Integrating statewide research and monitoring data for mule deer in Montana

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Annual report, December 2018

Project Personnel

Nick DeCesare, Research Biologist
Tonya Chilton-Radandt, Area Biologist - Libby
Brent Lonner, Area Biologist – Fairfield
Tim Thier, Area Biologist - Trego

Teagan Hayes, MS Student
Collin Peterson, MS Student
Chad Bishop, Director, Wildlife Biology Program
Mike Mitchell, Unit Leader, MCWRU

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Background and summary

Over the past century, mule deer (*Odocoileus hemionus*) have experienced periods of population growth and decline throughout their range (Mackie et al. 1998, Pierce et al. 2012, Bergman et al. 2015). Studies of mule deer population dynamics have revealed a suite of interacting factors which influence annual variation and trends in population growth (Mackie et al. 1998, Unsworth et al. 1999, Pierce et al. 2012, Monteith et al. 2014, Hurley et al. 2014, Ciuti et al. 2015). The complexity of mule deer population dynamics creates a challenge for biologists seeking to monitor local deer populations and respond with appropriate management decisions in a timely manner (White and Bartmann 1998, Bishop et al. 2005).

Mule deer population trends are of particular concern in Montana, where significant declines in hunter harvest and abundance have been documented in many areas throughout the state. Wildlife managers are tasked with the difficult mission of maintaining or recovering deer populations, dampening the magnitude of potential future declines, and stabilizing hunter opportunity. Therefore, improved quantitative understanding of mule deer dynamics is of particular relevance across Montana. The methods by which Montana Fish, Wildlife and Parks (MFWP) currently monitors and manages mule deer were established in 2001 with the adoption of the Adaptive Harvest Management (AHM) system (MFWP 2001). This system included four components: 1) population objectives, 2) monitoring program, 3) hunting regulation alternatives, and 4) population modeling. The population modeling component of AHM was initially designed to predict future deer dynamics given a suite of harvest and weather scenarios. Despite being founded upon very powerful data sets, Pac and Stewart (2007) found the AHM population models achieved mixed results and subsequently recommended they remain in an experimental phase rather than be implemented as a management tool.

MFWP currently collects multiple sources of monitoring data to guide management decisions under the AHM system, and distinct from this current process are other vital rate data collected as part of research studies. With this project, we seek to leverage existing monitoring and research data together for an integrated quantitative assessment of mule deer dynamics for guiding management. Additionally, we aim to collect novel field data in portions of northwest Montana and along the Rocky Mountain Front where biologists are faced with reduced mule deer numbers yet lack basic ecological and population information to manage with strong confidence.

Location

Field studies are focused in Lincoln, Flathead, and Lewis and Clark counties, where mule deer use 3 different and less understood habitat types. Population modeling involves utilization of research and monitoring mule deer data from across their statewide distribution.

Study Objectives (2017-2018)

During the 2018 calendar year, the primary objectives were to;

1) Begin development of integrated population models: compile population monitoring data for population modelling at a statewide scale

2) Initiate mule deer field studies in 3 study areas of Montana
   2.1 Continue winter deer captures across 3 study areas
   2.2 Begin vital rate monitoring of adult female mule deer
   2.3 Monitor seasonal space use and migration of adult female mule deer.

3) Initiate study of mule deer habitat selection and foraging in 3 study areas
   3.1 Preliminary assessment of summer habitat use
   3.2 Apply DNA-based techniques to estimate seasonal diets
   3.3 Conduct field work to assess forage species composition, biomass and quality

Objective #1: *Integrated population modelling*

Integrated population models (IPMs) are growing in use by management agencies seeking to accommodate multiple data streams that characterize populations (Cooper et al. 2003, Schaub et al. 2007, Johnson et al. 2010, McCaffery and Lukacs 2016). One advantage to this approach is that it aligns multiple data streams into a single model of the population, while weighting the contribution of each data set according to its relative precision. A second advantage is that it formalizes the level of uncertainty surrounding any given point estimate, such that estimates of population trend or recruitment ratios come with explicit attention to precision. Third, one can incorporate links to environmental covariates into population models, which show particular potential for mule deer given links between remotely-sensed metrics of climate and vegetation and concurrent deer population dynamics (Mackie et al. 1998, Hurley et al. 2014, Ciuti et al. 2015, Stoner et al. 2016). Lastly, these models could conceivably facilitate the extrapolation of patterns from data-rich hunting districts to those without comparable monitoring data.

Much of the model building necessary for this portion of the project has yet to gain substantial progress. We have setup a contract with University of Montana researchers and collaborative work on population models will continue in calendar year 2019. Substantial effort by MFWP staff including Jay Newell, MFWP Wildlife Division Survey and Inventory Specialist (retired) and Wildlife Division Biometrician Kevin Podruzny has resulted in standardized databases of mule deer monitoring data, including aerial survey and hunter harvest data statewide. We expect to build population models that leverage data from 2005–2018, founded about monitoring data, and additionally informed by vital rate data from research projects and values from the literature.

Objective #2: *Field studies in 3 study areas of Montana*

2.1. Animal capture and handling

Across 3 study areas, we have captured and radio-collared 101 adult female mule deer for the purposes of studying vital rates, seasonal space use and migration, habitat selection, and summer forage species composition, quantity, and quality. All deer were fit with GPS radio-collars (Lotek LifeCycle330), and deer were caught using a combination of helicopter net-gunning and ground trapping with alfalfa-baited Clover traps (Figure 1; Table 1).

Figure 1. *Mule deer field research study area locations (map also showing deer population management units [PMUs] and hunting districts), and a remote camera photo of deer approaching a baited Clover trap site in the Fisher River study area, January 2018.*

Table 1. *Numbers of adult female mule deer captured and radio-collared across 3 study areas, 2 winter seasons, and 3 capture techniques, Montana, 2017–2018.*

	Rocky Mtn Front		Fisher River		Whitefish Range	
	Helicopter net-gun	Ground darting	Helicopter net-gun	Clover trap	Helicopter net-gun	Clover trap
2017	30	2	0	0	2	0
2018	12	0	16	10	0	29
Total	44		26		31	
Currently on-air, 12/12/2018	26		21		19	

2.2 Vital rate monitoring

Capture and collaring of adult female deer in 3 study areas facilitates the monitoring of adult female survival and pregnancy rates. To date, we have monitored adult female survival for a total of 7,186 deer-days from 26 deer in the Fisher, 18,073 deer-days from 41 deer in the Rocky Mountain Front, and 7,417 deer-days from 31 deer in the Whitefish Range. We have yet to complete a full year of survival monitoring in the Fisher and Whitefish Range study areas; thus we will not report survival rates at this time. We have documented probable causes of death for a number of mortalities by inspecting carcasses an average of 2.7 days (range 0-12) following collar notification of mortality events (Table 2). Remote locations of some mortality sites have prevented us from determining causes in all cases.

Table 2. *Causes of mortality as determined from inspection of carcasses of GPS-collared adult female mule deer across 3 study areas in western Montana, 2017–2019. Note these data exclude 3 capture-related mortalities and are the result of 2 years of survival monitoring of 41 deer on the Rocky Mtn Front study area and 1 year of monitoring 26 deer in the Fisher River and 31 deer in the Whitefish Range study areas.*

Cause of mortality	Rocky Mtn Front	Fisher River	Whitefish Range	Total
Health related	2	1	2	5
Infected wound	1			1
Predation, lion	3	2	7	12
Predation, wolf	2	1		3
Unknown	6		3	9
Total	14	4	12	30

At the time of capture, blood samples are collected for pregnancy determination via lab analysis of pregnancy-specific protein B (PSPB) levels in deer serum (Wood et al. 1986). This assay is most effective ≥40 days following conception. The peak period of breeding for mule deer in Montana is estimated to occur in mid-November; thus we censored 8 samples from our pregnancy analyses collected in December when PSPB results were not yet reliable. This leaves us with a remaining total of 97 serum samples collected during January–March across the 3 study areas.

Pregnancy rates thus far have been estimated as 76% in the Fisher River (N=21), 100% (N=46) in the Rocky Mountain Front, and 100% (N=30) in the Whitefish Range. Just 5 females, all from the Fisher River study area, were estimated as non-pregnant. Of these 5, 3 were aged in the field as yearlings, and age was unknown for the other 2. Pregnancy of yearling mule deer has been shown to be more sensitive to a population's average nutritional status than that of adult does (Julander et al. 1961, Monteith et al. 2014). Thus, it is possible that lower yearling pregnancy in this population is indicative of a limiting role of nutrition in overall population-level dynamics. However, pregnancy rate for this population in particular is founded upon a relatively low sample size of individuals (N=21), and testing may have missed late-estrus pregnancies as well. Additional pregnancy sampling during the winter of 2018–2019 will improve our understanding of this vital rate across all populations.

2.3. Space use and seasonal migrations

Deer populations in all 3 study areas exhibited some degree of partial-migration behavior, in which some individuals remained resident in an annual range, whereas others migrated various distances from winter to summer range.

<u>Rocky Mountain Front</u>

Of 30 deer alive on June 1, 2018, 7 migrated <4 km and were considered residents. Mean straight-line migration distance (the distance between the winter and summer home range centroids) was 20.44 km (SD=16.5, range=0.47–59.1). Of the deer that migrated, the majority moved westward into the Bob Marshall Wilderness Complex; however, 2 deer migrated south along the Rocky Mountain Front and remained in plains habitat yearlong (Figure 2).

A)

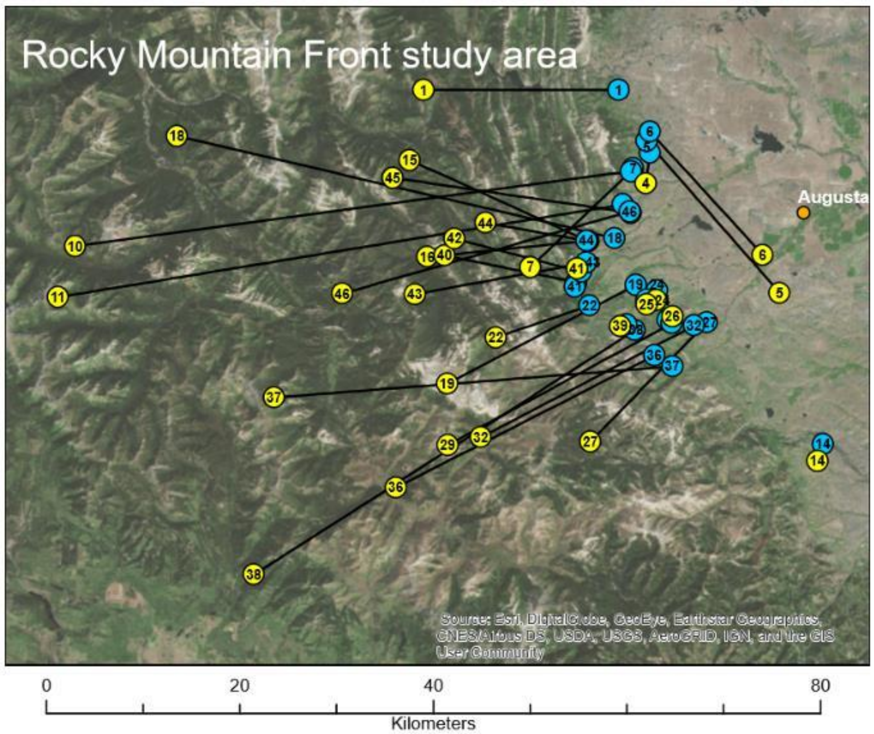
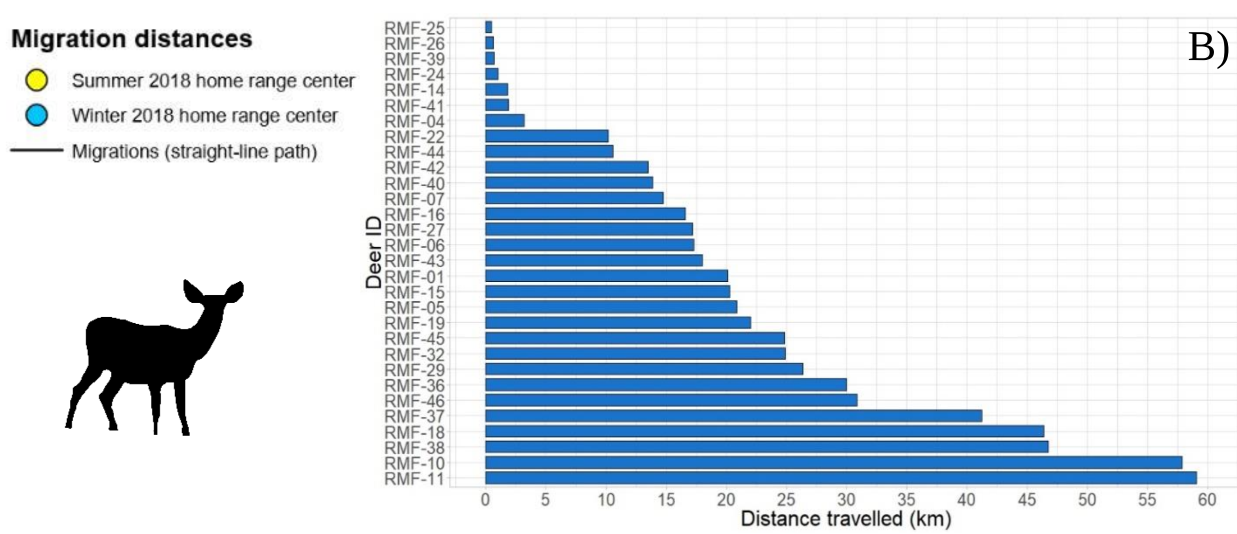


Figure 2. *A) Straight-line migration paths and B) straight-line migration distances between individual deer 2018 winter and summer home range centroids for adult female mule deer in the Rocky Mountain Front study area, Montana.*



<u>Fisher River / Salish Range</u>

Of the 21 deer in the Fisher River study area still alive June 1, 2018, 2 remained resident. Mean migration distance was 30 km (SD = 11.76 km, range = 0.23 – 45.96 km). The direction deer migrated appeared dependent on which side of the Fisher River they over-wintered on. Of the 8 deer collared on the west side of the Fisher, 7 migrated west and eventually summered in the Cabinet Mountains, while 1 remained resident. Of the 13 deer collared on the east side, 12 migrated east into the Salish Mountains and 1 remained resident (Figure 3).

A)

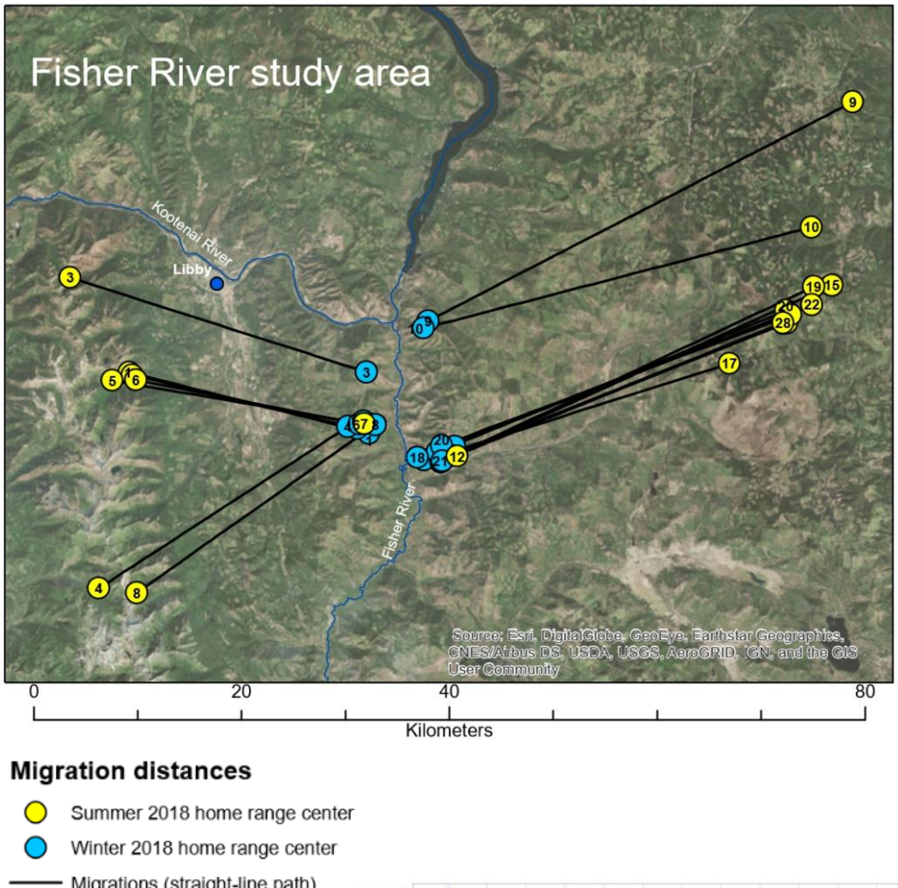
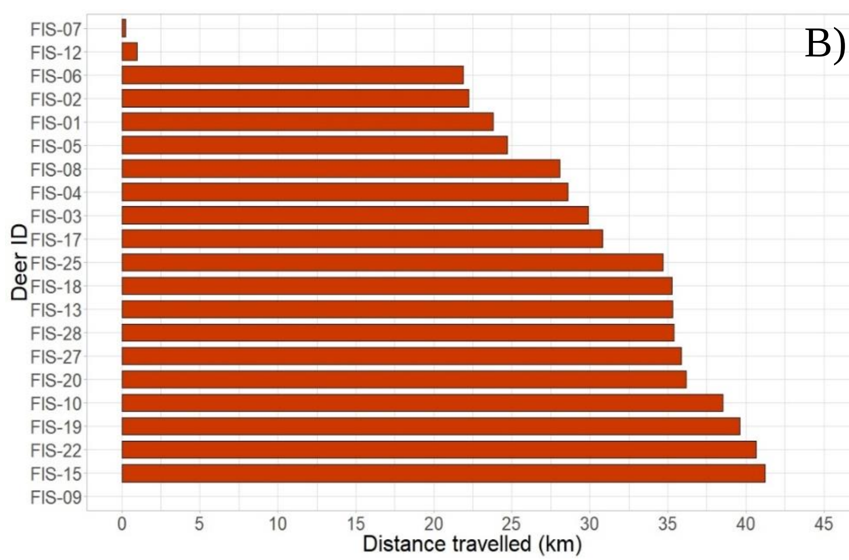


Figure 3. *A) Straight-line migration paths and B) straight-line migration distances between individual deer 2018 winter and summer home range centroids for adult female mule deer in the Fisher River area, Montana.*

B)



Whitefish Range
Of the 21 deer in the Whitefish Range study area still alive June 1, 2018, 3 remained resident. Mean migration distance was 20.71 km (SD = 12.46 km, range = 0.53 – 42.45 km). 4 deer crossed the Canadian border and spent their summers in British Columbia, and the majority of the remaining deer migrated east into the Whitefish Range (Figure 4).

A)

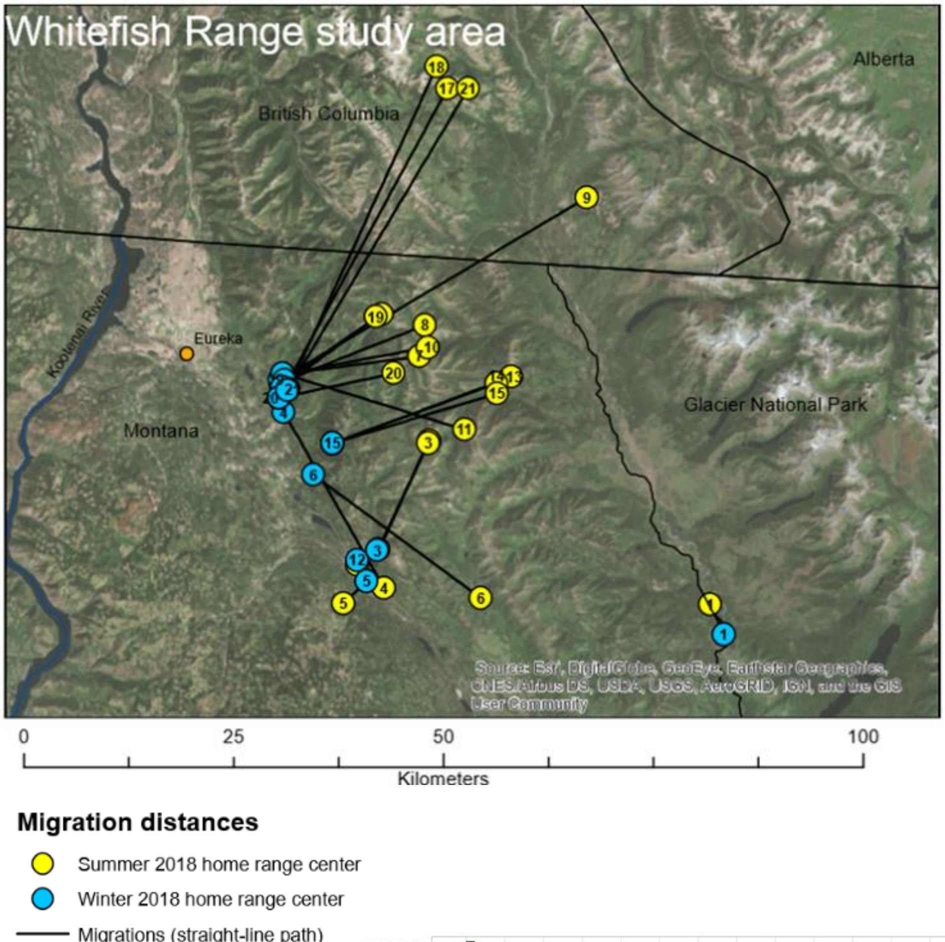
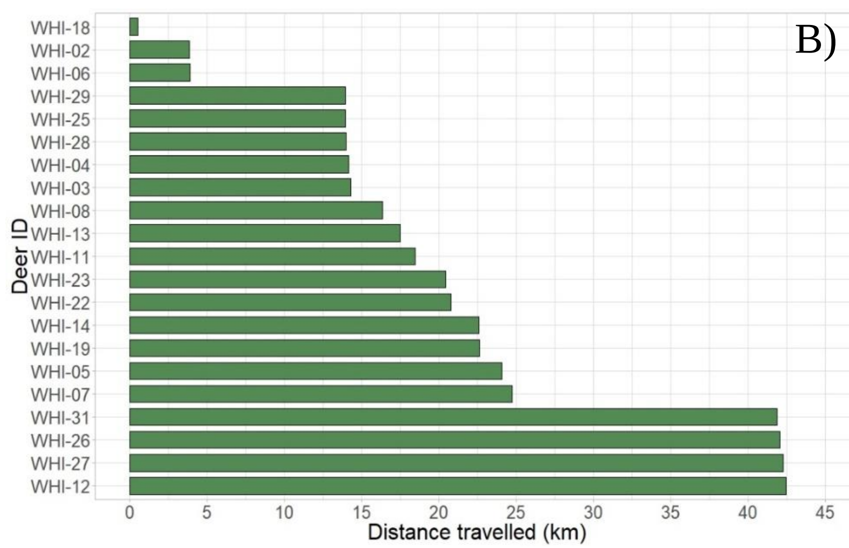


Figure 4. *A) Straight-line migration paths and B) straight-line migration distances between individual deer 2018 winter and summer home range centroids for adult female mule deer in the Whitefish Range study area, Montana.*



Objective #3. *Mule deer habitat selection and forage studies*

3.1 Habitat use and selection

The habitat an animal uses is dependent on both the availability of different habitat components (the proportion of a population range comprised of a particular habitat-type) and the degree to which particular features are selected or avoided. This project will include multi-scale analyses of mule deer habitat selection across seasonal ranges. In this annual report, we provide initial descriptive summaries of mule deer habitat use of vegetation types, measured as the proportional use of vegetation types from collared deer GPS locations. To determine vegetation types and disturbances used by mule deer, we extracted landcover data from the Fire History polygons for the USDA Forest Service Northern Region (R1) layer (available online at https://fam.nwcg.gov/fam-web/), LANDFIRE disturbance layers (www.landfire.gov), and the Montana State Data Infrastructure (MSDI) land use and landcover dataset (http://geoinfo.msl.mt.gov/msdi).

Mule deer use was highly variable both within and between study areas. Summer (June–September) habitat use by deer in the Rocky Mountain Front included 16% of GPS collar locations in grasslands, including both montane grasslands and meadows as well as lowland prairies and plains habitats, 21% of locations in conifer forests, and 52% of locations in burns ranging from 0 to 30 years old (Figure 5). In the Fisher River study area, 80% of summer locations occurred in burns, and 80% of these locations were in 6 to 15 year-old burns (though many of these locations correspond with 9 deer that spent summered in the same burn in the Salish Range). An additional 13% of use occurred in conifer forest, and 4% occurred in harvested forest (Figure 5). It is noteworthy that landcover data used for this analysis may not include the most recent timber harvest information, and thus use of harvested habitats may be an underestimate. In the Whitefish Range study area 19% of deer locations (from 4 deer) occurred in Canada. Of deer that remained in the United States, 46% of locations were in conifer forest, 28% were in burned habitats, and 18% were in grasslands and deciduous shrublands, many of which were in high elevation meadows, ridgelines, and avalanche chutes (Figure 5).

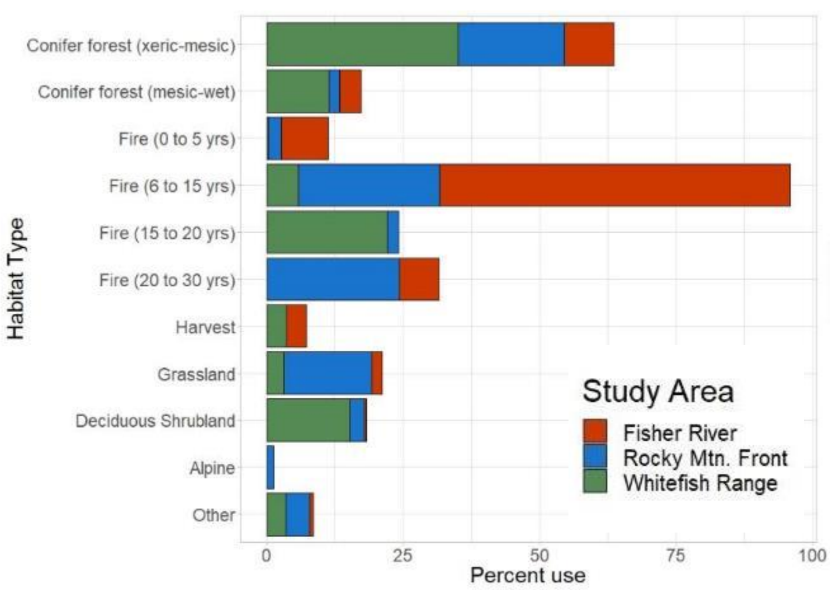


Figure 5. *Habitat use by adult female mule deer in 3 study areas according to the proportional occurrence of GPS collar locations during June 1–Sep. 1, 2018. "Harvest" category includes clear-cut and thinning practices. "Other" category includes riparian, wetlands, deciduous forests, sagebrush steppe, agricultural fields, talus, insect-killed forests, prescribed fires, and human development.*

3.2 Seasonal diet sampling

Diet and nutrition have been consistently shown to be important drivers of mule deer survival, reproduction and overall population stability (Bishop et al. 2009, Monteith et al. 2014). Therefore, understanding mule deer diet helps to inform population and habitat management. During winter captures, we collected fecal pellets from newly collared mule deer. In addition, we collected fecal pellets from observed or other opportunistic collared and un-collared mule deer during summer and fall. We will continue this work during both seasons, including devoting additional field effort towards summer sampling to estimate both individual- and population-level diets across seasons and study areas (Table 3).

Table 3. *Fecal samples collected during fall, winter, and summer, where applicable. Samples may be from collared and un-collared mule deer, including males and females.*

	2017			2018			*Total*
	Winter	*Summer*	*Fall*	*Winter*	*Summer*	*Fall*	
Rocky Mountain Front	34	12	9	12	15	-	82
Fisher / Salish Range	-	-	-	27	19	4	50
Whitefish Mountains	2		-	32	4	-	38
Total	57			113			170

Traditional methods of microhistology assess diet composition based on fecal plant fragments; however, this method can underestimate the importance of forage plants with higher digestibility or faster decomposition (Alipayo et al. 1992). DNA-based approaches select and sequence a standardized region (DNA barcode) from DNA in fecal samples and compare it to a reference database for identification. The development of next generation sequencing (NGS) can identify up to thousands of species simultaneously (DNA metabarcoding), making DNA-based methods more accessible, faster, and more accurate than ever before (Pompanon et al. 2012). NGS returns the relative quantities of plant species in mule deer diets.

Preliminary results from 2017 diet analysis of mule deer on the Rocky Mountain Front indicate a shift in forage plants between winter and summer seasons (Table 4). In winter, deer diets expanded to a greater number of crop/forage grass species. Winter forage also tended to include species with higher winter nutritional value including evergreen trees and shrubs and forbs that remain nutritious under snow and degrade relatively slowly under freeze/thaw conditions. In summer, deer diets included more forbs and shrubs that peak in summer months but degrade more quickly with the onset of winter.

Table 4. *Forage species in Rocky Mountain Front mule deer diets. Fecal samples were collected in 2017 during winter (34 samples) and summer (12 samples). The table shows approximately the top 20 forage plants during each season, sorted from top (most) to bottom (least) according to the total quantity of reads across all samples using a DNA metabarcoding approach. Diet analyses for other study areas are underway.*

RMF 2017 Winter diet			RMF 2017 Summer diet		
Plant species	Common name	Plant type	Plant species	Common name	Plant type
Pseudotsuga menziesii	Douglas fir	tree	*Rosa* spp.	rose	shrub
Juniperus sp.	juniper	shrub/ tree	*Chamerion angustifolium*	fireweed	forb
Geum triflorum	prairie smoke	forb	*Fragaria* spp.	strawberry	forb
Cerastium sp.	chickweed	forb	*Salix* spp.	willow	shrub
Grass/forage crop spp.	-	grass	*Ribes* spp.	currant	forb
Larix sp.	larch	tree	*Pinus* spp.	pine	tree
Eriogonum umbellatum	buckwheat	forb	*Potentilla* spp.	cinquefoil	forb/ shrub
Rosa sp.	rose	shrub	Grass/forage crop spp.	-	grass
Trisetum flavescens	oatgrass	grass	*Glycyrrhiza lepidota*	wild licorice	forb
Douglasia sp.	douglasia	forb	Aster spp.	aster	forb
Berberis repens	Oregon grape	shrub	*Pyrus* sp.	orchard apple	tree
Phleum pratense	timothy	grass	*Poa* spp.	bluegrass	grass
Poa spp.	bluegrass	grass	*Prunus* sp.	chokecherry	shrub
Heuchera sp.	alumroot	forb	*Rubus* sp.	raspberry	forb
Digitaria ischaemum	crabgrass	grass	*Spiraea* spp.	spirea	shrub
Penstemon sp.	beardtongue	forb	*Geranium* spp.	geranium	forb
Mitella sp.	miterwort	forb	*Rhus trilobata*	skunkbush sumac	shrub
Festuca idahoensis	Idaho fescue	grass	*Trisetum flavescens*	oatgrass	grass
Calamagrostis sp.	pinegrass	grass	*Silene* sp.	campion	forb
Fragaria sp.	strawberry	forb	*Elaeagnus* sp.	silverberry	shrub

3.3 Summer forage species composition, biomass and quality

University of Montana MS students Teagan Hayes and Collin Peterson have developed research proposals broadly focused on movement and nutrition of mule deer in forested ecosystems of western Montana. Their research questions investigate the influences of forest disturbances including fire and logging on deer nutrition and movement as well as the factors that influence selection of habitat and security on multiple scales.

Collin and Teagan, with help from a crew of 6 technicians (Figure 6), conducted field work in all three study areas from June through August 2018 during the second summer field season on this project. They collected fecal samples to characterize mule deer diets and completed vegetation surveys to quantify how vegetation and nutrition is distributed on the landscape. Vegetation and habitat surveys will continue for one more season in the summer of 2019.

During vegetation surveys, field personnel recorded species composition of forbs, graminoids, and shrubs. They also recorded canopy cover of all species and clipped all herbaceous plants (Figure 6). Biomass was weighed after the field season, and these data will be combined with plant species composition to estimate the available forage in sampled areas. Field crews sampled plots across a stratification of habitat types including grassland, deciduous shrubland, and conifer forest (Figure 7). They also conducted additional plots in disturbances that included wildfire, prescribed fire, and timber harvest of a wide range of ages. In total 407 vegetation plots (123 in Rocky Mountain Front, 163 in Fisher River, and 121 in Whitefish Range) were surveyed during the 2018 field season (Figure 7). Additionally, 53 plots were surveyed in the Rocky Mountain Front during summer 2017.

Figure 6. *Field crew members trained together in early June to calibrate measurements during vegetation surveys. They then moved on to work in separate study areas for the remainder of the field season.*

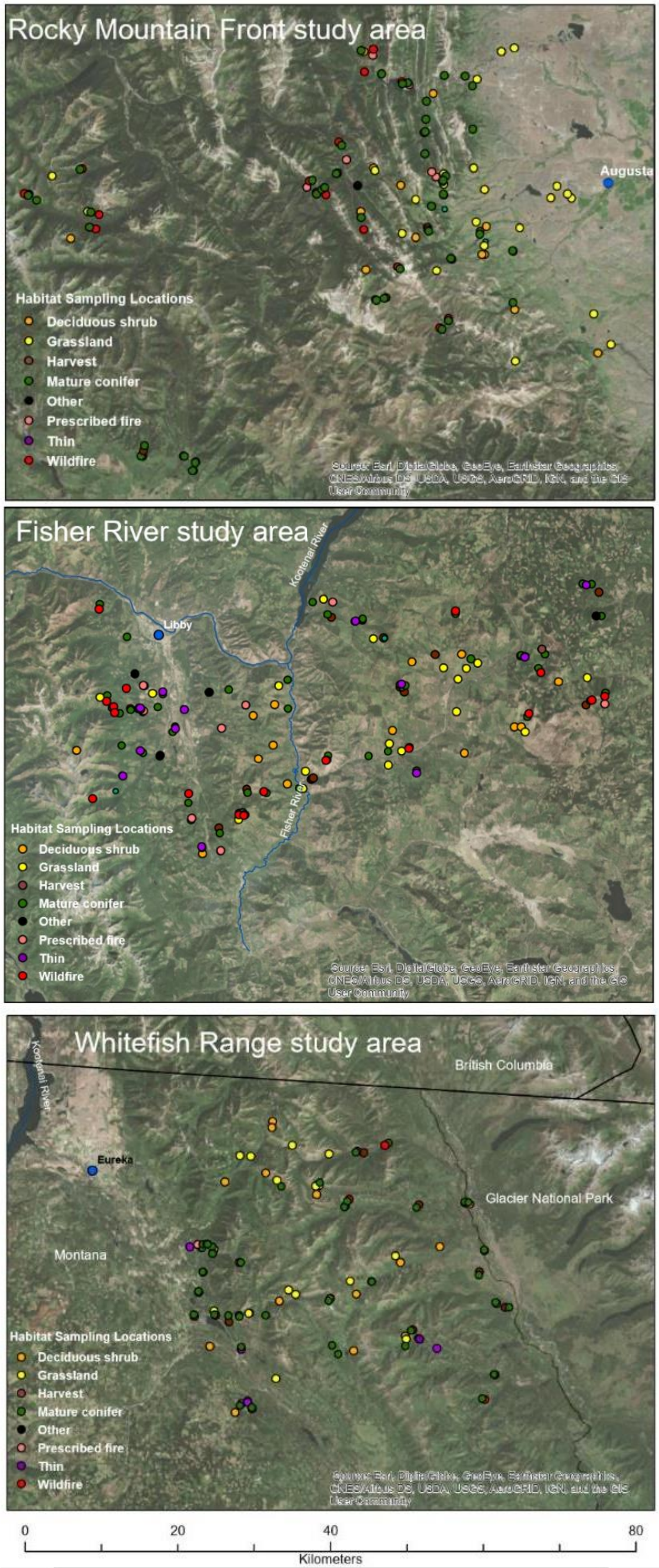


Figure 7. *Summer vegetation sampling locations in the a) Rocky Mountain Front, b) Whitefish Range and c) Fisher / Salish Range study areas, Montana, 2018.*

Acknowledgements
We are particularly thankful to the US Forest Service, the Nature Conservancy, Weyerhaeuser, Stimson Lumber Company, and many additional private landowners and area residents who graciously allowed us to conduct captures, ground monitoring and vegetation data collection on their properties. We are very grateful for the privilege to work on these properties and for all the time and help of these cooperators.

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