2013 - JCR Evaluation Form

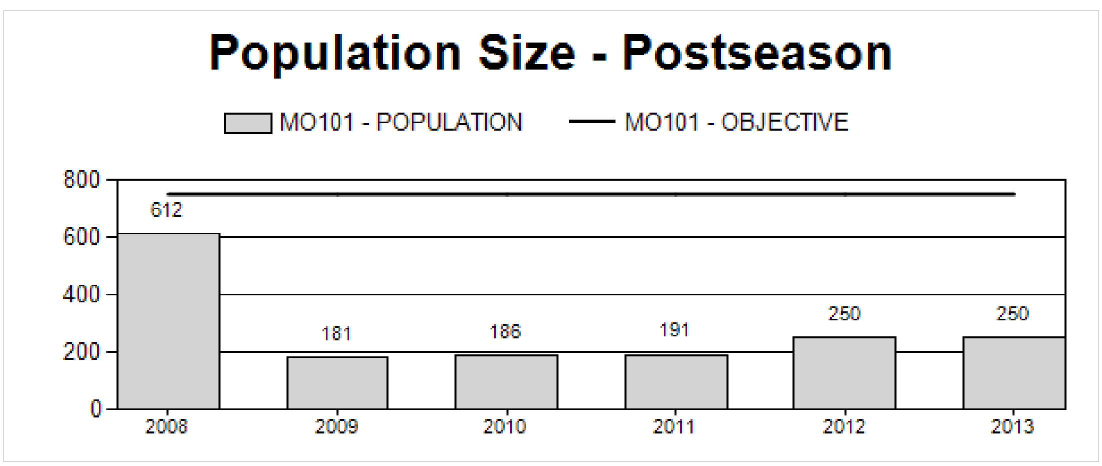
Species: Moose	Period: 6/1/2013 - 5/31/2014
Herd: MO101 - TARGHEE	
Hunt Areas: 16, 37, 900	Prepared By: ALYSON COURTEMANCH

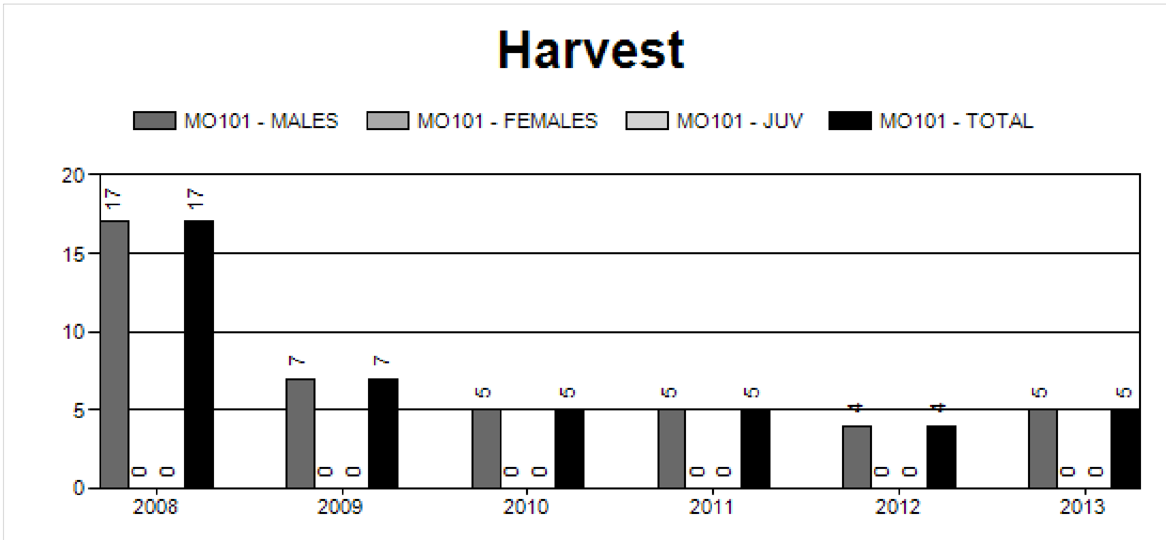
	2008 - 2012 Average	**2013**	**2014 Proposed**
Population:	284	250	250
Harvest:	8	5	4
Hunters:	11	5	5
Hunter Success:	73%	100%	100 %
Active Licenses:	11	5	5
Active License Percent:	73%	100%	100 %
Recreation Days:	95	24	40
Days Per Animal:	11.9	4.8	10
Males per 100 Females	85	0	
Juveniles per 100 Females	31	0	

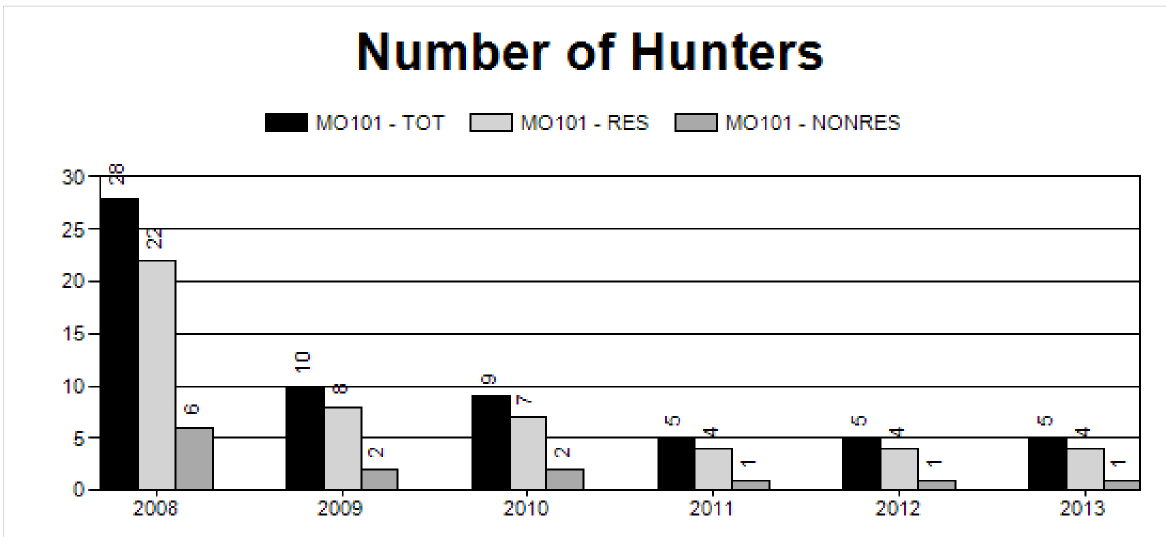
Population Objective:	750
Management Strategy:	Special
Percent population is above (+) or below (-) objective:	-66.7%
Number of years population has been + or - objective in recent trend:	0
Model Date:	None

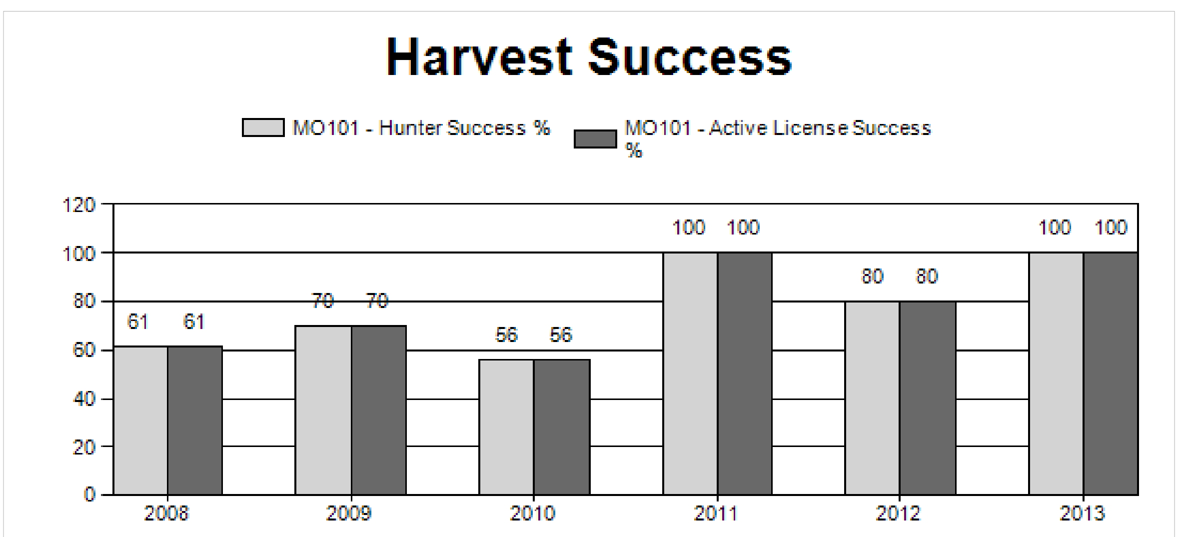
Proposed harvest rates (percent of pre-season estimate for each sex/age group):

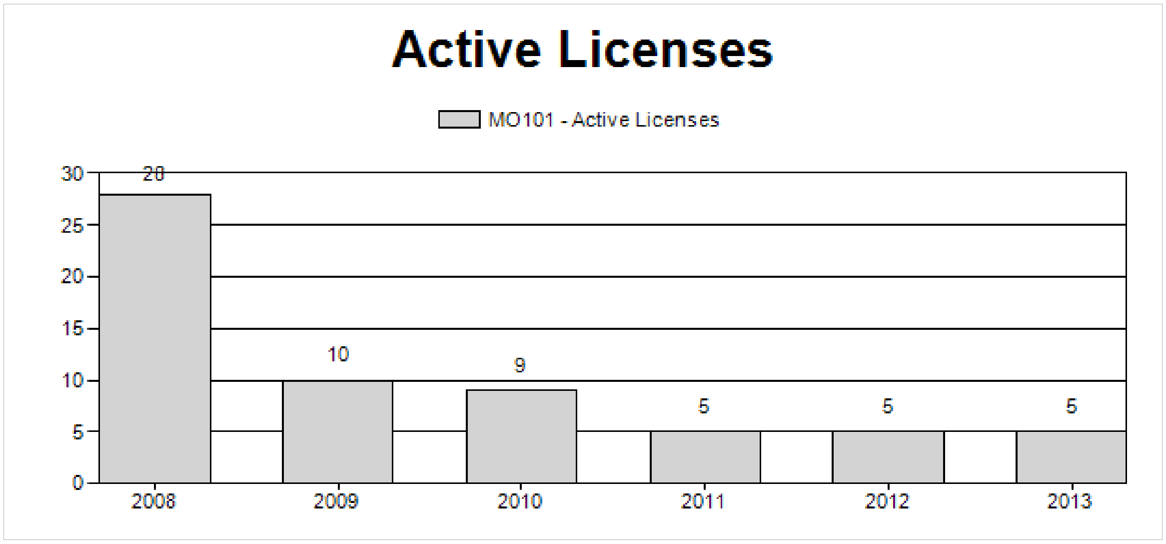
	JCR Year	**Proposed**
Females ≥ 1 year old:	na%	na%
Males ≥ 1 year old:	na%	na%
Juveniles (< 1 year old):	na%	na%
Total:	na%	na%
Proposed change in post-season population:	na%	na%

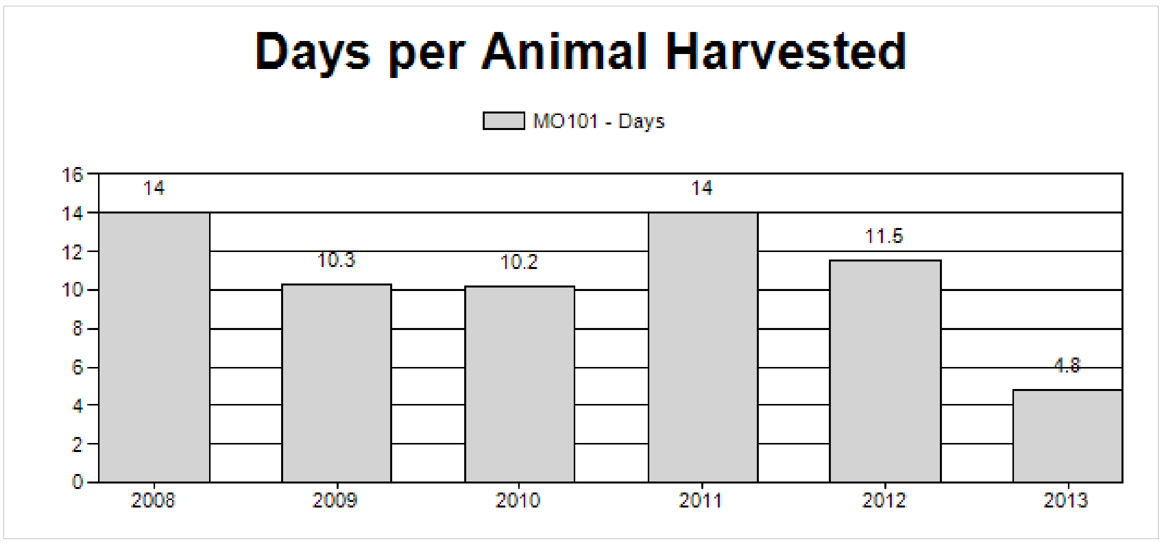


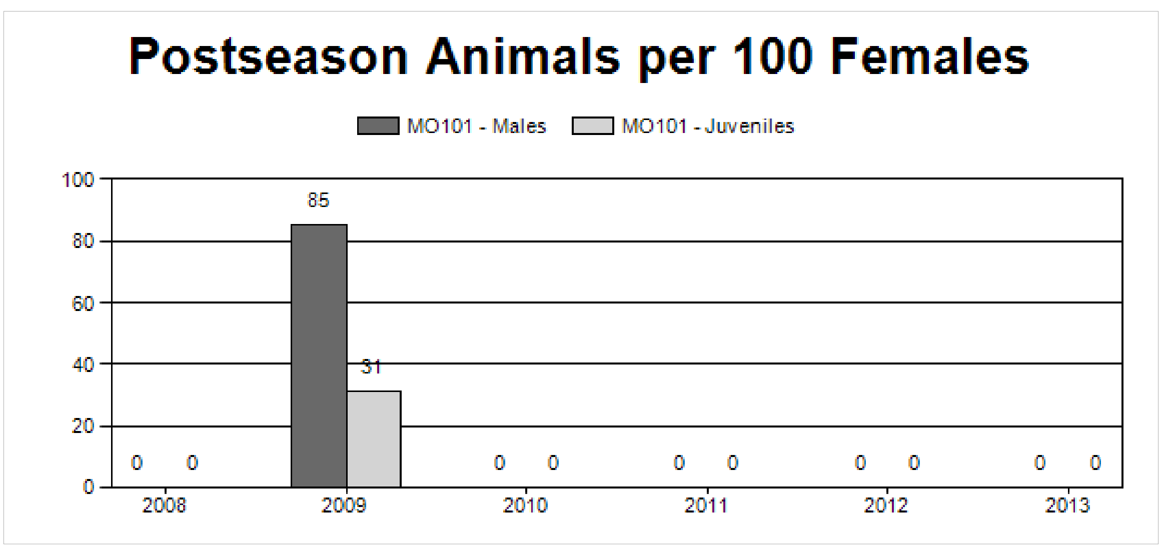

Harvest
MO101 - MALES
MO101 - FEMALES
MO101 - JUV
MO101 - TOTAL
20
15
10
5
0
17
0
0
17
7
0
0
7
5
0
0
5
5
0
0
5
4
0
0
4
5
0
0
5
2008
2009
2010
2011
2012
2013


Number of Hunters
MO101 - TOT
MO101 - RES
MO101 - NONRES
30
25
20
15
10
5
0
28
22
6
10
8
2
9
7
2
5
4
1
5
4
1
5
4
1
2008
2009
2010
2011
2012
2013

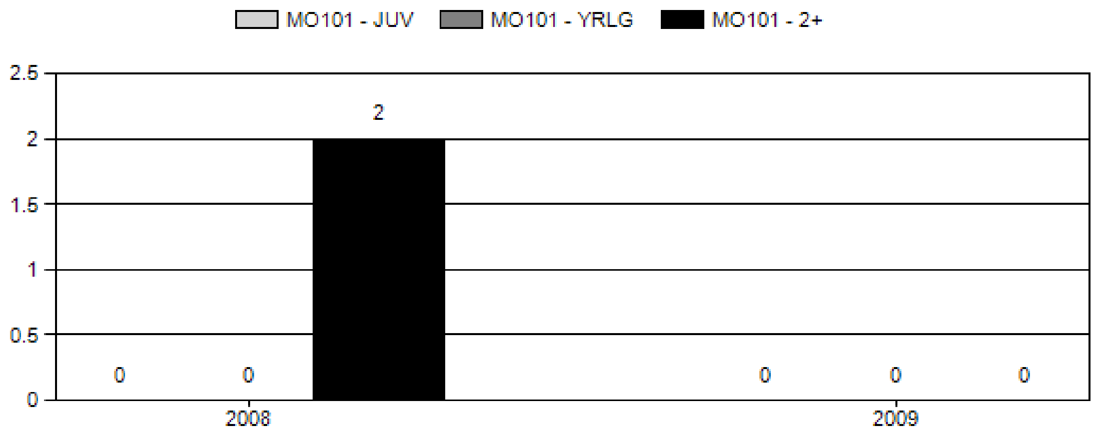

Harvest Success
MO101 - Hunter Success %
MO101 - Active License Success %
120
100
80
60
40
20
0
61
61
70
70
56
56
100
100
80
80
100
100
2008
2009
2010
2011
2012
2013


Active Licenses
MO101 - Active Licenses
30
25
20
15
10
5
0
28
10
9
5
5
5
2008
2009
2010
2011
2012
2013

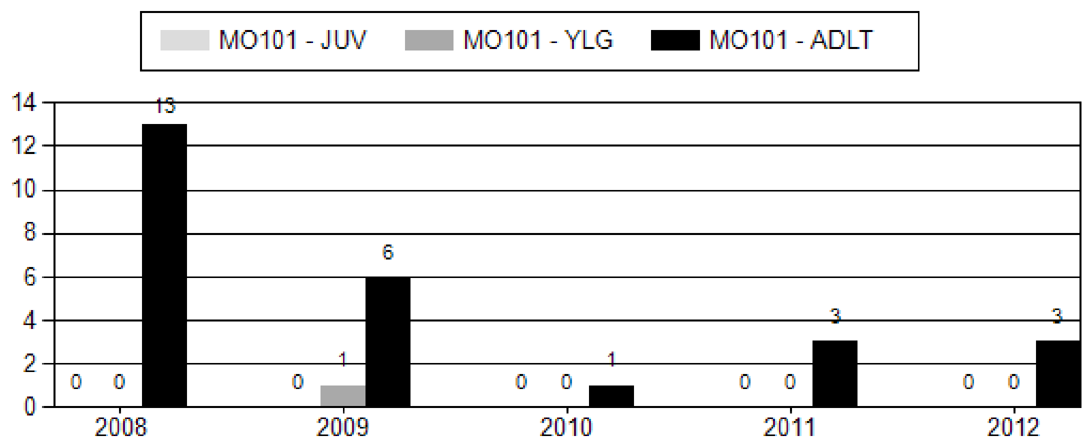

Days per Animal Harvested
MO101 - Days
16
14
12
10
8
6
4
2
0
14
10.3
10.2
14
11.5
4.8
2008
2009
2010
2011
2012
2013


Postseason Animals per 100 Females
MO101 - Males
MO101 - Juveniles
100
80
60
40
20
0
0
0
85
31
0
0
0
0
0
0
0
0
2008
2009
2010
2011
2012
2013

Age Structure of Field Checked Males

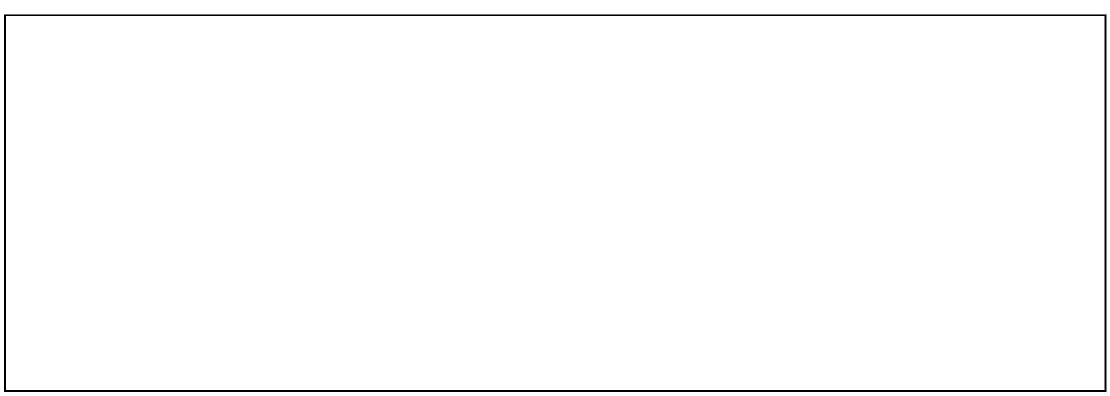


Age Structure Data (Field and Laboratory) - Male



Age Structure Data (Field and Laboratory) - Female

No Data Available



2008 - 2013 Postseason Classification Summary

for Moose Herd MO101 - TARGHEE

		MALES				FEMALES		JUVENILES				Males to 100 Females				Young to		
Year	Post Pop	Ylg	Adult	Total	%	Total	%	Total	%	Tot Cls	Cls Obj	Ylng	Adult	Total	Conf Int	100 Fem	Conf Int	100 Adult
2008	612	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	± 0	0	± 0	0
2009	181	0	0	57	39%	67	46%	21	14%	145	168	0	0	85	± 0	31	± 0	17
2010	186	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	± 0	0	± 0	0
2011	191	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	± 0	0	± 0	0
2012	250	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	± 0	0	± 0	0
2013	250	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	± 0	0	± 0	0

2014 HUNTING SEASONS
TARGHEE MOOSE HERD (MO101)

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

Special Archery Seasons

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

Summary of 2014 License Changes

Hunt Area	Type	Changes from 2013
16, 37	1	-5 days
		+5 days for archery season

Management Evaluation

Current Postseason Population Management Objective: 750
Management Strategy: Special
2013 Postseason Population Estimate: ~150
2014 Proposed Postseason Population Estimate: ~150

The management objective for the Targhee Moose Herd Unit is 750 moose. Spreadsheet models developed for this moose herd do not appear to adequately simulate observed trends and therefore managers will develop alternative objectives for this herd in 2014.

Herd Unit Issues

The current objective is based on a POPII simulation that overestimates the population of moose along the Wyoming-Idaho state line. This population is likely below the post season management objective based on field observations of moose along the state line. Post-season classification surveys are not flown in this herd due to budget constraints.

Weather

Following an extremely dry summer and fall in 2012, weather conditions in 2013 were considerably wetter. The area received significant pulses of spring and fall moisture, which improved forage conditions for elk and other big game. Winter precipitation was reported at 109% of normal by mid-February 2014. Please refer to the following web sites for specific weather station data. **http://www.ncdc.noaa.gov/temp-and-precip/time-series** and **http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/pdiimage.html**

Habitat

No habitat data has been collected on mule deer summer and winter ranges in recent years. There are several historical vegetation transects that have not been monitored in the past 5 years. Several habitat improvement projects are being implemented in this herd unit, including the Hill Creek Prescribed Burn, which is scheduled for completion in 2014. This project will improve conifer-encroached aspen stands in the foothills of the Teton Range. In addition, a habitat treatment in Teton Canyon is currently in the planning stages to improve mountain shrub and aspen communities for moose. Please refer to the 2013 Annual Report Strategic Habitat Plan Accomplishments for Jackson Region habitat improvement project summaries (**http://wgfd.wyo.gov/web2011/wildlife-1000708.aspx**).

Field Data

There was no field data collected in the Targhee Herd Unit during the 2013 biological year.

Harvest Data

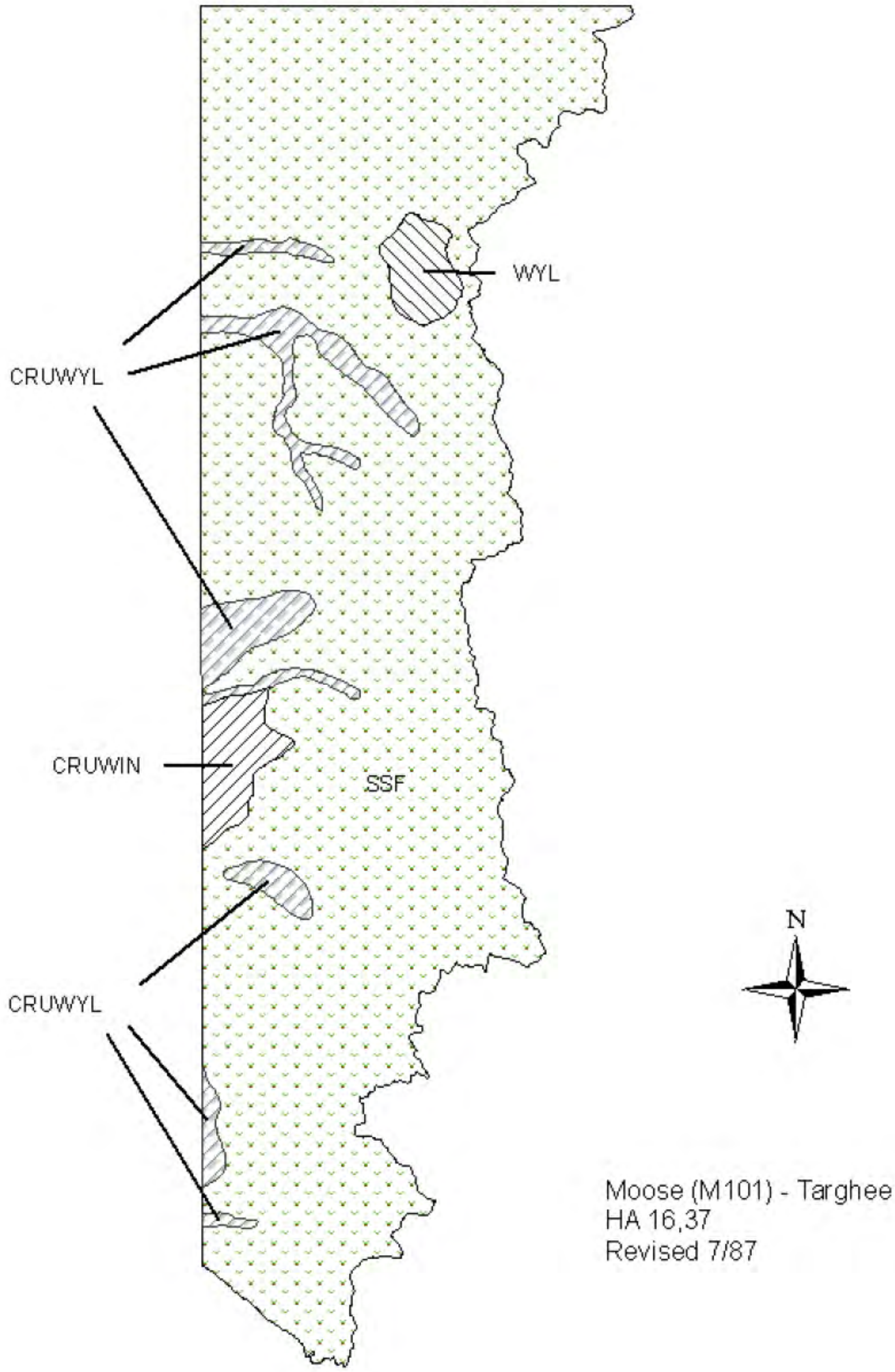
To offset observed population declines, antlerless harvest was eliminated from the Targhee moose herd in 2006 and the two hunt areas were combined in 2011. In spite of these changes the moose population does not appear to be increasing. Data from the 2013 harvest survey indicate that 5 hunters harvested 5 bulls. Harvest success has been consistently high for past 3 years. The average number of days to harvest was relatively low in 2013 at 4.8 days compared to 11.5 days in 2012 and 14 days in 2011. 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 below the post season management objective. 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. Managers plan to maintain limited hunting opportunity west of the Teton Range until harvest statistics and field observations warrant additional review.


WYL
CRUWYL
CRUWIN
SSF
CRUWYL
N
Moose (M101) - Targhee
HA 16,37
Revised 7/87

2013 - JCR Evaluation Form

SPECIES: Moose | PERIOD: 6/1/2013 - 5/31/2014

HERD: MO103 - JACKSON

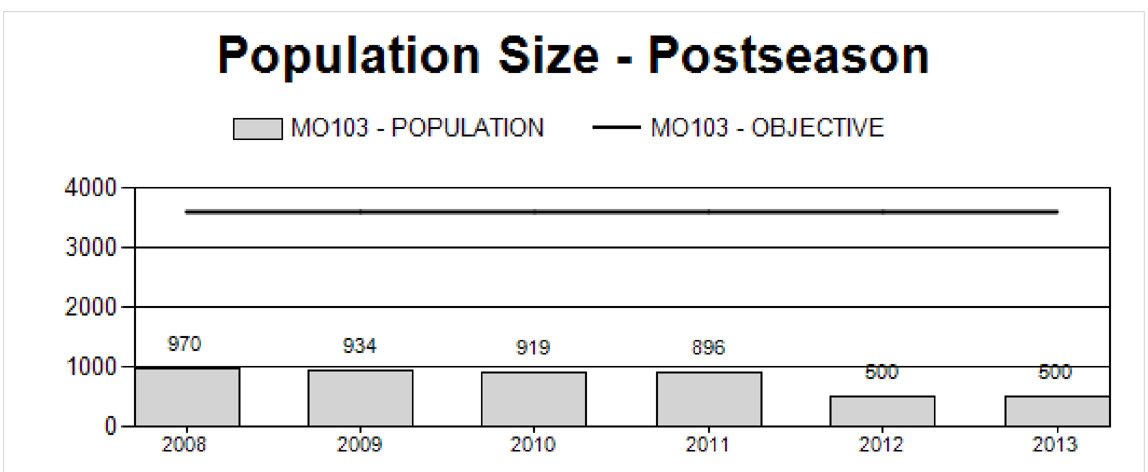
HUNT AREAS: 7, 14-15, 17-19, 28, 32, 777, 888 | PREPARED BY: ALYSON COURTEMANCH

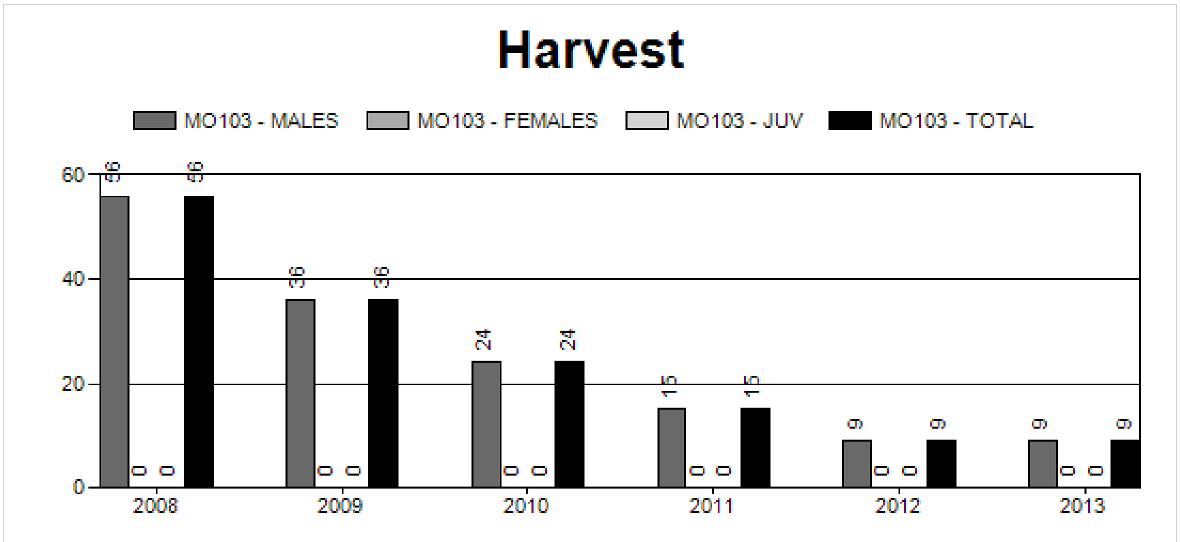
	2008 - 2012 Average	2013	2014 Proposed
Population:	844	500	500
Harvest:	28	9	10
Hunters:	34	9	10
Hunter Success:	82%	100%	100%
Active Licenses:	34	9	10
Active License Percent:	82%	100%	100%
Recreation Days:	252	39	60
Days Per Animal:	9	4.3	6
Males per 100 Females	69	89	
Juveniles per 100 Females	23	37	

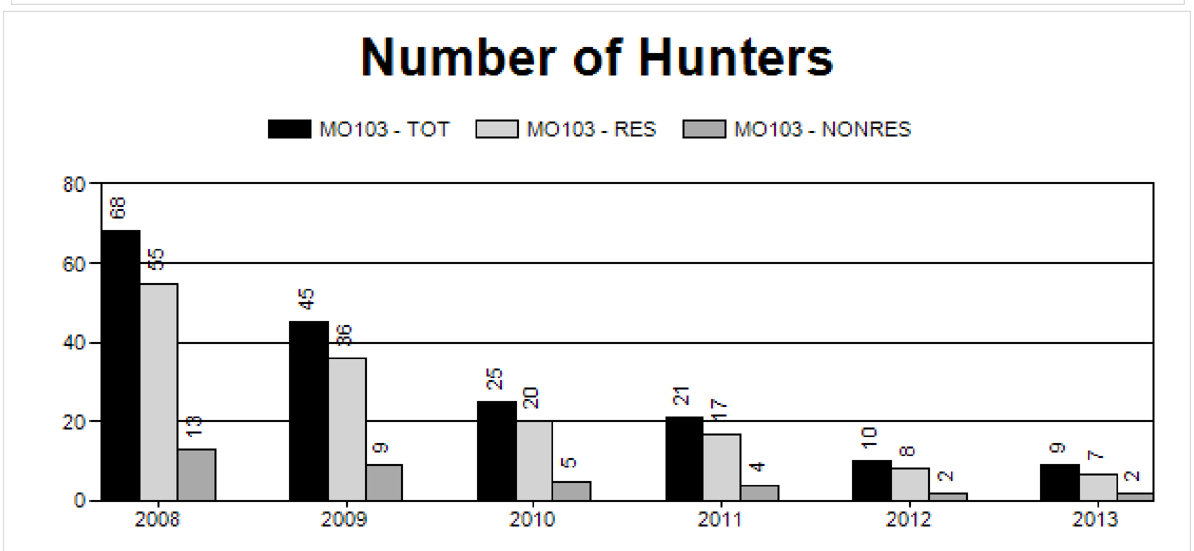
Population Objective:	3,600
Management Strategy:	Special
Percent population is above (+) or below (-) objective:	-86.1%
Number of years population has been + or - objective in recent trend:	0
Model Date:	None

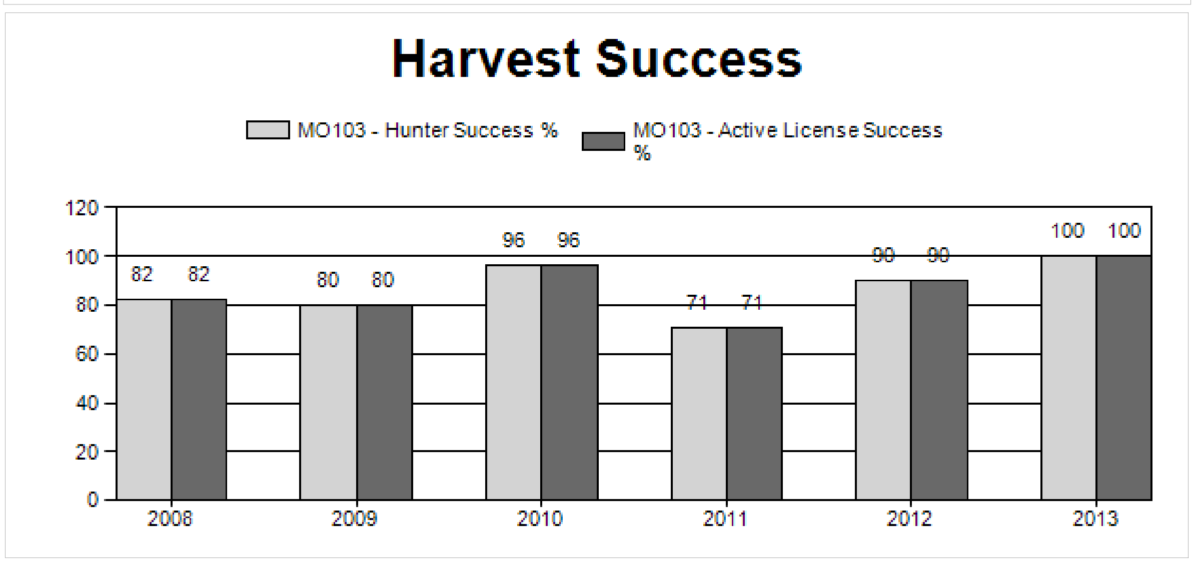
Proposed harvest rates (percent of pre-season estimate for each sex/age group):

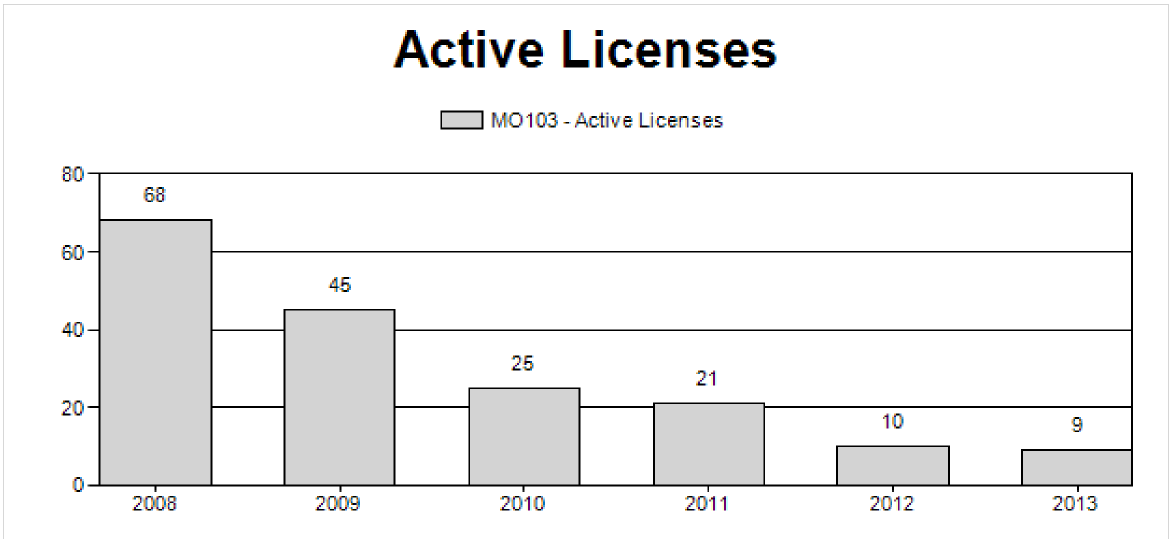
	JCR Year	Proposed
Females ≥ 1 year old:	na%	na%
Males ≥ 1 year old:	na%	na%
Juveniles (< 1 year old):	na%	na%
Total:	na%	na%
Proposed change in post-season population:	na%	na%

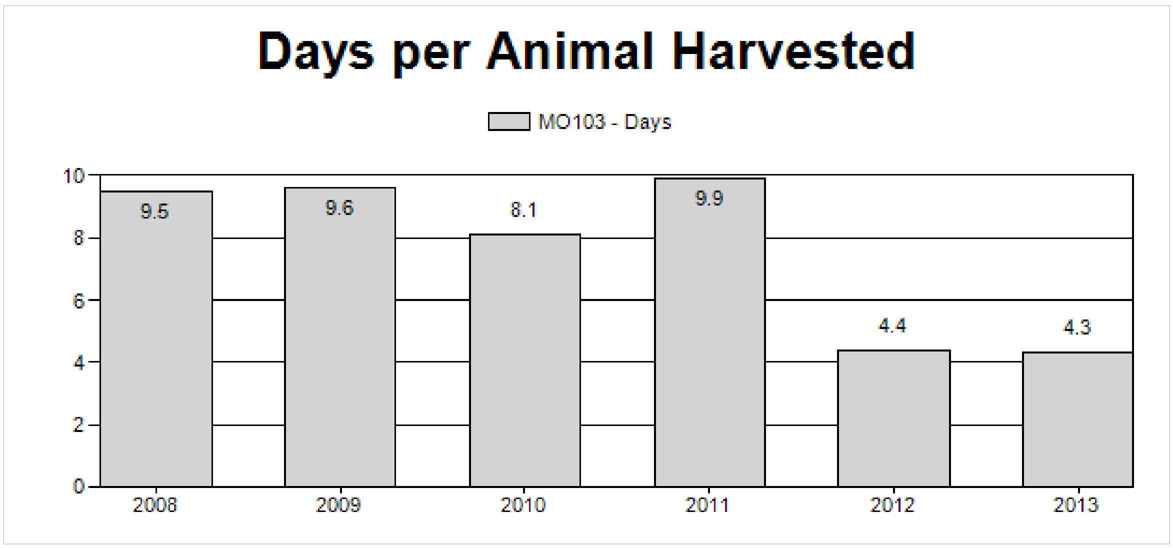


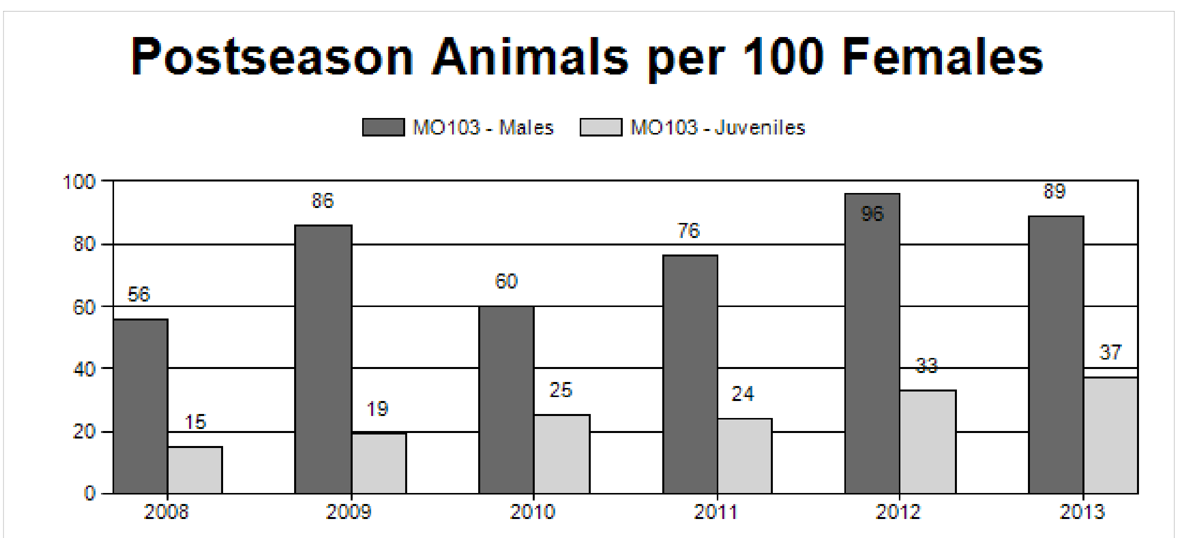

Harvest
MO103 - MALES
MO103 - FEMALES
MO103 - JUV
MO103 - TOTAL
60
40
20
0
56 0 0 56
36 0 0 36
24 0 0 24
15 0 0 15
9 0 0 9
9 0 0 9
2008
2009
2010
2011
2012
2013

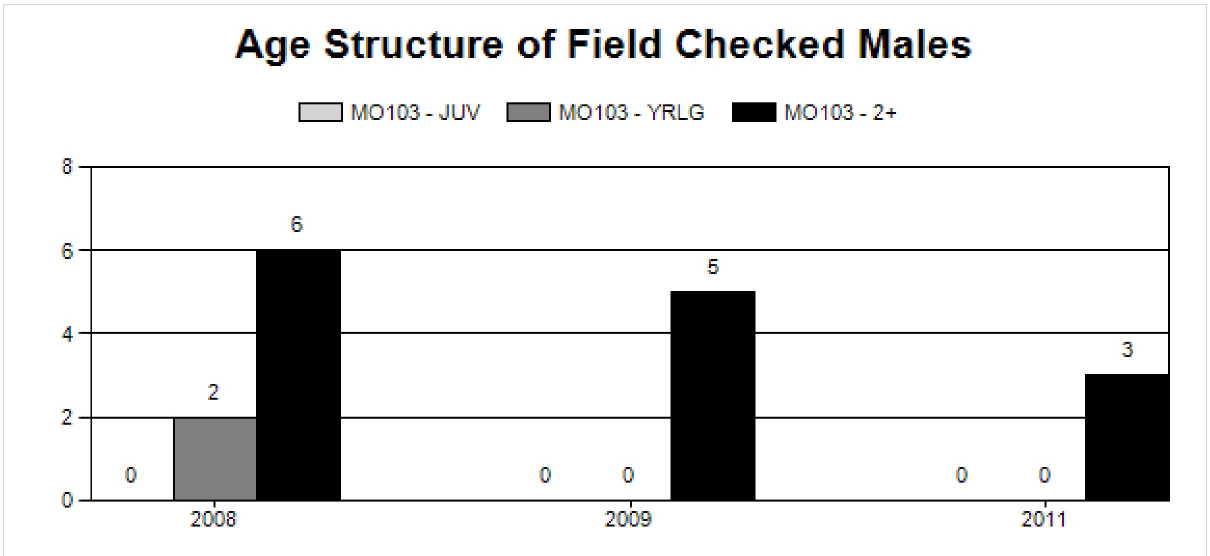

Number of Hunters
MO103 - TOT
MO103 - RES
MO103 - NONRES
80
60
40
20
0
68 55 13
45 36 9
25 20 5
21 17 4
10 8 2
9 7 2
2008
2009
2010
2011
2012
2013

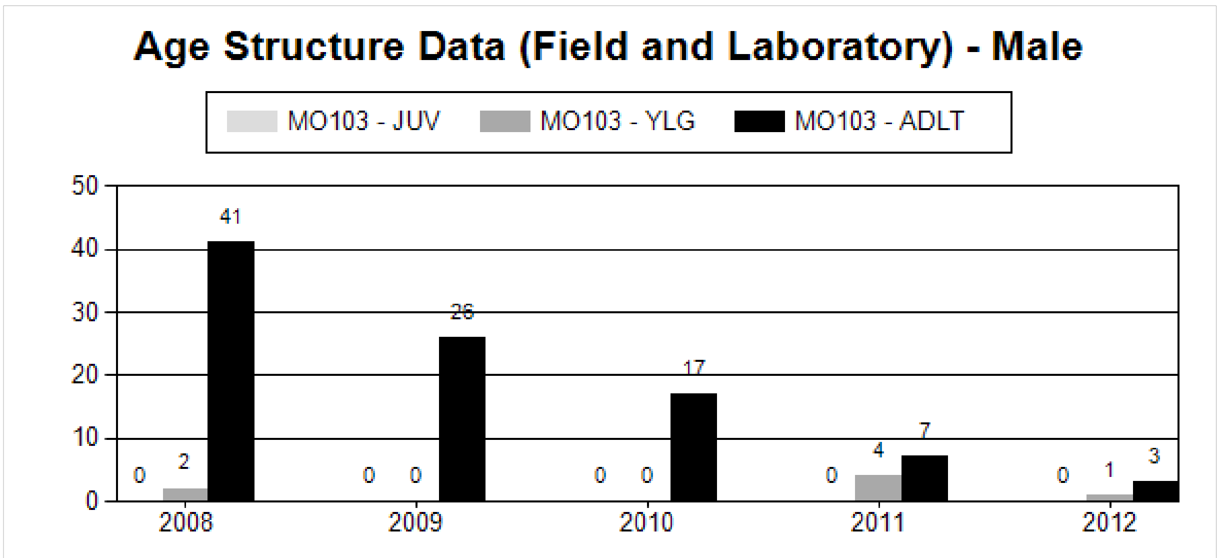

Harvest Success
MO103 - Hunter Success %
MO103 - Active License Success %
120
100
80
60
40
20
0
82 82
80 80
96 96
71 71
90 90
100 100
2008
2009
2010
2011
2012
2013

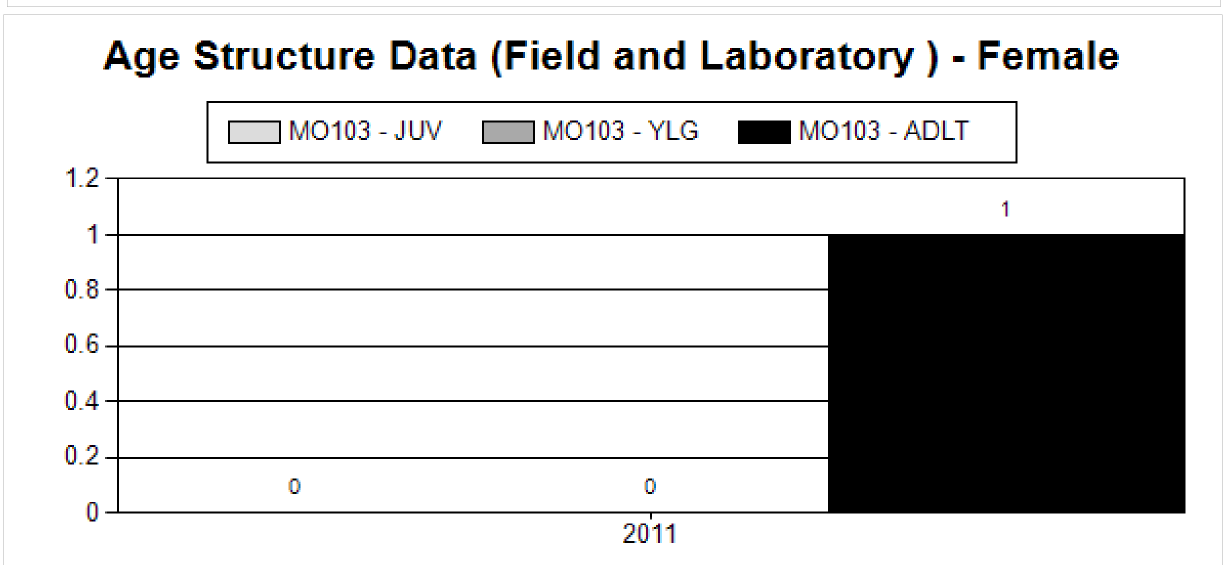

Active Licenses
MO103 - Active Licenses
80
60
40
20
0
68
45
25
21
10
9
2008
2009
2010
2011
2012
2013


Days per Animal Harvested
MO103 - Days
10
8
6
4
2
0
9.5
9.6
8.1
9.9
4.4
4.3
2008
2009
2010
2011
2012
2013


Postseason Animals per 100 Females
MO103 - Males
MO103 - Juveniles
100
80
60
40
20
0
56
15
86
19
60
25
76
24
96
33
89
37
2008
2009
2010
2011
2012
2013


Age Structure of Field Checked Males
MO103 - JUV
MO103 - YRLG
MO103 - 2+
8
6
4
2
0
6
2
0
5
0
0
3
0
0
2008
2009
2011


Age Structure Data (Field and Laboratory) - Male
MO103 - JUV
MO103 - YLG
MO103 - ADLT
50
40
30
20
10
0
41
0
2
26
0
0
17
0
0
4
7
0
1
3
0
2008
2009
2010
2011
2012


Age Structure Data (Field and Laboratory) - Female
MO103 - JUV
MO103 - YLG
MO103 - ADLT
1.2
1
0.8
0.6
0.4
0.2
0
1
0
0
2011

2008 - 2013 Postseason Classification Summary

for Moose Herd MO103 - JACKSON

		MALES				FEMALES		JUVENILES				Males to 100 Females				Young to		
Year	Post Pop	Ylg	Adult	Total	%	Total	%	Total	%	Tot Cls	Cls Obj	Ylng	Adult	Total	Conf Int	100 Fem	Conf Int	100 Adult
2008	970	0	0	116	33%	208	58%	32	9%	356	502	0	0	56	± 7	15	± 3	10
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	109	109	40%	122	44%	44	16%	275	417	0	89	89	± 10	36	± 5	19

2014 HUNTING SEASONS
JACKSON MOOSE HERD (MO103)

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

Summary of
2014 License Changes

Hunt Area	Type	Change from 2013
17, 28	1	- 5 days
		+5 days for archery season

Management Evaluation

Current Postseason Population Management Objective: 3,600
Management Strategy: Special
2013 Postseason Population Estimate: ~500
2014 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 as the benchmark for this population in 2016. The management strategy for this herd is designated as Special Management and was last revised in 1999.

Herd Unit Issues

This population is well below the post season management objective. Population declines were most evident from 2000 – 2003 and research on moose in the northern portion of the herd unit indicated that a number of factors were influencing this population (Becker 2008, Vartanian 2011). In spite of hunting season closures and a reduction in the number of permits, this population has been delayed in responding to management changes. Large scale wildfires during the late 1980s and more recently have also influenced summer moose habitat. Re-colonizing carnivores and parasites such as carotid artery worm and winter ticks also pose additional challenges.

Weather

Following an extremely dry summer and fall in 2012, weather conditions in 2013 were considerably wetter. The area received significant pulses of spring and fall moisture, which improved forage conditions for moose and other ungulates. At the time of the mid-winter survey, winter precipitation was reported at 109% of normal. Deep snow was observed in several moose winter ranges during the mid-winter survey. Please refer to the following web sites for specific weather station data. **http://www.ncdc.noaa.gov/temp-and-precip/time-series** 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 have not been monitored in winter 2013/2014. Live-dead indices are generally positive, indicating that browsing pressure is not preventing willows from reaching their natural height. This 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 Coop Unit (Vartanian, 2011) suggests that high intensity wildfires also negatively impact forage quality for moose.

The Wyoming Game and Fish Department and Bridger-Teton National Forest 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.

The Dry Quad Prescribed Burn was completed in fall 2013 in cooperation with Bridger Teton National Forest to improve elk and moose habitat. The burn treated approximately 60 acres of decadent aspen stands south of Spread Creek. Please refer to the 2013 Strategic Habitat Plan Annual Report for Jackson Region habitat improvement project summaries (**http://wgfd.wyo.gov/web2011/wildlife-1000708.aspx**).

Field Data

In February 2014, classification surveys were flown over low elevation winter ranges. We observed 275 moose this year, up from the 237 observed last year. The herd unit calf:100 cow ratio continued to improve with 36:100 this year. This ratio has been slowly improving every year since 2008 when a ratio of 15:100 was observed. The bull:100 cow ratio also remained high this year at 89:100. Ratios differed between herd segments in the Gros Ventre and Buffalo Valley. Buffalo Valley ratios were higher overall with a calf:cow ratio of 44:100 and a bull:cow ratio of 148:100. The calf:cow ratio in the Gros Ventre was 33:100 and the bull:cow ratio was 76:100. The highest densities of moose were observed along Fish Creek, along the Gros Ventre River east of the Fish Creek feedground, in the Buffalo Valley, and along the Buffalo Fork near Moran Junction. Due to unfavorable weather conditions, not all of the areas normally flown were surveyed this year. The total count would likely be higher if we were able to survey all areas.

Moose densities in the Willow Flat/Oxbow Bend Area (24 km^2) have declined from an average of 4 moose per km^2 in 2000 (n=48 moose) to 0.16 moose per km^2 in 2010 and 2012 (n=4). The density of moose has also declined on winter ranges in the Buffalo Valley (30 sq km^2). Houston (1968) documented 20 moose per km^2 and densities have declined to 7 moose per km^2 in 1999, 2.7 moose per km^2 in 2009 and 1.6 moose per km^2 in 2012.

Harvest Data

During the 2013 season, 9 bull moose were harvested. License quotas were decreased during each of the last five years in response to declining trends. During 2013 hunter success remained high and hunter effort remained similar to 2012 at 4.3 days per animal. Winter classification and trend data from this past winter indicate that the herd may be rebounding.

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 is less than 500 animals in this population. Although the population remains low, aerial survey data from recent postseason classifications indicate a high number of bull moose in the population and an improving calf:cow ratio. It is possible that the Jackson moose population may have bottomed out and with the observed increased calf:cow ratios this population may be able to sustain a low level of harvest.

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. Bull 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 for the 2012 season. Despite these changes the moose population north of Jackson continued to decline through 2012. It is possible that with the current trend of improved calf production, limited hunting opportunity can be sustained several more years unless the overall number of cows in the population declines.

Conservative hunting seasons are again planned for 2014 with 10 licenses offered for the Gros Ventre drainage. Total cow numbers and calf:cow ratios show a promising improvement this year, but the herd will continue to be closely monitored in future years to evaluate whether additional hunting opportunities can be provided. The overall number of cows improved this year and with the improved calf:cow ratios, a complete closure to hunting moose north of Jackson is not warranted at this time.

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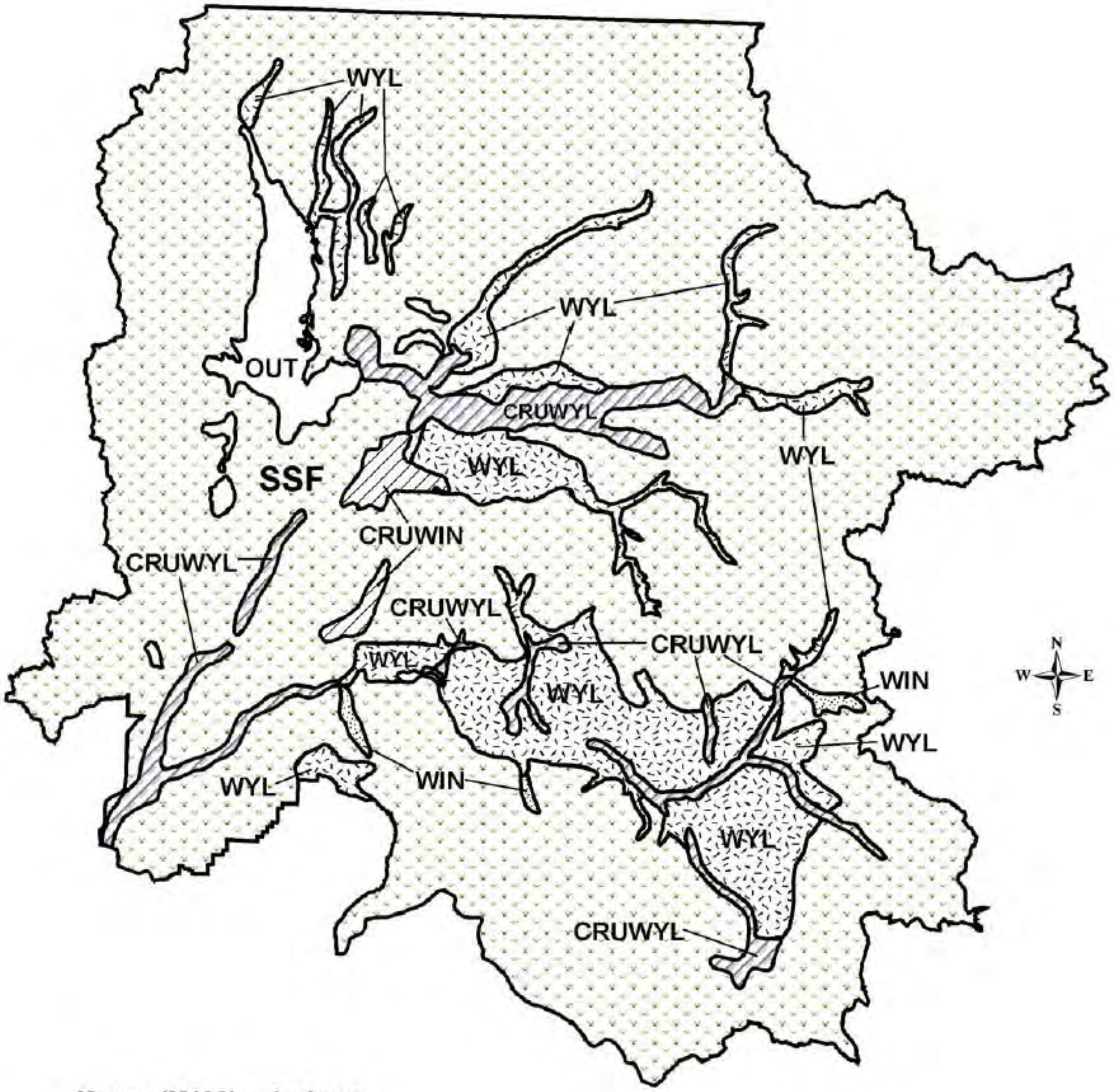

Moose (M103) -- Jackson
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Statewide Moose Habitat Project:

Linking Habitat and Nutrition with Population Performance in Wyoming Moose

Annual Report 2013

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Background & Objectives

The Wyoming Game & Fish Department (WGFD), Wyoming Cooperative Fish and Wildlife Research Unit, and the University of Wyoming initiated the Statewide Moose Habitat Project in June 2011. Currently, Shiras moose (*Alces alces shirasi*) herds in the state (Fig. 1) are exhibiting a wide range of population performance, with some declining and some relatively stable or even increasing despite historic declines (Fig. 2). For the declining herds, potential mechanisms that may affect carrying capacity 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 review) or other disturbances, such as large, intense wildfire (Vartanian 2011) or bark beetle (*Dendroctonus* spp.) outbreaks. 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 can not 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 and survival of moose.

In combination with the observed range in population performance, variability of moose habitat (see Vartanian 2011, Monteith *et al.* in review) in the state represents a timely opportunity to evaluate habitat-performance relationships (i.e. local carrying capacities). Such a statewide habitat evaluation could serve as a benchmark to understand the relationship between moose habitat and population performance and would provide the WGFD with "early warning" metrics to predict where and when declines are likely to occur, and would improve the scientific basis of moose population 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 populations proximity to carrying capacity and adapt management strategies accordingly. Therefore, we have developed the following objectives:

1. Understand the relationship between resource limitation and herd productivity.
2. Establish meaningful browse condition indices for monitoring and management purposes.
3. Explore alternative 'early warning' metrics to preempt declines in herd productivity.

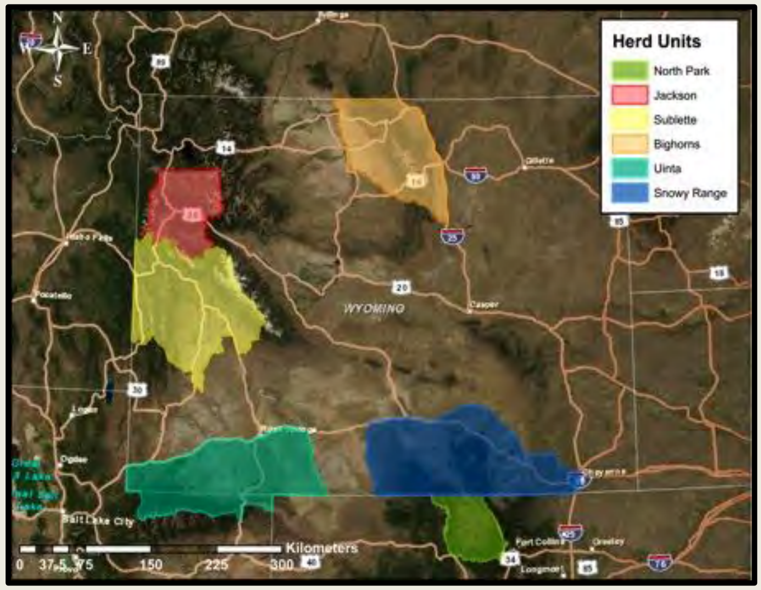


Fig. 1- Map depicting the project study areas.

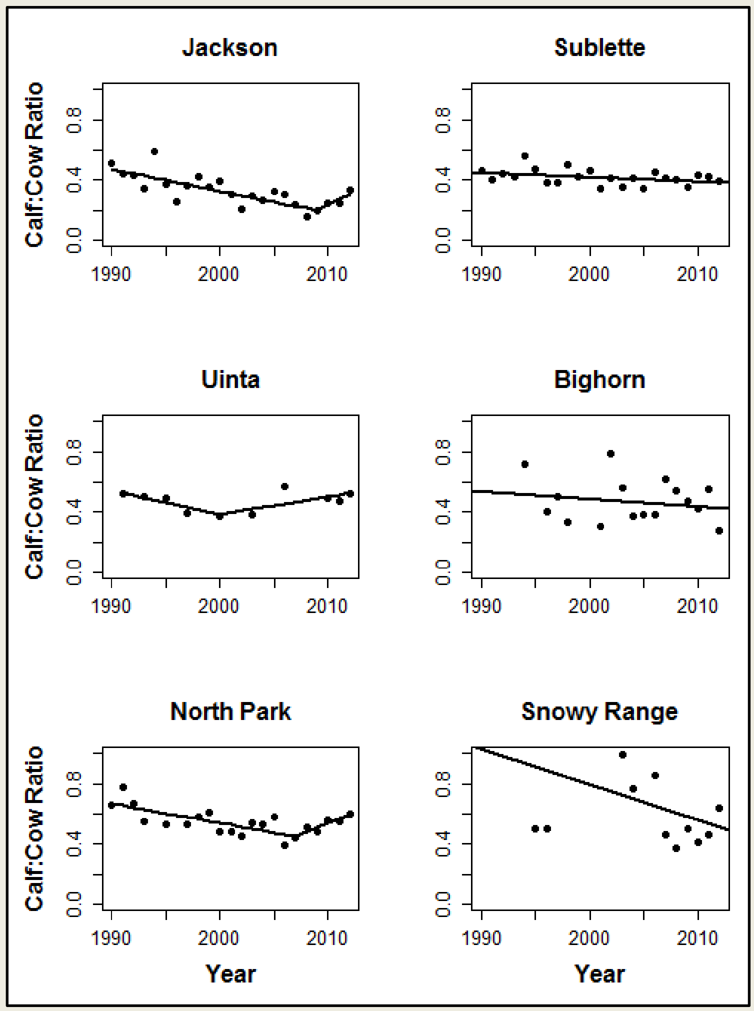


Fig. 2 – Trends in calf-cow ratios from 1990-2012 across our six areas. Trend lines established through piecewise regression. Piecewise regression quantifies multiple differing trends in a single data set. Note that the trend lines represented for the Snowy Range and Bighorn herd units are not statistically significant (P>0.05), meaning slopes are not different than zero.

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 the WGFD Wildlife Observation System (WOS) moose location dataset 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. 3, 4 and 5). Only WOS location data collected post-hunt from 2000 through 2012 were used in herd-range analyses.

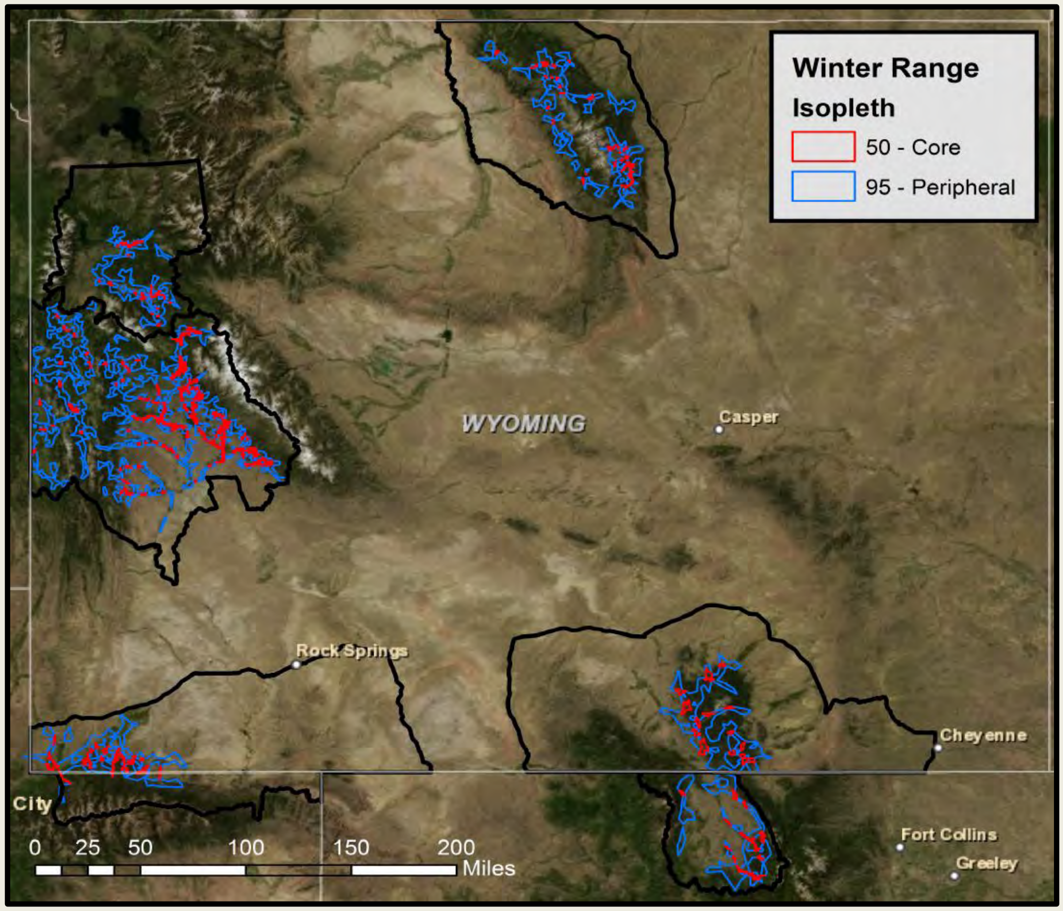


Fig. 3- Distribution of core (50%; red) and peripheral (95%; blue) moose winter ranges across the six study areas. Note- not all core and peripheral areas displayed here were sampled (see pg. 4 for details).

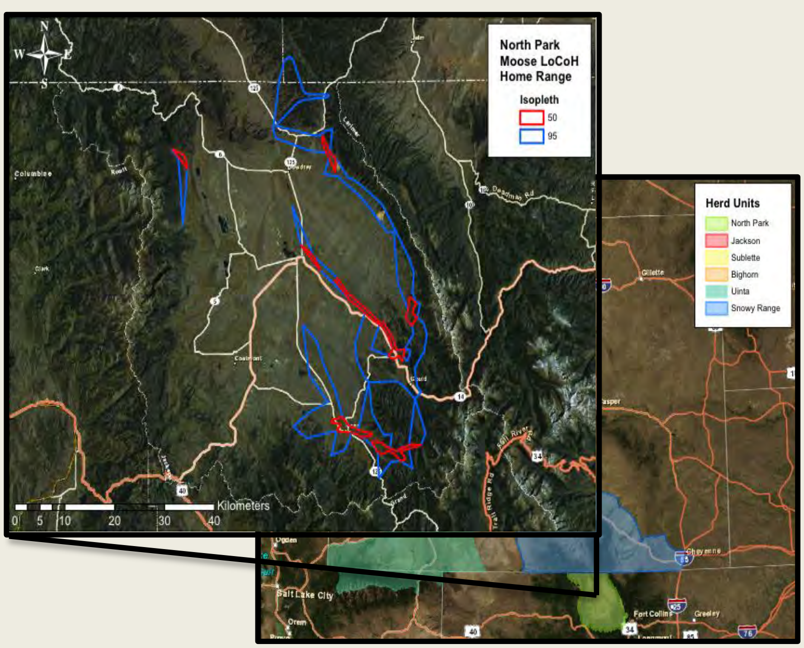


Fig. 4- In each herd unit, such as North Park (shown here), core (red) and peripheral (blue) moose habitat was identified to guide sampling of willow browse conditions and scat (see pg. 5 for details).

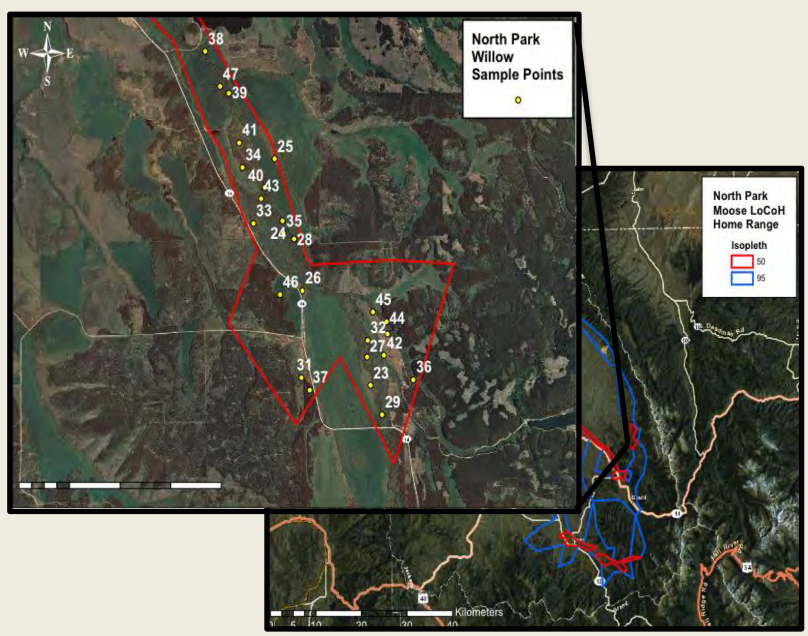


Fig. 5- Within each core and peripheral range, such as North Park's Michigan River (shown here), randomly generated points were drawn in willow habitat to prevent observer bias (see pg. 5 for details).

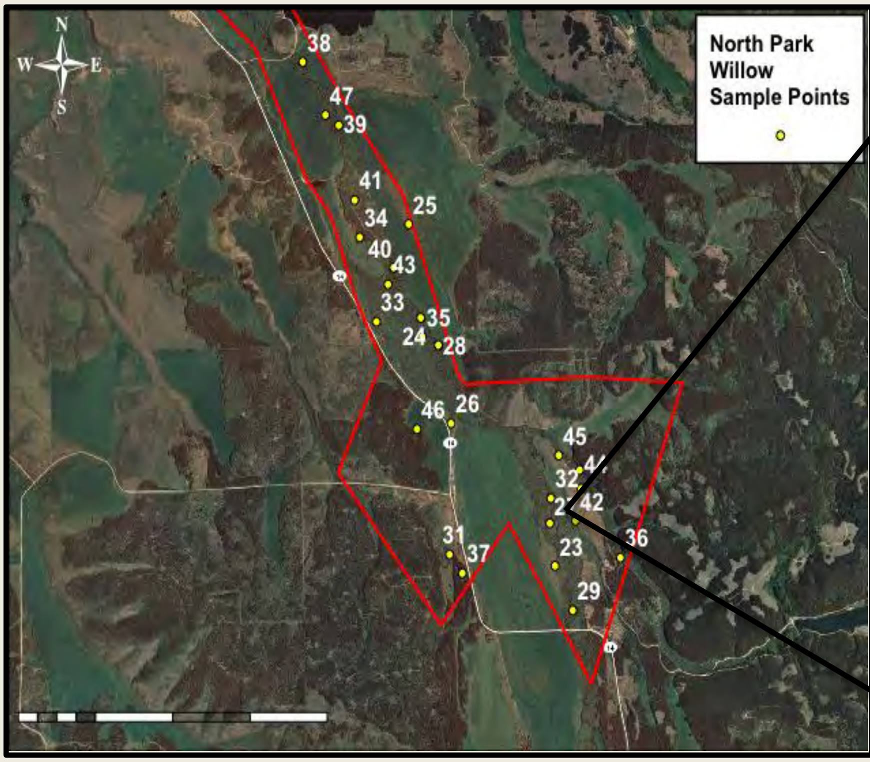


Fig. 6- Map depicting randomly generated sample sites in willow habitat along the Michigan River, Jackson County, CO.

Fig. 7- Technician**,** Allie Hunter, takes an LD reading along Spread Creek, Teton County, WY.

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. 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 scat samples opportunistically and along LD transects (Fig. 8) according to a sterile protocol developed to eliminate cross contamination. We only collected scats that appeared to be fresh and were determined to have originated from an adult moose according to morphometrics (i.e. size). Using molecular techniques we will group scat 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 scats, 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.

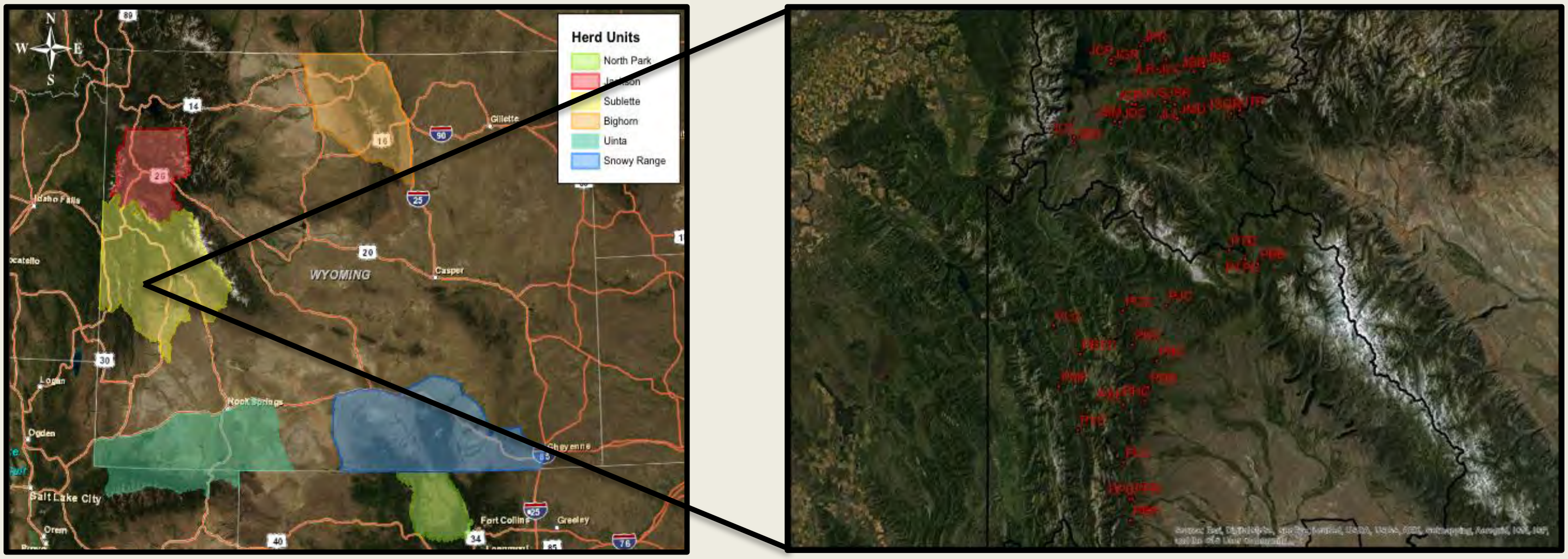


Fig. 9- Map depicting randomly generated sample sites across different habitats where summer scats were sampled in Sublette and Teton Counties, WY.

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 scat-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 (i.e. statewide n=120) 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.

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 (microhistology or qPCR) and forage quality (fecal nitrogen) analyses.

Fig. 10- Map illustrating a scat transect (5-6 km each) in willow habitat. Kilgore Creek, Sublette County, WY.

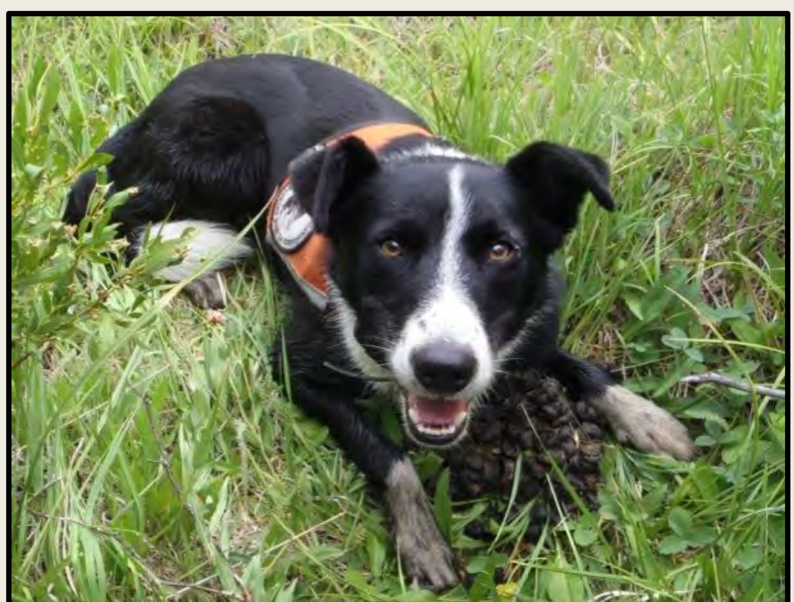
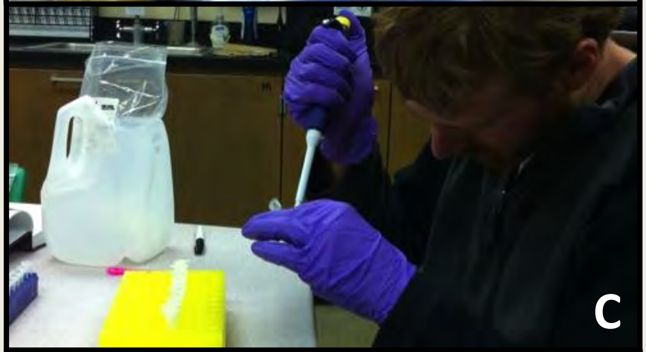


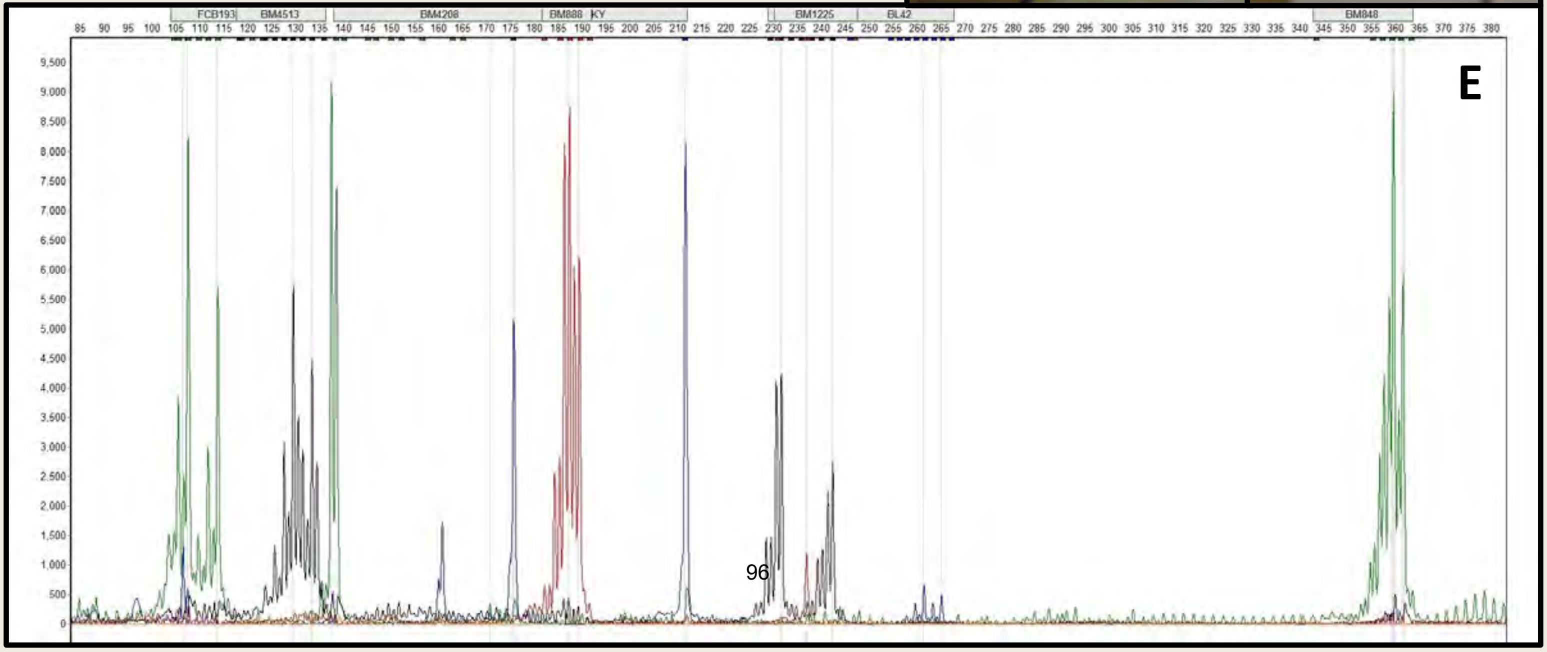
Fig. 11- Orbee the detection dog is very proud of his find (mostly he just wants his reward; a short game of fetch with a ball).

Only ‘fresh’ (i.e. typically <1 week old) scats were collected along each transect. 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.

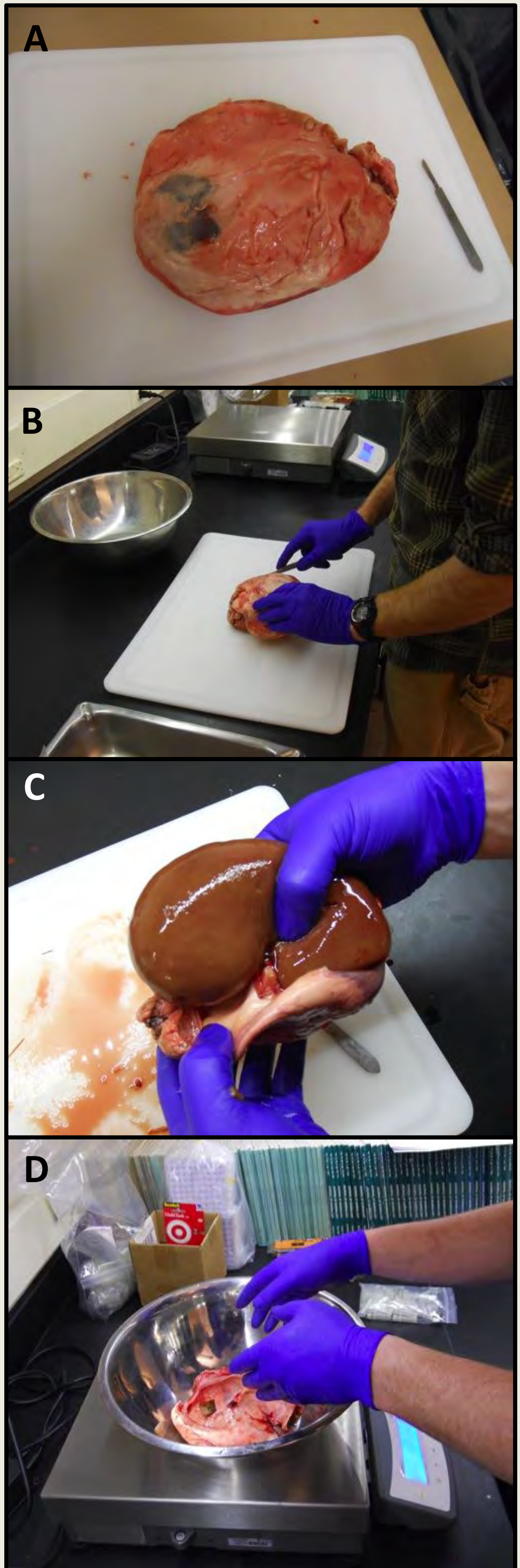


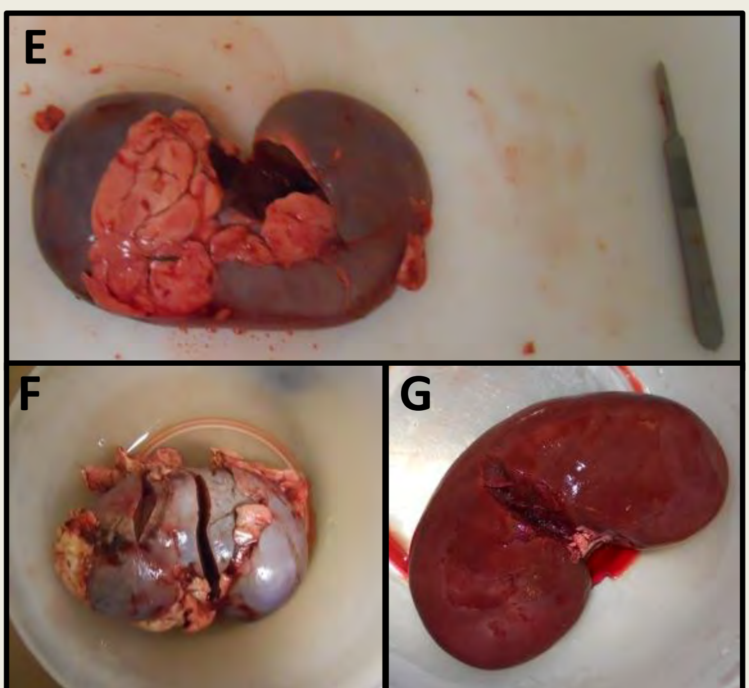


To understand how winter habitat condition and quality, and summer diet and forage quality affect the **nutritional condition** of moose, we are measuring autumn kidney fat. The amount of fat found attached to the kidney is a good predictor of total body fat in moose (Stephenson *et al*. 1998). We collaborated with the WGFD, Colorado Division of Parks and Wildlife (CDPW) and the Utah Division of Wildlife Resources (UDWR) to solicit hunters to collect kidneys from harvested moose. With each kidney, hunters and WGFD, CDPW 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, CDPW 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 perirenal 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, and therefore likelihood of pregnancy, in ungulates (Parker *et al.* 2009). 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).

We completed 349 LD transects, representing 6980 individual willow plants measured, during 2012-2013. During 2011-2012 we analyzed 346 undisturbed kidneys for nutritional condition assessment. In 2013 we collected an additional 190 kidneys to supplement our sample. Nutritional condition was significantly different between the six herd units (Fig. 12; ANCOVA: P=0.02; note small sample size in Jackson). Willow condition according to the LD index was also significantly different amongst herd units (Fig. 13; ANOVA: P=<0.001). Interestingly, Baigas (2008) reported to the WGFD even poorer LD values for planeleaf willow. Also, we found that LD values for planeleaf willow and Booth's willow differed (T-test: P=<0.001). It is important to note that, although LD measures for all herd units dominated by planeleaf are statistically similar, the herd units exhibiting greater overall variation in willow condition (i.e. more patches in relatively good condition) are those herd units which are exhibiting better population performance (see figs. 14 and 15). Planeleaf is highly preferred by all large herbivores and consistently

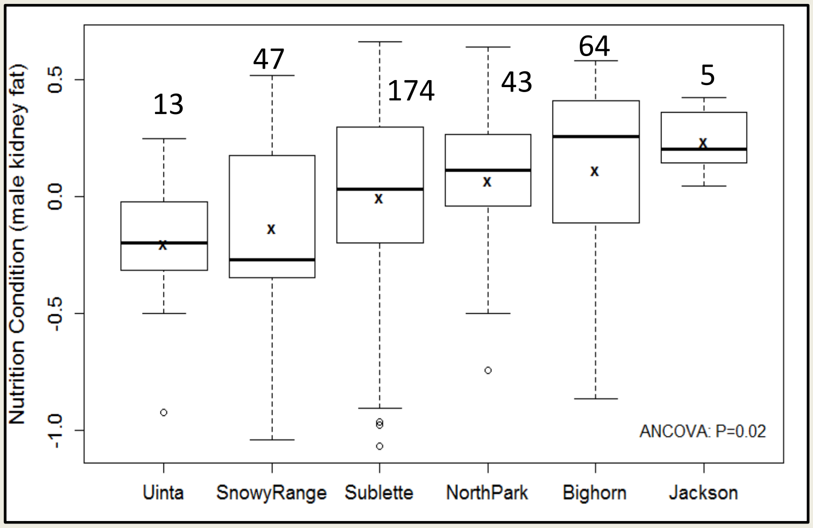


Fig. 12- Variation in male nutritional condition. X's represent means, bars represent medians, vertical lines represent the data range, circles represent outliers, and numbers represent sample sizes.

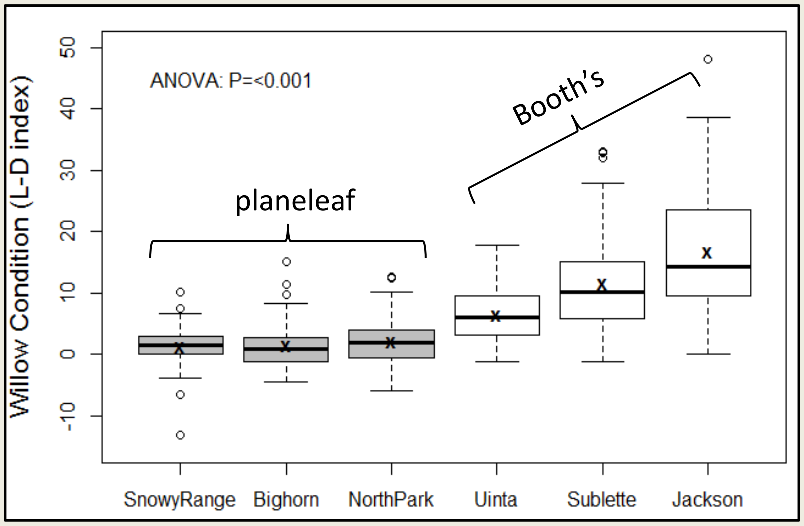
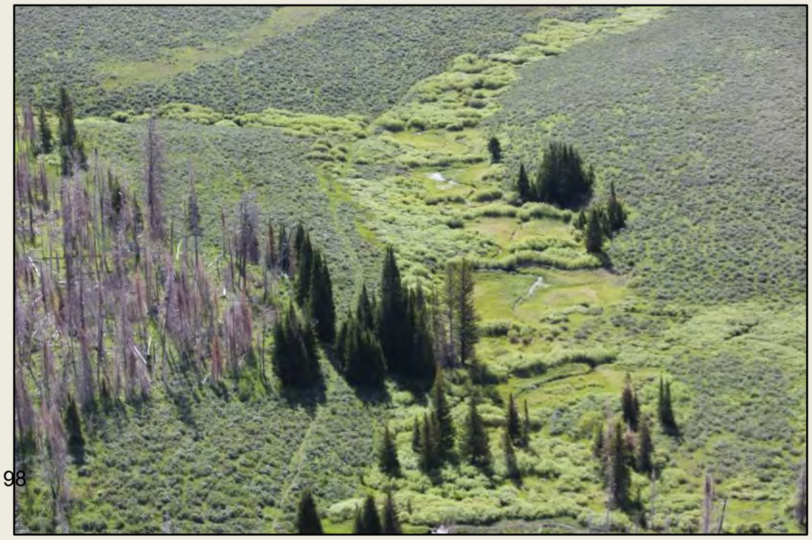


Fig. 13- Variation in willow condition. X's represent means, bars represent medians, vertical lines represent the data range, circles represent outliers, and numbers represent sample sizes.



browsed heavily. We further summarize the data using the means (x's) from figures 14 and 15 to assess the general relationships between winter forage condition, nutritional condition, and population performance (i.e. recruitment rates). Figure 14 suggests a positive relationship between winter willow condition and population performance. Figure 15 reveals that male nutritional condition in autumn is likely a good indicator of local population performance. Being able 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.

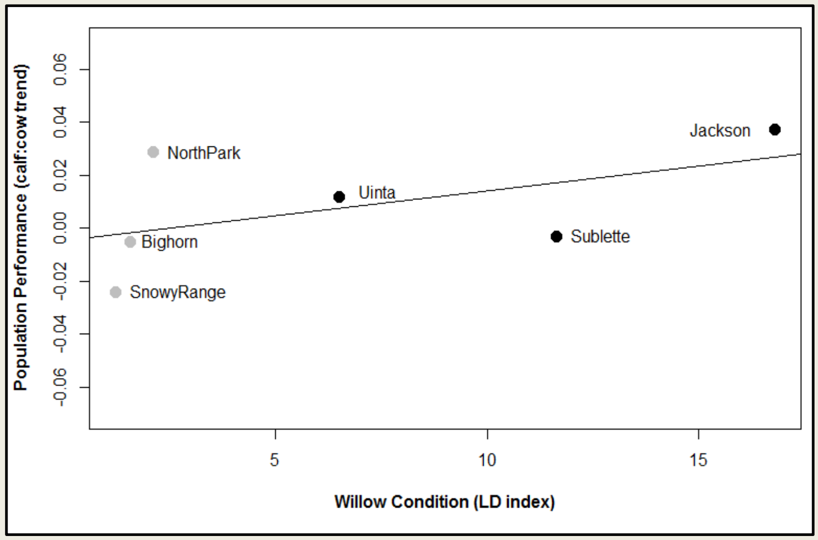


Fig. 14- General relationship between willow condition and nutritional condition of moose. Herd units dominated by the highly preferred planeleaf willow (grey circles) decline in performance as variation in willow declines, whereas herd units dominated by Booth's will decline in performance as overall willow condition declines (see fig. 13 and page 8 for details).

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 the fall of 2014. We are making daily progress with DNA extractions and genotype analysis. In 2013 we completed and a second round of winter scat collections willow condition transects. Additionally, we completed a third round of kidney collections, which represents the finalization of our field efforts. During spring 2014 we plan complete genetic analyses of 1022 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 state and federal agencies, provide presentations and materials for the general public, and publish our results in peer-reviewed scientific journals during summer and fall 2014.

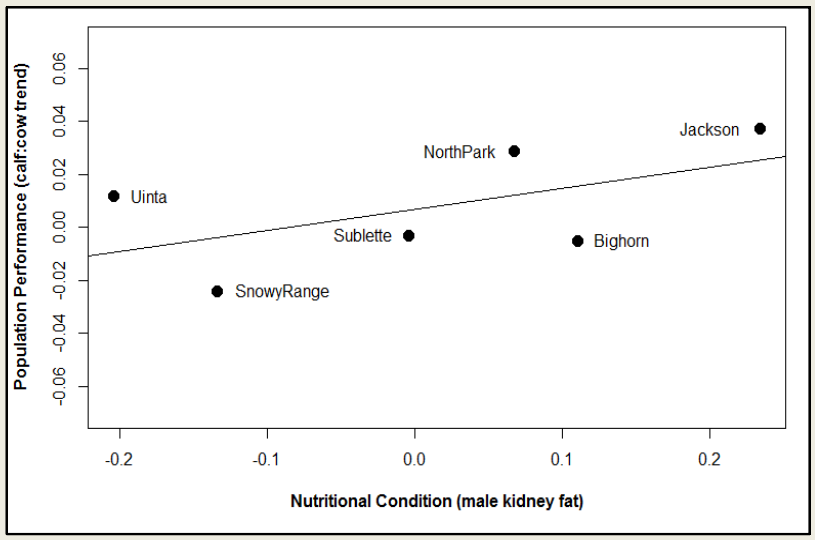


Fig. 15- General relationship between moose nutritional condition and population performance.

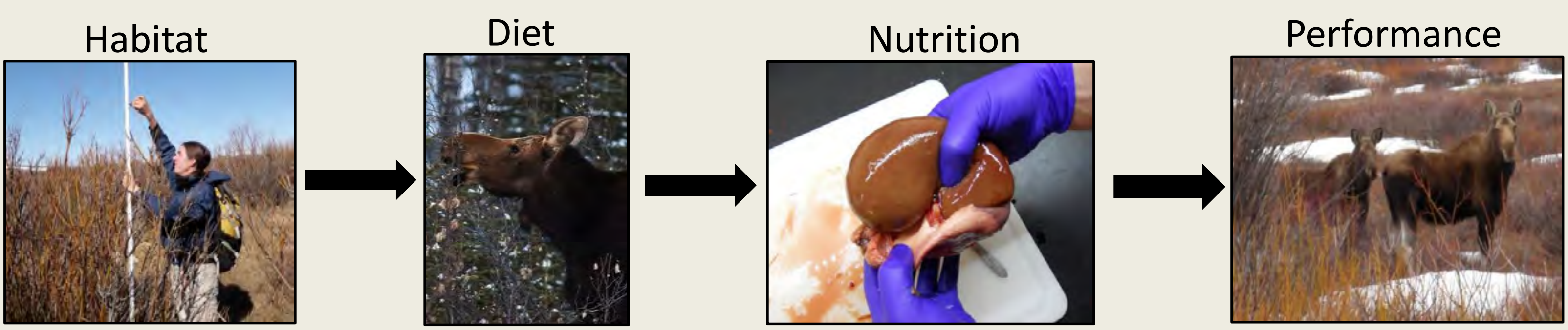


Fig. 16- General conceptual model depicting the linkages between habitat condition, diet quality and composition, and nutritional condition to population performance in Shiras moose. Once we able to quantify how these factors influence population performance, we will be able to provide managers with 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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Allie Hunter
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Lyn Snoddy
Clint Atkinson
Thomas Day
Tina Helseth
Mark Baran
Caitlin Danies
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