

2015 - JCR Evaluation Form

SPECIES: Bighorn Sheep

PERIOD: 6/1/2015 - 5/31/2016

HERD: BS106 - TARGHEE

HUNT AREAS: 6

PREPARED BY: ALYSON COURTEMANCH

	<u>2010 - 2014 Average</u>	<u>2015</u>	<u>2016 Proposed</u>
Harvest:	1	1	2
Hunters:	2	3	2
Hunter Success:	50%	33%	100 %
Active Licenses:	2	3	2
Active License Success:	50%	33%	100 %
Recreation Days:	13	65	40
Days Per Animal:	13	65	20
Males per 100 Females:	155	100	
Juveniles per 100 Females	30	30	

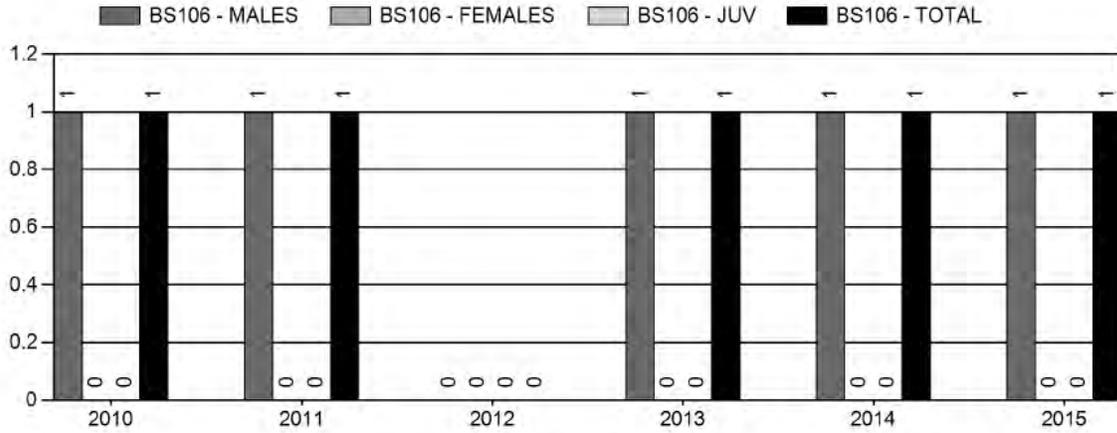
Management Strategy:	Special
Percent population is above (+) or (-) objective:	0%
Number of years population has been + or - objective in recent trend:	0

Population Objective Type: Alternative, Bighorn Sheep

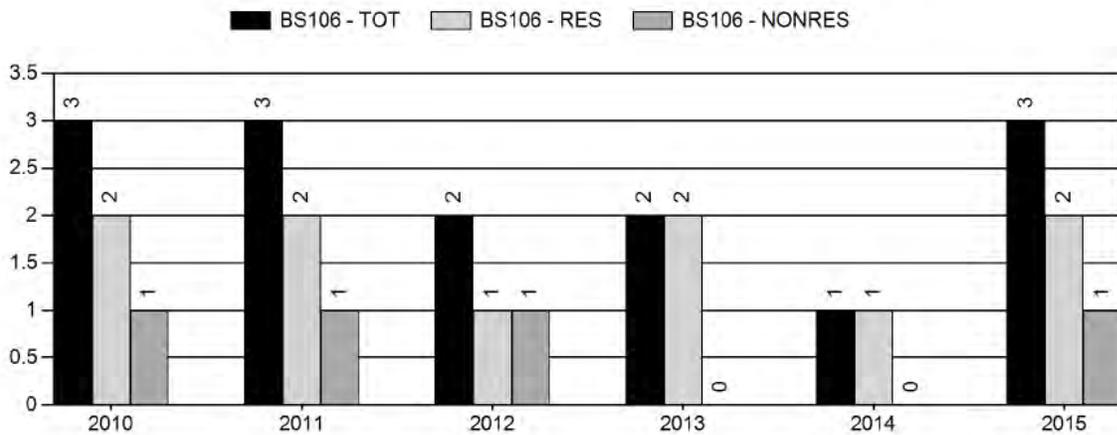
Objectives:

1. Achieve a 5-year average harvest age of 6-8 years,
2. Achieve a 5-year average hunter success of $\geq 50\%$, and
3. Document occurrence of adult rams in the population, especially on National Forest lands.

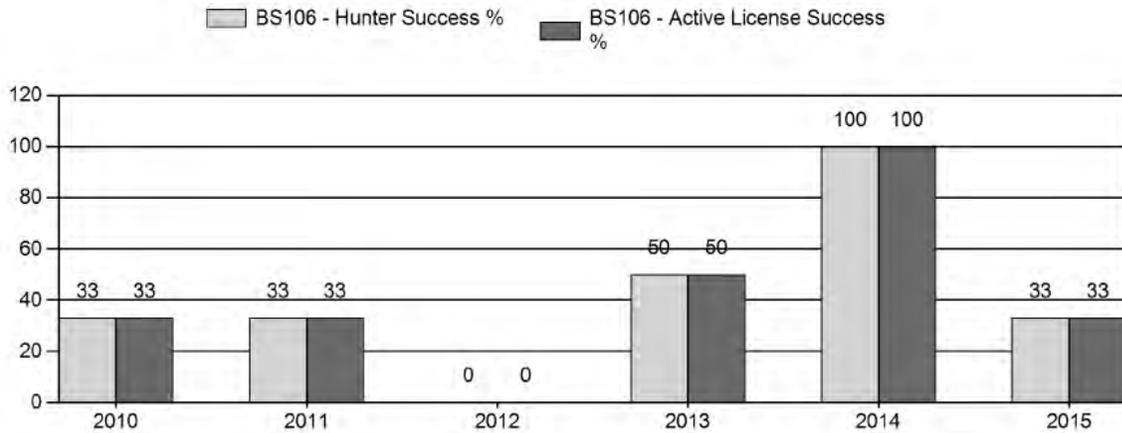
Harvest



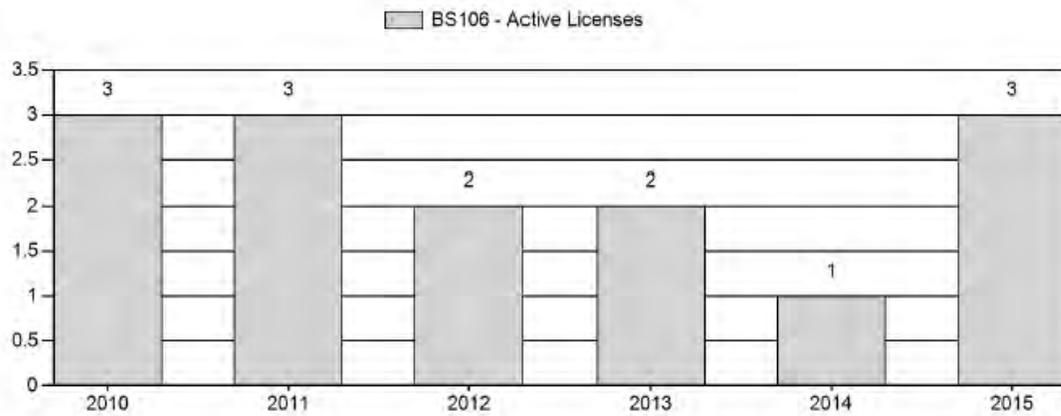
Number of Hunters



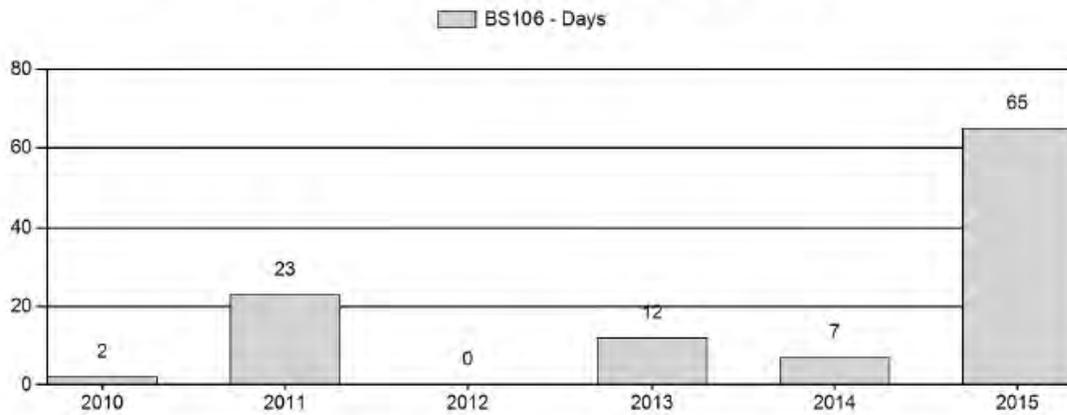
Harvest Success



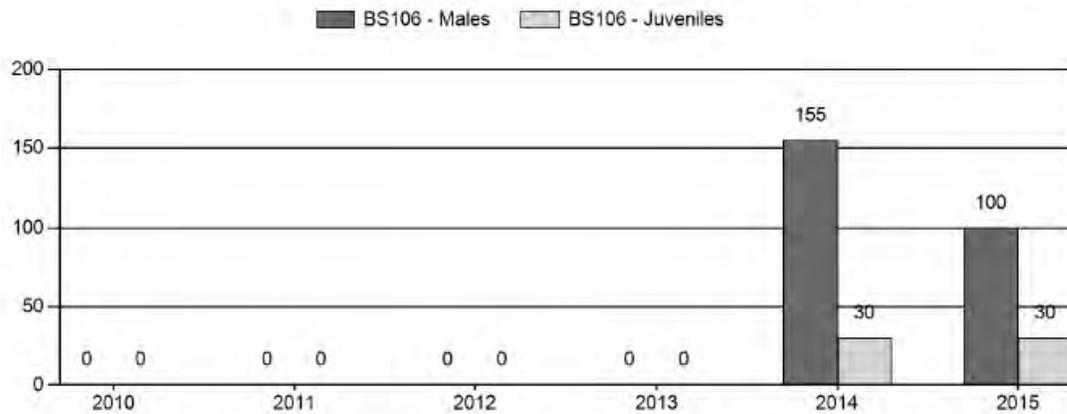
Active Licenses



Days per Animal Harvested



Postseason Animals per 100 Females



2010 - 2015 Postseason Classification Summary

for Bighorn Sheep Herd BS106 - TARGHEE

Year	Post Pop	MALES				FEMALES		JUVENILES		Tot Cls	Cls Obj	Males to 100 Females			Young to			
		Ylg	Adult	Total	%	Total	%	Total	%			Ylng	Adult	Total	Conf Int	100 Fem	Conf Int	100 Adult
2010	0	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	±0	0	±0	0
2011	0	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	±0	0	±0	0
2012	125	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	±0	0	±0	0
2013	125	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	±0	0	±0	0
2014	125	3	28	31	54%	20	35%	6	11%	57	123	15	140	155	±42	30	±13	12
2015	125	1	19	20	43%	20	43%	6	13%	46	120	5	95	100	±0	30	±0	15

**2016 HUNTING SEASONS
TARGHEE BIGHORN SHEEP HERD (BS106)**

Hunt Area	Type	Dates of Seasons		Quota	License	Limitations
		Opens	Closes			
6	1	Aug. 15	Oct. 31	2	Limited quota	Any ram (1 resident, 1 nonresident)

Special Archery Seasons

Hunt Area	Season Dates	
	Opens	Closes
6	Aug. 1	Aug. 14

Summary of 2016 License Changes

Hunt Area	Type	Change from 2015
6	1	- 1 resident, + 1 nonresident

Management Evaluation

Management Strategy: Special

Population Objective Type: Alternative, Bighorn Sheep

Objectives:

1. Achieve a 5-year average harvest age of 6-8 years,
2. Achieve a 5-year average hunter success of $\geq 50\%$, and
3. Document occurrence of adult rams in the population, especially on National Forest lands.

The Wyoming Game and Fish Department (WGFD) proposed changing the objective for the Targhee Bighorn Sheep Herd from a postseason population objective to an alternative population objective in 2014. The objective change was needed because the herd is rarely surveyed due to budget constraints, challenging weather conditions, and spreadsheet models do not appear to adequately simulate observed population trends. Alternative population objectives were adopted in 2014 after public review (listed above).

Three hunters hunted in the Targhee Herd in 2015 (2 residents, and 1 nonresident with a medical carryover from 2014). One resident hunter harvested an 8.5 year-old ram in 2015. The 5-year average age of harvested rams is 6.35 years (Fig. 1). Therefore, the first objective of a 5-year average harvest age of 6-8 years is currently met.

In 2015, hunter success was 33%. The 5-year average hunter success is 43.2%, which is below the objective of $\geq 50\%$ (Fig. 2). Therefore, the second objective was not met. Success is highly variable year to year due to extremely challenging terrain and movement of sheep between Caribou-Targhee National Forest (CTNF) and Grand Teton National Park (GTNP). Hunter success has improved over the past 10 years in this herd unit, from an average of only 16.6% from 2001-2005.

WGFD staff conducted 3 days of bighorn sheep ground surveys in Hunt Area 6 during July and August 2015. Weather conditions were challenging with poor visibility due to smoke. Three rams (1/2 curl) were observed above Camp Lake in the South Fork of Bitch Creek on CTNF in July 2015. In addition, winter aerial surveys of the Targhee Bighorn Sheep Herd were conducted in March 2015 and February 2016. A summary report of these surveys is included in Appendix I. A total of 46 sheep were observed during the 2016 survey (20 ewes, 6 lambs, 1 yearling ram, and 19 mature rams (11 of these had $>3/4$ curl horns)). A total of 57 sheep were observed during the 2015 survey (20 ewes, 6 lambs, 3 yearling rams, 18 rams with $<3/4$ curl horns, and 10 rams with $>3/4$ curl horns). Sightability of sheep was difficult both years due to the unusually warm weather, which caused sheep to move off their high elevation winter ranges early and onto open, south-facing slopes at mid-elevations during the survey. As a result, sheep were widely distributed and difficult to track and observe from the air, which led to lower counts than expected. The third objective is met because rams were documented using areas on National Forest lands in summer and in winter.

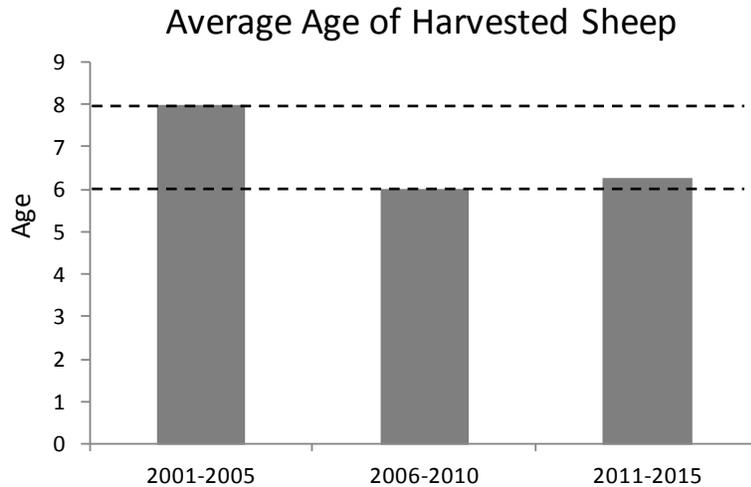


Fig 1. Five-year averages of age of harvested bighorn sheep in the Targhee Herd, 2001-2015. Dashed lines represent objective of 6-8 years old.

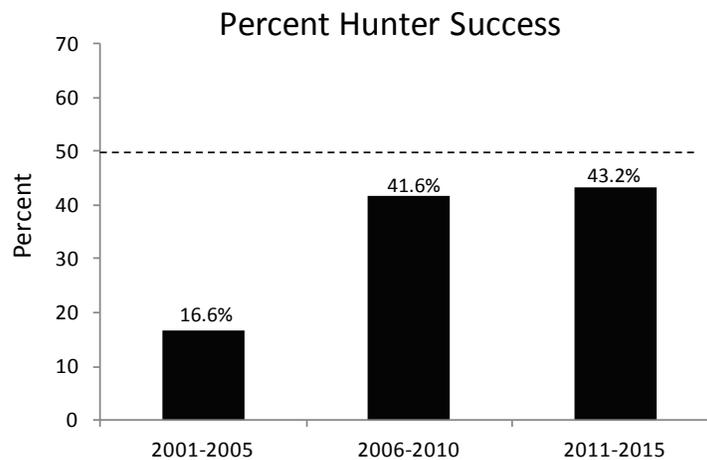


Fig. 2. Five-year averages of percent hunter success in the Targhee Herd, 2001-2015. Dashed line represents objective of $\geq 50\%$ success.

Herd Unit Issues

Current bighorn sheep occupied habitat is located at high elevations year-round in the Teton Range, mostly in GTNP. Bighorn sheep winter on high elevation, windswept ridgelines in upper Jensen Canyon, Mt. Hunt, Prospectors Mountain, Static Peak, Mt. Wister, Ranger Peak, Doane Peak, and Elk Mountain. Winter habitat is most likely the limiting factor for this population. Transitional and summer ranges also include Darby, Fox, Moose and Teton Creeks on CTNF. Historically, this population was migratory and wintered at low elevations around Jackson Hole and Teton Valley, Idaho. In the past, hunters have had a difficult time locating sheep outside of GTNP. However, bighorn sheep have recently increased their use of habitats on CTNF due to willing-seller buy-outs of domestic sheep allotments brokered by the Wyoming Wild Sheep

Foundation. In 1997 the revised CTNF Plan called for the retirement of the domestic sheep allotments on the west side of the Tetons. In 2004, the fifth and final domestic sheep allotment was bought with bighorn sheep conservation funds and closed by CTNF. Recently, data from radio-collared bighorn sheep have showed the importance of these areas, especially during the spring.

Mountain goat sightings have been increasing north of Wyoming Highway 22 indicating that their distribution is expanding north from the Snake Range into the Teton Range. In 2008, the first confirmed sighting of a nanny with kids was reported, suggesting an establishing population. It is estimated that approximately 60 mountain goats currently occupy the Teton Range. GTNP deployed radio-collars on 5 mountain goats in December 2014. Disease sampling of those individuals found that they carry the respiratory bacteria *Bibersteinia trehalosi*. In the future, field managers may need to consider potential impacts of an expanding mountain goat population on this small, native bighorn sheep herd.

Expanding winter backcountry recreation also impacts available winter habitat for bighorn sheep. Recent research from the Wyoming Cooperative Research Unit indicates that Targhee bighorn sheep avoid backcountry ski routes, even if they are in otherwise high quality habitat. This further constricts available winter habitat for bighorn sheep (Courtemanch, 2014).

Additional research on this herd is planned beginning in 2016. Objectives of the research are to capture and collar at least 10 ewes, obtain respiratory disease samples and blood samples to test pregnancy, and monitor movements and habitat use in relation to collared mountain goats. GTNP is currently developing a mountain goat management plan that is expected to be released for public comment in 2016.

Weather

Spring and summer 2015 produced consistent moisture, leading to good forage production. Fall was relatively mild with no significant snowfall until mid-December. By early February, low elevation slopes were beginning to melt out. At the time of the mid-winter survey, winter precipitation was reported at 91% of normal in the Snake River Basin. 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

A habitat treatment in Teton Canyon is currently in the planning stages to improve historical bighorn sheep winter and summer habitat. The WGFD is assisting Caribou-Targhee National Forest (CTNF) with vegetation monitoring pre and post-treatment. Please refer to the 2015 Annual Report Strategic Habitat Plan Accomplishments for Jackson Region habitat improvement project summaries (<https://wgfd.wyo.gov/Habitat/Habitat-Plans/Strategic-Habitat-Plan-Annual-Reports>).

Field Data

WGFD personnel conducted 3 days of bighorn sheep ground surveys in Hunt Area 6 during July and August 2015. Areas in Darby Canyon and the North and South Forks of Bitch Creek were surveyed. Weather conditions were challenging with poor visibility due to smoke. Three rams (1/2 curl) were observed above Camp Lake in the South Fork of Bitch Creek on CTNF in July 2015.

In addition, winter aerial surveys of the Targhee Bighorn Sheep Herd were conducted in February 2016 and March 2015. A summary report of these surveys is included in Appendix I. A total of 46 sheep were observed during the 2016 survey (20 ewes, 6 lambs, 1 yearling ram, and 19 mature rams (11 of these had $> \frac{3}{4}$ curl horns)). Of these, 6 mature rams, 7 ewes, and 1 lamb were observed in Hunt Area 6 (see Appendix I). The lamb:ewe ratio was 30:100 and the ram:ewe ratio was 100:100. A total of 57 sheep were observed during the 2015 winter survey (20 ewes, 6 lambs, 3 yearling rams, 18 rams with $< \frac{3}{4}$ curl horns, and 10 rams with $> \frac{3}{4}$ curl horns). The lamb:ewe ratio was 30:100 and the ram:ewe ratio was 155:100. Sightability of sheep was difficult both years due to the unusually warm weather this year, which caused sheep to move off their high elevation winter ranges early and onto open, south-facing slopes at mid-elevations during the survey. As a result, sheep were widely distributed and difficult to track and observe from the air, which led to lower counts than expected.

Harvest Data

In 2015, there were 3 active licenses in the Targhee Herd (2 residents and 1 nonresident with a medical carryover). One resident hunter harvested an 8-year old ram. The hunter spent 65 days in the field.

Population

This population is estimated to be stable at approximately 100-125 animals.

Management Summary

Two licenses will be available for this herd in 2016 (1 resident and 1 nonresident). No changes are proposed to the 2016 hunt season. This bighorn sheep population is distributed both within GTNP and along its boundary in remote steep terrain making it difficult for hunters to locate and stalk sheep. As a result, harvest levels have remained low and on some years no sheep are harvested. Given the limited number of ram-only licenses available and periodic harvest, hunting is likely not having an impact on this population. Two licenses for any ram will be offered for future hunts until more sheep are observed occupying areas outside GTNP on CTNF lands.

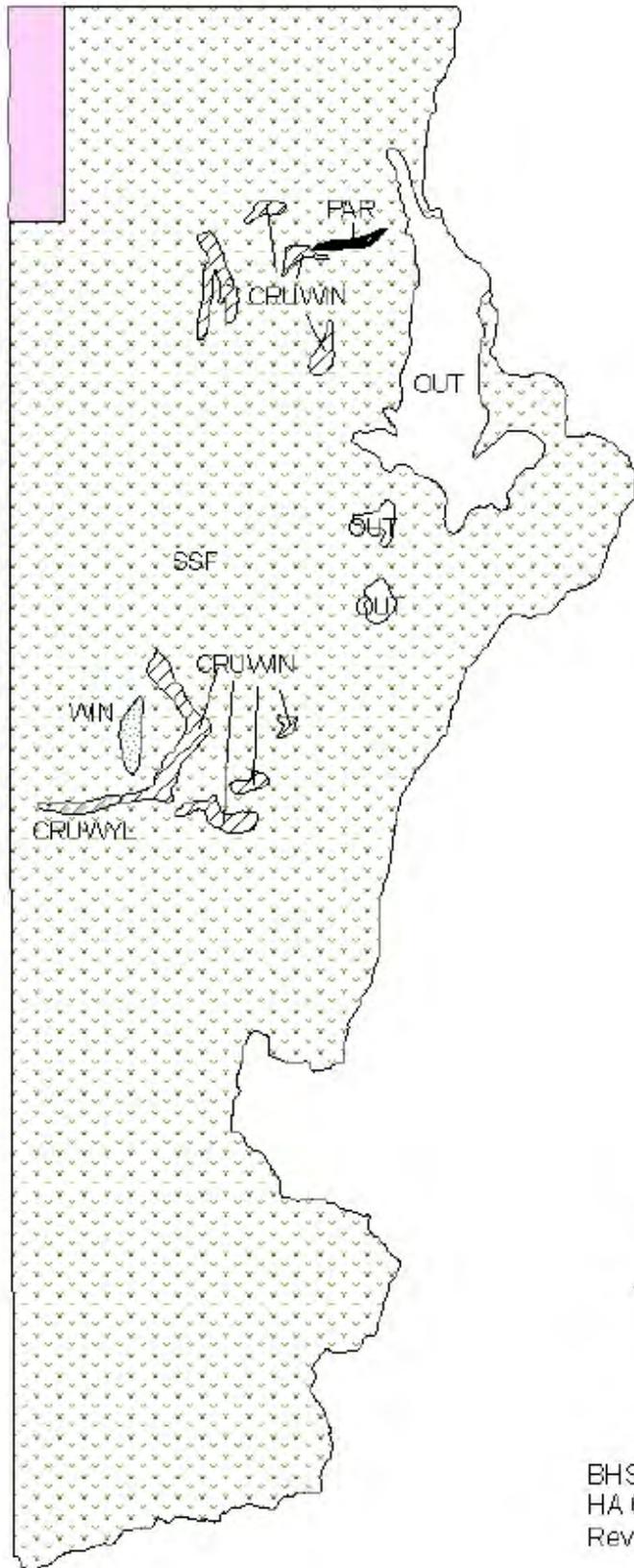
Bibliography

Courtemanch, A.B. 2014. Seasonal habitat selection and impact of winter backcountry recreation on a formerly migratory bighorn sheep population in northwest Wyoming. M.S. Thesis. University of Wyoming, Laramie, WY, USA.

Fitzsimmons, N., S.W. Buskirk, and M.H. Smith. 1995. Population history, genetic variability and horn growth in bighorn sheep. *Conservation Biology* 9:314-323.

Kardos, M.D., S. Dewey, S.J. Amish, J. Stephenson, and G. Luikart. *In prep.* Strong fine-scale population structure of Grand Teton National Park bighorn sheep suggests important role of philopatry in bighorn population subdivision.

Whitfield, M.B. 1983. Bighorn sheep history, distributions and habitat relationships in the Teton Mountain Range, Wyoming. M.S. Thesis. Idaho State University, Pocatello, Idaho, USA.



BHS106 - Targhee
HA 6
Revised 9/02

2015 - JCR Evaluation Form

SPECIES: Bighorn Sheep

PERIOD: 6/1/2015 - 5/31/2016

HERD: BS107 - JACKSON

HUNT AREAS: 7

PREPARED BY: ALYSON COURTEMANCH

	<u>2010 - 2014 Average</u>	<u>2015</u>	<u>2016 Proposed</u>
Trend Count:	258	307	350
Harvest:	8	9	12
Hunters:	11	11	12
Hunter Success:	73%	82%	100%
Active Licenses:	11	11	12
Active License Success	73%	82%	100%
Recreation Days:	82	158	168
Days Per Animal:	10.2	17.6	14
Males per 100 Females:	62	46	
Juveniles per 100 Females	31	41	

Trend Based Objective ($\pm 20\%$)

400 (320 - 480)

Management Strategy:

Special

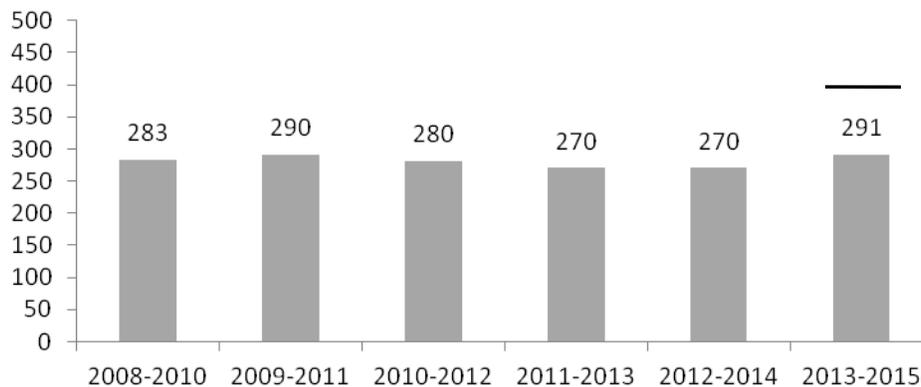
Percent population is above (+) or (-) objective:

-23.2%

Number of years population has been + or - objective in recent trend:

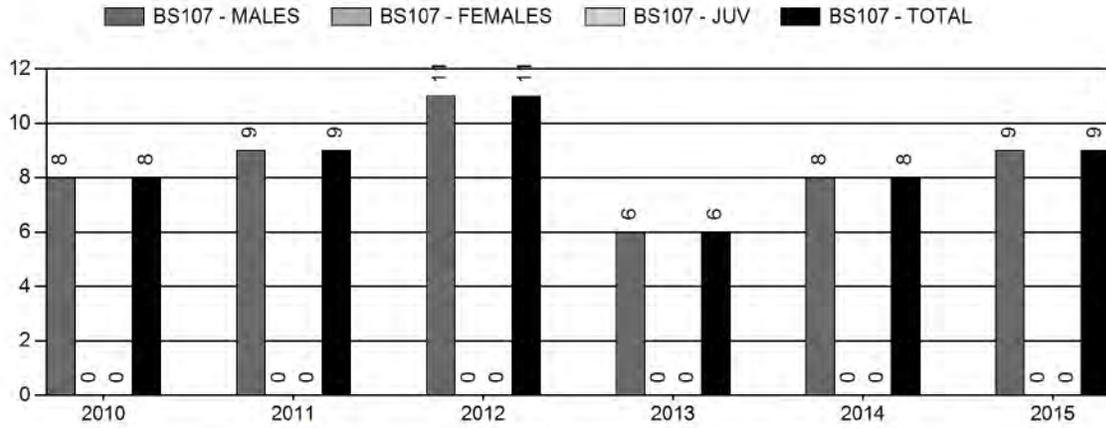
13

BS107 Trend Count

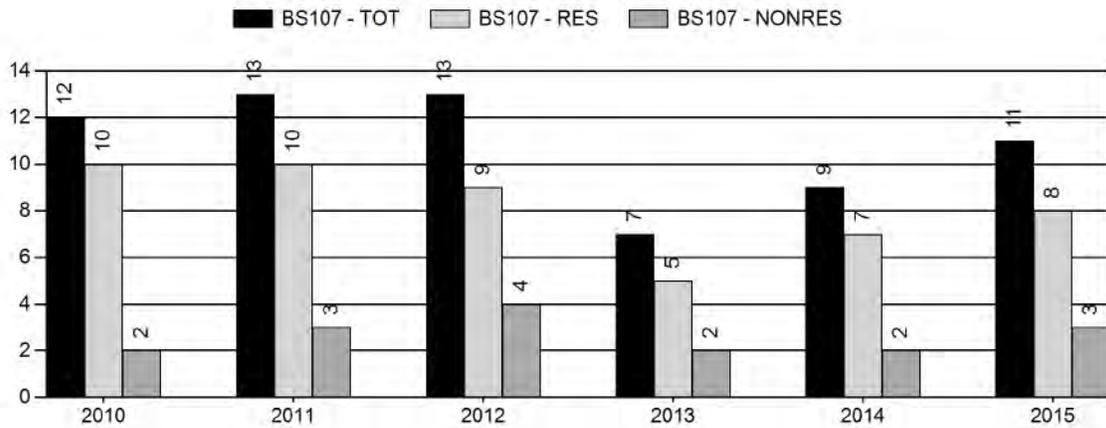


Three year average trend counts on key winter ranges

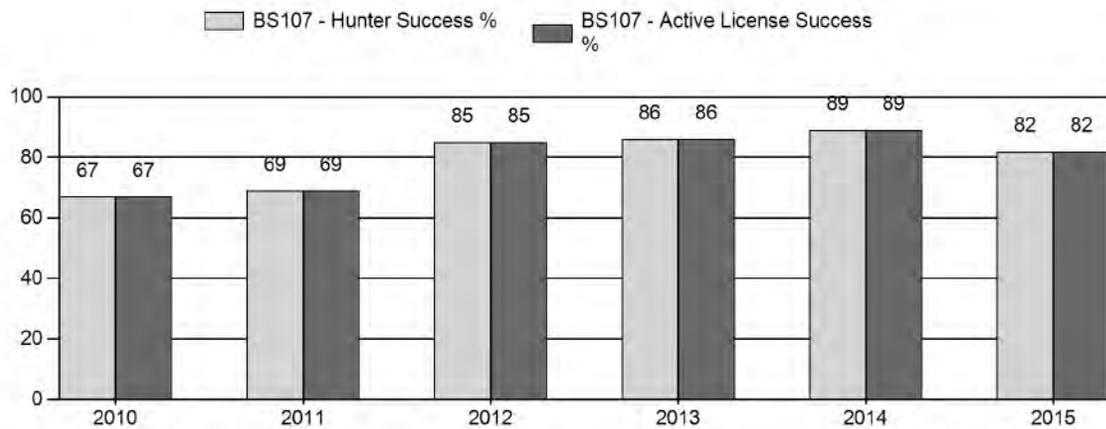
Harvest



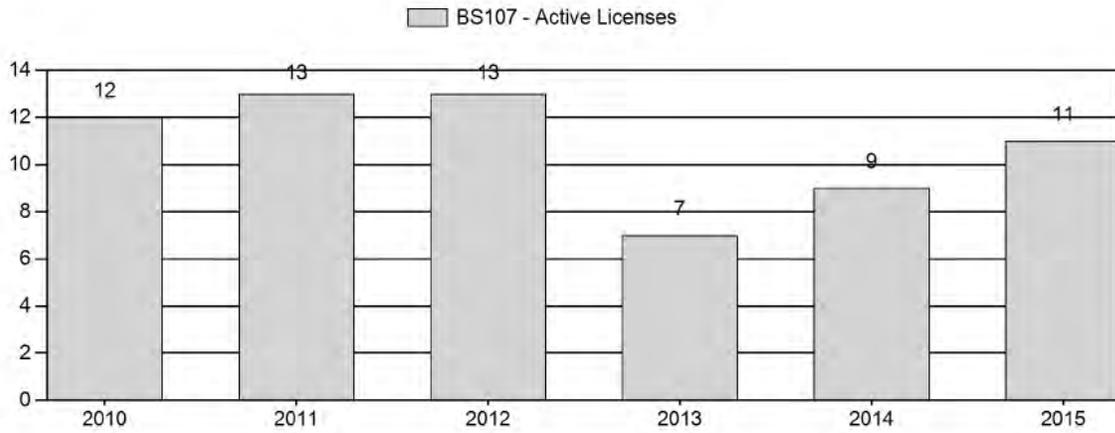
Number of Hunters



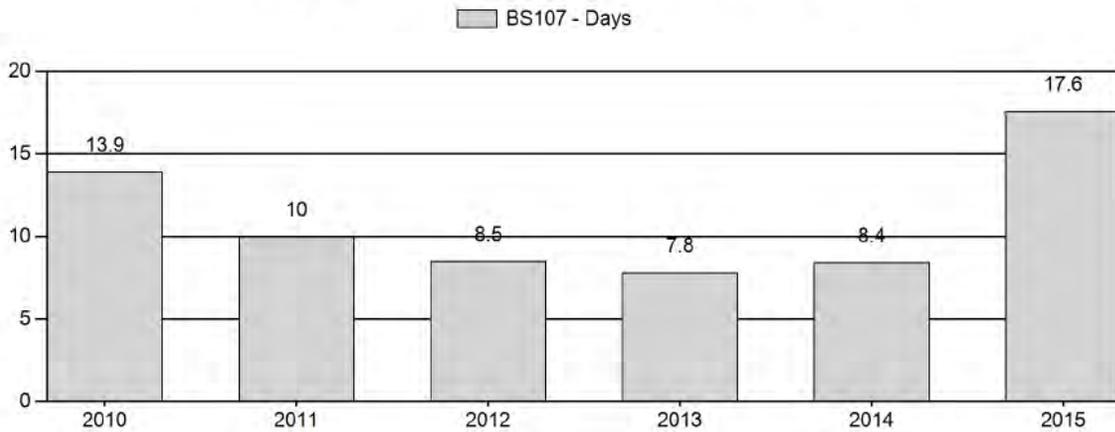
Harvest Success



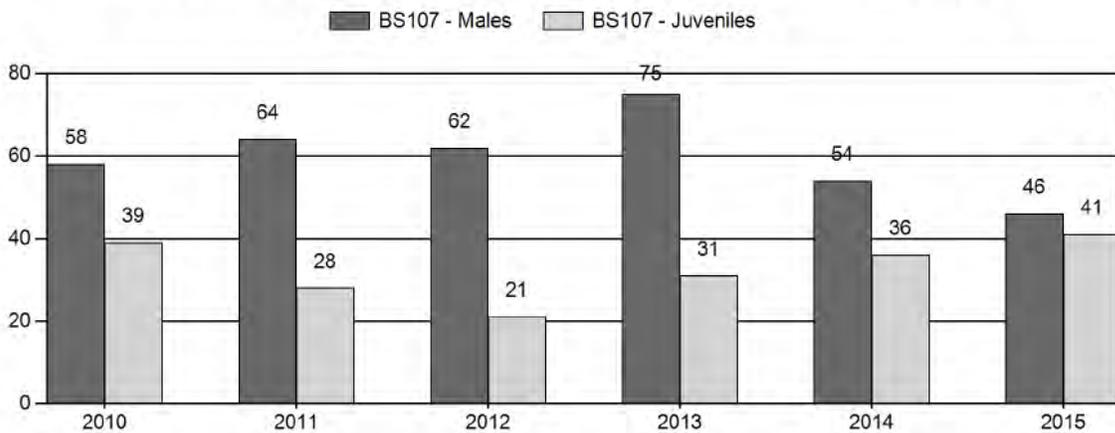
Active Licenses



Days per Animal Harvested



Postseason Animals per 100 Females



2010 - 2015 Postseason Classification Summary

for Bighorn Sheep Herd BS107 - JACKSON

Year	Post Pop	MALES				FEMALES		JUVENILES		Tot Cls	Cls Obj	Males to 100 Females				Young to		
		Ylg	Adult	Total	%	Total	%	Total	%			Ylg	Adult	Total	Int	Conf	100 Fem	Conf
2010	423	17	71	88	29%	152	51%	59	20%	299	298	11	47	58	± 6	39	± 4	25
2011	454	18	121	139	33%	217	52%	61	15%	417	349	8	56	64	± 3	28	± 1	17
2012	350	17	65	82	34%	133	55%	28	12%	243	256	13	49	62	± 6	21	± 3	13
2013	350	14	84	98	37%	130	49%	40	15%	268	292	11	65	75	± 6	31	± 3	18
2014	400	10	84	94	28%	173	52%	63	19%	330	285	6	49	54	± 4	36	± 3	24
2015	425	12	75	87	25%	188	53%	77	22%	375	280	6	40	46	± 0	41	± 0	28

**2016 HUNTING SEASONS
JACKSON BIGHORN SHEEP HERD (BS107)**

Hunt Area	Type	Season Dates		Quota	License	Limitations
		Opens	Closes			
7	1	Sep. 1	Oct. 31	12	Limited quota	Any bighorn sheep

Special Archery Seasons

Hunt Area	Season Dates	
	Opens	Closes
7	Aug. 15	Aug. 31

Summary of 2016 License Changes

Area	Type	Quota change from 2015	Other changes from 2015
7	1	+1	+1 license will be nonresident

Management Evaluation

Mid-Winter Trend Count Objective: 400 on key winter ranges

Secondary Objective:

Maintain a 3-year running average age of harvest rams 6-8 years old

Management Strategy: Special

2015 Mid-Winter Trend Count: 307 on key winter ranges

2016 Proposed Mid-Winter Trend Count: 350

3-Year Mid-Winter Trend Average (2013-2015): 291

The mid-winter trend count objective for the Jackson Bighorn Sheep Herd is 400 sheep on key winter ranges. The management strategy is special and the objective and management strategy were last revised in 2015. The herd objective was publicly reviewed in 2015 and changed to a mid-winter trend count objective of 400 sheep because spreadsheet models do not adequately simulate population trends. The current trend count is 307 sheep on key winter ranges.

The secondary objective for the herd is to maintain a 3-year running average age of harvested rams between 6-8 years old. Currently, this objective is being met. The average age of harvested rams in 2015 was 7.3 years (max = 9.3 years). The average age from 2013-2015 is 7.3 years.

Herd Unit Issues

This population is approximately 23% below the postseason objective of 400 sheep on key winter ranges. This population experienced a pneumonia-related die-off in 2002 and again in 2012. An estimated 30% of the population died during the latest pneumonia event. However, lamb survival rebounded within a couple of years after both outbreaks, leading to relatively quick herd recoveries. If the current trajectory continues, the population should reach objective again within 2-3 years. From 2011–2015, over 40 bighorn sheep were radio-collared to monitor disease, herd demographics, body condition, and migration patterns.

Weather

Spring and summer 2015 produced consistent moisture, leading to good forage production. Fall was relatively mild with no significant snowfall until mid-December. By early February, low elevation slopes were beginning to melt out. At the time of the mid-winter survey, winter precipitation was reported at 91% of normal in the Snake River Basin. 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

The Wyoming Game and Fish Department (WGFD) and Bridger-Teton National Forest (BTNF) initiated a project in 2012 to evaluate the short-term and long-term nutritional changes in bighorn sheep forage after wildfire. This project will track the nutritional content over 10 years of key forage species that burned at different fire severities during the Red Rock Fire in the Gros Ventre. Other than this project, there are no established vegetation transects in this herd unit.

The Bryan Flats Habitat Enhancement and Fuels Reduction Project is scheduled for implementation in fall 2016. This prescribed burn project is led by BTNF and will improve bighorn sheep habitat in the Hoback Canyon area. Please refer to the 2015 Annual Report Strategic Habitat Plan Accomplishments for Jackson Region habitat improvement project summaries (<https://wgfd.wyo.gov/Habitat/Habitat-Plans/Strategic-Habitat-Plan-Annual-Reports>).

Field Data

In the Gros Ventre drainage, approximately 30% of radio-collared bighorn ewes died during a pneumonia outbreak in 2012 and lamb ratios declined from a high of 50 lambs:100 ewes in late June 2012 to 15:100 by February 2013. Carcasses retrieved during the summer indicated that sheep likely died from pneumonia. Additional sampling of live sheep during and after the outbreak indicates that Jackson sheep carry *Mycoplasma ovipneumoniae*, leukotoxin-positive *Mannheimia spp.*, and leukotoxin-positive *Bibersteinia spp.*. Helicopter captures in March 2016, as part of a study with the Wyoming Cooperative Fish and Wildlife Research Unit, found several ewes with contagious ecthyma symptoms. Additional ground observations of sheep on Miller Butte recorded approximately 60% of sheep in some groups with symptoms. Additional research is planned for 2015-2017 to track respiratory pathogens, contagious ecthyma, seasonal body condition, pregnancy, and lamb recruitment of individual ewes over time in collaboration with WGFD Vet Services and Wyoming Cooperative Fish and Wildlife Research Unit (see Appendix I and II).

In February 2016, classification surveys were flown over both low and high elevation winter ranges. Bighorn sheep on Miller Butte and Camp Creek were classified from the ground. A total of 375 sheep were observed including 188 females, 77 lambs, 75 adult males, 12 yearling males, and 23 unclassified sheep. Three hundred and two sheep were observed on key winter ranges (areas on Miller Butte, Curtis Canyon, Flat Creek, Hoback area, Lower Slide Lake, Red Hills, and Grey Hills) compared to 299 sheep last year. Herd unit ratios in 2015 were 41 lambs:100 ewes, 40 adult rams:100 ewes and 6 yearling rams:100 ewes. The lamb ratio is higher than last year's ratio of 36:100, and a ratio of 31:100 in 2013, which suggests that the population is rebounding from the pneumonia outbreak.

Harvest Data

Data from the 2015 harvest survey indicate that 11 hunters harvested 9 rams (82% success). The median age of harvested rams in 2015 was 7.3 years (max = 9.3 years), similar to 2014 at 7.3 years and 2013 at 8.3 years. The number of licenses was increased for the 2015 season from 8 to

11 in response to the growing population and strong ram to ewe ratio. Based on classification surveys and the number of mature rams observed in February 2016 (n=75; 45 rams > ¾ curl horns), ram harvest has not affected the ability of the population to recover from the pneumonia outbreak. Given the recent trend of population recovery, managers are increasing licenses to 12 for 2016. Licenses will be distributed to 9 residents and 3 non-residents.

Population

This population is estimated to be approximately 425 sheep, with 307 observed on key winter ranges during 2015 postseason classifications. Past trends seem to indicate that pneumonia outbreaks occur when the population reaches 500-600 animals. Currently, the population is increasing due to relatively high lamb:ewe ratios and may approach the 500 objective within 2-3 years. Therefore, the public and managers should monitor the herd closely and anticipate another pneumonia outbreak in the near future.

Management Summary

Trend data indicate that the Jackson Bighorn Sheep Herd is recovering relatively quickly from a pneumonia outbreak in 2012. Overall numbers have increased in the past 3 years and lamb:ewe ratios continue to improve. Based on past history, pneumonia outbreaks seem to occur when the population reaches 500-600 animals. Therefore, another outbreak should be expected within 2-5 years. Due to the increasing population and availability of rams, managers are increasing licenses from 11 to 12 for 2016. Although this level of ram harvest is not expected to affect population increase, it will provide hunters with harvest opportunities before another pneumonia outbreak occurs. The WGFD plans to continue to monitor the population using radio-collars, disease sampling, and body condition measurements in 2015-2017 to learn more about the interaction of respiratory pathogens, body condition, and population density in causing pneumonia outbreaks.

References

Honess, R.F. and N.M. Frost. 1942. A Wyoming bighorn sheep study. Wyoming Game and Fish Department Bulletin No. 1, 127 pp.

Appendix I

2015 Jackson Sheep Monitoring Annual Report Permit #798

Contact: Alyson Courtemanch
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Project Background

The Jackson bighorn sheep herd experienced a die-off during 2001-2002 in which approximately 50% of the population died. However, bighorn sheep numbers rebounded to within 10% of the population objective (500 animals) by 2010. During 2010, two male lambs were removed from Russold Hill in early March after it was observed that some of the animals wintering on Russold Hill were exhibiting signs of pneumonia (e.g. coughing, runny nose etc.). Both lambs had minor cases of pneumonia (~15% of the lungs affected), but otherwise were in good health with moderate fat stores. Over the next couple of years, an effort was made to capture and radio-collar bighorn sheep on winter ranges north of Jackson and in the Camp Creek area to track survival and movements. In 2011 and 2012, approximately 30% of radio-collared sheep died, with several confirmed pneumonia cases. Population classifications also showed an overall 30% decline in the herd, likely due to another pneumonia outbreak. Efforts have continued to maintain a sample of collared sheep to track survival and movements. Sheep have also been tested for bacterial pathogens during the past two years as part of the Statewide Bighorn Sheep Disease Surveillance Program. No new sheep were collared in 2015 under this permit however, the Wyoming Cooperative Research Unit at the University of Wyoming initiated a project in collaboration with the Wyoming Game and Fish Department to capture, collar, and sample sheep in the Jackson, Whiskey, and Absaroka Herds.

Results

During 2014, 8 ewes were captured and fitted with GPS collars using both helicopter netgunning and ground darting. Six ewes were captured in the Curtis Canyon and Flat Creek winter ranges using a helicopter and two were darted near Camp Creek. Animals were fitted with a GPS collar, which is programmed to drop off after 2 years (spring 2016), and VHF micro collars. This approach will enable two tiers of data collection; GPS collars will provide fine-scale movement data while VHF collars allow us to track survival over the longer term. These captures were part of the Statewide Disease Surveillance Program under Chapter 33 Permit #854. Additional details regarding capture locations and disease testing results can be found in that permit's 2014 report.

Data from radio collars recovered during 2012-2015 were shared with the Greater Yellowstone Area Mountain Ungulate Project at Montana State University. This research is a collaborative initiative to study the ecology and population dynamics of bighorn sheep and mountain goats throughout the Yellowstone ecosystem (<http://gyamountainungulateproject.com/contact.html>). Data were also shared with the Wyoming Migration Initiative at the University of Wyoming.

Twenty-one collared bighorn sheep were monitored in 2015 (Table 1). One GPS-collared bighorn sheep died during 2015 (Figure 1). This ewe appeared to have died in a fall on a cliff in Sheep Creek. There were no pneumonia outbreaks detected in the Jackson Herd in 2015.

There were two telemetry flights conducted in 2015 to monitor collared bighorn sheep, one in July and one in December (Figure 2).

Table 1. Bighorn sheep collar frequencies in the Jackson herd, 2015. These do not include bighorn sheep collared as part of the Wyoming Cooperative Research Unit study.

Sheep ID	GPS collar frequ	Micro VHF collar frequ	Visibility tags	Capture Date	Notes
211		150.263			Alive Dec. 2015 – incorporated into Dr. Monteith’s study
653		150.352			Alive Dec. 2015
684		150.482			Alive Dec. 2015
743	-	150.493	Yellow #26	4/11/2013	Alive Dec. 2015 – incorporated into Dr. Monteith’s study
893		150.540		12/10/2012	Unknown – not heard in 2015
390		150.390	blue 7B		Alive Dec. 2015
500	150.500	150.500	green 2B		Alive Dec. 2015
630		150.630	white/yellow 6B		Alive Dec. 2015
410	150.160	150.160	purple 1B	3/5/2013	Alive Dec. 2015
219	219.010				Unknown – not heard in 2015
218		218.160		5/8/2012	Unknown – not heard in 2015
218_2		150.464	Yellow #27	4/17/2013	Alive Dec. 2015
110	149.110		Yellow #28	5/1/2013	Alive Dec. 2015 – no VHF signal
755	150.754		Yellow #5 (L), #6 R	1/26/2014	Alive Dec. 2015 - incorporated into Dr. Monteith’s study
530	150.530	150.530	Yellow #2 (L), #1 R	1/26/2014	Mortality in Nov. 2014 near Turquoise Lake - predation
562	150.560	150.560	Yellow #5 (8), #67 R	1/26/2014	Mortality in Flat Creek Nov. 2014 – snow slide
411	150.410	150.410	Yellow #4 (L), #3 R	1/26/2014	Alive Dec. 2015
662	150.662		Yellow #10 (L), #9 R	1/26/2014	Alive Dec. 2015 – incorporated into Dr. Monteith’s study
212	150.211	150.211	Yellow #12 (L), #11 R	1/26/2014	Mortality in Curtis Canyon in winter 2015
763	150.763	150.763	Yellow #15 R	1/26/2014	Alive Dec. 2015
783	150.783	150.783	Yellow #14 R	1/26/2014	Alive Dec. 2015

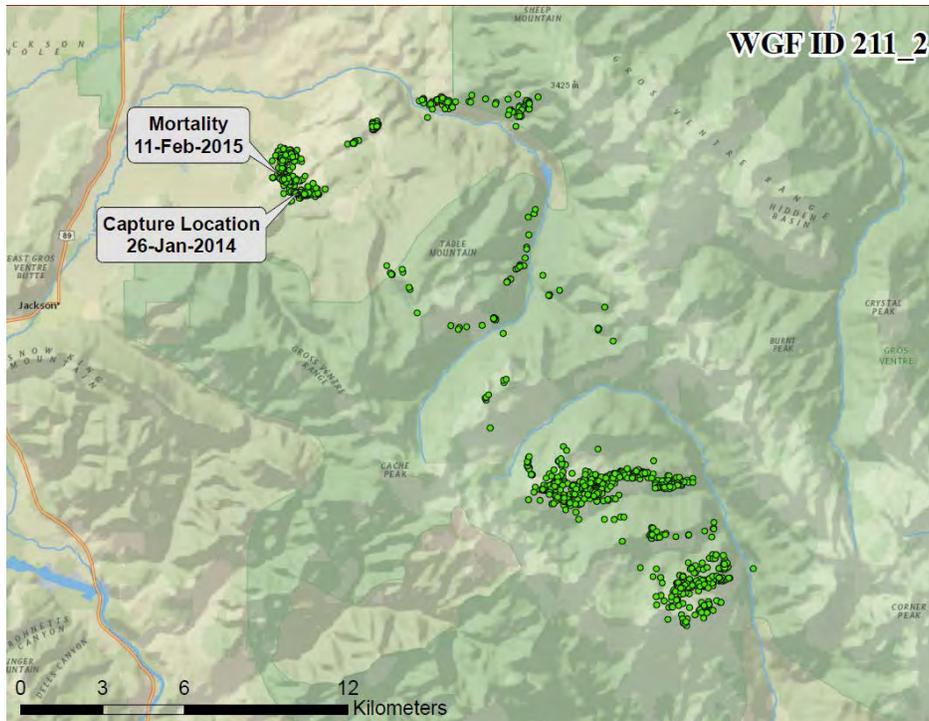


Figure 1. GPS-collar locations from sheep 212, which died from a fall in Curtis Canyon on February 2015. This ewe wintered in the Curtis Canyon area and migrated to summer range in the Pinnacle Peak area.

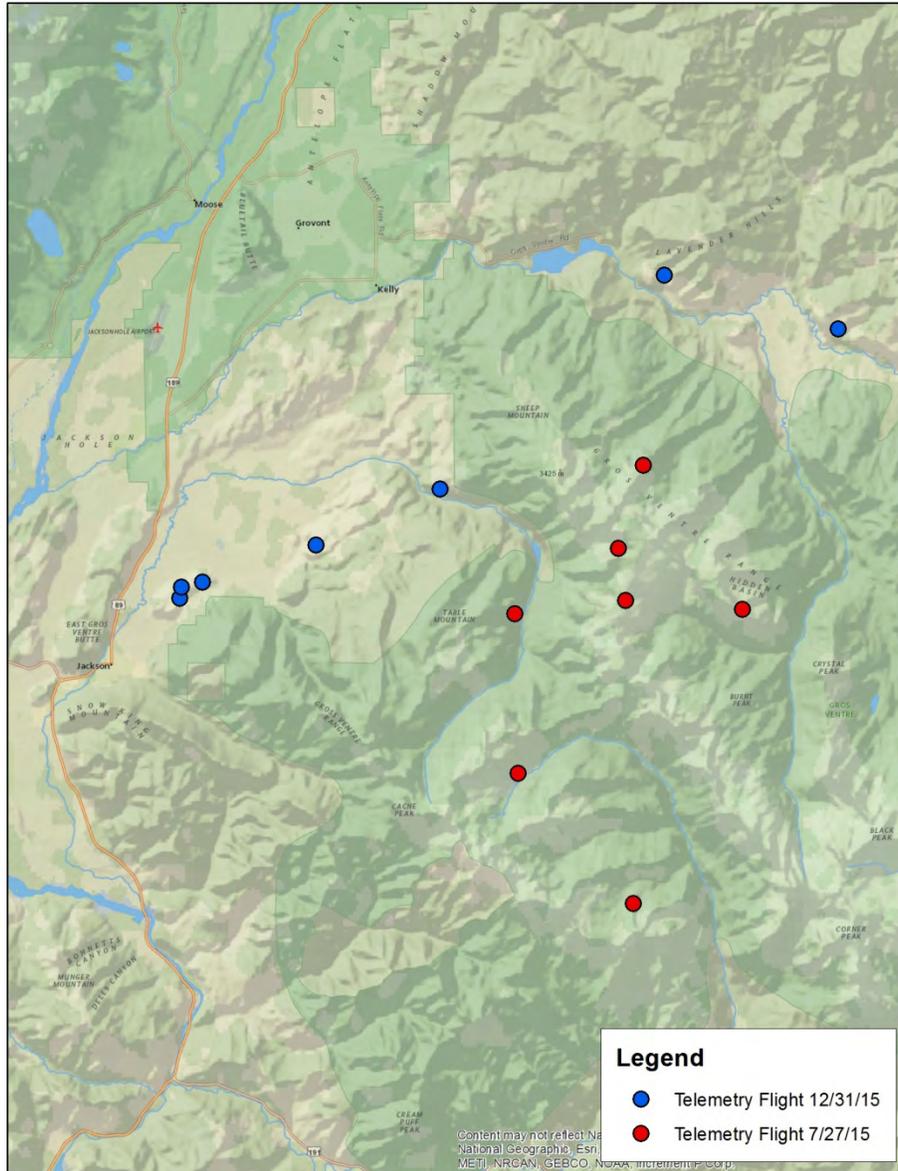
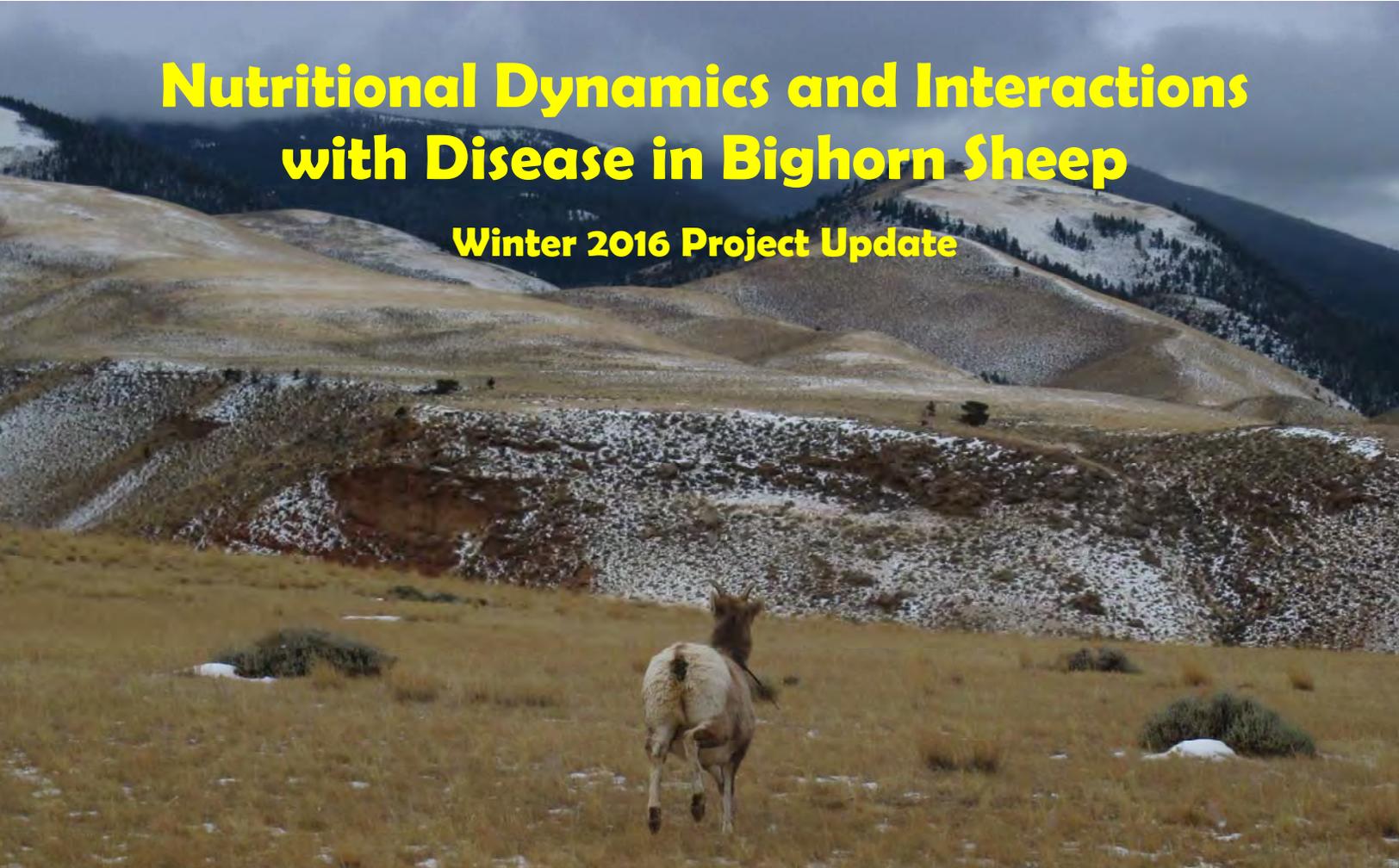


Figure 2. Collared bighorn sheep locations from telemetry flights, 2015.

Nutritional Dynamics and Interactions with Disease in Bighorn Sheep

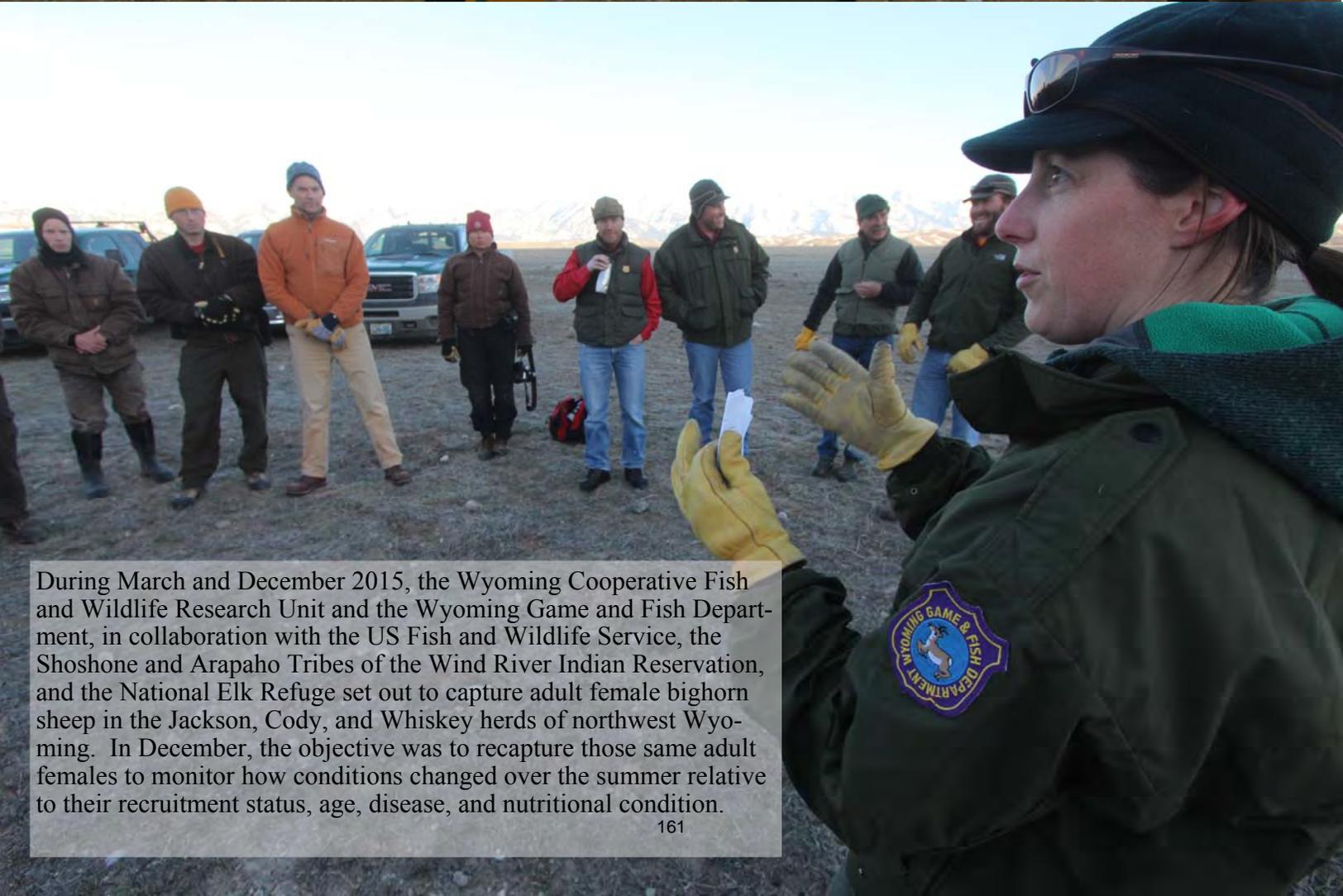
Winter 2016 Project Update



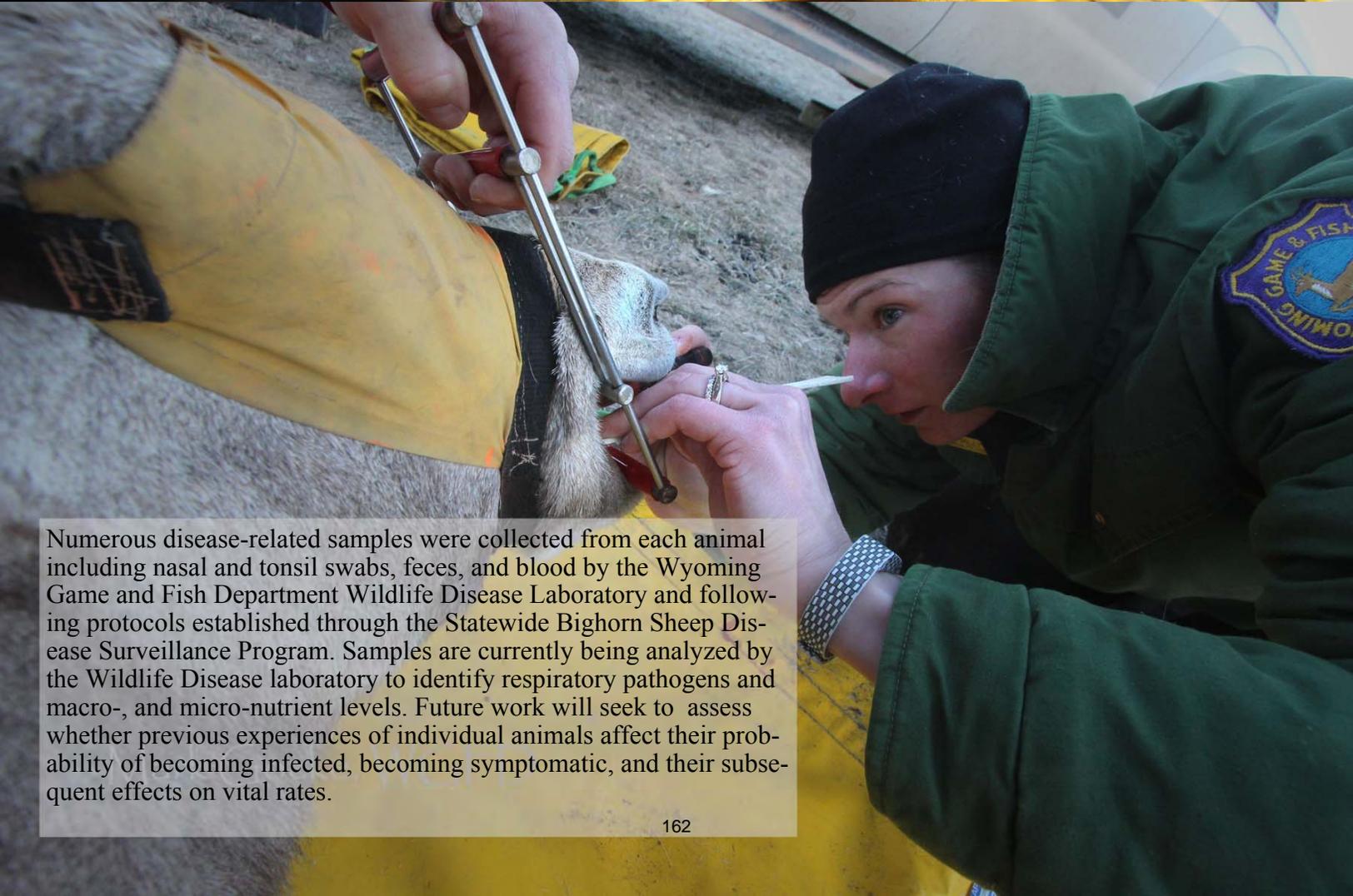
The entrance of epizootic pneumonia to bighorn sheep populations muddles the already complicated processes underlying population dynamics, and is often the culprit for massive population crashes of sheep populations. Although pneumonia caused by bacterial respiratory pathogens is known to be the underlying driver of the massive mortality events, the frequency and intensity of the dieoffs are inconsistent and infections are not always manifested in disease. Therefore, dieoffs may be dependent upon certain ecological or environmental conditions—the understanding of which could yield management alternatives to help reduce the frequency of outbreaks. Our goal with the Bighorn Sheep Nutrition/Disease Project is to begin to unravel the interactions among animal density, nutrition, and disease in an effort to identify potential management options for and improve our understanding of pneumonia in bighorn sheep, and identify the range limits (i.e., Nutritional Carrying Capacity) for our bighorn sheep populations in northwest Wyoming.



In Wyoming, the Statewide Bighorn Sheep Disease Surveillance Program, led by the Wyoming Game and Fish Department, has documented many bacterial pathogens in herds across the state. While some herds continue to do well, others have undergone repeated pneumonia outbreaks and recoveries, and others have never recovered from dieoffs. We are adding another component to the ongoing Disease Surveillance Program by investigating bacterial pathogens, nutritional condition, survival, pregnancy, and lamb recruitment in female bighorn sheep from three herds over time.



During March and December 2015, the Wyoming Cooperative Fish and Wildlife Research Unit and the Wyoming Game and Fish Department, in collaboration with the US Fish and Wildlife Service, the Shoshone and Arapaho Tribes of the Wind River Indian Reservation, and the National Elk Refuge set out to capture adult female bighorn sheep in the Jackson, Cody, and Whiskey herds of northwest Wyoming. In December, the objective was to recapture those same adult females to monitor how conditions changed over the summer relative to their recruitment status, age, disease, and nutritional condition.



Numerous disease-related samples were collected from each animal including nasal and tonsil swabs, feces, and blood by the Wyoming Game and Fish Department Wildlife Disease Laboratory and following protocols established through the Statewide Bighorn Sheep Disease Surveillance Program. Samples are currently being analyzed by the Wildlife Disease laboratory to identify respiratory pathogens and macro-, and micro-nutrient levels. Future work will seek to assess whether previous experiences of individual animals affect their probability of becoming infected, becoming symptomatic, and their subsequent effects on vital rates.



Body mass of sheep was measured using an electronic platform scale. Body mass represents a combination of the overall size and composition of an animal.

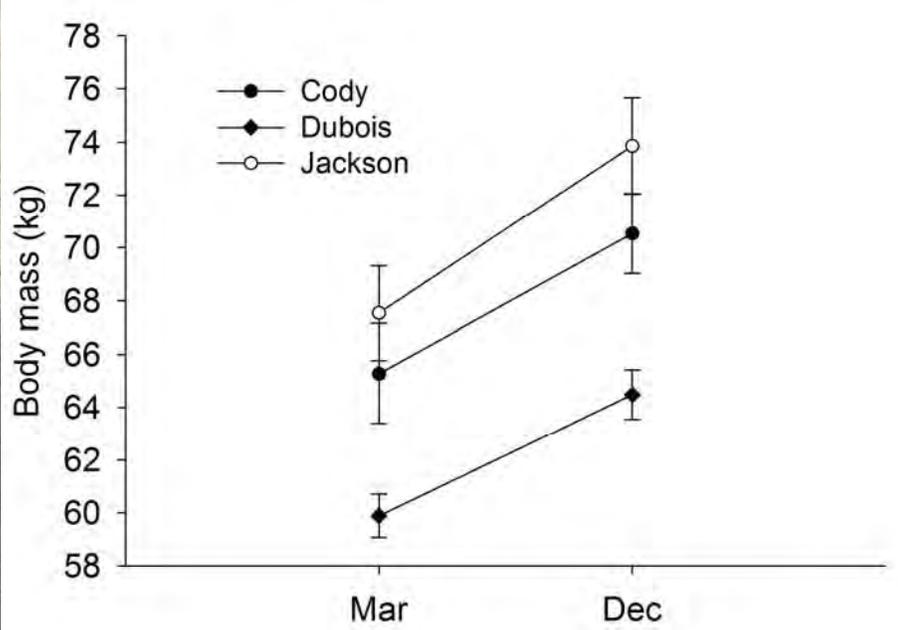


Fig. 1. Average body mass ($\text{kg} \pm \text{SE}$) of adult female bighorn sheep in March and December 2015 in the Cody, Whiskey, and Jackson herds of northwest Wyoming.



Age was estimated using a combination of toothwear and replacement patterns, and by counting horn annuli. Age data are critical to understanding behavior, nutritional condition, reproductive performance, and disease exposure of individuals.

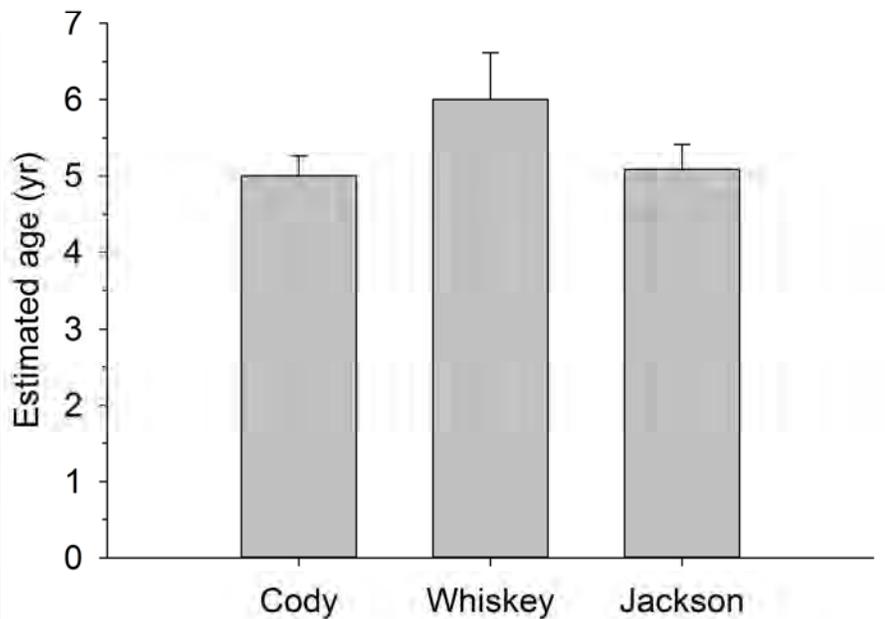


Fig. 2. Average estimated age ($\text{yr} \pm \text{SE}$) of adult female bighorn sheep at initial capture in March, 2015 in the Cody ($N=10$), Whiskey ($N=20$), and Jackson ($N=12$) herds of northwest Wyoming.

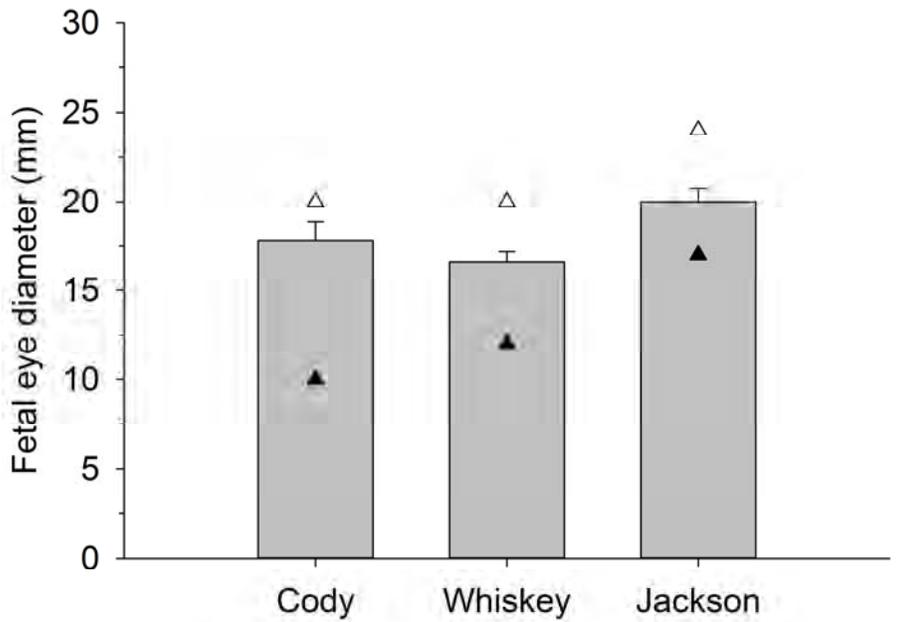


Fig. 3. Eye diameter (mm±SE) of fetuses for pregnant adult female bighorn sheep in March, 2015 in the Cody (N=10), Dubois (N=13), and Jackson (N=9) herds of northwest Wyoming. Triangles represent range in observed eye diameters.

We assessed pregnancy status and size of fetus using ultrasonography and transabdominal scanning. Pregnancy rates among the animals we measured were 100% in Cody, 90% in Whiskey, and 92% in Jackson herds. Of those animals that were pregnant however, size of those fetuses as indicated by fetal eye diameter was variable.



Image of bighorn sheep fetus recorded during captures.



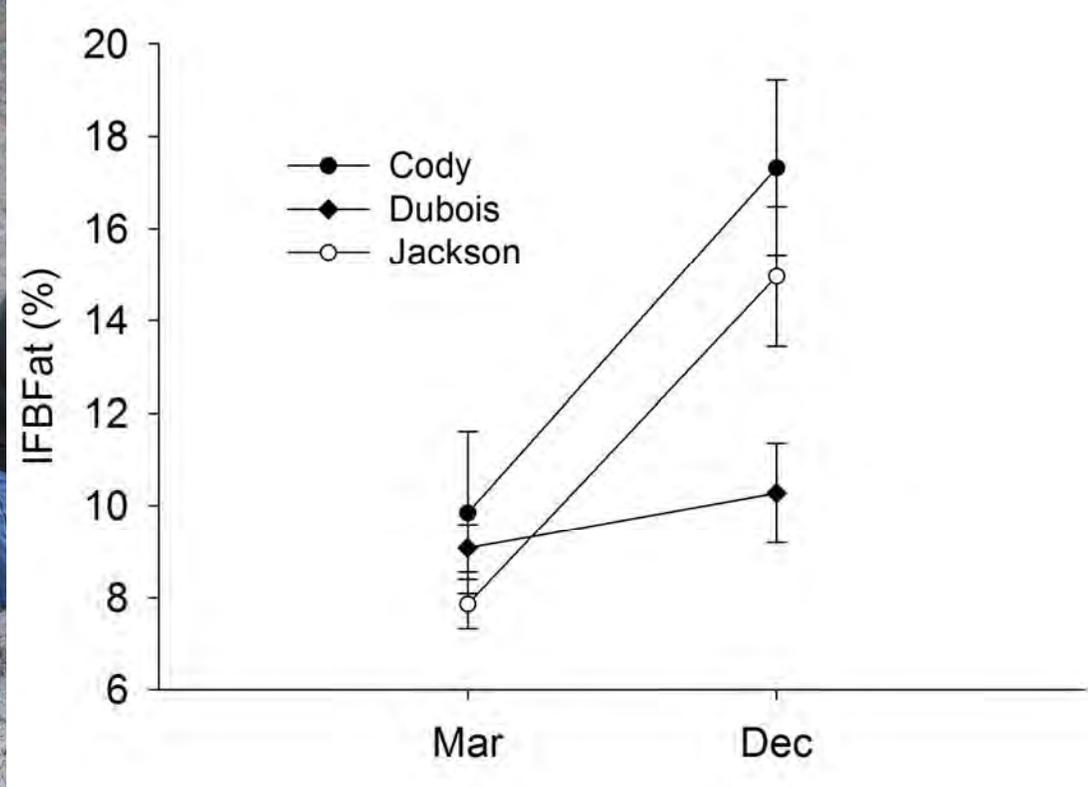


Fig. 4. Ingesta-free body fat ($\% \pm SE$) of adult female bighorn sheep in March and December, 2015 in the Cody, Dubois, and Jackson herds of northwest Wyoming.

We measured nutritional condition using a combination of ultrasonography and body condition scoring based on standardized methods developed for bighorn sheep. Nutritional condition of an animal is a product of its environment and therefore, represents the energetic gains and deficits experienced by an animal, as well as the nutritional reserves it carries into the upcoming season.

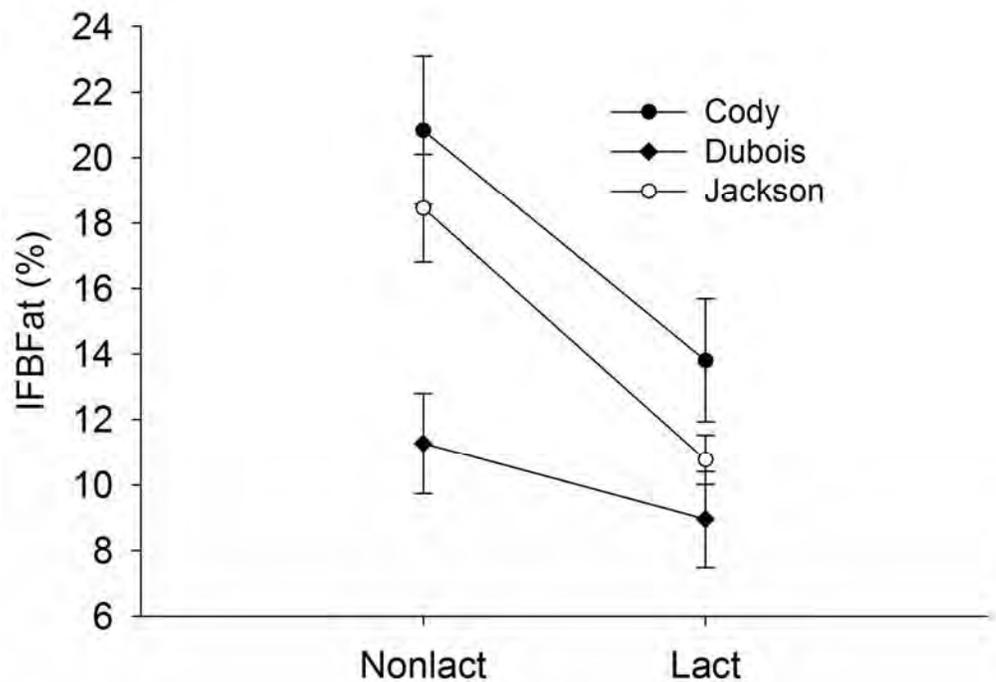
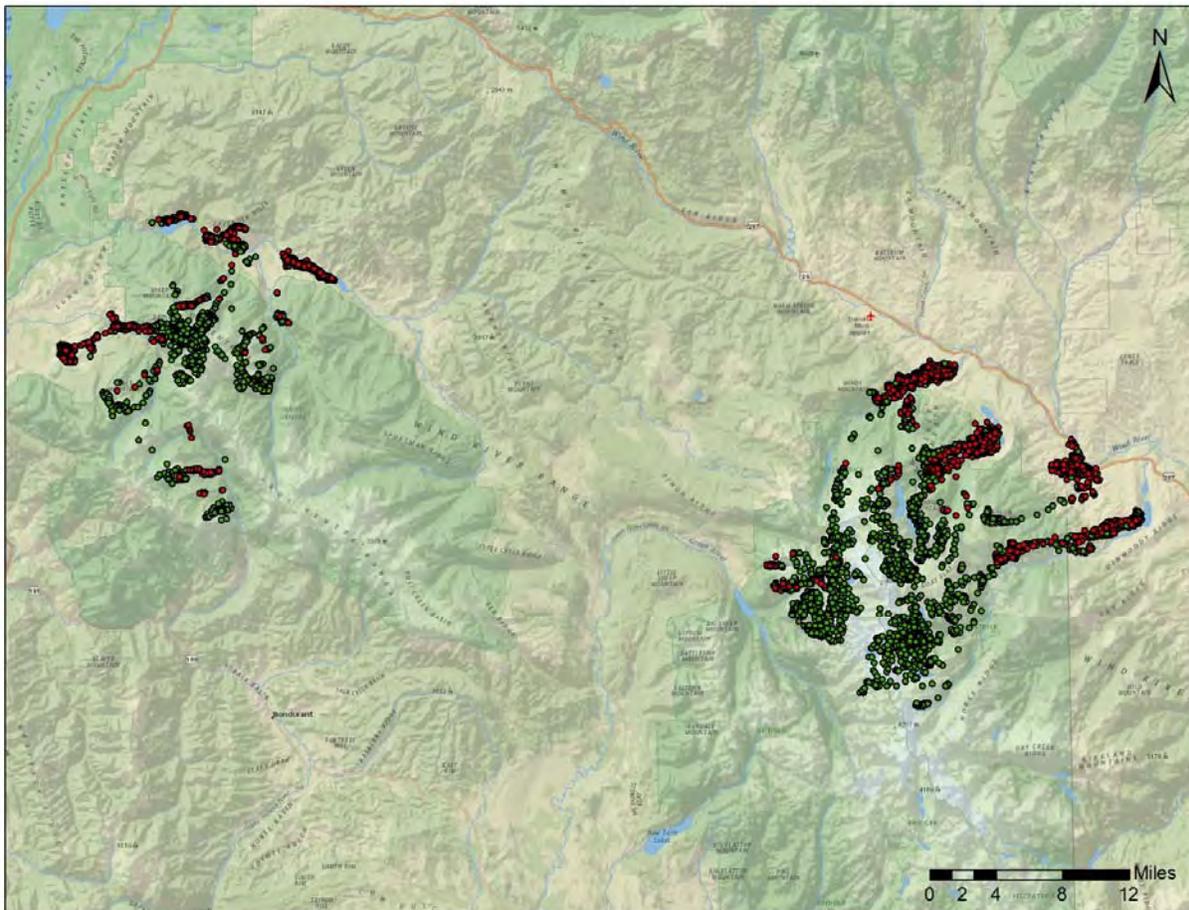


Fig. 4. Ingesta-free body fat ($\% \pm SE$) of adult female bighorn sheep relative to lactation status in December, 2015 in the Cody, Dubois, and Jackson herds of northwest Wyoming. Lactation rates were 50% in Cody, 43% in Dubois, and 45% in Jackson.



All animals were fit with either a store-on-board GPS radiocollar (Cody sheep), or a live satellite collar designed to collect 2 GPS fixes per day and transmit those data every 3 days (Jackson and Whiskey sheep). Having GPS data will allow us to learn more about migration patterns and occupancy of seasonal ranges that will prove valuable in land management and understanding how contributions of seasonal ranges influence nutrition, demography, and potentially disease interactions.



All current locations recorded in the Jackson and Whiskey herds for sheep wearing satellite collars with data uplink capability. Red locations are those recorded during May–October, and those in green were recorded during November–April, 2015.

Looking ahead.....

This past year capture marks the beginning of what we hope to be a long-term research project to explore the disease-nutrition interface in bighorn sheep, and to develop an understanding of the range limits (i.e., nutritional carrying capacity) of our sheep populations in northwest Wyoming. Future work will include annual assessment of recruitment status for marked females, continued monitoring of survival, and subsequent recaptures of radiomarked females during mid-December and mid-March to assess their nutritional status and presence of respiratory pathogens following summer and winter each year. With time, we will begin to piece together each female's history to describe how she interacts with her environment, understand her success to survive and reproduce or lack thereof, and how she fits within the population in which she resides. By piecing together the histories of each female we monitor, we hope to add an important piece to the puzzle of the complex interactions of environment, disease, and dynamics of our cherished bighorn sheep populations. Although there is still much work to do, and much more support needed to accomplish these goals, we are grateful for the funding and logistical support to date that has made the initiation of this project possible.



Acknowledgments

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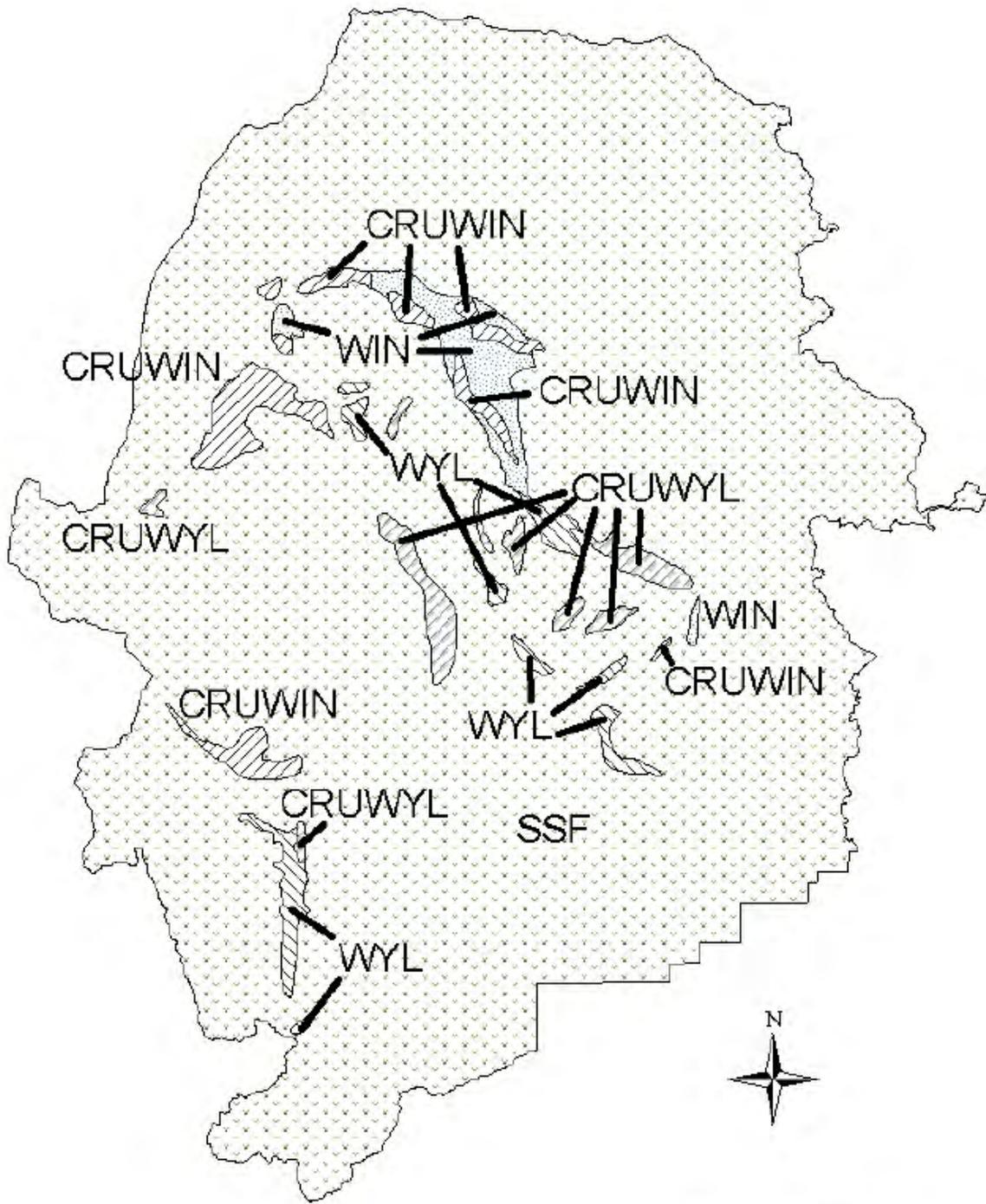
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