BIGHORN SHEEP UNIT MANAGEMENT PLAN
KAIPAROWITS WMU #26
East / West / Escalante
August 2019

BOUNDARY DESCRIPTIONS

Kane and Garfield Counties -

Kaiparowits, East - Boundary begins at the north shore of Lake Powell and the Utah-Arizona state line; west on this state line to US-89; north and west along US-89 to the Smoky Mountain road; north on this road to SR-12; east on SR-12 to the Hole-in-the-Rock road; southeast on this road to the north shore of Lake Powell; southwest along this shore to the Utah-Arizona state line.

Kaiparowits, West - Boundary begins at US-89 and the Utah-Arizona state line; west on this state line to the Cockscomb-House Rock Valley road; north on this road to US-89; west on US-89 to the Johnson Canyon road; north on this road to the Skutumpah road; northeast on this road to the Cottonwood Canyon road; north on this road to SR-12; east on SR-12 to the Smoky Mountain road; south on this road to US-89; southeast on US-89 to the Utah-Arizona state line.

Kaiparowits, Escalante - Boundary begins at SR-12 and the Burr Trail road in Boulder, Utah; southeast along the Burr Trail road to the north shore of Lake Powell; southwest along the north shore of Lake Powell to the Hole-in-the-Rock road; northwest along this road to SR-12; northeast along this road to the Burr Trail road in Boulder, Utah.

LAND OWNERSHIP

Land ownership and approximate area of modeled bighorn sheep habitat for the Kaiparowits bighorn sheep management sub-units.

Kaiparowits, East

Ownership	**MODELED BIGHORN HABITAT**	
	Area (acres)	**%**
Bureau of Land Management	257,910	68.4%
National Parks	118,600	31.4%
Utah State Institutional Trust Lands	570	0.2%
Private	159	<0.1%
State Sovereign Land	1	<0.1%
Totals	**377,239**	**100%**

Kaiparowits, West

Ownership	MODELED BIGHORN HABITAT	
	Area (acres)	%
Bureau of Land Management	489,244	94.3%
Utah State Institutional Trust Lands	9,008	1.7%
Private	8,104	1.6%
National Parks	6,069	1.2%
National Forest	4,329	0.8%
Utah State Parks	1,777	0.3%
Utah Division of Wildlife Resources	150	<0.1%
Totals	**518,681**	**100%**

Kaiparowits, Escalante

Ownership	MODELED BIGHORN HABITAT	
	Area (acres)	%
National Parks	246,069	64.7%
Bureau of Land Management	131,147	34.5%
Utah State Institutional Trust Lands	1,628	0.4%
Private	1,003	0.3%
National Forest	205	0.1%
Utah Department of Transportation	2	<0.1%
Totals	**380,055**	**100%**

UNIT MANAGEMENT GOALS

The Kaiparowits unit is located in south-central Utah and includes the Kaiparowits Plateau. Prominent features of the area are the Grand Staircase and the Escalante Canyons. Much of the area is administered by the Bureau of Land Management's Grand Staircase Escalante National Monument (GSENM) whereas the National Park Service administers the Glen Canyon National Recreation Area. Lake Powell serves as the southern boundary for much of the unit where most bighorn sheep occupy the canyons along the lake shore (Figure 1). Specific goals are to:

1) Manage for a healthy population of desert bighorn sheep capable of providing a broad range of recreational opportunities, including hunting and viewing.
2) Balance bighorn sheep impacts with other uses such as authorized grazing and local economies.
3) Maintain a population that is sustainable within the available habitat in the unit boundary.

HISTORY AND CURRENT STATUS

This area includes historical accounts of large numbers of bighorn sheep prior to pioneer settlement. The first record of bighorn sheep documented in Utah was by Father Escalante in 1776, who reported bighorns were abundant along the Colorado River and the frequency of their tracks was comparable to large flocks of domestic sheep (Dalton and Spillet 1971). Since the general extirpation of bighorn sheep in Utah, the Utah Division of Wildlife Resources has restored many populations through an aggressive transplant program. The Kaiparowits unit was largely repopulated from desert bighorn herds in Arizona, Nevada and other sources in Utah (Appendix A).

The need to distribute hunters and provide additional hunting opportunities resulted in the creation of the 3 subunits: East, West, and Escalante (Figure 1). Hunters tended to focus on areas with greater access and areas in the East and Escalante units were not generating any harvest. Although these areas are referred to as separate populations, the subunits have extensive habitat connectivity. Past radio collar data suggests there are movements across much of this area and the riparian areas, particularly Escalante River, do not serve as barriers to movement.

Currently, populations are stable to increasing, especially in areas with recent transplants. Pathogens have been detected in these herds but substantial die offs have not been documented at this time. Since this area is remote and observations of sheep are often limited to aerial surveys, continued monitoring of GPS collared animals will assist in annual survival estimates and detection of any disease events. The creation of additional water sources may alleviate disease concerns by distributing sheep into lower densities and thus mitigate or reduce any negative impacts from disease transmission.

ISSUES AND CONCERNS

Potential Habitat: We modeled potential bighorn sheep habitat on the Kaiparowits unit using methodology outlined by O'Brien et al. (2014). Bighorn sheep select habitat based on the proximity of steep-sloped escape terrain, forage availability, ruggedness, and horizontal visibility (Bleich et al. 1997, Valdez and Krausman 1999, Sappington et al. 2007). Bighorn sheep habitat is located throughout the unit in suitable rugged locations (Figure 1).

Livestock Competition: Bighorn sheep annual use of forage classes, when compared to cattle, differ significantly (Dodd and Brady 1988). Likewise, bighorn sheep generally avoid areas where cattle are present (Bissonette and Steinkamp 1996), and also select areas with a much higher degree of slope (Ganskopp and Vavra 1987). For these reasons, competition between cattle and bighorns should not be a significant concern within this unit. Because of the risk of pathogen transmission between bighorns and domestic sheep, the areas where domestic sheep are present are not suitable for bighorn sheep.

Disease: Disease, especially bacterial pneumonia, has been responsible for numerous declines in bighorn populations throughout North America (Cassirer and Sinclair 2007). Pneumonia outbreaks typically affect all age/sex cohorts and are usually followed by several years of annual pneumonia outbreaks in lambs that dramatically reduce population growth (Spraker et al. 1984,

Ryder et al. 1992, George et al. 2008). These events are attributed to the transfer of pathogens from domestic sheep (*Ovis aries*) or goats (*Capra aegagrus hircus*) to wild sheep through social contact (Singer et al. 2000, Monello et al. 2001, Cassirer and Sinclair 2007). Disease-induced mortality rates in bighorn sheep vary substantially by population due to multiple processes including contact rates, social substructuring, pathogen virulence, and individual susceptibility (Manlove et al. 2014, 2016). Therefore, spatial separation from domestic sheep and goats is the most important factor in maintaining overall herd health. It is not the intent of this plan or the Utah Division of Wildlife Resources (DWR) to force domestic sheep operators off public lands or out of business. Rather, the intent is to look for opportunities that will protect bighorn sheep populations while working with the domestic sheep industry and individual grazers.

Predation: Cougar predation may limit bighorn sheep in locations where predator populations are largely supported by sympatric prey populations (Hayes et al. 2000, Schaefer et al. 2000, Ernest et al. 2002), which, in this case, includes a limited amount of mule deer. It has been hypothesized that declines in sympatric ungulate populations can increase predation on bighorn sheep as cougars switch to bighorns as an alternate prey source (Kamler et al. 2002, Rominger et al. 2004). It is anticipated that cougars will be the main predator of bighorns in the Kaiparowits. If predation becomes a limiting factor, predator control work will be administered within the guidelines of the DWR Predator Management Policy. Predator management is coordinated with USDA Wildlife Services.

POPULATION MANAGEMENT

Population Management Objective:

1) Manage for up to 1,350 desert bighorn sheep across all subunits with the following distribution and densities:
   - Kaiparowits, East: 400 bighorn sheep
   - Kaiparowits, West: 550 bighorn sheep
   - Kaiparowits, Escalante: 400 bighorn sheep

   All population objectives are well below the recommended 1.9 bighorn sheep/square km (Van Dyke 1983). These objectives can be reasonably achieved at this time and populations should be evaluated for disease transmission prior to any further population objective increases.

Population Management Strategies:

There are two areas with potential for bighorn sheep expansion. These areas should be evaluated for potential disease issues and local support for bighorn sheep.

1) The Gulch: Boundary begins at the junction of SR 12 and the Burr Trail; north along SR 12 to the Garfield County line; east along this County line to the Capitol Reef National Park Boundary; south along the park boundary to the Burr Trail; west along the Burr Trail to SR 12.
   - This area already has dispersing sheep from either or both the Capitol Reef National Park and the Kaiparowits, Escalante populations. A regular

survey of this area should be considered to evaluate occupancy in order to facilitate decisions on hunting opportunities and maintaining spatial separation.
    - Manage for no more than 50 bighorn sheep in this area to discourage substantial forays from this area.
    - If this area is occupied by a bighorn sheep population capable of sustaining harvest, consider inclusion into the Kaiparowits, Escalante hunt boundary.
    - The area to the north in Wayne County is a not a suitable area for bighorn sheep due to its proximity to the infected bighorn sheep in Capitol Reef National Park. Wandering sheep should always be immediately removed to promote spatial separation and protect sheep populations within Capitol Reef National Park.
2) Box Death Hollow: Boundary begins at the junction of SR 12 and the North Creek Road; north along the North Creek Road to the Whites Flat USFS 152 road; east along this road to the Hells Backbone USFS rd 153; east and south to SR 12; west along SR 12 to the North Creek Road.
    - This area will continue to be evaluated for potential expansion and/or reintroduction. Source herds would have to consider disease and/or prior pathogen exposure.
    - If this area is found to be acceptable for bighorn sheep, population numbers should be kept low to promote separation between wild and domestic sheep.
    - Any sheep discovered in this area should be GPS collared if possible to determine movements within the area.

Population Monitoring Plan:

Monitor population size and composition alternating between the three subunits every 2-3 years by helicopter. The Kaiparowits East and West are typically flown together and the Kaiparowits Escalante is typically flown individually. Efforts should be made to ensure data can be separated and herd performance evaluated amongst subunits.
The Escalante unit will require approximately 35 hours of flight time. The Kaiparowits East and West will also collectively require approximately 35 hours of flight time. The Gulch area and areas north of Burr Trail within Capitol Reek National Park should be surveyed at least every 2-3 years to determine occupancy and will require approximately 15 hours of survey time. Box Death Hollow does not likely require aerial surveys at this time but may be completed opportunistically if conditions warrant.
Conduct ground classification as conditions permit. This data can be valuable in monitoring herd health and easily obtained in areas near Coyote Creek, Paria River, Tibbets Canyon, Wiregrass Canyon, and Smokey Mountain. A shoreline survey has also proven to be effective in Rock Creek and Dangling Rope.
Monitor bighorn sheep using GPS collars to obtains annual survival estimates and when possible cause-specific mortality.
All population data will be collected and submitted on standardized forms, including all GIS data (waypoints, flight paths, etc.).

Trend Count and Classification Data

Table 1. Summary of recent aerial trend counts and classification surveys on Kaiparowits East.

Year	Pop Est	Total Count	Total Ewes	Total Lambs	Total Rams	Lambs/100 Ewes	Rams/100 Ewes
2003	63	38	20	11	7	55	35
2005	92	55	31	11	13	35	42
2007	45	27	11	7	9	64	82
2009	83	50	29	11	10	38	34
2011	140	84	39	22	23	56	59
2013	238	143	88	28	27	32	31
2018	370	222	113	49	60	43	53

Table 2. Summary of recent aerial trend counts and classification surveys on Kaiparowits West.

Year	Pop Est	Total Count	Total Ewes	Total Lambs	Total Rams	Lambs/100 Ewes	Rams/100 Ewes
2003	75	45	18	13	14	72	78
2005	135	81	37	22	22	59	59
2007	128	77	32	19	26	59	81
2009	148	89	36	12	41	33	114
2011	193	116	64	19	33	30	52
2013	327	196	115	35	46	30	40
2018	437	262	126	40	96	32	76

Table 3. Summary of recent aerial trend counts and classification surveys on Kaiparowits Escalante.

Year	Pop Est	Total Count	Total Ewes	Total Lambs	Total Rams	Lambs/100 Ewes	Rams/100 Ewes
2004	252	151	67	37	47	55	70
2006	165	99	47	22	30	47	64
2008	192	115	59	15	41	25	69
2010	145	87	45	11	30	24	67
2012	118	71	41	9	21	22	51
2014	153	92	51	18	23	35	45
2017	147	88	48	10	30	21	62

Transplant Plan:

This unit has vast amounts of unoccupied habitat and therefore has received a number of supplemental transplants in recent years (Table 4). Due to the extensive network of connective

habitat, disease profiles of source herds and destination herds should be undertaken prior to any additional transplants.

As augmentations take place, a representative sample of sheep should be fitted with GPS collars. An analysis of their survival and general movements should be evaluated, and the data should be evaluated when considering future transplant decisions.

The Kaiparowits Escalante has tested positive for *Mycoplasma* sp. (see Appendix B). There have been 2 transplant efforts on the Escalante that were intended to create new herds on the periphery of occupied habitat; however surveys have shown some individuals have wandered into occupied habitat. It is therefore necessary that this herd and the recently transplanted sheep be monitored for a few years prior to any additional transplant efforts.

The Kaiparowits West has also tested positive for *Mycoplasma* sp. (see Appendix C-D). Since this herd has been increasing, transplants within this unit may be appropriate once all analyses are complete. Potential release sites on the Kaiparowits West include:

- John Henry and Wesses Canyons (Ship Mountain)
- Upper portions of Hackberry and Paria River

The Kaiparowits East has received a few transplants from Nevada. *Mannehaemia* sp were detected in some of the 25 sheep released in Cave Point/Sooner Slide in 2012. Some of these transplanted sheep have been observed in the Rock Creek area, which is a densely populated portion of this unit. Since this population is surrounded by areas where *Mycoplasma* sp. has been detected, it is not recommended to continue transplants into this area at this time.

Table 4. Recent transplants and ear tag colors for desert bighorn sheep on the Kaiparowits unit.

	Year	Source	Release Site	Ear Tag Color	Number
Kaiparowits, West	2006	Fallon, NV	Tibbets Canyon	Green	20
	2014/15	Residents	Residents	White	12
Kaiparowits, East	2009	Lake Mead, NV	Croton Canyon	Orange	20
	2012	River Mtns, NV	Cave Pt/Sooner Slide	Yellow	25
	2012	Muddy Mtns, NV	Last Chance Creek	Blue	24
Kaiparowits, Escalante	2013	Residents	Residents	White	17
	2013	Muddy Mtns, NV	Long Cyn/Annies Cyn	Orange	49
	2014	Muddy Mtns, NV	Silver Falls	Green	37
	2014	Muddy Mtns, NV	25 Mile Wash	Red	34

*Only resident captures have been given white ear tags.

Predator Management:

1) All 3 of the Kaiparowits subunits are managed as an unlimited harvest on cougars despite limited harvest results (Table 5).
2) If cougar predation is shown to have adverse impacts on bighorn sheep establishment, cougar management may be accomplished through established DWR policy and

procedures. Cougar removal efforts may be conducted by DWR personnel, and Wildlife Services.

3) Cougars have been suspected to have an adverse impact on sheep in the Escalante; however due to the remote and rugged nature of the unit, cougar harvest has been challenging. In recent years, Wildlife Services has removed cougars for bighorn sheep predation on the Smokey Mountain and 50 Mile Mountain on the Kaiparowits East. Continued efforts to address cougars on the Escalante using Wildlife Services are recommended.
4) A predator management plan is in place for the Kaiparowits subunits since the population is below 90% of objective and the area serves as a transplant site. All options for predator control should be included in this plan.

Table 5. Cougar harvest over the past 10 years on the Kaiparowits unit.

Year	Harvest Objective Quota	Males	Females	Total Harvest	Average Age
2004	10	1	0	1	1.0
2005	10	0	1	1	-
2006	10	1	1	2	3.5
2007	10	0	1	1	3.0
2008	7	0	1	1	2.0
2009	7	1	0	1	6.0
2010	7	4	1	5	2.0
2011	6	1	1	2	4.0
2012	7	1	1	2	3.0
2013	7	0	0	0	-
2014	Unlimited	3	0	3	4.0
2015	Unlimited	0	1	1	3.0
2016	Unlimited	2	0	2	-
2017	Unlimited	0	0	0	-
2018	Unlimited	1	0	1	4.0
2019	Unlimited	1	3	4	3.0
Total	151	19	10	29	3.5

Research Needs:

1) Regularly sample resident bighorns to upkeep health profiles throughout all subunits.
2) GPS data from collared sheep may be used to evaluate movements and annual survival and facilitate future transplant decisions.
3) Determining the peak lambing periods may provide insight to future transplant decisions, particularly on the Kaiparowits West.
4) Cause-specific mortality from GPS collars and/or track surveys on the Kaiparowits Escalante may prove useful in evaluating predator management programs.

5) Disease testing of bighorn sheep east of Torrey would be beneficial to assess disease risks to the greater populations to the south and facilitate transplant decisions on the Henry Mountains. Increased GPS collars on rams would also be beneficial to evaluate the extent of connectivity and movement between these areas.

DISEASE MANAGEMENT

Disease Management Objective:

1) Maintain a healthy population of desert bighorn sheep on the Kaiparowits unit.
2) Strive for spatial separation from domestic sheep and goats.

Disease Management Strategies:

Disease Monitoring: The DWR may perform periodic live captures to assess herd health, as well as take advantage of opportunistic sampling of hunter harvested bighorns or bighorns that are found dead. Live captures have been performed in each of the sub-units (see appendices B-D). Pathogens causing respiratory disease have been found in each sub-unit.

Spatial Separation: Work with land management agencies and private landowners to implement agency guidelines for management of domestic sheep and goats in areas likely to be occupied by bighorn sheep.
Domestic sheep grazing allotments pose little risk to this unit, where the nearest active allotments are over 30 miles away from occupied habitat. The Box Death Hollow and The Gulch areas will be in closer proximity to active allotments. Manage for spatial separation between wild and domestic sheep and goats.
Farm flocks in the small communities surrounding bighorn sheep habitat also pose a risk for disease transmission. These areas include Big Water, Church Wells, Escalante, Boulder, and Kanab. Outreach efforts and potential double-fencing projects may increase understanding and implementation of spatial separation. Additionally, Johnson Canyon has several private properties where domestic sheep are grazed. Due to the connective habitat along the Vermillion Cliffs, all wild sheep should be immediately removed west of Johnson Canyon to US89 north of Kanab to protect wild sheep from comingling with domestics and prevent continued pathogen transmission

Risk Management and Response Plan:

Feral domestic goats and sheep pose the greatest risk to spatial separation. If stray animals are reported, every reasonable effort should be made to remove the disease threat as per UDWR GLN-33. All wandering wild sheep will be handled following

the UDWR GLN-33. The need to test wandering bighorn sheep from this unit will be evaluated on a case by case basis. All feral or stray domestic animals should be tested.

HABITAT MANAGEMENT

Habitat Management Objectives:

1) Maintain or improve sufficient bighorn sheep habitat to achieve population objectives.
2) Continue to identify crucial bighorn sheep habitats, and work with land managers to protect these areas.
3) Assist land management agencies in monitoring bighorn habitat to detect changes in habitat quantity or quality.
4) Work with land management agencies and private landowners to implement agency guidelines for management of domestic sheep and goats in bighorn areas.

Potential Threats to Habitat:

Human disturbance can result in abandonment or degradation of bighorn habitat. Due to the rugged nature and low density of roads in sheep habitat, human disturbance of bighorn on this unit is expected to be low. If disturbance becomes an issue, the DWR will work with and support federal agencies (BLM, GSENM, USFS, NPS) on travel management plans, oil and gas exploration, and other land use plans.

Vegetation Management Projects:

1) Initiate vegetative treatment projects to improve bighorn habitat lost to natural succession or human impacts. Cooperate with the USFS, BLM, and GSENM to utilize controlled burns and/or mechanical treatments to remove conifer encroachment on open hillsides to increase and improve bighorn sheep habitat across the subunit.
2) The northern portion of this unit has a higher density of pinion and juniper trees in bighorn sheep habitat. This has been identified in previous unit management plans as a limiting factor to bighorn sheep expansion. Substantial escape terrain exists and a "let burn" prescription would promote bighorn habitat throughout these areas. A few examples of specific areas include the following:
    - 50 Mile Mountain
    - Sunday and Monday Canyons
    - Drip Tank
    - Upper Coyote Canyon
    - Upper Wahweap Creek
    - Hackberry Canyon
    - Paria River
    - Collet Canyon

Water Management Projects:

1) Work with GSENM, NPS, and SITLA to locate and improve water sources across bighorn habitat.
2) Cooperatively modify or improve existing water developments and guzzlers for bighorns.
    - Croton Canyon
    - Burning Hills
    - Navajo Valley
    - 50 mile Mountain
    - Smokey Mountain
        - Rim of Last Chance Creek
    - Nipple Bench
    - Tibbet Canyon
    - Brigham Plains
3) Develop natural waters that may be beneficial to bighorn sheep.
    - Tibbet Canyon
    - Smokey Hollow
4) Install new water developments or guzzlers in bighorn habitat where water may be lacking. This is particularly advantageous to promote bighorn sheep distribution and potentially mitigate disease concerns from high densities of sheep on limited water resources. The impact of humans to this area and the creation of the lake have already provided unnatural conditions and therefore additional steps must be taken to protect this native species. A few specific areas for new water developments include but are not limited to:
    - Southern end of Smokey Mountain
    - Middle Warm Creek Point
    - Croton Canyon
    - Little Valley Canyon
    - Sunday and Monday Canyon
    - John Henry and Wesses Canyons
    - West Bench
    - Tibbet Bench

RECREATION MANAGEMENT

Recreation Management Objectives:

1) Provide hunting opportunities on the Kaiparowits unit that are a quality experience.
2) Increase public awareness and expand viewing opportunities of bighorn sheep.

Recreation Management Strategies:

Hunting: Hunting and permit allocation recommendations will be made in accordance with the Utah Bighorn Sheep Statewide Management Plan. Ewe hunts may be utilized as a tool for maintaining population objective.

Harvest Statistics

	Kaiparowits, East			Kaiparowits, West			Kaiparowits, Escalante		
Year	Permits	Mean Days	Harvest	Permits	Mean Days	Harvest	Permits	Mean Days	Harvest
2002	5	-	100%	5	-	100%	5	-	100%
2003	2	9.5	100%	4	3	100%	7	11	86%
2004	4	11.8	100%	1	3	0%	7	7	100%
2005	5	6.6	100%	1	2	100%	6	13.5	100%
2006	2	15	100%	1	6	100%	8	9.6	67%
2007	3	18	100%	2	13.5	100%	7	16.6	50%
2008	3	6.7	100%	2	13	50%	7	7.7	100%
2009	3	9.7	100%	2	2	100%	6	15.8	100%
2010	4	8.3	100%	2	4	100%	5	9.6	80%
2011	4	6.5	75%	3	3.7	100%	6	7.4	67%
2012	4	6.8	100%	3	3	100%	5	14.2	67%
2013	4	7.3	100%	3	10.3	100%	2	11.5	50%
2014	2	5.5	100%	4	5.5	100%	2	10	100%
2015	3	2.3	100%	7	9	100%	2	10	50%
2016	5	3.4	100%	5	11.2	100%	2	12	100%
2017	8	2.5	100%	7	5.1	100%	2	10.5	100%
2018	8	4.5	100%	6	3.2	100%	5	6	75%

Non-Consumptive Uses: The DWR will look for opportunities to increase public awareness and expand viewing opportunities of bighorn sheep through viewing events and public outreach. Significant viewing opportunities are available in Lone Rock Canyon, Wiregrass Canyon, Rock Creek Bay, Dangling Rope Marina.

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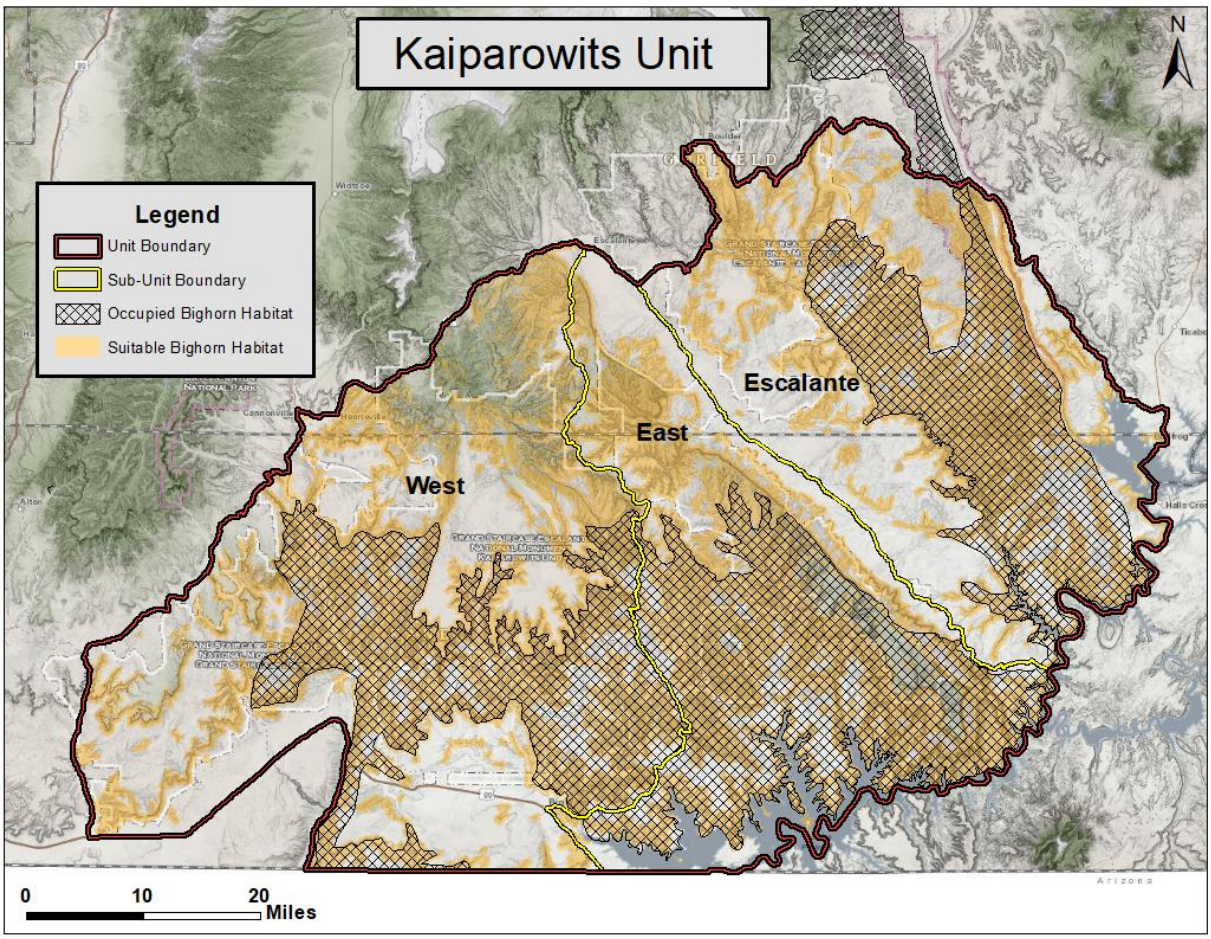

Figure 1. Kaiparowits unit management boundary, modeled suitable bighorn sheep habitat, and currently occupied bighorn habitat.

Appendix A. Summary of bighorn sheep transplant efforts into the Kaiparowits.

Release Unit / Area	Year	# Released	Source
Kaiparowits, East	1980	20	Cataract/White Canyons, UT
Kaiparowits, East	1982	12	Canyonlands NP, UT
Kaiparowits, East	1993	13	Escalante, UT
Kaiparowits, East	1995	17	Escalante, UT
Kaiparowits, East	2009	20	Lake Mead, NV
Kaiparowits, East	2012	25	River Mountains, NV
Kaiparowits, East	2012	25	Muddy Mountains, NV
Kaiparowits, West	1995	21	Black Mountains, AZ
Kaiparowits, West	1995	2	Escalante, UT
Kaiparowits, West	1996	20	Lake Mead, NV
Kaiparowits, West	1999	21	Lake Mead, AZ
Kaiparowits, West	2000	20	Lake Mead, NV
Kaiparowits, West	2006	20	Fallon, NV
Kaiparowits, Escalante	1975	4	Gypsum Canyon, UT
Kaiparowits, Escalante	1976	12	Gypsum Canyon, UT
Kaiparowits, Escalante	1978	7	Cataract Canyon, UT
Kaiparowits, Escalante	1986	4	Canyonlands NP, UT
Kaiparowits, Escalante	1995	6	Escalante, UT
Kaiparowits, Escalante	1995	18	Escalante, UT
Kaiparowits, Escalante	1998	7	Escalante, UT
Kaiparowits, Escalante	2013	49	Muddy Mountains, NV
Kaiparowits, Escalante	2014	37	Muddy Mountains, NV
Kaiparowits, Escalante	2014	34	Muddy Mountains, NV

Escalante Bighorn Sheep Disease Profile

SEROLOGY

Whole blood was collected from 17 bighorn sheep and tested for antibodies for the following respiratory and viral diseases:

- Bovine Respiratory Synctial Virus (BRSV) – 4 of 17 (24% prevalence rate) samples had titres for BRSV. All titres in this population were detected at low levels meaning that at some point they were exposed to this virus but there is not likely an active infection.
- Infectious Bovine Rhinotracheitis (IBR) – All 17 samples were negative for titres to IBR.
- Parainfluenza III (PI3) – 5 of 17 (29%) samples had titres for PI3. Most titres were less than 1:4 which indicates previous exposure but not active infection.
- *Mycoplasma ovipneumonia* ELISA – Antibodies for *Mycoplasma ovipneumonia* were detected in 15 of the 17 (88%) samples and two were indeterminant. The test is designed for classification of populations, not individuals. Populations not exposed to *M. ovipneumonia* will have 0-10% of the population with detected antibodies, whereas exposed populations will have 30-100% of animals with detected antibody.
- Bluetongue virus (BTV) – 9 of 17 samples (53%) were positive for bluetongue antibodies. The positive result is only an indication of exposure not a current infection.
- Epizootic hemorrhagic disease (EHD) – 10 of 17 (59%) of the samples were positive for EHD. This only indicates exposure not a current infection.

FECAL

Fecal samples were collected from 17 of 17 animals. *Nematode* ova were detected in only one sample. Nematode spp. belong to the phylum of roundworms and include the superfamily *metastrongyloidea* (lungworms). Unfortunately, we can't get more specific than phylum using the submitted samples.

Oropharyngeal and Nasal Swabs - Oropharyngeal and nasal swabs were collected from all 17 animals, 2 per animal, with a total of 34 swabs.

- *Mycoplasma ovipneumonia* – 34 swabs were collected, 2 per sheep and placed in Mycoplasma broth and submitted for PCR screening to detect presence of *mycoplasma ovipneumonia* antibodies. *Mycoplasma* was detected in 4 of the 17 samples and two were classified as indeterminant.

Another 34 swabs were collected, 2 per sheep and placed into a port-a-cul media that supports growth of aerobic and anaerobic microorganisms.

- *Mannheimia* species – *Mannheimia* species were isolated from 8 of 17 (47%) animals. Three species of *Mannheimia* were detected and included *M. haemolytica, glucosida,* and *ruminalis*. What is important with these bacteria is if they are betahemolytic and have the ability to produce leukotoxin and result in damage to leukocytes in tissue in the lungs during a pneumonia infection. All 3 strains were betahemolytic and were reported at low to moderate frequencies.
- *Bibersteinia trehalosi* – previously known as *pasteurella trehalosi*. *Bibersteinia trehalosi* was detected in 13 of 17 swabs samples (76%) and several were classified as betahemolytic and ranged from low to very high frequencies.
- *Pasteurella multocida* – *P. multocida* was isolated from 2 of 17 samples (11%) with frequency low to very high.
- *Truperella (Arcanobacter pyogenes*) – *Truperella*, also known as *Arcanobacter pyogenes* is a common bacteria associated with abscesses and wound related infections. It is often found within the respiratory system and is usually of no consequence until something happens that triggers formation of a pneumonia event, such as a stressor. *Truperella* was isolated from 5 of 17 (29%) samples.
- *Mycoplasma* culture – The lab attempted to grow *mycoplasma* spp from the port-a-cul swabs that were submitted for bacterial testing. *Mycoplasma* was grown in culture from 3 of the 17 samples (18%).
- *Mycoplasma* PCR and genetics – The lab also takes the swabs and tests the samples using PCR to detect for mycoplasma and then tries to speciate it to either *Ovipneumonia* or *marginalis*. The 3 strains were identified as *marginalis* and 2 others were classified as suspect for *mycoplasma ovipneumonia*.

Kaiparowits West bighorn sheep disease testing

A total of 12 female bighorn sheep were sampled for disease testing in the West Kaiparowits Mountains on November 18th, 2014. Ten of the 12 bighorn sheep were aged between 3 and 8 years, whereas the age was not reported for 2 animals. Blood was collected for serology, and nasal and oropharyngeal swabs were collected for PCR and culture. Captured animals were treated with an antiparasitic (Ivermectin), an anti-inflammatory drug (Flunixin meglumine), and an antibiotic (Florfenicol).

Highlight of the most important findings:

Bighorn sheep in this population have been exposed and are shedding to *Mycoplasma ovipneumoniae*, which is considered an important pathogen in the bighorn sheep respiratory disease complex. Although no clinically diseased sheep were reported during the capture, the population can be considered exposed to respiratory pathogens that may have negative population effects. In the future, it cannot be recommended that bighorn sheep from this population be moved to other areas, or that this population be augmented with bighorn sheep from other populations.

Detailed results:

Serology:

- Bovine Respiratory Synctial Virus (BRSV) – 3 of 12 samples had low titers (1:4 and 1:8) for BRSV. This only indicates previous exposure. The remaining 8 samples were negative for BRSV, which means no antibodies were detected.
- Infectious Bovine Rhinotracheitis (IBR) – 9 of 9 samples were negative for IBR which means no antibodies were detected.
- *Mycoplasma ovipneumoniae* (*M. ovi*) ELISA – 9 of 12 samples (75%) of samples tested positive. The ELISA test is designed for classifying populations, not individuals. Populations not exposed to *M. ov*i will have 0-10% of animals with detected antibody, whereas exposed populations will have 30-100 % of animals with detected antibody. Hence, this population can be classified as exposed.
- Bluetongue virus (BTV) – 7 of 12 (58%) of samples were positive for antibodies to BTV. The presence of antibodies indicates previous exposure. The BTV test can cross-react with antibodies to EHD virus.
- Epizootic hemorrhagic disease (EHD) – 8 of 12 (67%) samples were positive for antibodies to EHD. The presence of antibody indicates previous exposure. The EHD test can cross-react with antibodies to BTV virus.
- Bovine Viral Diarrhea (BVD) – 12 of 12 (100%) samples were negative for BVD.
- Parainfluenza Type 3 (PI3) – 1 of 12 (8.3%) of samples were positive for antibodies to PI3 at a titer of 1:16. This is a low titer that indicates previous exposure, not recent or current infection.
- *Brucella ovis* – not done

Fecal:

Fecal samples were not collected.

Oropharyngeal and Nasal Swabs

- Two oropharyngeal and 2 nasal swabs were collected from all 12 captured sheep. One nasal and one oropharyngeal swab per sheep and placed in media that promotes the growth of *Mycoplasma* spp. These swabs were cultured and tested with PCR for the presence of *Mycoplasma ovipneumoniae*. One nasal and 1 oropharyngeal swab per sheep was placed into a port-a-cul media that supports growth of aerobic and anaerobic microorganisms.

  Swabs in Mycoplasma medium:
  - *Mycoplasma ovipneumoniae* was detected by PCR in 1 of 12 (8.3%) bighorn sheep.

  Swabs in Port-a-cul medium:
  - *Mannheimia* species – *Mannheimia* species were isolated from 4 of 12 samples at high frequency. Three strains were betahemolytic strains. Beta hemolytic means that the bacterium's hemolytic enzymes can completely break down cells.
  - *Bibersteinia trehalosi –Bibersteinia trehalosi* was detected in 7 of 12 (58.3%) samples and all were nonhemolytic strains.
  - *Pasteurella spp* – This bacterium was not isolated from any of the samples.
  - *Trueperella (*previously *Arcanobacter pyogenes*) – *Trueperella* is a common bacterium associated with abscesses and wound related infections. It is often found within the respiratory system and is usually of no consequence until something happens that triggers formation of a pneumonia event, such as a stressor. This bacterium was found in 10 of 12 (83.3%) of samples at low to moderate frequency.
  - Various other bacteria were isolated but they are considered of little to no consequence.

Appendix D. Disease profile of bighorn sheep in the Kaiparowits, December 2016.

Kaiparowits bighorn sheep disease testing, 2016

A total of 24 female and 6 male bighorn sheep were sampled in the Kaiparowits for disease testing on December 13 – 15, 2016. The animals were captured at Kelly Grade (9), Last Chance (6), Wahweap (14), and Rock Creek Bay (1). The ages ranged from 1 to 8 years of age. Blood was collected for serology and trace minerals, nasal and tonsilar swabs were collected for PCR and culture, ear swabs were collected to test for ear mites, and fecal samples were collected for parasites. Captured animals were treated with an antiparasitic (Long Range), Selenium and Vitamin E, and an anti-inflammatory drug (Flunixin meglumine). Animals with ear tick infestations were further treated topically with Catron antiparasitic spray on the ears. All animals were released on site after processing.

One mortality occurred during the capture. The animal was not sampled. One additional bighorn sheep died a few weeks after the capture. No other significant injuries occurred.

Highlight of the most important findings:

This population is positive for *Mycoplasma ovipneumoniae*, which is considered an important pathogen in the bighorn sheep respiratory disease complex. Multiple animals also cultured positive for *Mannheimia hemolytica* and *Bibersteinia trehalosi* and were leukotoxin A positive on the tonsilar swabs. Leukotoxin producing *M. hemolytica* or *B. trehalosi* is known to contribute to bighorn sheep respiratory disease. The seroprevalences for respiratory viruses such as parainfluenza type 3, infectious bovine rhinotracheitis, and bovine respiratory syncytial virus were low. Forty percent were seropositive for bluetongue virus and epizootic hemorrhagic disease virus. Fecal parasite loads were low, and no significant trace mineral deficiencies were detected.

Detailed results:

Serology:

- Bovine Respiratory Synctial Virus (BRSV) – 3 of 30 (10%) samples had titers (one at 1:32 and two at 1:64) for BRSV. The titers only indicate previous exposure.
- Infectious Bovine Rhinotracheitis (IBR) – 0 of 30 (0%) of samples were positive for IBR.
- *Mycoplasma ovipneumoniae* (*M. ovi*) ELISA – 17 of 30 (57%) were seropositive for *M. ovi*, indicating that the population previously has been exposed.
- Bluetongue virus (BTV) – 12 out of 30 (40%) were seropositive for antibodies to BTV. The BTV test can cross-react with antibodies to the EHD virus.
- Epizootic hemorrhagic disease (EHD) – 12 out of 30 (40%) were seropositive for antibodies to EHD.
- Bovine viral diarrhea (BVD) – 0 of 30 (0%) were seropositive for BVD.
- Parainfluenza Type 3 (PI3) – 3 of 30 (10%) of samples were seropositive for antibodies to PI3 at a titer ranging from 1:8 - >1:512. Low titers only indicate previous exposure, whereas high titers could indicate recent exposure or current infection.

Fecal:

Fecal floats were run on 16 samples. Strongyle ova were detected in one of 16 (6%) of samples.

Ear swabs:

- Ear mites (*Psoroptes ovis*) were detected in 4 of 30 (13%) of samples. One tick (*Dermacentor* spp.) was identified as well.

Tonsilar and Nasal Swabs

- Two tonsilar and 1 nasal swab was collected from all captured bighorn sheep. One nasal swab per sheep was tested with PCR for the presence of *Mycoplasma ovipneumoniae*. One tonsilar swab was placed into a cryogenic medium that preserves aerobic and anaerobic microorganisms. One tonsilar swab was placed into an empty red top blood tube for a leukotoxinA PCR test.

Nasal swabs in Mycoplasma medium:

- *Mycoplasma ovipneumoniae* was detected in 3/30 (10%) of bighorn sheep on PCR. Strain typing is pending.

Tonsilar swabs in cryogenic medium:

- *Mannheimia hemolytica* – was isolated at low frequency in 5 of 30 (17%) of samples. Other species of *Mannheimia* were detected at low frequency in 12/30 (40%) of animals. Some strains of this bacterium are known to play a role in the bighorn sheep respiratory disease complex.
- *Bibersteinia trehalosi* – *Bibersteinia trehalosi* was detected in 20 of 30 (67%) of the bighorn sheep. Four of these exhibited betahemolysis. Betahemolytic strains are considered more pathogenic than non-betahemolytic strains, which may naturally occur in the respiratory tract of healthy animals.
- *Pasteurella multocida* – Was not isolated from these sheep. Some strains of this bacterium are of concern in the bighorn sheep respiratory disease complex.
- *Truperella pyogenes* – was detected in 8/30 (27%) of samples. *Truperella pyogenes* is a common bacterium associated with abscesses and wound related infections. It is often found within the respiratory system and is usually of no consequence in otherwise healthy animals.

Leukotoxin A PCR from tonsilar swabs:

- Leukotoxin A was detected in 4/30 (13%) of samples by PCR. A positive PCR test for leukotoxin A only indicates the presence of the leukotoxin A gene, not that it necessarily is expressed by the bacterium carrying the gene.
- Leukotoxin expressing *Mannheimia hemolytica* or *Bibersteinia trehalosi* are of concern for respiratory disease in bighorn sheep.
- One of the positive animals cultured positive for both betahemolytic *Mannheimia hemolytica* and *Bibersteinia trehalosi*. One animal cultured positive for betahemolytic *M. hemolytica* and

non-hemolytic *B. trehalosi*, one cultured positive for non-hemolytic *M. hemolytica* and *B. trehalosi*, and the last animal was only culture positive for non-hemolytic B*. trehalosi*. Again, it is not certain that these bacteria actually were expressing the leuktoxin gene.

Trace mineral analysis:

Mineral (ug/g)	Mean	Median	Range	Ref range (ug/g) Puls (1994)	Ref range (ug/g) Poppenga et al. (2012)
Calcium	91.2	94.2	73.3 - 103	80 - 100	81 - 122
Phosphorus	47.2	46.4	27.9 – 68,3	35 - 82	27 - 104
Copper	0.67	0.65	0.48 – 1.1	1.17 – 2.56	0.49 – 1.39
Iron	1.1	1.1	0.51 – 1.7	1.60 – 2.20	0.61 – 3.20
Magnesium	26.3	26.00	22 – 33	10 - 33	23.2 - 49
Selenium	0.27	0.21	0.11 – 0.79	0.13 – 0.23	-
Zinc	0.80	0.81	0.55 – 1.00	0.9 – 1.84	0.32 – 1.52
Manganese	Below detection limit			-	-

Reference ranges for minerals in bighorn sheep have not been conclusively established. The two cited references are the best available. The Poppenga et al. ranges are based on data from bighorn sheep populations in California.

Overall, there do not appear to be any significant mineral deficiencies in this population. Several bighorn sheep have copper concentrations below the reference range proposed by Puls et al., but when using the ranges proposed by Poppenga et al., only one animal falls outside the range.

References:

Poppenga et al., 2012 Journal of Veterinary Diagnostic Investigation 24(3):531-538.
Puls R. 1994. Mineral Levels in Animal Health Diagnostics: Diagnostic Data. 2nd ed. Clearbrook, British Columbia, Canada: Sherpa International.