2018 - JCR Evaluation Form

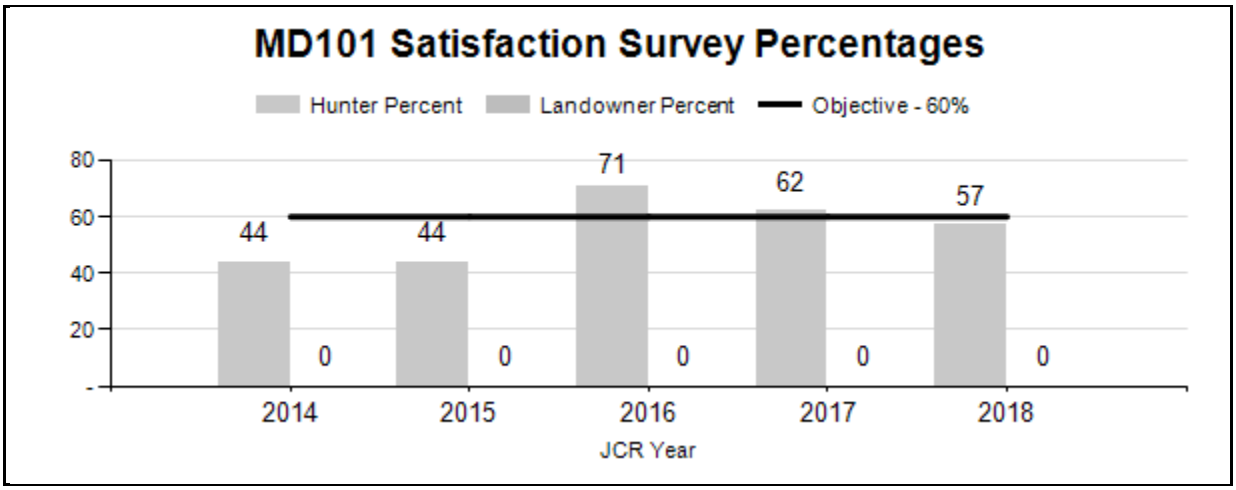
SPECIES: Mule Deer
PERIOD: 6/1/2018 - 5/31/2019

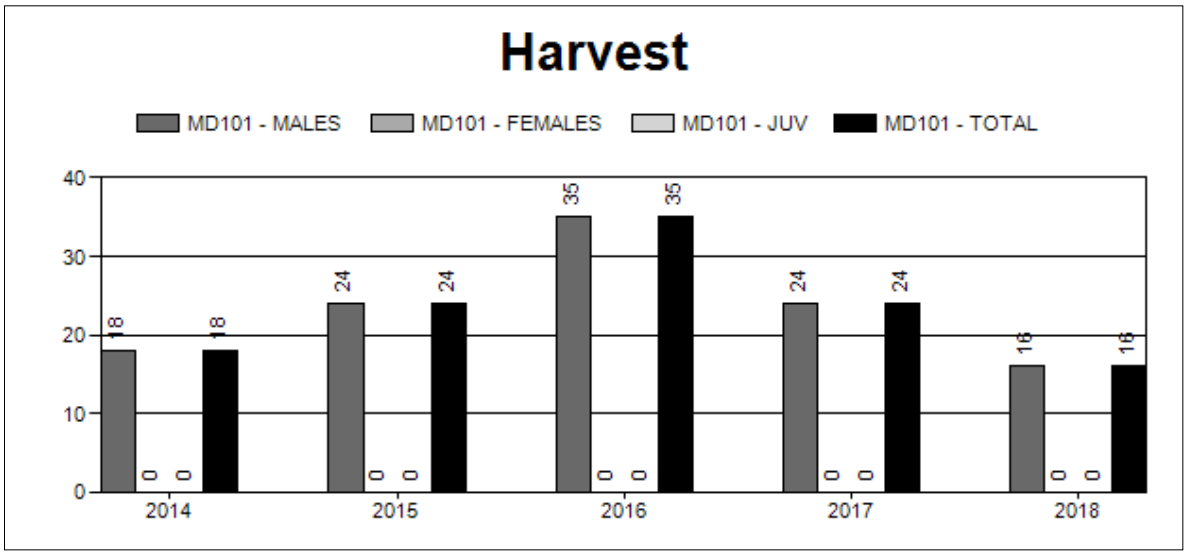
HERD: MD101 - TARGHEE

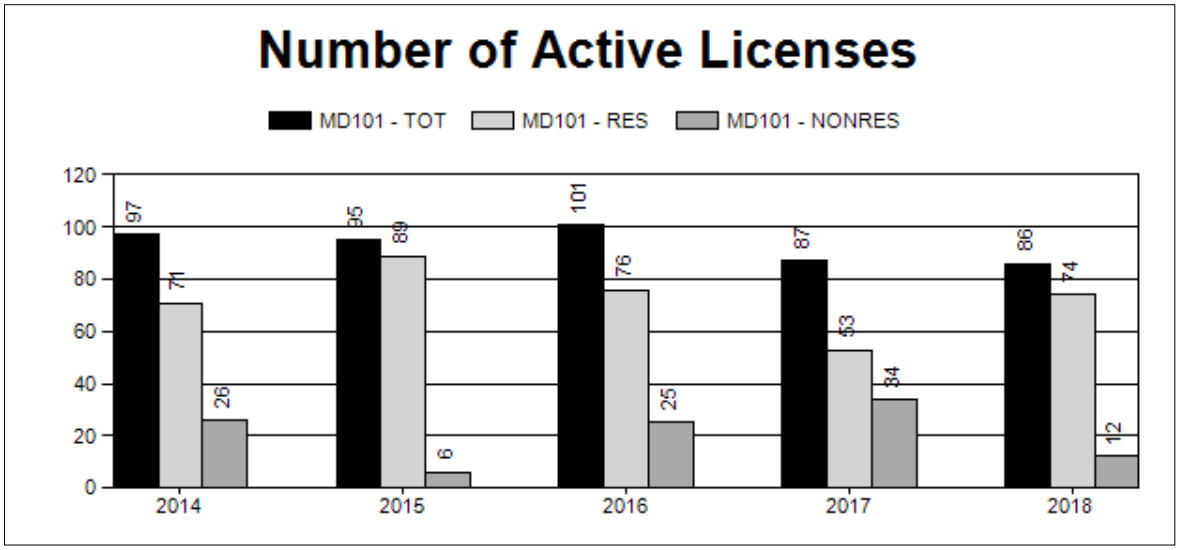
HUNT AREAS: 149
PREPARED BY: ALYSON COURTEMANCH

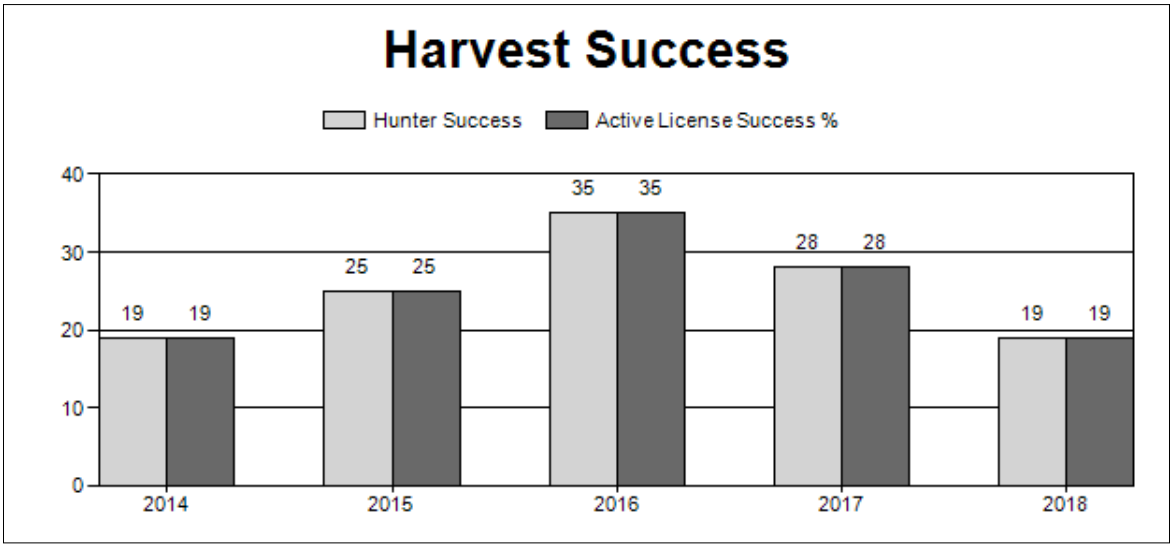
	2013 - 2017 Average	2018	2019 Proposed
Hunter Satisfaction Percent	53%	57%	60%
Landowner Satisfaction Percent	0%	0%	0%
Harvest:	23	16	25
Hunters:	91	86	90
Hunter Success:	25%	19%	28 %
Active Licenses:	91	86	90
Active License Success:	25%	19%	28 %
Recreation Days:	435	509	250
Days Per Animal:	18.9	31.8	10
Males per 100 Females:	0	0	
Juveniles per 100 Females	0	0	

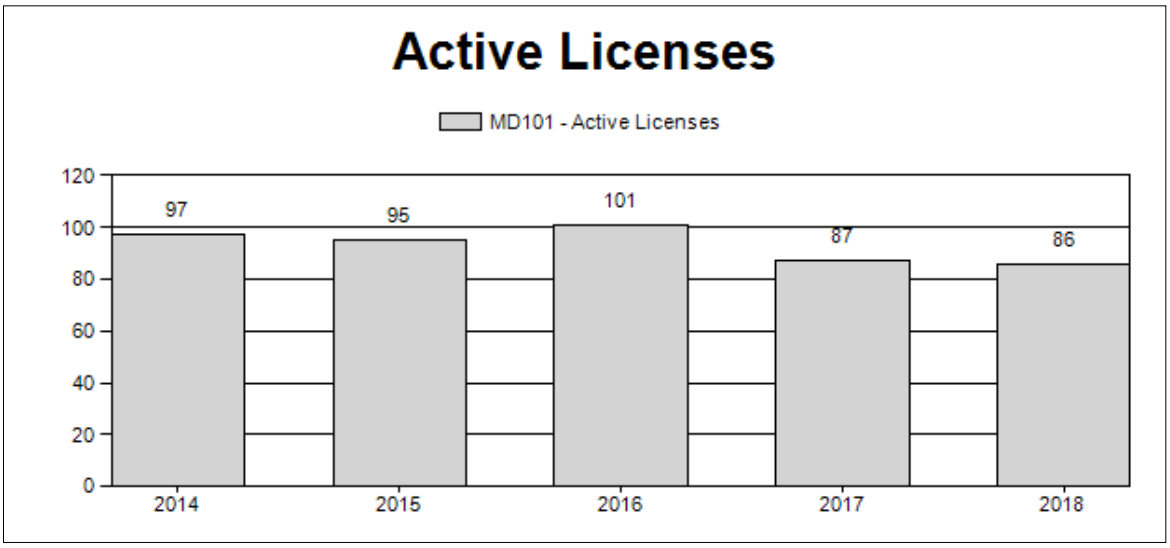
Satisfaction Based Objective	60%
Management Strategy:	Recreational
Percent population is above (+) or (-) objective:	N/A%
Number of years population has been + or - objective in recent trend:	1

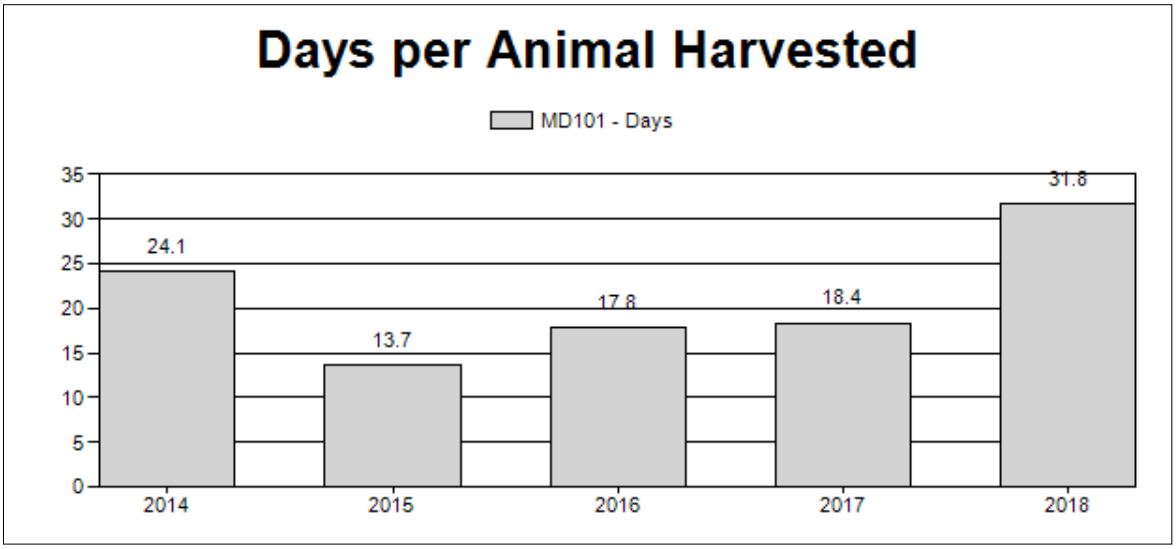


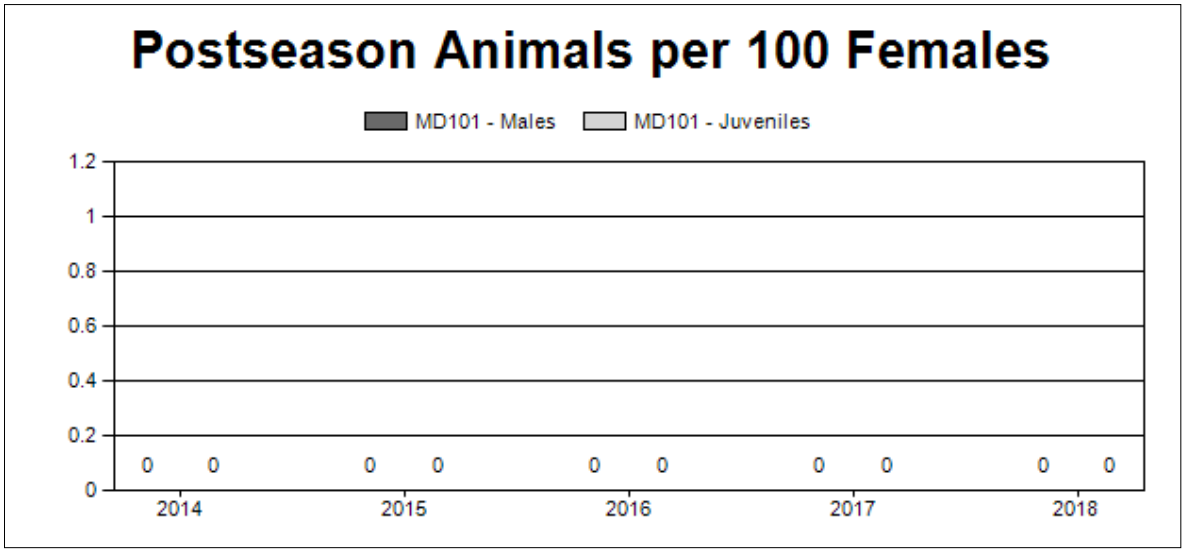

Harvest
MD101 - MALES
MD101 - FEMALES
MD101 - JUV
MD101 - TOTAL
40
30
20
10
0
18
0
0
18
24
0
0
24
35
0
0
35
24
0
0
24
16
0
0
16
2014
2015
2016
2017
2018


Number of Active Licenses
MD101 - TOT
MD101 - RES
MD101 - NONRES
120
100
80
60
40
20
0
97
71
26
95
89
6
101
76
25
87
53
34
86
74
12
2014
2015
2016
2017
2018


Harvest Success
Hunter Success
Active License Success %
40
30
20
10
0
19
19
25
25
35
35
28
28
19
19
2014
2015
2016
2017
2018


Active Licenses
MD101 - Active Licenses
120
100
80
60
40
20
0
97
95
101
87
86
2014
2015
2016
2017
2018


Days per Animal Harvested
MD101 - Days
35
30
25
20
15
10
5
0
24.1
13.7
17.8
18.4
31.8
2014
2015
2016
2017
2018


Postseason Animals per 100 Females
MD101 - Males
MD101 - Juveniles
1.2
1
0.8
0.6
0.4
0.2
0
0 0
0 0
0 0
0 0
0 0
2014
2015
2016
2017
2018

2019 HUNTING SEASONS
TARGHEE MULE DEER HERD (MD101)

Hunt Area	Type	Season Dates		Quota	License	Limitations
		Opens	Closes			
149		Sep. 15	Oct. 6		General	Antlered mule deer three (3) points or more on either antler or any white-tailed deer
	3	Sep. 15	Nov. 30	15	Limited quota	Any white-tailed deer
	8	Sep. 15	Nov. 30	50	Limited quota	Doe or fawn white-tailed deer
149	Archery	Sep. 1	Sep. 14			Refer to Section 2 of this Chapter

Management Evaluation

Management Strategy: Recreational

Population Objective Type: Hunter Satisfaction
Primary Objective: Achieve a 3-year average of ≥ 60% of hunters indicating they are "satisfied" or "very satisfied" on the harvest survey.
Secondary Objective: Achieve a 3-year average of ≥ 15% harvest success.
Evaluation: meeting primary and secondary objectives

The Wyoming Game and Fish Department (WGFD) proposed changing the objective for the Targhee Mule Deer Herd from a postseason population objective to a hunter satisfaction objective in 2014. The objective change was needed because the herd is rarely surveyed due to budget priorities elsewhere and spreadsheet models do not appear to adequately simulate observed population trends. In addition, the interstate nature of the herd poses additional challenges to population surveys and management since the majority of the herd winters in Idaho. A hunter satisfaction objective was adopted in 2014 after public review, and included a primary and secondary objective (listed above). The region did not adopt a landowner satisfaction objective because the majority of the herd unit is located on public lands.

In 2018, 57% of hunters indicated they were "satisfied" or "very satisfied" with hunting in the Targhee Mule Deer Herd. The average satisfaction for the past 3 years is 63%. Therefore, the herd is meeting its primary objective of ≥ 60% hunter satisfaction.

In 2018, 19% of hunters were successful in the Targhee Mule Deer Herd. The 3-year average of hunter success is 27%. Therefore, the herd is meeting the secondary objective of an average of ≥ 15% harvest success over 3 years.

Herd Unit Issues

The current objective and management strategy for this herd will be maintained based on internal discussions and conversations with our constituents. Population status was evaluated and it was determined a change is not warranted at this time. These objectives will be reviewed again in 2024; however, if a situation arises that requires immediate change, proposals will be developed and submitted as needed.

Post-season classification surveys are not flown in this herd due to budget constraints. Many of the historical winter ranges for the Targhee Herd have been converted to agriculture and residential development in Idaho. Winter ranges that remain are primarily low elevation mountain shrub and aspen communities in Wyoming and riparian areas in Idaho along the Teton River. Many of the mountain shrub and aspen communities along the state line are old and decadent and are being encroached by conifers. More restrictive hunting seasons have been implemented to allow this population to increase and increase hunter success. Beginning in 2015, a Type 8 doe/fawn white-tailed deer license was added to the hunt area due to several private landowners expressing interest in controlling white-tailed deer numbers. In 2017, a Type 3 any white-tailed deer license was also added.

Weather

Spring and summer 2018 produced average moisture. Fall and early winter weather was very mild with warm temperatures and little snowfall at high elevations. This may have increased days to harvest for hunters. However, several large snowstorms occurred in February that resulted in the rapid accumulation of a deep snowpack. Please refer to the following web sites for specific weather station data. http://www.wrds.uwyo.edu/wrds/nrcs/snowprec/snowprec.html and http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/pdiimage.html

Habitat

There are no permanent vegetation transects in mule deer winter ranges for the Targhee Herd. Several habitat improvement projects are being planned in this herd unit, including the Hill Creek Prescribed Burn, which is scheduled for completion in 2019. In addition, a habitat treatment in Teton Canyon is currently in the planning stages to improve mountain shrub and aspen communities for deer and other big game with potential for implementation beginning in 2019. The WGFD is assisting Caribou-Targhee National Forest (CTNF) with vegetation monitoring in aspen stands pre and post-treatment. Please refer to the 2018 Annual Report Strategic Habitat Plan Accomplishments for Jackson Region habitat improvement project summaries (https://wgfd.wyo.gov/Habitat/Habitat-Plans/Strategic-Habitat-Plan-Annual-Reports).

Field Data

No field data were collected in the Targhee Herd Unit during the 2018 biological year.

Harvest Data

Based on harvest statistics, the density of mule deer in the Targhee Herd continues to be a concern. However, there has been a promising trend in the last 3 years of increased hunter success

and satisfaction in this herd unit. The average days to harvest was 31.8 in 2018, indicating that it is difficult for hunters to find deer. Eighty-six hunters hunted in this herd unit for mule deer and 16 mule deer were harvested. Thirty-eight hunters hunted white-tailed deer and 19 deer were harvested.

Population

This population likely declined following liberal hunting seasons in Idaho. Data are limited for this population. Mule deer winter and transitional ranges in Wyoming are dominated by older age class shrubs and conifer-encroached aspen stands. Many mountain shrub communities are decadent, with plants reaching over 10 feet in height, well above a mule deer's browse zone.

Management Summary

Due to the "interstate" nature of this mule deer population, managing this herd is difficult. Observations of deer along the state line indicate this population remains at a low density even though hunting seasons are conservative. Antlered mule deer seasons will close on October 6 to coincide with hunt season closures adjacent to Jackson.

Several private landowners have expressed interest in expanded white-tailed deer hunting opportunities in Hunt Area 149. Therefore, a new Type 8 license was offered beginning in 2015 for doe or fawn white-tailed deer with 50 licenses. Fifteen Type 3 licenses valid for any white-tailed deer were offered beginning in 2017. This is in response to a growing white-tailed deer population near private lands in the herd unit and requests by the public for additional license types. Since the majority of white-tailed deer occur on private land, access is likely a limiting factor for white-tailed deer harvest. White-tailed deer licenses will help maintain low densities to prevent competition with mule deer, reduce damage to private lands, and create additional deer hunting options in this area.

2018 - JCR Evaluation Form

SPECIES: Mule Deer | PERIOD: 6/1/2018 - 5/31/2019

HERD: MD131 - WYOMING RANGE

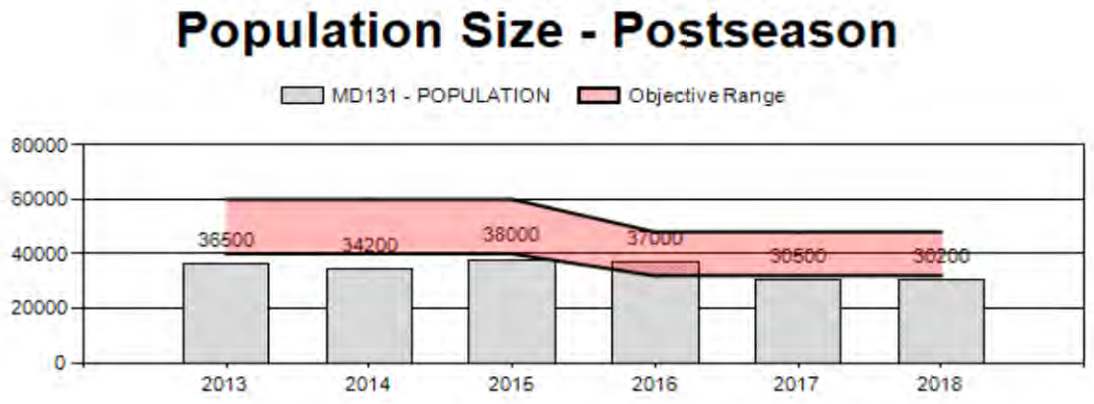
HUNT AREAS: 134-135, 143-145 | PREPARED BY: GARY FRALICK

	2013 - 2017 Average	2018	2019 Proposed
Population:	35,240	30,200	30,720
Harvest:	2,620	1,799	2,332
Hunters:	5,904	4,840	5,100
Hunter Success:	44%	37%	46 %
Active Licenses:	5,904	4,840	5,100
Active License Success:	44%	37%	46 %
Recreation Days:	32,077	26,464	28,000
Days Per Animal:	12.2	14.7	12.0
Males per 100 Females	37	30	
Juveniles per 100 Females	63	60	

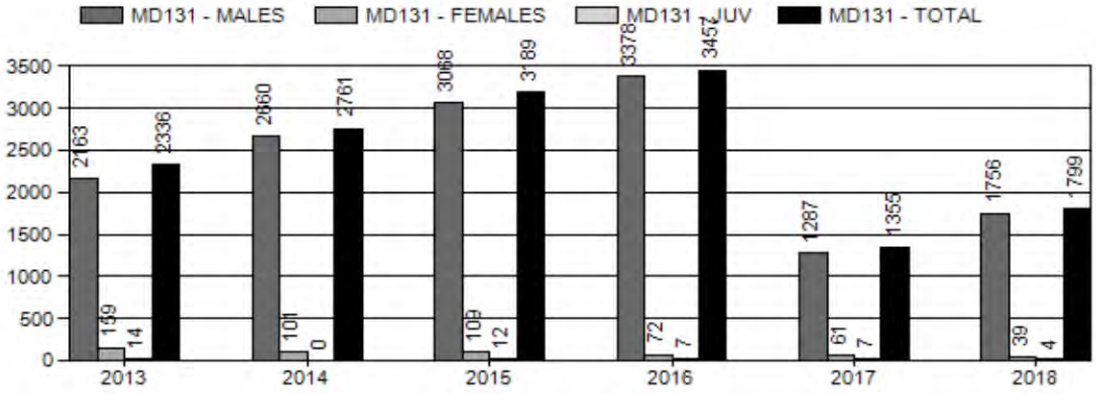
Population Objective (± 20%) :	40000 (32000 - 48000)
Management Strategy:	Special
Percent population is above (+) or below (-) objective:	-24.5%
Number of years population has been + or - objective in recent trend:	26
Model Date:	02/21/2019

Proposed harvest rates (percent of pre-season estimate for each sex/age group):

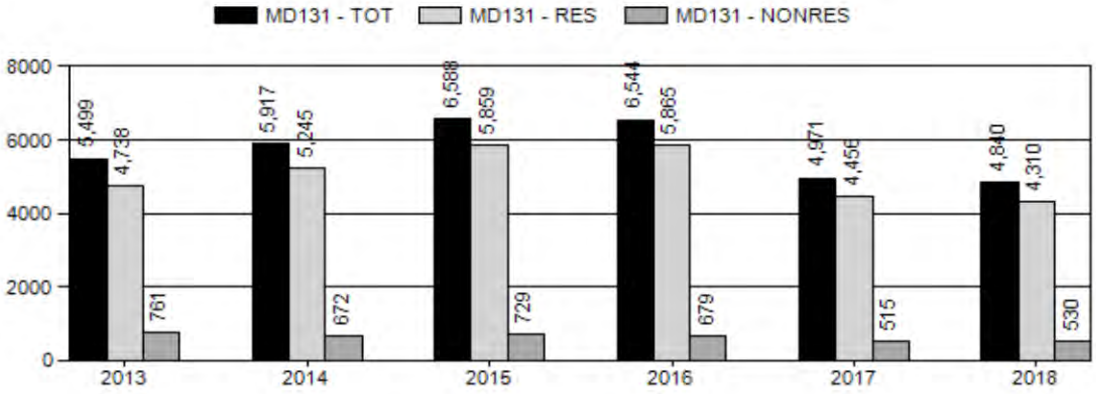
	JCR Year	Proposed
Females ≥ 1 year old:	2%	4%
Males ≥ 1 year old:	28%	33%
Total:	6%	8%
Proposed change in post-season population:	-1%	+2%



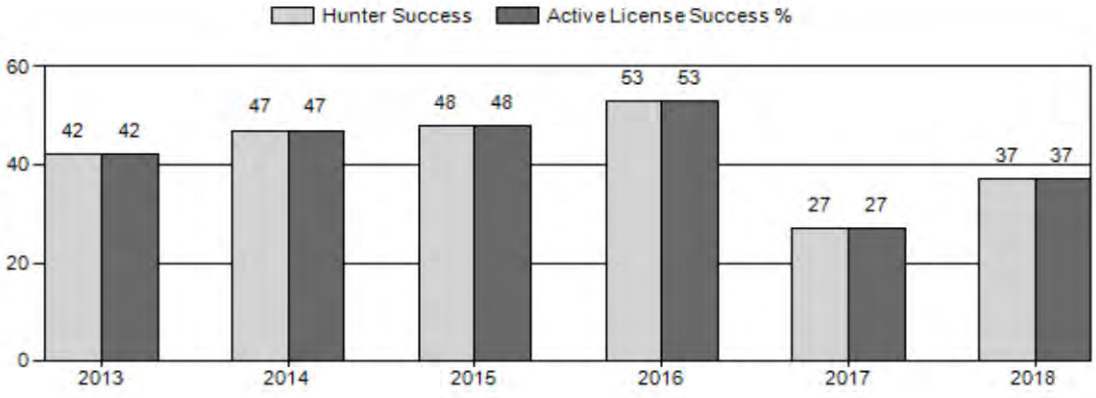
Harvest



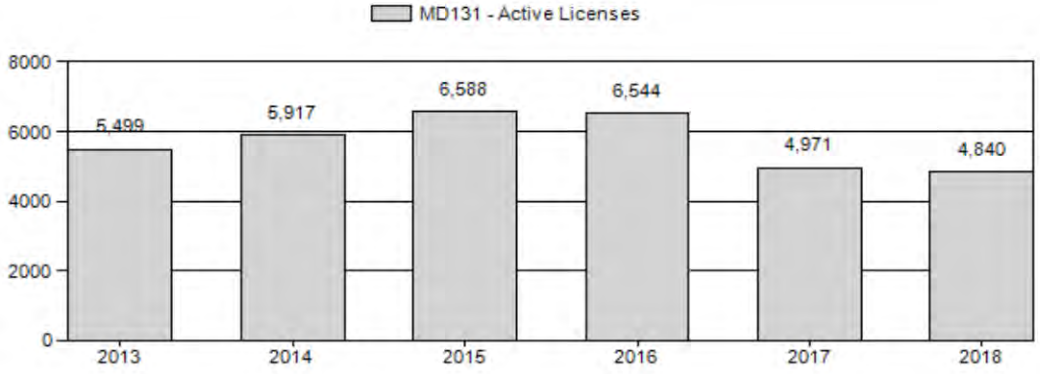
Number of Active Licenses



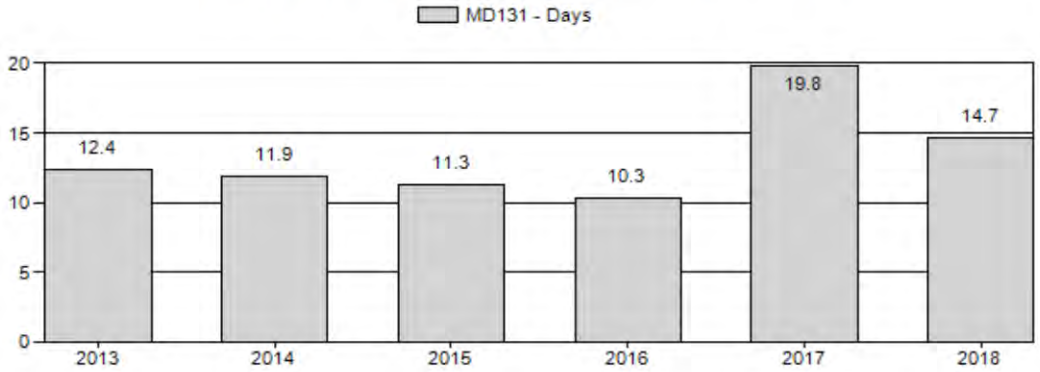
Harvest Success



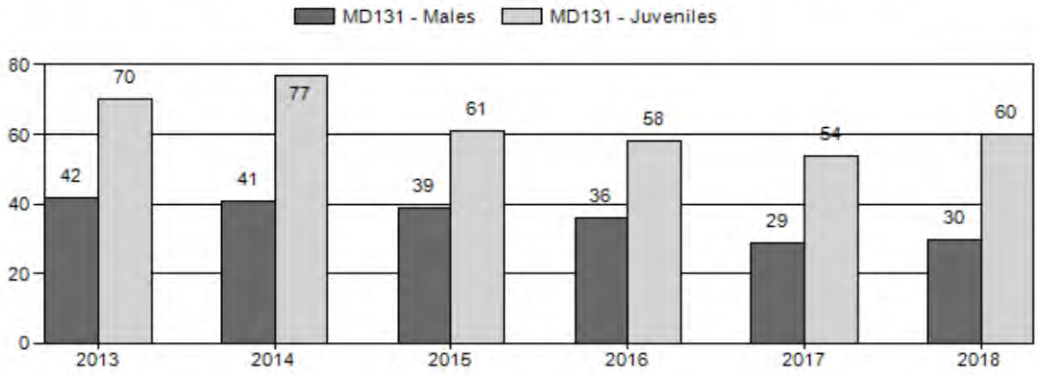
Active Licenses



Days per Animal Harvested



Postseason Animals per 100 Females



2013 - 2018 Postseason Classification Summary

for Mule Deer Herd MD131 - WYOMING RANGE

		MALES							FEMALES		JUVENILES				Males to 100 Females				Young to		
Year	Post Pop	Ylg	2+ Cls 1	2+ Cls 2	2+ Cls 3	2+ UnCls	Total	%	Total	%	Total	%	Tot Cls	Cls Obj	Yling	Adult	Total	Conf Int	100 Fem	Conf Int	100 Adult
2013	36,500	544	0	0	0	704	1,248	20%	2,946	47%	2,065	33%	6,259	0	18	24	42	± 2	70	± 2	49
2014	34,200	582	627	428	274	0	1,313	19%	3,239	46%	2,478	35%	7,030	0	18	23	41	± 2	77	± 2	54
2015	38,000	672	408	308	158	0	1,546	20%	3,930	50%	2,381	30%	7,857	0	17	22	39	± 1	61	± 2	43
2016	37,000	533	420	303	107	0	1,363	18%	3,810	52%	2,220	30%	7,393	0	14	22	36	± 1	58	± 2	43
2017	30,500	172	428	281	74	0	955	16%	3,324	55%	1,791	30%	6,070	0	5	24	29	± 1	54	± 2	42
2018	30,200	509	287	313	149	0	1,258	16%	4,252	53%	2,533	31%	8,043	0	12	18	30	± 1	60	± 2	46

2019 HUNTING SEASONS
WYOMING RANGE MULE DEER HERD (MD131)

Hunt Area	Type	Season Dates Opens	Closes	Quota	License	Limitations
134		Oct. 1	Oct. 14		General	Antlered mule deer three (3) points or more on either antler or any white-tailed deer
135		Oct. 1	Oct. 14		General	Antlered mule deer three (3) points or more on either antler or any white-tailed deer
143		Sep. 15	Oct. 6		General	Antlered mule deer three (3) points or more on either antler or any white-tailed deer
144		Sep. 15	Oct. 6		General	Antlered mule deer three (3) points or more on either antler or any white-tailed deer
145		Sep.15	Oct. 6		General	Antlered mule deer three (3) points or more on either antler or any white-tailed deer
145	3	Nov. 1	Nov. 15	50	Limited quota	Any white-tailed deer
145	3	Nov. 16	Jan. 31			Antlerless white-tailed deer
134, 135		Sep. 1	Sep. 30			Archery only – Refer to Section 3
143, 144, 145		Sep. 1	Sep. 14			Archery only – Refer to Section 3

REGION G NON-RESIDENT QUOTA - 400 LICENSES

SUMMARY OF PROPOSED CHANGES BY LICENSE NUMBER

Area	License Type	Change from 2018
134	General	Closing date from Oct. 10 to Oct. 14
135	General	Closing date from Oct. 10 to Oct. 14
143, 144, 145	General	No Changes
Region G Licenses	NR Region G	No Changes
Herd Unit Total		No Changes

Management Evaluation
Current Postseason Population Management Objective: 40,000
Management Strategy: Special
2018 Postseason Population Estimate: 30,200
2019 Proposed Postseason Population Estimate: 30,700

The management objective was reviewed in 2015. The current population objective for Wyoming Range mule deer herd is 40,000 deer. The management strategy is special.

In February 2018 the first animal abundance survey was conducted in this herd unit. A total of 25,317 deer were counted on Wyoming Range winter ranges (North winter ranges - 10,074 deer, 40% of sample; South winter ranges - 15,243 deer, 60% of sample). The spreadsheet model was updated with current year's classification and harvest data, annual survival estimates for adult does and fawns, and the 2018 sightability estimate. Based on these parameters and observed data from the sightability survey, the 2018 posthunt population estimate is 30,200 deer. The projected 2019 posthunt population is approximately 30,700 deer.

Herd Unit Issues

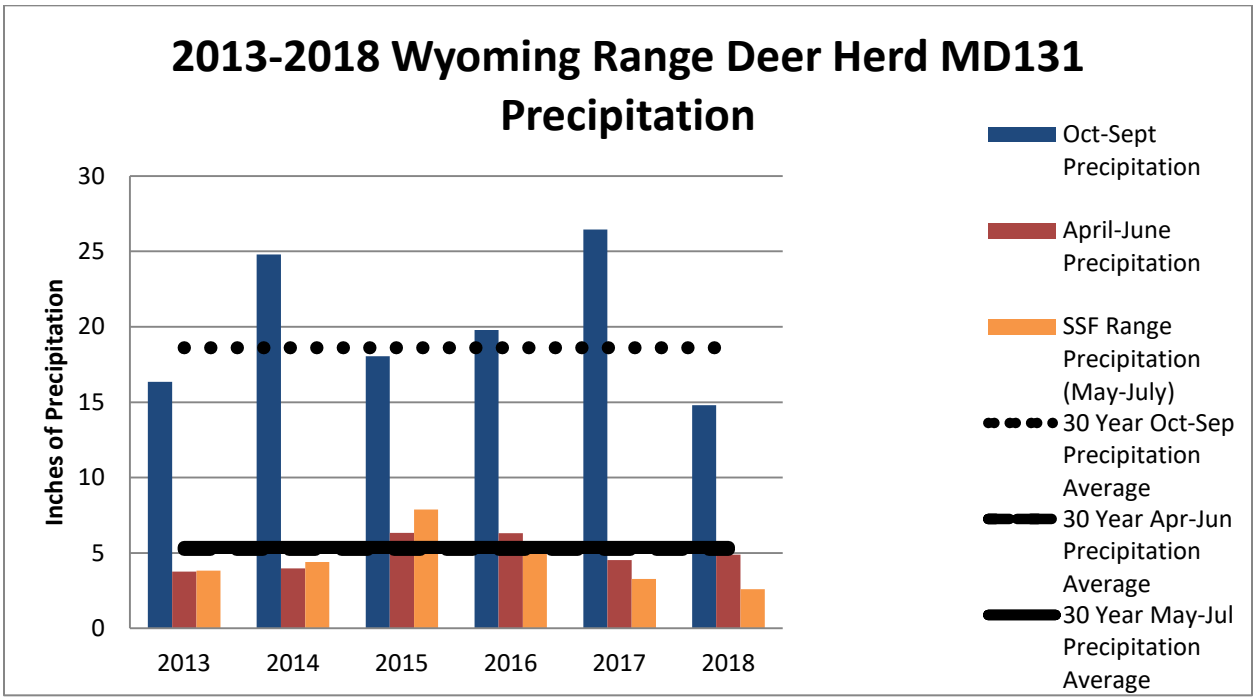
Management strategies since 1993 emphasized hunting antlered deer in an effort to promote population growth. Antlered deer hunts occur in mid-September and early October throughout the herd unit. Hunt seasons close in the northern hunt areas prior to the onset of the annual fall migration in order to minimize vulnerability of bucks that migrate from subalpine summer ranges to sagebrush winter ranges in the Upper Green River Basin. Sustained population growth has been difficult because of the frequency of high to extreme overwinter mortality every 3 years on crucial winter ranges, low vigor and productivity of important winter range browse, and reduced fawn survival and recruitment.

The Wyoming Range Mule Deer Project was launched in March 2013. The overall goal of this research project is to address important research and management needs indentified by the Wyoming Mule Deer Initiative and Wyoming Range Mule Deer Initiative. An important aspect of this research is to investigate the nutritional relationships between mule deer population

dynamics, energy development and disturbance, habitat conditions, and climate to provide a mechanistic approach to monitoring and management of mule deer (Appendix A).

A planned approach is to integrate data on nutritional condition, forage production and utilization, and population performance to understand factors regulating Wyoming Range mule deer and the ability of the current habitat to support mule deer. In addition, there is an opportunity to address secondary objectives including nutritional contributions of winter and summer ranges, factors affecting reproduction, identification of habitats of nutritional and reproductive importance to mule deer, timing and delineation of important migration routes, and direct assessment of the effects of energy development on nutrition and survival of mule deer (Appendix A).

Weather



Precipitation

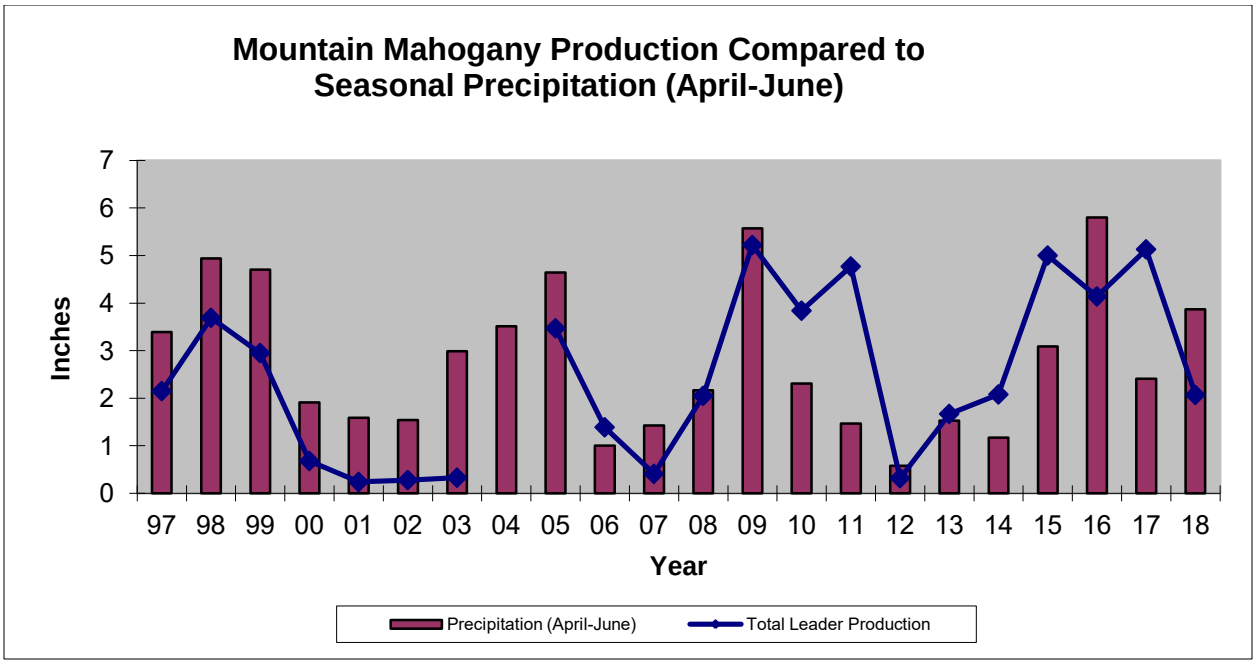
Overall precipitation from October 2017 through September 2018 was well below average when evaluated across the entire herd unit, over the water year (October through September of the following year). The general characteristics included a very mild and dry winter followed by average spring precipitation. Although growing season (April through June) precipitation was near average due to several significant precipitation events, summer (May-July) precipitation was significantly below average and resulted in less than ideal growing conditions on summer range.

Winter Severity
The 2018-2019 winter started mild but turned severe in February and were increasingly tough for wildlife with regard to snow accumulation and cold temperatures on winter ranges. This was especially true for the southern winter ranges, where adult and fawn survival was considerably lower than that of deer on Big Piney-LaBarge winter ranges.

Habitat
In 2018, annual leader production on important forage shrubs was significantly less than the last three years. This reduction is due not only to less overall precipitation, but also relatively higher than average temperature during the growing season, which affected the availability of soil moisture which is an important resource for plants to put into growth. As of late February, lower stature sagebrush are only available in areas with favorable topography but taller shrubs such as true mountain mahogany and serviceberry are largely still available. Snow crusting has been noteworthy which limits mobility and requires deer to expend more energy moving between patches of habitat.

Significant Events
Habitat treatments were conducted at several locations in 2018 throughout the herd unit. The Wyoming Range Mule Deer Habitat Project accomplishments for 2018 include: 1,014 acres of sagebrush mowing, 355 acres of sagebrush aerator thinning, 263 acres of aspen mechanical preparation (slashing and cut-pile), 806 acres of prescribed burning aspen, 17,083 acres of cheatgrass herbicide application, and three livestock riders were hired to manage livestock distribution post-treatment. Generally, vegetation has responded very well to disturbance with increased aspen density in the prescribed burn, improved leader length on sagebrush plants, increased production of herbaceous species, reduction of cheatgrass, and establishment of seeded species in treatments. Additionally in 2018, 2.4 miles of fence was converted to wildlife friendly design in the LaBarge Creek drainage on private land. More detailed information can be obtained by reading the Pinedale Region report in the 2018 Strategic Habitat Plan (SHP) Annual Report.

Habitat Monitoring
Leader production in 2018 for True Mountain Mahogany decreased from an average of 5.13 inches in 2017 to 2.07 inches in 2018 across the four transects that were monitored. Other shrub species within habitat treatments are also being monitored and are discussed in more detail in the 2018 Strategic Habitat Plan Report.



Rapid Habitat Assessments

In 2016, Department personnel initiated the Rapid Habitat Assessment methodology to survey important mule deer habitats. This method strives to capture large-scale habitat quality metrics to better understand how the habitat is providing for the current population of mule deer. The overall end result of this effort will be to provide a standardized habitat component to discussions about how mule deer objectives should or should not be adjusted based on the general concept of carrying capacity. In 2018, 759 acres of Aspen RHAs and 8,031 acres of Rangeland RHAs were completed in the Wyoming Range Mule Deer herd by personnel in the Pinedale and Green River Regions.

Field Data

The Wyoming Range deer herd has been unable to sustain population growth for more than 4 consecutive years since the early 1990s. Normal to high over-winter mortality, in addition to other factors identified by research associated with the Wyoming Range Mule Deer Project continues to suppress this population's ability to sustain growth for more than four consecutive years because of poor survival and recruitment of fawns.

Since the initiation of the Wyoming Range Mule Deer Project, radio-collared adult does have provided an index of two important metrics: adult survival and fetal rates. Phase II – the fawn survival component of the project was implemented in 2015 to provide an assessment of annual fawn survival. The Phase II segment of the project focused on measuring survival and cause-specific mortality of mule deer fawns to quantify the relative roles of habitat, nutrition, and predation on recruitment of young (Appendix A). Specific objectives of this project quantified the effects of predation and other mortality factors on survival of young mule deer, and provided a relative assessment of the effect of juvenile mortality on the annual population dynamic.

During 2015 an important, but previously unknown, mortality factor was discovered in this deer herd. The disease, Adenovirus Hemorrhagic Disease (AHD) was determined to be responsible for killing radio-collared newborn fawns and un-collared fawns as old as 5 months old throughout the herd unit. Although the impact to the annual population dynamic is unknown at this time, it is suspected that AHD, in addition to predation and malnutrition, and fawn mortality at parturition played important roles in the mortality of a substantial percentage of fawns born in 2015 - 2017.

In December 2018 Phase III of the Wyoming Range Mule Deer project has begun to disentangle many of the factors that may regulate mule deer herds in Wyoming, but there is still a critical gap in understanding the ecology of this herd. Despite the fact that males are often the segment of the population most valued by the public, there exists little information on how their ecology differs from females, and thus, how males may behave or respond differently from females to regulating or limiting factors (Appendix B). In an effort to better understand the ecology of male deer in the Wyoming Range, males were captured on LaBarge and Kemmerer/Evanston winter ranges in December 2018 and January 2019.

The overarching goal of this work is to improve our understanding of the ecology of male mule deer, with a specific eye towards characterizing seasonal behavior, migration, survival and vulnerability to harvest, and growth and recruitment. Given the long-term and ongoing research associated with the Wyoming Range Mule Deer Project, we have a unique opportunity to gain much value-added through minimal additional investment to fill a current gap in understanding. To achieve this goal, we propose to fit male mule deer of varying age with GPS collars and monitor them over time to:

1) Evaluate migratory behaviors and migratory routes of adult males, and identify how they differ from adult females.
2) Evaluate how male deer select habitat relative to females, during summer and winters.
3) Assess how males occupy the landscape and ultimately stock the ranges in which hunters cherish as hunting destinations.
4) Evaluate the vulnerability of male mule deer to harvest as a function of both age, behavior, and size.
5) Examine temporal and spacial characteristics of male deer during hunting seasons and at time of harvest.
6) Should time and resources allow, with the recent decline in population abundance following the 2016-17' winter and the corresponding rise in nutritional condition of females, we aim to evaluate how characteristics of the population (i.e., population density, nutritional condition of females, etc) during the year of birth affects growth and ultimately, the size obtained by males at maturity.

Adult survival exceeded 85% during the period from 2013 – 2015. During the same three year period, fetal rates averaged 1.6 fetuses/doe. An on-going effort to monitor population dynamics with posthunt herd composition surveys provided an assessment of buck recruitment and fawn production and survival. From 2015 – 2017 total fawn mortality was estimated at 54%, 100%, and 59% of the radio-collared fawns marked in June died during this three period, respectively.

The 2016-2017 winter resulted in the highest recorded mortality of mule deer in at least 33 years. Annual survival of radio-collared does and fawns was the lowest recorded since inception of the Wyoming Range mule deer project in 2013. Collared fawn mortality was observed at 100%; while 37% of radio-collared does succumbed to the winter (Appendix C). The over-winter population declined by as much as 35%-45%, with varying degrees of mortality observed over the many distinct winter range complexes found on the North (Big Piney-LaBarge, Ryegrass, Star Valley) and South Winter Ranges (Kemmerer, Evanston, Cokeville).

During the 2017-2018 winter, core winter ranges received substantially less accumulated snowfall and fewer extended subzero temperature periods that persisted throughout the winter. The diminished effects of this winter on population performance promoted the conditions for initial population recovery following the record level of mule deer losses observed in 2017. Consequently, adult and fawn survival was estimated at 100% and 93%, respectively (Kevin Monteith, pers. comm.) of radio-collared deer associated with the Wyoming Range mule deer research.

The current winter resulted in substantially different impacts on segments of the population because precipitation and temperature regimes varied across the major winter ranges in the herd unit Appendix D). The winter of 2018-19 was characterized by high over winter survival on the Big Piney-LaBarge winter ranges for all age and sex age classes of mule deer. By the end of March, survival was estimated at 86%, and 70% for radio-collared does and fawns, respectively (Tayler LaScharr, pers. comm.). Conversely, mule deer that spent the winter on the South Winter Ranges (Kemmerer, Cokeville, and Evanston) experienced normal to relatively high winter losses depending on age/sex class. An index of over winter survival was estimated by the fate of radio-collared mule deer. By the end of March, 70% and 40% of radio-collared does and fawns, respectively were alive.

Buck:doe ratios have met or exceeded the special management objective of 30-45 bucks:100 does in the posthunt population since 1990 in all years except 2004, 2017, and 2018 (Appendix E). During these three years the observed buck:doe ratio was 29 bucks:100 does. During the most recent 5-period (2013 – 2017) high overwinter survival in all years except 2017 has contributed to recruitment of 1.5+ year old bucks. Despite lower fawn survival and recruitment, buck ratios have met management goals. Since 2012 buck:does ratios have exceeded 39:100 in three of the last seven years.

Harvest

Hunting seasons since 1993 have been designed to allow 8 - 14 days of hunting recreation in the southern areas (Areas 134,135) and 16-23 days of hunting in the northern areas (Areas 143-145) of the herd unit. Antlered only hunting, and the near absence of antlerless harvest has failed to produce the sustained (≥4 consecutive years) population increase since the late 1990s. Nonresident licenses were reduced from 800 licenses to 600 licenses in Region G beginning in 2012, and were further reduced in 2017 to 400 licenses. A conservative management approach of closing hunting seasons prior to the annual fall migration in the northern hunt areas has promoted the recruitment of trophy class bucks into the posthunt population.

Overall hunter success declined from 53% in 2016 to 27% in 2017. Hunters tallied 34% success in 2018. A total of 1799 deer were harvested in 2018, which reflects the initial recovery of the population from the 1355 deer taken in 2017, but less than the 3457 deer taken in 2016 prior to the severe winter losses in winter 2017. Additional harvest statistics, such as days/harvest and recreation days, provide additional metrics that reflect the downturn in the annual population dynamic from 2016 – 2017. This population correction is directly associated with high over-winter mortality in 2017. Consequently, hunters expended more days (N=20 days) to harvest a deer in 2017 than in 2016 (N=10 days). In 2018, hunter effort declined to 14 days/harvest in response to higher over winter survival during the 2018.

Doe harvest typically accounts for less than 5% of the total annual harvest. In 2014 – 2016, 1.5+ year old does accounted for 4%, 3%, and 2% of the total herd unit harvest, respectively. In 2017, 61 does were harvested which accounted for only 1% of the herd unit's total harvest. A total of 39 does were taken in 2018, which comprises 2% of the total harvest. Nonresident hunters contributed 18% of the total deer harvest in 2018. In nonresident Region G, nonresidents accounted for 16% of the total harvest in Areas 135, 143-145. Resident Hunters accounted for 87%, 96%, 76%, and 79%, of the total harvest in Areas 135, 143-145, respectively.

Hunt Area 135 accounted for 28% of all Region G nonresident hunters in 2018, while the three northern hunt areas of the herd unit, Areas 143-145, accounted for 72% of all Region G nonresident hunters. Interestingly, Hunt Areas 144 and 145 accounted for 68% of Region G Hunters while only 16 nonresident hunters, or 3% of nonresident hunters.

Population

The model was updated with the sightability estimate and standard error information. The "Time Sensitive Juvenile – Constant Adult Mortality Rate" (TSJ,CA) spreadsheet model was used to derive the post season population estimate. The TSJ,CA model showed the best overall fit compared to the suite of available models (Fit=1, Relative AICc=100). In addition, observed data and model derived output such as adult and fawn survival, postseason buck ratios, and the sightability estimate derived in February 2018 aligns within the identified constraints that are based on model Fit and Relative AICc parameters.

Management Summary

The population remains below the ± 20% management threshold of the population objective. The 2019 hunting season is designed to promote population growth and retain bucks in the posthunt population by closing hunt seasons prior to the onset of the fall migration and influx of elk hunters in preparation for the October 15 hunting season opener. The hunting seasons are proposed to remain conservative because of the extremely high winter mortality noted during the previous winter, postseason buck:doe ratios that were below the management minimum of 30 buck:100 does, a population below the ±20% management threshold, and a public sentiment that requests a conservative management approach. Additionally, Nonresident Region G licenses are proposed to remain at 400 licenses.

The hunt season in Hunt Area 134 will increase the number of days from 10 days to 14 days of general season antlered deer only hunting, with a continuation of the added restriction that antlered deer with three points or more on either antler may be taken. In Hunt Area 135, the

season will be lengthened from October 10 to October 14, with the added restriction that antlered deer may be taken with three points or more on either antler which has been in place since the 2017 season. The increase in length of the seasons in Areas 134 and 135 is an attempt to return hunting season structure to historical closing dates. Both areas typically offered closing dates between October 8 and October 14, which also encompassed at least one weekend of hunting opportunity. The 2017 hunt season was the first year in at least 20 years in which Area 135 did not offer at least one weekend of hunting opportunity. Perhaps more importantly, the proposal to provide a few more days of hunting recreation in 2019 will not adversely impact buck ratios, the annual population dynamic or overall survival of the adult female, or reproductive, segment of the population. Perhaps just as important in the deer management program in southwest Wyoming is the proposed increase in hunting recreation in Area 135 which will likely mitigate the displacement of hunters into other surrounding areas (i.e. Area 134). An extended season may also disperse hunters over a longer period of time, and thereby reduce hunter congestion in 2019 in southwestern Wyoming hunt areas. Moreover, a significant number of publics throughout southern Lincoln County and Uinta County request that deer seasons are proposed to provide at least one weekend of hunting opportunity.

Similar to the last two years, Hunt Areas 143-145 will close on October 6 in 2019, and offer hunters the opportunity to harvest antlered mule deer with three points or more on either antler. This Antlered Point Restriction is a continuation from the 2017 hunting season, and consideration will be given to returning to antlered deer only hunting in 2020. The October 6 closing date is the same closing date in 2018, and is a management strategy that provides the public with a consistent closing date. The October portion of the hunting season in the northern areas will close prior to the onset of the fall migration which typically begins in late September; it is during the fall migration that bucks are most vulnerable when snow accumulations at higher elevations force deer to into areas that are more accessible to hunters. Season closure prior to this migration will ensure that overharvest of bucks does not occur. Shorter season dates in these areas is in response to public concerns regarding deer numbers following the severe winter. A shorter season in the northern three areas is an assurance that bucks are not taken during the fall migration when they can be more vulnerable to late season harvest. This management strategy is supported by the hunting public.

In Area 145, a limited quota any white-tailed deer hunt will continue to allow hunters to take any white-tailed deer during a portion of the November hunting season. The number of Type 3 licenses will be maintained at 50 licenses, and the segment of the any white-tailed deer hunt will continue to be November 1 - November 15 for the 2018 hunt. Doe and fawn white-tailed deer may be taken from November 16 – December 31. Public concerns have focused on a general lack of access to suitable hunting locations and fewer white-tailed deer being observed in those areas. Also, there has been a decrease in reported chronic damages to stored crops on private property by landowners in recent years thereby resulting in the proposed reduction in hunting opportunity for the Type 3 license.

The 2019 hunting seasons are projected to harvest approximately 2330 deer. The population is projected to remain essentially unchanged from 2018 levels because, in part, to the above normal winter mortality observed on the southern Wyoming Range winter ranges. The posthunt 2019 population is projected at 30,700 deer.

APPENDIX A

Nutritional carrying capacity and factors limiting population growth of mule deer in the Wyoming Range

Wyoming Cooperative Fish and Wildlife Research Unit
Wyoming Game and Fish Department
University of Wyoming
2013

PROJECT TITLE
Nutritional carrying capacity and factors limiting population growth of mule deer in the Wyoming Range

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DURATION: 1 July 2012 – 30 June 2016

INTRODUCTION

Concerns over population performance and factors limiting population growth have heightened in recent decades in response to near ubiquitous declines in the abundance of mule deer (*Odocoileus hemionus*) throughout much of the West. Factors responsible for such declines remain largely speculative and controversial (deVos et al. 2003); however, recent comprehensive research has identified habitat quality and winter severity as important factors that are currently limiting mule deer in the Intermountain West (Bishop et al. 2009, Hurley et al. 2011). In response to concerns of mule deer populations in Wyoming, in 2007, the Wyoming Game and Fish Commission adopted the *Wyoming Mule Deer Initiative* (MDI) with the intent to develop individual management plans or strategies for key herd units based on overarching goals and objectives. Separately, the Mule Deer Working Group (2007) recognized that the *"Success and implementation of these plans will depend upon our ability to identify limiting factors to mule deer populations and their habitats"*.

Of particular concern is the Wyoming Range mule deer herd in western-central Wyoming- one of the largest mule deer herds in the state and a premier destination for mule deer hunting in the country. The Wyoming Range mule deer population (MD131) has undergone dynamic changes in recent decades from a population high of >50,000 in the late 1980s, to a sustained population of ~30,000 during the last decade. Prior to the acceptance of the MDI, the Wyoming Range mule deer herd was a top priority for the development of a management plan according to the MDI. The first of the herd-specific management plans, the *Wyoming Range Mule Deer Initiative* (WRMDI), was finalized in 2011 following a collaborative public input process. The proposed research we describe here stems directly from research and management issues identified by the Mule Deer Working Group in the WRMDI, and we have proposed to conduct this research on Wyoming Range mule deer because of its priority status and controversy behind its population dynamics.

The marked decline of this deer population following the 1992-93 winter, and the near absence of any substantial recovery, has engaged the WGFD in controversy regarding management and herd unit objectives. Despite conservative harvest focused on the antlered portion of the population with limited to no harvest of females, the population has failed to recover to the herd unit objective of 50,000 animals. Given current population trends, severity of winters, and deteriorating range conditions, it has become apparent that

the habitat is not capable of supporting the current herd unit objective. Nevertheless, identifying the current capacity of the habitat to support mule deer in the Wyoming Range has been a persistent management challenge. Habitat conditions on both winter and summer range occupied by Wyoming Range mule deer have been deteriorating as a result of both drought and land-use practices. Declines in snowpack and rising spring temperatures have been pronounced in recent decades across much of the Rocky Mountains (Westerling et al. 2006, Pederson et al. 2011); both of which have a negative effect on forage quality and abundance, thereby influencing carrying capacity.

PRIMARY OBJECTIVE

The overall goal of this research project is to address important research and management needs indentified by the MDI and WRMDI. **Overall, we seek to investigate the nutritional relationships between mule deer population dynamics, energy development and disturbance, habitat conditions, and climate to provide a mechanistic approach to monitoring and management of mule deer.** Our approach is to mesh data on nutritional condition, forage production and utilization, and population performance to understand factors regulating Wyoming Range mule deer and the ability of the current habitat to support mule deer. In addition, we have the opportunity to address secondary objectives including nutritional contributions of winter and summer ranges, factors affecting reproduction, identification of habitats of nutritional and reproductive importance to mule deer, timing and delineation of important migration routes, and direct assessment of the effects of energy development on nutrition and survival of mule deer.

BENEFITS

The impetus behind this project follows from questions underlying the population dynamics of the Wyoming Range mule deer herd, and was formulated to meet multiple objectives outlined by the Mule Deer Working Group in the *Wyoming Mule Deer Initiative*, and the herd-unit specific *Wyoming Range Mule Deer Initiative* (WRMDI). Our proposed study will meet objectives under 5 of the 6 management issues identified in the WRMDI which was finalized in 2011, including but not limited to:

• Estimate the nutritional capacity of existing habitat available to mule deer in the Wyoming Range to evaluate whether revision of the current population objective of 50,000 wintering mule deer is warranted.

• Characterize existing habitat conditions with respect to population density by implementing a nutritionally based approach to estimating carrying capacity that could be applied to other herd units in Wyoming.

• Link habitat use with vital rates and nutritional processes will help identify vegetation communities and habitat treatments most beneficial for mule deer to enhance mule deer populations as wells as identifying effective mitigation strategies.

• Assess the nutritional capacity for survival and reproduction will help characterize the potential effects of predation on mule deer, as well as the benefits of predator control efforts already in place.

• Evaluate patterns of mule deer migration will delineate important mule deer migration corridors, and provide predictive models for timing of seasonal migration to identify critical migration periods.

• Evaluate the physiological effects of oil and gas development will help to quantify the direct and indirect effects of habitat loss and disturbance on mule deer in the Wyoming Range, as well as identifying habitat manipulations that are likely to be most effective in mitigating the effects of energy development.

• Results of this research project will be presented in public forums in conjunction with the public input process, and by way of other venues to inform the public and stakeholders of issues facing Wyoming Range mule deer as well as management strategies likely to be most beneficial to the mule deer population.

APPENDIX B

ECOLOGY OF MALE MULE DEER IN THE WYOMING RANGE: MOVEMENT, GROWTH, AND SURVIVAL

PRINCIPAL INVESTIGATORS

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BACKGROUND

Mule deer are an iconic species of the West, and highly valued by hunters and wildlife enthusiasts. The Wyoming Range mule deer herd is one of the most cherished populations of mule deer in Wyoming, and there is substantial interest among both the public and researchers in understanding the factors that regulate this population. This herd holds substantial cultural and economic importance, in part because of the opportunities it provides for hunters from both Wyoming and throughout the West to harvest male deer, and for some, to harvest large males. Despite the importance of male mule deer in the Wyoming Range to both the public and economy, we still lack fundamental understandings of much of the ecology of males (i.e., migratory behaviors, vulnerability to harvest, dispersal from natal home ranges), and thus, many questions arise as to how season dates should be established, how male deer respond to harvest pressure, and whether males are being recruited into older age segments. Or for example, even more basic questions associated with how population processes are stocking high-elevation basins with male deer remains largely unknown.

In 2013, the Wyoming Range Mule Deer project was initiated to address goals and objectives outlined by the Wyoming Game and Fish Commission and the public in the Wyoming Mule Deer Initiative (MDI). The goal of the Wyoming Range Mule Deer project has been to elucidate the relative roles of nutrition, habitat, anthropogenic disturbance, changing climates, predation, and disease on regulating populations of mule deer in the Wyoming Range. In March 2013, 70 adult females were captured and collared and each subsequent winter and spring, those individuals have been recaptured. The longitudinal design of this study has revealed important patterns in nutritional condition of females coming out of and going into winter ranges (see Spring Update), has disentangled the direct and indirect effects that energy development can have on winter ranges

(Dwinnell et al. *in revision*), and has provided insight into how climate change may influence use of important migratory routes (Aikens et al. 2017; *in prep*). To better understand the most sensitive demographic of the population, a neonatal survival component was added to the project in the summer of 2015, with the goal of monitoring and evaluating survival and cause-specific mortality of newborns in the population. Beginning in 2015, and each subsequent summer, newborns belonging to radiocollared females have been captured and monitored throughout the summer and following winter, with each year revealing fluctuating contributions to mortality of young including disease, predation, and malnutrition. Thus far, the work that has been conducted on this population has been restricted to females and neonates, in large part because females are the reproductive drivers and most important component in regulating populations.

The Wyoming Range Mule Deer project has begun to disentangle many of the factors that may regulate mule deer herds in Wyoming, but there is still a critical gap in understanding the ecology of this herd. Despite the fact that males are often the segment of the population most valued by the public, there exists little information on how their ecology differs from females, and thus, how males may behave or respond differently from females to regulating or limiting factors. Indeed, harvest of females has been restricted almost completely in the Wyoming Range since 1993 and thus, almost all harvest-related opportunity in the population is provided by the male segment. The Wyoming Range herd is universally considered by many to be one of the premier herds for hunting large mule deer in North America. Accordingly, most conversations associated with management of the Wyoming Range herd, and many others for that matter, is focused around harvest of males. Outside of antler morphology characteristics (Table 1 and 2) and age specific data (Table 3) that is collected in the field by managers subsequent to harvest, little information is available that contributes to the management of the male cohort (Fralick 2001). In fact, other than posthunt male:female ratios, there are no other long-term, consistently obtained or reliable data sets that describe the annual population dynamic, or effects of management action on the 1+-year old male cohort (Fralick 2007). Consequently, we generally lack empirical information to help inform discussions as to management of males. This discussion occurs at a time when segments of the hunting public are asking for a dichotomous, and inherently conflicting, set of management actions be implemented that dramatically restricts hunting of males, as well as providing increased opportunity to harvest trophy class males during the migratory period (i.e., longer hunting seasons) or when males arrive on winter ranges.

Existing evidence and theory indicates that male ungulates differ markedly in their behavior, nutritional dynamics, and growth (Barboza and Bowyer 2000, Monteith et al. 2009, Monteith et al. 2018), and as a consequence, can exhibit demographics divergent to that of females (Stevenson and Bancroft 1995, Ditchkoff et al. 2001). In fact, it has been recommended that male ungulates be considered as essentially a different species compared with females, because of their striking differences in life history (Kie and Bowyer 1999). Although they represent a flexible resource within populations because harvest of males plays little role in affecting population dynamics for polygynous ungulates (Mysterud et al. 2002, Freeman et al. 2014), increasing interest in maintaining male:female ratios at specified levels and maintaining a specific age structure has become common criteria in management plans. Moreover, heightened discussions on harvest

pressure and the topic of limited quota harvest regimes exemplify the need for additional insight into the ecology of male deer.

PRIMARY OBJECTIVE

The overarching goal of this work is to improve our understanding of the ecology of male mule deer, with a specific eye towards characterizing seasonal behavior, migration, survival and vulnerability to harvest, and growth and recruitment. Given the long-term and ongoing research associated with the Wyoming Range Mule Deer Project, we have a unique opportunity to gain much value-added through minimal additional investment to fill a current gap in understanding. To achieve this goal, we propose to fit male mule deer of varying age with GPS collars and monitor them over time to:

1) Evaluate migratory behaviors and migratory routes of adult males, and identify how they differ from adult females.
2) Evaluate how male deer select habitat relative to females, during summer and winters.
3) Assess how males occupy the landscape and ultimately stock the ranges in which hunters cherish as hunting destinations.
4) Evaluate the vulnerability of male mule deer to harvest as a function of both age, behavior, and size.
5) Examine temporal and spatial characteristics of movement by male deer during hunting seasons and at time of harvest.
6) Should time and resources allow, with the recent decline in population abundance following the 2016-17' winter and the corresponding rise in nutritional condition of females, we aim to evaluate how characteristics of the population (i.e., population density, nutritional condition of females, etc) during the year of birth affects growth and ultimately, the size obtained by males at maturity.

METHODS

To achieve our objectives, we propose to capture male deer via either ground darting and chemical immobilization or helicopter netgunning on winter range. Our goal is to fit a minimum of 30 adult (>1 yr old) male deer and any surviving juvenile deer that we captured as neonates on summer range with expandable GPS collars. Recapturing of surviving juveniles will be key to evaluating dispersal from natal ranges and ultimately, what shapes distribution of adult males on summer ranges. For males of unknown age, we will remove an incisiform canine from each newly captured deer to determine age via cementum annuli. Finally, for each captured male, we will measure body mass, morphological structure or size, and measure antler size using the Boone and Crockett scoring system. In subsequent years, we will evaluate antler size of surviving males via photography and cartographic software designed for measuring antler size (Buckscore ©). Using GPS data from collared male mule deer, we will:

1. Identify migratory behaviors, and important migratory routes for male mule deer and compare those behaviors and routes to that of females.
2. Identify changes in movement behavior between hunting and non-hunting seasons as a function of both age and size.

3. Identify summer ranges of males collared as neonates, and compare to the summer ranges of females within their family (i.e., mothers and sisters).

BENEFITS

Despite the inherent social and economic value of the male deer in the Wyoming Range and other ranges across the West, we have yet to develop a comprehensive understanding of the ecology and life history of male deer. For legitimate reasons, most work to date has focused on the segment of the populations that are responsible for producing and rearing young. And although we have learned much, the point between a surviving male offspring to an independent, adult male on the landscape has and remains a missing link. Nevertheless, it is those males that are providing valuable wildlife viewing and hunting opportunity that is at the core of our outdoor heritage in Wyoming. In achieving the objectives associated with this proposed research, we will help fill this missing link and provide valuable information as to the ecology of male deer that will be a key point of information for future discussions on management and harvest. Moreover, we propose to do our work in one of the premier destinations for mule deer hunters in Wyoming and throughout the West, and in a place that offers the greatest amount of recreational opportunity in pursuit of mule deer in the state of Wyoming. To say the Wyoming Range mule deer herd is a treasure of the state of Wyoming would not be overstated. Male deer are truly a different beast, both figuratively and literally, and thus, perhaps it's time we truly do better to understand how they are and what that should mean for us in an ever-changing world.

PROJECTED BUDGET

Personnel capacity and support will be provided by the ongoing work associated with the Wyoming Range Mule Deer Project and thus, needs for this work are associated only with collars and capture of males, travel for fieldwork, and minor supplies and support for outreach efforts.

Description	FY2019	FY2020	FY2021
Radiocollars			
Live Satellite GPS radiocollars $800per	36,000	12,000	0
Satellite uplink fees at $250/collar/yr	11,250	15,000	15,000
Animal capture			
Mid-winter helicopter capture @600/per	9,000	9,000	0
Chemical immobilization	3,000	0	0
Mortality replacement	0	3,600	3,600
Personnel, Travel, Supplies			
Travel (fieldwork, collaboration, conference, etc.)	8,500	4,500	4,500
Lab analyses (tooth sectioning)	500	250	250
Field equipment (darts, cameras, optics)	6,000	1,500	1,500
Publications and outreach	0	0	3,000
Accounting and technical support	5,713	4,292	3,392
Projected annual cost for project:	$79,963	$50,142	$31,242
		Project Total:	**$161,347**

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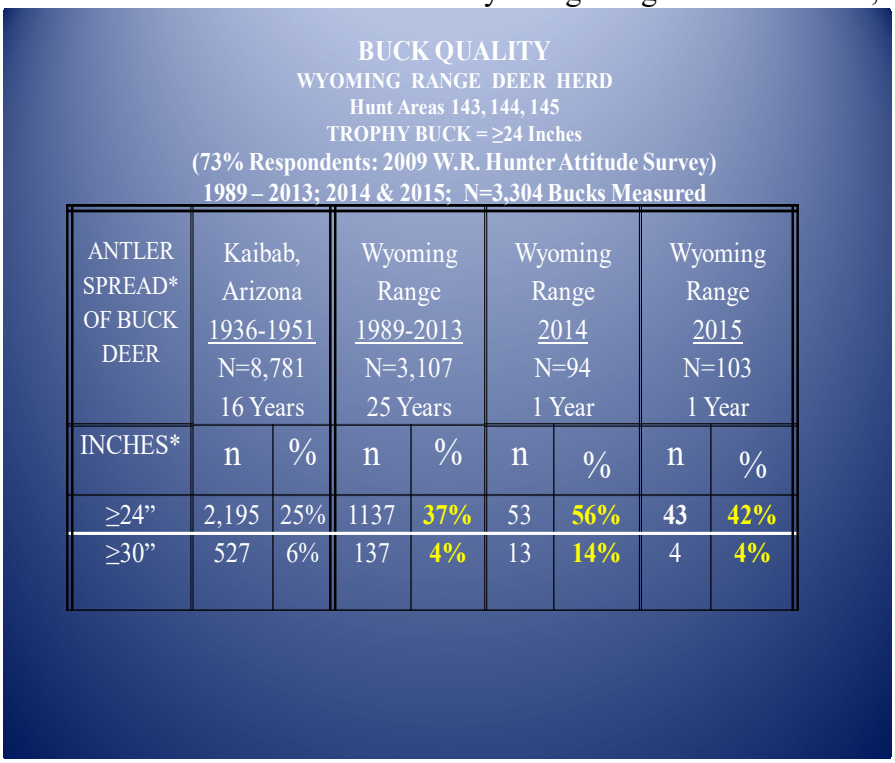
Table 1. A summary of antler point characteristics of male deer harvested in the Wyoming Range mule deer herd, 1989 - 2015, (N=3,304).

BUCK QUALITY
WYOMING RANGE DEER HERD
HUNT AREAS 143, 144, 145
TROPHY BUCK = ≥4-POINTS
(75% Respondents: 2009 W.R. Hunter Attitude Survey)
1989 – 2013; 2014 & 2015; N=3,304 Bucks Measured

4-POINTS OR BETTER PER ANTLER	Wyoming Range 1989-2013 N=3,107 25 Years		Wyoming Range 2014 N=94 1 Year		Wyoming Range 2015 N=103 1 Year	
	n	%	n	%	n	%
4-Points	2,429	78%	91	97%	96	93%

Table 2. A summary of antler morphology characteristics based on widest outside measurement of male mule deer harvested in the Wyoming Range mule deer herd, 1989 – 2015 (N=3,304).



BUCK QUALITY
WYOMING RANGE DEER HERD
Hunt Areas 143, 144, 145
TROPHY BUCK = ≥24 Inches
(73% Respondents: 2009 W.R. Hunter Attitude Survey)
1989 – 2013; 2014 & 2015; N=3,304 Bucks Measured

ANTLER SPREAD* OF BUCK DEER	Kaibab, Arizona 1936-1951 N=8,781 16 Years		Wyoming Range 1989-2013 N=3,107 25 Years		Wyoming Range 2014 N=94 1 Year		Wyoming Range 2015 N=103 1 Year	
INCHES*	n	%	n	%	n	%	n	%
≥24”	2,195	25%	1137	37%	53	56%	43	42%
≥30”	527	6%	137	4%	13	14%	4	4%

Table 3. A summary of age at harvest based on cementum annuli estimation of hunter-harvested mule deer bucks, Wyoming Range mule deer herd, 1988-2001 (N=3,153).

AGE CLASSES OF HARVESTED MULE DEER BUCKS										
Year	1	2	3	4	5	6	7	8	9	10
1988	109	63	57	40	9	18	7	2	2	0
1989	57	37	42	19	6	0	3	1	4	0
1990	117	21	56	44	14	6	1	0	0	0
1991	189	84	94	57	22	9	3	1	2	1
1992	64	57	93	37	28	13	4	1	0	0
1993	5	7	12	11	4	1	2	0	0	0
1994	33	4	12	20	11	7	1	0	1	0
1995	67	15	24	19	12	8	2	2	0	0
1996	43	35	38	12	13	20	8	2	1	0
1997	19	17	32	17	8	5	4	2	0	0
1998	40	18	44	36	15	10	7	7	4	0
1999	101	39	46	49	34	15	1	3	5	0
2000	104	53	74	36	43	29	12	2	3	1
2001	79	46	60	27	24	16	15	2	3	0
Totals	1027	496	684	424	243	157	70	25	25	2

Wyoming Range Mule Deer Project

Winter 2017-18 Update

UNIVERSITY OF WYOMING

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WYOMING RANGE MULE DEER PROJECT

Project Background

In recent decades, mule deer abundance throughout the West has struggled to reach historic numbers, and Wyoming is no exception to the nearly ubiquitous trend of population declines. In response to concerns of mule deer populations in Wyoming, in 2007, the Wyoming Game and Fish Commission adopted the *Wyoming Mule Deer Initiative* (MDI) with the intent to develop individual management plans for key populations. Of particular concern was the Wyoming Range mule deer population in western Wyoming—one of the largest mule deer herds in the state and a premier destination for mule deer hunting in the country. The Wyoming Range mule deer population has undergone dynamic changes in recent decades from a population high of >50,000 in the late 1980s, to a sustained population of ~30,000 during much of the last decade (Fig. 1). Consequently, the Wyoming Range mule deer population was identified as a top priority for the development of a management plan according to the MDI. The first of the population-specific management plans, the *Wyoming Range Mule Deer Initiative* (WRMDI), was finalized in 2011 following a collaborative public input process. To direct development of an effective management plan, it was recognized by the Mule Deer Working Group (2007) that the *"Success and implementation of these plans will depend upon our ability to identify limiting factors to mule deer populations and their habitats"*. Accordingly, the Wyoming Range Mule Deer Project was initiated 2013 to address the need for research in identifying the factors that regulate the Wyoming Range mule deer population.

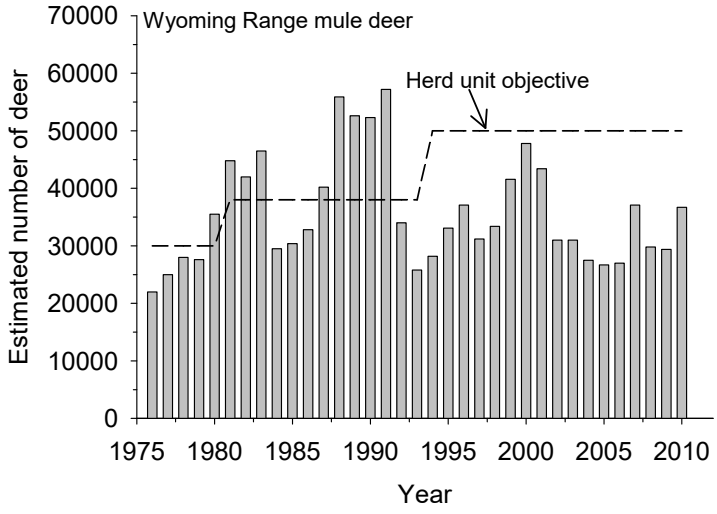


Figure 1. Estimated population size of the Wyoming Range mule deer herd relative to herd unit objective, 1976-2010.

The overarching goal of the Wyoming Range Mule Deer Project is to investigate the nutritional relationships among habitat conditions, climate, and behavior to understand how these factors interact to regulate population performance. We initiated the project in March 2013 with the capture of 70 adult, female mule deer on two discrete winter ranges for migratory, Wyoming Range mule deer (Fig. 2). In summer 2015, we initiated Phase II of the Wyoming Range Mule

Deer Project that focuses on survival and cause-specific mortality of neonate mule deer. Since the initiation of the project, we have tracked and monitored the survival, behaviors, reproduction, and habitat conditions of 202 adult female and 195 juvenile mule deer of the Wyoming Range. This update highlights some of our many discoveries on mule deer ecology since the initiation of the project.

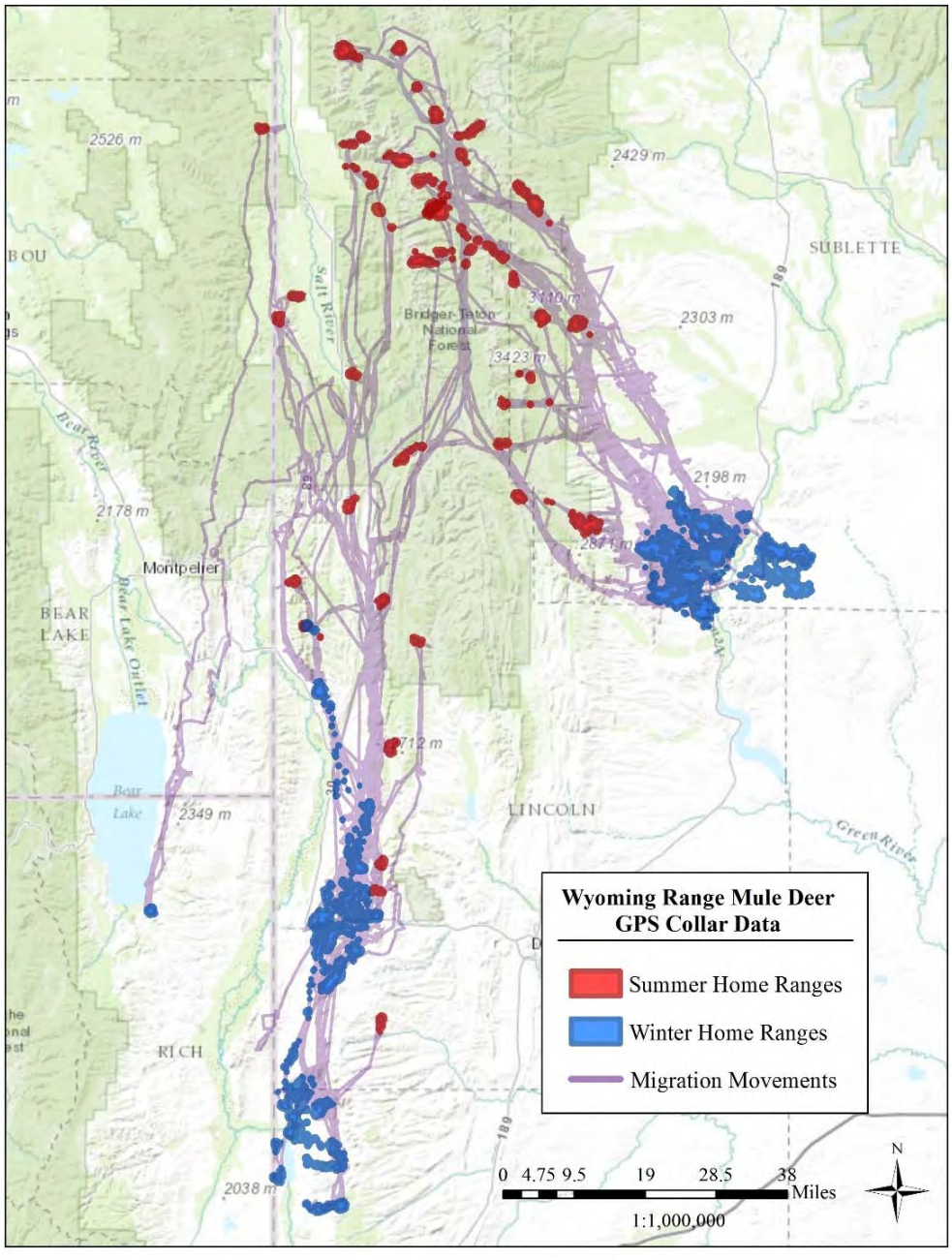


Figure 2. Winter and summer home ranges (based on 95% Kernel Utilization Distribution of GPS collar data) as well as migration movements of Wyoming Range mule deer.

A Nutritional Ecology Framework: Linking the Individual to the Population

Using a nutritional ecology framework, we aim to evaluate how conditions of all seasonal ranges mule deer encounter throughout the year—ranges used during summer, winter, and migration—affect individual animals. Using this unique approach, we can develop a comprehensive understanding of how the connections individual mule deer have with their environments influences population dynamics.

Mule Deer Capture

Since March 2013, we have captured and recaptured 202 adult, female mule deer. Upon each capture, in addition to fitting each animal with a GPS collar, we collect a suite of data on individual animals including age, nutritional condition, morphometry, and pregnancy. Animals are recaptured each spring (in March) and autumn (in December) to monitor longitudinal changes in nutritional condition and reproduction. In doing this, we can link various life-history characteristics with behaviors and habitat conditions of individual animals.

Nutritional Condition

At each capture event, we use ultrasonography to measure fat reserves (i.e., % body fat). By recapturing collared mule deer and measuring body fat each autumn and spring, we are able to track changes in nutritional condition between summer and winter seasons.

Although most animals lost fat in the winter and gained fat in the summer, the rate at which fat reserves increased or decreased varied widely among individual animals (Fig. 3). A suite of factors can influence fat dynamics between winter and summer seasons, but availability of food on seasonal ranges and number of fawns a female raises have the greatest effect on fat dynamics.

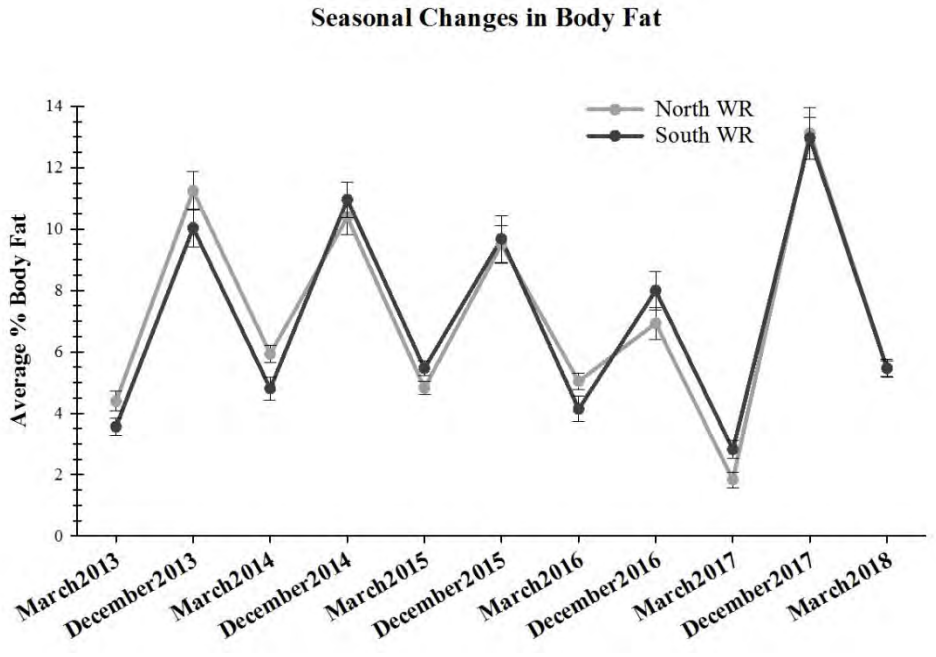


Figure 3. Average % body fat of adult, female mule deer on North (near Big Piney, WY) and South (near Cokeville and Evanston, WY) winter ranges for Wyoming Range mule deer.

Reproduction

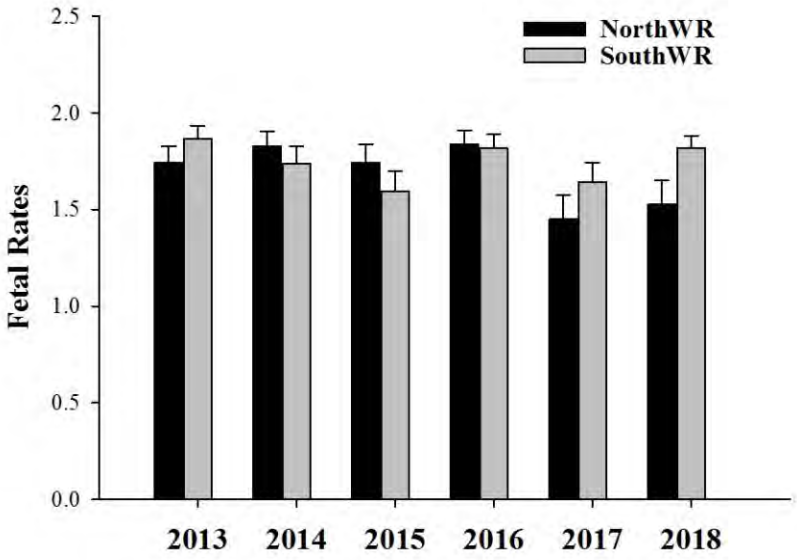


Figure 4. Fetal rates (average number of fetuses per pregnant animal) on North (near Big Piney, WY) and South (near Cokeville and Evanston, WY) winter ranges for Wyoming Range mule deer in 2013-2018.

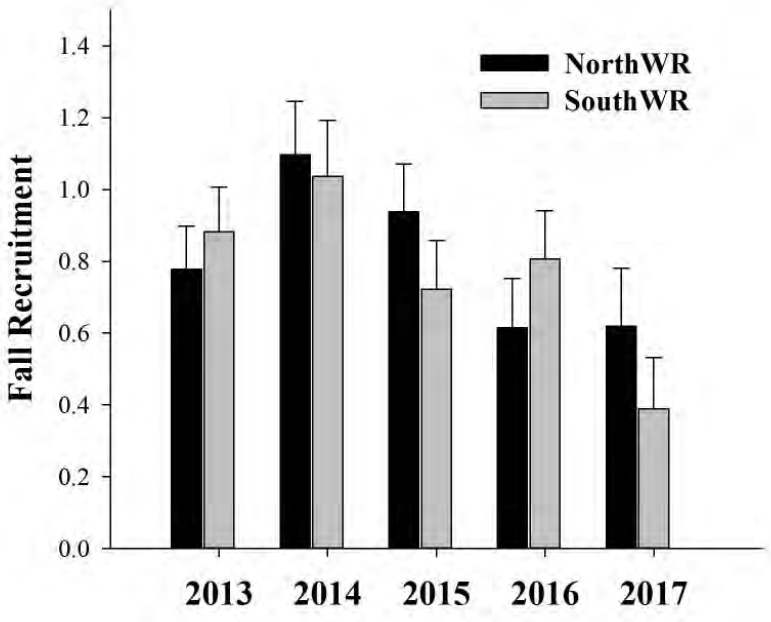


Figure 5. Recruitment rates on North (near Big Piney, WY) and South (near Cokeville and Evanston, WY) winter ranges for Wyoming Range mule deer in 2013-2017.

Reproductive success of individual animals greatly influences population dynamics; therefore, we closely monitor pregnancy and recruitment of young for each of our study animals. We use ultrasonography to monitor pregnancy rates of our study animals during spring capture events. Each autumn, as animals arrive to winter range, we evaluate fall recruitment using on-the-ground observations of the number of fawns at heel of our collared adults.

Pregnancy rates among mule deer of the Wyoming Range were typically high and ranged between 90-99%. Furthermore, most animals were pregnant with twins each year resulting in relatively high fetal rates (average number of fetuses per pregnant animal was 1.71 ± 0.03 across years; Fig. 4). Although fetal rates tended to be high, recruitment of young tended to be low. Since 2013, approximately half of the potential fawns born in early summer survived to autumn, and fall recruitment averaged 0.83 ± 0.05 fawns per collared female for Wyoming Range mule deer 2013-2016 but dropped to 0.51 ± 0.11 in 2017, following severe winter conditions of 2016/2017 (Fig. 5).

Disentangling the Relative Role of Predation, Habitat, Climate, and Disease on Fawn Survival

Fawn Capture

In March 2015, we initiated Phase II of the Wyoming Range Mule Deer Project by recapturing collared deer and deploying a vaginal implant transmitter (VIT) in pregnant females. VITs were used to indicate where and when birth occurred. Once birth events were identified, we captured and collared fawns born to our collared females as well as fawns that were found opportunistically throughout the Wyoming Range. Since 2015, we have successfully tracked 194 fawns and have been continually monitoring their survival.

	2015	2016	2017
Number of Fawns Tracked	58	70	67
Median Birthdate	June 10	June 13	June 17
Summer Mortality	45%	56%	52%
Winter Mortality	10%	44%	7%
Total Mortality	55%	100%	NA

Cause-Specific Mortality of Fawns

To evaluate cause-specific mortality of fawns, we tracked daily survival of all fawns captured 2015 – 2017. When a mortality was detected, we immediately investigated the event to ensure an accurate assessment of the cause of mortality. There was a breadth of various causes for fawn mortality including predation, disease, malnutrition, drowning, hypothermia, vehicle-collision, and just being caught in vegetation. The proportion of fawns that died because of the aforementioned causes varied from year to year (Fig. 7).

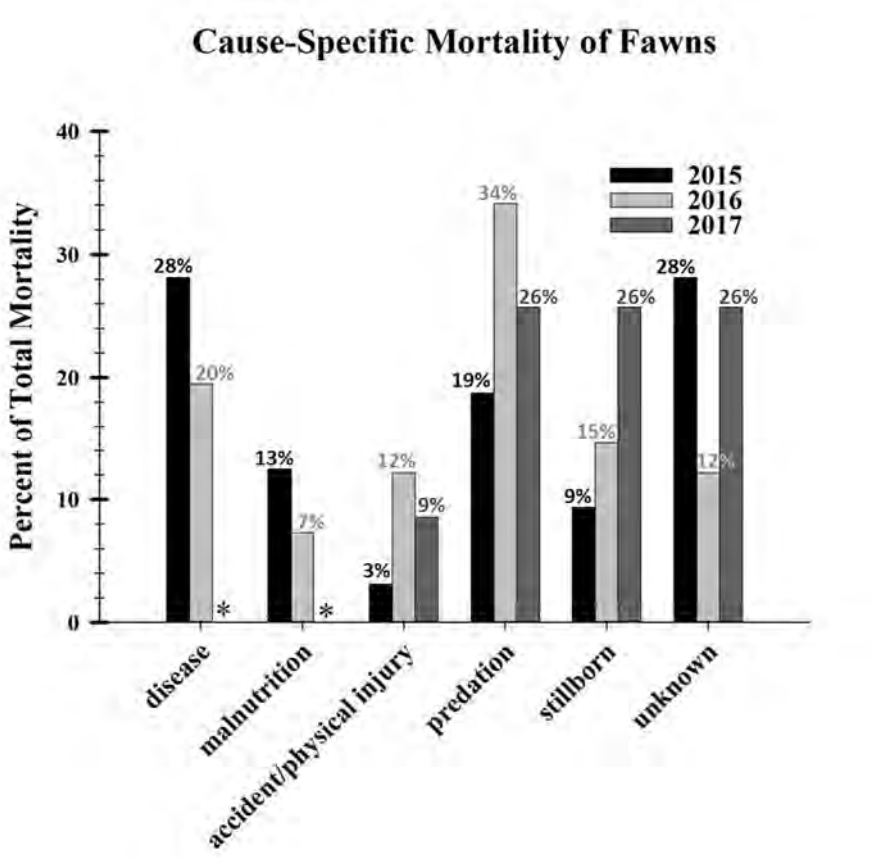


Figure 7. The relative occurrences of various causes of mortality for mule deer fawns of the Wyoming Range in 2015-2017. Asterisks indicate lab results from 2017 that are still pending.

In 2015, disease was the leading cause of death and accounted for 28% of all mortalities. The most prevalent disease adenovirus hemorrhagic disease (AHD). AHD is a viral disease that can cause internal hemorrhaging and pulmonary edema. Although AHD was detected in mule deer populations before, it was not previously known to be a major mortality factor in Wyoming. Nevertheless, the discovery of AHD in the Wyoming Range mule deer population has been motivation for further research into the epidemiology of AHD. We are still awaiting necropsy results from the Wyoming State Vet Lab from samples collected from fawn mortalities in 2017; therefore, the relative influence of various causes of mortality—specifically, disease and malnutrition—on fawn mortality is still pending. Regardless, 26% of mortalities in 2017 were because fawns were stillborn. Currently, this ties with predation as the leading cause of death for fawns in 2017.

Habitat and Maternal Conditions

The condition of a female and the habitat conditions she experiences in the summer may be very important in predicting and understanding fawn survival—especially in understanding the influence of malnutrition and disease on fawn survival. Therefore, we are coupling data on summer habitat conditions with information on maternal condition (i.e., nutritional condition) to evaluate how it influences fawn survival.

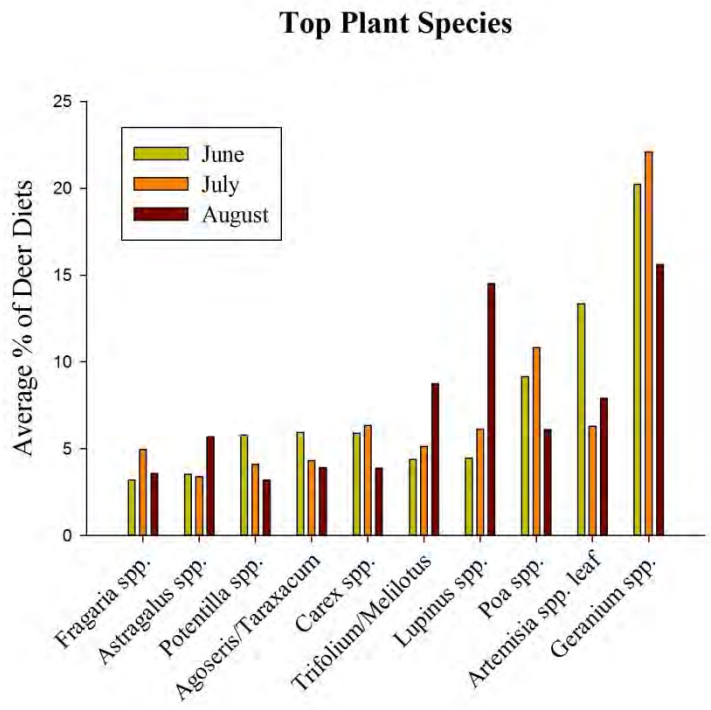


Figure 8. The top ten plant genera within diets (according to the average % of diets comprised of each plant genera) of Wyoming Range mule deer. Diet composition was evaluated in June, July, and August of 2013 and 2014.

Since 2013, we have evaluated the quality and availability of plants within the diets of Wyoming Range mule deer during summer. To assess mule deer diets, we collected fecal samples from summer home ranges of collared deer and used microhistology to identify plant species within their diets (Fig. 8) in summer 2013 and 2014. Based on frequency of plants within mule deer diets, we then collected plant clippings that we analyzed for quality (e.g., crude protein and digestibility). We are now coupling data on diet quality with forage availability by quantifying the abundance of key forage species at known locations of collared mule deer throughout the summer.

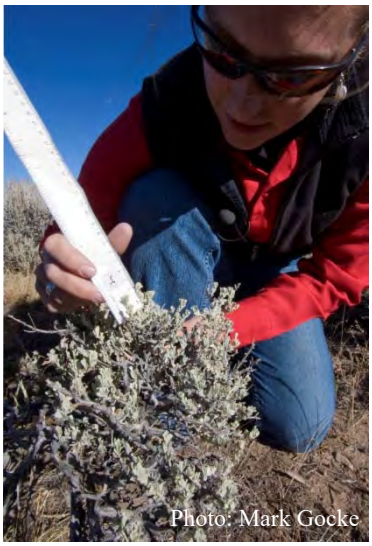


Photo: Mark Gocke

Effects of Winter Severity on Survival and Reproduction

Adult Winter Survival

Winter of 2016/2017 proved to be a tough on mule deer. Conditions on winter ranges for Wyoming Range mule deer were severe with snowpack levels exceeding 200% and numerous days of sub-zero weather. These harsh winter conditions strongly affected winter survival and only 63% of our collared adults survived from November until summer 2017 (compared with >90% in years past). Older animals and animals that entered winter in poor condition were more susceptible to succumbing to winter exposure (Fig. 9).

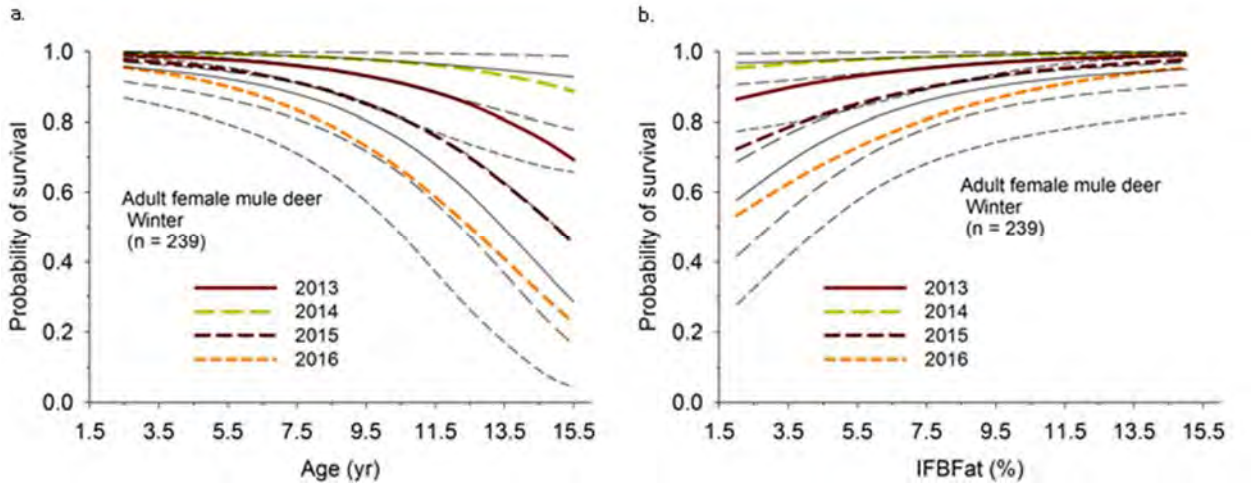


Figure 9. The effects of age (a) and December body fat (IFBFat %; b) on the probability of survival overwinter. Probability of survival decreased as animals aged and as the % body fat (IFBFat %) in December decreased.

Fawn Winter Survival

Winter conditions tend to have the greatest effect on survival of fawns, and this winter was no exception. We observed 100% mortality of the fawns we collared in summer 2016 (44% died overwinter). Mortality rates of that caliber can have substantial repercussions on population dynamics because the majority of an entire cohort of deer is gone. Although these numbers are staggering, winter die-offs, as the one observed this winter, do occasionally occur and populations do eventually rebound. We have now found ourselves with a unique opportunity to evaluate how mule deer populations rebound from harsh winters.

Nutritional Condition

Nutritional condition in March 2017, measured as % body fat, was the lowest we have observed in our research (2.3% in 2017 compared with 4.0–5.3% in 2013–2016; Fig. 10). Although it is rare to see animals in this poor of condition, it was surely a product of deep snow restricting access to forage and heightened energy expenditures associated with locomotion in deep snow and thermoregulation in plummeting temperatures.

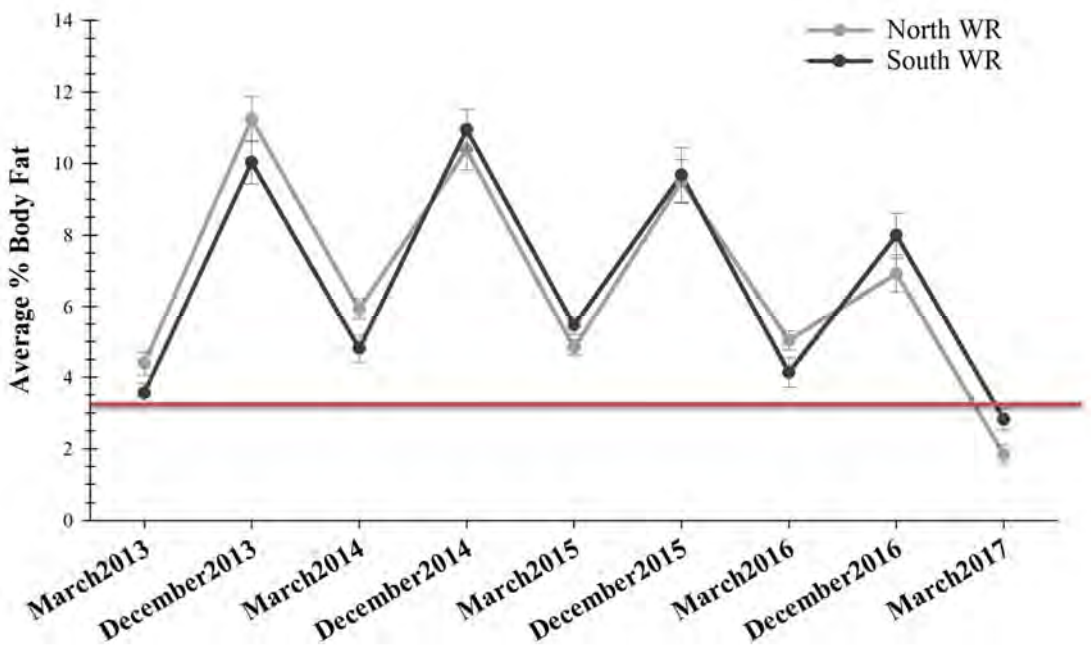


Figure 10. Average % body fat of adult, female mule deer on North (near Big Piney,WY) and South (near Cokeville and Evanston, WY) winter ranges for Wyoming Range mule deer in March 2013 – March 2017. Following the sever winter conditions of 2017, animals were in the worst nutritional condition recorded since the beginning of our research in 2013.

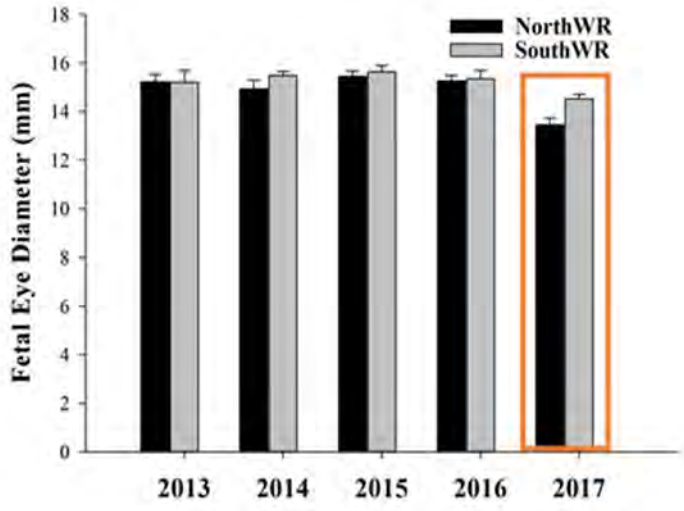


Figure 11. Average fetal eye diameter measured in March of each year. Fetal eye diameter was significantly smaller in March 2017 compared with any other year.

Pregnancy

Despite extremely poor nutritional condition of animals in March 2017, fetal rates among winter ranges were comparable to the preceding 4 years (Fig. 4) and pregnancy rates remained high. Interestingly, average eye diameter of fetuses was lower in March 2017 (14.0 ± 0.18) than in previous years (15.3 ± 0.11; Fig. 11). Fetal eye diameter is a measure of fetal development and is often used to estimate the timing of birth.

Carryover Effects

Newborn fawns caught in 2017 were significantly lighter than newborn fawns caught in previous years (Fig. 12). This was of little surprise because of the overall poor nutritional condition of pregnant females and the smaller eye diameter of fetuses measured in March 2017. With this information, we are now in a position to better evaluate the influence of birth weight and maternal condition on summer survival of fawns.

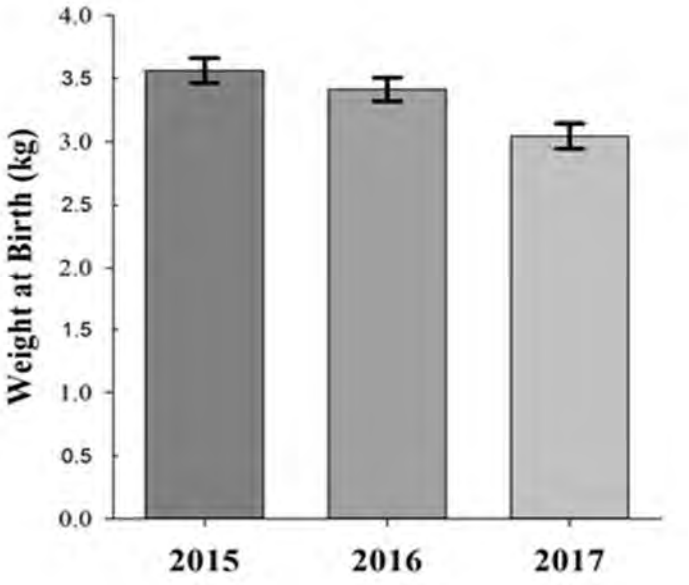


Figure 12. Average weight of fawns captured <48hours from birth. Fawns were significantly lighter in 2017 compared with the previous two years.

Population Benefits of Reduced Deer Density

Following the severe winter of 2016/2017, the Wyoming Range mule deer population had found itself in an interesting place. The high adult morality and depressed reproduction in the summer following undoubtedly resulted in decreased abundance of deer in the Wyoming Range. The silver lining to the decrease in the population is that population growth is often higher when abundance is low (Fig. 13). This is because deer populations are relieved from competition with other deer.

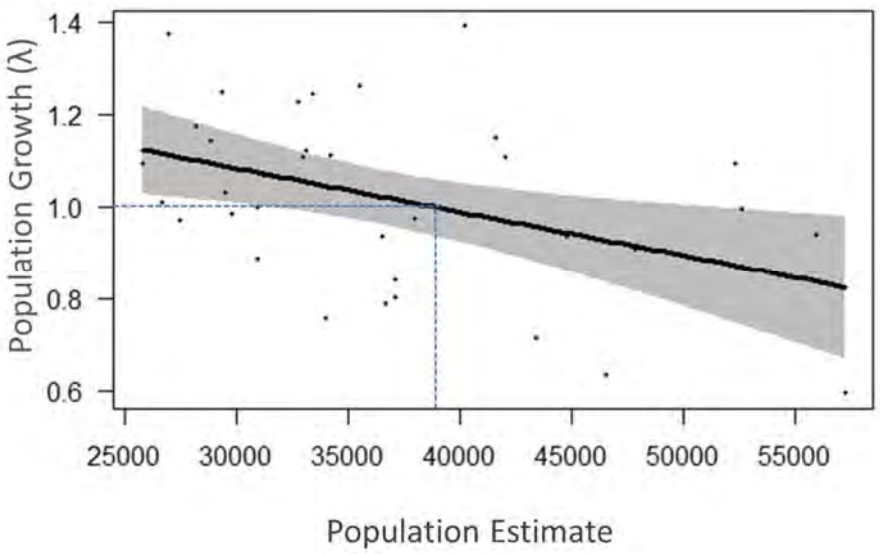


Figure 13. The relationship between population growth (λ) and estimated population abundance of Wyoming Range mule deer. As population abundance decreases, the growth rate (λ) of that population increases.

As deer density decreases, per capita food increases. Consequently, populations at low abundance, relative to the carrying capacity (*K*) of their landscape, tend to be in overall better nutritional condition because each individual has access to more food (Fig. 14). Conversely, deer populations that are at or near carrying capacity tend to be in overall worse nutritional condition because deer are competing with other deer for food. Some of these trends were reflected in our longitudinal data of trends in fat dynamics since 2013, and deer were in the greatest nutritional condition we had observed in March 2017 (Fig. 15).

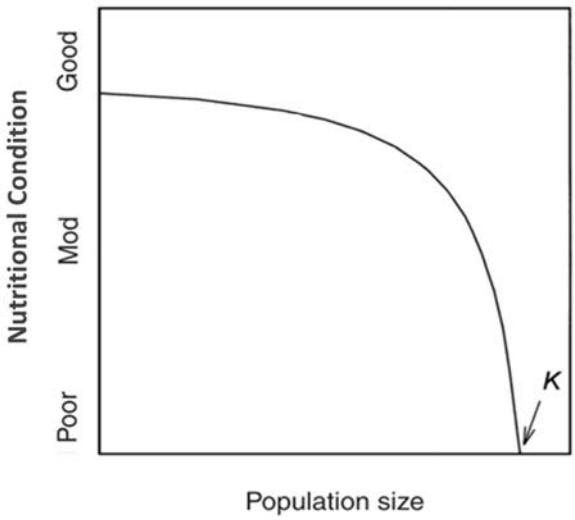


Figure 14. The relationship between population size and nutritional condition of ungulate populations. As population size increases and approaches carrying capacity (*K*), the overall nutritional condition of that population decreases (Kie et al. 2003).

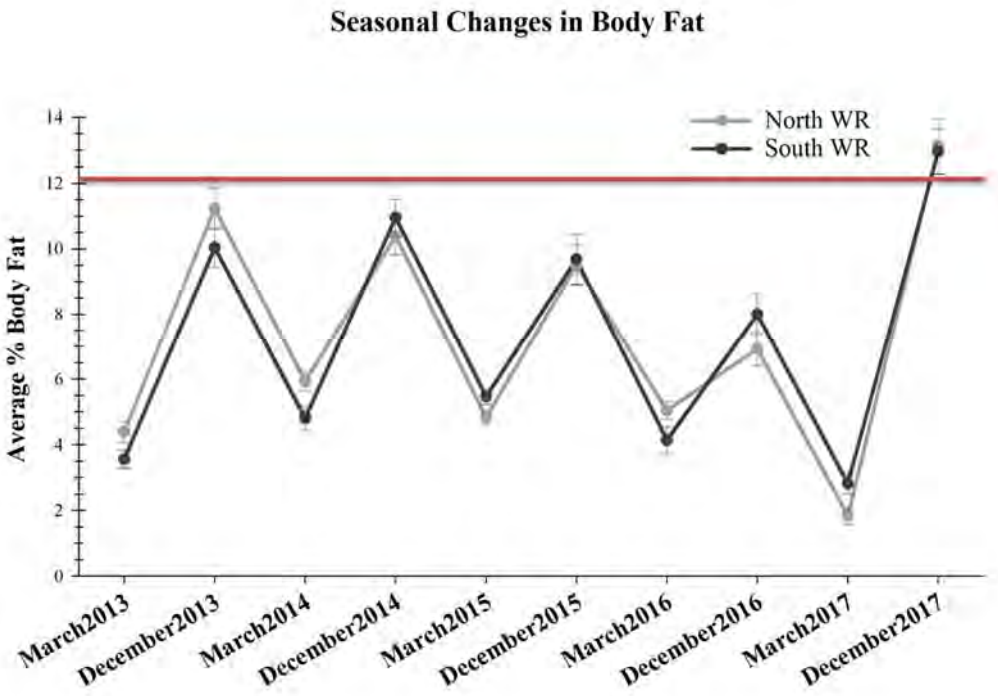


Figure 15. Average % body fat of adult, female Wyoming Range mule deer in March 2013 – March 2017. Following the population decline after the severe winter conditions of 2016/2017, animals were in the best nutritional condition recorded since our research began in March 2013. Essentially, the Wyoming Range mule deer population went from the worst nutritional condition to the best nutritional condition over a summer.


Photo: Gary Fralick

The nutritional condition of mom (i.e., maternal condition) can have life-long effects on her offspring. Previous research by Dr. Monteith (Monteith et al. 2009, *Journal of Mammalogy*) has shown that antler size of male deer is influenced more by maternal condition than genetics. Dr. Monteith, along with colleagues, observed that male fawns born to mothers in good maternal condition grew to be larger deer that exceeded the size of their fathers. Considering these research findings, Wyoming Range mule deer that can exploit their high nutritional condition (relative to previous years) observed in December 2017 may be better poised in allocating stored fat to fetal development and provisioning of young that are born in spring/early summer 2018. The summer of 2018 will be telling for the propensity for population growth and potential for large male deer in years to come.

A Positive Outlook for the Future

Overall survival throughout winter 2017/2018 was high (100% of collared adults and 93% of collared fawns survived), and in March 2018, we recaptured all surviving adult deer and their female offspring. Average % body fat in March 2018 was slightly higher than the overall average over the 6 years of our research (average of 5.46 ± 0.20% in March 2018 compared with overall study average of 4.46 ± 0.10% in March 2013-2018; Figure 3). Also, as would be expected for this population of mule deer, pregnancy rates and fetal rates were comparable to previous observations—94% of animals were pregnant and most were pregnant with twins (fetal rate was 1.68 ± 0.07, which is similar to the average throughout the study; figure 4).

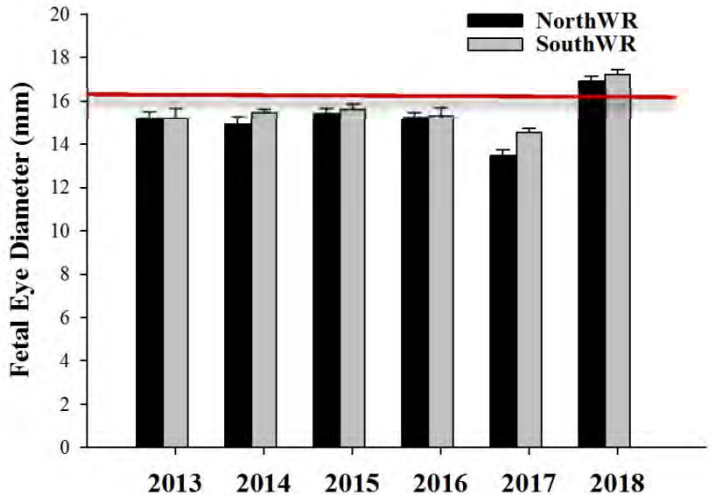


Figure 16. Average fetal eye diameter (mm) measured in March 2013-2018. Fetal eye diameter was significantly higher in 2018

Although nutritional condition and pregnancy in March 2018 were not significantly greater than what has been observed previously, we did observe notable differences in investment in reproduction throughout winter 2017/2018. More specifically, fetuses were significantly larger in March 2018 than in previous years (fetal eye diameter of 17.08 ± 0.16mm compared with a study average of 15.40 ± 0.09; figure 16), and fetuses were 22% larger in March 2018 than in March 2017. This increased investment in fetal development may be a direct result from the high fat stores that Wyoming Range mule deer had coming into the winter. We are excited to see how such investment in fetal development influences timing of birth and the size of young born in May and June.

Spring Migration Ecology of Mule Deer

At the largest spatial scale, migration is recognized as a strategy that allows migrants to exploit high-quality resources available on one seasonal range, while avoiding resource deficiencies on the other. Much less is known, however, about the fine scale movement behaviors that animals make during migration. This portion of the Wyoming Range Mule Deer Project aims to understand the importance of food resources available during migration, and how the habitat quality of migratory routes influences survival and reproduction of migratory mule deer in the Wyoming Range.

Spring migration is a critical time for migrants, in which they must recover from harsh winter conditions and prepare for upcoming reproductive costs. It is hypothesized that movement from low elevation winter ranges to high elevation summer ranges, allows migrants to extend the amount of time they are exposed to young, highly palatable forage. Following a wave of newly emergent, high-quality forage along elevational gradients, is known as “surfing the green wave”. This project will investigate the role of the migration route as critical habitat, with the aim to better understand the importance of migration as well as to inform management strategies to protect migration in the Wyoming Range and beyond.

Project Objectives

1. Test the green wave hypothesis in migratory mule deer and explore the source of individual variability in green-wave surfing (Completed, see below).

2. Investigate the influence of drought on green-wave surfing (In progress).

3. Understand the relative importance of green-wave surfing to fitness (In progress).

Testing the Green Wave Hypothesis

Deer should select plants that are at intermediate growth stages (i.e. not too old or not too young) because plants which are greening up are both easy to digest and available in large enough quantities to maximize energetic gains. If deer surf a wave of plant green-up, then the timing of their movements during spring migration should be perfectly matched with the timing of peak green-up in plants. When we tested this prediction, this is indeed what we found (Figure 1). We noticed, however, that there was a lot of variability in the green-wave surfing ability of individuals. To further investigate the source of this difference in green-wave surfing we considered how the progression of the green-wave across individual routes may differ. We found that some routes had long, easy to follow gradients in plant green-up, while other routes had short, rapid and difficult to follow gradients in plant green-up. Together this difference in the amount of time when green-up was available along a migration route (i.e. the green-up duration) and the gradient of green-up from winter range to summer range (i.e. the order of green-up), which we refer to as the "greenscape", largely explained the differences in green-wave surfing across individual deer using different migration routes.

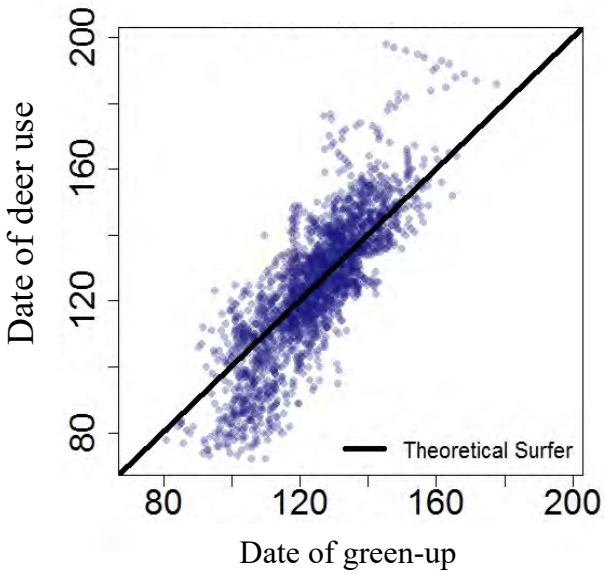


Figure 16. Evidence for green-wave surfing by mule deer in the Wyoming Range. The black line represents the theoretical prediction of a perfect match between the date of green-up and the date of deer use. Data points fall close to this line, suggesting that in general deer are surfing the green wave.

What have we learned?

- Green wave surfing is key to the foraging benefit of migration.
- The migration route provides critical habitat.
- Timing is key, thus activities that may alter the ability of deer to exploit the green wave should be avoided or minimized during the spring migration period.
- The greenscape (i.e. the duration and order of green-up along a migration route) determines the quality of a route.

This research is published! For more information, see:

Aikens, E.O., M. J. Kauffman, J. A. Merkle, S. P. H. Dwinnell, G. L. Fralick, and K. L. Monteith. 2017. The greenscape shapes surfing of resource waves in a large migratory herbivore. *Ecology Letters* 20:741-750.

The Rose Petal Project

While seasonal migration occurs in diverse animals and habitats, large ungulate migrations are some of the most spectacular wildlife events in the world. Migration is crucial to maintaining large, robust populations of large ungulates, and the western US boasts many populations of migratory ungulates, such as pronghorn (*Antilocapra americana*), elk (*Cervus elaphus*), moose (*Alces alces*), and mule deer (*Odocoileus hemionus*). Among ungulate migrations, mule deer migrations are extraordinary because animals can migrate extensive distances (up to 260 km) over extremely rugged terrain. Despite being able to travel all over a landscape, mule deer tend to move over this rugged terrain using the same migratory routes and seasonal ranges year after year, yet the question remains: how do mule deer know how to migrate?

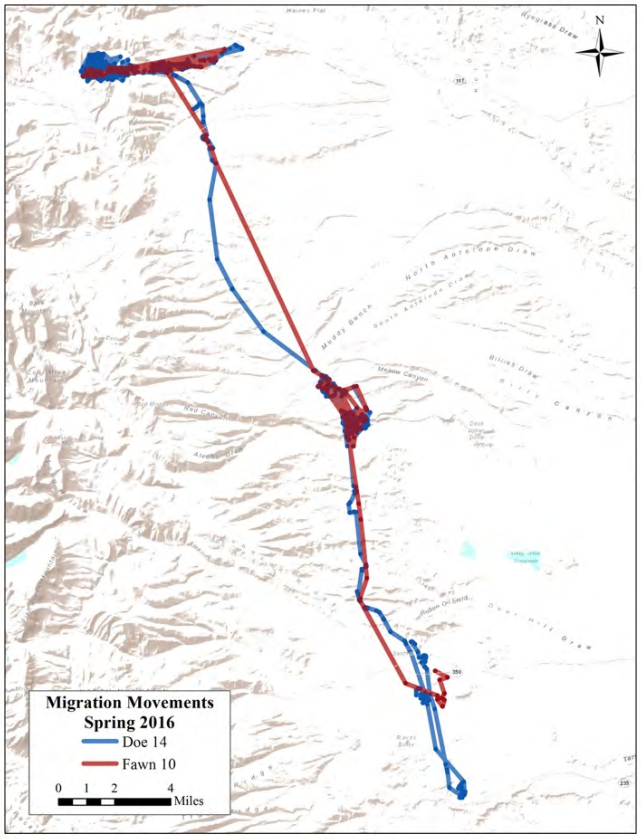
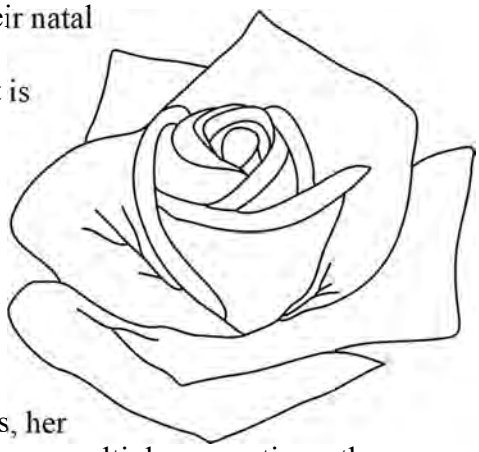


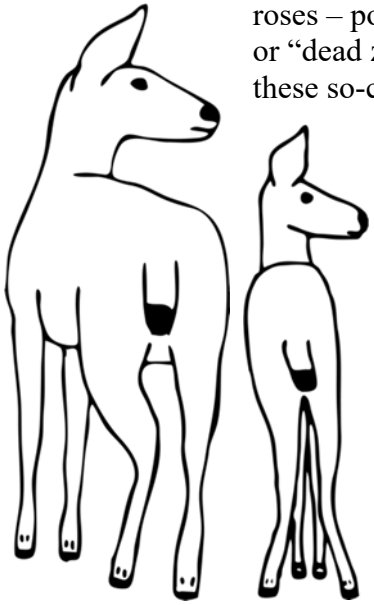
Fig 17. Paired migratory movements of mother (blue) and daughter (red) mule deer in Wyoming, USA. The migration paths of mother and daughter overlap considerably, and warrant investigation of the role of cultural inheritance in shaping migratory behaviors.
Credit: S. Dwinnell.

Ungulates may know how to migrate if information on migratory traits (e.g., timing to initiate migration, rate of movement, migration path, seasonal range characteristics) is passed down from parent to offspring. Two potential mechanism could facilitate this transmission from parent to offspring: genetic inheritance and cultural inheritance. While genetics may underpin migratory traits in some bird species, whether genetics underpin ungulate migration remains to be discovered. Additionally, migratory traits may be passed from mother to offspring if offspring migrate alongside and learn the behaviors of the mother – in other words, through cultural inheritance. Depending on the mechanism responsible for determining the transmission of migratory traits, we may need to alter our management strategies to ensure robust deer populations. Before we can understand these mechanisms, however, we need to test an overlooked assumption: that migration is passed from generation to generation at all, regardless of the mechanism responsible.

In mule deer, managers and scientists currently assume that mothers migrate with their newborn offspring from summer range to winter range, and return with their offspring to summer range the following spring (Fig. 1). The transmission of migratory traits (through either genetic or cultural inheritance) could allow parents to pass information about already successful or familiar habitats and routes to their offspring. While scientists have largely overlooked the transmission of migratory behaviors from parent to offspring, studying whether information is transmitted across generations has huge ramifications for understanding the ontogeny – or development – of migratory behaviors.

In addition to being fascinating, understanding the ontogeny of migration could change how we manage populations of migratory mule deer and other migratory ungulates. Because the females in many species of ungulates do not disperse far from their natal range, clusters of closely related females will form when mothers successfully raise offspring. This behavior of spatial arrangement is deemed the *rose petal hypothesis*, and results in clusters of mule deer families while they are on summer range. Passing migratory behaviors from parent to offspring could have population-level consequences if inherited behaviors constrain the habitat which family lineages can access. For example, if a mother mule deer transmits information about high-quality habitat to her daughter, that daughter may be more successful at having and raising offspring of her own. Alternatively, if a mother transmits information that leads her daughter to low-quality seasonal ranges, her daughter may have lower reproductive success. When combined over multiple generations, the inheritance of migratory traits of differing quality could produce differences in the sizes of these roses – potentially creating areas analogous to mule deer "hot spots" (robust rose) or "dead zones" (dilapidated rose). Identifying the migratory traits that result in these so-called "hot spots" could provide managers with information about which individuals, management areas, or behaviors to prioritize.





Are migratory traits transmitted from mother to daughter?

We aim to identify whether migratory traits are transmitted from generation to generation in mule deer. We expect that if migratory traits are transmitted, offspring will display migratory traits (e.g., migration timing, rate of movement, migration route, and quality of seasonal ranges) resembling their mothers (Fig. 2a).

To test whether migratory traits are transmitted, we will compare migration characteristics among and between mother-daughter pairs of Wyoming Range mule deer fitted with GPS collars. We began collaring efforts in 2016, and expect to collar approximately 50 mother-daughter

pairs by the end of the project. We will use a suite of analyses including movement coordinate index, linear regression, and utilization distribution overlap index to quantify similarities between mother-offspring migratory traits.

What are the population consequences of transmitting migratory traits?

If migratory traits are transmitted, lineages may be constrained in the habitat they can occupy, such that transmission of certain combinations of migratory traits will lead to differential reproduction and local density. We expect founding mothers that inherit access to advantageous habitat will successfully raise more offspring over their lifetime, while mothers that inherit access to low-quality habitat will raise fewer offspring (Fig. 2b). Differences in reproduction, and the resulting differences in local density, may then influence landscape-scale spatial distribution.

To test whether the inheritance of migration traits has consequences of mule deer populations, we will compare local density around each collared female with mother-offspring migration trait similarities. We will determine local density by searching for fecal samples along belt transects centered around the summer range of each collared mother-daughter pair. Using genetic information extracted from fecal pellets, we will determine individual identification and genetic relatedness to the collared female. We will then test whether similarities in migration traits between mother and offspring influence local density.

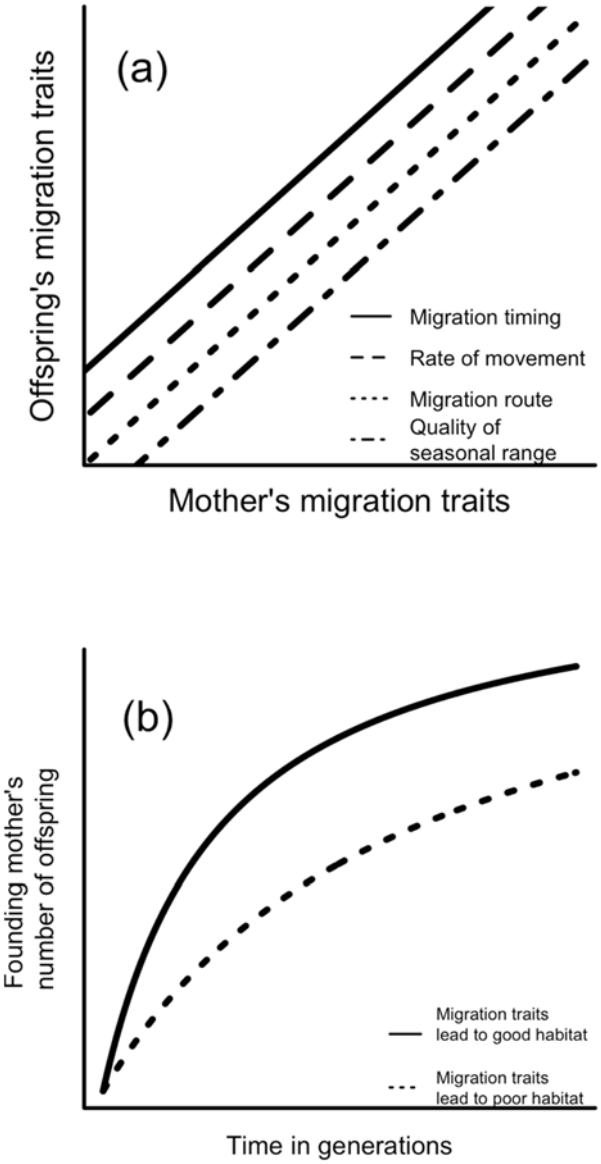


Fig. 18. Predictions associated with the cultural inheritance hypothesis (a) and the population consequences hypothesis (b).

Management implications

Despite the importance of migration to many ungulate species, anthropogenic change is rapidly altering landscapes and, consequently, migratory behaviors. Halting or altering migratory behaviors could impact ungulate population trajectories by rendering segments of seasonal habitats unused, ultimately constraining species abundance, occupancy, and distribution. Because migration strategies developed under past conditions, properly managing ungulates in a rapidly changing world relies on characterizing the factors shaping migratory traits and the subsequent population ramifications.

Future Directions

The effects of the 2016-17 winter has been distressing, but we now are uniquely poised to document the long-term effects severe winters and understand the factors that will influence population recovery from the devastating losses. We have been extremely fortunate to have been conducting research on this herd, not only through the course of this harsh winter, but for several years prior, which will yield the data to address questions associated with how severe winters may affect mule deer herds throughout the state. With dramatic reductions in density, forage resources available per individual should be bolstered and thus, nutritional condition, reproductive success, and survival may well all respond very favorably. Nevertheless, with lower deer density compared with recent decades, the role of predators in this population also may change in either positive or negative ways. The marked decline of the Wyoming Range deer population following the 1992-93 winter, and the near absence of any substantial recovery thereafter, also begs the question to what extent recovery will occur given historic patterns. Regardless, the overwhelming management desire is for recovery, and our aim is to document recovery and the mechanisms that underpin it.

The overall goal of our continued work in the Wyoming Range will be to build on our understanding of the nutritional and population ecology of this herd to document the carryover effects of the severe winter of 2016-17, and how and to what extent the population will rebound from the dramatic reduction in abundance. As before, our overall approach will continue to mesh data on nutritional condition, habitat condition, and population performance to understand factors regulating Wyoming Range mule deer and the ability of the current habitat to support mule deer—with now a distinct reduction in density, habitat and density-dependent feedbacks onto the population should illuminate ever more so than previously. Our approach will allow us to continue to elucidate the relative roles of habitat, nutrition, predation, and disease on the regulation of deer in western WY, and fully grasp the magnitude and extent of the effects of the transient, but clearly regulatory role of winter.

Partners

The Wyoming Range Deer Project is a collaborative partnership in inception, development, operations, and funding. Without all the active partners, this work would not be possible. Funds have been provided by the Wyoming Game and Fish Department, Wyoming Game and Fish Commission, Wyoming Wildlife and Natural Resource Trust, Muley Fanatic Foundation, Bureau of Land Management, Knobloch Family Foundation, U.S. Geological Survey, National Science Foundation, Wyoming Governor's Big Game License Coalition, Boone and Crockett Club, Animal Damage Management Board, Ridgeline Energy Atlantic Power, Bowhunters of Wyoming, and the Wyoming Outfitters and Guides Association. Special thanks to the Wyoming Game and Fish Department, Bureau of Land Management, and Wyoming State Veterinary Lab for assistance with logistics, lab analyses, and fieldwork. Also, thanks to the Cokeville Meadows National Wildlife Refuge and U.S. Forest Service for providing field housing.

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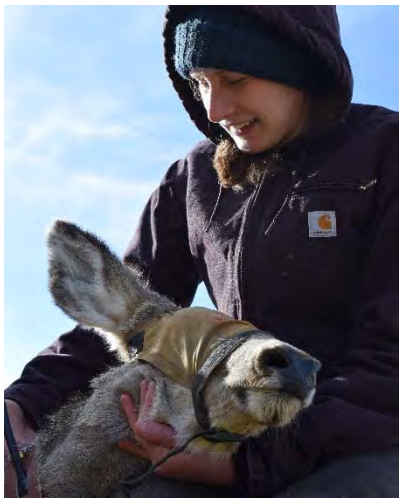
PROJECT TEAM MEMBERS

Kevin Monteith

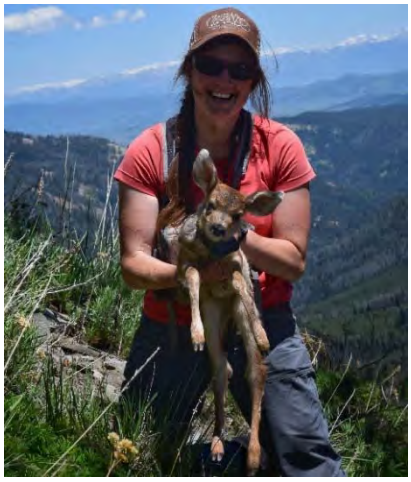
Kevin Monteith is an Assistant Professor of the Haub School of Environment and Natural Resources and the Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology at the University of Wyoming. After receiving his BSc and MSc in Wildlife and Fisheries Sciences from South Dakota State University, he went on to obtain his PhD in Biology from Idaho State University in 2011. Kevin's research program is focused on integrating nutritional ecology with intensive field studies of large ungulates to elucidate the mechanisms that underpin behavior, growth, reproductive allocation, predator-prey dynamics, and ultimately, the factors affecting population growth. Kevin and his graduate students are currently conducting research on most of Wyoming's large ungulates; topics are centered on establishing a protocol for habitat-based, sustainable management of ungulate populations, while investigating the effects of predation, habitat alteration, climate change, migration tactics, and novel disturbance.

Ellen Aikens



Ellen is a PhD candidate in the Program in Ecology at the University of Wyoming. Ellen is fascinated by animal movement, especially migration. Ellen plans to pursue a career in research, with a focus on the interface between fundamental research and applied conservation and management. Before coming to Wyoming, Ellen worked at the Smithsonian Conservation Biology Institute's GIS lab, where she analyzed remote sensing and GPS telemetry data for conservation research projects across the globe. Ellen is a recipient of the National Science Foundation Graduate Research Fellowship and the Berry Fellowship. Ellen earned her bachelor's degree in Biology and Environmental Studies from Ursinus College.

Samantha Dwinnell



Samantha Dwinnell is a Research Scientist with the Haub School of Environment and Natural Resources. Samantha is the first student to miraculously graduate (May 2017) with a MSc from the Monteith Shop. Immediately following her defense that was made successful through bribery, she foolishly convinced Dr. Monteith to hire her as a Research Scientist to manage the Wyoming Range Mule Deer Project. Samantha's graduate research was focused on the nutritional relationships among mule deer behavior, forage, and human disturbance. Currently, her research is focused on disentangling the relative influence of various factors that affect fawn survival. Although Samantha is most interested in research aimed at informing management and conservation of wildlife, she also dedicates research efforts into finding ways to mountain bike and ski without her boss knowing.

Rhiannon Jakopak

Rhiannon is currently a master's student in the Cooperative Fish and Wildlife Research Unit at the University of Wyoming. She received dual bachelor's degrees in Wildlife and Fisheries Biology and Management and Religious Studies at the University of Wyoming in 2016. She is broadly interested in population ecology and mammalogy, and more specifically interested in the processes regulating the distribution of species. Her master's project seeks to identify the factors which influence the development of migration and the subsequent population consequences.

Tayler LaSharr

Tayler LaSharr is a MSc student in the Cooperative Fish and Wildlife Research Unit. Tayler grew up in Phoenix, AZ and attended the University of Arizona where she obtained a BSc in Natural Resources with an emphasis in Conservation Biology and a minor in Chemistry in May of 2015. During her time at the University of Arizona, she studied life history tradeoffs in Western and Mountain Bluebirds and the effects of aggression in closely related species on habitat and range dynamics. In the summer of 2015, she began work in the Wyoming Cooperative Fish and Wildlife Research Unit as a technician on a fawn survival study of mule deer in the Wyoming Range. In the fall of 2015, she began work on her own research, which focuses on understanding the effects of harvest on horn size of mountain sheep. Following the completion of her MSc work in the spring of 2018, she will transition to a PhD working on a component of the Wyoming Range Mule Deer Project assessing population recovery following a severe winter.

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Wyoming Range Mule Deer Project

Winter 2018-19 Update

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WYOMING COOPERATIVE FISH & WILDLIFE RESEARCH UNIT

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WYOMING RANGE MULE DEER PROJECT

Project Background

In recent decades, mule deer abundance throughout the West has struggled to reach historic numbers, and Wyoming is no exception to the nearly ubiquitous trend of population declines. In response to concerns of mule deer populations in Wyoming, in 2007, the Wyoming Game and Fish Commission adopted the *Wyoming Mule Deer Initiative* (MDI) with the intent to develop individual management plans for key populations. Of particular concern was the Wyoming Range mule deer population in western Wyoming—one of the largest mule deer herds in the state and a premier destination for mule deer hunting in the country. The Wyoming Range mule deer population has undergone dynamic changes in recent decades from a population high of >50,000 in the late 1980s, to a sustained population of ~30,000 during much of the last decade (Fig. 1). Consequently, the Wyoming Range mule deer population was identified as a top priority for the development of a management plan according to the MDI. The first of the population-specific management plans, the *Wyoming Range Mule Deer Initiative* (WRMDI), was finalized in 2011 following a collaborative public input process. To direct development of an effective management plan, it was recognized by the Mule Deer Working Group (2007) that the *"Success and implementation of these plans will depend upon our ability to identify limiting factors to mule deer populations and their habitats"*. Accordingly, the Wyoming Range Mule Deer Project was initiated 2013 to address the need for research in identifying the factors that regulate the Wyoming Range mule deer population.

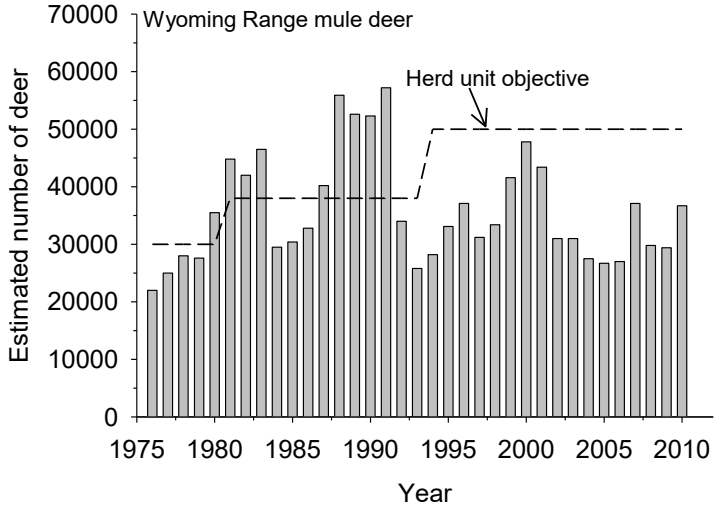


Figure 1. Estimated population size of the Wyoming Range mule deer herd relative to herd unit objective, 1976-2010.

The overarching goal of the Wyoming Range Mule Deer Project is to investigate the nutritional relationships among habitat conditions, climate, and behavior to understand how these factors interact to regulate population performance. We initiated the project in March 2013 with the capture of 70 adult, female mule deer on two discrete winter ranges for migratory, Wyoming Range mule deer (Fig. 2). In summer 2015, we initiated Phase II of the Wyoming Range Mule Deer Project that focuses on survival and cause-specific mortality of neonate mule deer. In the fall of

2018, we began Phase III of the project, which is focused on the recovery of the population following the severe winter of 2016-17 in the Wyoming Range that resulted in almost complete removal of a cohort from the population and high adult mortality. Since the initiation of the project, we have tracked and monitored the survival, behaviors, reproduction, and habitat conditions of 202 adult female and 277 juvenile mule deer of the Wyoming Range. This update highlights some of our many discoveries on mule deer ecology since the initiation of the project.

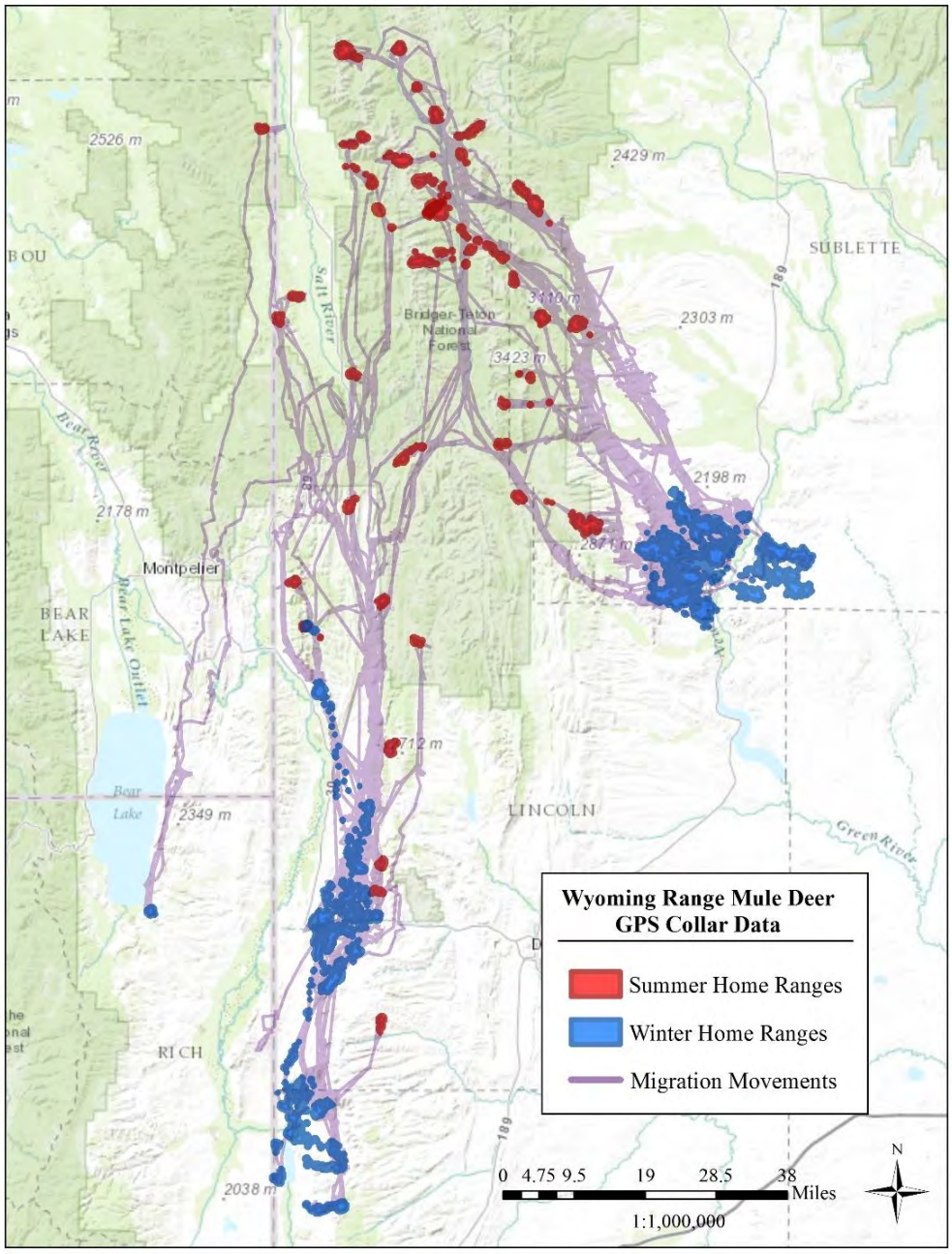


Figure 2. Winter and summer home ranges (based on 95% Kernel Utilization Distribution of GPS collar data) as well as migration movements of Wyoming Range mule deer.

The Wyoming Range Mule Deer Project

Using a nutritional ecology framework, we aim to evaluate how conditions of seasonal ranges mule deer encounter throughout the year—ranges used during summer, winter, and migration—affect individual animals. Using this unique approach, we aim to develop a comprehensive understanding of how the connections individual deer have with their environments influences population dynamics.

Adult Captures

Since March 2013, we have captured and recaptured 202 adult, female mule deer. Upon each capture, in addition to fitting each animal with a GPS collar, we collect a suite of data on each animal including age, nutritional condition, morphometry, pregnancy, and fetal rates. Animals are recaptured each spring (in March) and autumn (in December) to monitor longitudinal changes in nutritional condition and reproduction. In doing this, we can link various life-history characteristics with behaviors and habitat conditions of individual animals.

At each capture event, we use ultrasonography to measure fat reserves (i.e., % body fat). By recapturing collared mule deer and measuring body fat each autumn and spring, we are able to track changes in nutritional condition between summer and winter seasons.

Although most animals lost fat in the winter and gained fat in the summer, the rate at which fat reserves increased or decreased varied widely among individual animals. A suite of factors can influence fat dynamics between winter and summer seasons, but availability of food on seasonal ranges and number of fawns a female raises have the greatest effect on fat dynamics.

Reproductive success of individual animals greatly influences population dynamics; therefore, we closely monitor pregnancy and recruitment of young for each of our study animals. We use ultrasonography to monitor pregnancy rates of our study animals during spring capture events. Each autumn, as animals arrive to winter range, we evaluate fall recruitment using on-the-ground observations of the number of fawns at heel of our collared adults.

Neonate Captures

In March 2015, we initiated Phase II of the Wyoming Range Mule Deer Project by recapturing collared deer and deploying a vaginal implant transmitter (VIT) in pregnant females. VITs were used to indicate where and when birth occurred. Once birth events were identified, we captured and collared fawns born to our collared females as well as fawns that were found opportunistically throughout the Wyoming Range. Since 2015, we have successfully tracked 277 fawns and have been continually monitoring their survival.

To evaluate cause-specific mortality of fawns, we tracked daily survival of all collared fawns each summer beginning in 2015. When a mortality was detected, we immediately investigated the event to ensure an accurate assessment of the cause of mortality. We have detected a breadth of various causes for fawn mortality including predation, disease, malnutrition, drowning, hypothermia, vehicle-collision, and just being caught in vegetation.

In 2015, disease was the leading cause of death for collared fawns and accounted for 28% of all mortalities. The most prevalent disease, adenovirus hemorrhagic disease (AHD), is a viral disease that can cause internal hemorrhaging and pulmonary edema. In 2017, 26% of fawn mortalities were the result of stillborns. Conversely, in 2018, only 1 of the 83 fawns collared was stillborn. We are still waiting on results from the Wyoming State Vet Lab to determine the leading cause of death for fawns in the summer of 2018.

	2015	**2016**	**2017**	**2018**
Number of Fawns Tracked	58	70	67	83
Median Birthdate	June 10	June 13	June 17	June 11
Average Birthweight	7.9 lb	7.5 lb	6.7 lb	7.6 lb
Summer Mortality	45%	56%	52%	49%
Winter Mortality	9%	44%	7%	3%*
Total Mortality	54%	100%	59%	NA

Summer mortality is based on survival until October 31st in the year a fawn was born. Winter mortality is based on survival from November 1st to April 30th.

** Winter mortality as of 7 January 2019*

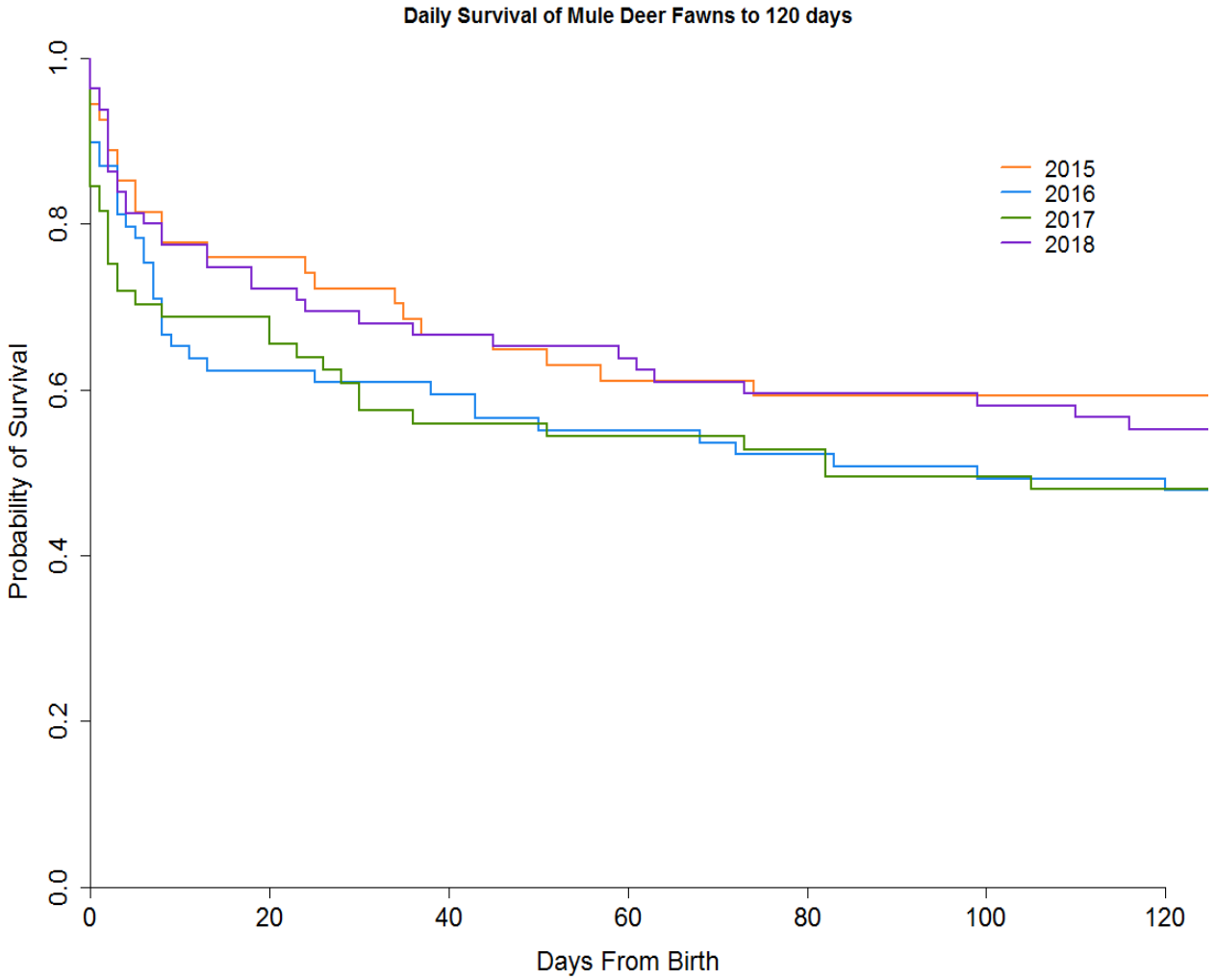
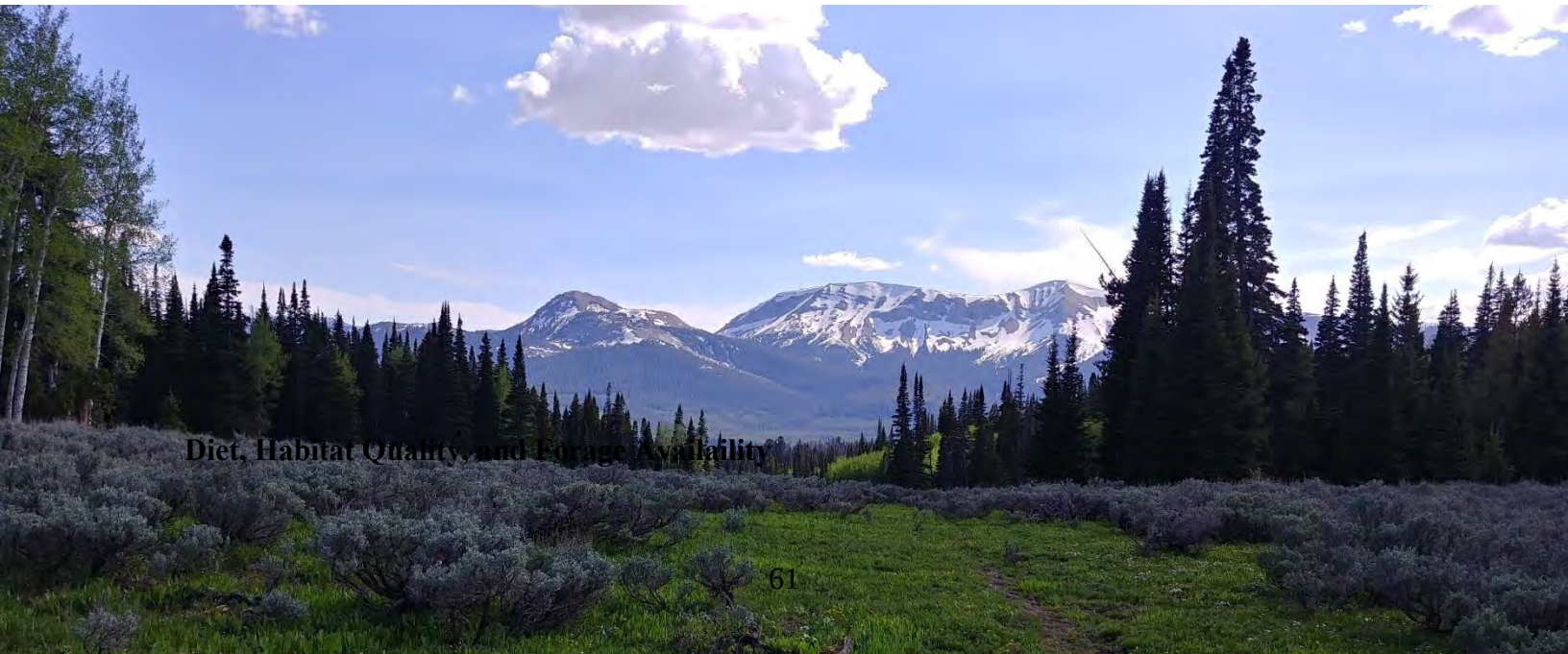


Figure 3. Probability of surival of neonatal mule deer in the Wyoming Range from birth up to 120 days in each summer from 2015 to 2018.



The condition of a female and the habitat conditions she experiences in the summer may be very important in predicting and understanding fawn survival—especially in understanding the relative contributions of nutrition and disease to vulnerability to mortality. Therefore, we are coupling data on summer habitat conditions with information on maternal condition (i.e., nutritional condition) to evaluate how it influences fawn survival.

In 2013 and 2014, we evaluated the quality and availability of plants within the diets of Wyoming Range mule deer during summer. To assess mule deer diets, we collected fecal samples from summer home ranges of collared deer and used microhistology and DNA metabarcoding to identify plant species within their diets in summer 2013 and 2014. Based on frequency of plants within mule deer diets, we then collected plant clippings that we analyzed for quality (e.g., crude protein and digestibility). We began collecting fecal samples from summer home ranges again in the summer of 2018.

In addition to assessing quality and diet composition, we have been evaluating key species of forage in summer home ranges of collared females at known locations during different periods of reproduction (i.e., partition and peak lactation) since the summer of 2015.

Ecology of Spring Migration

At the largest spatial scale, migration is recognized as a strategy that allows migrants to exploit high-quality resources available on one seasonal range, while avoiding resource deficiencies on the other. Much less is known, however, about the fine scale movement behaviors that animals make during migration. This portion of the Wyoming Range Mule Deer Project aims to understand the importance of food resources available during migration, and how the habitat quality of migratory routes influences survival and reproduction of migratory mule deer in the Wyoming Range.

Spring migration is a critical time for migrants, in which they must recover from harsh winter conditions and prepare for upcoming reproductive costs. It is hypothesized that movement from low elevation winter ranges to high elevation summer ranges, allows migrants to extend the amount of time they are exposed to young, highly palatable forage. Following a wave of newly emergent, high-quality forage along elevational gradients, is known as "surfing the green wave". This project will investigate the role of the migratory route as critical habitat, with the aim to better understand the importance of migration as well as to inform management strategies to protect migration in the Wyoming Range and beyond.

Project Objectives

1. Test the green wave hypothesis in migratory mule deer and explore the source of individual variability in green-wave surfing (Completed, see below).

2. Investigate the influence of drought on green-wave surfing (In progress).

3. Understand the relative importance of green-wave surfing to fitness (In progress).

Testing the Green Wave Hypothesis

Deer should select plants that are at intermediate growth stages (i.e. not too old or not too young) because plants which are greening up are both easy to digest and available in large enough quantities to maximize energetic gains. If deer surf a wave of plant green-up, then the timing of their movements during spring migration should be perfectly matched with the timing of peak green-up in plants. When we tested this prediction, this is indeed what we found (Figure 3). We noticed, however, that there was a lot of variability in the green-wave surfing ability of individuals. To further investigate the source of this difference in green-wave surfing we considered how the progression of the green-wave across individual routes may differ. We found that some routes had long, easy to follow gradients in plant green-up, while other routes had short, rapid and difficult to follow gradients in plant green-up. Together this difference in the amount of time when green-up was available along a migration route (i.e. the green-up duration) and the gradient of green-up from winter range to summer range (i.e. the order of green-up), which we refer to as the "greenscape", largely explained the differences in green-wave surfing across individual deer using different migration routes.

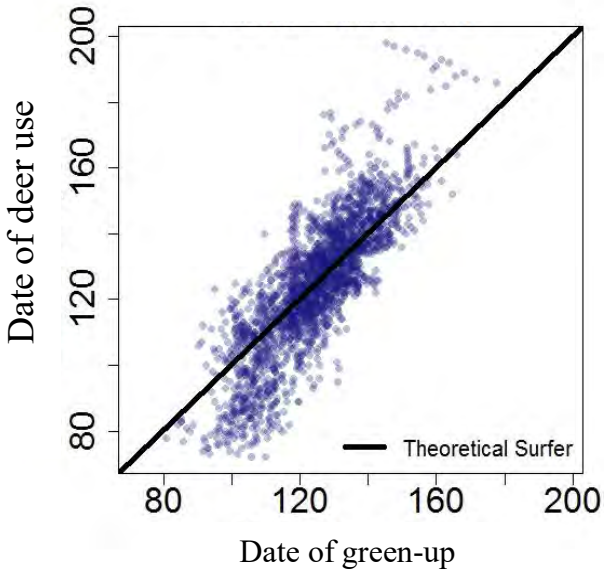


Figure 3. Evidence for green-wave surfing by mule deer in the Wyoming Range. The black line represents the theoretical prediction of a perfect match between the date of green-up and the date of deer use. Data points fall close to this line, suggesting that in general deer are surfing the green wave.

What have we learned?

- Green wave surfing is key to the foraging benefit of migration.
- The migration route provides critical habitat.
- Timing is key, thus activities that may alter the ability of deer to exploit the green wave should be avoided or minimized during the spring migration period.
- The greenscape (i.e. the duration and order of green-up along a migration route) determines the quality of a route.

This research is published! For more information, see:

Aikens, E.O., M. J. Kauffman, J. A. Merkle, S. P. H. Dwinnell, G. L. Fralick, and K. L. Monteith. 2017. The greenscape shapes surfing of resource waves in a large migratory herbivore. *Ecology Letters* 20:741-750.

Evaluating the ontogeny of ungulate migration

Each year, millions of animals migrate between distinct portions of their home ranges. This behavior allows animals to increase fitness by prolonging or increasing access to high-quality resources and at times reducing predation risk. Through both their seasonal ranges and migratory routes, animals can access markedly more resources without diminishing them because of their diffuse presence on a landscape, potentially bolstering carrying capacity and promoting larger populations of migratory animals than non-migratory animals. Despite its central role in a variety of ecological processes, we lack a mechanistic understanding of how these behaviors originate and are maintained.

Figure 1. Year-round GPS points of F014 (2 years old) and her mother, 108.

In ungulates, migration is thought to be maintained via cultural inheritance. Mule deer, for example, are a social species that exhibit maternal care for the first year of life, which may allow for the cultural transmission of migratory information if offspring migrate with their mother for their first migration. Additionally, mule deer are faithful to their migratory routes and seasonal ranges. Whereas fidelity might boost familiarity or indicate strategies that have already been successful, rigidity that may have ensured success in the past may challenge persistence in a changing world.

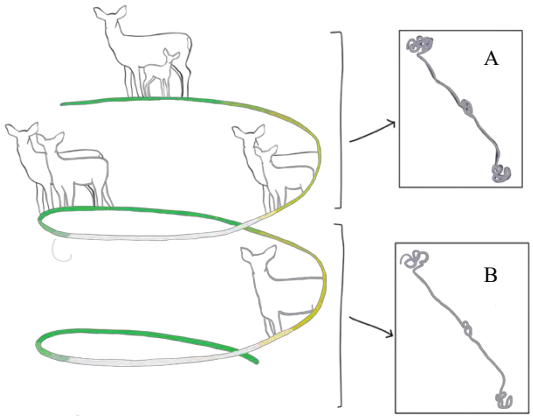
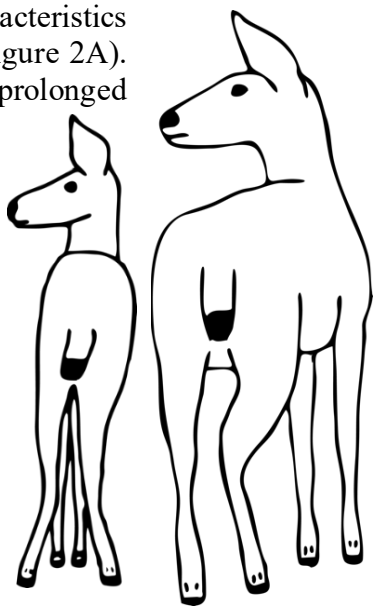


Figure 2. Fawns (purple) live with through at least their first fall (right side of spiral) and spring (left side of spiral) migrations. Fawn and mother's migrations should overlap considerably during the first year of life (A). If migration is culturally inherited from mother during the first year of life, fawn will migrate similarly to their mother, even after maternal investment has ended (B).

Despite mounting evidence for the cultural inheritance of migratory behaviors and its potential ramifications for populations, we still lack a mechanistic understanding of how migratory behaviors are maintained in a population, and the degree to which this mechanism is flexible. To that end, we are working to identify the mechanism underpinning migration in mule deer. We hypothesize that an individual's migratory characteristics are inherited from their mother (Figure 2A). Additionally, we hypothesize that prolonged maternal investment will facilitate the cultural transmission of migratory behaviors (Figure 2B) by establishing patterns that are followed into adulthood.



Using the Wyoming Range Mule Deer project as a study system, we will evaluate these hypotheses using mother-daughter pairs that have been fitted with GPS collars. Through understanding how migration originates, we will gain a deeper understanding of how to protect migratory behaviors into the future.

Assessing public beliefs of ecological concepts regarding mule deer management

Communication with the public makes up an increasing proportion of wildlife management and research. As reflected by the North American Model of Wildlife Conservation, wildlife are a public resource; communicating with stakeholders therefore is part of wildlife professionals' ethical obligation to ensure that the public is informed and has a voice regarding wildlife-related actions. Although communication is an integral part of any wildlife professional's job, many struggle to effectively communicating with the public, in large part because we still lack fundamental understandings of the public.

When wildlife professionals communicate information to members of the public, this message must navigate through a variety of cognitive levels to be absorbed by an individual. Wildlife value orientations provide a useful framework for relating how fundamental aspects of an individual, such as their values and beliefs, will shape their engagement with a variety of wildlife issues through their attitudes and behaviors. Despite the utility of wildlife value orientations as a framework, the explicit roles of beliefs in shaping attitudes and behaviors are often overlooked in wildlife-related issues. Beliefs can shift through time as an individual learns additional information and incorporates it into their belief structure. Therefore, assessing wildlife-related beliefs among members of the public and identifying mismatches with scientific facts could assist in promoting effective communication of wildlife-related issues.

Although all wildlife-related issues likely have potential for mismatch between individual beliefs and knowledge gained via science, management issues concerning ungulates frequently create division among members of the public and wildlife professionals or within sections of the public. Mule deer, for example, are a popular game species in the western United States, but population numbers are declining or stagnant throughout most of their range. In Wyoming in 2017, resident and non-

resident hunters purchased 69,558 licenses and provide a substantial amount revenue to the state wildlife agency (Wyoming Game and Fish Department 2017). Because of the substantial public interest in big game management, wildlife professionals frequently communicate with the public regarding management decisions. It is often unclear, however, whether these messages are constructed and delivered in a way that is poised to be understood by the public.

To aid in improving communication efforts between wildlife managers and the public, we are beginning a study to identify mismatches between information held by citizens of Wyoming who are invested in Wyoming's mule deer populations and knowledge generated by the scientific community related to mule deer management. We aim to work collaboratively with Wyoming Game and Fish Department, non-profits, NGOs, and individual stakeholders to broadly deliver a survey assessing the public's values and beliefs regarding mule deer management. Through these surveys, we aim for this information to provide specific ways for wildlife professionals to improve communication efforts with members of the public.

Assessing Carryover Effects of a Severe Winter

The winter of 2016-17 proved to be tough on mule deer in the Wyoming Range. Conditions on winter ranges for Wyoming Range mule deer were severe with snowpack levels exceeding 200% and numerous days of sub-zero weather. These harsh winter conditions strongly affected winter survival and only 63% of our collared adults survived from November until summer 2017 (compared with >90% in years past). For adults, survival was dependent on both age and condition; older animals and animals that entered winter in poor condition were more susceptible to succumbing to winter exposure than young or fat indivdiuals. Furthermore, we saw a dramatic effect of the harsh winter on survival of fawns. Winter conditions tend to have the greatest effect on survival of fawns, and the 2016-17 winter was no exception. We observed 100% mortality of the radiocollared fawns that entered the winter. Mortality rates of that caliber can have substantial repercussions on population dynamics because the majority of an entire cohort of deer is gone. Although these numbers are staggering, winter die-offs, as the one observed this winter, do occasionally occur and populations do eventually rebound. We have now found ourselves with a unique opportunity to evaluate how mule deer populations rebound from harsh winters.

Nutritional condition in March 2017, measured as % body fat, was the lowest we have observed in our research (2.3% in 2017 compared with 4.0–5.3% in 2013–2016). Although it is rare to see animals in this poor of condition, it was surely a product of deep snow restricting access to forage and heightened energy expenditures associated with locomotion in deep snow and thermoregulation in plummeting temperatures. Following the summer of 2017, we saw collared individuals entering the 2017/2018 winter in the best condition that we have observed in this population, with body fat levels close to two times the levels what we had seen in the autumn of 2016.

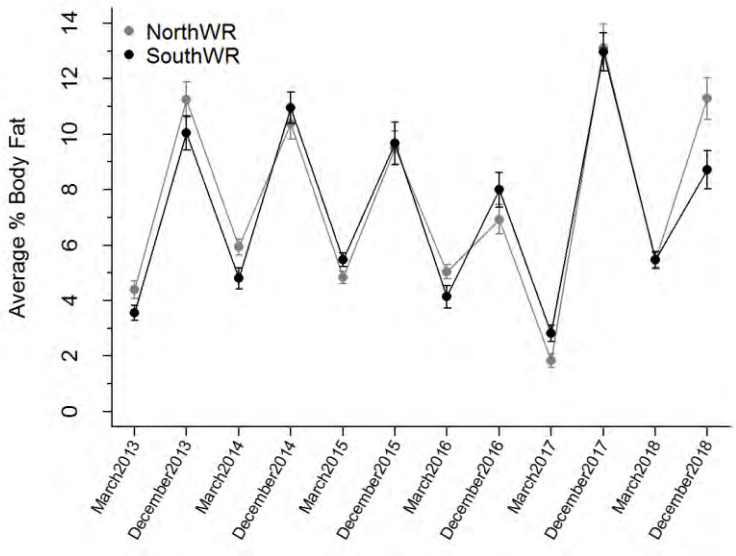
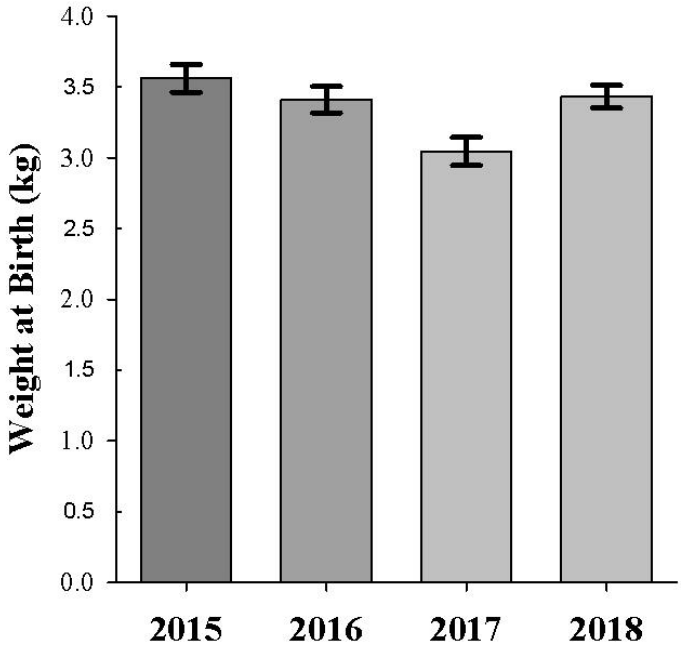


Figure 4. Average percent of ingesta-free body fat of adult, female mule deer in the Wyoming Range from March 2013 to December 2018.

We saw the effects of the harsh winter in 2016-17 in fawns born in the summer of 2017. Newborn fawns caught in 2017 were significantly lighter than newborn fawns caught in previous years, and over a quarter of the summer mortalities that year were from collared females giving birth to stillborns. In line with poor development of offspring at birth was the smallest eye diameter of fetuses measured in March 2017. In 2018, not only had eye diameter of developing fetuses climb to higher levels that we had seen previously, birth weights also increased back to levels that were comparable to what had been seen in the population before the summer of 2017. With this information, we are now in a position to better evaluate the influence of birth weight and maternal condition on summer survival of fawns.

Following the severe winter of 2016-17, the Wyoming Range mule deer population had found itself in an interesting place. The high adult morality and depressed reproduction in the summer following undoubtedly resulted in decreased abundance of deer in the Wyoming Range. The silver lining to the decrease in the population is that population growth is often higher when abundance is low.

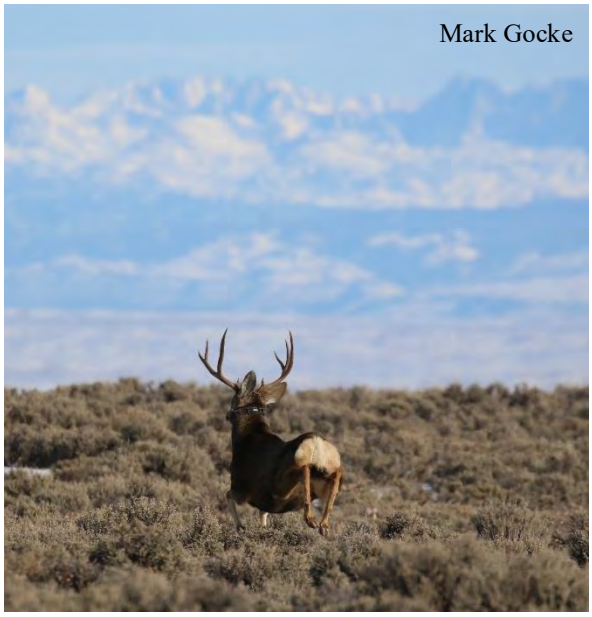


As the density of deer decreases, the food available to each individual on a landscape increases. Consequently, populations at low abundance, relative to the capacity that their landscape can support, tend to be in overall better nutritional condition because each individual has access to more food. Conversely, deer populations that are at or exceeding the capacity a landscape can support tend to be in overall worse nutritional condition

because deer are competing with each other for food. Some of these trends are reflected in our longitudinal data of trends in fat dynamics since 2013. Deer were in the poorest nutritional condition we had observed in March 2017, and following the population crash and reduction of individuals on the landscape, we observed the best nutritional condition we've ever seen in this population in December of 2017.

The effects of the 2016-17 winter has been distressing, but we now are uniquely poised to document the long-term effects of severe winters and understand the factors that will influence population recovery from the devastating losses. We have been extremely fortunate to have been conducting research on this herd, not only through the course of this harsh winter, but for several years prior, which will yield the data to address questions associated with how severe winters may affect mule deer herds throughout the state. With dramatic reductions in density, forage resources available per individual should be bolstered and thus, nutritional condition, reproductive success, and survival may well all respond very favorably. Nevertheless, with lower deer density compared with recent decades, the role of predators in this population also may change in either positive or negative ways. The marked decline of the Wyoming Range deer population following the 1992-93 winter, and the near absence of any substantial recovery thereafter, also begs the question to what extent recovery will occur given historic patterns. Regardless, the overwhelming management desire is for recovery, and our aim is to document recovery and the mechanisms that underpin it

Understanding the Ecology of Male Mule Deer in the Wyoming Range


Mark Gocke

The Wyoming Range mule deer herd holds substantial cultural and economic importance, in part, because of the opportunities it provides for hunters from both Wyoming and throughout the West to harvest male deer, and for some, to harvest large males. Despite the importance of male mule deer in the Wyoming Range to both the public and economy, we still lack fundamental understandings of much of the ecology of males (i.e., migratory behaviors, vulnerability to harvest, dispersal from natal home ranges), and thus, many questions arise as to how season dates should be established, how male deer respond to harvest pressure, and whether males are being recruited into older age segments. Or for example, even more basic questions associated with how population processes are stocking high-elevation basins with male deer remains largely unknown.

Beginning in the autumn of 2018, we began to collar male mule deer as part of the Wyoming Range Mule Deer project, and hope to continue these efforts over the next three years. The Wyoming Range Mule Deer project has begun to disentangle many of the factors that may regulate mule deer herds in Wyoming, but there is still a critical gap in understanding the ecology of this herd. Despite the fact that males are often the segment of the population most valued by the public, there exists little information on how their ecology differs from females, and thus, how males may behave or respond differently from females to regulating or limiting factors. Indeed, harvest of females has been restricted almost completely in the Wyoming Range since 1993 and thus, almost all harvest-related opportunity in the population is provided by the male segment. The Wyoming Range herd is universally considered by many as one of the premier herds for hunting large mule

deer in North America. Accordingly, most conversations associated with management of the Wyoming Range herd, and many others for that matter, is focused around harvest of males. Outside of antler morphology characteristics and age specific data that is collected in the field by managers subsequent to harvest, little information is available that contributes to the management of the male cohort. In fact, other than posthunt male:female ratios, there are no other long-term, consistently obtained or reliable data sets that describe the annual population dynamic, or effects of management action on the 1+-year old cohort of males. Consequently, we generally lack empirical information to help inform discussions as to management of males. This discussion occurs at a time when segments of the hunting public are asking for a dichotomous, and inherently conflicting, set of management actions be implemented that dramatically restricts hunting of males, as well as providing increased opportunity to harvest trophy class males during the migratory period (i.e., longer hunting seasons) or when males arrive on winter ranges.

Existing evidence and theory indicates that male ungulates differ markedly in their behavior, nutritional dynamics, and growth, and as a consequence, can exhibit demographics divergent to that of females. It has been recommended that male ungulates be considered as essentially a different species compared with females, because of their striking differences in life history. Although they represent a flexible resource within populations because harvest of males plays little role in affecting population dynamics for polygynous ungulates, increasing interest in maintaining male:female ratios at specified levels and maintaining a specific age structure has become common criteria in management plans. Moreover, heightened discussions on harvest pressure and the topic of limited quota harvest regimes exemplify the need for additional insight into the ecology of male deer.

Future Directions

The overall goal of our continued work in the Wyoming Range will be to build on our understanding of nutritional and population ecology of this herd to answer a suite of questions that can only be addressed using long-term and continuous data. The mule deer of the Wyoming Range are one of the most cherished populations of wildlife in western North America, and we seek to gain a better understanding of how this population is responding to an increasingly changing environment, while simultaneously answering complex questions critical to advancing our understanding of this species that have long eluded ecologists. By following individuals from birth throughout their life, we can begin to better understand the behavioral and physiological adaptations these animals possess to persist in such a stochastic landscape, and identify what factors may play crucial roles on long-term population dynamics. Our work has begun to identify the effects of a severe winter on this population of mule deer, and we are now equipped to identify the severity and longevity of carryover effects on a population following an extreme winter. Further, we are beginning to understand how migratory patterns are passed from generation to generation, and will soon be able to assess how those patterns differ between males and females, and ultimately what dictates patterns of occupancy by deer across a diverse landscape. Our approach will allow us to continue to elucidate the relative roles of habitat, nutrition, predation, and disease on the regulation of deer in western Wyoming, and to begin to address questions that require long-term data but are crucial to the successful management of mule deer in Wyoming.

Partners

The Wyoming Range Deer Project is a collaborative partnership in inception, development, operations, and funding. Without all the active partners, this work would not be possible. Funds have been provided by the Wyoming Game and Fish Department, Wyoming Game and Fish Commission, Wyoming Wildlife and Natural Resource Trust, Muley Fanatic Foundation, Bureau of Land Management, Knobloch Family Foundation, U.S. Geological Survey, National Science Foundation, Wyoming Governor's Big Game License Coalition, Boone and Crockett Club, Animal Damage Management Board, Ridgeline Energy Atlantic Power, Bowhunters of Wyoming, and the Wyoming Outfitters and Guides Association. Special thanks to the Wyoming Game and Fish Department, Bureau of Land Management, and Wyoming State Veterinary Lab for assistance with logistics, lab analyses, and fieldwork. Also, thanks to the Cokeville Meadows National Wildlife Refuge and U.S. Forest Service for providing field housing.

MONTEITH SHOP

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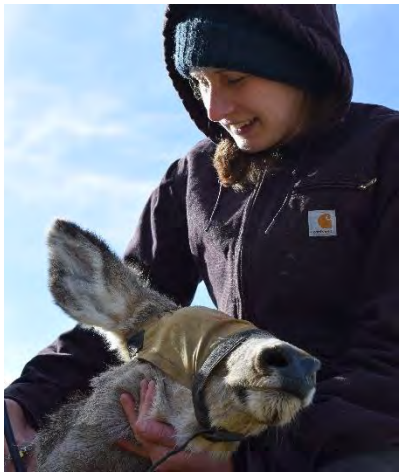
Kevin Monteith

Kevin Monteith is an Assistant Professor of the Haub School of Environment and Natural Resources and the Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology at the University of Wyoming. After receiving his BSc and MSc in Wildlife and Fisheries Sciences from South Dakota State University, he went on to obtain his PhD in Biology from Idaho State University in 2011. Kevin's research program is focused on integrating nutritional ecology with intensive field studies of large ungulates to elucidate the mechanisms that underpin behavior, growth, reproductive allocation, predator-prey dynamics, and ultimately, the factors affecting population growth. Kevin and his graduate students are currently conducting research on most of Wyoming's large ungulates; topics are centered on establishing a protocol for habitat-based, sustainable management of ungulate populations, while investigating the effects of predation, habitat alteration, climate change, migration tactics, and novel disturbance.

Ellen Aikens



Ellen is a PhD candidate in the Program in Ecology at the University of Wyoming. Ellen is fascinated by animal movement, especially migration. Ellen plans to pursue a career in research, with a focus on the interface between fundamental research and applied conservation and management. Before coming to Wyoming, Ellen worked at the Smithsonian Conservation Biology Institute's GIS lab, where she analyzed remote sensing and GPS telemetry data for conservation research projects across the globe. Ellen is a recipient of the National Science Foundation Graduate Research Fellowship and the Berry Fellowship. Ellen earned her bachelor's degree in Biology and Environmental Studies from Ursinus College.

Samantha Dwinnell

Samantha Dwinnell is a Research Scientist with the Haub School of Environment and Natural Resources. Samantha is the first student to miraculously graduate (May 2017) with a MSc from the Monteith Shop. Immediately following her defense that was made successful through bribery, she foolishly convinced Dr. Monteith to hire her as a Research Scientist to manage the Wyoming Range Mule Deer Project. Samantha's graduate research was focused on the nutritional relationships among mule deer behavior, forage, and human disturbance. Currently, her research is focused on disentangling the relative influence of various factors that affect fawn survival. Although Samantha is most interested in research aimed at informing management and conservation of wildlife, she also dedicates research efforts into finding ways to mountain bike and ski without her boss knowing.

Rhiannon Jakopak

Rhiannon is currently a master's student in the Cooperative Fish and Wildlife Research Unit at the University of Wyoming. She received dual bachelor's degrees in Wildlife and Fisheries Biology and Management and Religious Studies at the University of Wyoming in 2016. She is broadly interested in population ecology and mammalogy, and more specifically interested in the processes regulating the distribution of species. Her master's project seeks to identify the factors which influence the development of migration and the subsequent population consequences.

Tayler LaSharr

Tayler LaSharr is a PhD student in the Cooperative Fish and Wildlife Research Unit. Tayler is originally from Phoenix, AZ and attended the University of Arizona where she obtained a BSc in Natural Resources with an emphasis in Conservation Biology and a minor in Chemistry in May of 2015. During her time at the University of Arizona, she studied life history tradeoffs in Western and Mountain Bluebirds and the effects of aggression in closely related species on habitat and range dynamics. She completed her MSc in the Monteith shop in the spring of 2018 assessing the effects of harvest on horn size of mountain sheep. She now is working on a component of the Wyoming Range Mule Deer Project assessing population recovery following a severe winter for her PhD research.

Haub School of Environment and Natural Resources

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Appendix D. Wyoming Range Mule Deer Herd, posthunt herd composition data, 2012-2018.										
							Ratio:100 Females			
2012	Yrlng Males	Adult Males	Total Males	Does	Fawns	Total	Yrlng Males	Adult Males	Total Males	Fawns
HA134	55	103	158	635	404	1197	9	16	25	64
HA135	80	159	239	822	647	1708	10	19	29	79
HA143	116	177	293	799	505	1597	14	22	37	63
144/145	Survey conducted in February 2013					764				
TOTAL	251	439	690	2256	1556	5266	11	19	30	69
2013										
HA134	99	175	274	660	496	1430	15	26	41	75
HA135	145	203	348	913	672	1933	16	22	38	74
HA143	300	326	626	1373	897	2896	22	24	46	65
144/145	Survey conducted in March 2014					805				
TOTAL	544	704	1248	2946	2065	7064	18	24	42	70
2014										
HA134	100	138	238	565	466	1269	18	24	42	82
HA135	191	322	513	1386	1128	3027	14	23	37	81
HA143	291	271	562	1288	884	2734	22	21	43	68
144/145	Survey conducted in February 2015					1005				
TOTAL	582	731	1313	3239	2478	8035	18	22	40	76
2015										
HA134	81	173	254	737	406	1397	11	23	34	55
HA135	176	302	478	1188	828	2494	15	25	40	70
HA143	415	399	814	2005	1147	3966	21	20	41	57
144/145	Survey conducted in February 2016					440				
TOTAL	672	874	1546	3930	2381	8297	17	22	39	60
2016										
HA134	95	190	285	774	489	1549	12	24	36	63
HA135	182	380	562	1605	1008	3175	11	24	35	63
HA143	256	260	516	1430	723	2669	18	18	36	50
144/145	Survey conducted in February 2017					517				
TOTAL	533	830	1363	3809	2220	7910	14	22	36	58
2017										
HA134	14	153	167	672	389	1228	2	23	25	58
HA135	47	282	329	1105	701	2135	4	25	30	63
HA143	111	348	459	1547	701	2707	7	22	30	45
144/145	Sightability Survey Conducted in February 2018					1405				
TOTAL	172	783	955	3324	1791	7475	5	23	29	54
2018										
HA134	134	135	269	1223	721	2213	11	11	22	59
HA135	197	375	572	1752	1070	3394	11	21	33	61
HA143	178	239	417	1277	742	2436	14	19	33	58
144/145	Survey to be conducted in February 2019									
TOTAL	509	749	1258	4252	2533	8,043	12	18	29	59

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