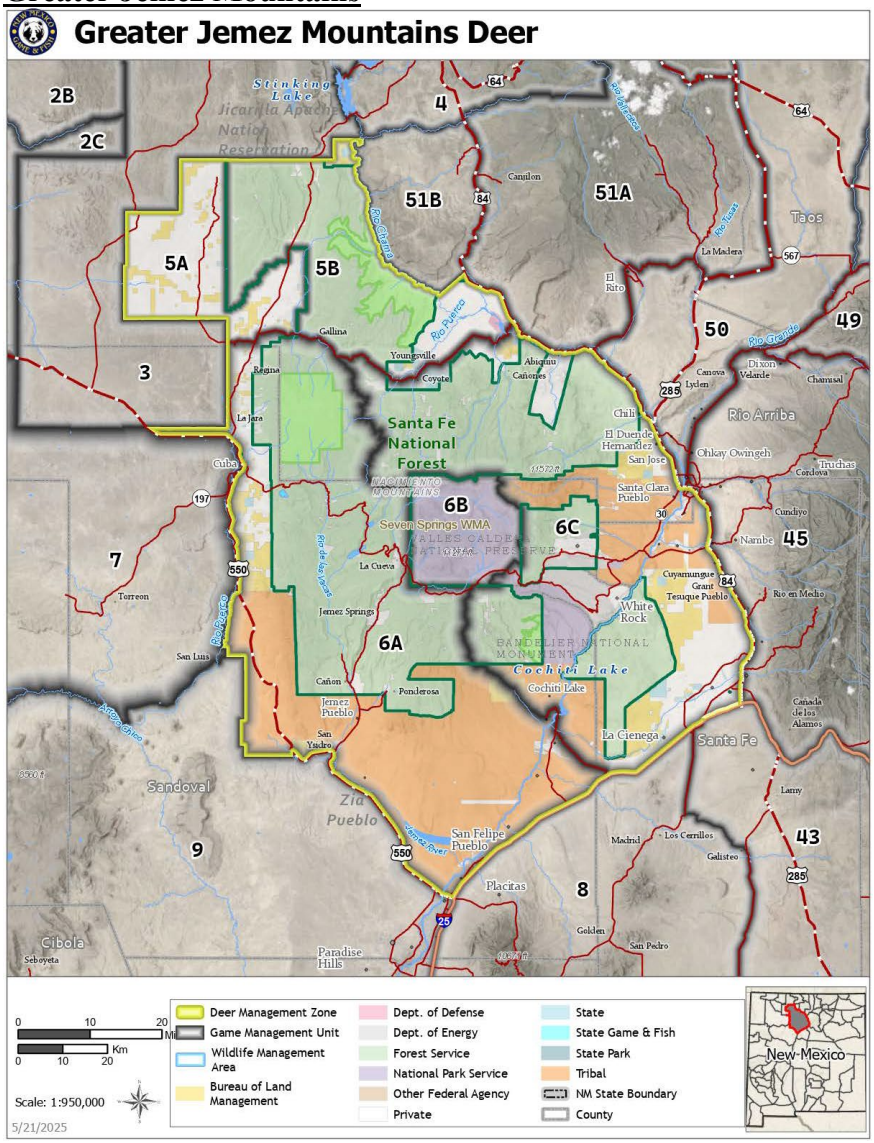
James W. Cain III[1], Jana B. Ashling[1], Stewart G. Liley[2]

[1]Department of Fish, Wildlife and Conservation Ecology, New Mexico State University
[2]New Mexico Department of Game and Fish

ABSTRACT – Many mule deer (*Odocoileus hemionus*) populations in New Mexico have failed to recover from previous population declines, while some populations near urban areas have increased, resulting in more frequent human–wildlife conflicts. Translocations were used in an effort to simultaneously reduce an urban mule deer population and augment two low-density populations in south-western New Mexico, USA. Because of insufficient monitoring, the efficacy of many ungulate translocations is unknown. Our goal was to monitor cause-specific mortality and 1 year post-release survival of mule deer translocated during 2013 and 2014. We compared survival rates of mule deer released with a hard- versus soft-release during the 2014 translocation. We translocated 218 mule deer in 2013 and 2014 into the Peloncillo Mountains (PM) and San Francisco River Valley (SFRV); 106 adult female mule deer were fitted with telemetry collars to determine cause-specific mortality and estimate survival 1 year post-release.

All deer were hard-released in 2013. In 2014, translocated mule deer were either held in a soft-release pen (0.81 ha) for approximately 3 weeks or hard-released into their new environment. We used a Kaplan–Meier approach to estimate survival of translocated mule deer at each release area and to compare survival of mule deer translocated using each release method (i.e. hard- versus soft-release). In 2013–14, survival of hard-released deer in the PM was 0.627 (s.e. = 0.09), compared with 0.327 (s.e. = 0.10) in the SFRV. In 2014–15, survival of hard–released deer in the PM was 0.727 (s.e. = 0.13) and survival of soft-released deer was 0.786 (s.e. = 0.11). In the SFRV, survival of hard- and soft-released deer was 0.656 (s.e. = 0.14) and 0.50 (s.e. = 0.16), respectively. Causes of mortality were predation (51%), potential disease (9%; blue tongue or epizootic haemorrhagic disease), accident (5%), poaching (5%) and unknown (20%). Translocations can be an effective management tool to augment populations of mule deer while reducing overabundant urban populations. Soft-released mule deer did not have higher survival than hard-released mule deer, although the length and conditions of the acclimation period were limited in our study. Overabundant mule deer populations in urban areas may serve as sources of animals to bolster declining populations. Soft-release pens of smaller size and short period of acclimation did not influence survival.

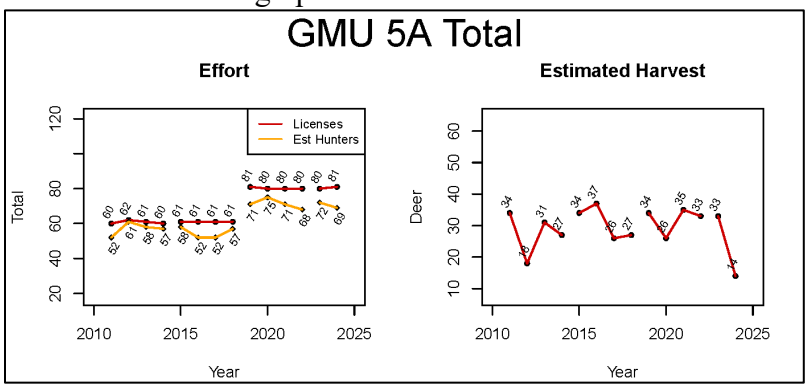
Greater Jemez Mountains

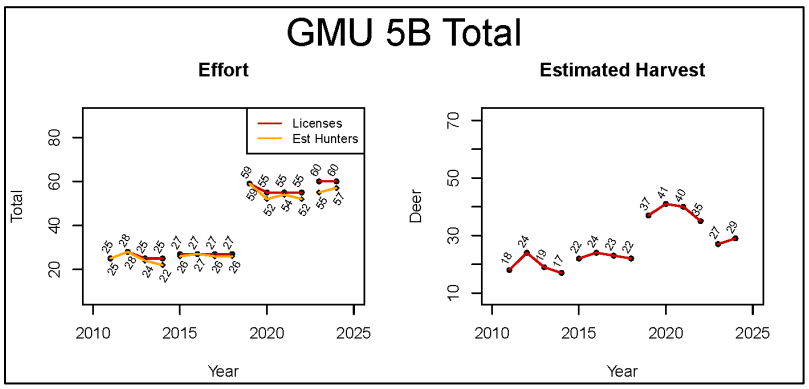


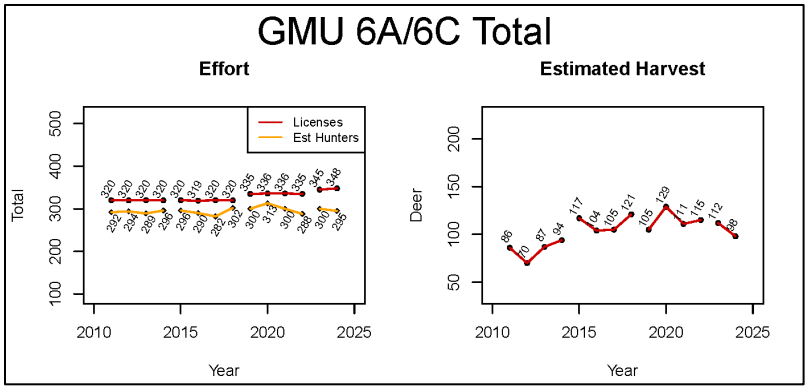
BIOLOGY – Deer in the Greater Jemez Mountains are short distance migrants. They will migrate out of higher elevations when the snowpack is heavy. GPS collar data shows some deer move from the San Pedro Parks Wilderness into GMU 2C for the winter. The habitat in the Greater Jemez Mountains is very productive. Additionally, several fires that were beneficial to deer have burned in the last 10-15 years. Because of these factors, the deer population is stable to increasing with good deer densities found throughout.

HUNTING – The habitat in the Jemez Mountains varies with mixed-conifer/aspen forests, subalpine grasslands and spruce-fir at the higher elevations. Lower elevations contain sagebrush, scrub oak, and PJ woodlands. Deer can be found in good densities throughout the DMZ, and some large antlered bucks are taken each year. Public hunting access in the Greater Jemez Mountains is through the extensive USFS lands. Several tribal reservations are found in this

DMZ and are close to public hunting. GMU 5B is a Quality Hunt Unit; the remainder of the Greater Jemez Mountains DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.







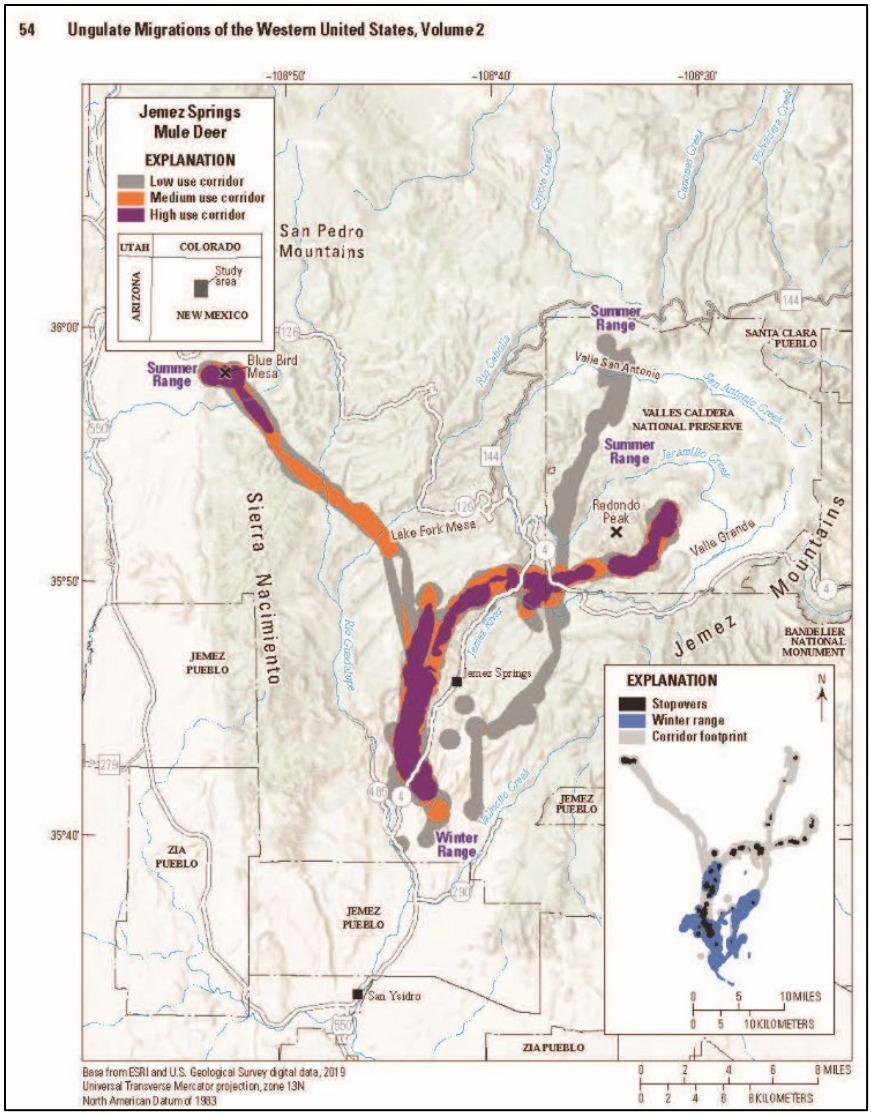
RESEARCH – GMU 6A: Jemez Springs

Migration Mapping: Ungulate Migrations of the Western US Volume 2. United States Geological Survey Report. 2022.

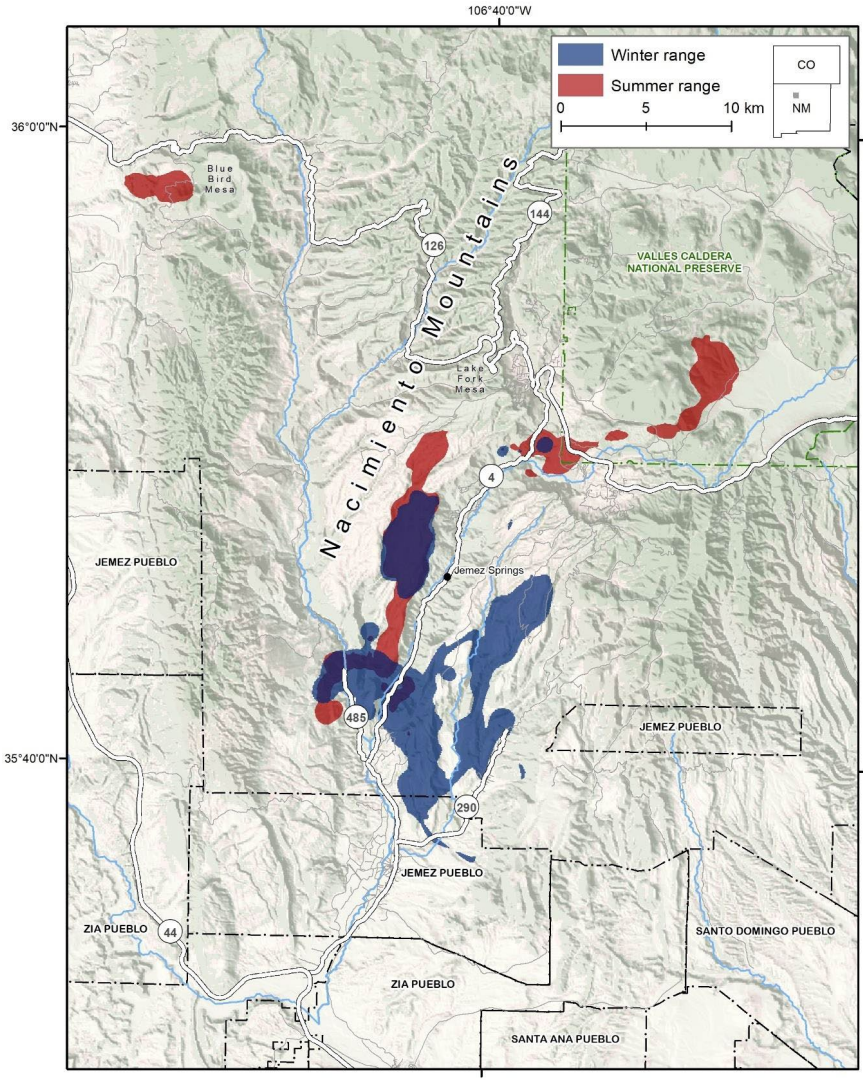
Ungulate Migrations of New Mexico. NMSU Report. 2025.

Matthew Kauffman, James W. Cain III, Craig Reddell, Orrin Duvuvuei, and others.

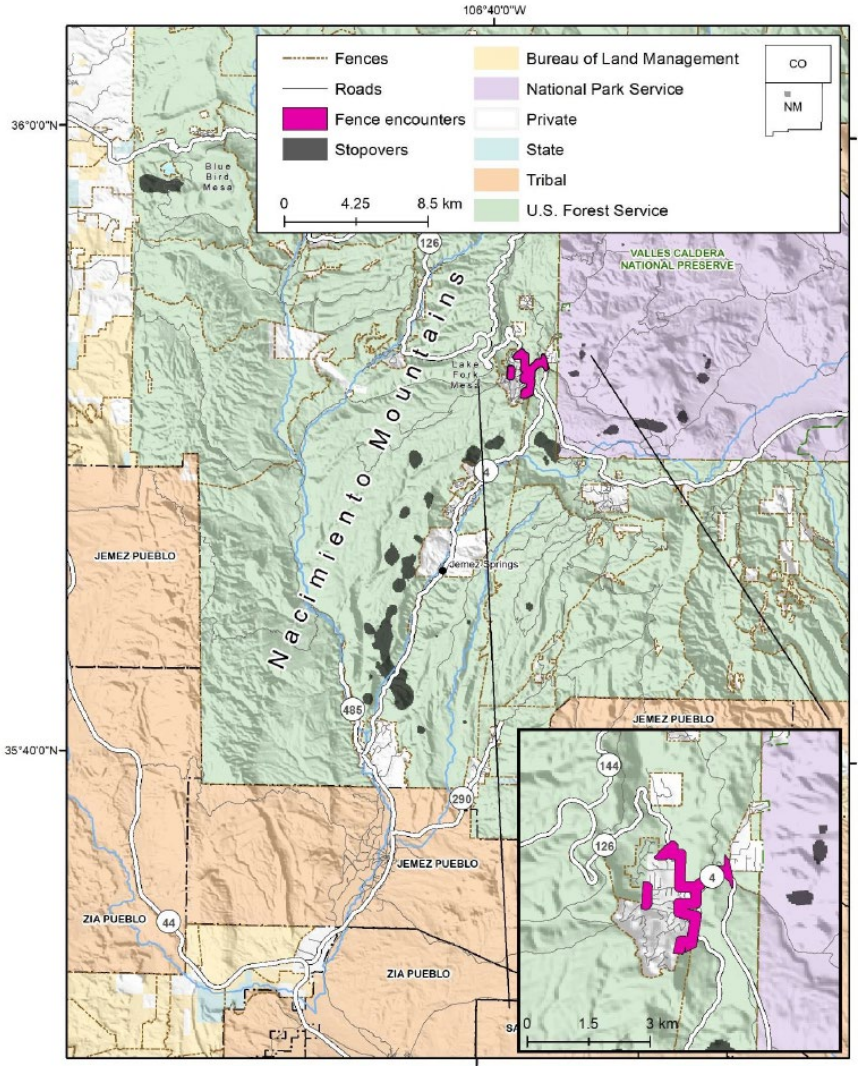
SUMMARY – The Department partnered with the NMSU Cooperative Fish and Wildlife Research Unit tso map migration and habitat use of mule deer in the Jemez Mountains. A segment of the Jemez Springs mule deer herd winters in the southwestern Jemez Mountains. Individuals migrated an average of 16.2 miles, either to the western edge of the Jemez Mountains, near Blue Bird Mesa, or to the Valles Caldera National Preserve. The central migration route follows the top of a 1,300-foot escarpment paralleling and eventually crossing New Mexico State Route 4 twice. The summer range is dominated by ponderosa pine and mixed-conifer forests, along with open grasslands in the Valles Caldera. The herd is only partially migratory, as resident individuals are found on the winter range and on Lake Fork Mesa, west of the caldera. State Route 4 may act as a slight obstacle to migration, as one of the larger stopover sites was located between the two road crossings. For more information on this project, including migration start and end dates, sample size, and summaries on the corridors see Volume 2 of the Ungulate Migrations of the Western US.



Migration corridors, seasonal ranges, and stopover areas for the Jemez Springs mule deer herd, New Mexico, USA. From USGS Ungulate Migrations of the Western United States, Vol. 2 (pg. 54).

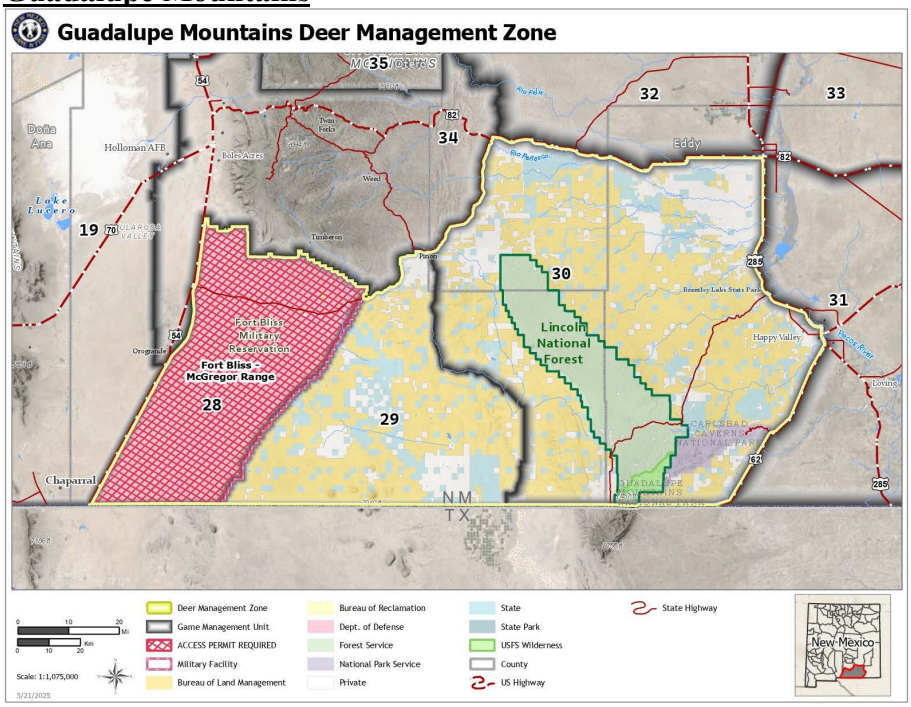


Winter and summer ranges of the Jemez Springs mule deer herd, New Mexico, USA.



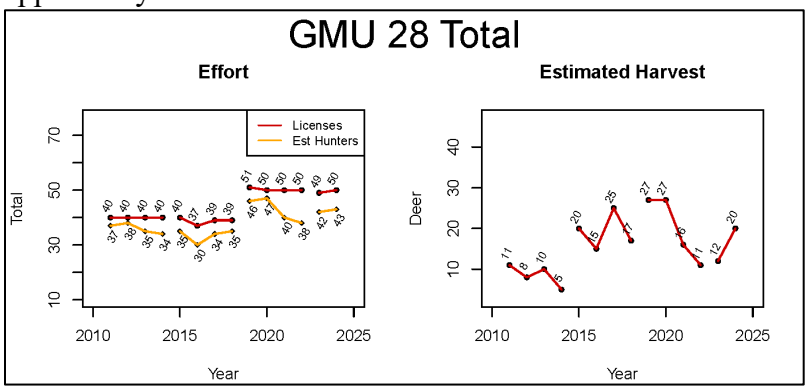
Stopovers and sections of fences (pink) with high-density encounter rates of the Jemez Springs mule deer herd, New Mexico, USA.

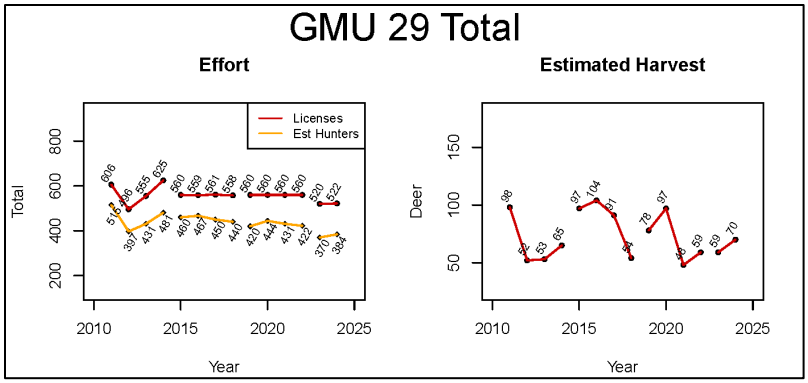
Guadalupe Mountains

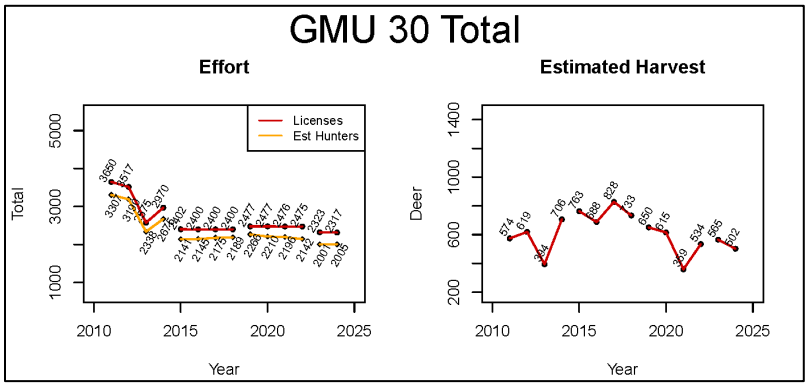


BIOLOGY – Deer in the Guadalupe Mountains are year-round residents, but they might make short movements to take advantage of favorable conditions in this arid landscape. Hunter harvest data provides an index of population productivity. Deer densities and the resulting population size in the Guadalupe Mountains are considered low. CWD has been detected in GMUs 28 and 29.

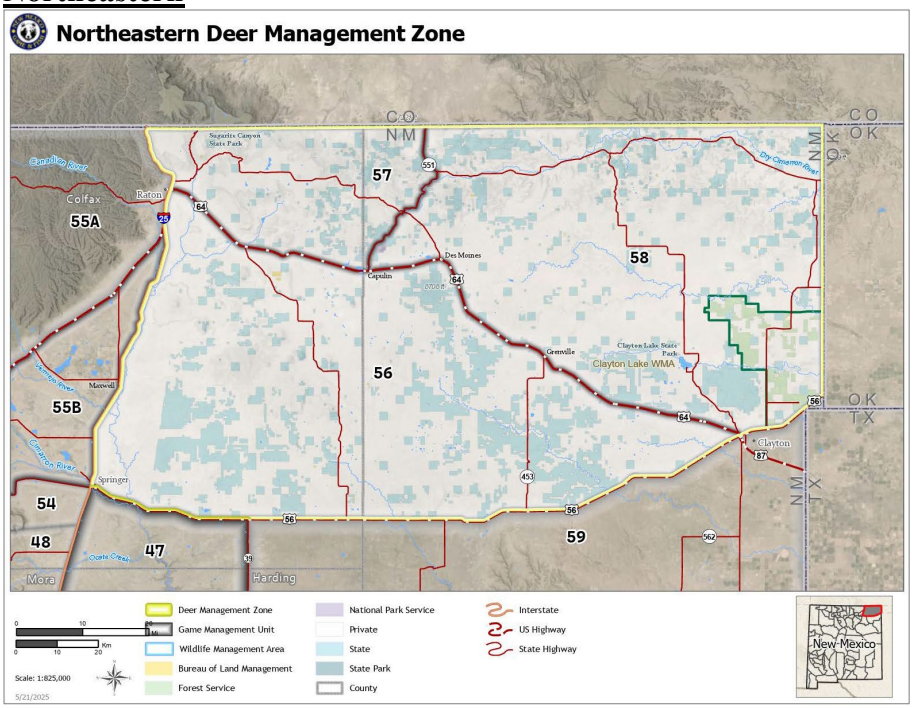
HUNTING – The majority of the Guadalupe Mountains is characterized by open, desert habitat except for the Guadalupe Mountain itself. The Guadalupe Mountain contains PJ habitat. Deer can be found in localized pockets throughout this DMZ. Water can be scarce, so hunting within 1.5 miles of water sources is recommended. Public hunting access can be obtained through abundant BLM, SLO, and USFS lands. The Guadalupe Mountains DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.





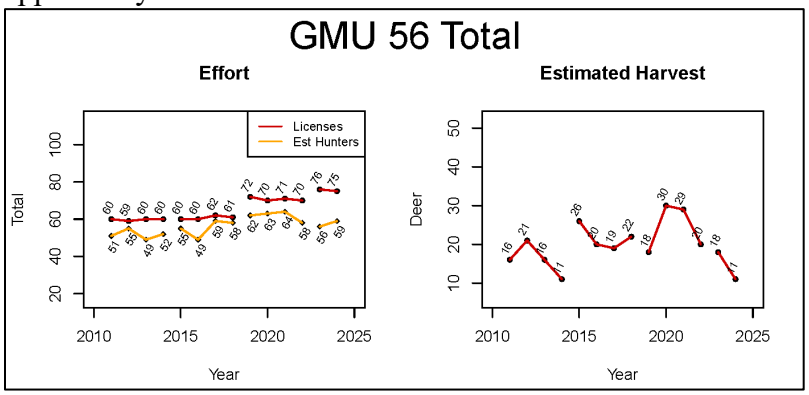


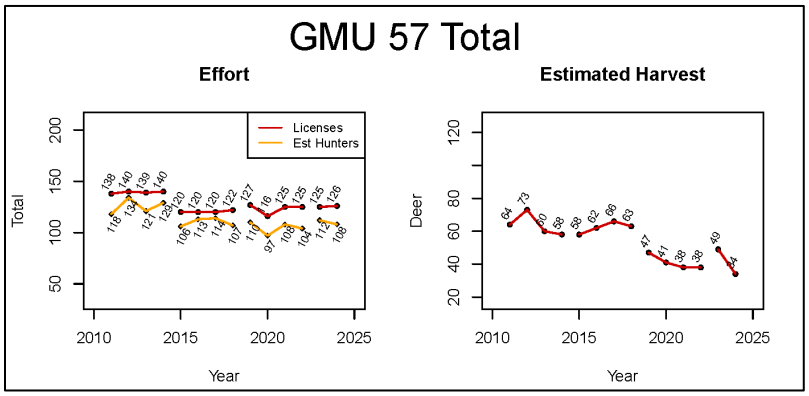
Northeastern

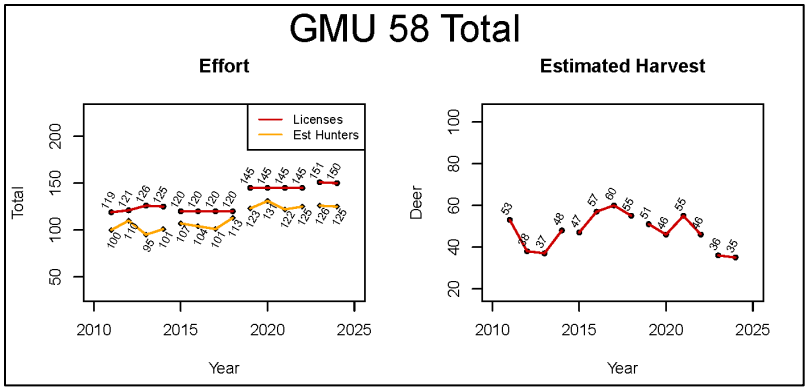


BIOLOGY – Deer in the Northeastern DMZ are year-round residents. Deer herds in the Northeastern DMZ are generally productive, but growth is limited by available habitat. Deer population growth in the eastern portion of this DMZ is further limited by precipitation patterns. In areas with good habitat, such as along the mesa edges and on the mountain slopes, deer densities can be high; however, deer densities are very low between these landscape features. The deer population is considered stable.

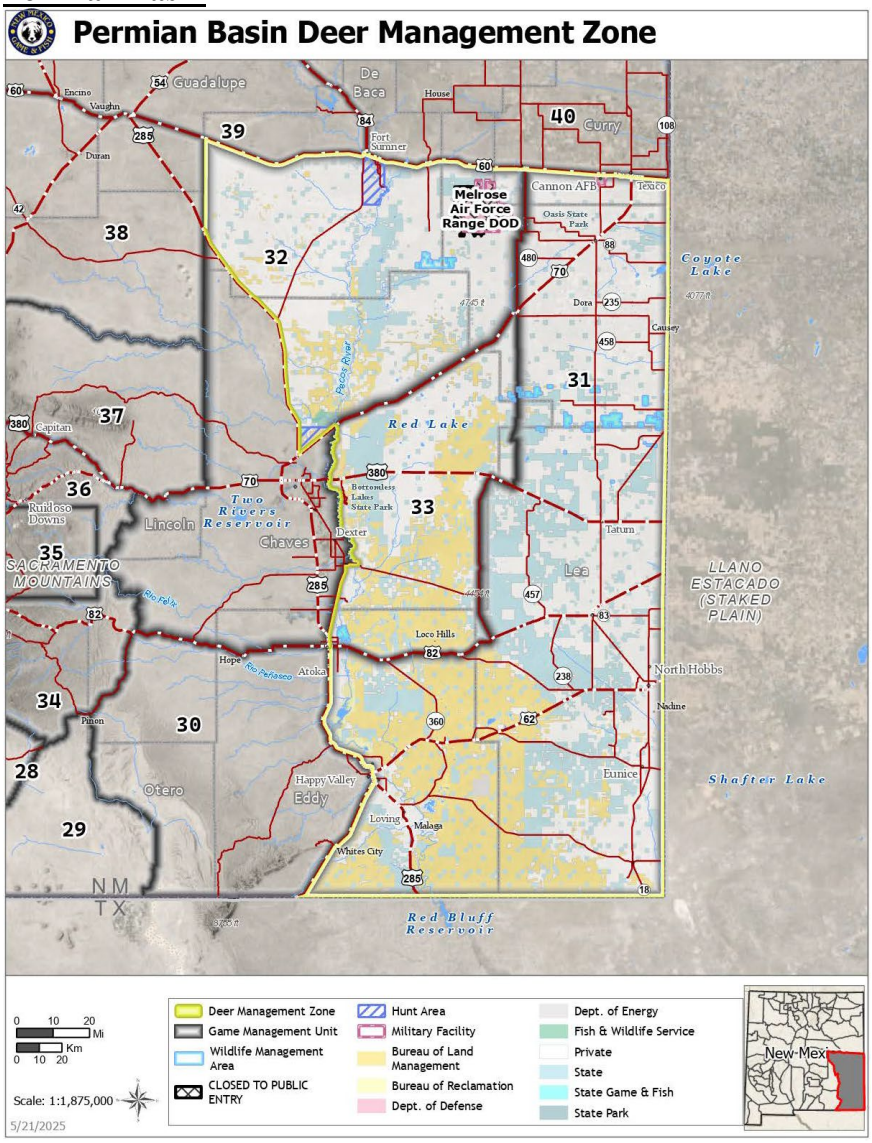
HUNTING – This region is characterized by a network of mesas and volcanic cones that are separated by expanses of plains and grasslands. The slopes and escarpments are dominated by scrub oak and PJ woodlands while the mesa tops and lowlands are predominately grasslands. Because of the expansive private lands, bucks can reach old age classes. However, this DMZ isn't known to produce large numbers of record book bucks. Public hunting in these units is available through the patchwork SLO parcels. The Northeastern DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.





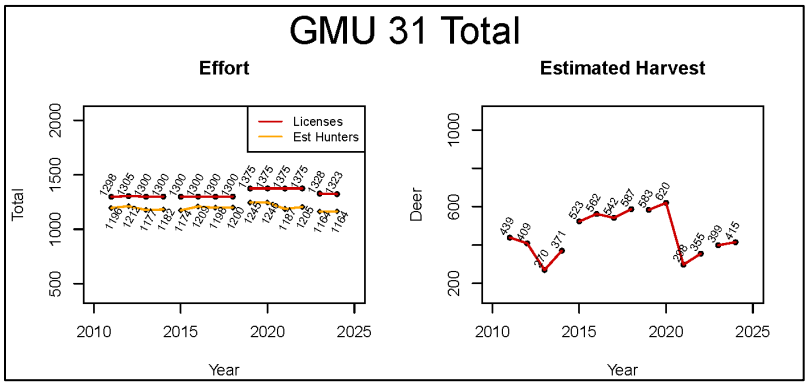


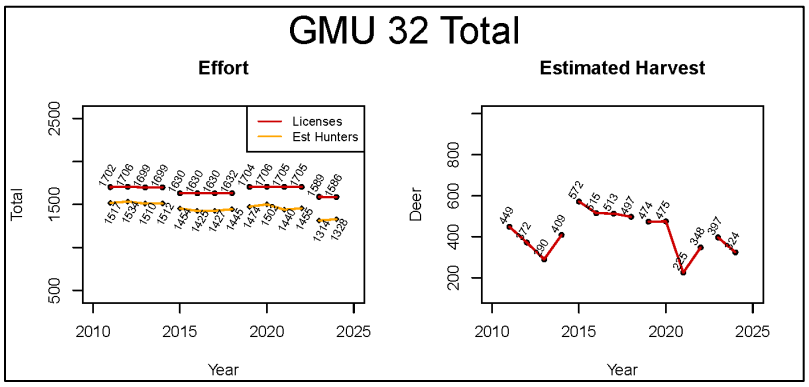
Permian Basin

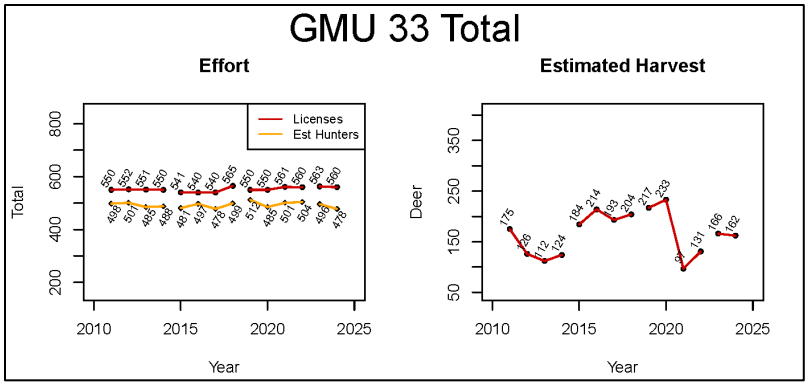


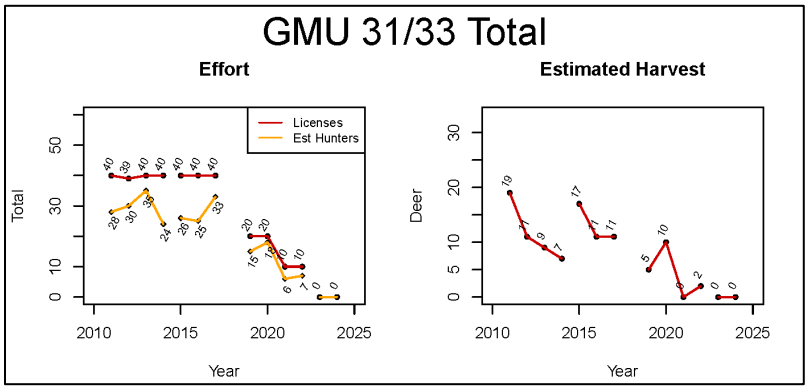
BIOLOGY – Deer in the Permian Basin are generally considered year-round residents, but during dry conditions, they may make short movements to take advantage of seasonal rains and return to their home ranges when conditions become favorable. The deer population in the Permian Basin is considered stable, but landscape changes due to anthropogenic influences can reduce habitat carrying capacity.

HUNTING – GMU 33 is managed as a Quality Hunt Unit while the remaining GMUs are managed as Opportunity Hunt Units. The Permian Basin is dominated by sandhills with shinnery oak and other nutritious forbs and shrubs that benefit deer. Although this DMZ isn't the first place that hunters think about when looking for a record buck in New Mexico, large antlered bucks are regularly harvested in this DMZ, particularly in GMU 33. Public hunting access is available through the extensive BLM and SLO land; some of this land can be checkerboarded, but it is still easily accessible. Trends in harvest for each GMU can be found in the graphs below.









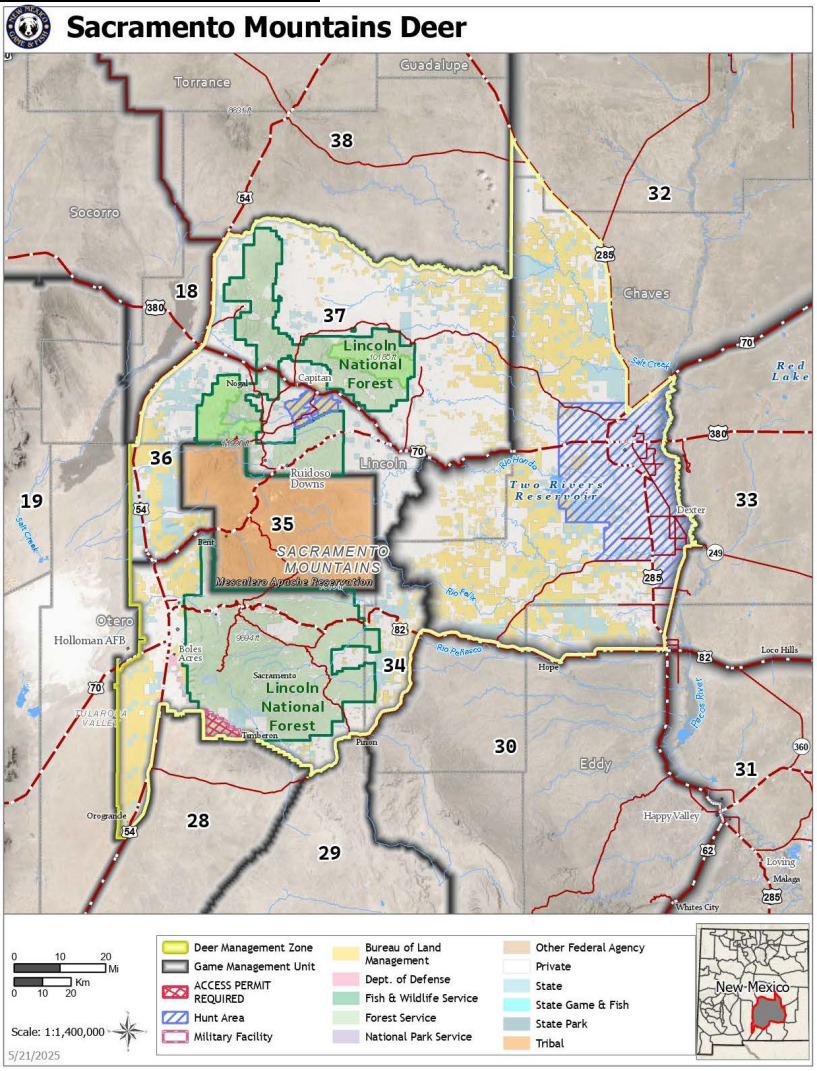
RESEARCH – GMU 31

Kermit Conveyor System - Mule Deer and Pronghorn Monitoring. NMSU Project (ongoing).

James W. Cain III, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University

SUMMARY – The Department partnered with NMSU and Atlas Energy LLC to monitor responses of mule deer to construction activities and operation of Kermit Conveyor System in southeastern New Mexico. The goal is to determine if there are any adverse impacts on movements, home range utilization or habitat selection of mule deer and to contribute to development of mitigation efforts, as applicable. Data is being analyzed, and reports on the project are forthcoming.

Sacramento Mountains

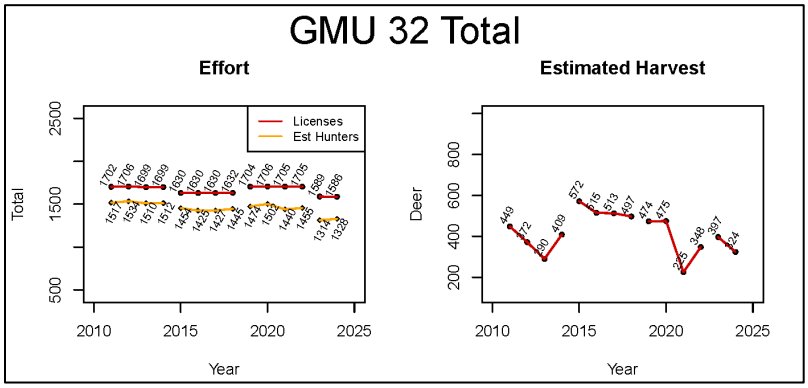


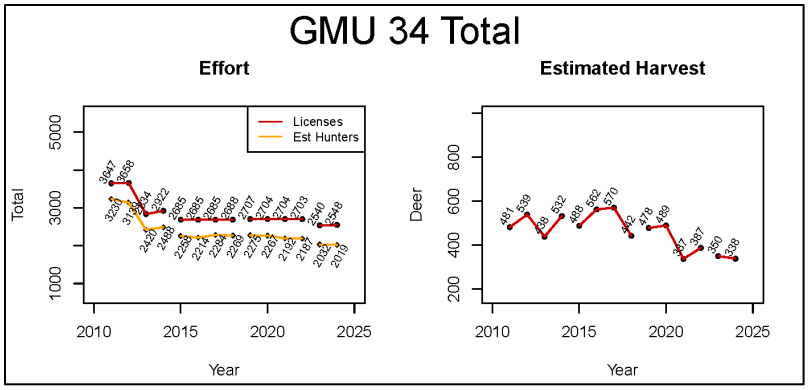
BIOLOGY – Deer in the Sacramento Mountains DMZ are partially migratory. They will migrate out of high elevations during periods of high snowpack and return as the snow melts. In lower elevations, deer do not tend to migrate and are year-round residents. Overall, the Sacramento Mountains have good deer numbers, and densities can be higher in some pockets. The deer population is considered stable. CWD has been detected in GMU 34.

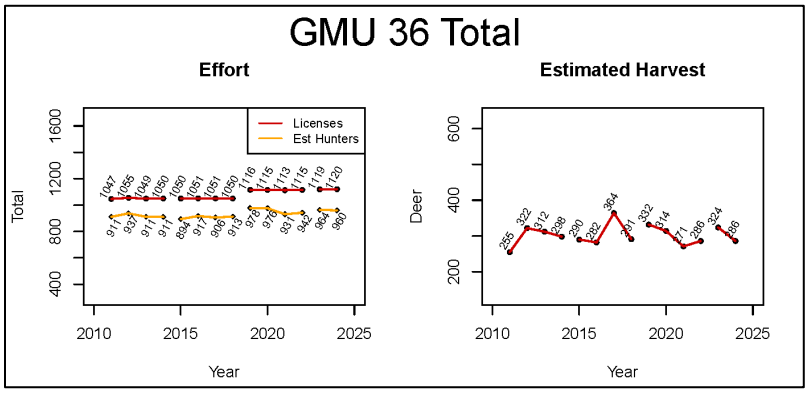
HUNTING – The Sacramento Mountain DMZ is characterized by mixed conifer forests at higher elevations with PJ woodlands at mid-elevations, and desert scrub at the lower elevations. The mountains typically receive abundant moisture which stimulates vegetation growth. As such, forage and deer productivity are generally high. Public hunting access is available through the extensive USFS and BLM land. The Mescalero Apache Reservation is also located in this mountain range and is closed to public hunting. Hunting on tribal lands is managed by each tribe.

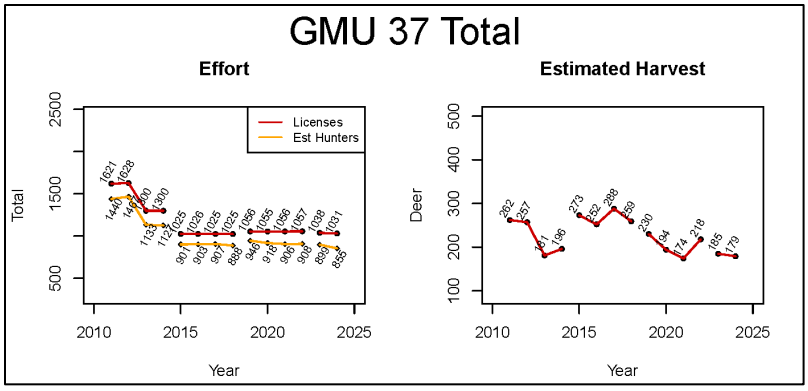
Large forest fires burned in GMU 36 during the summer of 2024. The burned areas should produce ample deer browse and hiding cover, likely resulting in increased deer numbers

in future years. Although mule deer are the most common, white-tailed deer can also be found in some river bottoms. The Sacramento Mountains DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.

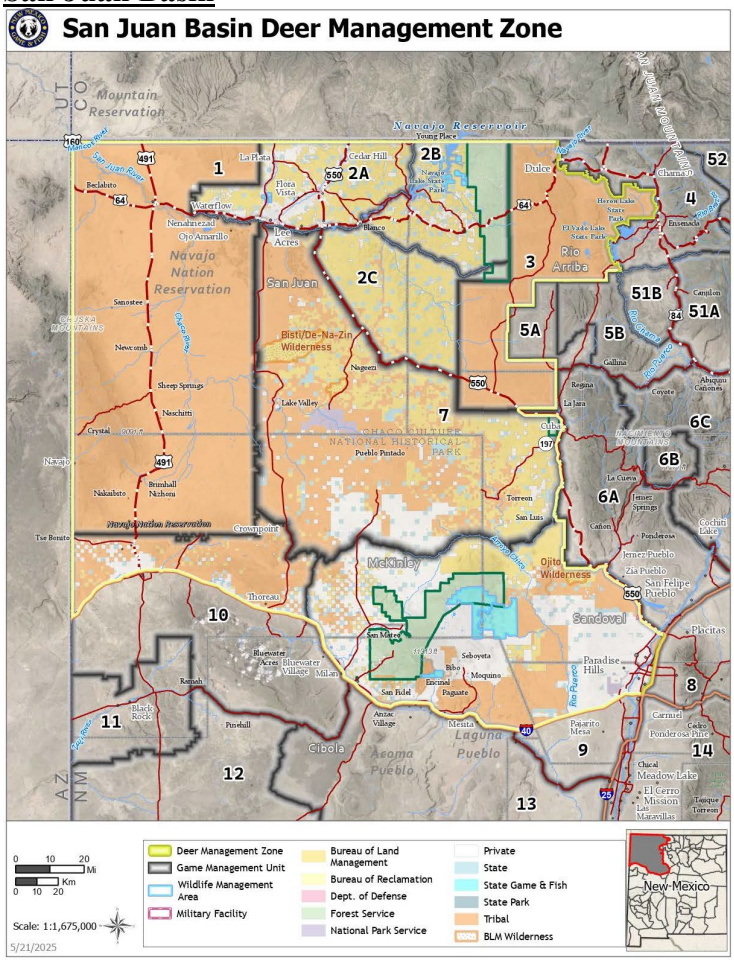








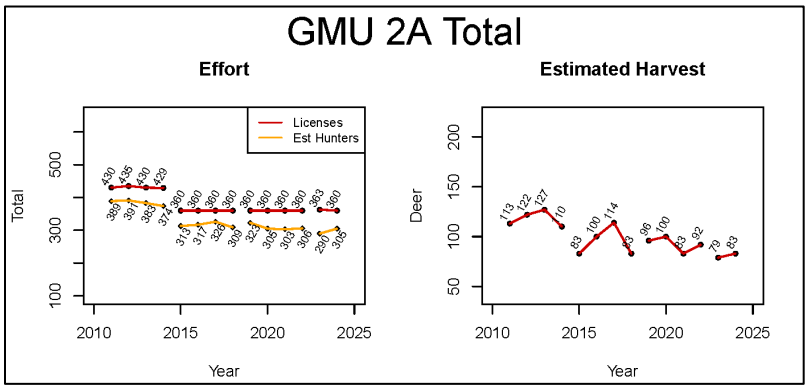
San Juan Basin

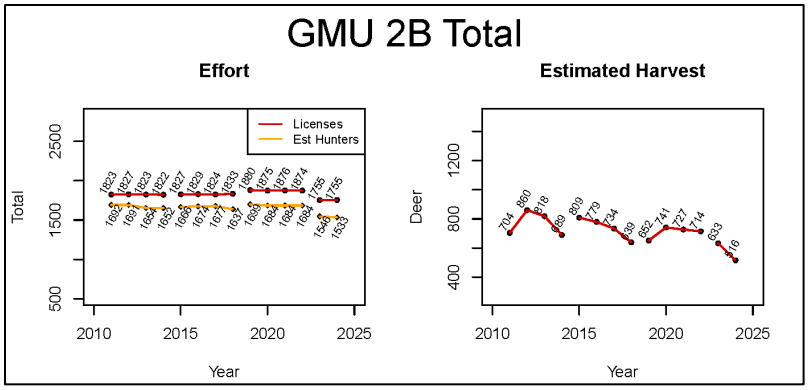


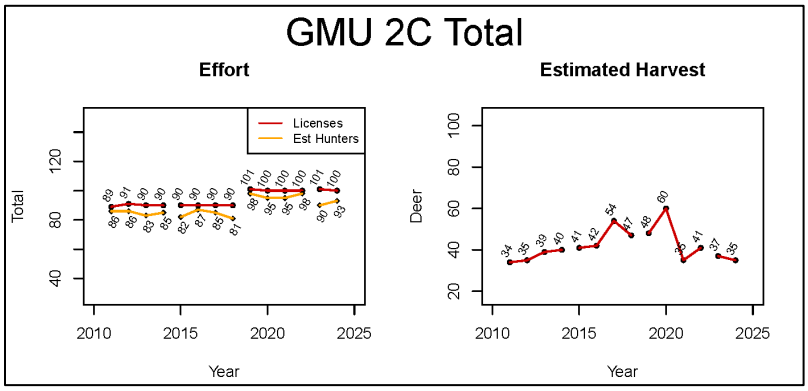
BIOLOGY – The deer in the San Juan Basin DMZ are a mix of migratory, partially migratory, and resident deer. Deer in GMU 2B are predominately migratory; these deer migrate 40-70 miles from their high elevation summer range in Colorado to winter west of Jicarilla Apache tribal lands in GMU 2B. Migration starts in the middle of October each year regardless of snowpack,

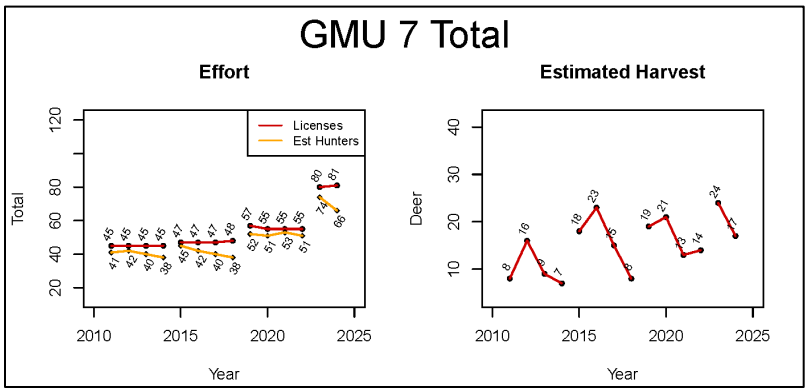
and the deer arrive on the winter range within ~14 days. Deer in GMU 9 are partially migratory; some of these deer will summer on Mount Taylor and move to lower elevations when snowpack is high. Deer in GMUs 2A, 2C, 7, and 10 are considered year-round residents. Although considered stable, the deer population in this DMZ is lower than historically reported. CWD has been detected in

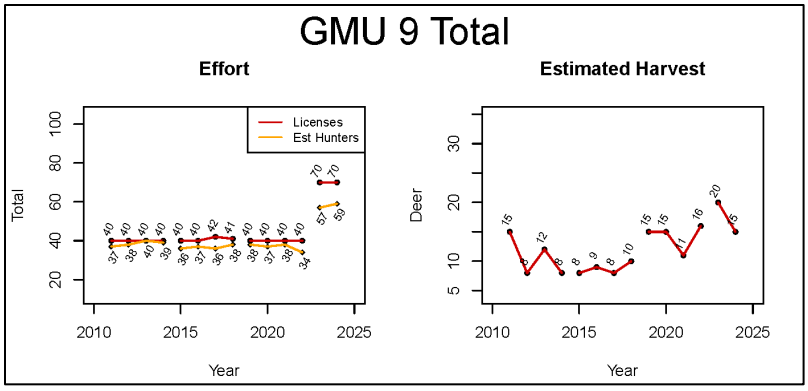
HUNTING – The habitat in this DMZ is diverse. Much of this DMZ is characterized by canyons, mesas and rimrock. There are some high elevation ridges in GMU 2B and Mount Taylor is in GMU 9. GMUs 2A, 2B, 2C, are dominated by sagebrush mesas with PJ along the mesa edges and throughout the canyons. These mesas and canyons give way to higher elevation mixed-conifer ridges east. Low elevation grasslands, scablands, and PJ forests are found in GMUs 7, 9, and 10. Mount Taylor in GMU 9 have mixed conifer forests and aspens in the high elevations. Deer hunting licenses in GMUs 2B and 2C are highly sought after by hunters; several exceptional bucks are harvested in these GMUs each year. Public hunting access is available through the extensive USFS and BLM land. Hunters should be aware that several tribal reservations are found throughout GMUs 7, 9, and 10; these lands are closed to public hunting. GMU 2C is managed as a Quality Hunt Unit while the remaining GMUs are managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.




GMU 2B Total
Effort
Estimated Harvest
Licenses
Est Hunters
Total
Deer
Year
2010
2015
2020
2025


GMU 2C Total
Effort
Estimated Harvest
Licenses
Est Hunters
Total
Deer
Year
2010
2015
2020
2025


GMU 7 Total
Effort
Estimated Harvest
Licenses
Est Hunters
Total
Deer
Year
2010
2015
2020
2025



RESEARCH – GMU 2B: Rosa mule deer migration research.

All routes are not created equal: An ungulate's choice of migration route can influence its survival. Journal of Applied Ecology. 2019.

Hall Sawyer, Chad W. LeBeau, Trent L. McDonald, Wenjing Xu, and Arthur D. Middleton.

ABSTRACT

Our knowledge of migration ecology has progressed quickly in concert with technological advances that collect fine-scale movement data through time. We now know that migration plays a critical role in the annual nutritional cycle of large herbivores and that sustaining functional migratory routes is key to long-term conservation. Yet, we lack basic information on whether one migratory route may function better than another, or more specifically, if choosing one route over another has fitness consequences – knowledge that could help inform conservation and restoration efforts.

During this project, we examined how a suite of migratory parameters influenced the survival of mule deer (*Odocoileus hemionus*) that shared a common winter range in New Mexico, but migrated to various summer ranges in Colorado, USA. We used a Cox proportional hazard model and longitudinal global positioning system data collected over a 7-year period to investigate whether the mortality risk of 66 deer was affected by choice of migratory route, summer range, migration distance, speed or the number of administrative boundaries each route crossed.

We found mule deer survival was not influenced by migratory distance, speed or number of administrative boundaries, but was strongly affected by the choice of migratory route and summer range. The magnitude of these effects was surprisingly large, doubling or tripling mortality risk. Cumulative survival rates showed that regardless of summer range, individuals migrating along high-use *exterior* routes had cumulative survival rates approximately 30% lower than individuals migrating along high-use *interior* routes. To our knowledge, this is the first direct evidence that a mammal's choice of migration route can influence its probability of survival.

Our finding that large herbivores may experience up to three times higher mortality risk by using a different migratory route reveals a novel link between migration and demography.

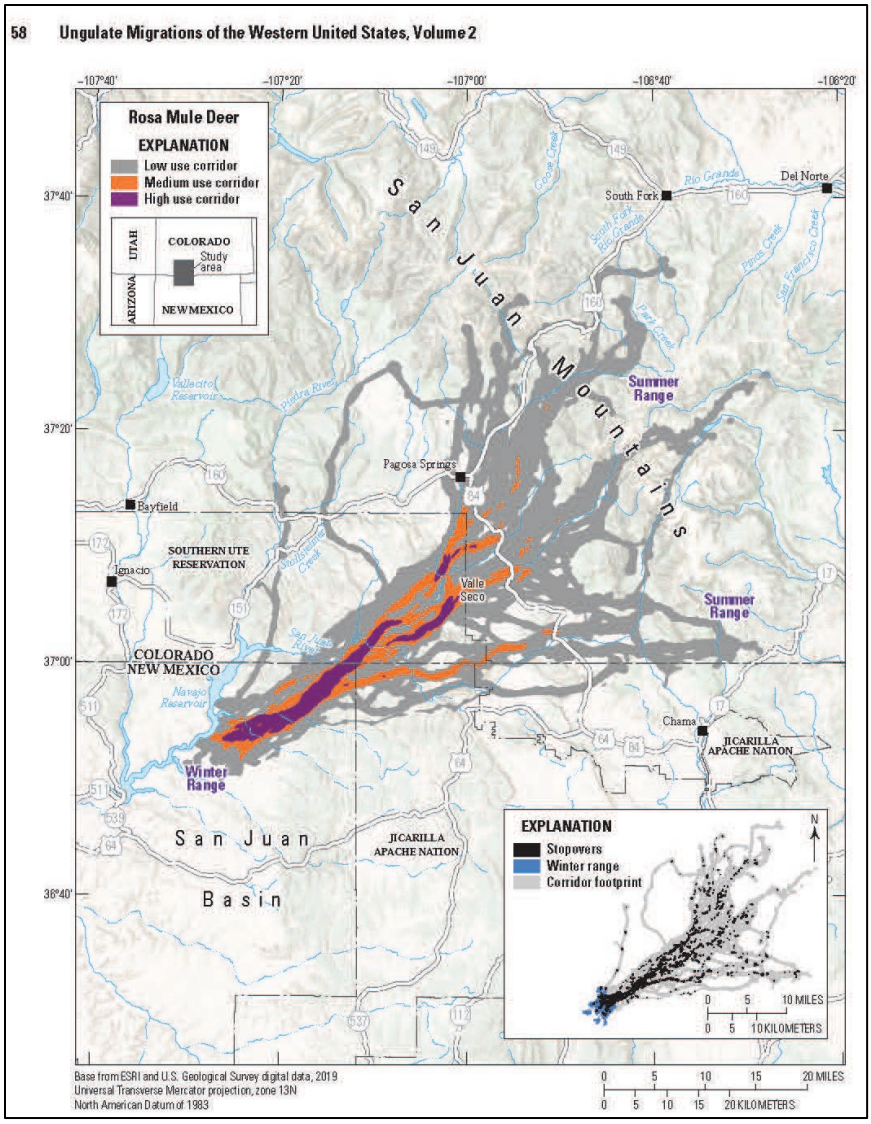
Importantly, our results also suggest that spatially explicit model parameters and predictions could help in the conservation and restoration of migratory populations by identifying specific migratory routes or seasonal ranges that reduce survival.

RESEARCH – GMU 2B: Rosa mule deer migration

Migration Mapping: Ungulate Migrations of the Western US Volume 2. United States Geological Survey Report. 2022.

Matthew Kauffman, James W. Cain III, Hall Sawyer, and others.

SUMMARY - The Rosa mule deer herd migrates an average of 45 miles from northwest New Mexico to southwest Colorado. Their winter range is located in the upper San Juan Basin, east of the Navajo Reservoir, and is dominated by pinyon juniper woodlands and sagebrush grasslands. The Rosa herd use three distinct areas as summer range: the lower elevation Valle Seco, consisting primarily of ponderosa pine woodland and big sagebrush shrubland, and the higher elevation north and south San Juan Mountains, consisting of ponderosa pine and aspen mixed woodlands. The herd collectively migrates northeast from their winter range for around 12 miles before a second route branches off the main corridor, with these individuals traveling to summer ranges in the Valle Seco and south San Juan Mountains. The main corridor continues for another 7 iles before splitting into three separate corridors leading into the north and south San Juan Mountains. Challenges to migration include crossing U.S. Highways 160 and 84 and increasing residential development around Pagosa Springs, Colorado. Ongoing and future energy development projects, including the drilling of well pads and use of maintenance roads, in the upper San Juan Basin may also cause disturbances to mule deer migration and their winter range. For more information on this project, including migration start and end dates, sample size, and summaries on the corridors see Volume 2 of the Ungulate Migrations of the Western US.



Migration corridors and stopover areas for the Rosa mule deer herd, New Mexico, USA.

RESEARCH – GMU 2C: Crow Mesa mule deer migration

Crow Mesa Deer Study Final Report. Funded by BLM and conducted by Western Ecosystems Technology. 2021.

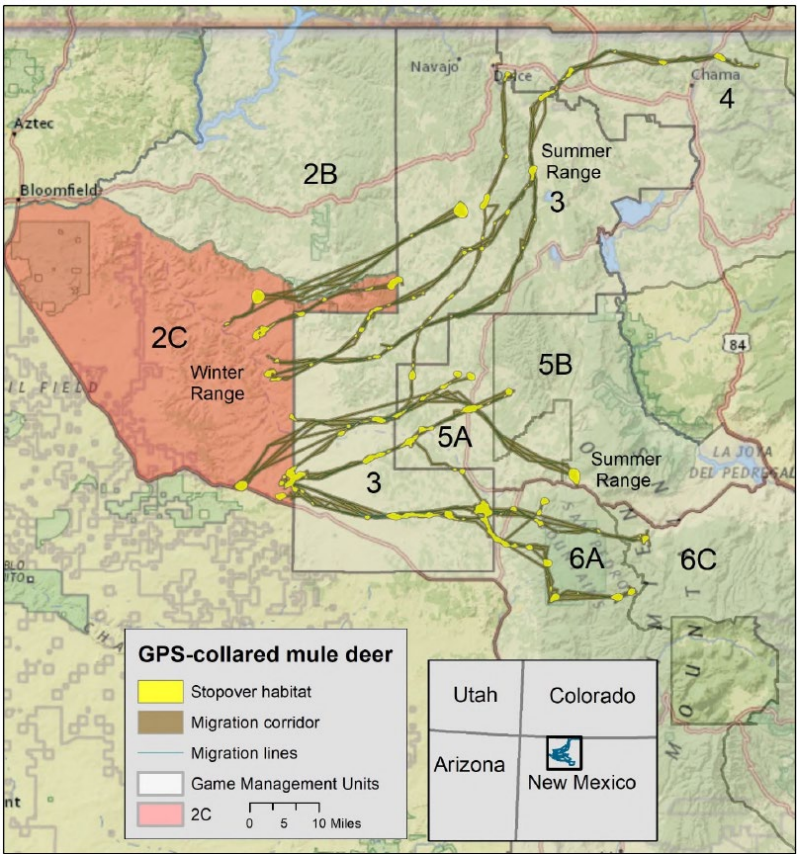
Hall Sawyer

The Crow Mesa Mule Deer Study was initiated in 2019 to identify the seasonal movement and distribution patterns of mule deer in the eastern half of GMU 2C. This GPS study built on nearby mule deer and elk studies conducted by the Bureau of Land Management, the Southern Ute, the Jicarilla Apache Nation, and the New Mexico Department of Game and Fish.

Most mule deer populations are partially migratory – where one segment of the population migrates and the other does not. Unlike the nearby Rosa population in GMU 2B where all deer were migratory, only 30% of the deer in GMU 2C were migratory and the other 70% were non-migratory. While management of the resident segment is relatively straight-forward, managing deer populations that migrate long distances is inherently difficult because of the mix of land ownership, land uses, and jurisdictional boundaries involved. Migratory deer from GMU 2C rely largely on winter ranges administered by the Bureau of Land Management, but migrate through, and summer on, an assortment of private, tribal, and US Forest Service lands. The detailed migration corridors and stopover sites revealed from this study can help inform transboundary management (e.g., habitat treatments, road crossings, development proposals, hunting regulations) and highlight the critical role that tribal lands play with migratory deer in GMU 2C. Mapping migratory corridors and stopover sites can help agencies, tribes, and other stakeholders improve planning, management, and mitigation efforts in GMU 2C and surrounding areas. For example, the 2018 Secretarial Order 3362 issued by the Department of Interior directs the BLM, the National Park Service, and the US Fish and Wildlife Service to work with states and private landowners to minimize development and disturbance in migration corridors and winter ranges used by elk, mule deer and pronghorn. Additionally, the state of New Mexico recently passed a Wildlife Corridors Act into law. The information provided here, on migration corridors and winter range, provides an intuitive and science-based tool for implementing and informing federal and state initiatives like Secretarial Order 3362 and the Wildlife Corridors Act.

Mule deer survival rates in the GMU 2C were generally lower than those recorded for other mule deer populations across the West, which typically average 0.85 or higher. Annual survival ranged from 0.81 in 2020 to 0.71 in 2021, for a two-year average of 0.76. Most mortality occurred in February and August. Unfortunately, we did not collect cause-specific mortality data because collars generally could not be recovered soon enough to determine cause of death. Migration timing of mule deer can vary considerably from year to year or even among individuals that migrate different distances. For deer in the 2C population, the timing of autumn migration was consistent, but spring migrations began earlier each year of study. It is difficult to draw any firm conclusions from only 3 years of data, but other ungulate populations in the Intermountain West are changing the timing of their migrations to match vegetation green up associated with warming climates.

Worth noting, we documented several unusual deer movements that were neither traditional migratory or non-migratory movements. Most of these movements were short-term, unpredictable movements of 10-15 miles. Given that the migratory and resident behaviors of mule deer tend to be very strong, it is unclear what triggers these type of unpredictable movements.



Migration corridor, stopover habitat, and migration sequences from mule deer collared on Crow Mesa between 2019 and 2021. Crow Mesa, New Mexico, USA.

RESEARCH – GMU 2C: Crow Mesa mule deer migration

Migration Mapping: Ungulate Migrations of the Western US Volume 3. United States Geological Survey Report. 2023.

Matthew Kauffman, James W. Cain III, Hall Sawyer, and others.

SUMMARY – The Crow Mesa Mule Deer study was initiated in 2019 to identify the seasonal movements and distribution patterns of mule deer in the eastern half of GMU 2C. This GPS study builds on nearby studies of mule deer and elk conducted by the BLM, the Southern Ute Tribe, the Jicarilla Apache Nation, and the New Mexico Department of Fish and Game. Migration corridors extended 20–75 mi (32–110 km) from the winter ranges in GMU 2C to various summer ranges on national forest lands to the northeast near Dulce, and to the southeast near Cuba. The Crow Mesa mule deer herd relies largely on winter ranges administered by the BLM, where approximately 70 percent of the population remains year round (Sawyer, 2021). The other 30 percent of the herd migrates through and summers on an assortment of private, Tribal, and FS lands. Notably, all recorded mule deer migration corridors crossed Jicarilla Apache Nation Reservation immediately east of this herd's winter range. Key management challenges with this deer herd include fence barriers, highway crossings, and habitat loss and human disturbance associated with energy development. For more information on this project, including migration start and end dates, sample size, and summaries on the corridors see Volume 3 of the Ungulate Migrations of the Western US Report.

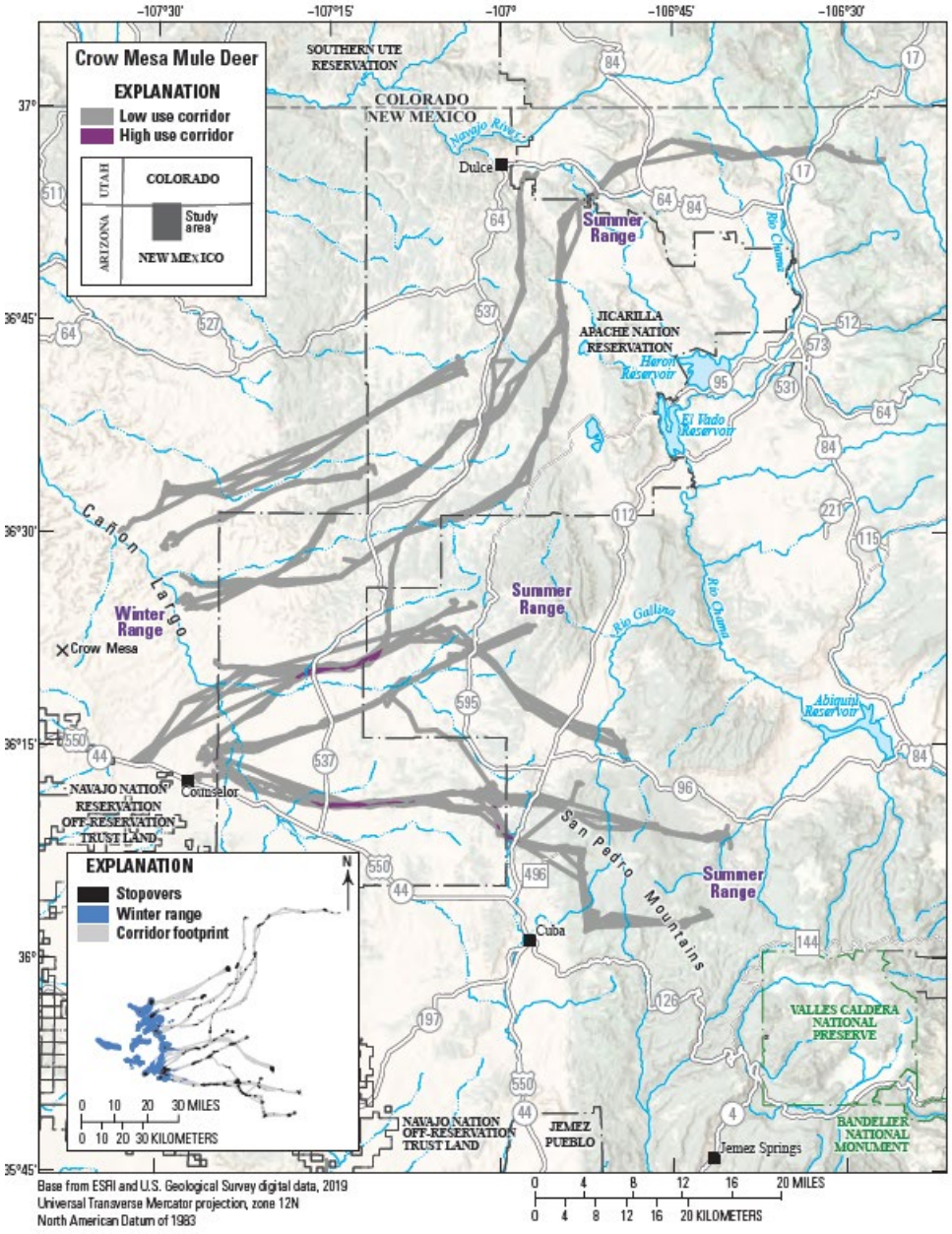
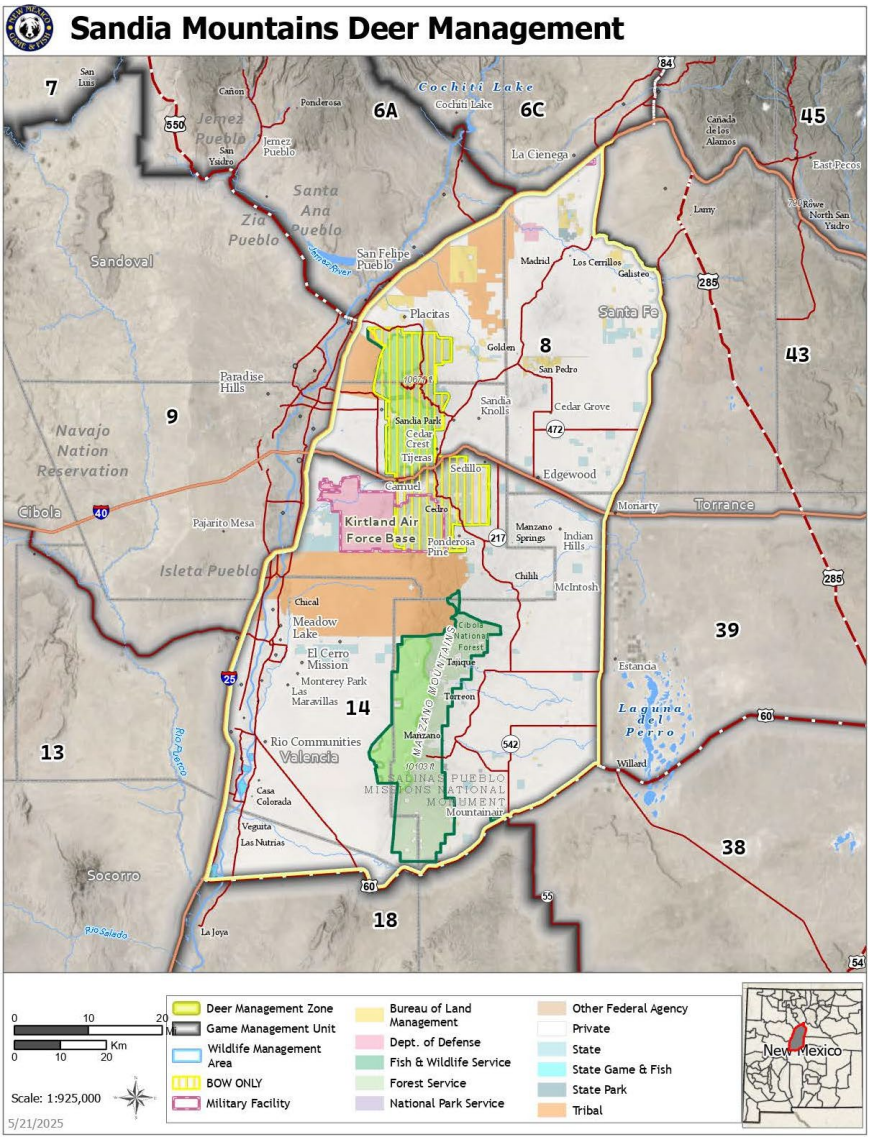


Figure 23. Map showing migration corridors, stopovers, and winter ranges of the Crow Mesa mule deer herd.

Movement pathways and winter range for the Crow Mesa mule deer herd, New Mexico, USA.

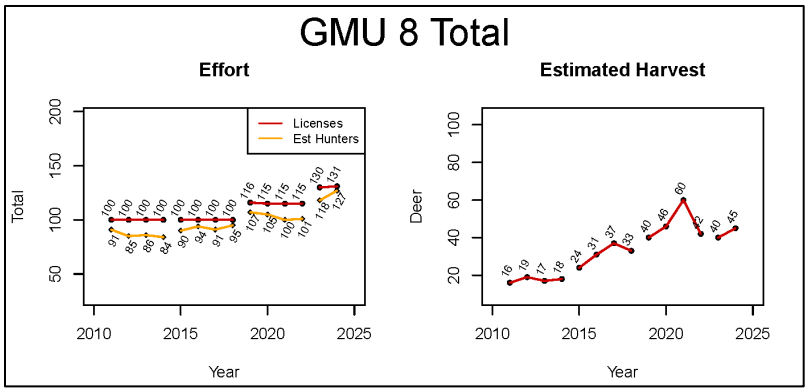
Sandia Mountains

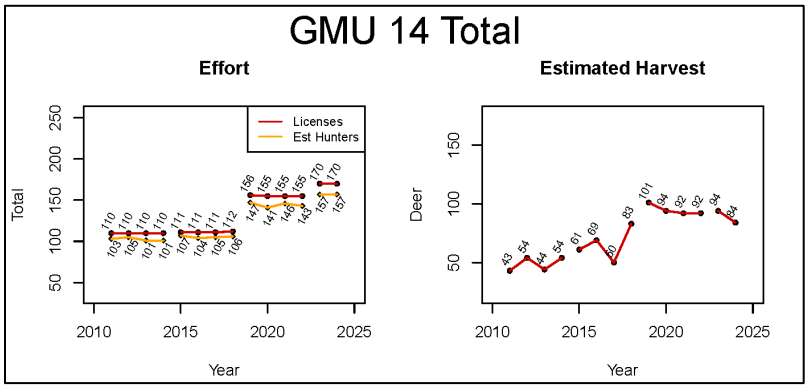


BIOLOGY – Deer in the Sandia Mountains DMZ are year-round residents. Snowpack might temporarily force some deer to lower elevations, but they return as the snow melts. Deer densities in the Sandia Mountains DMZ are high, and the overall deer population is very healthy. This population is considered stable to increasing.

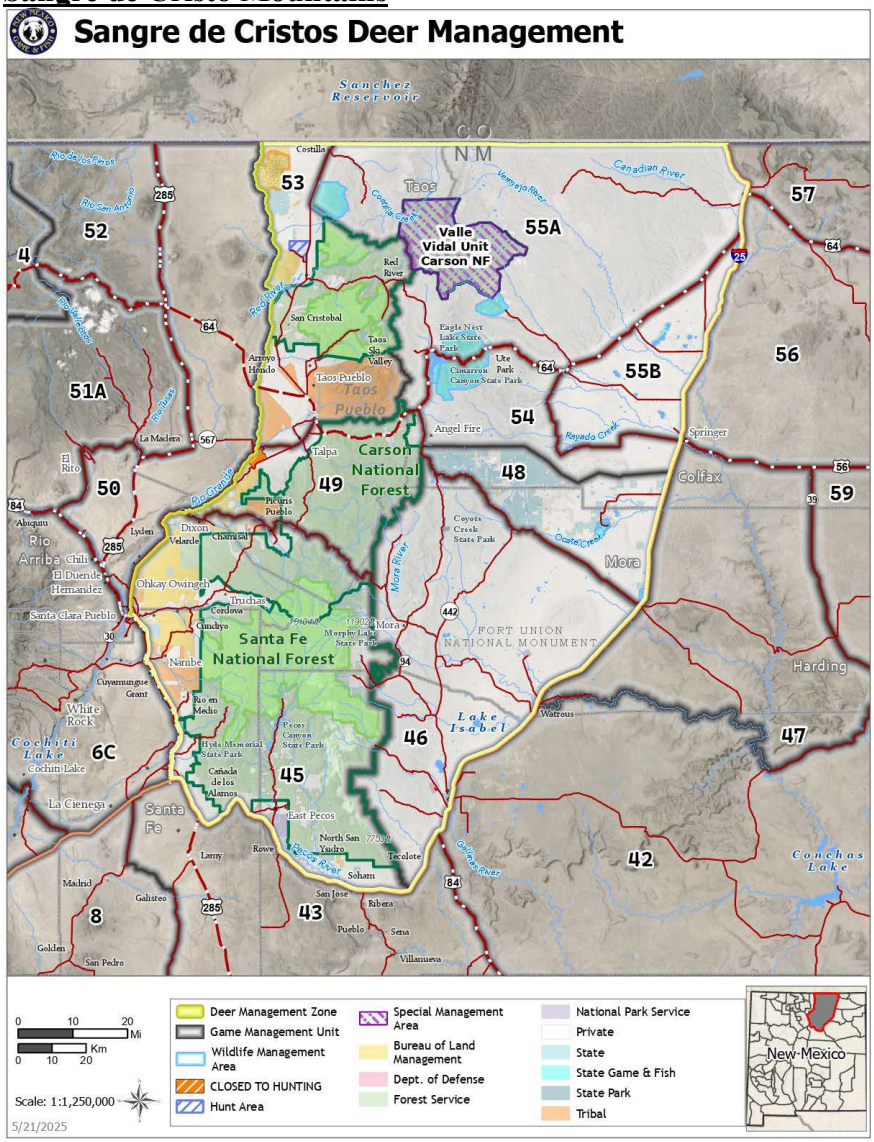
HUNTING – The Sandia Mountains DMZ is comprised of 2 mountains, the Sandia Mountain in GMU 8 and the Manzano Mountain in GMU 14. Due to proximity to Albuquerque, the Sandias are the most visited mountain range in New Mexico, so hunters often see hikers and other recreationists when hunting. Compared to the Sandias, the Manzanos are much less visited by recreationists. This DMZ consists of a mixture of grasslands, shrublands, and PJ woodlands at lower elevations. Higher elevations are dominated by Ponderosa pine, Gambel oak, and mountain mahogany. At some of the highest points, subalpine forests with spruce, firs, and aspens can be found.

The mountain ranges have extensive USFS lands while the lower elevations are almost completely privately owned. Several tribal reservations are found in this DMZ and are close to public hunting. Public draw hunts in GMU 8 are limited to archery only. The Sandia Mountains DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.





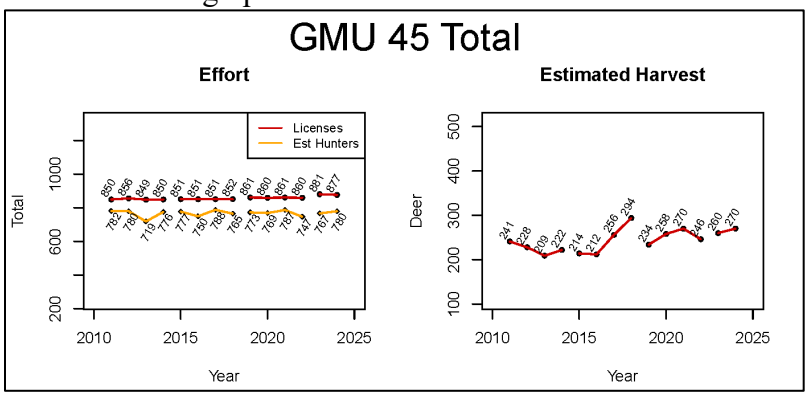
Sangre de Cristo Mountains

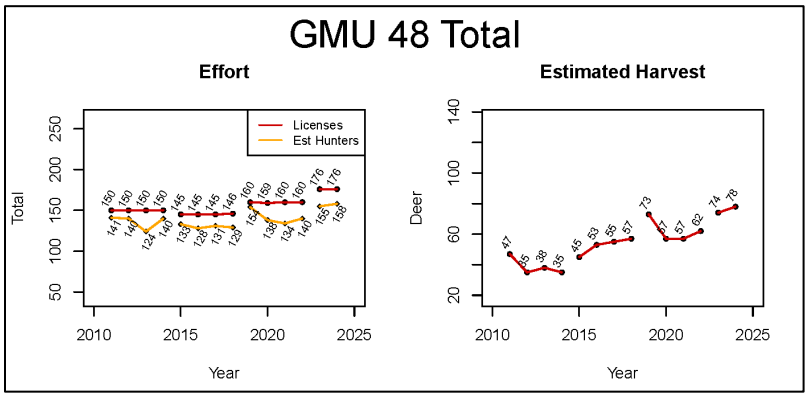


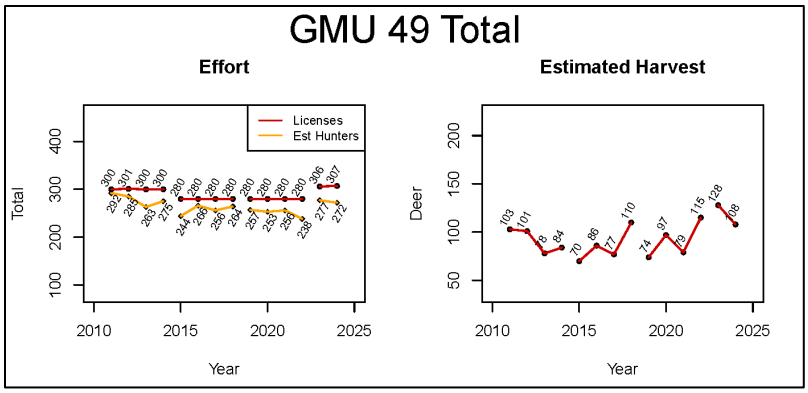
BIOLOGY – Deer in the Sangre de Cristo Mountains DMZ make elevational migrations. They summer at higher elevations, and they migrate up and down the elevational gradient depending on snowpack. The deer population in this DMZ is very healthy and is considered stable to increasing.

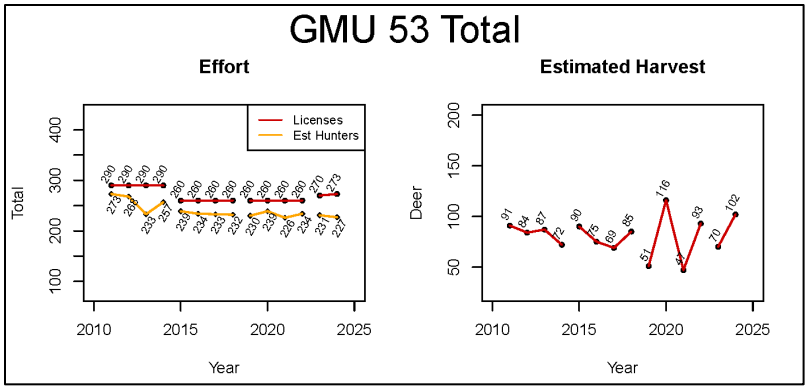
HUNTING – The Sangre de Cristo Mountains DMZ is predominately dominated by high elevation mountain ranges that receive an abundance of summer and winter moisture. Habitat in these high elevations range from mixed conifer and aspen forests, subalpine forests with spruce and firs, and alpine tundra. On the eastern side of the Sange de Cristo Mountains DMZ, the mountains give way to plains with interspersed PJ. The Calf Canyon/Hermit Peak fire burned a large portion of GMU 45 in 2022. This has created prime deer habitat in much of the burned area. Public hunting access is obtained through the extensive USFS lands that dominate this

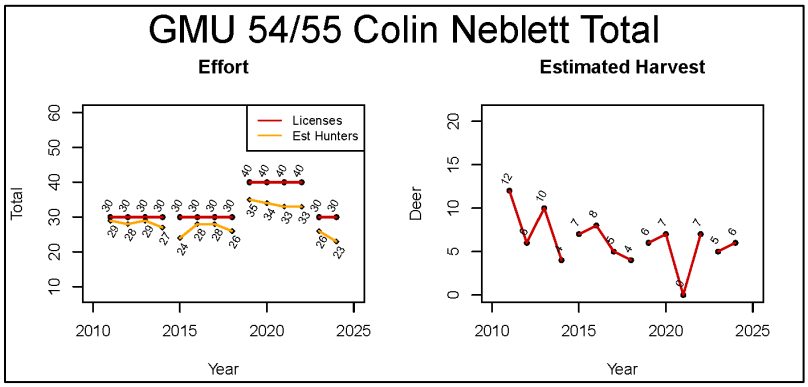
DMZ. Several tribal reservations are found in this DMZ and are close to public hunting. The Sangre de Cristo Mountains are managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.

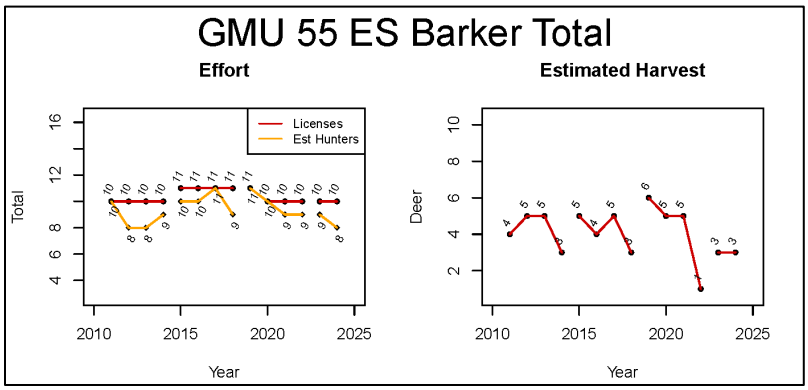


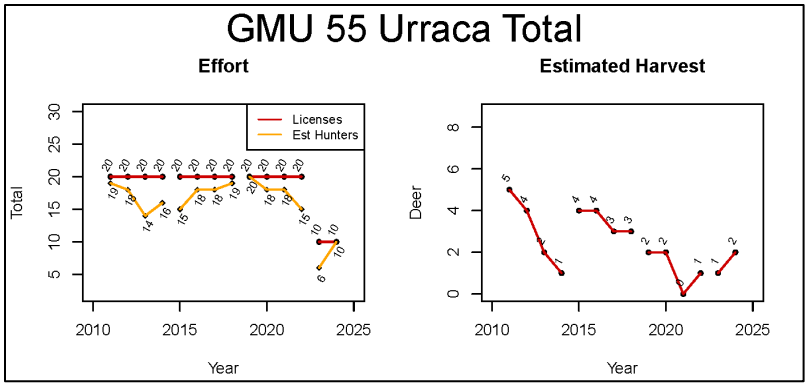





GMU 53 Total
Effort
Estimated Harvest
Licenses
Est Hunters
Total
Deer
Year
Year


GMU 54/55 Colin Neblett Total
Effort
Estimated Harvest
Licenses
Est Hunters
Total
Deer
Year
Year


GMU 55 ES Barker Total
Effort
Estimated Harvest
Licenses
Est Hunters
Total
Deer
Year
Year



RESEARCH – GMU 55B: Whittington Center mule deer project

Ungulate exclusion, conifer thinning and mule deer forage in northeastern NM. Journal of Arid Environments. 2015.

David W. Kramer, Grant E. Sorenson, Chase A. Taylor, James W. Cain III.

ABSTRACT – The southwestern United States has experienced expansion of conifer species (*Juniperus* spp. and *Pinus ponderosa*) into areas of semi-arid grassland over the past century. The expansion of conifers can limit palatable forage and reduce grass and forb communities. Conifer species are sometimes thinned through hydraulic mulching or selective cutting. We assessed the effects of these treatments on mule deer (*Odocoileus hemionus*) habitat in northeastern New Mexico to determine if conifer thinning improved cover of preferred forage species for mule deer in areas with and without ungulates. We measured plant cover and occurrence of preferred forage species in the summers of 2011 and 2012. An ongoing regional drought probably reduced vegetation response, with preferred forage species and herbaceous cover responding to conifer thinning or ungulate exclusion immediately following treatment, but not the following year. In 2011, areas that received thinning treatments had a higher abundance of preferred forage when compared to sites with no treatment. Grass coverage exhibited an immediate response in 2011, with ungulate exclosures containing 8% more coverage than areas without exclosures. The results suggest that conifer thinning and ungulate exclusion may elicit a positive response, however in the presence of drought; the positive effects are only short-term.

Mule deer habitat selection following vegetation thinning treatments. Wildlife Society Bulletin. 2020.

Grant E. Sorenson, David W. Kramer, Chase A. Taylor, James W. Cain III.

ABSTRACT – Mule deer (*Odocoileus hemionus*) survival and population growth in north-central New Mexico, USA, was previously reported to be limited by nutritional constraints due to poor forage conditions in degraded habitats. Management recommendations suggested thinning of pinyon-juniper to improve habitat quality for mule deer. To evaluate the influence of

these vegetation treatments, we monitored habitat selection by 48 adult female mule deer from 2011 to 2013 in a population previously reported to be nutritionally limited. Monitoring occurred 1-4 years after completion of treatments that were intended to improve forage conditions, including mechanical reduction of pinyon pine (*Pinus edulis*) and juniper (*Juniperus* spp.) density and senescent brush (*Quercus gambelii*-*Cercocarpus montanus*) cover. During the summer season, deer selected recently treated areas, but odds ratios decreased with treatment age. However, during winter, deer avoided more recently treated areas and selected thinned areas >4 years old. Deer selected mixed oak (*Quercus* spp.) and pinyon-juniper savanna vegetation cover types with a moderately open canopy and ponderosa pine (*Pinus ponderosa*) forests while avoiding grasslands and montane shrub-lands across all seasons. Deer selected areas closer to water and developed areas, northeast aspects, on gentle slopes, and at lower elevations. Creating a savanna-like cover type may elicit a positive deer response as a result of their strong avoidance of dense, closed canopy pinyon-juniper woodlands.

RESEARCH GMU 53: Migration project, mule deer in the Sangre de Cristos

Migration Mapping: Ungulate Migrations of the Western US Volume 4. United States Geological Survey Report. 2024.

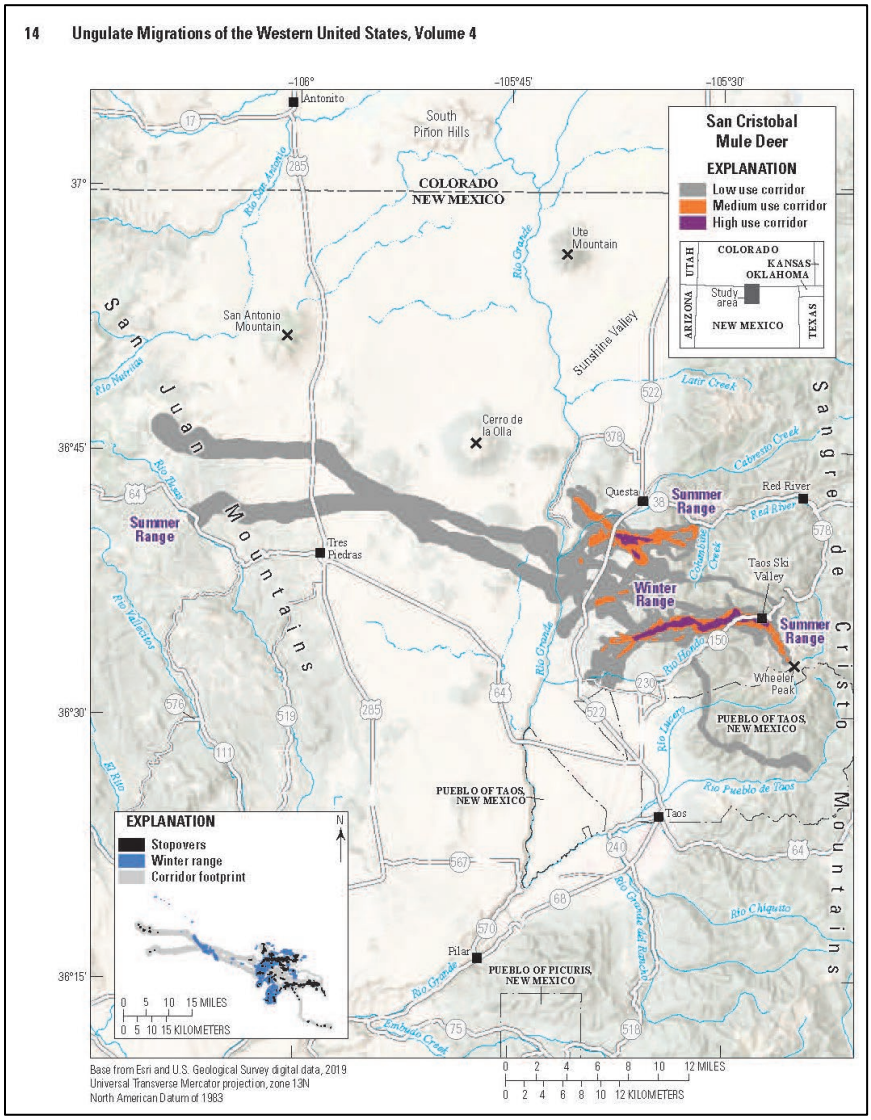
Ungulate Migrations of New Mexico. NMSU Report. 2025.

Matthew Kauffman, James W. Cain III, Craig Reddell, Orrin Duvuvuei, Nicole Tatman, and others.

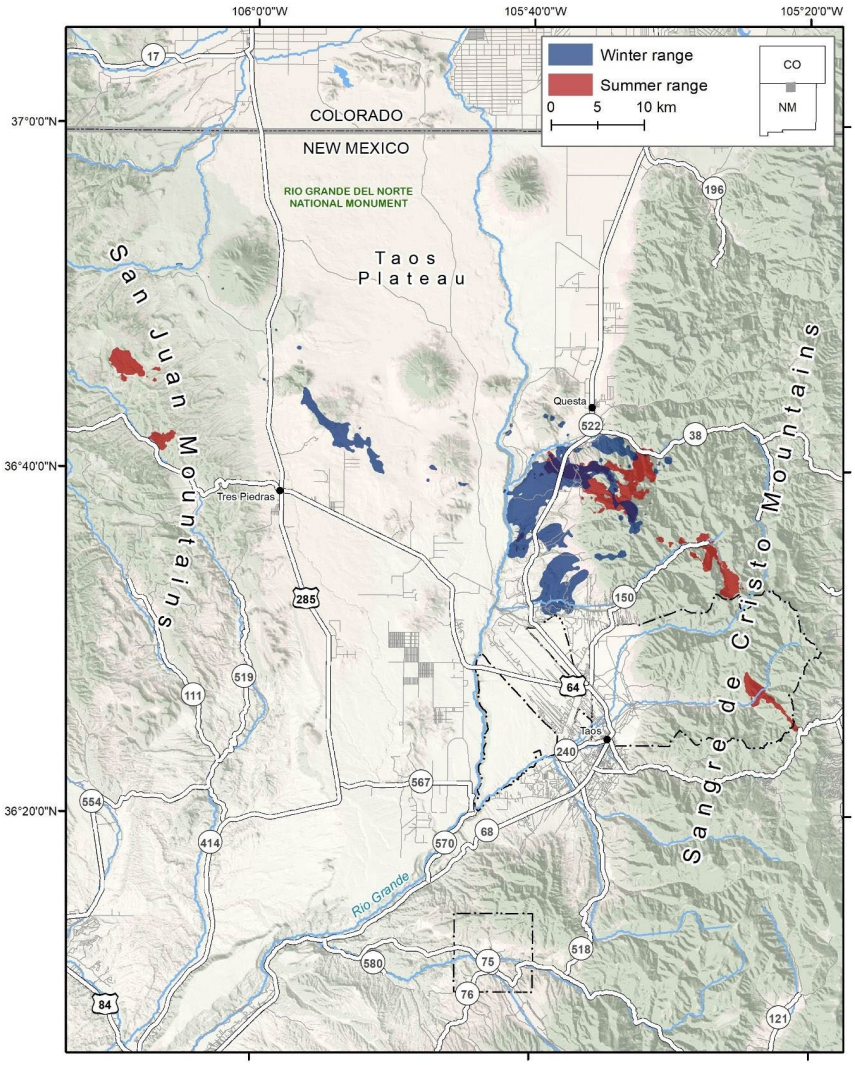
The Department funded mule deer migration research in GMU 53 and partnered with the NMSU co-op to conduct the analyses. The herds that were researched in this DMZ include the San Cristobal mule deer herd and the Urraca mule deer herd.

SUMMARY – The San Cristobal mule deer herd uses a patchwork of winter ranges in the western foothills of the Sangre de Cristo Mountains south of Questa, New Mexico. Winter ranges, bisected by State Route 522, are shared by deer that migrate east and west to summer ranges in the Sangre de Cristo and San Juan Mountains, respectively. The mule deer use multiple migration corridors; most of the herd migrates east into regional national forest and wilderness areas, using shorter, eastern corridors in the Sangre de Cristo Mountains. However, some individuals migrate west from shared winter ranges, moving across U.S. Highway 285, to summer ranges in the San Juan Mountains. *Quercus* spp. (oak) woodlands, *Pinus ponderosa* (ponderosa pine), aspen, and mixed-conifer forests characterize the eastern corridors and sagebrush steppe, grasslands, *Pinus* spp. (pinyon)-juniper mesas, oak woodlands, ponderosa pine, aspen, and mixed-conifer forests characterize the western corridors and stopovers. The eastern corridor is split into two main sections, one heading north and the other heading south. The northern route terminates south of the Red River and west of Columbine Creek. The southern route terminates near Taos Ski Valley northwest of Wheeler Peak, New Mexico's highest peak (13,167 ft). Challenges for this herd include potential development on winter ranges

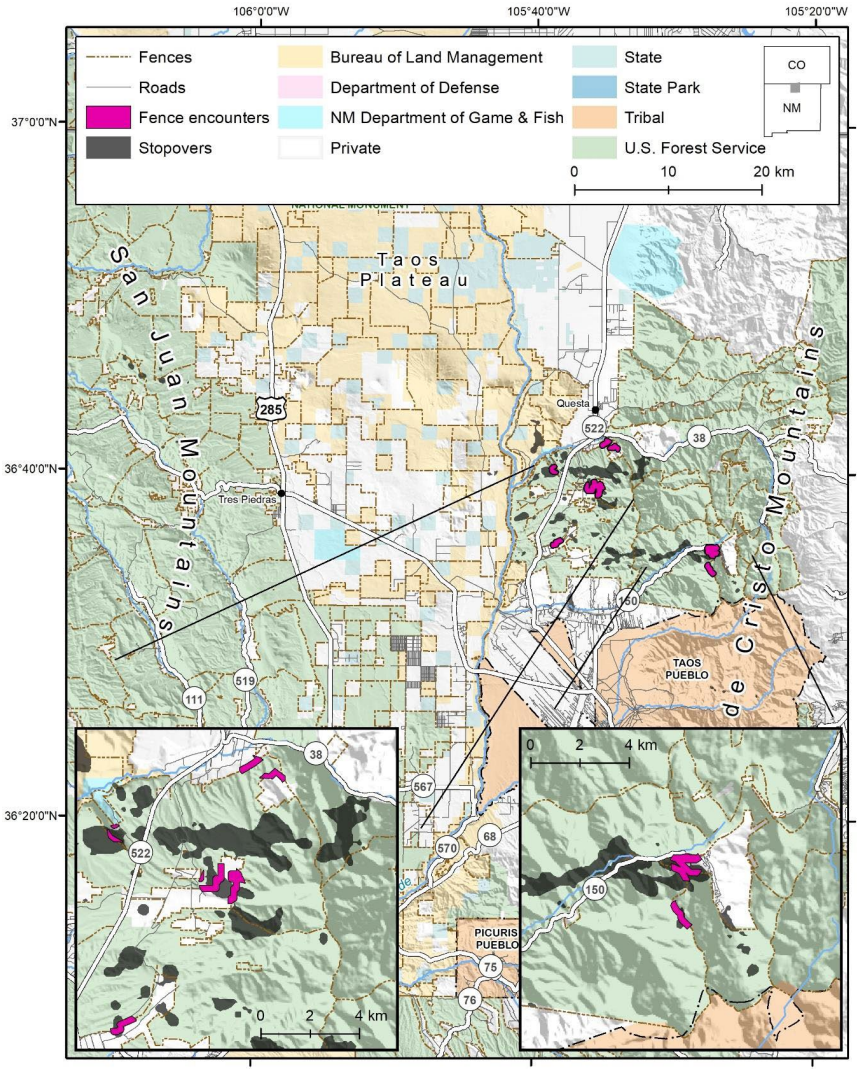
and crossing State Route 522 and U.S. Highway 285. For more information see Volume 4 of the Ungulate Migrations of the Western US.



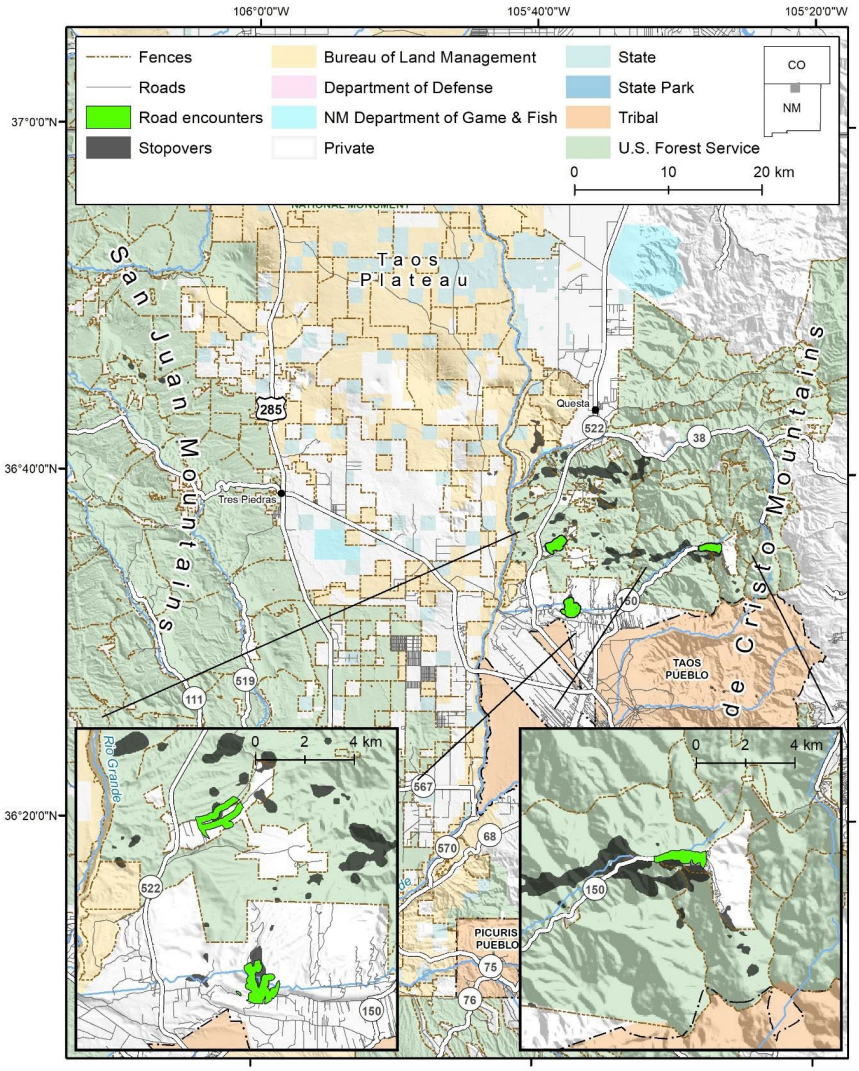
Migration corridors and stopover areas for the San Cristobal mule deer herd, New Mexico, USA.



Winter and summer ranges of the San Cristobal mule deer herd, New Mexico, USA.

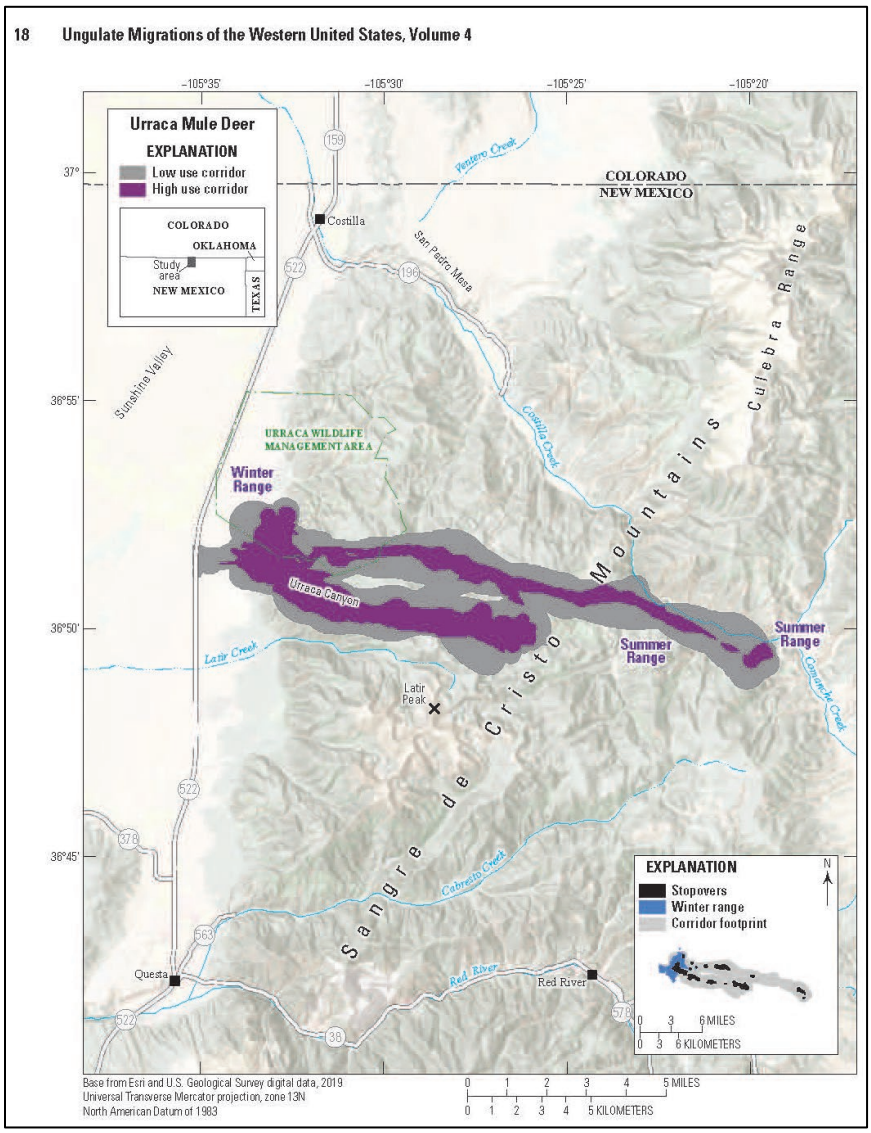


Stopovers and sections of fences (pink) with high-density encounter rates of the San Cristobal mule deer herd, New Mexico, USA.

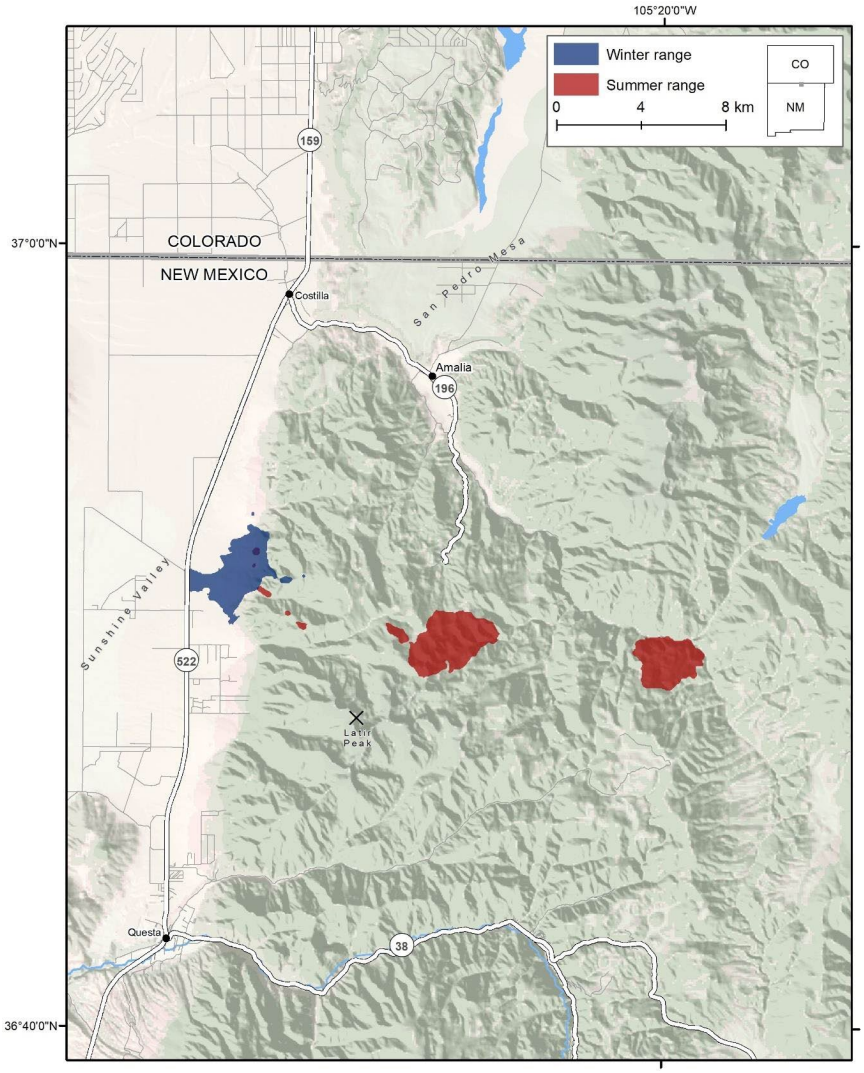


Stopovers and sections of roads (green) with high-density encounter rates of the San Cristobal mule deer herd, New Mexico, USA.

SUMMARY – The Urraca mule deer herd inhabits an area north of Questa in north-central New Mexico, on the eastern side of Sunshine Valley and the western base of the Sangre de Cristo Mountains. The winter range primarily comprises sagebrush flats east of State Route 522. The mule deer use two primary migration corridors spanning the Urraca Wildlife Management Area and a mosaic of private lands. The southern corridor follows the Urraca Canyon east and terminates at an approximate elevation of 11,000 ft. The northern corridor runs north of Urraca Canyon and ends southwest of the confluence of Costilla Creek and Comanche Creek in New Mexico, at 9,500 ft. Dense conifer and aspen forests interspersed with meadows and creeks characterize the corridors and stopovers. High-elevation summer ranges are northeast of Latir Peak (12,670 ft). For more information see Volume 4 of the Ungulate Migrations of the Western US.

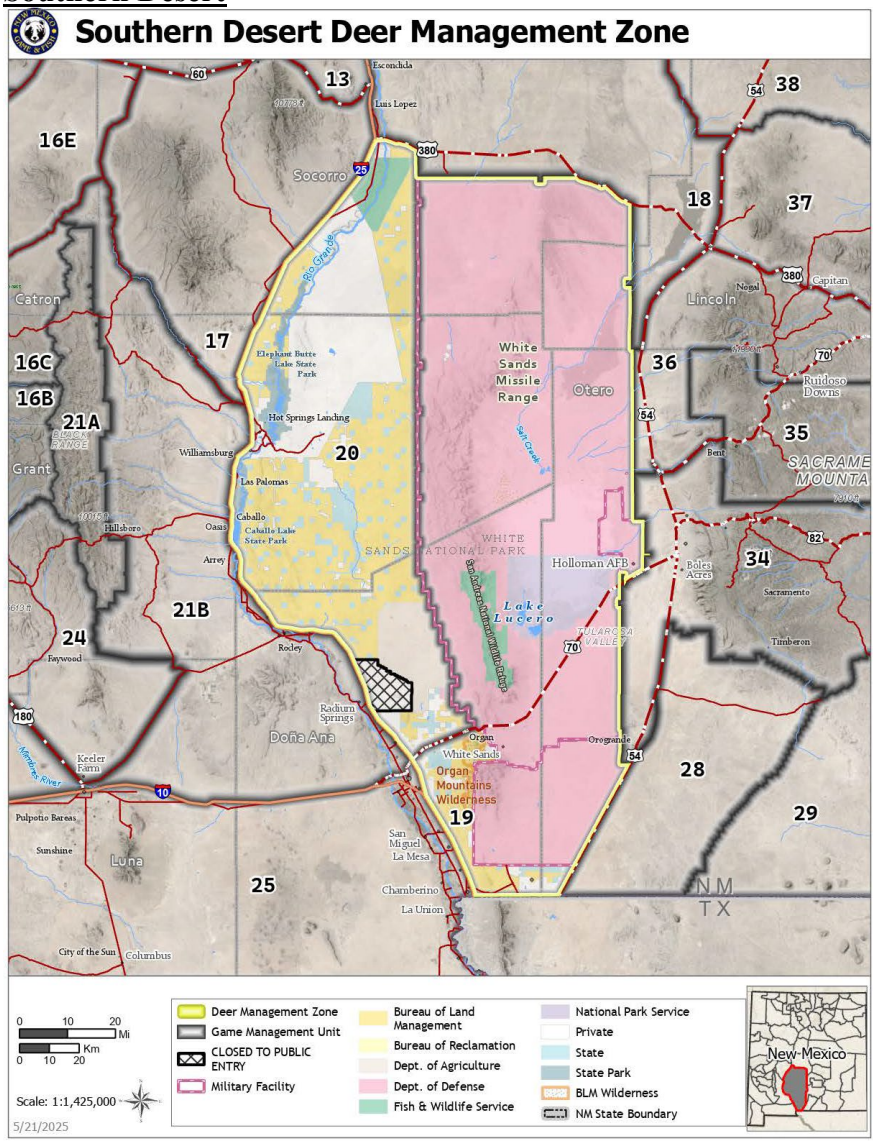


Migration corridors and stopover areas for the Urraca mule deer herd, New Mexico, USA.



Winter and summer ranges for the Urraca mule deer herd, New Mexico, USA.

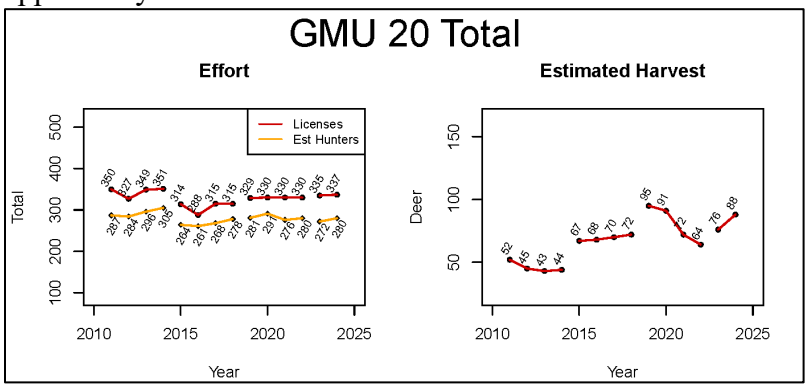
Southern Desert

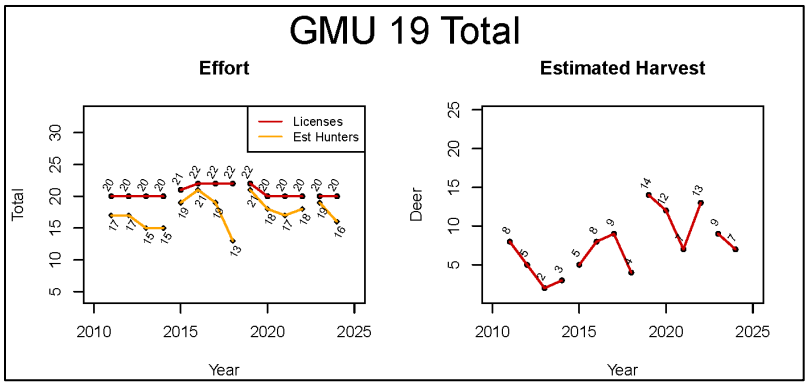


BIOLOGY – Deer in the Southern Desert DMZ are year-round residents. However, they may make seasonal movements in response to monsoonal rain patterns, livestock use, or breeding behavior. Some of these movements might be substantial to escape unfavorable conditions, such as when water sources dry up. They typically return to their known ranges when conditions become favorable. Deer numbers in this area are largely influenced by the timing and amount of rainfall. As such, deer densities can be sporadic in these desert habitats, but good numbers can be found in pockets. The deer population in this DMZ is low but stable. CWD has been detected in GMU 19.

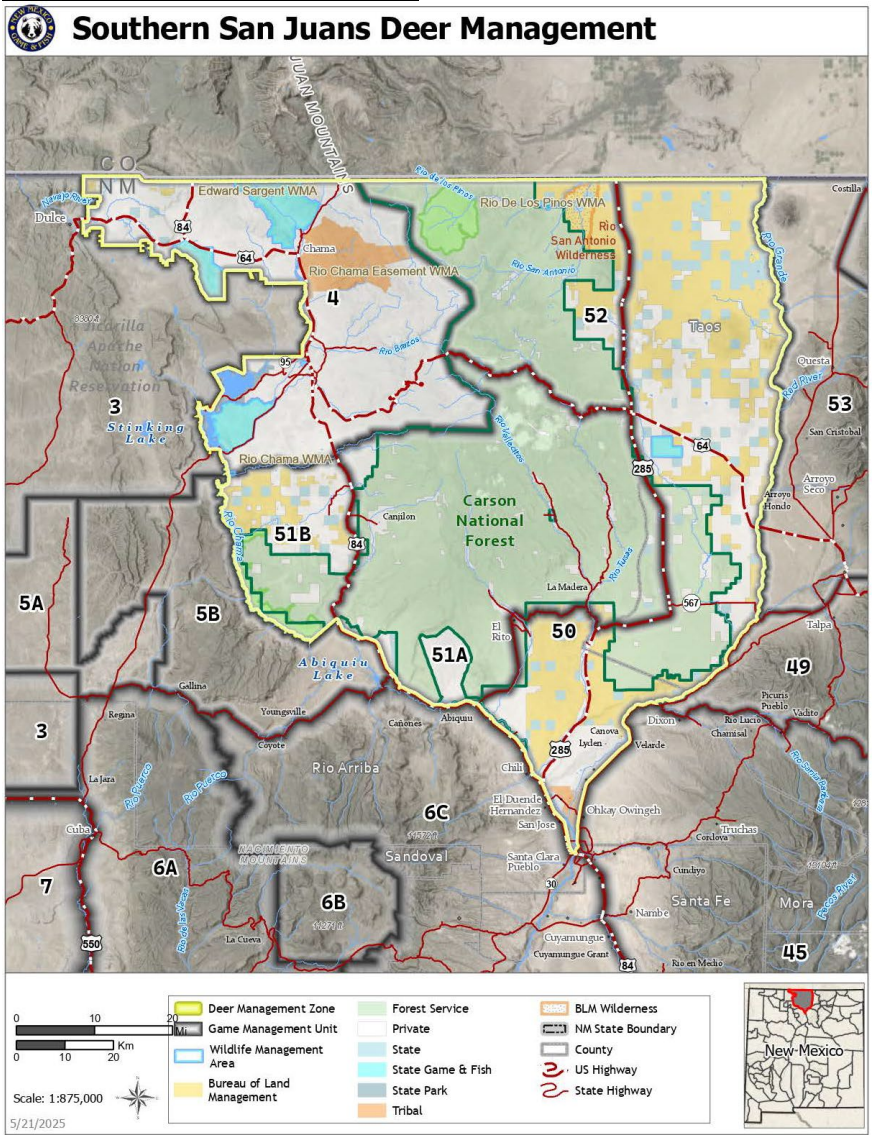
HUNTING – The Southern Desert DMZ is dominated by two desert mountain ranges: Caballos Mountain in GMU 20 and San Andres Mountain in GMU 19. Desert scrub and PJ are found on the mountains and creosote dominated desert flats are found between the mountain ranges.

Public hunting access in GMU 20 and the southern portion of GMU 19 is through the extensive BLM lands. The majority of GMU 19 is owned by the White Sands Missile Range (WSMR); hunting access must be obtained through WSMR. The Southern Desert DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.





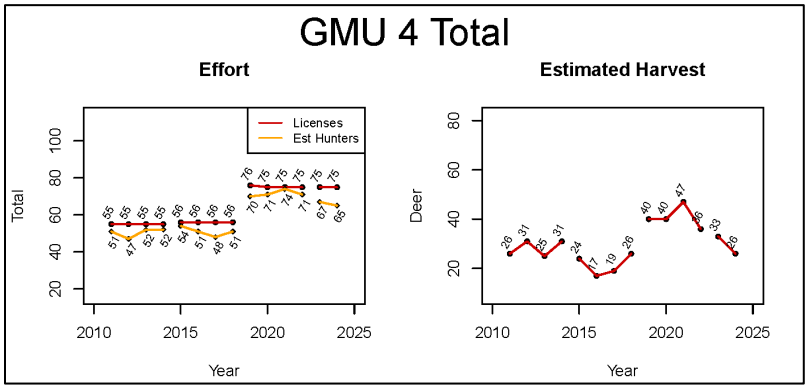
Southern San Juan Mountains

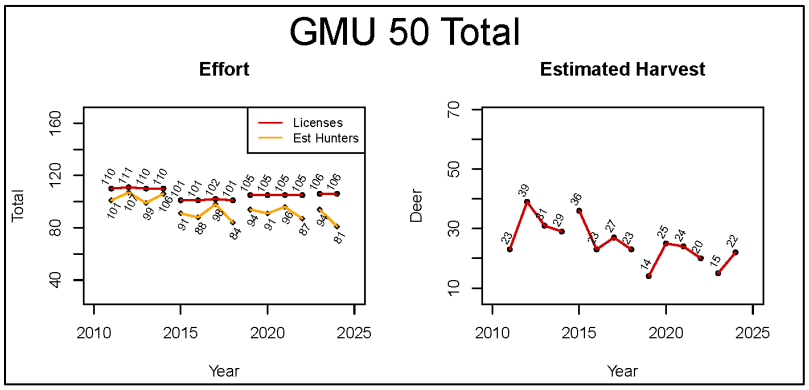


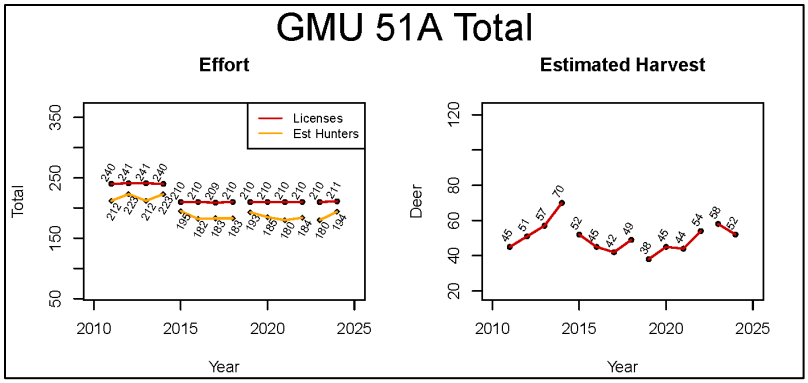
BIOLOGY – Deer in the San Juan Mountains are migratory or partially migratory. Deer that summer in GMUs 51A and 52 migrate to lower elevations in the winter. Deer that winter in GMU 4 have been documented to summer in Colorado to the north or in the high elevation mountains to the east. Deer in GMU 50 are predominately year-round residents. The deer herd in this GMU is considered stable to increasing. Deer numbers in GMU 50 are low.

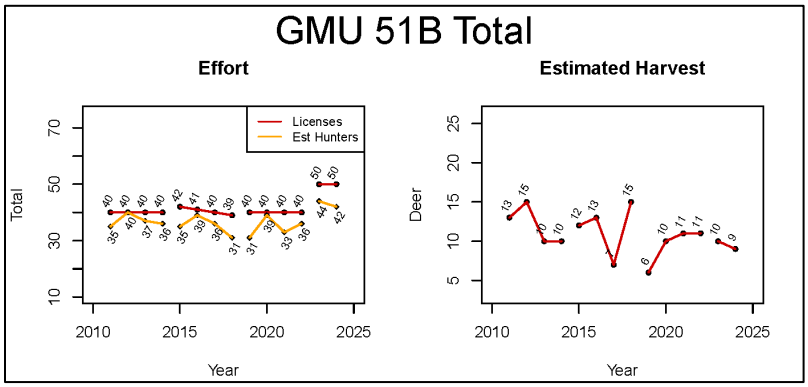
HUNTING – The Southern San Juan Mountains DMZ is characterized by mountainous terrain containing dark conifer and aspen forests with pockets of open meadows and mountain shrubs. The lower elevations contain scrub oak, mountain mahogany, PJ, and sagebrush. Public hunting access is through the extensive USFS and BLM land. In GMU 4, public hunting is restricted to the Department owned Wildlife Management Areas. GMU 4 is a Quality Hunt Unit while the remainder of the Southern San Juan Mountains is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.

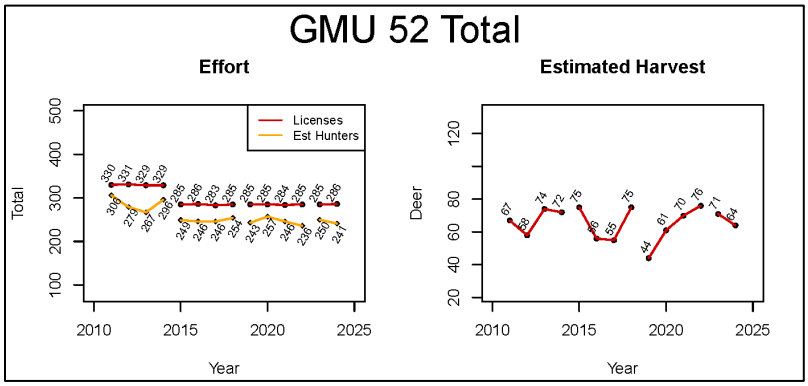

Photo by O. Duvuvuei











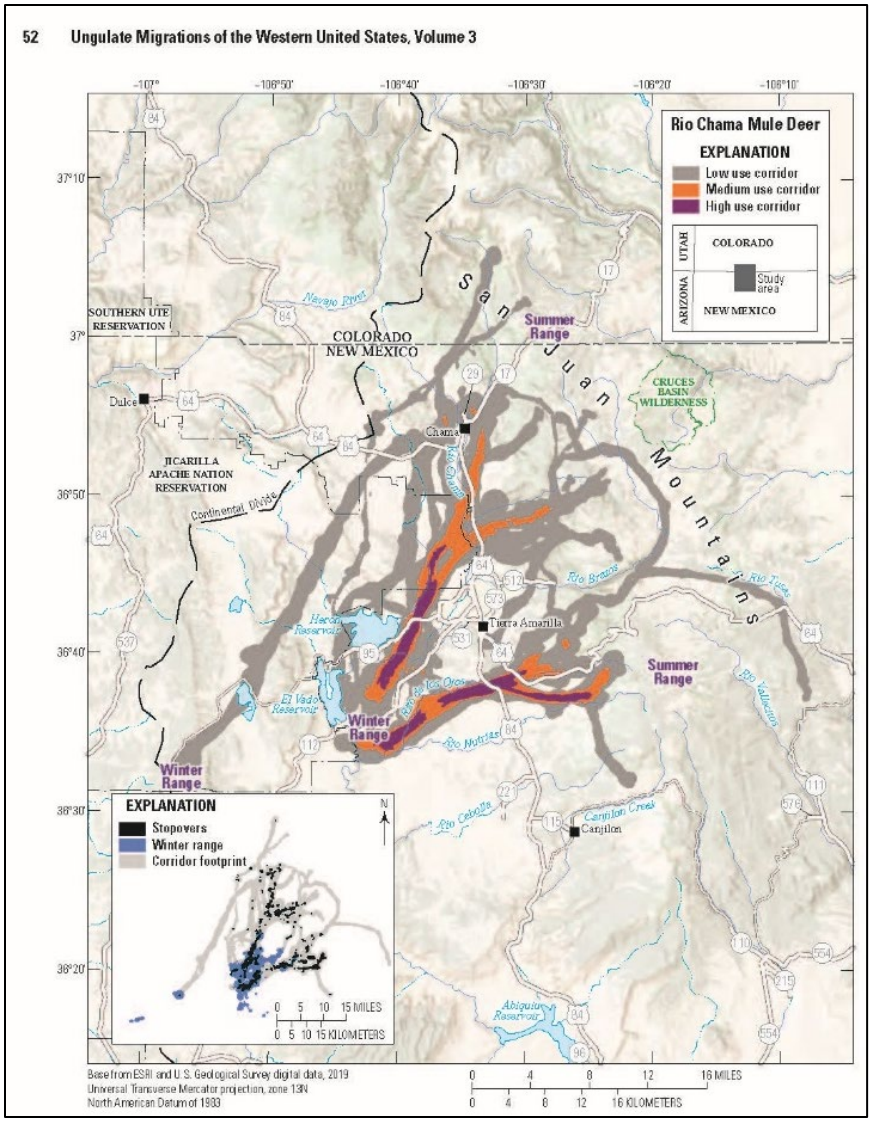
RESEARCH – GMU 4: Rio Chama mule deer migration

Migration Mapping: Ungulate Migrations of the Western US Volume 3. United States Geological Survey Report. 2023.

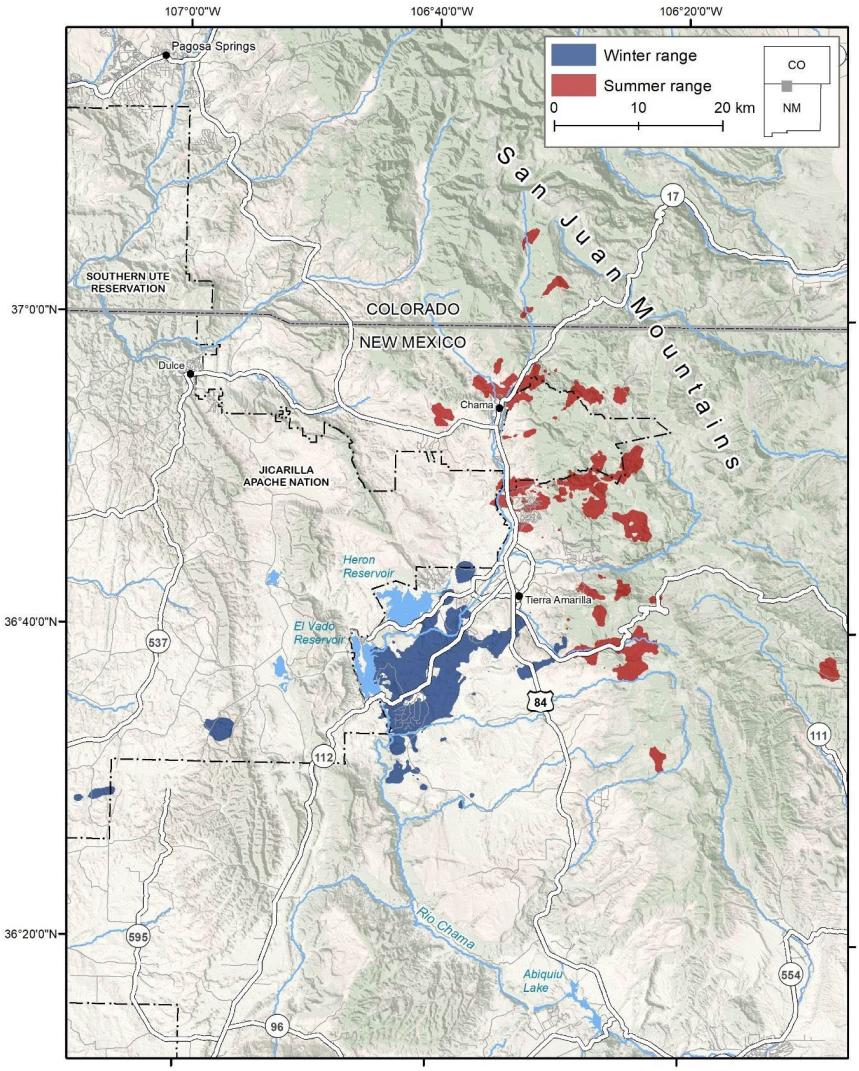
Ungulate Migrations of New Mexico. NMSU Report. 2025.

The Department funded mule deer migration research in GMU 4 and partnered with the NMSU co-op to conduct the analyses. The herds that were researched in this DMZ include the Rio Chama mule deer herd.

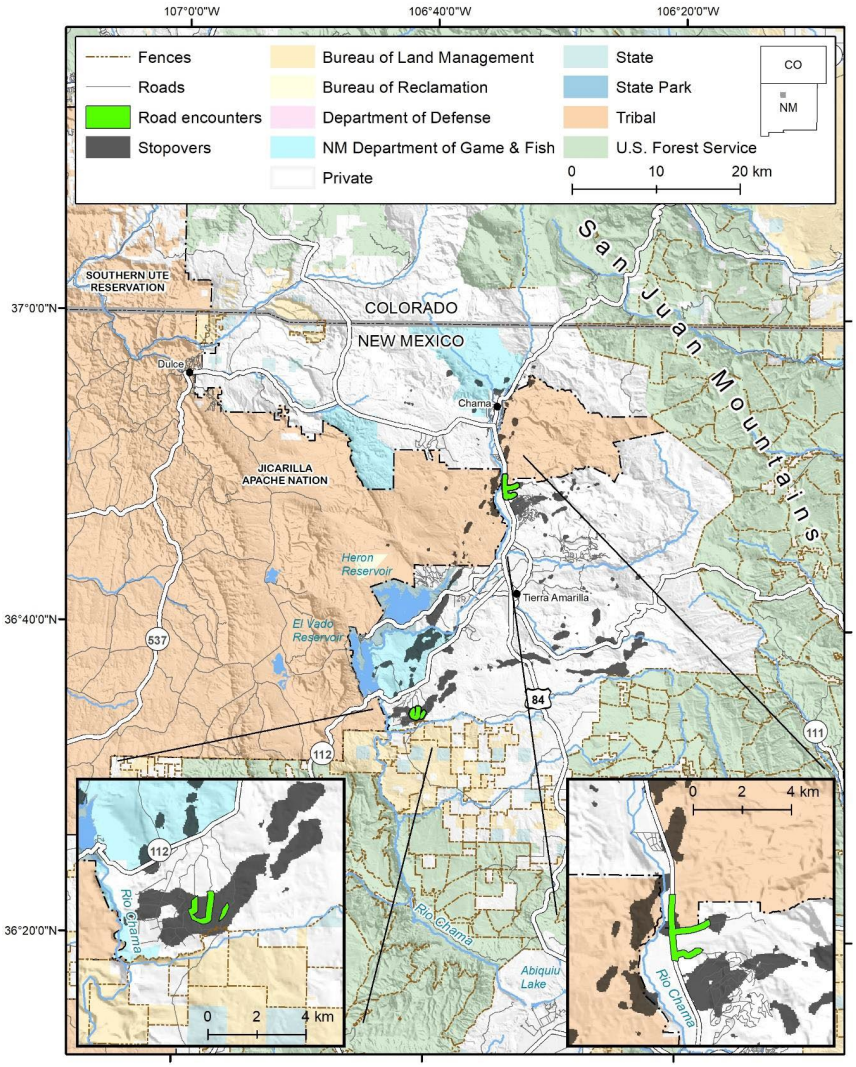
SUMMARY – The Rio Chama mule deer herd is one of the highest-density populations of any herd in New Mexico. The herd migrates from north-central New Mexico along the Continental Divide and through the San Juan Mountains, with some individuals moving to summer ranges in southern Colorado (7,871–11,500 ft elevation). These deer migrate through a mosaic of private, public, and Jicarilla Apache Nation Reservation lands. The herd winters south and east of Heron Reservoir and El Vado Reservoir in habitat consisting primarily of sagebrush steppe, grasslands, pinyon-juniper mesas, and oak woodlands. The mule deer use two primary migration corridors: One corridor follows the Rio Chama to the northeast and a shorter corridor heads east across U.S. Highways 84 and 64. The shorter corridor initially follows Rio de los Ojos before branching into separate corridors north and south of U.S. Highway 64. Interspersed agricultural lands along the Rio Chama and U.S. Highways 84 and 64 may serve as stopover sites for some mule deer during their spring migration. Ponderosa pine, mixed conifer, and *Populus tremuloides* (quaking aspen) forests characterize the corridors and stopovers within mid-elevation landscapes. As the Rio Chama mule deer continue northeast, they travel through subalpine spruce-fir forests and montane meadows until reaching their high-elevation summer range, which consists of mixed conifer and aspen forests. Challenges the herd faces include crossing U.S. Highways 84 and 64, increasing density of housing subdivisions in some areas along the routes, and fencing, especially taller fencing that mule deer cannot jump. For more information see Volume 3 of the Ungulate Migrations of the Western US report.



Migration corridors and stopover areas for the Rio Chama mule deer herd, New Mexico, USA.



Winter and summer ranges of the Rio Chama mule deer herd, New Mexico, USA.



Stopovers and sections of roads (green) with high-density encounter rates of the Rio Chama mule deer herd, New Mexico, USA.

RESEARCH – GMU 4 mule deer

Migratory mule deer and elk decide how long to remain at stopovers depending on landscape conditions. Master's Thesis. 2025.

Joanna Ennis

The Department funded mule deer migration research in GMU 4 and partnered with the NMSU co-op to conduct the analyses. The herds that were researched in this DMZ include the Rio Chama mule deer herd.

ABSTRACT – Migratory large herbivores face increasing challenges in navigating complex and changing environments, with migration plasticity emerging as a vital mechanism for the survival of migratory populations in a rapidly changing world. Yet, significant knowledge gaps remain in understanding large herbivore migration ecology and behavioral plasticity. We investigated multiscale habitat selection of elk and mule deer during spring migration in the southern San Juan Mountains, evaluating how landscape and anthropogenic features influenced selection at the landscape, migration route, and local scales. We also compared habitat selection during periods when elk and mule deer used extended stopovers to periods with conventional stopover use. We observed high and low heterogeneity in selection responses across species and spatial scales, with elk displaying more varied selection across habitat features and spatial scales. Both species selected habitats offering cover at broader scales, while selecting terrain features that facilitated movement during migration and vegetation features providing foraging opportunities at the finest scale. Mule deer occupied valley bottoms during extended stopover use, especially in drought years, while elk selected cooler, wetter gentle slopes under similar conditions and hotter, drier slopes during conventional stopover use, particularly in non-drought years. These strategies likely minimized energy expenditure and maximized resource gains in a mountainous landscape with unpredictable climatic conditions. Both species remained close to water sources at broader scales but maintained greater distances at the local scale, likely due to their short-distance migrations ($\bar{x}$ = 36.3 km for elk and $\bar{x}$ = 29.3 km for mule deer) in a region where water is less of a limiting factor. Mule deer exhibited stronger selection for proximity to anthropogenic disturbances at finer scales, as developed land is more prevalent within their population home range compared to elk. Both species selected agricultural areas at broader scales, particularly during years of extended stopover use, suggesting they may have foraged in these areas. Elk remained closer to dirt roads on tribal lands but maintained greater distances on public and private lands, likely due to lower human presence on tribal lands. The observed variation in selection patterns and migration strategies may serve as a mechanism to avoid phenological mismatch in climatically and topographically complex landscapes. Animals typically spend < 12 days across all conventional stopover sites along their migration routes, while extended stopover site durations range from 2 to 17 weeks at each unique location. Extended stopovers likely serve the same purpose as conventional stopovers but may also act as staging grounds, allowing animals to adjust migration pace to local conditions in a landscape where the consequences of not adapting to environmental changes are greater. As the pressures of habitat fragmentation and drought continue to rise, conservation strategies must account for a diversity of migratory behaviors, closely monitor changes in these behaviors, and incorporate migration plasticity into frameworks to ensure the persistence and resilience of these populations.

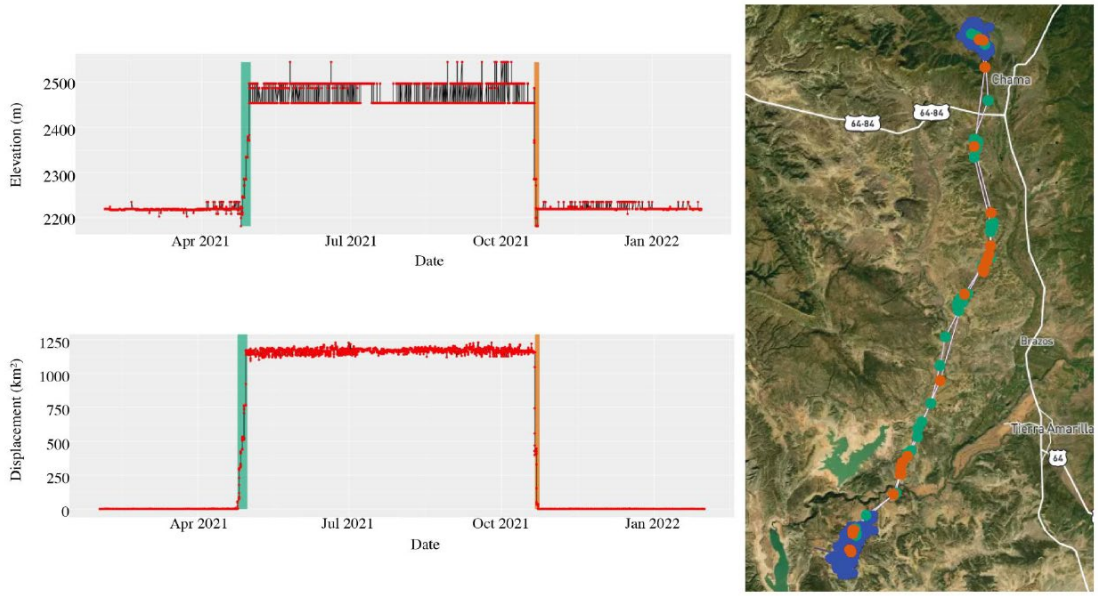


Figure D3. Conventional stopover behavior of an adult female mule deer in northcentral New Mexico, illustrated with GPS collar locations highlighting spring (blue-green; April – May 2021) and autumn (orange; October 2021) migration sequences. Conventional use of stopover sites lasted on average 1 – 2 days, with the total migration duration of 8 days in spring and 3 days in autumn. The middle panel displays net squared displacement (km²) of spring and autumn isopleths, while the top panel presents movement relative to elevation (m).

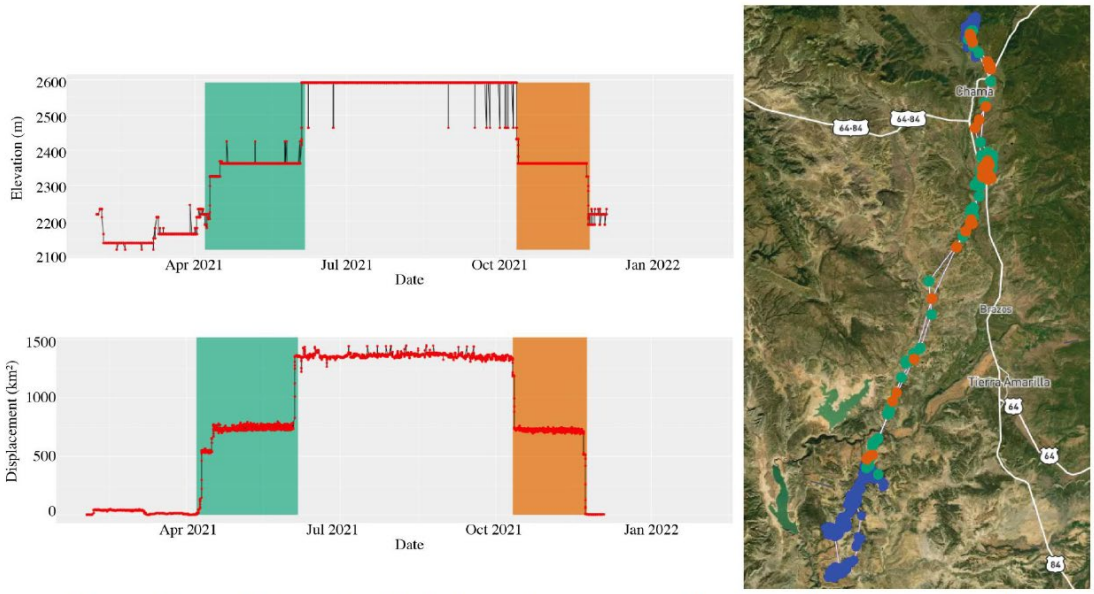
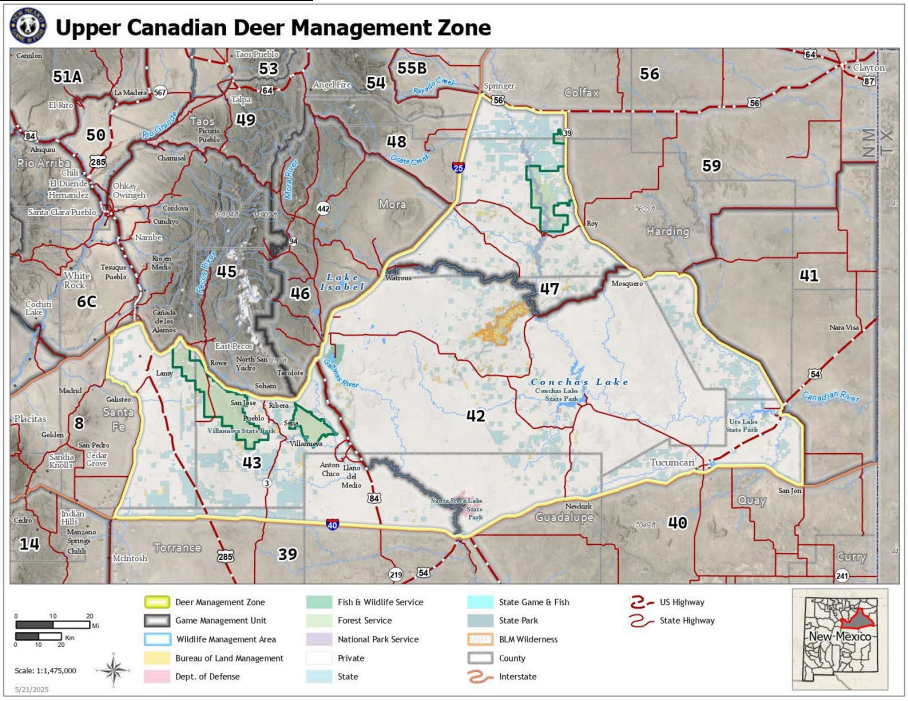


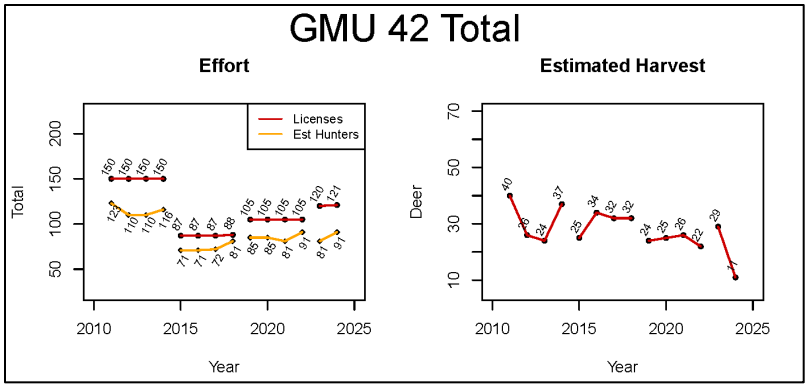
Figure D4. Extended stopover behavior of an adult female mule deer in northcentral New Mexico, illustrated using GPS collar data showing spring (blue-green; April – June 2021) and autumn (orange; October – November 2021) migration sequences. The top panel displays movement relative to elevation (m). The middle panel shows net squared displacement (NSD; km²), with both spring and autumn depicting extended (plateau on the NSD curve) and conventional stopovers. Extended stopover sites lasted 49 days during spring migration and 41 days during autumn migration, with total migration durations of 60 days in spring and 44 days in autumn.

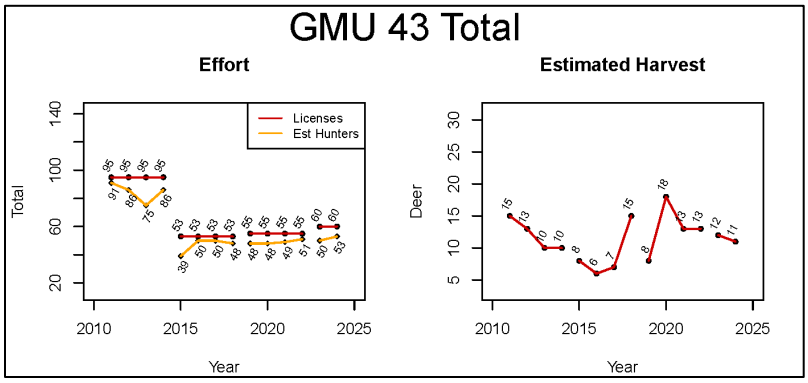
Upper Canadian River

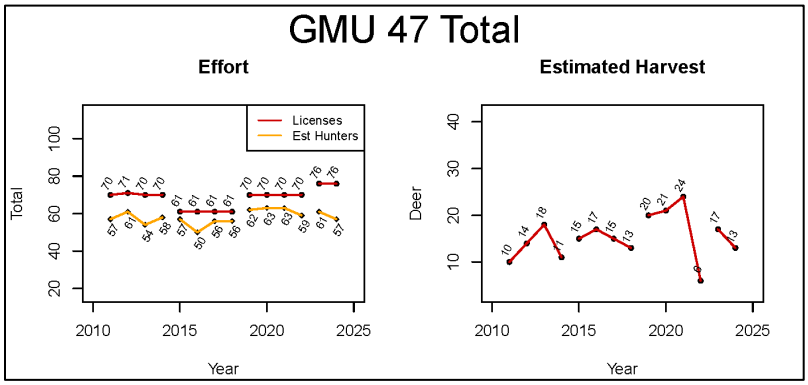


BIOLOGY – Deer in the Upper Canadian River DMZ are year-round residents. Deer might make short movements to take advantage of favorable conditions but predominately stay within their home ranges. The deer population in this DMZ is considered stable, but densities are low.

HUNTING – The Upper Canadian River DMZ is dominated by plains and rolling hills with some canyons and escarpments. The canyons and escarpments have PJ habitat, and grasslands are found in the plains. The Canadian River breaks and surrounding areas are most likely to hold deer. Most of this unit is privately owned. Public land hunting opportunities in these units are available through the interspersed patches of SLO land with a large block of Santa Fe National Forest land located in GMU 43. The Upper Canadian River DMZ is managed for opportunity. Trends in harvest for each GMU can be found in the graphs below.


GMU 42 Total
Effort
Licenses
Est Hunters
Total
Year
Estimated Harvest
Deer
Year


GMU 43 Total
Effort
Licenses
Est Hunters
Total
Year
Estimated Harvest
Deer
Year


GMU 47 Total
Effort
Licenses
Est Hunters
Total
Year
Estimated Harvest
Deer
Year

Literature Cited

Ames, N. 1967. Game census and harvest data. Pages 25-30. New Mexico Wildlife Management. New Mexico Dept. of Game and Fish. Santa Fe, N. M.

Andelt, W.F. 1996. Evaluation of coyote removal strategies for reducing predation on livestock and game animals.

Cain, J. W., Ashling, J. B., & Liley, S. G. 2018. Survival and cause-specific mortality of translocated female mule deer in southern New Mexico, USA. *Wildlife Research*, *45*(4), 325-335.

Cain III, J. W., Kay, J. H., Liley, S. G., & Gedir, J. V. 2024. Mule deer (Odocoileus hemionus) resource selection: trade-offs between forage and predation risk. *Frontiers in Ecology and Evolution*, *12*, 1121439.

Ennis, A, J. R. 2025. Identification and characterization of habitat conditions of elk, mule deer, and pronghorn migration routes and stopover sites in northcentral New Mexico. Thesis. New Mexico State University.

Ennis, A, J. R., & III B, J. Cain. 2023. Elk and mule deer spring migration in New Mexico: Movement strategies for navigating through a monsoonal landscape.

Gruell, G.E. 1986. Post-1900 mule deer irruptions in the Intermountain West: principle cause and influences. USDA For. Serv. Gen. Tech. Report INT-206

Fischer, J., & B. Lindenmayer, D. 2006. Beyond fragmentation: the continuum model for fauna research and conservation in human-modified landscapes. *Oikos*, *112*(2), 473-480.

Forrester, T. D., and H. U. Wittmer. 2013. A review of the population dynamics of mule deer and black-tailed deer *Odocoileus hemionus* in North America. Mammal Review 43:292–308.

Harrington, J. L., & Conover, M. R. 2006. Characteristics of ungulate behavior and mortality associated with wire fences. *Wildlife Society Bulletin*, *34*(5), 1295-1305.

Haskell, S. P., W. B. Ballard, J. T. McRoberts, M. C. Wallace, P. R. Krausman, M. H. Humphrey, and D. A. Butler. 2017. Growth and mortality of sympatric white-tailed and mule deer fawns. Journal of Wildlife Management 81:1417–1429.

Heffelfinger, J. R. 2006. Deer of the Southwest: a complete guide to the natural history, biology, and management of mule deer and white-tailed deer. Texas A&M University Press, College Station, USA.

Howard, V. W. 1991. Effects of electric predator-excluding fences on movements of mule deer in pinyon/juniper woodlands. *Wildlife Society Bulletin (1973-2006)*, *19*(3), 331-334.

Kauffman, M., et al. 2022a. Ungulate migrations of the western United States, volume 2: U.S. Geological Survey Scientific Investigations Report 2022–5008, 160 p., https://doi.org/10.3133/sir20225008.

Kauffman, M., et al. 2022b. Ungulate migrations of the western United States, volume 3: U.S. Geological Survey Scientific Investigations Report 2022–5088, 114 p., https://doi.org/10.3133/sir20225088.

Kauffman, M., et al. 2024. Ungulate migrations of the Western United States, volume 4: U.S. Geological Survey Scientific Investigations Report 2024–5006, 86 p., 1 pl., https://doi.org/10.3133/sir20245006.

Kauffman, M., et al. 2025. Ungulate migrations of the Western United States, volume 5: U.S. Geological Survey Scientific Investigations Report 2024–5111, 96 p., https://doi.org/

10.3133/sir20245111. Kramer, D. W., Sorensen, G. E., Taylor, C. A., Cox, R. D., Gipson, P. S., & Cain III, J. W. (2015). Ungulate exclusion, conifer thinning and mule deer forage in northeastern New Mexico. *Journal of Arid Environments*, *113*, 29-34.

Lawrence, R. K., S. Demarais, R. A. Relyea, S. P. Haskell, W. B. Ballard, and T. L. Clark. 2004. Desert mule deer survival in southwest Texas. Journal of Wildlife Management 68:561–569.

Leopold, A., L.K. Sowls, and D.L. Spencer. 1947. A survey of over-populated deer ranges in the United States. Journal of Wildlife Management. 11 (2):162-177.

Lutz, D. W., M. Cox, B. F. Wakeling, D. McWhirter, L. H. Carpenter, S. Rosenstock, D. Stroud, L. C. Bender, and A. F. Reeve. 2003. Impacts and changes to mule deer habitat. Pages 13–61 *in* J. C. deVos, Jr., M. R. Conover, and N. E. Headrick, editors. Mule deer conservation: issues and management

Marshal, J. P., P. R. Krausman, V. C. Bleich, W. B. Ballard, and J. S. McKeever. 2002. Rainfall, El Nino, and dynamics of mule deer in the Sonoran Desert, California. Journal of Wildlife Management 66:1283–1289.

Mills, S. L., and H. E. Johnson. 2013. Wildlife population dynamics. Pages 84–111 *in* P. R. Krausman, and J. W. Cain III, editors. Wildlife management and conservation: contemporary principles and practices. Johns Hopkins University Press, Baltimore, Maryland, USA.

Richardson, C. 2003. Trans-Pecos vegetation: a historical perspective. Trans-Pecos Wildlife Management Series, Leaflet No. 7. Texas Parks and Wildlife Department, Austin, USA.

Sawyer, H., LeBeau, C. W., McDonald, T. L., Xu, W., & Middleton, A. D. 2019. All routes are not created equal: an ungulate's choice of migration route can influence its survival. *Journal of Applied Ecology*, *56*(8), 1860-1869.

Sawyer, H. 2021. Crow Mesa Mule Deer Study – Final Report. Western Ecosystems Technology, Inc., Laramie, WY.

Smith, R. H., and A. LeCount. 1979. Some factors affecting survival of desert mule deer fawns. Journal of Wildlife Management 43:657–665.

Sorensen, G. E., Kramer, D. W., Cain III, J. W., Taylor, C. A., Gipson, P. S., Wallace, M. C., ... & Ballard, W. B. 2020. Mule deer habitat selection following vegetation thinning treatments in New Mexico. *Wildlife Society Bulletin*, *44*(1), 122-129.

Stewart, R. 1962. Investigations of big game and ranges, historical background of the Black Range. Job Comp. Report, WP20, Job 7, W-75-R-9. New Mexico Dept. Of Game and Fish. 47pp.

Stewart, R. 1967. Mule Deer. New Mexico Wildlife Management. New Mexico Dept. of Game and Fish. Santa Fe, N. M. pp. 42-50