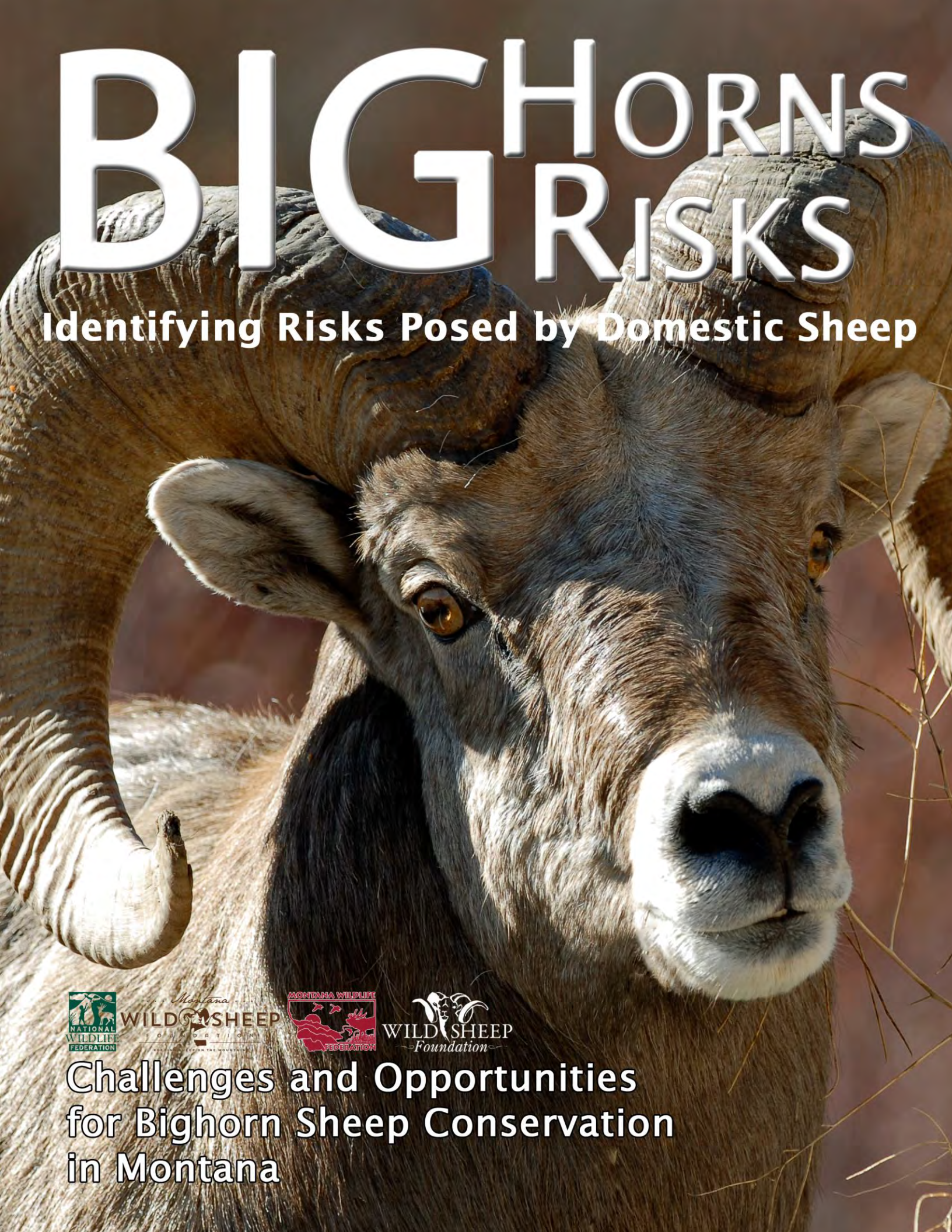
BIG HORNS RISKS

Identifying Risks Posed by Domestic Sheep



Challenges and Opportunities for Bighorn Sheep Conservation in Montana

Bighorns, Big Risks

Identifying Risks Posed By Domestic Sheep

Challenges and Opportunities for Bighorn Sheep Conservation in Montana

Report by ROBB KREHBIEL

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Executive Summary

BIGHORN SHEEP ARE an iconic species of the American West, yet unlike many other ungulates that declined after European expansion, bighorns are still struggling. Out of the several issues facing bighorn sheep, the most severe is pneumonia. Observations from almost a century ago noted that pneumonia outbreaks were seen in bighorn herds after the arrival of domestic sheep on the landscape. Research since then has confirmed that healthy domestic sheep can carry the disease and transfer it to bighorn sheep. This decimates wild herds, with pneumonia outbreaks resulting in up to 90% mortality. Biologist and wildlife managers agree that pneumonia is a significant limiting factor for bighorn sheep, and the most effective way to mitigate this risk is to promote separation between domestic and bighorn sheep.

Maintaining this separation, though, is extremely difficult. Eliminating, reducing and better managing the risk of disease transmission facing Montana's bighorn sheep herds is a significant challenge requiring long-term, strategic approaches that emphasize collaboration among sportsmen, landowners and sheep producers, agricultural organizations, local government, state wildlife managers and public land managers.

It is not feasible to address these risks with all vulnerable bighorn sheep herds in Montana at once, but the risks can be reduced systematically over time through a prioritized approach that identifies opportunities and needs based on population, disease history, habitat security, ability to expand and other factors. The degree of risk facing each herd and opportunities to mitigate the risk also can guide selection of priority herds. While all bighorn herds in Montana have conservation merit, one way to start reducing disease risk is to select those herds that are the most likely to remain secure and robust, are able to expand their range, and have risks that can be more easily mitigated – in effect, keeping bad from going to worse for Montana's bighorn sheep.

The National Wildlife Federation, Montana Wildlife Federation and Wild Sheep Foundation are committed to a neighbor-to-neighbor search for solutions. To move that hard work forward, we have summarized in this report the full range of risks, from which we hope to identify priorities and begin resolving them. By looking 20 miles around each of Montana's bighorn herds, we found that 39 of 46 herds face some risk of contact with domestic sheep. We chose 20 miles for

this search to be confident we have identified all the most predictable problems and therefore have a good set from which to pick priorities to begin working on first. The potential problems and the number of bighorn herds at risk are listed below, from most common to least:

- Private production herds located on private lands (34 of 46)
- Hobby herds: very small herds (26 of 46)
- Federal public-land sheep-grazing allotments (18 of 46)
- Weed-control projects using domestic sheep or goats to graze weeds (9 of 46)

The priorities among these problems will depend on the status of bighorn herds affected; the degree of risk of disease; and interest among sportsmen, woolgrowers, and others to work together on solutions.

To secure bighorn sheep herds, Montanans have a variety of opportunities to expand current efforts, establish relationships with new partners, and create new programs to mitigate risks from domestic sheep. These tools include:

1. Expand public outreach and education, especially with hobby herders.

2. Work with private landowners to provide incentives and assistance to help manage private lands and flocks to minimize contact.

3. Voluntary retirement of problematic grazing allotments or conversion of public-land grazing retirements from sheep to cattle.

4. Develop multi-prong approaches to weed control projects that use domestic sheep.

5. Increase the use and research of coexistence tools.

6. Re-examine and refine state management of bighorn sheep.

In Montana, as it is across the West, bighorn sheep and domestic sheep represent two powerful legacies: the history of the wool industry and the dramatic movement of sportsmen using private and public funds to restore game animals and other wildlife. Our organizations, working with woolgrowers and state and federal agencies can ensure that bighorn restoration continues and the domestic-sheep industry adapts and thrives.

A Struggle to Recover Bighorn Sheep in the West

BIGHORN SHEEP (*Ovis canadensis*) are an iconic species in the American West. Once numbering close to 2 million animals, the species was reduced to 15,000 to 18,000 individuals by 1960 (Buechner, 1960). Despite intensive management and restoration efforts, bighorn populations continue to struggle, and the species has not recovered to the extent of many other ungulates (Besser et al., 2013).

While several factors have led to this decline, one of the most important and limiting issues affecting bighorn sheep today is pneumonia (Besser et al., 2012; Buechner, 1960; Carpenter et al., 2014; Cassirer and Sinclair, 2007; Gross et al., 2000). Pneumonia outbreaks have the potential to cause a 30-90% mortality rate within a population. Additional outbreaks continue occurring within a herd several years after the initial outbreak, especially impacting lamb survival (Cassirer and Sinclair, 2007; Cassirer et al., 2013; George et al., 2008; Ryder et al., 1992; Spraker et al., 1984). Once a herd is exposed to pneumonia, it will be continually impacted, making it extremely difficult for the population to recover.

Anecdotal evidence from almost 90 years ago noted that the presence of domestic sheep (*Ovis aries*) in bighorn habitat coincided with disease outbreaks in bighorn herds (Grinnell, 1928; Marsh, 1938; Schillenger, 1937). Over the past several decades, further research has confirmed that domestic sheep are a disease vector, carrying pneumonia and transferring it to bighorn sheep (Dassanayake et al., 2009). Several controlled experiments have shown that domestic sheep can appear healthy while carrying the disease. In these experiments, when domestic sheep carrying pneumonia were in placed in the same enclosure as bighorn sheep, the bighorn typically contracted the disease and died (Besser et al., 2012; Foreyt and Silflow, 1996; Foreyt, 1994; Lawrence et al., 2010; Onderka et al., 1988). Field studies have also observed pneumonia outbreaks in free-ranging bighorns after contact with domestic sheep (Coggins, 1988; Foreyt and Jessup, 1982; George et al., 2008; Goodson, 1982).

While research is continuing on the risks that domestic sheep pose to wild sheep, many state wildlife agencies, federal land managers, conservation organizations, and independent scientists firmly endorse policies that promote spatial and/or temporal separation between wild bighorn sheep and domestic sheep (WSWG, 2012).

Domestic Sheep Risks to Bighorns in Montana

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS (FWP) manages, by the most recent count, 46 bighorn sheep herds in five metapopulations (Figure 1). Despite extensive management efforts, the state's bighorn sheep herds are a challenge to sustain, and many herds experience ongoing impacts from pneumonia. Several hunting districts have been closed recently due to massive die-offs (Kuglin, 2015; Zuckerman, 2015). Pneumonia has been so problematic for the Tendoy herd in southwestern Montana that FWP is working to completely eliminate the herd. Once the diseased herd is removed, FWP plans to transplant healthy sheep back in the area. This is the first time the state has purposefully set out to eliminate a bighorn population. (AP, 2015; French, 2015). Mitigating risks from domestic sheep near bighorn herds is a top priority for FWP and other land managers in the state. Domestic sheep range primarily on federal and private land, and the risk posed by domestic sheep herds varies based on land ownership and domestic-herd management.

Identifying sheep grazed on private land has been a significant challenge for Montana officials because there is no public database with this information available (FWP, 2010). Domestic sheep on private land are often used in weed-control projects, managed on private ranches, or in kept in small hobby herds. Theoretically, these risks could be located on any parcel of private land in the state (Figure 2).

A growing risk to bighorn sheep is the use of domestic sheep by cities, counties, and private landowners to manage invasive and noxious weeds, such as leafy spurge, in areas that overlap or potentially overlap with bighorn sheep range. While many wildlife agencies, such as FWP, appreciate the goals of reducing these problematic plants, use of domestic sheep to manage noxious weeds may pose a potential risk to wild bighorn populations. Several bighorn herds range within close proximity to weed-control projects that employ thousands of domestic sheep annually. Many of these projects are conducted through a Montana State University (MSU) program, often referred to as "sheep on wheels" (FWP, 2010). Large-scale domestic sheep production on private land is also a concern in areas that are close to bighorn sheep range.

According to FWP's management plan, private producers have domestic sheep herds on private lands in close proximity to at least 15 bighorn herds (FWP, 2010). Perhaps the greatest

source of contact risk, though, is from the expansion of hobby herds on private lands. These herds are typically small and are not the primary income source of the owner. Many are used in 4-H projects. Locating hobby herds has been challenging because they can be on almost any parcel of private land, and they are established and dissolved without public notice. While these herds are smaller than those managed by private sheep producers, they often pose a greater risk to bighorn sheep. Many hobbyists are less attentive to their domestic herds than larger-scale sheep producers, creating more opportunities for bighorn rams to go undetected if they come into contact with the herd. Other hobbyists enjoy seeing bighorns mingle with their flocks and do not understand the risk of disease transmission (FWP, 2015, personal communication). Hobby herds can be established near bighorn herds without notice by individuals with no training or education on effective sheep and goat husbandry in bighorn sheep habitat (FWP, 2015, personal communication). As more areas of Montana are subdivided, more private individuals are moving closer to bighorn sheep and bringing hobby herds with them (FWP, 2010).

On federal land, domestic sheep are found on grazing allotments managed by the U.S. Bureau of Land Management (BLM) and the U.S. Forest Service (USFS). Collectively, there are 344 federal sheep allotments (totaling 7,419 km^2 [1,833,227 acres]) in Montana and within 20 miles of the state's border (Figure 3). In Montana, the BLM has more land available for sheep grazing than the USFS. Additionally, the U.S. Sheep Experiment Station, operated by the U.S. Department of Agriculture's Agricultural Research Service, has agreements with the USFS and the BLM to graze sheep on some of their allotments. The Sheep Station also maintains several of its own grazing tracts in Montana and Idaho.

The National Wildlife Federation, Montana Wildlife Federation and Wild Sheep Foundation are committed to restoring bighorn sheep by significantly reducing contact between wild bighorn herds and domestic sheep. With a history of successful advocacy and innovative programs, such as the Wildlife Conflict Resolution Program, the National Wildlife Federation is positioned to further assist federal land managers, state agencies, and private landowners in planning effective conservation efforts. This analysis aims to supplement and expand on current bighorn sheep conservation work. In this report, we attempted to identify the location of known domestic sheep operations on public and private lands that pose a risk to bighorn sheep.

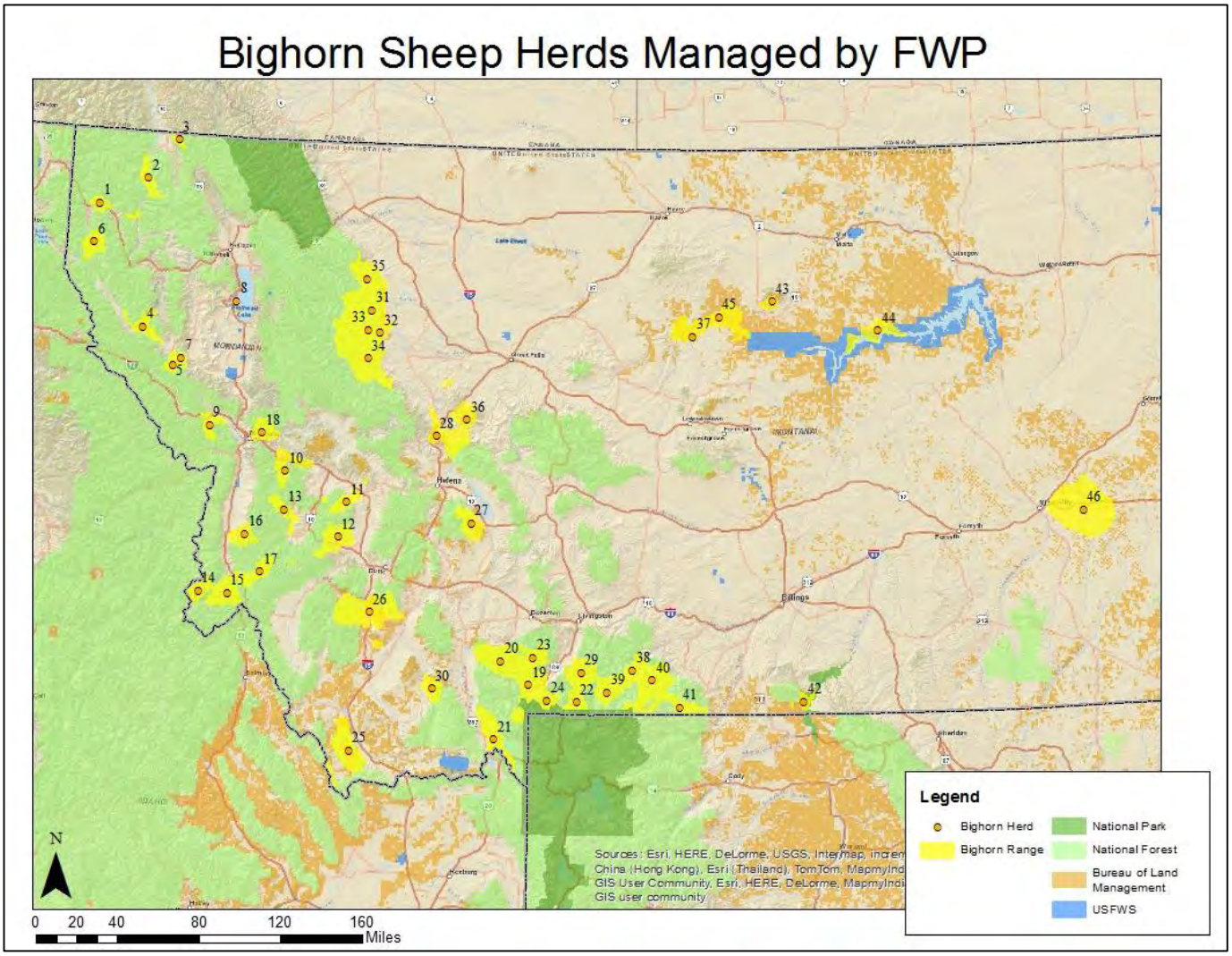

Figure 1. Sheep herds and their range in Montana. Numbers correspond the FWP's name for the herd. 1. Kootenai Falls, 2. Ural-Tweed, 3. Galton Range, 4. North Clark Fork, 5. Clark Fork Cut-Off, 6. Cabinet Mountains, 7. Paradise, 8. Wild Horse Island, 9. Grave Creek Range, 10. John Long Range, 11. Garrison, 12. Lost Creek, 13. West Rock Creek – Quigg Peak, 14. Watchtower, 15. Painted Rocks, 16. Skalkaho, 17. East Bitterroots, 18. Lower Blackfoot, 19. Gallatin-Yellowstone, 20. Spanish Peaks, 21. Hilgard, 22. South Absaroka, 23. Hyalite, 24. South Yellowstone, 25. Tendoy Mountains, 26. Highland Mountains, 27. Radersburg, 28. Sleeping Giant, 29. Mill Creek, 30. Greenhorns, 31. Deep Creek, 32. Castle Reef, 33. Gibson Lake North, 34. Ford Creek, 35. North Fork Birch Creek – Teton, 36. Beartooth WMA – GMWA, 37. Fergus, 38. Stillwater River, 39. Monument Peak, 40. Beartooth Mountains, 41. Hellroaring, 42. Pryor Mountains, 43. Little Rockies, 44. Middle Missouri Breaks, 45. Chouteau-Blaine-Phillips, 46. Blue Hills.

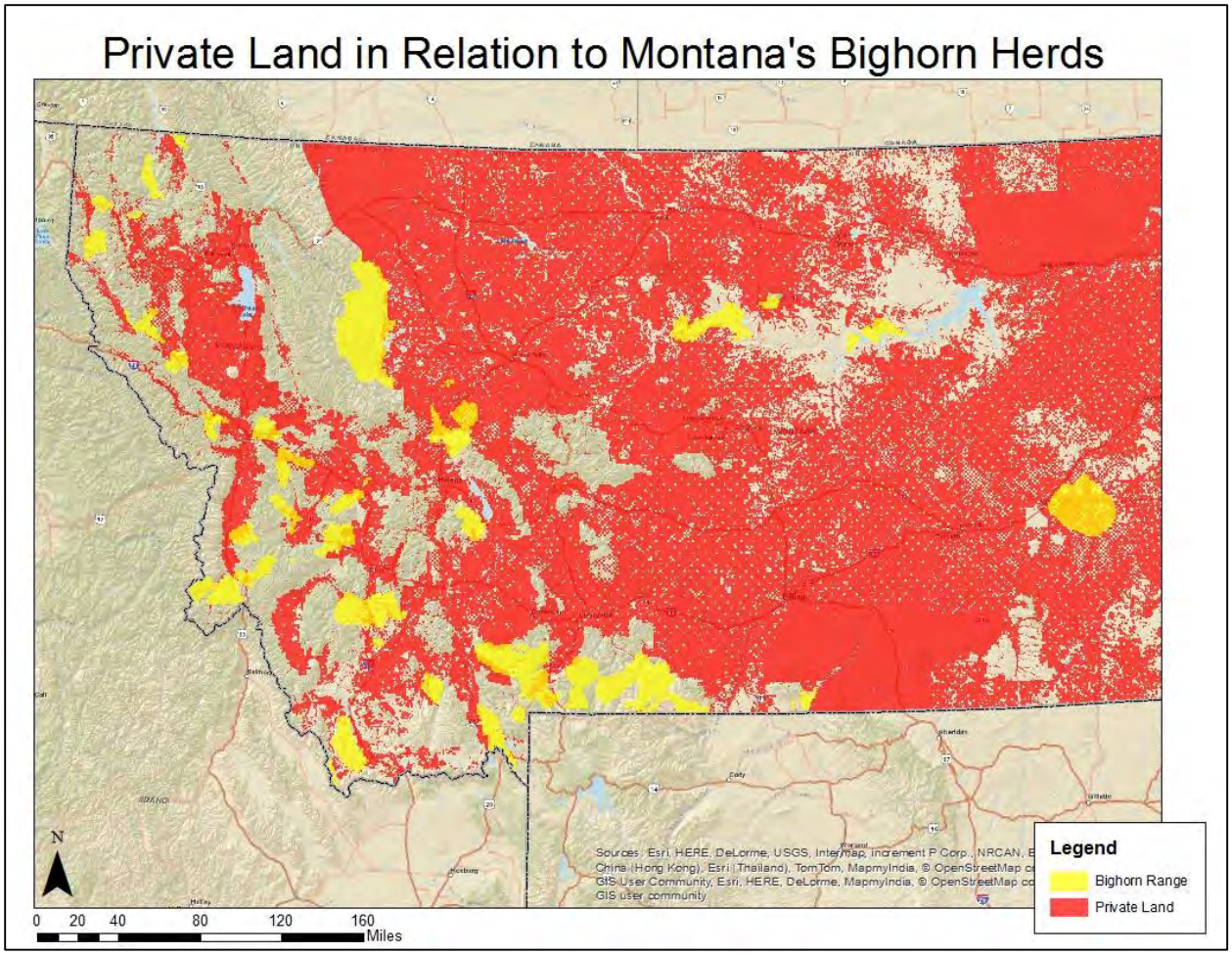

Figure 2. Private production herds and hobby herds can be found on private land. Hobby herds are especially difficult to regulate since any private landowner can establish a hobby herd, and it is often done without reporting. Weed control projects also occur on private lands frequently, as well as on city- and county-managed land regularly.

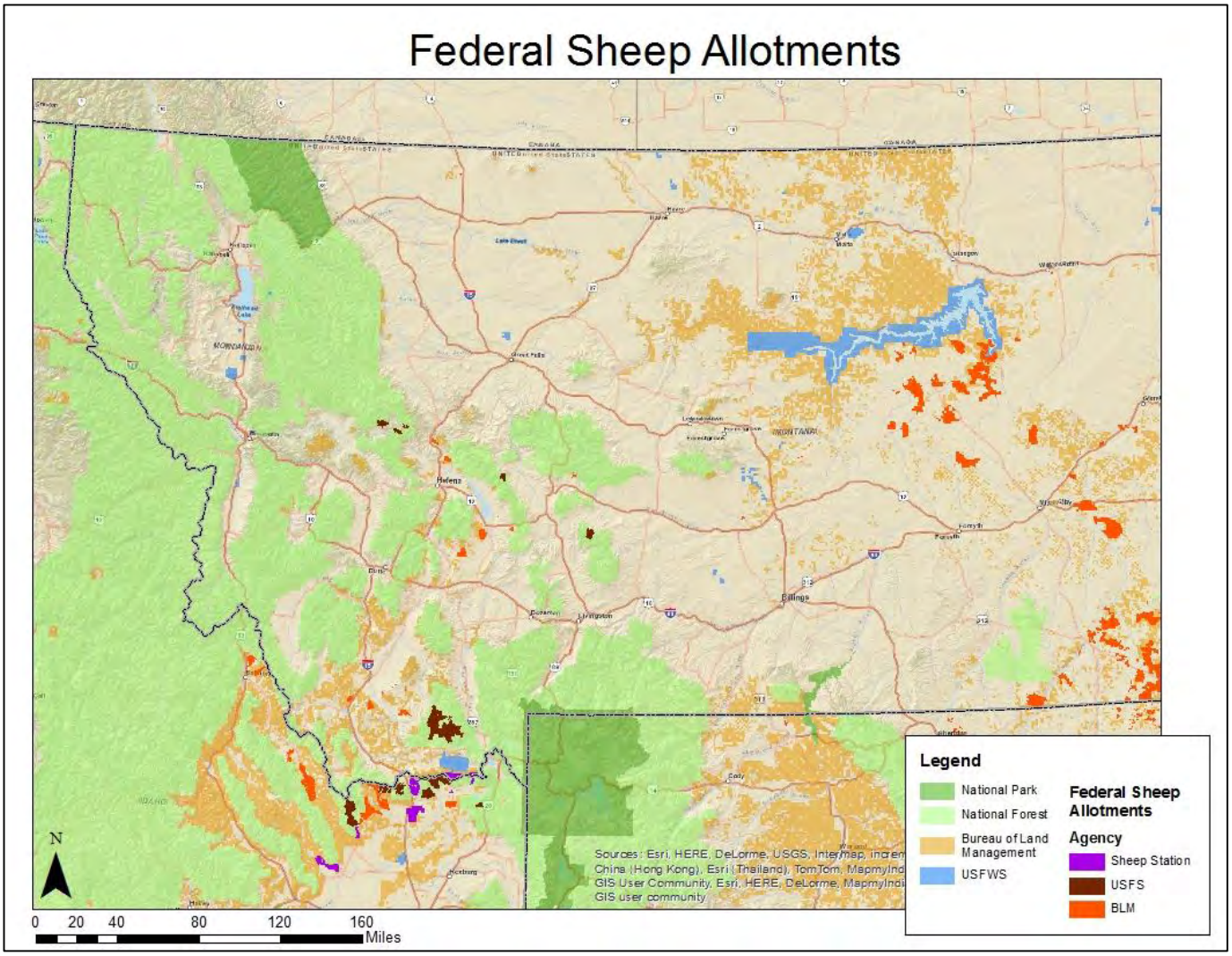

Figure 3. Federal sheep allotments in and within 20-miles of Montana. The majority of these allotments are managed by the BLM. No federal allotments are found in the northwest part of the state.

Assessing the Risk of Contact between Domestic Sheep and Bighorns

Separation of domestic and bighorn sheep is vital to ensuring bighorn herd health. Typically, this separation is achieved through the use of buffer zones between wild bighorn herds and domestic sheep and goats. Over time, state and federal agencies have used various distances between wild and domestic sheep to characterize the risk of contact between them. Initially, 9 miles was considered meaningful (approximately 14.5 km) (WSWG, 2012; FWP, 2010). Yet bighorn rams – which are the most mobile – have been seen nearly 20 miles from a herd's established home range (Cassirer and Sinclair, 2007; DeCesare and Pletscher, 2006). It is usually such wandering rams looking for mates that is the point of contact with domestic sheep (FWP, 2015, personal communication). Because of this, we used 20 miles to identify potential conflicts around priority bighorn herds (Figure 4). The solutions to the risk of contact between wild and domestic sheep depend on more than just distance alone, including factors of terrain and travel routes.

Within a 20-mile buffer, we tallied the potential risk of contact with domestic sheep on federal grazing allotments, weed-control projects, private ranches, and hobby herds. Federal allotment locations were obtained from the USFS and the BLM. Only sheep and goat allotments were used in this risk assessment. To identify weed-control projects, private production herds, and hobby herds, we relied primarily on expert opinion because spatially explicit data is not available for any of these risks. In some instances, FWP's Bighorn Management Plan describes the general location of domestic sheep. Phone calls and emails were also made to regional biologists to identify the location of any additional known domestic sheep operations on private land. While this aided in identifying some domestic sheep, it did not identify all domestic sheep operations in Montana.

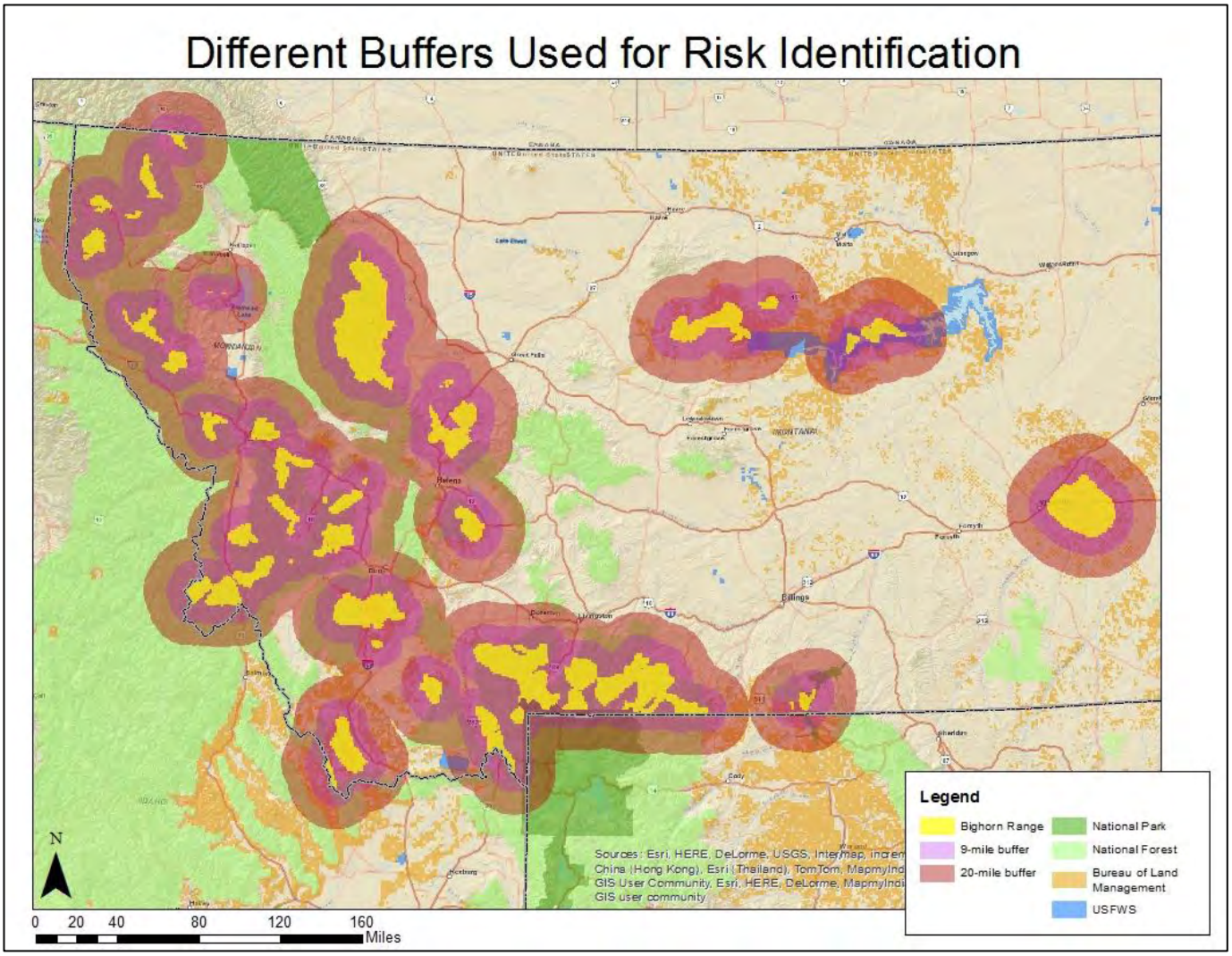

Figure 2. Traditional bighorn sheep management suggests a 9-mile buffer to identify potential risks to herds. For this analysis, we used a 20-mile radius around bighorn herds to identify all of the most predictable problems.

Sources of risk from domestic sheep for Montana's bighorn sheep herds

USING THE 20-MILE BUFFER to identify potential risks, we found that 39 of Montana's 46 bighorn herds are at risk of coming into contact with domestic sheep. Thirty-four of the 39 are at risk from private production herds. Twenty-six bighorn herds are at risk from hobby herds. Eighteen are at risk because of their close proximity to federal sheep-grazing allotments. Nine are at risk because of sheep weed-control projects (Table 1). Twenty-six Montana herds have experienced large population die-offs between 1984 and 2015. Seventeen of these die-offs have occurred within the past decade (Backus, 2015; FWP, 2010; Preston, 2015; Sells et al., 2015; Zuckerman, 2015), two of which have occurred in herds where there is no known exposure risk to domestic sheep (FWP, 2010; Sells et al., 2015).

Through conversations with FWP regional biologists and other experts, we were able to identify domestic sheep on private land that pose a disease risk to bighorn sheep. These include 47 private production herds; 11 hobby herds, including 9 communities and subdivisions with known hobby herds; and 6 sheep weed-control projects. We also identified MSU's Red Bluffs Ranch as a source of potential conflict. Only the Spanish Peaks herd is in close proximity to domestic sheep on the Red Bluffs Ranch. On federal land, there are 66 sheep grazing allotments in Montana may pose a risk to bighorn sheep. The USFS administers 19 of these, the BLM administers 44 of them, and three are used by the U.S. Sheep Experiment Station, including both of the Sheep Station's pastures in the Centennial Mountain.

Summaries of the risks associated with each bighorn sheep herd in Montana are presented in the Appendix, beginning on Page 27.

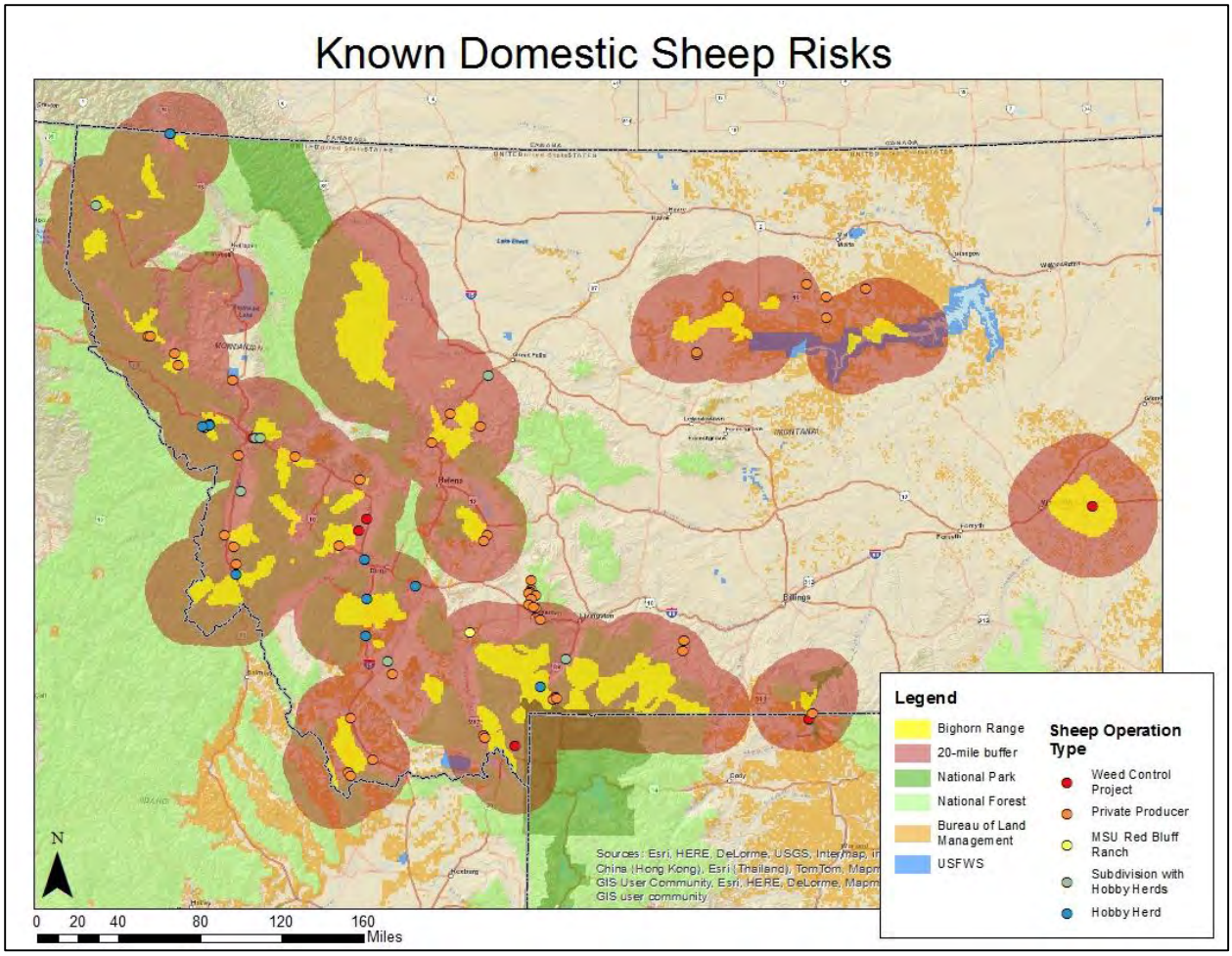

Figure 5. Known domestic sheep operations occurring on private land near bighorn sheep range. Locations are general and do not reflect precise location of projects. Points displayed here are only known operations. Other domestic sheep herds and operations are likely present on private land throughout the state.

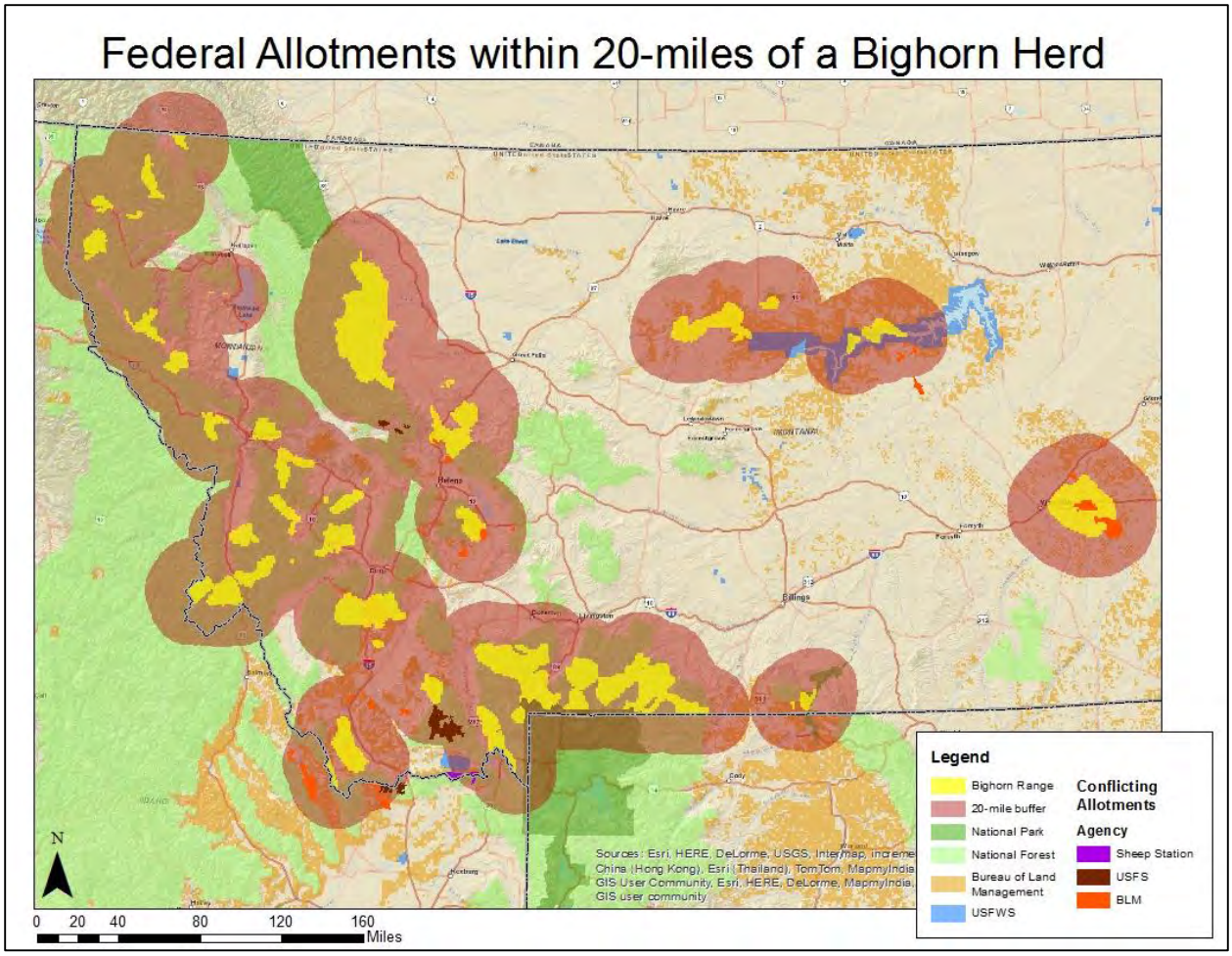

Figure 6. Federal sheep grazing allotments within 20-miles of a bighorn sheep herd. The activity of these allotments, management on them, number of sheep grazed, and time of grazing is unknown. Further investigation may be needed to fully assess the risk posed by these allotments.

Domestic Sheep Risks

Herd Name	Hunting District	Private Production Herd	Hobby Herd	Federal Allotment	Weed Control Project	Domestic Sheep Risk Present
Kootenai Falls	100		X			X
Ural-Tweed	101		X			X
Galton Range	102		X			X
North Clark Fork	121	X	X			X
Clark Fork Cut-Off	122	X	X			X
Cabinet Mountains	123		X			X
Paradise	124	X	X			X
Wild Horse Island	N/A					
Grave Creek Range	203	X	X		X	X
John Long Range	210	X			X	X
Garrison	212	X			X	X
Lost Creek	213	X	X		X	X
West Rock Creek - Quigg Peak	216		X			X
Watchtower	250	X	X			X
Painted Rocks	250	X	X			X
Skalkaho	261	X	X			X
East Bitterroots	270	X	X			X
Lower Blackfoot	283	X	X		X	X
Gallatin-Yellowstone	300	X	X	X	X	X
Spanish Peaks	301	X	X			X
Hilgard	302	X	X	X	X	X
South Absaroka	303	X	X	X		X
Hyalite	304	X	X	X		X
South Yellowstone	305	X	X	X		X
Tendoy Mountains	315	X		X		X
Highland Mountains	340	X	X	X		X
Radersburg	380	X	X	X		X
Sleeping Giant	381	X		X		X
Mill Creek	N/A	X	X	X		X
Greenhorns	N/A	X	X	X		X
Deep Creek	421					
Castle Reef	422					
Gibson Lake North	423					

Ford Creek	424	X		X		X
North Fork Birch Creek-Teton	441					
Fergus	482	X				X
Beartooth WMA-GMWA	455	X	X	X		X
Stillwater River	500	X	X	X		X
Monument Peak	500	X	X	X		X
Beartooth Mountains	501					
Hellroaring	502					
Pryor Mountains	503	X		X	X	X
Little Rockies	620	X				X
Middle Missouri Breaks	622	X		X		X
Chouteau-Blaine-Phillips	680	X				X
Blue Hills	N/A	X		X	X	X

Table 1. Summary of domestic sheep risks for each herd. If a federal allotment or known sheep operation was within twenty-miles of a herd, we considered it a risk. Thirty-nine herds have at least one domestic sheep risk within this buffer.

Bighorn Herd Susceptibility to Pneumonia

Herd Name	Population Size (in 2014)	Last Major Die-Off	Range Area (km^2)	Percent Fed. Land within Herd's Range	Percent Fed. Land within 20-mile Buffer	Probability of Disease in Year 1 (Sells et al., 2015)	Probability of Disease in 10 Years (Sells et al., 2015)
Kootenai Falls	85	1995	187.25	86.36	77.18	0.002	0.019
Ural-Tweed	25	1999	272.47	69.36	70.26	0.001	0.011
Galton Range	50	Never	101.12	60.85	43.09	0.203	0.897
North Clark Fork	65	Never	318.92	76.13	59.11	0.002	0.025
Clark Fork Cut-Off	110	2015	124.25	74.28	52.06	0.031	0.271
Cabinet Mountains	100	Never	300.64	27.25	76.02	0.001	0.014
Paradise	325	Never	104.20	67.63	43.02	0.012	0.114
Wild Horse Island	150	Never	5.93	74.37	15.34	0.041	0.34
Grave Creek Range	140	Never	233.35	0.00	58.02	0.038	0.32
John Long Range	140	2010	413.02	97.56	37.05	0.091	0.613
Garrison	40	Never	280.31	93.09	36.77	0.134	0.761
Lost Creek	100	2011	486.29	98.08	49.81	0.081	0.571
West Rock Creek - Quigg Peak	210	2010	275.45	98.08	63.45	0.021	0.194
Watchtower	90	Never	293.01	93.48	92.01	0.161	0.827
Painted Rocks	90	Never	457.42	98.16	89.24	0.161	0.827
Skalkaho	40	2012	270.63	91.46	72.35	0.109	0.685
East Bitterroots	130	2015	380.16	98.95	76.70	0.04	0.336
Lower Blackfoot	25	2010	293.04	87.82	31.40	0.108	0.681
Gallatin-Yellowstone	55	2013	602.96	92.49	73.68	0.151	0.806
Spanish Peaks	165	Never	703.14	63.29	46.14	0.011	0.103
Hilgard	208	1997	559.17	55.46	80.59	0.173	0.85
South Absaroka	35	2013	219.39	13.91	86.80	0.151	0.806
Hyalite	40	2013	371.58	25.42	50.25	0.002	0.019
South Yellowstone	90	2015	177.07	99.80	85.19	0.151	0.806
Tendoy Mountains	50	1999	764.10	84.86	63.27	0.019	0.178
Highland Mountains	75	2008	1184.05	88.13	50.51	0.025	0.226
Radersburg	45	2008	384.88	51.87	33.71	0.04	0.338
Sleeping Giant	65	2007	370.81	64.29	22.77	0.22	0.917
Mill Creek	25*	Never	494.94	52.95	75.37	0.026	0.229
Greenhorns	50	Never	265.43	48.47	41.03	N/A	N/A

Deep Creek	60*	1984	733.80	38.74	59.15	0.02	0.181
Castle Reef	215*	2010	174.94	57.88	52.01	0.118	0.714
Gibson Lake North	204*	2010	628.02	96.47	78.04	0.011	0.103
Ford Creek	298*	2010	904.51	67.04	64.66	0.084	0.584
North Fork Birch Creek-Teton	138*	1984	589.51	90.48	46.44	0.02	0.183
Fergus	545	Never	512.84	91.79	31.16	0.144	0.788
Beartooth WMA-GMWA	100	1984	582.50	71.99	13.23	0.22	0.917
Stillwater River	140	Never	710.46	45.50	77.53	0.017	0.155
Monument Peak	140	Never	710.46	99.40	77.53	0.013	0.123
Beartooth Mountains	140	Never	773.58	86.21	75.92	0.021	0.19
Hellroaring	45	Never	377.94	71.09	74.63	0.004	0.038
Pryor Mountains	140	1995	142.99	93.42	36.37	0.005	0.044
Little Rockies	380	1998	113.68	63.50	39.92	0.002	0.022
Middle Missouri Breaks	380	Never	445.75	95.16	60.37	0.002	0.018
Chouteau-Blaine-Phillips	645	Never	462.66	66.48	29.63	0.144	0.788
Blue Hills	50	Never	1749.02	20.79	17.54	N/A	N/A

Table 2. A herd's susceptibility to contract and/or respond to pneumonia is predicated on multiple factors. Identifying an appropriate balance of these factors is difficult. We assessed these factors to determine which herds had the greatest opportunities for conservation.

***Population estimate for 2014 was not available. The most recent, available population estimate was from 2010.**

Risk-Reduction Measures

MONTANANS COMMITTED TO BIGHORN CONSERVATION have a variety of opportunities to expand current efforts, establish relationships with new partners, and create new programs to mitigate risks from domestic sheep. The array of bighorn-conservation tools include:

Opportunities to work with private landowners

Nearly all Montanans value wildlife, bighorns included. Incentives and assistance provided to help private landowners manage their lands and flocks to minimize risk to bighorns can produce win-win solutions. Where incentive payments to, say, transition from sheep to cattle production are not workable, other measures may be possible – such as a cost-share program to establish effective fencing, purchase guard dogs, fund an experienced herder, or financially help with other coexistence tools. Several potential options exist and are mentioned in the Wild Sheep Work Group's 2012 report. Voluntary conservation easements negotiated within 20 miles of bighorn sheep herds could include provisions that eliminate potential conflicts between domestic sheep and bighorns.

Expanded public outreach and education

Hobby herds are potentially the most difficult to manage, because the herds often exist for a few years in one place then the next. This results in multiple herds coming and going on various private land plots near bighorn habitat (FWP, 2015, personal communication). People establish hobby herds for various reasons, and they can produce a variety of benefits. Many hobby herders may be unaware of the risk their sheep and the way they are managed create for bighorns. Education and outreach can be powerful tools to promote responsible husbandry, discourage ill-advised sheep-rearing near bighorn herds, and encourage alternatives to promote coexistence and mitigate contact between bighorn and domestic sheep

Voluntary retirement of problematic grazing allotments

Through willing seller/willing buyer agreements with cooperating sheep producers, retiring high-risk federal grazing allotments can create the necessary separation between bighorns and domestic sheep. The National Wildlife Federation's Wildlife Conflict Resolution Program, for example, has been effective at decreasing conflict and improving habitat quality for bighorn

sheep in several western states, including Montana. Incentive payments to woolgrowers can help them obtain alternative forage in areas without risk of disease transmission to bighorns.

Conversion of public-land grazing retirements

Short of retiring grazing allotments outright, voluntary agreements that convert use of the land from to cattle grazing instead of sheep grazing can be effective in eliminating potential contact between bighorns and domestic sheep.

Multi-prong approaches to weed control

Domestic-sheep grazing is one of the tools available to combat noxious weeds. But the use of domestic sheep is not appropriate in all areas. Controlling noxious weeds can generate important conservation benefits, but it makes little sense to do so in a way that's harmful to highly valued but struggling and vulnerable wildlife. Ideally, use of sheep to control noxious weeds should be eliminated from areas in proximity to bighorn herds. In instances where these programs cannot be eliminated, the operators can reduce – albeit not eliminate – risks by maintaining temporal and spatial separation between domestic sheep and bighorns. All weed-control projects should be required to have trained herders and guard dogs that are able to closely monitor domestic sheep around the clock and alert FWP officials if/when the flock comes into contact with bighorn sheep.

Coexistence tools

Stepping up the use of measures such as herders, fencing, and guard dogs to maintain separation between domestic sheep and bighorns will not eliminate risk of contact but can reduce that risk. Additional research is needed to improve the effectiveness of such measures.

Re-examine and refine state management of bighorn sheep

Despite tremendous commitment and investment by FWP, Montana's bighorn sheep herds are not adequately recovering, many are experiencing pneumonia outbreaks and die-offs, and nearly all remain vulnerable to disease transmission from domestic sheep herds. The status quo is neither desirable nor sustainable. Increased effort and new approaches are needed to create a secure future for one of Montana's most valued wildlife species. One seemingly small measure that could make a difference would be for the state Department of Revenue to coordinate with FWP to provide information to people who pay the per-capita fee charged for sheep – thus making it possible to open lines of communication for education and outreach to people raising

sheep in proximity to bighorns. Montana's Bighorn Management Plan needs review and problems with implementation need to be addressed. We suggest routine coordination among all FWP biologists who manage bighorn populations.

The Future of Montana's Bighorns Depends on Us

BIGHORN SHEEP ARE AN IMPORTANT SPECIES to the state of Montana. They provide recreation and generate revenue through hunting and wildlife viewing. They are a symbol of the rugged American West and the dramatic mountain ranges found throughout Montana. Current approaches to management do not provide adequate separation between wild bighorns and domestic sheep. Die-offs from disease are a recurring impediment to bighorn restoration, and most of Montana's bighorn herds remain vulnerable to the risk of disease transmission from domestic sheep.

Montanans have important opportunities to further advance bighorn conservation and restore the species. Securing and growing key populations throughout Montana may help these herds to grow and disperse to establish new healthy populations. By resolving conflicts with domestic sheep in high-risk areas, increasing public education about the potential risks of domestic and bighorn sheep contact, and working with landowners to promote separation between domestic and bighorn sheep, Montanans can take meaningful steps toward bighorn recovery. Additionally, improvements to the state's current management strategies and practices can ensure that the agency has the tools it needs to continue managing and restoring bighorn sheep.

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Appendix
Summary of risks associated with bighorn sheep herds

Herd Name: **Kootenai Falls**
Hunting District: 100
Demographic and Habitat Information:
Population Size in 2014: 85
Core Range Size: 187.25 km^2
Percent Federal within Core Range: 91.79%
Percent Federal within 20-Mile Buffer: 77.18%
Date of Last Major Outbreak: 1995
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: Development in Bighorn Terrace Subdivision upstream of Kootenai Falls WMA has brought in hobby sheep and goats (FWP, 2010).

Herd Name: **Ural-Tweed**
Hunting District: 101
Demographic and Habitat Information:
*Population Size in 201*4: 25
Core Range Size: 272.47 km^2
Percent Federal within Core Range: 99.40%
Percent Federal within 20-Mile Buffer: 70.26%
Date of Last Major Outbreak: 1999
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None

Herd Name: **Galton Range**
Hunting District: 102
Demographic and Habitat Information:
Population Size in 2014: 50
Core Range Size: 101.12 km^2
Percent Federal within Core Range: 92.49%
Percent Federal within 20-Mile Buffer: 43.09%
Date of Last Major Outbreak: Never
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: There is a private producer ¼ to ½ of a mile away from the Canadian customs area. West of her there are two other neighbors that have goats and sheep (Their, 2015, personal communication).

Herd Name: **North Clark Fork (Thompson Falls)**
Hunting District: 121
Demographic and Habitat Information:

Population Size in 2014: 65
Core Range Size: 318.92 km^2
Percent Federal within Core Range: 69.36%
Percent Federal within 20-Mile Buffer: 59.11%
Date of Last Major Outbreak: None

Summary of Domestic Sheep Risk (s):

Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: There are producers on Eddy Flats, west of Munsen Creek by about ¾ - 1 mile. Another producer is across from Munson Creek on the south side of the Clark Fork. Another producer is south of the bison range along Highway 200 (Sterling, 2015, personal communication).
Known Hobby Herds: These herds are "scattered throughout the area" and sheep from this herd may come into contact with them (FWP, 2010).

Herd Name: **Clark Fork Cut-Off**
Hunting District: 122
Demographic and Habitat Information:

Population Size in 2014: 110
Core Range Size: 125.25 km^2
Percent Federal within Core Range: 64.29%
Percent Federal within 20-Mile Buffer: 52.06%
Date of Last Major Outbreak: 2015

Summary of Domestic Sheep Risk(s):

Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: Domestic sheep are 1.25 miles up Henry Creek just east of Plains. There is also a producer that rents property at the junction of Highways 135 and 200 and winters his sheep across the bridge that crosses the Clark Fork (Sterling, 2015, personal communication).
Known Hobby Herds: These herds are "scattered throughout the area" and sheep from this herd may come into contact with them. One herd immediately next to occupied winter range (FWP, 2010).

Herd Name: **Cabinet Mountains**
Hunting District: 123
Demographic and Habitat Information:

Population Size in 2014: 100
Core Range Size: 300.64 km^2
Percent Federal within Core Range: 93.48%
Percent Federal within 20-Mile Buffer: 76.02%
Date of Last Major Outbreak: None

Summary of Domestic Sheep Risk(s):

Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: These herds are "scattered throughout the area" and sheep from this herd may come into contact with them (FWP, 2010).

Herd Name: **Paradise**
Hunting District: 124
Demographic and Habitat Information:
Population Size in 2014: 325
Core Range Size: 104.20 km^2
Percent Federal within Core Range: 27.25%
Percent Federal within 20-Mile Buffer: 43.02%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: These herds are "scattered throughout the area" and sheep from this herd may come into contact with them (FWP, 2010).

Herd Name: **Wild Horse Island**
Hunting District: N/A
Demographic and Habitat Information:
Population Size in 2014: 150
Core Range Size: 5.93 km^2
Percent Federal within Core Range: 0.00%
Percent Federal within 20-Mile Buffer: 15.34%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None
Special Note: These sheep are on an island in the middle of Flathead Lake.

Herd Name: **Grave Creek Range (Petty Creek)**
Hunting District: 203
Demographic and Habitat Information:
Population Size in 2014: 140
Core Range Size: 233.35 km^2
Percent Federal within Core Range: 60.85%
Percent Federal within 20-Mile Buffer: 58.02%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: Rural subdivisions in Petty Creek have increased number of small domestic sheep bands. There are covenants with Missoula County to restrict hobby sheep in three subdivisions, but enforcement is usually up to the homeowners (FWP, 2010). Bighorns in this herd have been seen with domestic speed. There's a hobbyist in the Madison Gulch area that owns multiple animals. They are not supposed to own sheep, but sheep have been seen on their property. They have no fencing, and it is likely that the sheep wander on to USFS land. Another hobbyist is along the west side of Petty Creek. This hobbyist has several small groups of domestic sheep just a few miles up the West Fork Road where it splits from the main road. There is some concern about hobby herds along the south-side road along the river. There are no known herds

there, but the subdivisions make it likely that some may arise (Bradley, 2015, personal communication).

Herd Name: **John Long Range (Lower Rock Creek)**
Hunting District: 210
Demographic and Habitat Information:
Population Size in 2014: 140
Core Range Size: 413.03 km^2
Percent Federal within Core Range: 38.74%
Percent Federal within 20-Mile Buffer: 37.05%
Date of Last Major Outbreak: 2010
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: A large producer operates directly adjacent to core area of the Bearmouth herd. Since Bearmouth sheep mingle with the John Long Range herd, these sheep are also at risk of coming into contact with these private production sheep (FWP, 2010).
Known Hobby Herds: No hobby herds known in the area, possibly because the Rock Creek area has more seasonal homeowners who do not have sheep. The year-round homeowners are also increasingly aware of the issues with domestic and bighorn sheep. There are occasional reports that there may be backyard sheep (Vinky, 2015, personal communication).

Herd Name: **Garrison**
Hunting District: 212
Demographic and Habitat Information:
Population Size in 2014: 40
Core Range Size: 280.31 km^2
Percent Federal within Core Range: 55.46%
Percent Federal within 20-Mile Buffer: 36.77%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: "(T)housands of domestic sheep" are being used in Deer Lodge Valley annually to control invasive plants (FWP, 2010).
Known Private Production Herds: Domestic sheep are also found five miles north of the main herd and within 2 miles of a satellite herd (FWP, 2010).
Known Hobby Herds: None

Herd Name: **Lost Creek**
Hunting District: 213
Demographic and Habitat Information:
Population Size in 2014: 100
Core Range Size: 489.29 km^2
Percent Federal within Core Range: 48.47%
Percent Federal within 20-Mile Buffer: 49.81%
Date of Last Major Outbreak: 2011
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: "(T)housands of domestic sheep" are being used in Deer Lodge Valley annually to control invasive plants. Another project employs "several thousand" domestic sheep

in the Racetrack drainage (FWP, 2010), although this project may be complete (Vinky, 2015, personal communication).
Known Private Production Herds: There are some domestic sheep producers in Anaconda's West Valley within bighorn year-round habitat (FWP, 2010).
Known Hobby Herds: Hobby herds are known to be present near the Lost Creek herd (FWP, 2010). Many hobby herds are known to be in the subdivisions along North Cable road Outside of Anaconda, roughly three miles from the Blue Eyed Nellie WMA (Vinky, 2015, personal communication).

Herd Name: **West Rock Creek – Quigg Peak (Upper Rock Creek)**
Hunting District: 216
Demographic and Habitat Information:
*Population Size in 201*4: 210
Core Range Size: 275.45 km^2
Percent Federal within Core Range: 51.87%
Percent Federal within 20-Mile Buffer: 63.45%
Date of Last Major Outbreak: 2010
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None

Herd Name: **Watchtower**
Hunting District: 250
Demographic and Habitat Information:
Population Size in 2014: 90
Core Range Size: 293.01 km^2
Percent Federal within Core Range: 51.87%
Percent Federal within 20-Mile Buffer: 63.45%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None

Herd Name: **Painted Rocks**
Hunting District: 250
Demographic and Habitat Information:
Population Size in 2014: 90
Core Range Size: 457.42 km^2
Percent Federal within Core Range: 93.09%
Percent Federal within 20-Mile Buffer: 89.24%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: There are domestic goats within eight miles of the herd. They often will wander onto USFS land (FWP, 2010).
Known Hobby Herds: None

Herd Name: **Skalkaho**
Hunting District: 261
Demographic and Habitat Information:
Population Size in 2014: 40
Core Range Size: 270.63 km^2
Percent Federal within Core Range: 45.00%
Percent Federal within 20-Mile Buffer: 72.35%
Date of Last Major Outbreak: 2012
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: One producer is located less than 1.5 miles south of the herd across Sleeping Child Creek. Another is 2.5 miles east across the Bitterroot River (FWP, 2010). There is also a producer on Mormon Creek between Missoula and Ravalli County, below Lolo Creek (Mowery, 2015, personal communication).
Known Hobby Herds: One known hobby herd is in Whiskey Gulch about 15 miles south of the herd's range (FWP, 2010). There are several other hobby herds throughout the Bitterroot Valley, and they are difficult to identify and manage (Mowery, 2015, personal communication).

Herd Name: **East Bitterroot**
Hunting District: 270
Demographic and Habitat Information:
Population Size in 2014: 130
Core Range Size: 380.16km^2
Percent Federal within Core Range: 84.86%
Percent Federal within 20-Mile Buffer: 76.7%
Date of Last Major Outbreak: 2015
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: Two private producers are located 15 miles north of the herd (FWP, 201). Another is located along Rye Creek (Mowery, 2015, personal communication).
Known Hobby Herds: There are numerous hobby herds in the Bitterroot Valley, including a larger one in Whiskey Gulch, which is inside of the herd's range (FWP, 2010).

Herd Name: **Lower Blackfoot (Bonner)**
Hunting District: 283
Demographic and Habitat Information:
Population Size in 2014: 25
Core Range Size: 293.04 km^2
Percent Federal within Core Range: 57.88%
Percent Federal within 20-Mile Buffer: 31.40%
Date of Last Major Outbreak: 2010
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: The City of Missoula is currently using domestic sheep to control weeds on Mount Jumbo (FWP, 2010). The city has hired a herder and has dogs with the project to help identify issues when they arise. In fifteen years, there were only two instances of a bighorn ram coming into contact with domestic sheep used in this project (in 2000 and 2014). The city also

avoids key areas, like the Jumbo Saddle, from May to July when young rams are more likely to be in that area (Bradley, 2015, personal communication).
Known Private Production Herds: None
Known Hobby Herds: There are several hobby herds in the rural subdivisions of East Missoula and Bonner (FWP, 2010). These producers are mostly in the West Riverside area near Bonner (Bradley, 2015, personal communication).

Herd Name: **Gallatin-Yellowstone**
Hunting District: 300
Demographic and Habitat Information:
Population Size in 2014: 55
Core Range Size: 602.96 km^2
Percent Federal within Core Range: 71.99%
Percent Federal within 20-Mile Buffer: 73.68%
Date of Last Major Outbreak: 2013
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Flatland. Number: 07708.
Weed Control Projects: None
Known Private Production Herds: There are several private producers throughout the Paradise Valley (Loveless, 2015, personal communication).
Known Hobby Herds: A small hobby herd is often grazed at the base of Tom Minor within 100 yards of the bighorn herd (Loveless, 2015, personal communication).

Herd Name: **Spanish Peaks**
Hunting District: 301
Demographic and Habitat Information:
Population Size in 2014: 165
Core Range Size: 703.14 km^2
Percent Federal within Core Range: 74.28%
Percent Federal within 20-Mile Buffer: 46.14%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: Montana State University's Red Bluff Ranch is within 4 miles of the Lee Metcalf Wilderness (which has good sheep habitat). This is the major obstacle to bighorn expansion (FWP, 2010). There are also two domestic sheep herds grazed near the junction of Highways 87 and 287. Additional points of known producers were provided by Cunningham near the Bridger range. The amount of sheep producers in the area precluded the establishment of a herd in this mountain range (Cunningham, 2015, personal communication).
Known Hobby Herds: Hobby farms are becoming more common in the Gallatin Range (Cunningham, 2015, personal communication).

Herd Name: **Hilgard**
Hunting District: 302
Demographic and Habitat Information:
Population Size in 2014: 208
Core Range Size: 559.17 km^2
Percent Federal within Core Range: 74.28%
Percent Federal within 20-Mile Buffer: 46.14%

Date of Last Major Outbreak: 1997

Summary of Domestic Sheep Risk(s):

Federal Allotments:

USFS allotment, Barnett. Number: 20159.
USFS allotment, Black Butte Bench. Number: 20124.
USFS allotment, Coal Creek. Number: 20131.
USFS allotment, Cottonwood. Number: 20169.
USFS allotment, Fossil-Hellroaring. Number: 20174.
USFS allotment, Lyon-Woverine. Number: 20185.
USFS allotment, Poison Basin. Number: 20122.
USFS allotment, Red Creek. Number: 20192.
USFS allotment, Upper Ruby. Number: 20154.
Sheep Station Centennial Mountains Sheep Experimental Station allotments
Sheep Station allotment, Meyers Creek S&G (leased from USFS), Number: 00225.

Weed Control Projects: Several weed control projects employ domestic sheep in the Madison Valley (FWP, 2010).

Known Private Production Herds: There are two domestic sheep herds grazed near the junction of Highways 87 and 287. Additional points of known producers were provided by Cunningham near the Bridger range. The amount of sheep producers in the area precluded the establishment

Known Hobby Herds: None

Herd Name: **South Absaroka**

Hunting District: 303

Demographic and Habitat Information:

Population Size in 2014: 35

Core Range Size: 219.39 km^2

Percent Federal within Core Range: 96.47%

Percent Federal within 20-Mile Buffer: 86.80%

Date of Last Major Outbreak: 2013

Summary of Domestic Sheep Risk(s):

Federal Allotments:

BLM allotment, Flatland. Number: 07708.

Weed Control Projects: None

Known Private Production Herds: There is a private producer who owns two domestic flocks on private land in the center of winter bighorn range. One is on the boundary of HD 303 and HD 305. Another producer slaughters lambs in the Gardiner Basin about a mile away from the other producer. (Loveless, 2015, personal communication).

Known Hobby Herds: A small hobby herd is often grazed at the base of Tom Minor within 100 yards of the bighorn herd (Loveless, 2015, personal communication).

Special Note: This herd is part of the Upper Yellowstone bighorn sheep management complex.

Herd Name: **Hyalite**

Hunting District: 304

Demographic and Habitat Information:

Population Size in 2014: 40

Core Range Size: 371.58 km^2

Percent Federal within Core Range: 93.42%

Percent Federal within 20-Mile Buffer: 50.25%

Date of Last Major Outbreak: 2013

Summary of Domestic Sheep Risk(s):

Federal Allotments:

BLM allotment, Flatland. Number: 07708.

Weed Control Projects: None

Known Private Production Herds: There are several private producers throughout the Paradise Valley (Loveless, 2015, personal communication).

Known Hobby Herds: A small hobby herd is often grazed at the base of Tom Minor within 100 yards of the bighorn herd (Loveless, 2015, personal communication).

Special Note: This herd is part of the Upper Yellowstone bighorn sheep management complex.

Herd Name: **South Yellowstone**
Hunting District: 305
Demographic and Habitat Information:

Population Size in 2014: 90

Core Range Size: 177.07 km^2

Percent Federal within Core Range: 67.04%

Percent Federal within 20-Mile Buffer: 85.19%

Date of Last Major Outbreak: 2015

Summary of Domestic Sheep Risk(s):

Federal Allotments:

BLM allotment, Flatland. Number: 07708.

Weed Control Projects: None

Known Private Production Herds: There is a private producer who owns two domestic flocks on private land in the center of winter bighorn range. One is on the boundary of HD 303 and HD 305. Another producer slaughters lambs in the Gardiner Basin about a mile away from the other producer. (Loveless, 2015, personal communication).

Known Hobby Herds: A small hobby herd is often grazed at the base of Tom Minor within 100 yards of the bighorn herd (Loveless, 2015, personal communication).

Special Note: This herd is part of the Upper Yellowstone bighorn sheep management complex.

Herd Name: **Tendoy Mountains**
Hunting District: 315
Demographic and Habitat Information:

Population Size in 2014: 50

Core Range Size: 764.10 km^2

Percent Federal within Core Range: 86.21%

Percent Federal within 20-Mile Buffer: 63.27%

Date of Last Major Outbreak: 1999

Summary of Domestic Sheep Risk(s):

Federal Allotments:

BLM allotment, Bench. Number: 06000.
BLM allotment, Center Ridge. Number: 06309.
BLM allotment, Conover AMP. Number: 10117.
BLM allotment, Hildreth-Indiv. Number: 30103.
BLM allotment, Middle Creek. Number: 06017.
BLM allotment, Pipe Organ Rock. Number: 10110.
BLM allotment, Spring Canyon. Number: 06310.
BLM allotment, Timber Creek. Number: 06224.
USFS allotment Chamberlain. Number: 80420.
USFS allotment East Indian – Modoc S&G. Number: 00137.
USFS allotment Idaho Hollow S&G. Number: 00142.
USFS allotment Limestone-Irving Creek S&G. Number: 00143.
USFS allotment Middle Creek S&G. Number: 00138.

USFS allotment Pleasant Valley – Stoddard CR S&G. Number: 00151.

Weed Control Projects: None

Known Private Production Herds: There are two producers in Big Sheep Basin in the SW corner of the Tendoys. One has a private flock close to Clark Canyon, 4 miles down Medicine Lodge Road. There are two goat producers. One is on the south end of Clark Canyon Reservoir (on north end of the Tendoys), and the other is in Lima, about a mile from base of hill where bighorns are known to be (Fager, 2015, personal communication).

Known Hobby Herds: None

Special Notes: These sheep are going to be completely removed. 50 healthy sheep will be put there after removal.

Herd Name: **Highland Mountains**
Hunting District: 340
Demographic and Habitat Information:

Population Size in 2014: 75

Core Range Size: 1184.05 km^2

Percent Federal within Core Range: 71.09%

Percent Federal within 20-Mile Buffer: 50.51%

Date of Last Major Outbreak: 2008

Summary of Domestic Sheep Risk(s):

Federal Allotments:

BLM allotment, Big Sheep Allot. Number: 10513.

BLM allotment, Hoffman Cr Isolated. Number: 10511.

Weed Control Projects: None

Known Private Production Herds: None

Known Hobby Herds: Several hobby farms are within the proximity of the Highlands herd. The following are the Cadastral locations of known hobby herds: Township 1 south, Range 9 west, Section 4; Township 4 south, Range 9 west, Section 3; Township 4 north, Range 9 west, section 31; Township 2 north, Range 5 west, Section 33 (Boccadori, 2015, personal communication).

Herd Name: **Radersburg (Elkhorn)**
Hunting District: 380
Demographic and Habitat Information:

Population Size in 2014: 45

Core Range Size: 384.88 km^2

Percent Federal within Core Range: 66.48%

Percent Federal within 20-Mile Buffer: 33.71%

Date of Last Major Outbreak: 2008

Summary of Domestic Sheep Risk(s):

Federal Allotments:

BLM allotment, Limestone East. Number: 20281.

BLM allotment, Ray Creek. Number: 10446.

BLM allotment, Summit. Number: 10282.

Weed Control Projects: None

Known Private Production Herds: As the herd grew, it came into contact with domestic sheep herds (FWP, 2010). Domestic sheep are grazed on the private lands interspersed with the BLM allotments. There are also domestic sheep are on the SE corner of the Elkhorns within 1 – 1.5 miles from the bighorn herd (Grove, 2015, personal communication).

Known Hobby Herds: While the location of hobby herds is unknown, it is thought that the last major die-off was caused by a domestic sheep that escaped from a hobby farm (Grove, 2015, personal communication).

Herd Name: **Sleeping Giant**
Hunting District: 381
Demographic and Habitat Information:
Population Size in 2014: 65
Core Range Size: 370.81 km^2
Percent Federal within Core Range: 20.79%
Percent Federal within 20-Mile Buffer: 22.77%
Date of Last Major Outbreak: 2007
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Hilger Hills. Number: 07710.
BLM allotment, Sieben. Number: 07709.
USFS allotment, Canyon Creek Sandborn. Number: 40404.
USFS allotment, Horsefly. Number: 40418.
Weed Control Projects: None
Known Private Production Herds: Two known producers. One is on the north end of the herd's core range. The owner of this ranch has both cattle and sheep. The other producer is in the southwest and is just outside of the herd's core range. This operation has both sheep and goats.
Known Hobby Herds: None

Herd Name: **Mill Creek**
Hunting District: N/A
Demographic and Habitat Information:
Population Size in 2010: 25
Core Range Size: 494.94 km^2
Percent Federal within Core Range: 91.46%
Percent Federal within 20-Mile Buffer: 75.37%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Flatland. Number: 07708.
Weed Control Projects: None
Known Private Production Herds: There is a private producer who owns two domestic flocks on private land in the center of winter bighorn range. One is on the boundary of HD 303 and HD 305. Another producer slaughters lambs in the Gardiner Basin about a mile away from the other producer. (Loveless, 2015, personal communication).
Known Hobby Herds: A small hobby herd is often grazed at the base of Tom Minor within 100 yards of the bighorn herd (Loveless, 2015, personal communication).

Herd Name: **Greenhorns**
Hunting District: N/A
Demographic and Habitat Information:
Population Size in 2014: 50
Core Range Size: 265.43 km^2
Percent Federal within Core Range: 63.29%
Percent Federal within 20-Mile Buffer: 41.03%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Big Sheep Allot. Number: 10513.

BLM allotment, Hoffman Cr Isolated. Number: 10511.
BLM allotment, Nyhart. Number: 20470.
BLM allotment, Rock Creek. Number: 10512.
BLM allotment, Timber Creek Isolat. Number: 10681.
USFS allotment, Barnett. Number: 20159.
USFS allotment, Black Butte Bench. Number: 20124.
USFS allotment, Canyon Creek Sandborn. Number: 40404.
USFS allotment, Coal Creek. Number: 20131.
USFS allotment, Cottonwood. Number: 20169.
USFS allotment, Fossil-Hellroaring. Number: 20174.
USFS allotment, Lyon-Woverine. Number: 20185.
USFS allotment, Poison Basin. Number: 20122.
USFS allotment, Red Creek. Number: 20192.
USFS allotment, Upper Ruby. Number: 20154.

Weed Control Projects: None
Known Private Production Herds: There is a large producer on west side of Ruby Mountains whose base of operation is between Twin Bridges and Dillon. These sheep summer on Federal Allotments. There are also domestic sheep in the Sweet Water basin toward Dillon (Waltee, 2015, personal communication).
Known Hobby Herds: There are several hobby herds north in the Ruby Valley (Waltee, 2015, personal communication).

Special Note: An MOU was signed between FWP and sheep producers saying that FWP could put bighorns in the Greenhorns as long as they do not try to close to federal allotments south of bighorn herd. To date, bighorns have not gone south, probably because of the thick forest acting like a natural barrier. There is currently an ongoing lawsuit about this herd filed by the Gallatin Wildlife Association (Waltee, 2015, personal communication).

Herd Name: **Deep Creek**
Hunting District: 421
Demographic and Habitat Information:
Population Size in 2010: 60
Core Range Size: 733.80 km^2
Percent Federal within Core Range: 87.82%
Percent Federal within 20-Mile Buffer: 59.15%
Date of Last Major Outbreak: 1984
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None
Special Note: This herd is part of Southern Rocky Mountain Front bighorn sheep management complex.

Herd Name: **Castle Reef**
Hunting District: 422
Demographic and Habitat Information:
Population Size in 2010: 215
Core Range Size: 174.94 km^2
Percent Federal within Core Range: 52.95%
Percent Federal within 20-Mile Buffer: 52.01%
Date of Last Major Outbreak: 2010

Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None
Special Note: This herd is part of Southern Rocky Mountain Front bighorn sheep management complex.

Herd Name: **Gibson Lake North**
Hunting District: 423
Demographic and Habitat Information:
Population Size in 2010: 204
Core Range Size: 628.02 km^2
Percent Federal within Core Range: 99.80%
Percent Federal within 20-Mile Buffer: 78.04%
Date of Last Major Outbreak: 2010
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None
Special Note: This herd is part of Southern Rocky Mountain Front bighorn sheep management complex.

Herd Name: **Ford Creek**
Hunting District: 424
Demographic and Habitat Information:
Population Size in 2010: 298
Core Range Size: 904.51 km^2
Percent Federal within Core Range: 88.13%
Percent Federal within 20-Mile Buffer: 64.66%
Date of Last Major Outbreak: 2010
Summary of Domestic Sheep Risk(s):
Federal Allotments:
USFS allotment, Canyon Creek Sandborn. Number: 40404.
USFS allotment, Horsefly. Number: 40418.
USFS allotment, Keep Cool Liverpool. Number: 40416.
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None
Special Note: This herd is part of Southern Rocky Mountain Front bighorn sheep management complex.

Herd Name: **North Fork Birch Creek – Teton**
Hunting District: 441
Demographic and Habitat Information:
Population Size in 2010: 138
Core Range Size: 589.51 km^2
Percent Federal within Core Range: 76.13%
Percent Federal within 20-Mile Buffer: 46.44%
Date of Last Major Outbreak: 1984
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None

Known Private Production Herds: None
Known Hobby Herds: None

Herd Name: **Beartooth WMA-GMWA**
Hunting District: 455
Demographic and Habitat Information:
Population Size in 2014: 100
Core Range Size: 582.50 km^2
Percent Federal within Core Range: 25.42%
Percent Federal within 20-Mile Buffer: 13.23%
Date of Last Major Outbreak: 1984
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Hilger Hills. Number: 07710.
BLM allotment, Sieben. Number: 07709.
USFS allotment, Canyon Creek Sandborn. Number: 40404.
Weed Control Projects: None
Known Private Production Herds: A small domestic herd is near Craig, MT at the mouth of Stickney Creek. There are larger herds in the area; one near Adel, MT and another near Sieben over the hill from the Missouri River. There is also a domestic herd located along the Missouri River by the Gates of the Mountains interstate exit (Loecker, 2015, personal communication).
Known Hobby Herds: Hobby herds are known to be within the Big Belt Mountains (FWP, 2010) and the subdivisions within the Missouri River Canyon (Loecker, 2015, personal communication).

Herd Name: **Fergus**
Hunting District: 482
Demographic and Habitat Information:
Population Size in 2014: 545
Core Range Size: 512.84 km^2
Percent Federal within Core Range: 67.63%
Percent Federal within 20-Mile Buffer: 31.16%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: There are two producers near the town of Winnefred. One is north of town and the other is just outside of town on the south side. They are within 8-15 miles of the herd (Anderson, 2015, personal communication).
Known Hobby Herds: None
Special Note: This herd is part of Missouri River Breaks bighorn sheep management complex. This herd is also growing, and as it expands, bighorn sheep are wandering down Judith River and into Arrow Creek. The risk posed by domestic sheep in these areas is largely unknown (Anderson, 2015, personal communication).

Herd Name: **Stillwater River (Boulder)**
Hunting District: 500
Demographic and Habitat Information:
Population Size in 2014: 140
Core Range Size: 710.46 km^2
Percent Federal within Core Range: 98.08%

Percent Federal within 20-Mile Buffer: 77.53%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Flatland. Number: 07708.
Weed Control Projects: None
Known Private Production Herds: The closest domestic sheep to the Stillwater winter range are near Fishtail, and there are several different producers in the Grove Creek drainage. These domestic sheep are roughly 17 miles east from the bighorn's primary winter range (Stuart, 2015, personal communication).
Known Hobby Herds: None
Special Notes: The herd's winter range is close to or at carrying capacity (Stuart, 2015, personal communication).

Herd Name: **Monument Peak (Boulder)**
Hunting District: 500
Demographic and Habitat Information:
*Population Size in 201*4: 140
Core Range Size: 710.46 km^2
Percent Federal within Core Range: 98.08%
Percent Federal within 20-Mile Buffer: 77.53%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Flatland. Number: 07708.
Weed Control Projects: None
Known Private Production Herds: The closest domestic sheep to the Stillwater winter range are near Fishtail, and there are several different producers in the Grove Creek drainage. These domestic sheep are roughly 17 miles east from the bighorn's primary winter range (Stuart, 2015, personal communication).
Known Hobby Herds: None
Special Notes: The herd's winter range is close to or at carrying capacity (Stuart, 2015, personal communication).

Herd Name: **Beartooth Mountains**
Hunting District: 501
Demographic and Habitat Information:
*Population Size in 201*4: 140
Core Range Size: 773.58 km^2
Percent Federal within Core Range: 98.16%
Percent Federal within 20-Mile Buffer: 75.92%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None

Herd Name: **Hellroaring**
Hunting District: 502
Demographic and Habitat Information:

Population Size in 2014: 45
Core Range Size: 377.94 km^2
Percent Federal within Core Range: 98.95%
Percent Federal within 20-Mile Buffer: 74.63%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None

Herd Name: **Pryor Mountains**
Hunting District: 503
Demographic and Habitat Information:
Population Size in 2014: 140
Core Range Size: 142.99 km^2
Percent Federal within Core Range: 95.16%
Percent Federal within 20-Mile Buffer: 36.37%
Date of Last Major Outbreak: 1995
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, BOR Lease 1403. Number: 01403.
Weed Control Projects: Wyoming Game and Fish uses goats for weed control in the Yellowtail Wildlife habitat Management Area, south of Horseshoe bend. This involves "several thousand goats…in this area during the summer months." Bighorns have been seen within five miles of this area (FWP, 2010).
Known Private Production Herds: There is a goat rancher on the other side of the border in Wyoming within 5 – 6 miles from the bighorn's winter concentration area. The goats are unherded and unfenced, and they may prevent the expansion of bighorns to the east end of the Big Pryor Mtns. (FWP, 2010).
Known Hobby Herds: None

Herd Name: **Little Rockies**
Hunting District: 620
Demographic and Habitat Information:
Population Size in 2014: 380
Core Range Size: 113.68 km^2
Percent Federal within Core Range: 63.50%
Percent Federal within 20-Mile Buffer: 39.92%
Date of Last Major Outbreak: 1998
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: None
Known Private Production Herds: None
Known Hobby Herds: None
Special Note: This herd is part of Missouri River Breaks bighorn sheep management complex.

Herd Name: **Middle Missouri Breaks**
Hunting District: 622
Demographic and Habitat Information:
Population Size in 2014: 380

Core Range Size: 445.75 km^2
Percent Federal within Core Range: 86.36%
Percent Federal within 20-Mile Buffer: 60.37%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Clarke Unit. Number: 00265.
BLM allotment, MacDonald. Number: 00239.
BLM allotment, McDonald Allotment. Number: 00248.
BLM allotment, Watt Allotment. Number: 00252.
Weed Control Projects: None
Known Private Production Herds: There are four known domestic sheep producers within the vicinity of this herd. Approximate locations were provided by Thompson for this analysis.
Known Hobby Herds: None
Special Note: This herd is part of Missouri River Breaks bighorn sheep management complex.

Herd Name: **Chouteau-Blaine-Phillips**
Hunting District: 680
Demographic and Habitat Information:
Population Size in 2014: 645
Core Range Size: 462.66 km^2
Percent Federal within Core Range: 74.37%
Percent Federal within 20-Mile Buffer: 29.63%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments: None
Weed Control Projects: Weed control projects have been seen further north, although the exact location of these projects is unknown. These projects may be far enough away from the herd to not be a concern. They are also managed well. Sheep are closely monitored by a shepherd (Hemmer, 2015, personal communication).
Known Private Production Herds: There's a small producer about 3 miles north of the herd along Cow Creek (Hemmer, 2015, personal communication).
Known Hobby Herds: None
Special Note: This herd is part of Missouri River Breaks bighorn sheep management complex.

Herd Name: **Blue Hills**
Hunting District: N/A
Demographic and Habitat Information:
Population Size in 2014: 50
Core Range Size: 1749.02 km^2
Percent Federal within Core Range: 13.91%
Percent Federal within 20-Mile Buffer: 17.54%
Date of Last Major Outbreak: None
Summary of Domestic Sheep Risk(s):
Federal Allotments:
BLM allotment, Colin-East Custer. Number: 01182.
BLM allotment, Dolatta. Number: 01307.
BLM allotment, Fortyfour Creek. Number: 00588.
BLM allotment, Gilman. Number: 01048.
BLM allotment, McAulay Ranch. Number: 01340.
BLM allotment, McAulay Ranch. Number: 10416.

BLM allotment, Pine Creek. Number: 00733.
BLM allotment, Thomason. Number: 00804.

Weed Control Projects: Domestic sheep are used along the Powder River to control weeds (FWP, 2010)

Known Private Production Herds: There are some domestic herds along the edge of the bighorn's range, although most private ranching in the area is cattle (Ensign, 2015, personal communication).

Known Hobby Herds: None

About the Author

Robb Krehbiel is a Missoula-based independent conservation consultant specializing in GIS, spatial analysis, landscape-level planning, and policy and management analysis. Krehbiel graduated magna cum laude from the University of Maryland with a master's degree in sustainable development and conservation biology, with research focused on wildlife conservation and federal land management in the Northern Rockies. He graduated magna mum laude from Drake University with a bachelor of science degree in environmental science and a bachelor of arts degree in politics. Krehbiel has used GIS programs and tools to aid in management of wildlife and federal lands, and has worked for a Washington nonprofit environmental organization.

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