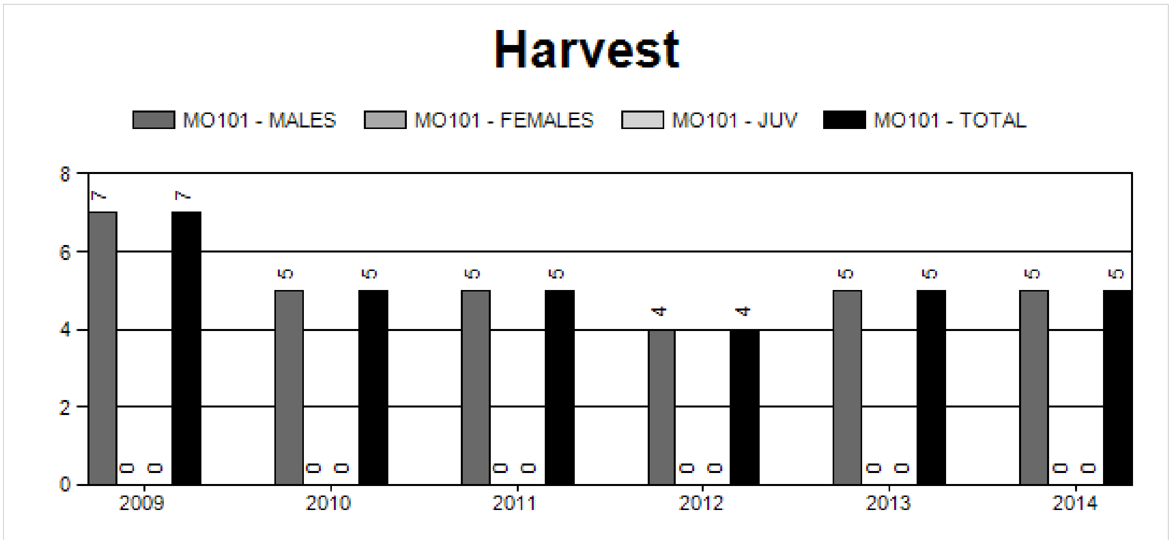
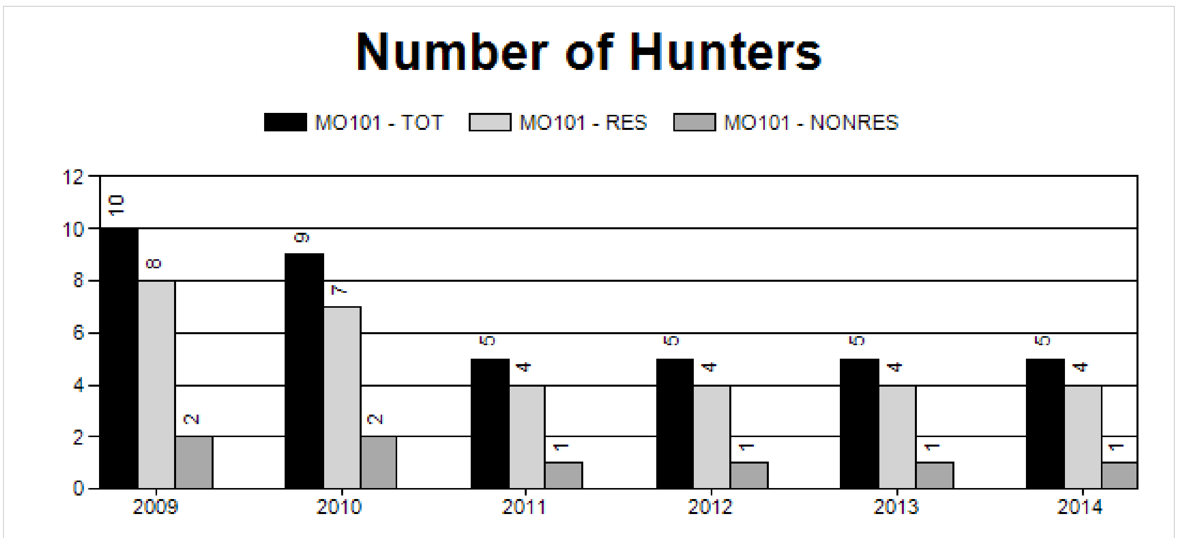
2014 - JCR Evaluation Form

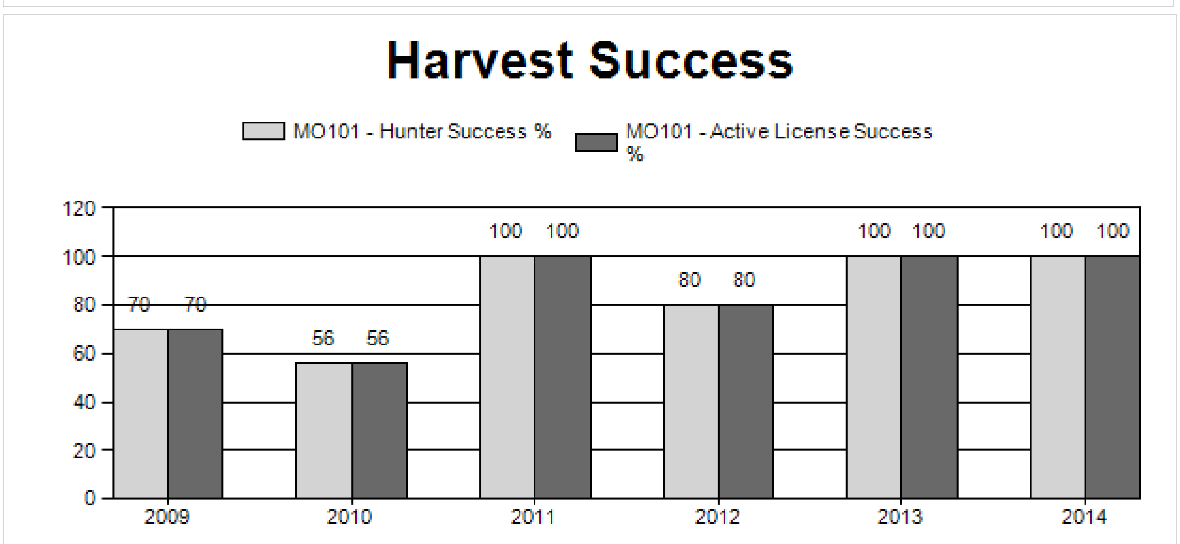
SPECIES: Moose
PERIOD: 6/1/2014 - 5/31/2015
HERD: MO101 - TARGHEE
HUNT AREAS: 16, 37
PREPARED BY: ALYSON COURTEMANCH

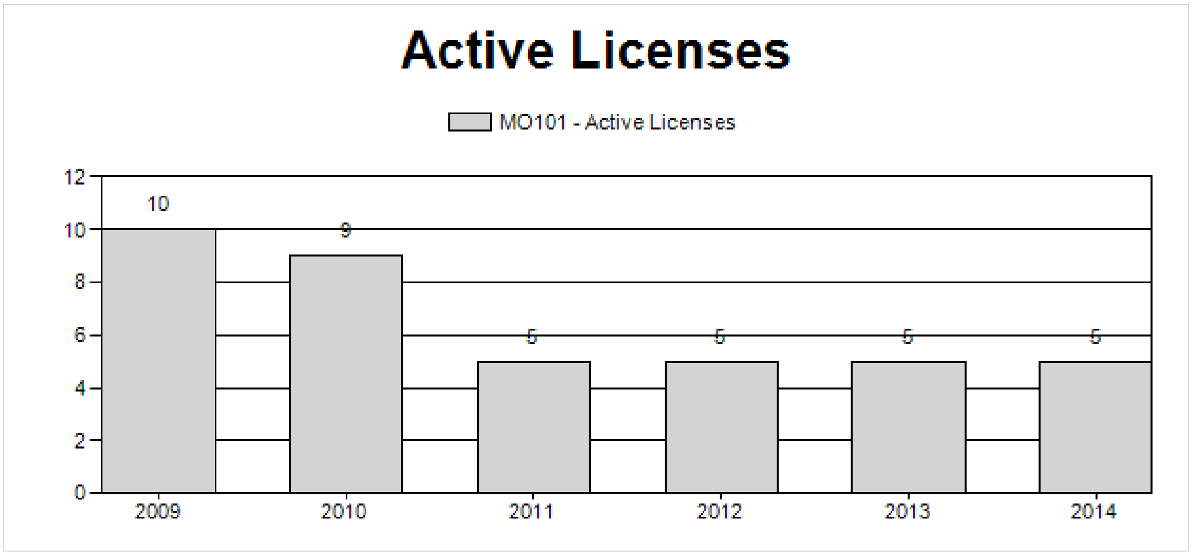
	2009 - 2013 Average	2014	2015 Proposed
Median Age of Harvest	3.5	3.5	4.5
Average Days to Harvest	8.9	4	7
Harvest:	5	5	5
Hunters:	7	5	5
Hunter Success:	71%	100%	100%
Active Licenses:	7	5	5
Active License Success:	71%	100%	100%
Recreation Days:	53	20	35
Days Per Animal:	10.6	4	7
Males per 100 Females:	85	0	
Juveniles per 100 Females	31	0	

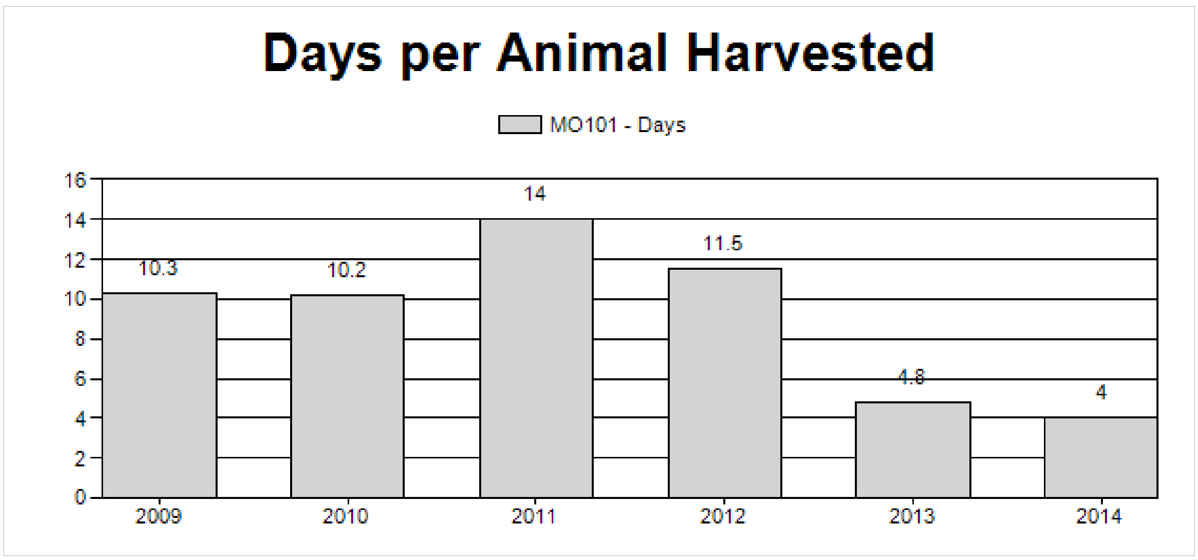
Limited Opportunity Objective:	≥ 4.5 years old ≤ 12 days to harvest
Management Strategy:	Special

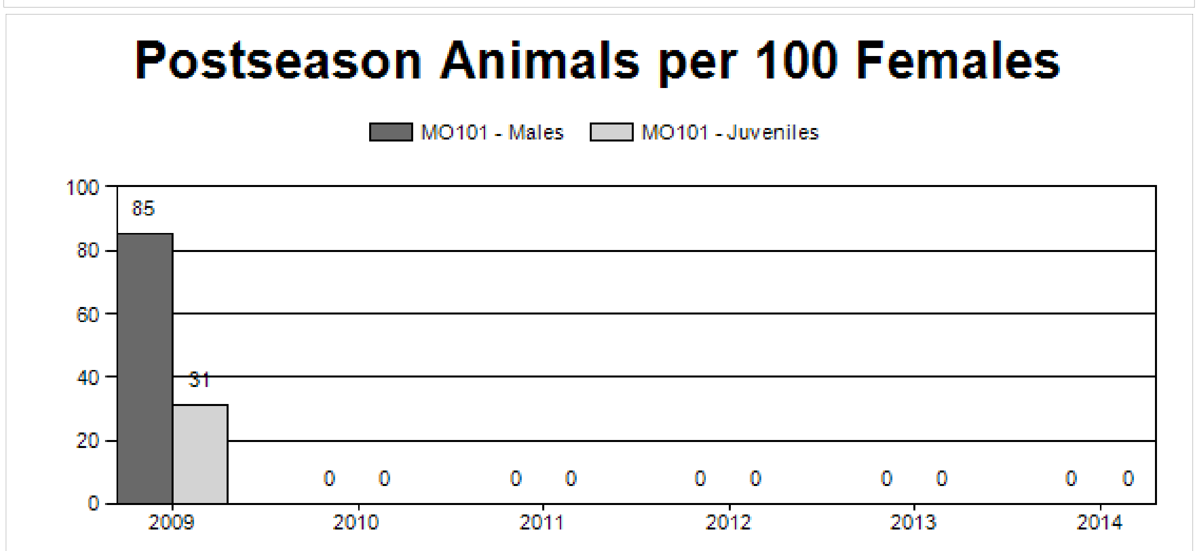

Harvest
MO101 - MALES
MO101 - FEMALES
MO101 - JUV
MO101 - TOTAL
2009
2010
2011
2012
2013
2014


Number of Hunters
MO101 - TOT
MO101 - RES
MO101 - NONRES
2009
2010
2011
2012
2013
2014


Harvest Success
MO101 - Hunter Success %
MO101 - Active License Success %
2009
2010
2011
2012
2013
2014


Active Licenses
MO101 - Active Licenses
12
10
8
6
4
2
0
10
9
5
5
5
5
2009
2010
2011
2012
2013
2014


Days per Animal Harvested
MO101 - Days
16
14
12
10
8
6
4
2
0
10.3
10.2
14
11.5
4.8
4
2009
2010
2011
2012
2013
2014


Postseason Animals per 100 Females
MO101 - Males
MO101 - Juveniles
100
80
60
40
20
0
85
31
0 0
0 0
0 0
0 0
0 0
2009
2010
2011
2012
2013
2014

2015 HUNTING SEASONS
TARGHEE MOOSE HERD (MO101)

Hunt Area	Type	Season Dates		Quota	License	Limitations
		Opens	Closes			
16, 37	1	Sep. 15	Nov. 15	5	Limited quota	Antlered moose

Special Archery Seasons

Hunt Area	Season Dates	
	Opens	Closes
16, 37	Sep. 1	Sep. 14

Management Evaluation

Management Strategy: Special
Limited Opportunity Objectives:
Primary Objectives:
1. Achieve a 5-year median age of ≥ 4.5 years for harvested moose, and
2. Achieve a 5-year average of ≤ 12 days/animal to harvest.

Secondary Objective:
Achieve a 5-year average of 40% of harvested moose are > 5 years of age.

The Wyoming Game and Fish Department (WGFD) proposed changing the objective for the Targhee Moose Herd from a postseason population objective to a limited opportunity 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. A limited opportunity objective was adopted in 2014 after public review, and included primary and secondary objectives (listed above).

In 2014, the median age of harvest moose was 3.5 years (n = 2 samples). The median age of harvested moose for the past 5 years is 3.5 years (n = 10 samples) (Figure 1). Therefore, the first primary objective of a median age of ≥ 4.5 years for harvested moose for 5 years is not currently met.

In 2014, the average number of days per animal to harvest was 4. The 5-year average of number of days per animal to harvest was 8.9 (Figure 2). Therefore, the second primary objective of a 5-year average of ≤ 12 days/animal to harvest is currently being met.

In 2014, two hunters submitted tooth samples from harvested moose for aging. Neither moose was > 5 years of age. During the past 5 years, 10 hunters have submitted moose tooth samples for aging. Of those, 4 moose were aged at > 5 years (5.5, 6.5, 7.5, and 10.5 years). Therefore, the secondary objective of at least 40% of harvested moose being > 5 years of age is currently met, although sample sizes are low.

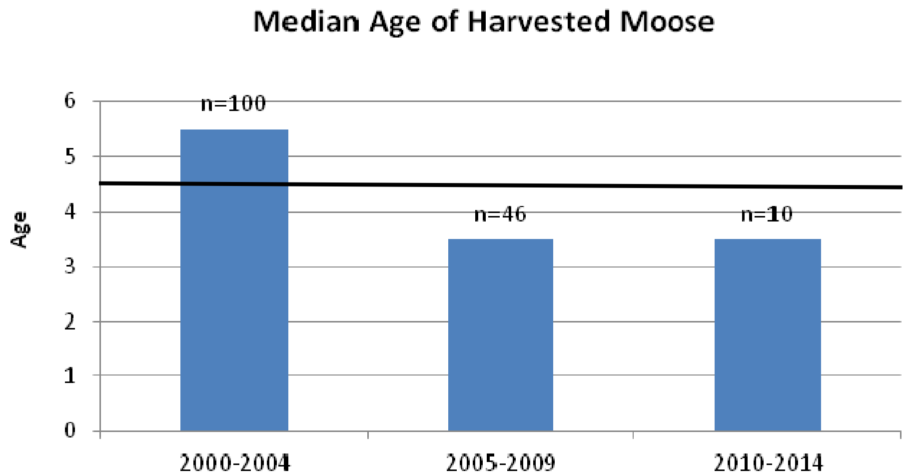


Figure 1. Median ages of harvested moose in the Targhee Herd in 5-year periods from 2000-2014. The black line indicates the objective of 4.5 years.

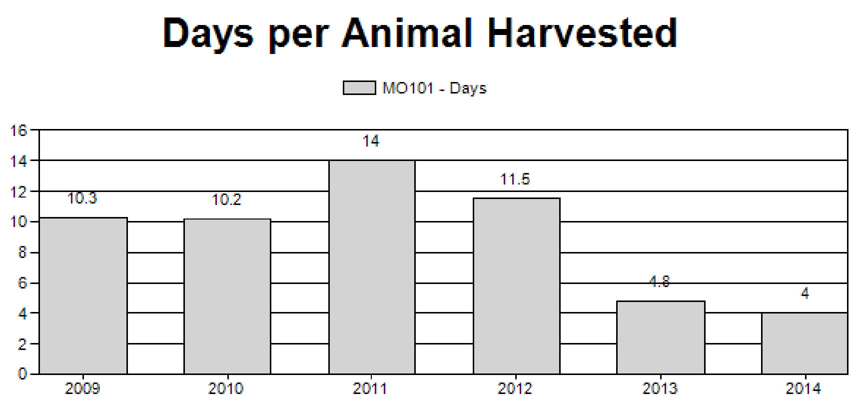


Figure 2. Average number of days per animal harvested in the Targhee Moose Herd from 2009-2014. The objective is ≤ 12 days per animal harvested.

Herd Unit Issues

Spreadsheet models developed for this moose herd do not appear to adequately simulate observed trends. This population is very difficult to survey and manage through harvest due to its interstate nature. Post-season classification surveys are not flown in this herd due to budget constraints. However, moose were opportunistically recorded during an aerial survey of the Targhee bighorn sheep herd in March 2015. Two cows, 2 calves, 5 bulls, and 1 unclassified adult were observed. Winter ranges are primarily low elevation mountain shrub and aspen communities and riparian willow and spruce/fir communities. On more severe winters moose may move west along riparian corridors towards the Teton River in Idaho. Many of the mountain shrub and aspen communities along the state line are old and decadent. Serviceberry, chokecherry, and mountain mahogany are often over 10 feet tall, above the browse zone for moose. Harvest has been as high as 70 moose in 1990 and 1991. License quotas were then decreased as harvest statistics and public comments indicated the population was decreasing. The license quota was decreased to 5 antlered moose in recent years.

Weather

Summer and fall 2014 produced consistent moisture, leading to good forage production. The Snake River Basin received above-average snowfall in December and early January, but weather turned warm and dry by February. Many low elevation slopes were snow-free by mid-February, but snow remained deep and heavy with a hard crust on north-facing slopes and higher elevations, which has likely increased energetic demands for moose and increased vulnerability to winter predation. At the time of the mid-winter survey, winter precipitation was reported at 91% of normal. 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 moose 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 2015. In addition, a habitat treatment in Teton Canyon is currently in the planning stages to improve mountain shrub and aspen communities for moose and other big game. The WGFD is assisting Caribou-Targhee National Forest (CTNF) with vegetation monitoring in aspen stands pre and post-treatment. Please refer to the 2014 Annual Report Strategic Habitat Plan Accomplishments for Jackson Region habitat improvement project summaries (https://wgfd.wyo.gov/web2011/wildlife-1000708.aspx).

Field Data

There was no field data collected in the Targhee Herd Unit during the 2014 biological year.

Harvest Data

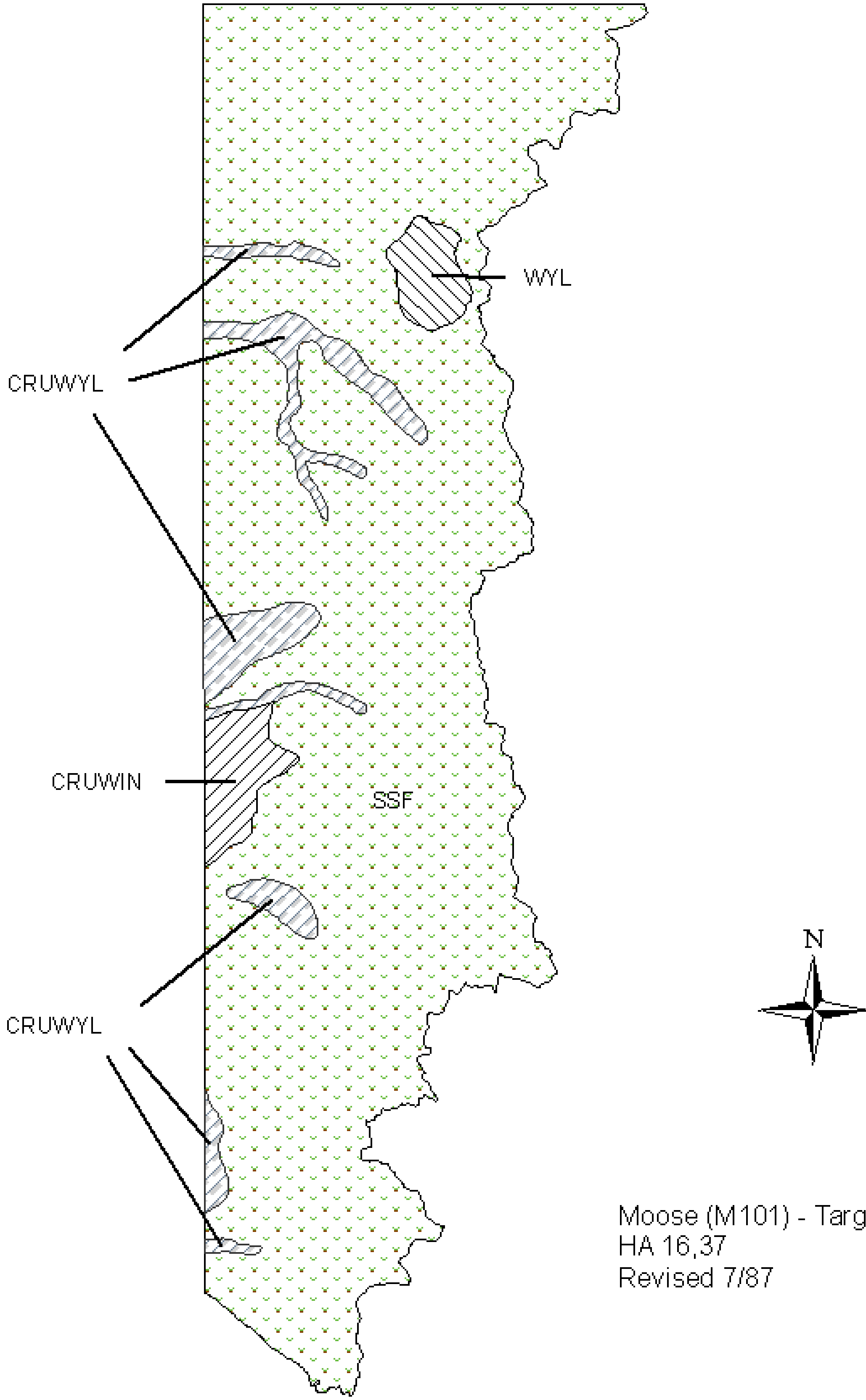
To offset observed population declines, antlerless harvest was eliminated from the Targhee moose herd in 2006 and the two hunt areas were combined in 2011. In spite of these changes the moose population did not increase significantly. Data from the 2014 harvest survey indicate that 5 hunters harvested 5 bulls. Harvest success has been consistently high for past 4 years. The average number of days to harvest was relatively low in 2013 at 4.8 days and 2014 at 4.0 days compared to 11.5 days in 2012 and 14 days in 2011. The recent decrease in the number of days to harvest may indicate the population is increasing and bulls are becoming easier for hunters to find. However, the low sample size makes a meaningful analysis difficult.

Population

Due to budget constraints there have been no mid-winter surveys in the Targhee herd since 2009. Based on the 2009 survey this population is likely 150-200 moose. Similar to the Jackson moose herd this population appeared to decline during the early 2000s.

Management Summary

Due to the "interstate" nature of this population, managing this herd is difficult. Moose along the state line spend summer and early fall in Wyoming and winter along drainages in the foothills of the Teton Range. The population has not responded to hunting season changes and it is likely that numerous factors are influencing recruitment and survival of moose in this population, including long-term drought, warming climate, parasites, disease, and predation. Managers plan to maintain limited hunting opportunity west of the Teton Range. Hunter success and effort from the last few years suggest this population may be increasing. Managers are not proposing an increase to licenses in 2015 and will continue to monitor average age and harvest statistics. Additional effort to contact hunters and increase tooth sample returns will be made. The WGFD continues to work closely with CTNF to develop habitat improvement projects for moose and other big game species.



Moose (M101) - Targhee
HA 16,37
Revised 7/87

2014 - JCR Evaluation Form

SPECIES: Moose | PERIOD: 6/1/2014 - 5/31/2015

HERD: MO103 - JACKSON

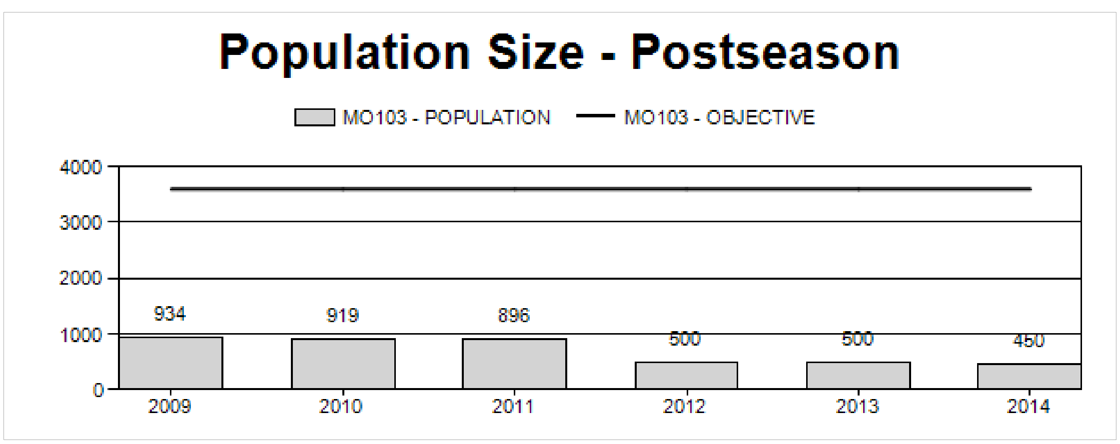
HUNT AREAS: 7, 14-15, 17-19, 28, 32 | PREPARED BY: ALYSON COURTEMANCH

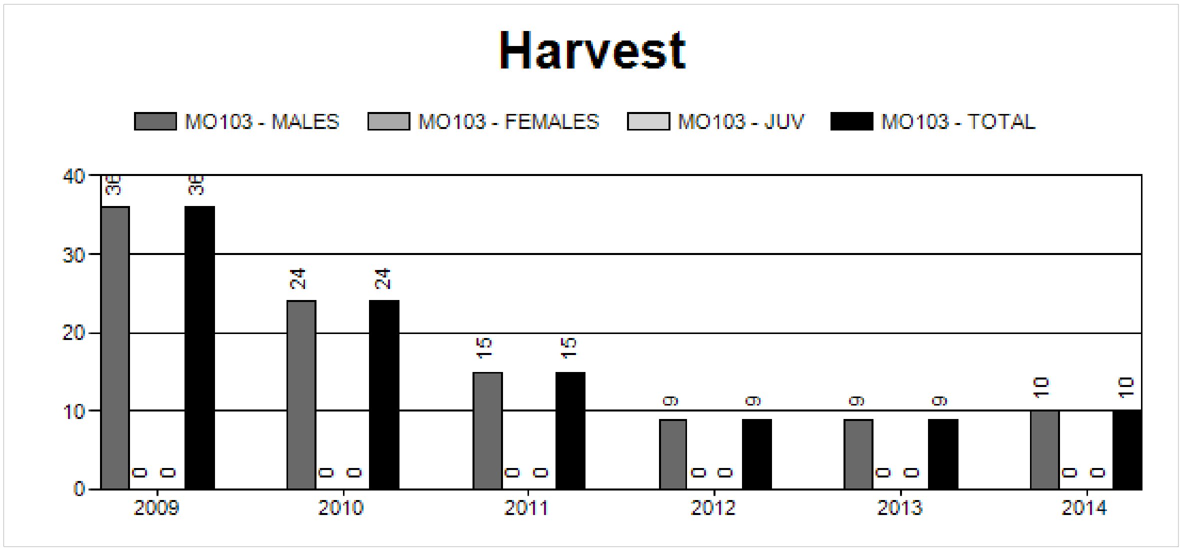
	2009 - 2013 Average	2014	2015 Proposed
Population:	750	450	500
Harvest:	19	10	10
Hunters:	22	10	10
Hunter Success:	86%	100%	100%
Active Licenses:	22	10	10
Active License Success:	86%	100%	100%
Recreation Days:	153	83	90
Days Per Animal:	8.1	8.3	9
Males per 100 Females	77	96	
Juveniles per 100 Females	28	33	

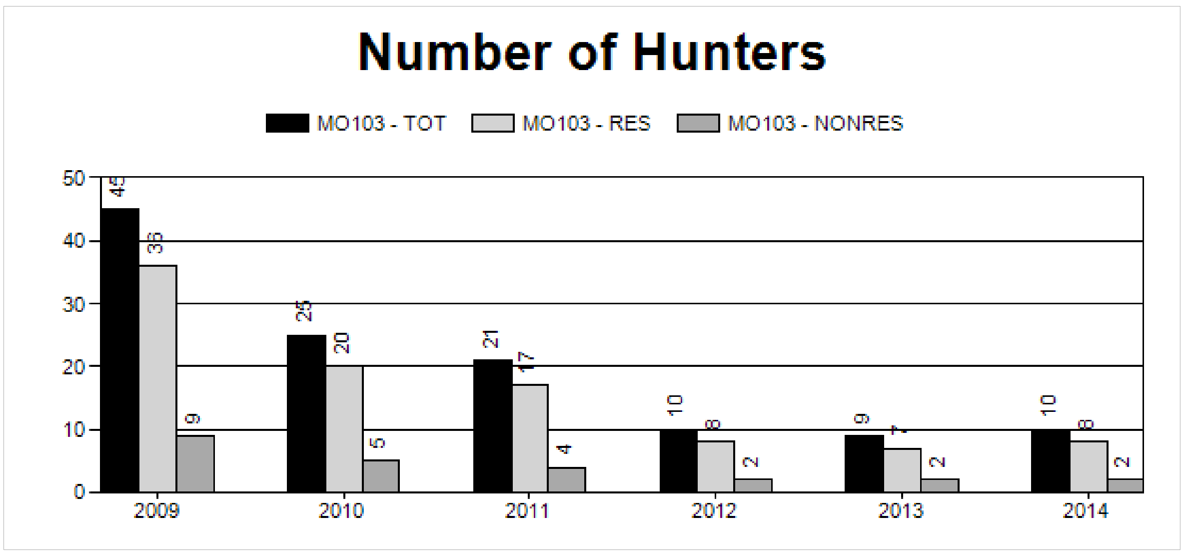
Population Objective (± 20%) :	3600 (2880 - 4320)
Management Strategy:	Special
Percent population is above (+) or below (-) objective:	-87.5%
Number of years population has been + or - objective in recent trend:	10
Model Date:	None

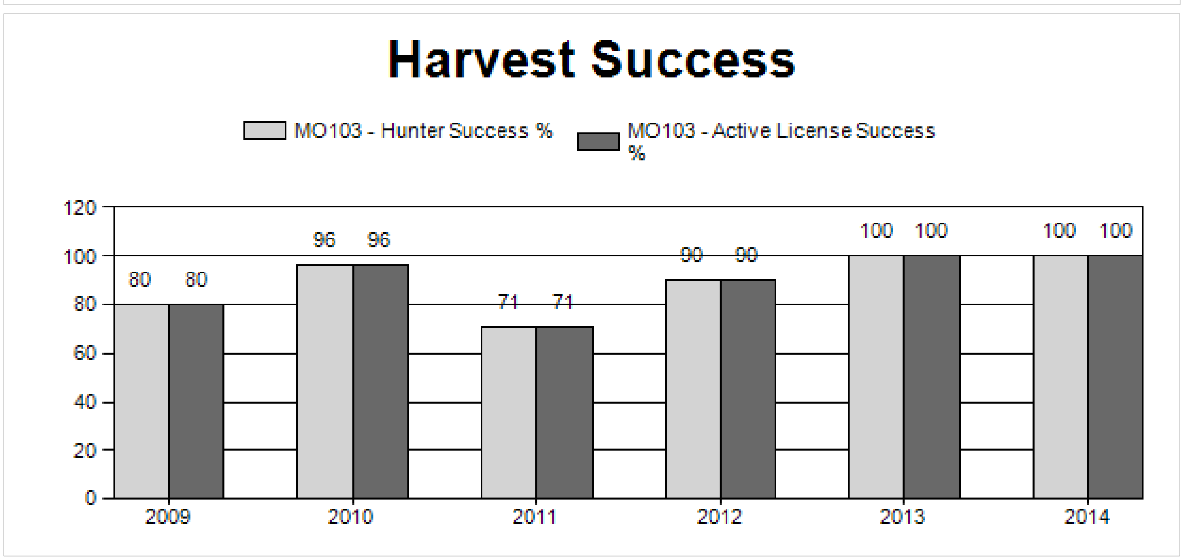
Proposed harvest rates (percent of pre-season estimate for each sex/age group):

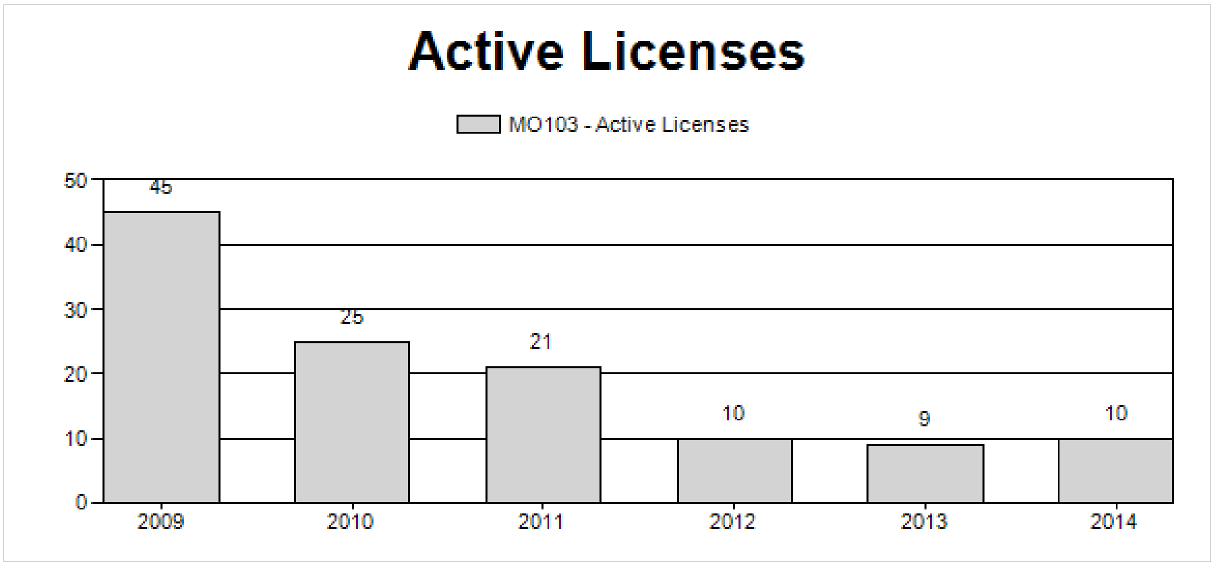
	JCR Year	Proposed
Females ≥ 1 year old:	na%	na%
Males ≥ 1 year old:	na%	na%
Juveniles (< 1 year old):	na%	na%
Total:	na%	na%
Proposed change in post-season population:	na%	na%

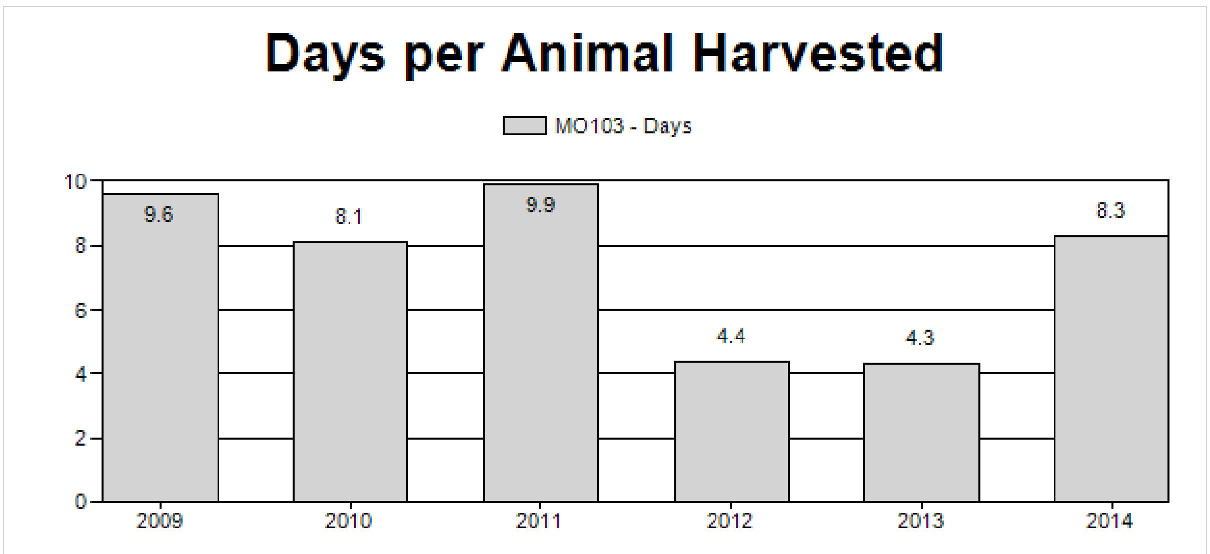


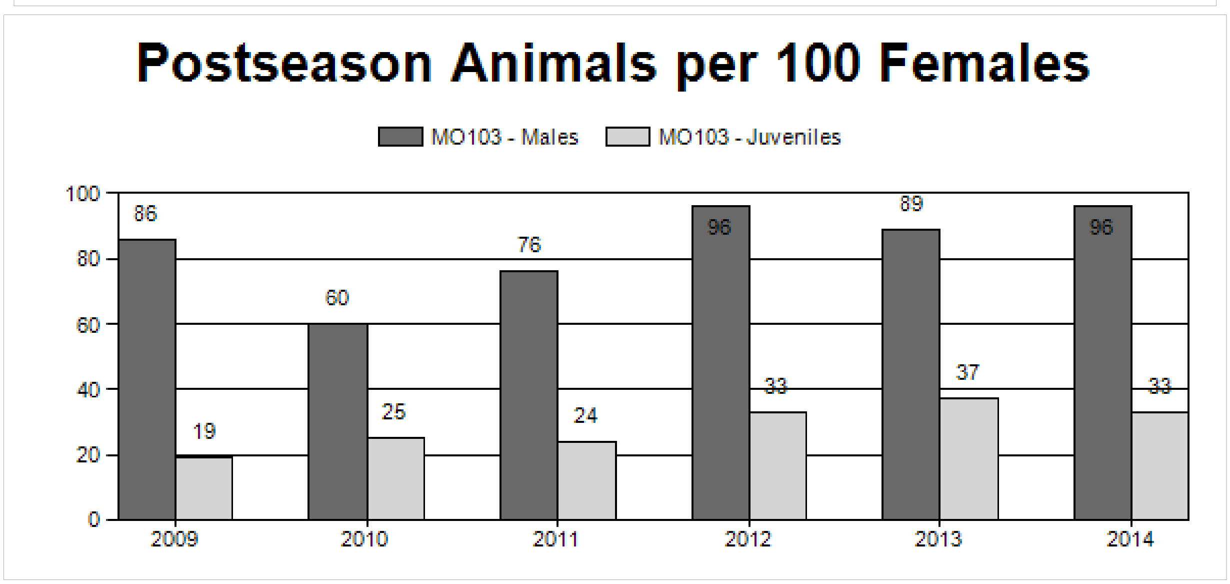

Harvest
MO103 - MALES
MO103 - FEMALES
MO103 - JUV
MO103 - TOTAL
2009
2010
2011
2012
2013
2014


Number of Hunters
MO103 - TOT
MO103 - RES
MO103 - NONRES
2009
2010
2011
2012
2013
2014


Harvest Success
MO103 - Hunter Success %
MO103 - Active License Success %
2009
2010
2011
2012
2013
2014


Active Licenses
MO103 - Active Licenses
50
40
30
20
10
0
45
25
21
10
9
10
2009
2010
2011
2012
2013
2014


Days per Animal Harvested
MO103 - Days
10
8
6
4
2
0
9.6
8.1
9.9
4.4
4.3
8.3
2009
2010
2011
2012
2013
2014


Postseason Animals per 100 Females
MO103 - Males
MO103 - Juveniles
100
80
60
40
20
0
86
19
60
25
76
24
96
33
89
37
96
33
2009
2010
2011
2012
2013
2014

2009 - 2014 Postseason Classification Summary

for Moose Herd MO103 - JACKSON

Year	Post Pop	MALES Ylg	MALES Adult	MALES Total	MALES %	FEMALES Total	FEMALES %	JUVENILES Total	JUVENILES %	Tot Cls	Cls Obj	Males to 100 Females Ylng	Males to 100 Females Adult	Males to 100 Females Total	Males to 100 Females Conf Int	Young to 100 Fem	Young to Conf Int	Young to 100 Adult
2009	934	0	0	49	42%	57	49%	11	9%	117	546	0	0	86	± 20	19	± 8	10
2010	919	0	0	134	32%	224	54%	55	13%	413	459	0	0	60	± 0	25	± 0	15
2011	896	0	0	113	38%	149	50%	36	12%	298	389	0	0	76	± 10	24	± 5	14
2012	500	0	0	99	42%	103	44%	34	14%	236	389	0	0	96	± 13	33	± 6	17
2013	500	0	112	112	39%	126	44%	46	16%	284	416	0	89	89	± 10	37	± 5	19
2014	450	0	101	101	42%	105	44%	35	15%	241	389	0	96	96	± 12	33	± 6	17

2015 HUNTING SEASONS
JACKSON MOOSE HERD (MO103)

Hunt Area	Type	Dates of Seasons Opens	Dates of Seasons Closes	Quota	License	Limitations
7, 14, 15, 19, 32						CLOSED
17, 28	1	Sep. 15	Oct. 31	5	Limited quota	Antlered moose
18	1	Oct. 1	Oct. 31	5	Limited quota	Antlered moose

Special Archery Seasons

Hunt Area	Dates of Seasons Opens	Dates of Seasons Closes
17, 28	Sep. 1	Sep. 14
18	Sep. 1	Sep. 30

Management Evaluation

Current Postseason Population Management Objective: 3,600
Management Strategy: Special
2014 Postseason Population Estimate: ~450
2015 Proposed Postseason Population Estimate: ~500

The management objective for the Jackson Moose Herd Unit is currently 3,600 moose. Spreadsheet models developed for this moose herd do not appear to adequately simulate observed trends and therefore managers will develop a proposal using a mid-winter trend count for this population in 2015. The management strategy for this herd is designated as Special Management and was last revised in 1999.

Herd Unit Issues

This population is 88% below its postseason management objective. Native moose populations naturally expanded and colonized the Jackson area in the late 19th century. The species' arrival was followed by a classic exponential population increase, peaking at approximately 3,000-5,000 animals (depending on modeling techniques). For many years, the Jackson Herd served as a source for moose transplants in multiple states and supported nearly 500 hunting licenses. However, the population underwent a dramatic population crash beginning in the early 1990s. Despite drastic reductions in hunting licenses, the population has failed to recover and continues to decline. Research on moose in the northern portion of the herd unit indicated that a number of factors are influencing this population (Houston 1968, Berger 2004, Becker 2008, Vartanian 2011). Similar to other moose herds throughout the western United States and New England, the Jackson Herd is impacted by a combination of factors, including long-term drought, severe wildfires, a warming climate, predation, parasites, and disease. Moose in the Jackson Herd are exposed to predation by several large carnivore species. Large scale wildfires during the late 1980s and more recently have influenced summer moose habitat. Parasites such as carotid artery worm and winter ticks, as well as re-colonization by large carnivores pose additional challenges. In spite of hunting season closures and a reduction in the number of licenses, this population has not responded to management changes.

Weather

Summer and fall 2014 produced consistent moisture, leading to good forage production. The Snake River Basin received above-average snowfall in December and early January, but weather turned warm and dry by February. Many low elevation slopes were snow-free by mid-February, but snow remained deep and heavy with a hard crust on north-facing slopes and higher elevations, which has likely increased energetic demands for moose and increased vulnerability to winter predation. At the time of the mid-winter survey, winter precipitation was reported at 91% of normal. 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

Browsing pressure varies greatly between winter ranges, but on average, about 25% of willow leaders were browsed in winter 2012/2013. Winter ranges were not monitored in winter 2013/2014 or 2014/2015. Live-dead indices are generally positive, indicating that browsing pressure is not preventing willows from reaching their natural height. Monitoring indicates that moose winter ranges are slowly improving north of Jackson. Summer habitat has been modified by several large-scale wildfires in recent years, greatly reducing thermal cover for moose. The Bear Cub Fire (6,493 acres) and North Buffalo Fire (29,950 acres) burned in the Teton

Wilderness in 2012, and the Nowlin Fire (4,422 acres) burned in 2011. Recent research by the Wyoming Cooperative Research Unit (Vartanian, 2011) suggests that high intensity wildfires also negatively impact forage quality for moose.

The Wyoming Game and Fish Department (WGFD) and Bridger-Teton National Forest (BTNF) initiated a project to monitor the short-term and long-term nutritional changes in moose forage species after wildfire at different severities. This project will track the nutritional content over 10 years of key forage species that burned at several fire severities during the Red Rock Fire in the Gros Ventre in 2011. Also, a current study by a doctoral student at the Wyoming Cooperative Research Unit (Brett Jesmer) is further investigating relationships between habitat condition and moose population performance statewide, including the Jackson herd (Appendix I).

The Northeast Quad Prescribed Burn was completed in fall 2014 in cooperation with BTNF to improve elk and moose habitat. The burn treated approximately 100 acres of decadent aspen stands near Blackrock Ranger Station. Please refer to the 2014 Strategic Habitat Plan Annual Report for Jackson Region habitat improvement project summaries (https://wgfd.wyo.gov/web2011/wildlife-1000708.aspx).

Field Data

In February 2015, classification surveys were flown over low elevation winter ranges. We observed 241 moose this year, down from the 284 last year (a 15% difference). The herd unit calf:100 cow ratio dropped slightly to 33:100 this year, compared to 36:100 last year. This ratio has been slowly improving since 2008 when a ratio of 15:100 was observed. The bull:100 cow ratio also remained high this year at 96:100. Ratios differed between herd segments in the Gros Ventre and Buffalo Valley. Forty-two fewer cows, 19 fewer bulls, and 15 fewer calves were observed in the Gros Ventre this year than last year.

Nineteen calf/cow pairs were observed in the Gros Ventre, with a calf:cow ratio of 35:100. Very few calf/cow pairs were observed in the Buffalo Valley and Spread Creek, with only 5 pairs for each area. The Buffalo Valley calf:cow ratio was 33:100 and Spread Creek was 26:100. The highest densities of moose were observed along Fish Creek and along the Gros Ventre River east of the Fish Creek feedground. Bull ratios continue to be high in the Gros Ventre at 108 bulls:100 cows.

Moose densities in the Willow Flat/Oxbow Bend Area have declined from an average of 4 moose per km^2 in 2000 to 0.16 moose per km^2 in 2010 and 2012. No moose were observed in the Willow Flats area during the February 2015 classification flight. The density of moose has also declined on winter ranges in the Buffalo Valley area. Houston (1968) documented winter moose densities as high as 50 moose per square mile. In recent years, the highest densities observed are 12-17 moose per square mile.

Harvest Data

During the 2014 season, 10 bull moose were harvested in the Jackson Herd in Hunt Areas 17/28 and 18 in the Gros Ventre drainage. During 2014, hunter success remained high at 100% but hunter effort increased to 8.3 days per animal compared to 4.3 days last year.

Population

POP II simulations likely overestimated moose numbers in the Jackson population. Spreadsheet models developed for this herd also do not appear to adequately simulate observed trends. Based on the observability of marked animals during recent research projects it is likely there are fewer than 500 animals in this population. Despite additional flight survey hours in February 2015, 43 fewer moose were observed this year than last year. Although the population remains low, aerial survey data from recent postseason classifications indicate a high number of bull moose and an improving calf:cow ratio. However, the low number of cows in the population suggests that any present or future recovery will be slow.

Management Summary

To offset observed population declines, antlerless moose hunting was eliminated in the Teton Wilderness in 2001 and in the Gros Ventre drainage in 2004. Antlered moose hunting seasons were closed in the Teton Wilderness in 2011 (Areas 7, 14, 15 and 32), and Areas 17 and 28 were combined into one unit beginning in the 2012 season. Despite these changes the moose population north of Jackson continued to decline through 2014. Although calf:cow ratios have improved in recent years, overall numbers of moose remain low. Even with current calf:cow ratios, any population recovery will be slow due to the low numbers of cow moose.

Conservative hunting seasons are again planned for 2015 with 10 licenses offered for the Gros Ventre drainage. The herd will continue to be closely monitored in future years to evaluate whether additional hunting opportunities can be provided. The high bull:cow ratios indicate that some harvest is sustainable at this time and complete closure to moose hunting in the Jackson Herd is not warranted for 2015. Managers will develop a proposal for public review to revise the population objective in spring 2015.

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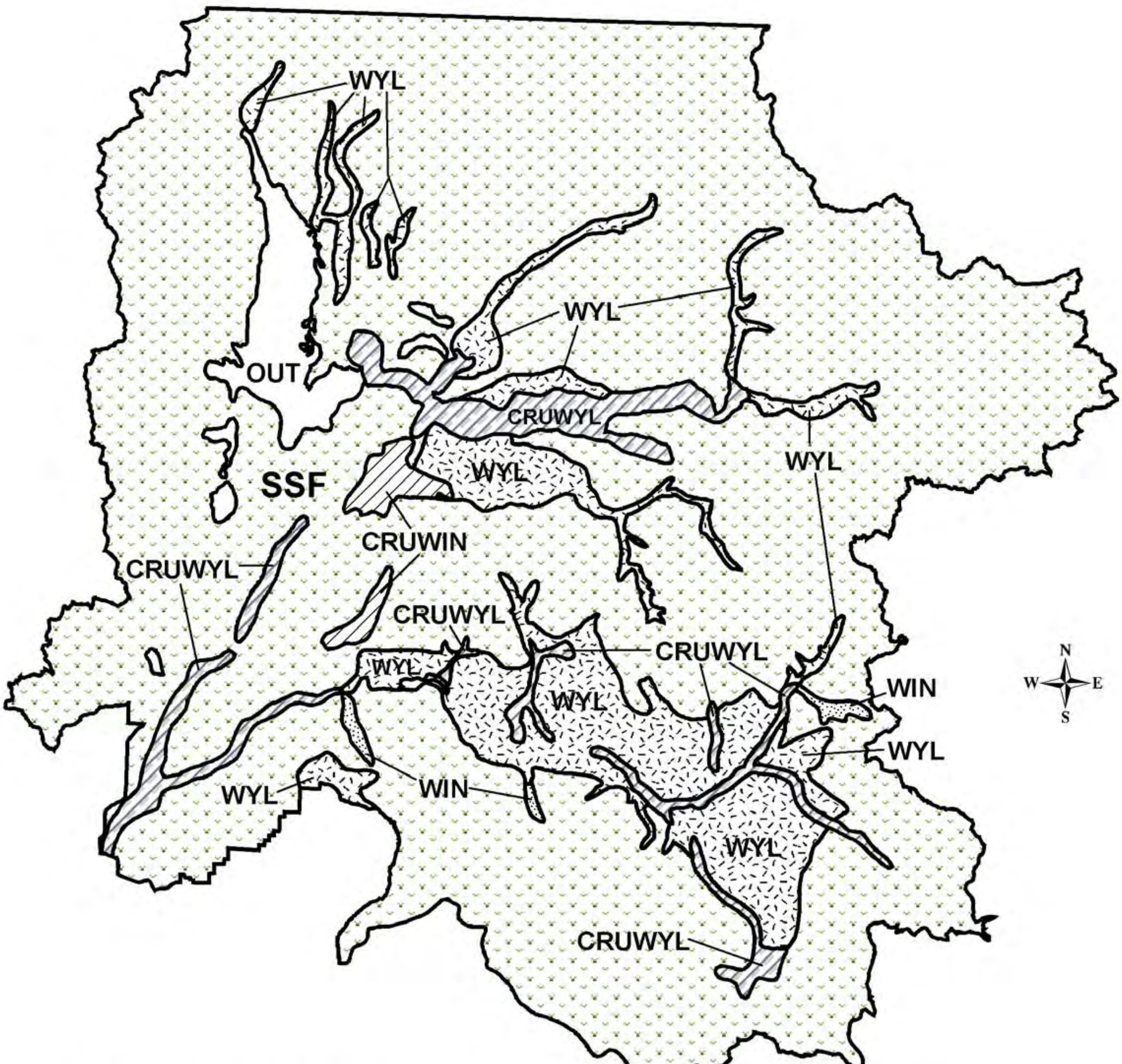

Moose (M103) -- Jackson
HA 7, 14, 15, 17-19, 28, 32
Revised 11/1994

Statewide Moose Habitat Project:

Linking Habitat and Nutrition with Population Performance in Shiras Moose

Annual Report 2014

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Background

Currently, Shiras moose (Alces alces shirasi) herds in the region (Fig. 1) are exhibiting a wide range of population performance, with some declining, some relatively stable or even increasing despite historic declines, and some too data poor to be certain about the trend (Fig. 2). Regardless of a given herd unit's recruitment trajectory, however, current (2011-2013) recruitment rates range from 40-60 calves per 100 cows in 'older' moose populations (i.e., Jackson, Sublette, Uinta, Bighorn) and 60-80 calves per 100 cows in 'younger' populations (i.e., Snowy Range, North Park, South Park, Flat Tops)(Fig. 2 & 3), suggesting density dependence is playing major role (Forsyth and Caley 2006). For the declining herds, potential mechanisms that may affect carrying capacity and population performance are habitat deterioration due to current and historic overbrowsing (Boertje et al. 2007; McArt et al. 2009), and regional variation in forage quality due to climatic warming and drying (Monteith et al. *In Press*). Additionally, a new and growing predator community is present in the northwest corner of the state and may prevent higher recruitment rates from being achieved, but these predators cannot account for declines elsewhere in Wyoming, Colorado, and Utah. Further, a newly emergent disease, the carotid artery worm (Elaeophora schneideri), appears to be prevalent in Wyoming (Henningsen et al. 2012). Unfortunately we do not yet understand the impacts of this disease on the nutritional condition, survival and reproduction of moose.

In combination with the observed range in population performance, variability of moose habitat (see Vartanian 2011, Monteith et al. *In Press*) in the state represents a timely opportunity to evaluate habitat-performance relationships. Such a statewide habitat evaluation could serve as a benchmark to understand the relationship between moose habitat conditions and population performance and would provide regional agencies with "early warning" metrics to predict when and where declines are likely to occur, and would improve the scientific basis of moose population objectives.

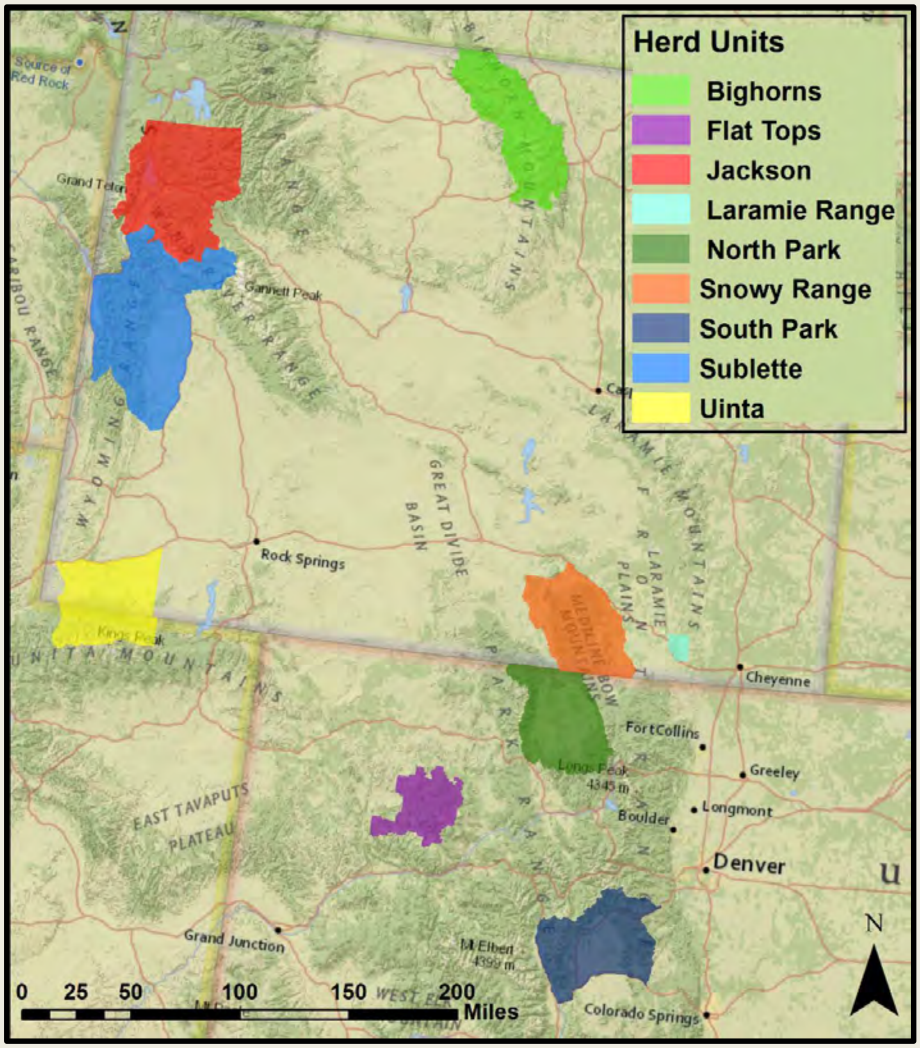


Fig. 1- Map depicting the project study areas.

Objectives

This project aims to both understand the role of habitat and nutrition in recent declines in population performance as well as provide managers with tools from which they can assess a population's proximity to nutritional carrying capacity and adapt management strategies accordingly. Therefore, we have developed the following objectives:

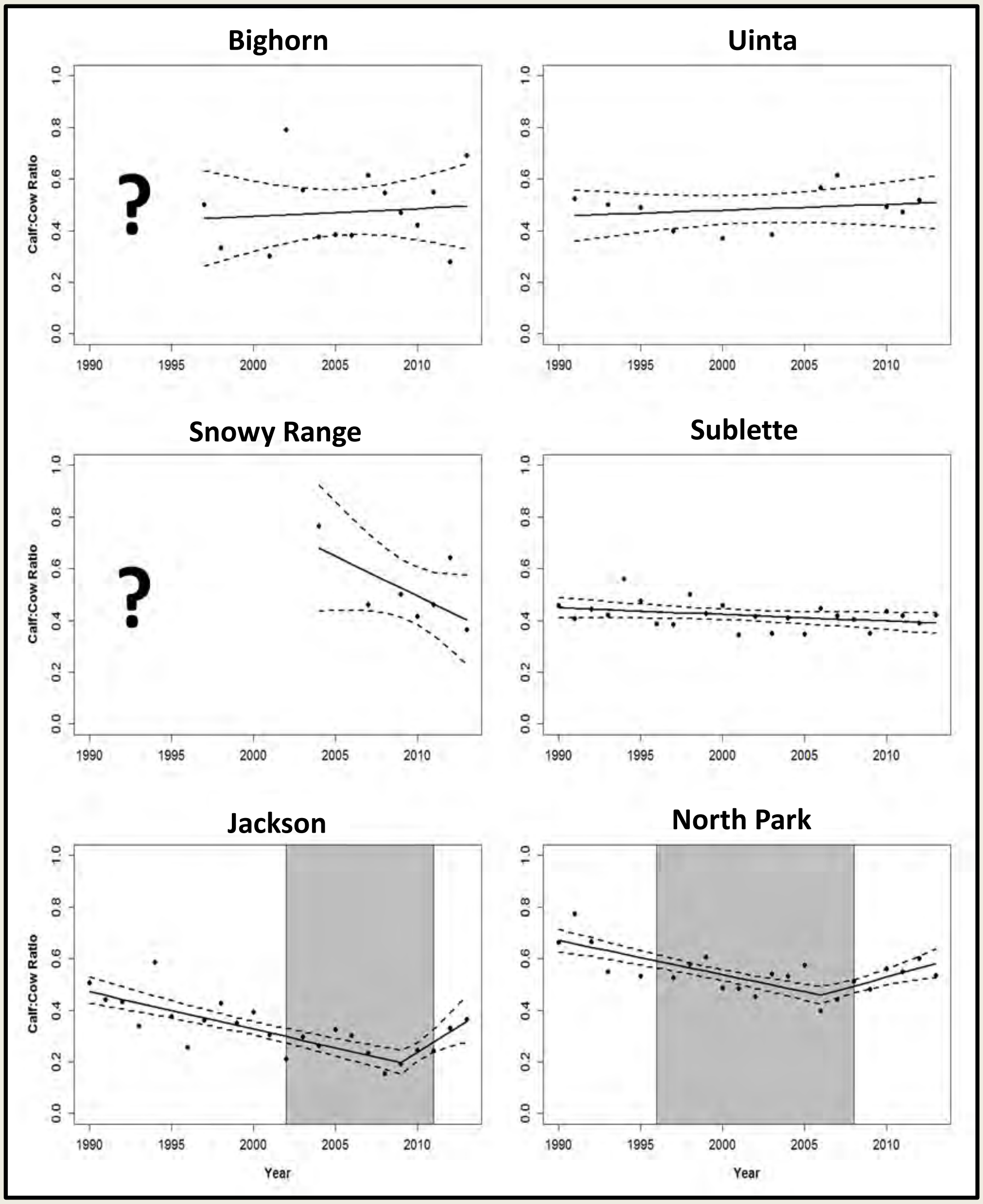
1. Understand the relationship between resource limitation (habitat conditions and drought) and herd productivity.

2. Establish browse condition indices for monitoring and management purposes.

3. Explore alternative 'early warning' metrics derived from simple fecal collections. These metrics include diet composition and quality, nutritional condition and reproduction.

4. Develop thresholds or guidelines in habitat and nutritional metrics that managers can use to help preempt declines in herd productivity.

Project Expansion in 2014



Upon initiation of the study in 2011 we expected the 'younger' (30-70 years) herd units in the eastern part of the study area (Snowy Range, North Park) to be characterized by good browse conditions and high levels of nutritional condition. We found these eastern herd units to be characterized by heavy browsing (hedging) of their most highly preferred willow species (*Salix planifolia*) and autumn nutritional condition to be similar to those herd units lying to the west. Therefore, we solicited CPW in an attempt to collect data on habitat and nutritional condition of moose in recently established (5-15 years) herd units (South Park and Flat Tops) in central Colorado. These populations are exhibiting high levels of population performance (Calves/100 Cows ≈ 70) and are likely not experiencing habitat limitation. In June 2014 CPW joined the effort and we began willow surveys and fecal collection. Additionally, we began data collection in another more recently established population, Laramie Range, WY.

Fig. 2 – Trends in calf-cow ratios from 1990-2013 across six of our study areas. Solid lines indicate the slope and direction of the trend while dashed lines indicate the 95% confidence interval for the slope. Years with less than 10 females classified were omitted from the data set. Most data points from Bighorn and Snowy Range classified <30 females. Trend lines were established through piecewise regression. Piecewise regression quantifies multiple differing trends in a single data set. Grey polygons represent 90% confidence intervals for detecting the year in which the trend changed. Note that the trend line for Uinta is not statistically significant (P>0.05), meaning the actual slope is likely zero. Herd units accompanied by a "**?**" (Bighorn & Snowy Range) are also not statistically significant and the confidence intervals indicate that the trend is unknown.

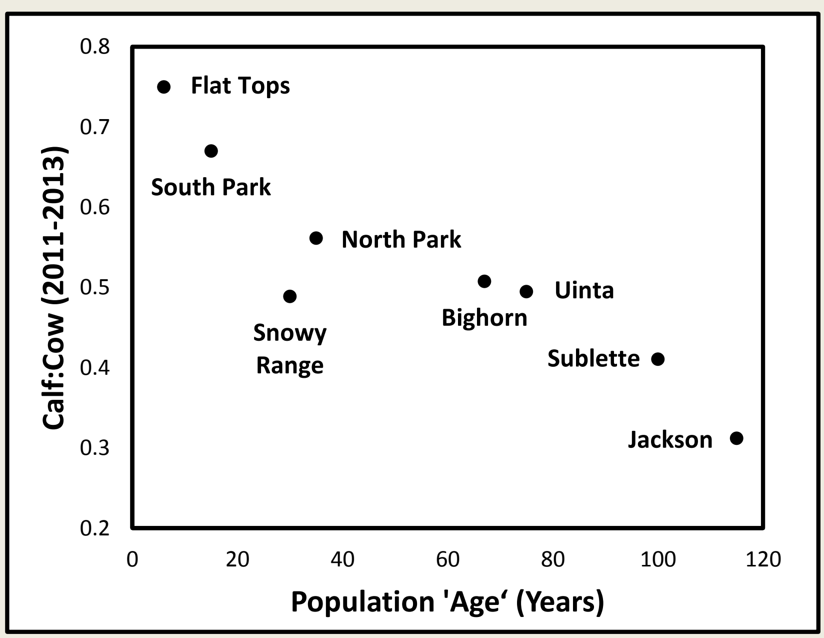


Fig. 3- Relationship between number of years since colonization or introduction of moose into currently defined herd units and current calf:cow ratios.

Research Design & Methods

Vartanian (2011) concluded that **winter-range** was non-limiting to the Jackson moose population because of the underutilization of ‘peripheral’ winter-ranges that were previously described as heavily used by Houston (1967). Therefore, we used stratified random sampling across core (red) and peripheral (blue) winter ranges (both ranges defined as areas available to overwintering moose) to characterize the extent of willow browse utilization in each of six study areas. To quantify **winter habitat condition**, we used moose locations during classification efforts by WGFD and CPW and a local convex hull (LoCoH) home-range estimator to calculate core (%50 herd-range; red) and peripheral (%95 herd-range; blue) herd-ranges (Figs. 4 and 5). Location data collected post-hunt from 2000 through 2012 were used in herd-range analyses. When sufficient location data was unavailable (i.e., Laramie Range, South Park, Flat Tops), we mapped the resource selection function of Baigas (2010) across each management unit and considered the75th quantile core-range, and peripheral-range the 50th quantile.

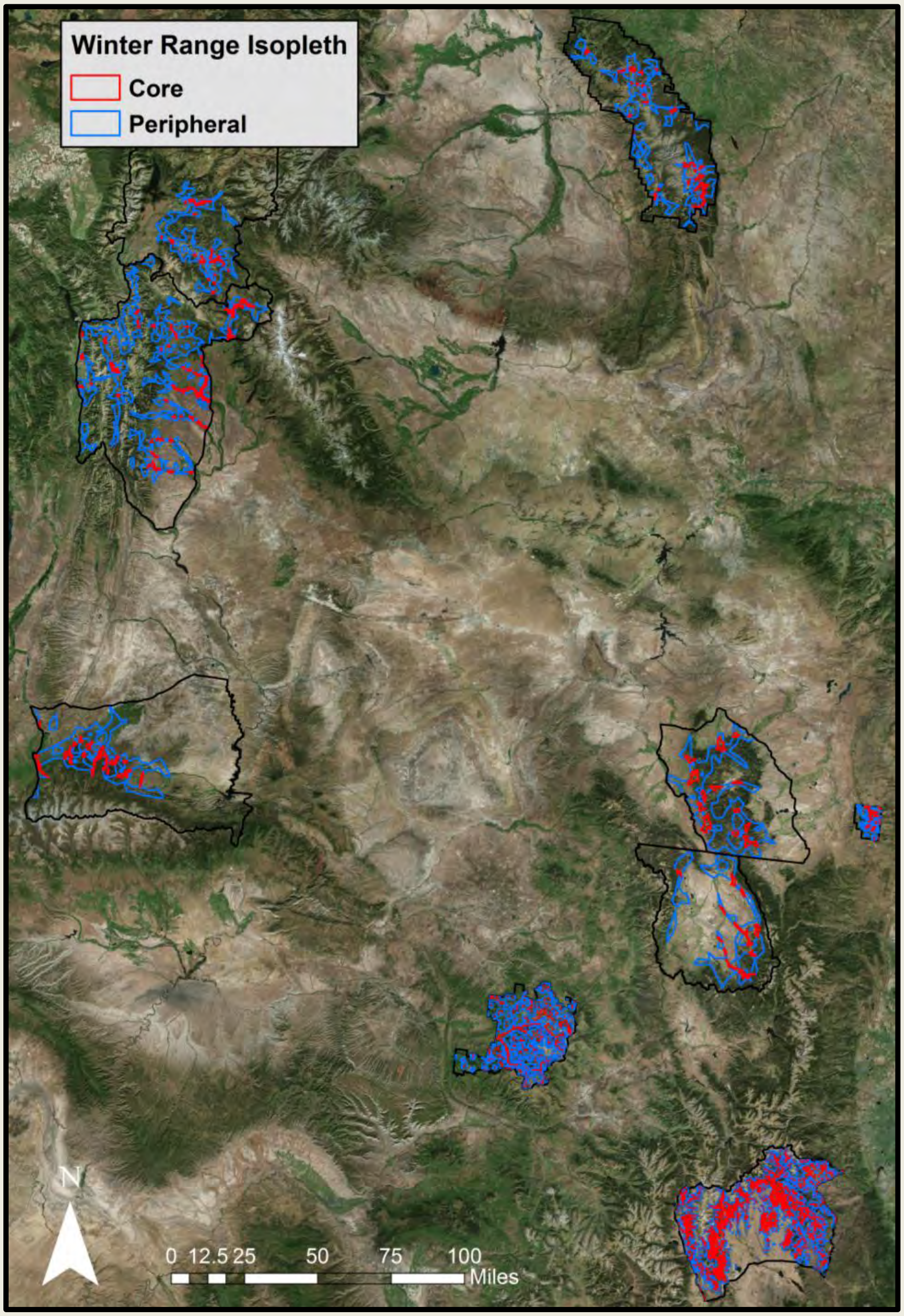
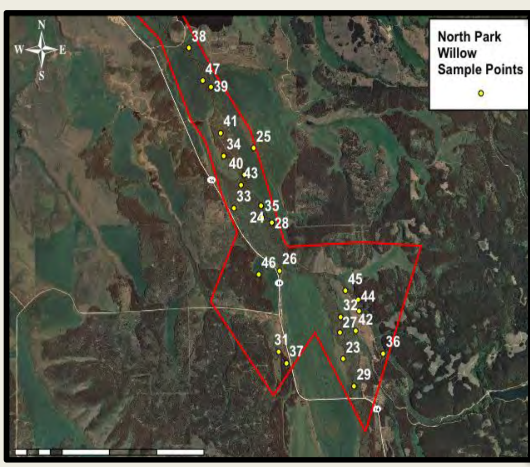
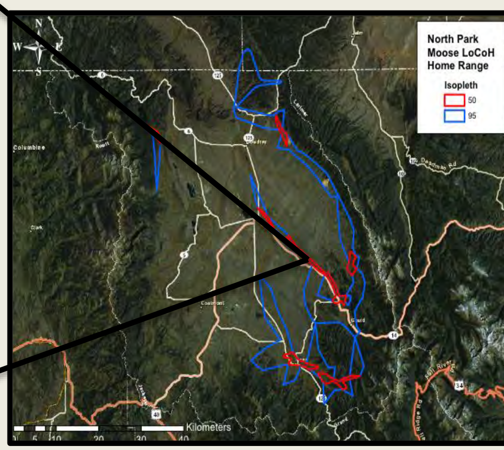


Fig. 4- Distribution of core (red) and peripheral (blue) moose winter ranges across the six study areas. Note- not all core and peripheral areas displayed here were sampled (see pg. 4 for details).





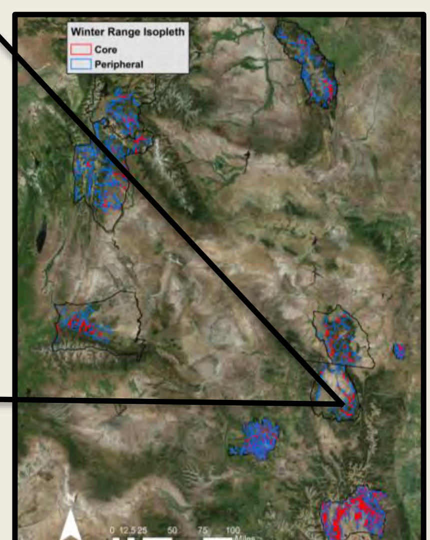


Fig. 5- Within each core and peripheral range, such as North Park’s Michigan River (shown here), randomly generated points were drawn in willow habitat to prevent observer bias (see pg. 5 for details).

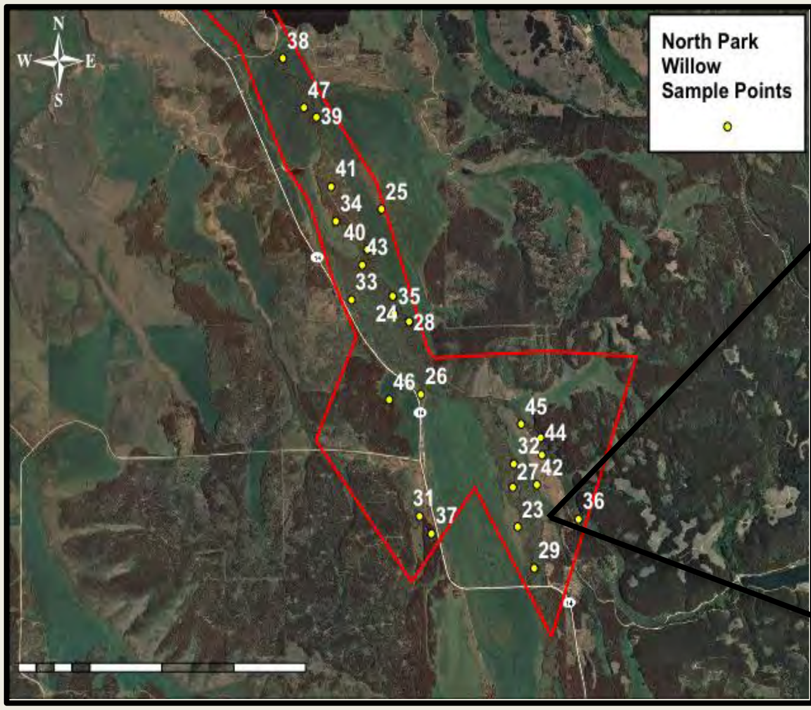


Fig. 6- Map depicting randomly generated sample sites in willow habitat along the Michigan River, Jackson County, CO.

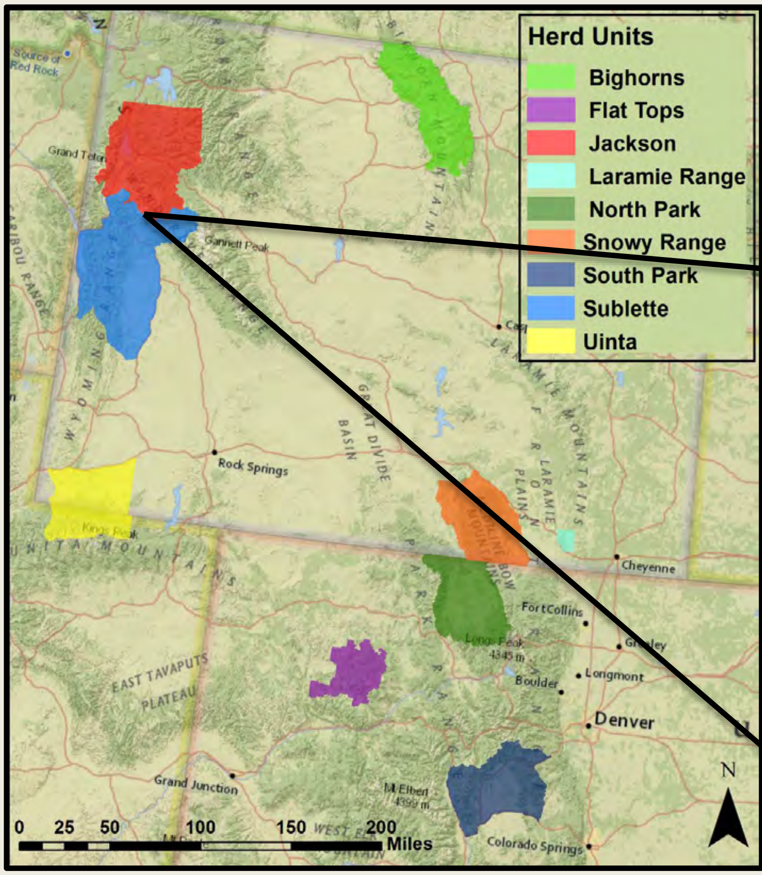
Fig. 7- Example of planeleaf willow transect in Flat Tops, Rio Blanco County, CO

Within core and peripheral ranges we plotted random points with a minimum of 200m spacing between points using a generalized random tessellation stratified (GRTS; Stevens and Olsen 2004) sample generator (R; Sdraw package) to develop a spatially-balanced random sample across the two strata. Using the NLCD we calculated sampling weights by determining the proportional amount of willow habitat in each polygon (i.e. drainage) per herd unit using the tabulate area tool in ArcGIS (ESRI 2011; spatial analyst tools); meaning drainages with relatively greater amounts of willow received greater number of sampling points. In 2012 financial and logistical constraints determined that 30 live-dead (LD; measure of willow condition; Keigley and Fager 2006) transects could be accomplished per herd unit. Therefore, we multiplied the proportion of willow (i.e. sampling weight) in each of the six drainages per herd unit by 30 to calculated the final number of transects per drainage. In 2013 we increased our sample by adding 5-10 transects per herd unit as time permitted. During summer of 2014 we completed approximately 30 LD transects in the South Park and Flat Tops herd units. Final sample sites were chosen in the sequential order that they were generated in GIS. However, in some cases a lack of land owner permissions or accessibility inhibited us from sampling in exact sequential order.

We completed LD transects at each randomly selected sampling point across the six study areas (Fig. 6 and 7). According to previously established protocols (see Keigley and Fager 2006; Vartanian 2011; Smith et al. 2011), 20 willow plants of the most preferred species (planeleaf willow (*Salix planifolia)* in the eastern herds, Booth's willow (*Salix boothii*) in the western herds) were measured along a random bearing every 10m starting at each sampling point. LD, leader length of the dominant apical meristem, percent browse, percent decadence, and plant height were recorded at each plant.

To assess **winter diet** (i.e. foraging behaviors) and identify important **winter forages**, we collected fecal samples opportunistically and along LD transects (Fig. 7) according to a sterile protocol developed to eliminate cross contamination. We only collected fecal samples that appeared to be fresh and were determined to have originated from an adult moose according to size. Using molecular techniques we will group fecal piles by individual and determine sex prior to diet and **pregnancy** analyses (via progestagen analysis; Monfort et al.1993), and potentially assess nutritional state via additional hormone (triiodothyronine (T3) and glucocorticoid (GC)) assays (Wasser et al. 2000, 2010). Progestagen, T3 and GC thresholds will be validated using feces, blood samples and ultrasonography data collected during captures associated with the Sublette and Uinta moose studies.

Fig. 8- Scats found along North Horse Creek, Sublette County, WY.



We collected moose scats along each transect when present (see figs. 10 and 11) using a sterile protocol. Currently, we are extracting DNA from scats (see pg. 6) to determine individuality and sex prior to diet (qPCR) and forage quality (fecal nitrogen and fecal neutral detergent fiber) analyses.

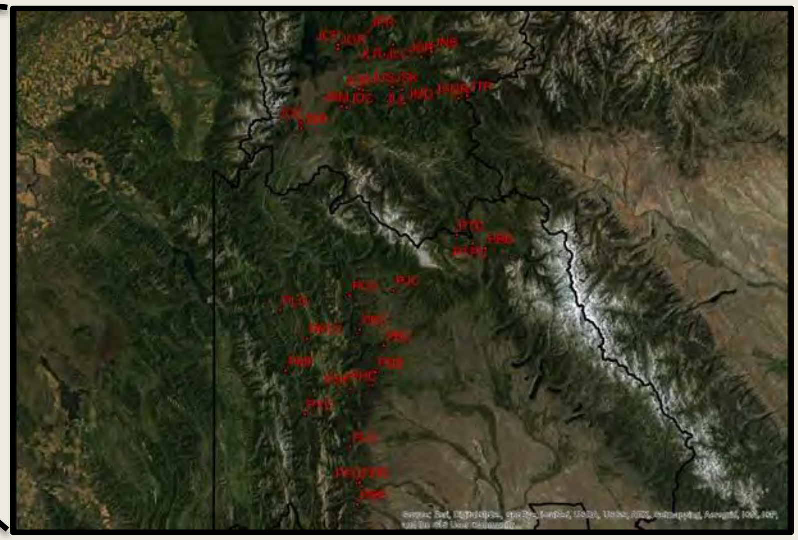


Fig. 9- Map depicting randomly generated sample sites across different habitats where summer fecal samples were sampled in Sublette and Teton Counties, WY.

To characterize the range of **diets** (i.e. foraging behavior) and the **quality of forages** used by moose on **summer ranges**, we once again employed a stratified random sampling design. Due to the widely-reported preference for riparian and upland shrub forage amongst moose inhabiting montane regions of North America (e.g., Renecker and Schwartz 2007), we chose two strata consisting of: (1) willow habitat, and (2) all other upland habitat types (i.e. deciduous forest, coniferous forest, mixed deciduous and coniferous forest, shrub-scrub, grassland-herbaceous, and emergent herbaceous wetlands) as defined by the NLCD. We again used a generalized random tessellation stratified sample generator to develop a spatially-balanced random sample across the two strata (Fig. 9). To ensure that our dog teams found as many fecal samples as possible, we restricted our search effort across strata to the top 25% quantile (summer core area) of the Baigas *et al*. (2010) summer RSF model. Logistical and financial constraints determined that 20 transects (10 willow, 10 upland) per herd unit could be completed within a single season. We chose sampling points in sequential order from which they were drawn until 10 samples from each strata were established using the following criteria: (1) < 1500m from a drivable road due to the limited distance in which a working dog can travel on any given day, (2) the willow patch must have been $\geq$ 2000m in Euclidean length, and (3) the patches were within a logistically feasible proximity (daily travel distance) to another sampling point whereby we could complete two transects per day. Each transect started at, or intersected with, the sampling point (Fig. 10).

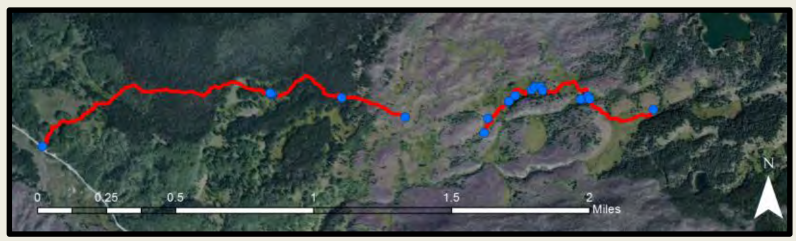


Fig. 10- Map illustrating a fecal transects (red; 5-6 km each) and fecal samples collected (blue) in both willow and upland habitat. Fish Creek, Rio Blanco County, CO.

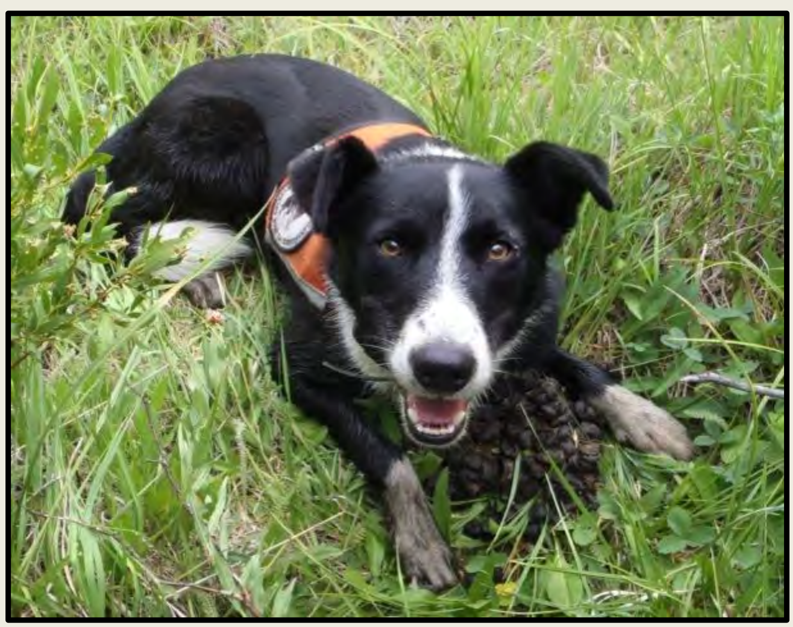
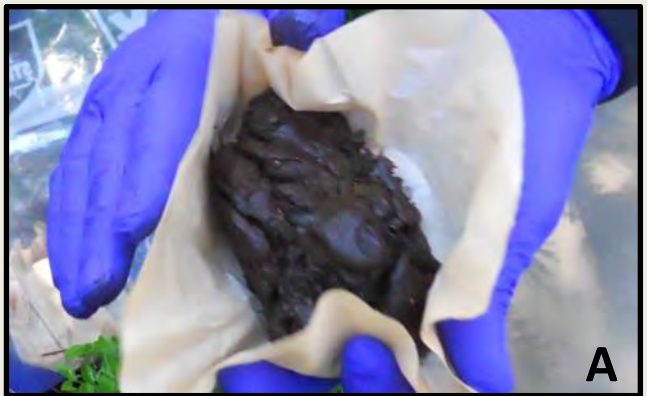


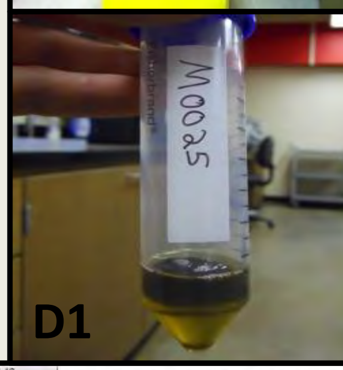
Fig. 11- Orbee the detection dog is very proud of his find (mostly he just wants his reward; a short game of fetch with a ball).

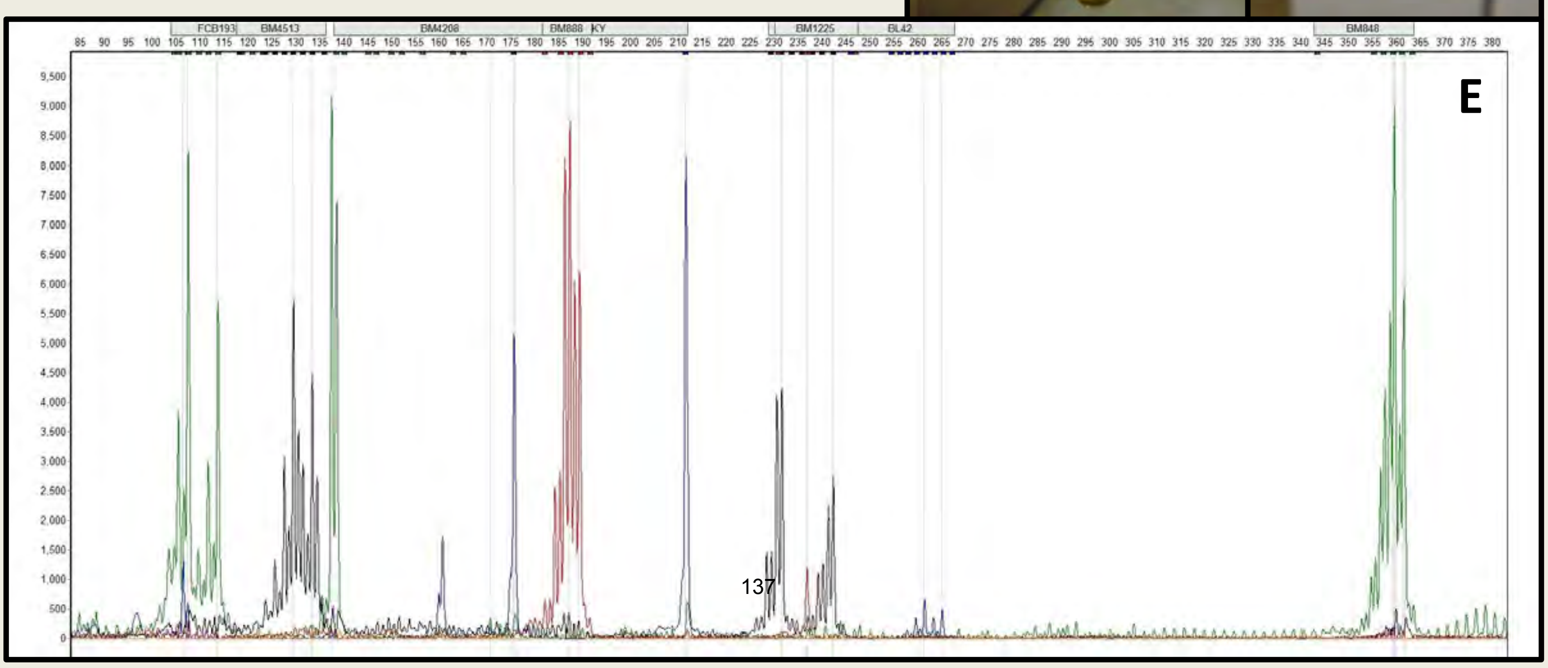
Only ‘fresh’ (i.e. typically <1 week old) scats were collected along each transect (Fig. 10). When a fresh scat was identified, approximate age, GPS location, and habitat information was collected. The scat was then wrapped in non-bleached filter paper (coffee filters) and placed inside a plastic freezer bag on a bed of silica desiccant (photo A). The desiccant removed moisture from the scat during the day while we were in the field to help reduce bacterial action which degrades genetic material. Scats were placed in a portable battery/propane-powered freezer immediately upon returning to the campsite; followed by a cryofreezer once returning to the University of Wyoming.



Most of the DNA in moose feces is found in a ‘mucusy membrane’ on the outside of the ‘pellets’ where intestinal cells are sloughed off as the pellets move through the intestinal track. We collect portions of this ‘mucusy membrane’ (photo B) and place in vials with a substance that breaks down cell walls to release the genetic material (photo D1). We used a modified ‘ungulate’ DNA extraction protocol tailored specifically for moose scat in combination with Qiagen- QIAamp DNA stool mini kits© to obtain purified DNA products (photo D2).

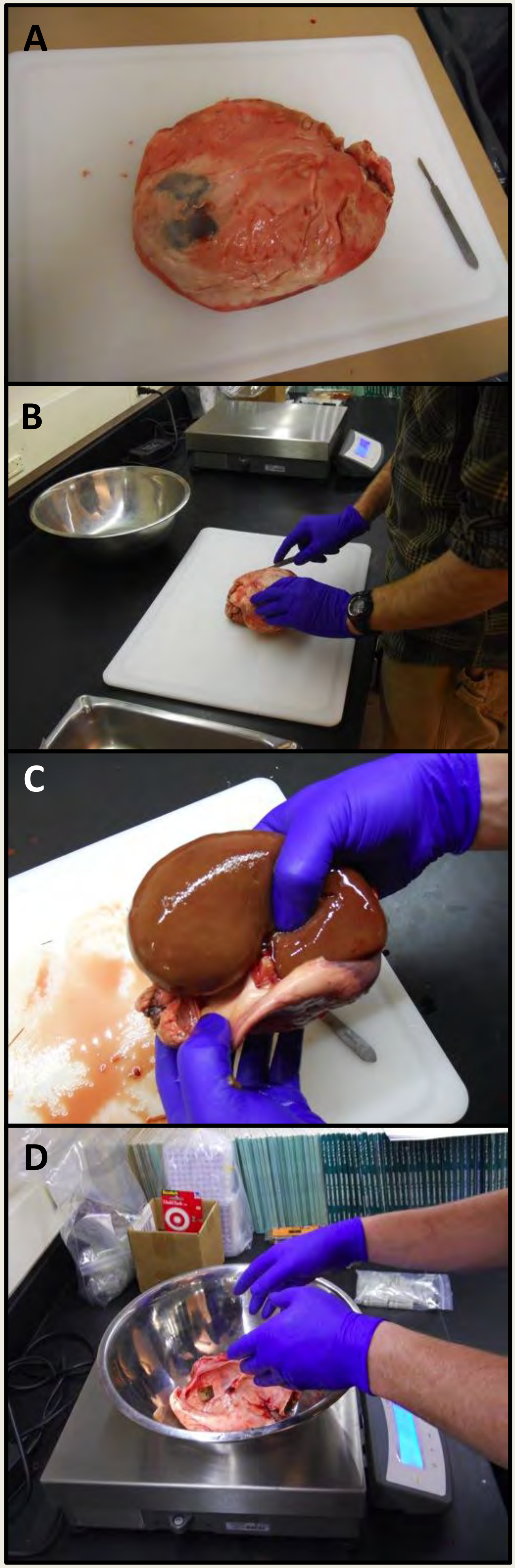
Through a series of chemical reactions (photo C) we duplicate the DNA many times over and characterize nine specific portions of the genome that allow us to ‘fingerprint’ the sample so that we can identify which individual the scat came from and its sex (photo E). For example, photo E depicts nine microsatellite loci, represented by black, green, red and blue ‘peaks’, amplified from one individual moose tissue sample. The two tall blue peaks near the middle of the graph represent genetic products associated with the X and Y chromosomes; meaning this individual is a male. This process is extremely similar to that used by criminal forensic scientists and has been streamlined so that individual and sex identifications can be assessed simultaneously. We repeat this process 2-3 times for each of 1022 fecal samples we have collected and use computer software to match the samples to individual moose.

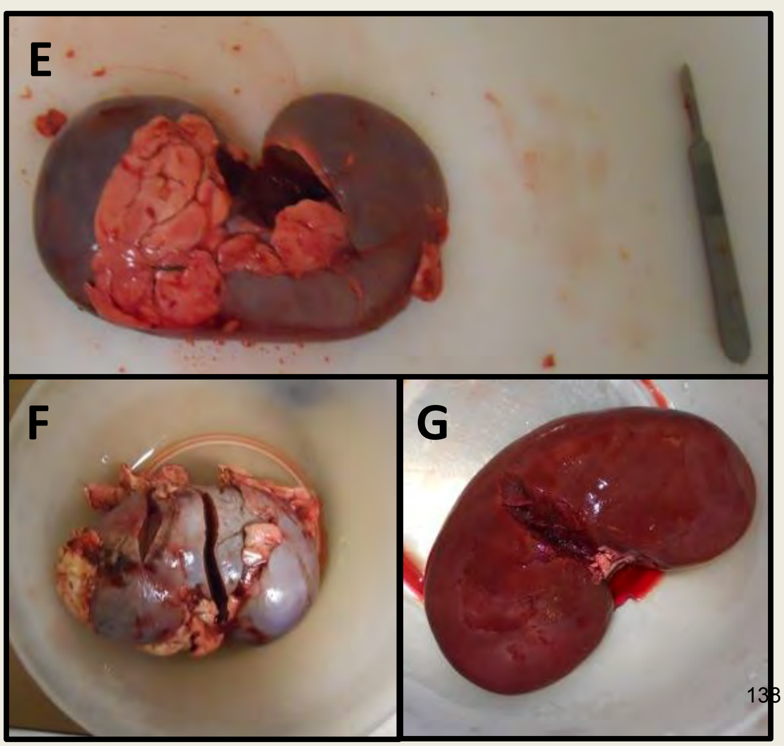




To understand how winter habitat condition and quality, and summer diet and forage quality affect the **nutritional condition** of moose, we are measuring autumn kidney fat. The amount of fat found attached to the kidney is a good predictor of total body fat in moose (Stephenson *et al*. 1998). We collaborated with the WGFD, Colorado Parks and Wildlife (CPW) and the Utah Division of Wildlife Resources (UDWR) to solicit hunters to collect kidneys from harvested moose. With each kidney, hunters and WGFD, CPW and UDWR biologists noted sex, age, location of harvest (hunt area and drainage or GPS location), antler size (if any), and parasite information.

Kidneys were gathered by regional WGFD, CPW and UDWR personnel and delivered to the University of Wyoming where we measured kidney fat levels according to the long-standing method of Riney (1955). Briefly, the kidney fat method requires an undisturbed kidney (photo A; identification of disturbed kidneys described below), trimming of excess fat to standardize the area of fat measured (photo B), removal of the fat and perineal membrane (photo C), and a weight measurement of both the kidney and the kidney fat (photo D). While processing each kidney, we noted whether or not the kidney and its fat appeared to be disturbed. Because some hunters are unfamiliar with moose anatomy and the exact location of the kidneys, they sometimes cut through visceral fat or the visceral cavity too quickly and end up cutting into the kidney fat (photo E) and even the kidney itself (photo F); and sometimes hunters even mistakenly removed all of the kidney fat (photo G). We omitted all samples from the final dataset that showed evidence of the fat being disturbed.





Preliminary Results

All results constitute preliminary summaries, not final statistical analyses, and should be interpreted with caution. Additionally, the data presented here only reflects autumn nutrition of moose and winter habitat condition (i.e. quantity of forage). Because winter habitat condition is only one of many factors that may influence autumn nutritional condition in moose (Parker *et al*. 2009), these trends may be strengthened or weakened once winter and summer diet and forage quality are included in the dataset. In fact, due to metabolic demands, summer forage quantity and quality is often considered to be more important to overall nutritional condition and pregnancy rates than winter forage condition or quality (Cook *et al*. 2004). It is also important to note that we only present nutritional condition data associated with male moose. The current and past (i.e. 1-2 years prior) reproductive history of all harvested female moose from which we received kidneys was unknown. The energetic demands associated with gestation, lactation, and calf rearing are important factors in determining autumn nutritional condition (Monteith et al. 2014), and therefore likelihood of pregnancy, in ungulates. Consequently, we chose to use males as our indicator of nutritional condition at the population level because they are not influenced by as many factors as females. Even though males do not represent the reproductive portion of the population, and therefore have less influence of population performance, their nutritional condition remains an excellent indicator of habitat quality (Parker *et al*. 2009).

During 2011-2013 we analyzed 544 undisturbed kidneys for nutritional condition assessment. Nutritional condition varied amongst the six herd units of interest (Fig. 12). We also received numerous kidneys from the Lincoln herd unit, so we include those data in figure 11. Although hunter harvested samples are vulnerable to inconsistencies amongst hunters, year to year measures of kidney fat within herd units does not differ (Fig. 12), providing us with confidence that this approach to collecting nutritional data is reliable. Kidney fat was positively related to trends in calves/100 cows censured between 1990 and 2013 (Fig. 13). With the exception of Jackson, kidney fat was also positively related to the mean number of calves/100 cows observed between 2011 and 2013 (Fig. 14).

We completed 435 LD transects, representing 7659 individual willow plants measured from 2012-2014. The condition of planeleaf and Booth's willow was positively related to autumn nutritional condition (kidney fat; Fig. 15). The linkages between willow condition, autumn

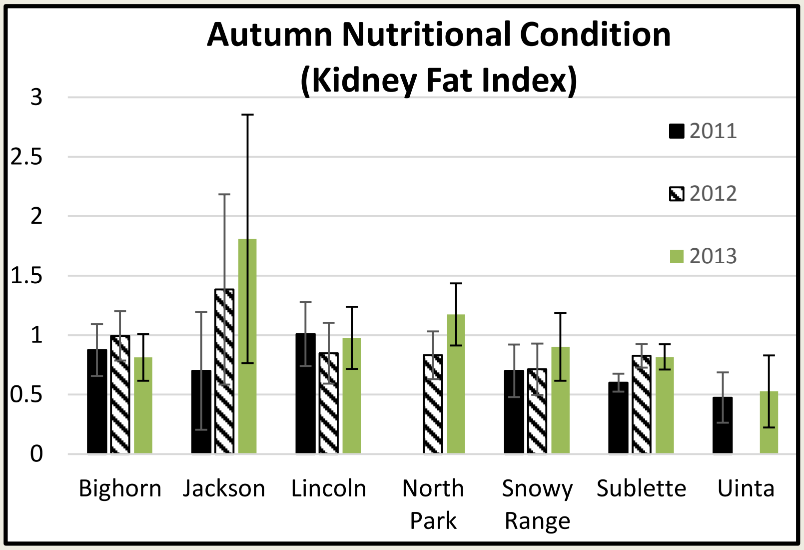


Fig. 12- Variation in male nutritional condition amongst herd units and years.

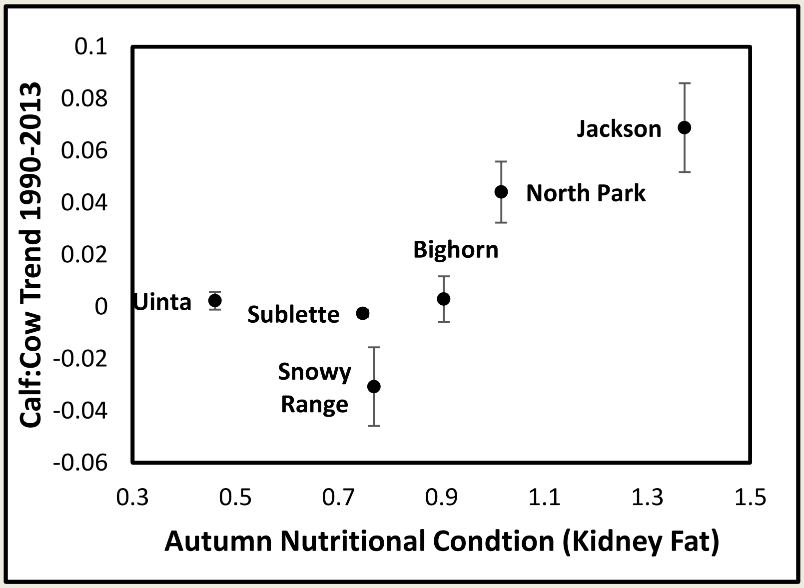


Fig. 13- Relationship between autumn nutritional condition and trends in calves/100 cows from 1990-2013 (see Fig. 2).

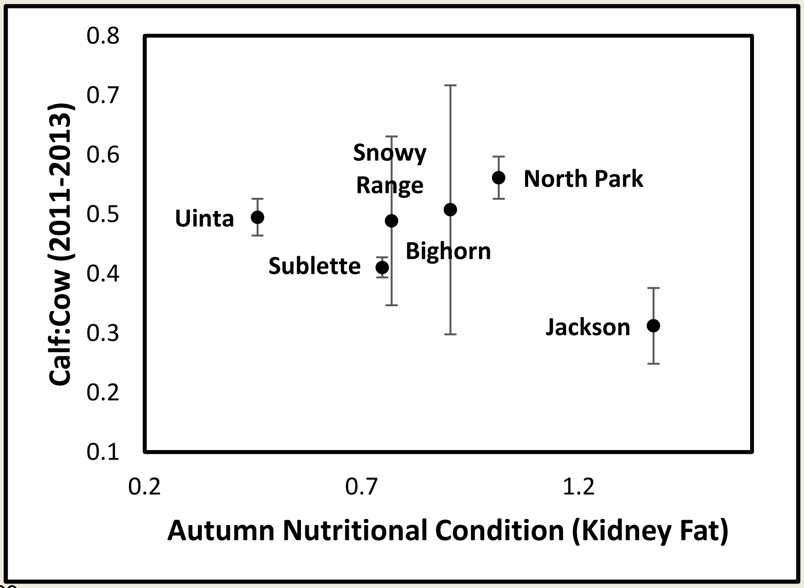


Fig. 14- Relationship between autumn nutritional condition and mean number of calves/100 cows from 2011-2013.

nutritional condition and herd performance indicate that resource limitation is likely contributing to the declines in productivity observed across the region. The ability to observe relationships between winter-range willow condition and population performance, and autumn nutritional condition and population performance using simple summary statistics is an encouraging result. We suspect that we will be able to make strong linkages between habitat, nutritional condition and population performance once we assess summer and winter forage selection and quality, spring nutritional condition, and herd unit pregnancy rates.

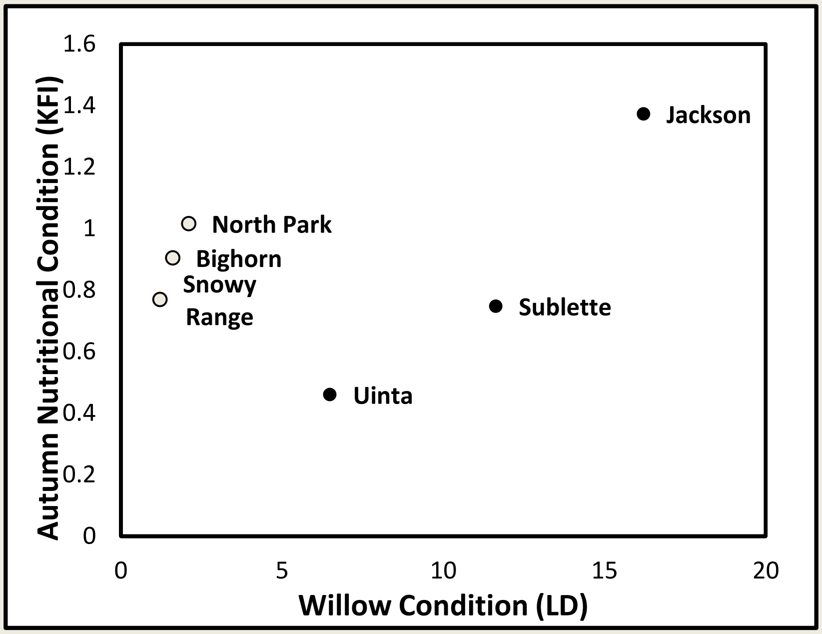


Fig. 15- Relationship between willow condition and nutritional condition of moose. Nutritional condition responds differently to planeleaf willow (open circles) versus Booth's willow (closed circles) condition.

Current and Future Work

We continue to work towards achieving our objective of linking habitat and nutrition to population performance (Fig. 16), and suspect to complete the project during early winter 2016. We are making daily progress with additional DNA extractions and genotype analysis. In 2014 we completed willow condition surveys and summer scat collections in South Park, Flat Tops and the Laramie Range. We are currently conducting winter scat collections at these three new units. Additionally, we began organizing kidney collection with CPW for the 2015 hunting season, which will represent the finalization of our field efforts. During spring 2015 we plan to complete genetic analyses of >1200 fecal samples and obtain finalized diet composition, diet quality, pregnancy and spring nutritional condition data sets. Once data production is completed, we will produce comprehensive reports for our state and federal agencies, provide presentations and materials for the general public, and publish our results in peer-reviewed scientific journals.

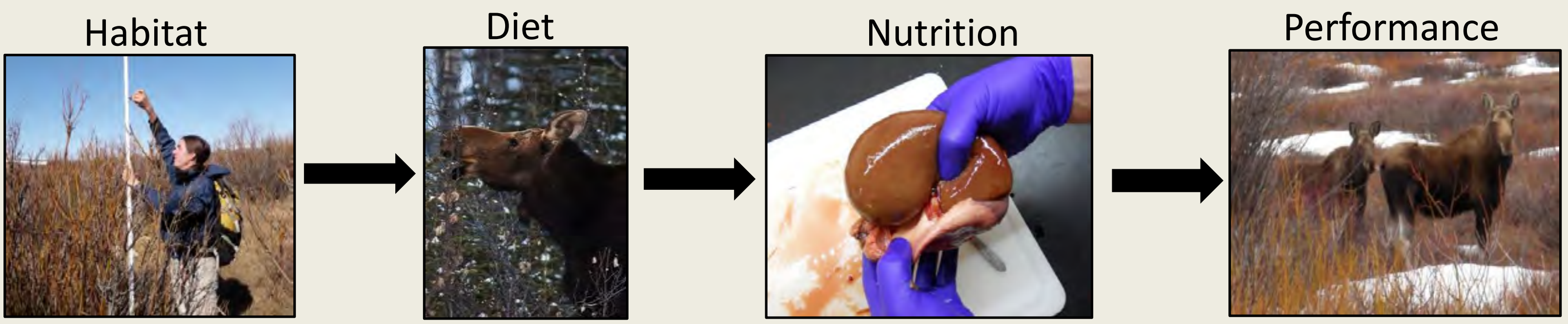


Fig. 16- General conceptual model depicting the linkages between habitat condition, diet quality and composition, and nutritional condition to population performance in Shiras moose. Once we able to quantify how these factors influence population performance, we will be able to provide managers with tools that will allow them to understand the proximity in which their population is to carrying capacity, and hence adapt management strategies accordingly.

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Kerry Murphy (BTNF)
Luke Decker (BNF)

USFWS
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Elizabeth Berkley (AWR)
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UDWR
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