INVASIVE PLANT MANAGEMENT ON BIGHORN SHEEP WINTER RANGES: BULL RIVER AND WIGWAM FLATS

FINAL REPORT: 2020-21
YEAR 4
FWCP Project No: COL-F21-W-3286 **HCTF Project: 4-556**

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Executive Summary

Rocky Mountain bighorn sheep (*Ovis canadensis*) are blue listed (vulnerable) within BC due to threats such as loss of habitat, predators and disease. Some bighorn sheep populations within the Kootenay Boundary Region have decreased since 2010. Possible causes of decline are increased winter severity, increased predator populations, and reduced winter range habitat condition

In the Forest Practices Board Report (2016) on rangelands, invasive plants were identified as an issue that threatens the sustainability of rangelands over the long term. Invasive plants are capable to alter habitats and disrupt essential ecosystem functions by displacing native vegetation. Invasive plants reduce soil productivity, impact water quality and quantity, degrade range resources and wildlife habitat, threaten biodiversity, and alter natural fire regimes. With declining effectiveness of biocontrol for St. John's Wort (*Hypericum perforatum*) in the East Kootenay and rapid invasion of new invasive plant species such as yellow hawkweed (*Hieracium spp*), intensified invasive plant management is required to restore bighorn sheep winter ranges.

This project aligns with the Upland & Dryland Action Plan: Action #11 Terrestrial Invasive Species. This report discusses results of Year 4: 2020-21 management of invasive plants at Bull River and Wigwam Flats. In Year 1, Treatment units were created and mapped, vegetation sampling plots were installed and sampled, selected units were treated with herbicide in the spring and selected sites with resulting low vegetation cover were seeded in the fall (fall rye), and vegetation sampling data was collated, analyzed and summarized. In Year 2, additional vegetation plots were installed, a subsample of vegetation plots were sampled, selected units were treated with herbicide in the spring, seeding of sites with low vegetation cover (agronomic mix) occurred in the fall and vegetation sampling data summarized. In Year 3, in addition to Year 2 activities we sampled most of the vegetation plots and conducted fertilizer trials. In Year 4, we sampled fertilizer trial areas.

Bighorn sheep inventories were conducted during winters of 2016-17, 2017-18 and 2018-19 and 2020-21 with funding from the Ministry. In 2018-19, 65 sheep were observed in Bull River. In 2020-21, 59 sheep were observed in Bull River. Previous inventories occurred in 2012 and 2014 with observed results of 100 and 97, respectively. Sheep population estimate has reduced from 120 in 2012 to 80 in 2019. The population appears to have declined 40% since 2012. Cause of decline is unknown but appears to be predation driven.

In Wigwam Flats, a total of 184 bighorn sheep were observed in February 2019 and 184 in March 2021. Bighorn sheep inventories were not conducted in this area in 2019-20. The population estimate has remained stable at approximately 230 sheep.

Six treatment units were delineated at Bull River covering a total of 166.1 hectares. At Bull River, 39 plots were established, 23 in 2017, 5 in 2018 and 11 in 2019. The 11 plots established in 2019 were to attempt to monitor fertilizer trials. Seven treatment units were established at Wigwam Flats covering 227 hectares. At Wigwam Flats, 25 plots were established, 18 in 2017 and 6 in 2018 and 1 in 2019. All plots were sampled prior to herbicide treatments.

Vegetation sampling was conducted on 17 plots in Bull River and 14 plots in Wigwam Flats during spring 2020 (4th year of sampling). Vegetation sampling method used was the same as 2017: 5 x 0.5 m radius circular plots at each permanent plot location; 1 plot in center and 1 plot in each of the 4 cardinal directions with each plot 5 m away from plot center (Phillips 2020).

In Year 4, in Bull River and Wigwam Flats we sampled plots that were fertilized in spring 2019 and plots nearby that were not fertilized. In Bull River, a total of 17 plots were sampled; 8 plots were fertilized while 9 plots were not. In 2019, in Wigwam Flats a total of 10 plots were sampled; 5 plots were fertilized while 5 were not. Samples sizes were small so statistical analysis was not completed. Results were the following:

Bull River: Results were different between treatment units. Fertilizer did not appear to increase vegetation cover in BRT1. However, in BTR2, it appears that fertilizer allowed for forbs, bunchgrasses, and other grasses to substantially surpass 2017 pre-herbicide treatment results. Invasive plants were not detected in either fertilized or unfertilized plots. In general, herbicide treatments to remove invasive plants has increased the cover of bunchgrasses and other grasses. In BRT2, fertilizer assisted with increase in forage species coverage where amount of bare ground was high (result of removal of invasive plants).

Wigwam Flats: Fertilizer did not appear to increase percent cover of bunchgrass or other grasses but did positively affect forbs. Forbs did increase in percent cover in fertilized plots in both WWT1 and WWT6 and were now approaching 2017 values (before herbicide use). Invasive plants were not detected in WWT6 but were found in WWT1 at low percentages (less than 1.2%). In general, herbicide treatments to remove invasive plants has increased the cover of bunchgrasses and other grasses.

In May/June 2020, a total of 39 ha was covered by foot or ATV in Bull River and 93 ha in Wigwam Flats. A total of 3.7 ha was treated at Columbia Lake East with this funding. A total of 7.6 L of Milestone and 312 grams of Clearview were applied by backpack at Bull River. A total of 520 g of Reclaim was applied along roadways by ATV at Bull River. A total of 3.5 L of Milestone was applied by backpack at Wigwam Flats and a total of 54.2 L of Milestone was applied by ATV.

In April 2019, in Bull River 400 kg of fertilizer was applied in 4.9 ha of BRT 1 and 2. In Wigwam Flats, 325kg was applied in 8.7 ha of WWT1 and 6. Fertilizer blend was 31-12-0-6.2S and nutrients per acre was 50 N-20 P-10 S. In late April 2020, in Wigwam Flats, 1275 kg of fertilizer was applied in WWT1, WWT5 and WWT6.

In late October 2020, 150 kg of orchard grass/sheep fescue/june grass/fall rye seed mix were placed in the Bull River primarily in the BRT5 area of Hatchery Ridge to try to outcompete persistent blueweed infestations. At Wigwam Flats, 100 kg of same seed mix was distributed in bare spots along the treated roadside and low slopes of WWT5.

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Introduction:

Rocky Mountain Bighorn Sheep (*Ovis canadensis*) are blue listed (vulnerable) within BC due to threats such as loss of habitat, predators and disease. Bighorn sheep population estimates within the Kootenay Region have declined since 2010 which was the highest estimate recorded at 2500 bighorn sheep. The 2019 estimate is 2000 bighorn sheep. This regional decline since 2010 is likely due to recent higher numbers of predators, increased severity of winters and reduced winter range habitat condition.

In the Forest Practices Board Report (2016) on rangelands, invasive plants were identified as an issue that threatens the sustainability of rangelands over the long term. Invasive plants can alter habitats and disrupt essential ecosystem functions by displacing native vegetation. Invasive plants reduce soil productivity, impact water quality and quantity, degrade range resources and wildlife habitat, threaten biodiversity, and alter natural fire regimes. With declining regional populations of biocontrol for St. John's Wort (*Hypericum perforatum*) and rapid invasion of new invasive plant species such as yellow hawkweed, intensified invasive plant management is required in bighorn sheep winter ranges.

Yellow hawkweed (*Hieracium s*p) is a European species which spreads by creeping roots as well as seed, so tends to form large monocultures that can suppress grasses and other forage plants. In the Kootenay Boundary Region, yellow hawkweed is rapidly spreading throughout both the Wigwam Flats and Bull River bighorn sheep winter ranges. This spread will undoubtedly result in large declines in forage quality and quantity if intensive management and research trials are not conducted.

Additionally, St John's Wort is extremely plentiful in Wigwam Flats and at higher elevations in Bull River. Ingestion of St. John's Wort by livestock or wild ungulates can cause photosensitization, central nervous system depression, spontaneous abortion, and death. Furthermore, in the current absence of a comprehensive invasive plant management program, the substantial loss of forage quality and quantity will ultimately result in declining bighorn sheep populations. Thus, preventative measures are imperative in bighorn sheep winter ranges such as Columbia Lake East where only minor infestations of invasive plants currently exist. Managing invasive plant species in the Wigwam Flats and Bull River winter ranges, as well as keeping Columbia Lake East free of these aggressive invaders, is of vital importance to the maintenance of bighorn sheep habitat and herd health.

This report discusses results of Year 4: 2020-21 management of invasive plants at Bull River and Wigwam Flats. This project falls within the the Upland & Dryland Action Plan: Action #11 Terrestrial Invasive Species which is listed as Priority 1.

Ecosystem restoration activities have occurred within bighorn sheep winter ranges in Bull River, Wigwam Flats and Columbia Lake East since 2000 with funding from FWCP. Conservation properties exist within Wigwam Flats, Bull River and Columbia Lake East that FWCP contributed towards purchase. This project will partner with other agencies to deliver a comprehensive strategy to manage invasive plants within bighorn sheep winter ranges at Wigwam Flats and Bull River. A variety of the most effective treatment and enhancement methods will be used to attempt to restore low elevation grassland ecosystems.

Enhancement efforts are required to halt the spread and decrease the coverage of invasive plants before the quality of these winter ranges becomes so impacted that recovery is impossible.

Study Area

The primary treatment areas are comprised of two important bighorn sheep winter ranges: Bull River and Wigwam Flats (Figure 1). Both areas exist in low elevation grasslands and fall within the Interior Douglas Fir Kootenay dry mild (IDFdm2) biogeoclimatic zone variant which is dominated by Douglas-fir (*Pseudotsuga menziesii*), western larch *(Larix occidentalis*) and lodgepole pine (*Pinus contorta*) (Braumandl and Curran 1992). Ponderosa Pine dry hot (PPdh2) borders both sites at lower elevations and Montane Spruce dry cool (MSdk1) borders above at higher elevations. These winter ranges are shared with other ungulate species such as elk, mule deer and white-tailed deer.

Bull River: From 2002-2010, invasive plant spread and occurrence was well under control. Invasive species such as spotted knapweed and blueweed were regularly treated along roads and right-of-ways. However, sulphur cinquefoil (*Potentilla recta*) was not treated during that time period. Biocontrol for hound's tongue (*Cynoglossum officinale*) was also released and has been extremely effective in controlling hound's tongue. Unfortunately, with the new and current invasion of yellow hawkweed invasive plant control is no longer the case. Current primary species of concern have been identified as: Yellow hawkweed, sulphur cinquefoil, St John's Wort and blueweed.

In addition to ungulate grazing at Bull River, 4 range tenures overlap the study area where cattle grazing occurs. Forage use by cattle in Big Bull Pasture (BRT 3 and 4 exist within this pasture) is based on accessibility and grass production data from 2003-2011. The average use by cattle over the past 10 years closely reflects the assigned use. In general, 40% of total grass production is allocated to combined use by cattle and wildlife. Of that 40%, half is allocated to cattle. Although forage production was relatively stable in the assessment years (2003, 2004, 2005, 2011) the expansion of invasive species into the area may have had significant impacts on forage/grass production. Grass production and forage assessment data should be updated to reflect current conditions (pers comm. H. McIntyre)

Wigwam Flats: Elk inventories conducted in 2008 and 2013 indicated substantially reduced use at Wigwam Flats with less than 20 elk observed. In the late 1990's it was common to observe 300 elk using the Flats during the winter. Since 2011, herbicide treatment has occurred primarily on roadways and pipeline right-of-ways. Wigwam Weed Days, a multi-stakeholder, 2 day event, was discontinued after 2011. The vegetation monitoring on native ranges that occurred from 2002-2011 indicated that controlling spotted knapweed within native ranges improved native plant health (Ross 2012). With the reduction of invasive plant coverage from 10% to 2%, native plant coverage slowly increased. However, during this period, St. John's Wort coverage ranged from 1 – 8% and the trend was increasing. In 2002, Yellow hawkweed was found within plots, but its coverage was found to be less than 0.4%. Unfortunately, yellow hawkweed has increased substantially since 2010. Additionally, biocontrol (*Chrysolina sp*) for St. John's Wort has become

less effective with anecdotal evidence suggesting that the number of *Chrysolina* beetles in southern BC has declined in the past twenty years (pers com. C. MacRae). Alternatively, spotted knapweed *(Centaurea maculosa)* biocontrol is still plentiful and functioning onsite. Primary species of concern for this area have been identified as: yellow hawkweed, St. John's Wort and sulphur cinquefoil with spotted knapweed maintenance. Cattle grazing does not occur within Wigwam Flats.

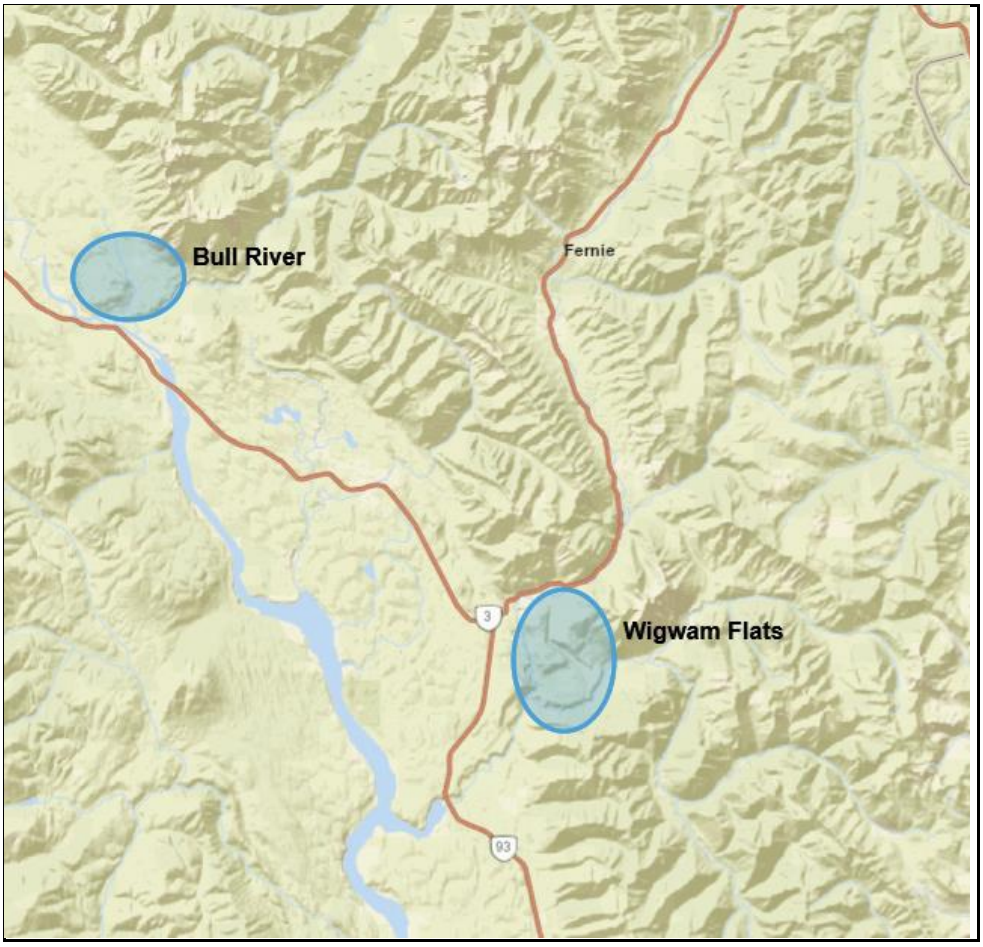

Figure 1: Map of Bull River and Wigwam Flats study areas

Access Management

The Wigwam Flats/Mt. Broadwood Access Management Area (AMA), Powerplant AMA and Columbia Lake East AMA restrict the use of motorized vehicles seasonally to designated roads only. These closures are monitored periodically by Conservation Officer Service. New AMA signage and kiosks were installed in 2008 at the 2 gated access points of Wigwam Flats AMA. New kiosks and AMA informational signage were

installed at Bull River and Columbia Lake East in 2016 and 2017. New kiosks and AMA informational signage were installed for Bull River and Columbia Lake East in 2016 and 2017. New educational signage discussing bighorn sheep, conservation lands and management activities was installed in Bull River in 2019.

Methods:

Project planning:

A comprehensive literature review concentrating on successful control and management techniques for yellow hawkweed, St. John's Wort, spotted knapweed, and sulphur cinquefoil was completed in April 2017. Literature review was conducted by Ministry of Forests, Lands and Natural Resource Operations (FLNRO) Invasive Plant Specialists.

Treatment units were mapped for both study areas. A Ministry of FLNRO biologist and GIS specialist mapped treatment units focussing on sites with high bighorn sheep use according to past and current telemetry and inventory data (Kinley 2007; FLNRO data).

Bighorn sheep inventories:

Bighorn sheep aerial inventories were conducted using RISC (2002) standards. Aerial surveys were conducted using a Bell 206B helicopter equipped with rear bubble windows and 3 experienced observers. Sheep were classified to Level 4 classification (RISC 2002), which consisted of lambs, ewes, and Class I, Class II, Class III, and Class IV rams. Animal locations and flight track were recorded with a hand-held GPS unit, which was later downloaded to an Excel spreadsheet.

Vegetation monitoring:

Bull River and Wigwam Flats sites were divided into treatment units and mapped. Treatment units were established in areas utilized by bighorn sheep which were identified from data obtained through inventories and radio-telemetry (FLNRO inventory data; Kinley 2007). Within the identified treatment units, vegetation plots were established; each plot represented the existing habitat type. At each plot a modified version of the Ministry of FLNRO Ecosystem Restoration Program's Routine Monitoring Protocols for Understory Cover Sampling was used (Harris and Greene 2015). At each plot centre, UTM locations were recorded and a 0.60 m diameter circular frame was centered over plot center. Using an iPad, a photo of each plot was taken approximately 1 m above the ground using Theodolite (Version 5.0), which also links each photo with a UTM location (Zone/Easting/Northing). Percent cover of all plant species rooted within the frame area were recorded to genus. An exception was made for Antelope-brush (*Purshia tridentata*) as bushes adjacent to plots would often provide cover over the plots. This overhang cover was included as a part of the total cover Antelope-brush. For invasive species, the density (number of individual plants) was also recorded. Other

data collected were the presence of elk, deer, cow and bighorn sheep feces and the percent cover of bare ground, rock, woody debris, cryptograms and litter.

This process was repeated in each of the cardinal directions 5 m from the plot center. Thus, a total of five vegetation plot samples were taken at each site (center, 5 m north, 5 m south, 5m east and 5 m west) (Figure 2).

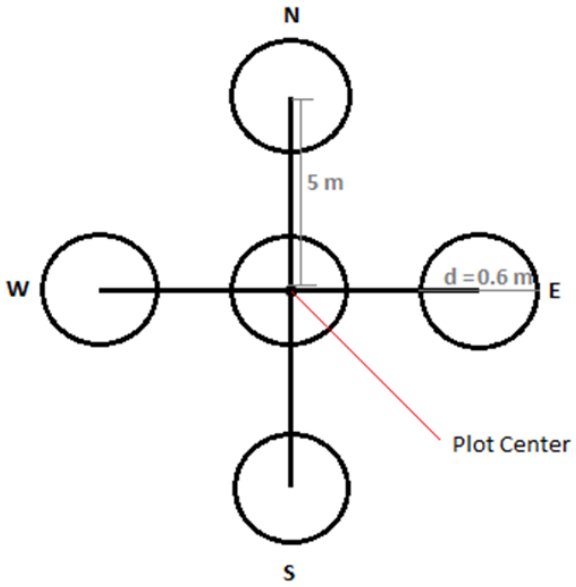

Figure 2: Diagram of a vegetation plot depicting subplot locations (created by H. McIntyre)

Data Comparisons for Fertilizer trials

To facilitate comparisons between plots that received fertilizer treatment and those that did not, data have been split by treatment unit (i.e. BRT1 and BRT2 for Bull River and WWT1 and WWT6 for Wigwam Flats) and by treatment type (i.e. fertilized and not fertilized in 2019). Plots have been split out this way for all summary statistics (2017, 2019 and 2020). Data from 2018 was not used as only a small number of plots were sampled that year, mostly to determine efficacy of herbicide treatments.

Summary comparisons should be viewed cautiously as the sample size was small for all treatment units summarized in this report, especially for 2017. Sample sizes ranged between one and six plots per treatment type per treatment unit. Due to small sample size, statistical analysis could not be done.

Herbicide treatments:

Motorized vehicles were used on treatment units that allow for safe herbicide application (flat ground). East Kootenay Invasive Species Council (EKISC) will deliver most of this work. Treatment units that occur on slopes or other inaccessible areas will be contracted to companies with the capacity for backpack herbicide application. Herbicide treatment records will be completed for each site. Herbicide efficacy monitoring will also occur for each study area.

We will be concentrating management efforts in areas with reduced invasive plant coverage and expanding outward. Many of the treatment units are within or adjacent to conservation lands where FWCP and HCTF have invested funding and effort.

Seeding/fertilizing:

Seeding and or fertilizing will be done manually using bucket seeders. FLNRORD staff and/or contractors will be used to seed/fertilize areas with reduced vegetation cover due to herbicide treatments. Seeding will be done in the late fall while fertilizing will be done in the early spring.

Precipitation Data:

Precipitation data for the Cranbrook airport (YXC) as recorded by the Government of Canada (2020) was presented to compare annual growing conditions. The monthly sum of total precipitation was used which includes total rainfall and the water equivalent of the total snowfall in millimetres (mm). Data were presented annually and for the growing season (April 1 to August 31) for years 2015 to 2020. In 2020, several months of precipitation data for the Cranbrook airport were missing. As a result, precipitation data from Cranbrook Airport Auto was used for the 2020 precipitation summary (Government of Canada 2020).

Results and Discussion

Treatment unit mapping:

The majoring of mapping of Bull River and Wigwam Flats into treatment units was completed during spring 2017 (Figure 3 and 5). Additional treatment units were added to Bull River within winter range existing to the west. (Figure 4). Treatment units were established in areas utilized by bighorn sheep which were identified from data obtained through inventories (FLNRORD data) and radio-telemetry (Kinley 2007; Jeremy Ayotte GPS collar data (in press)). A total of 6 treatment units covering 166.1 ha were established and mapped within Bull River in 2017 and 2018. Wigwam Flats has 7 treatment units covering a total of 227 ha.

Bighorn sheep inventories and research:

We conducted bighorn sheep inventories in Bull River, Wigwam Flats and Columbia Lake East during winter 2020-21. We received very little snow this winter at low elevations therefore sightability may have been reduced. In Bull River, 59 sheep were observed. In Columbia Lake East, 68 bighorn sheep were observed. In Wigwam Flats, 184 bighorn sheep were observed. All herds appear to be stable since 2019.

Figure 6 depicts bighorn sheep population estimates for both Wigwam Flats and Bull River sheep herds over time. In addition, GPS collar research continues for Bull River herd (J. Ayotte in press; Figure 7). Movements are similar to VHF collar research conducted in the late 1990s (Figure 8).

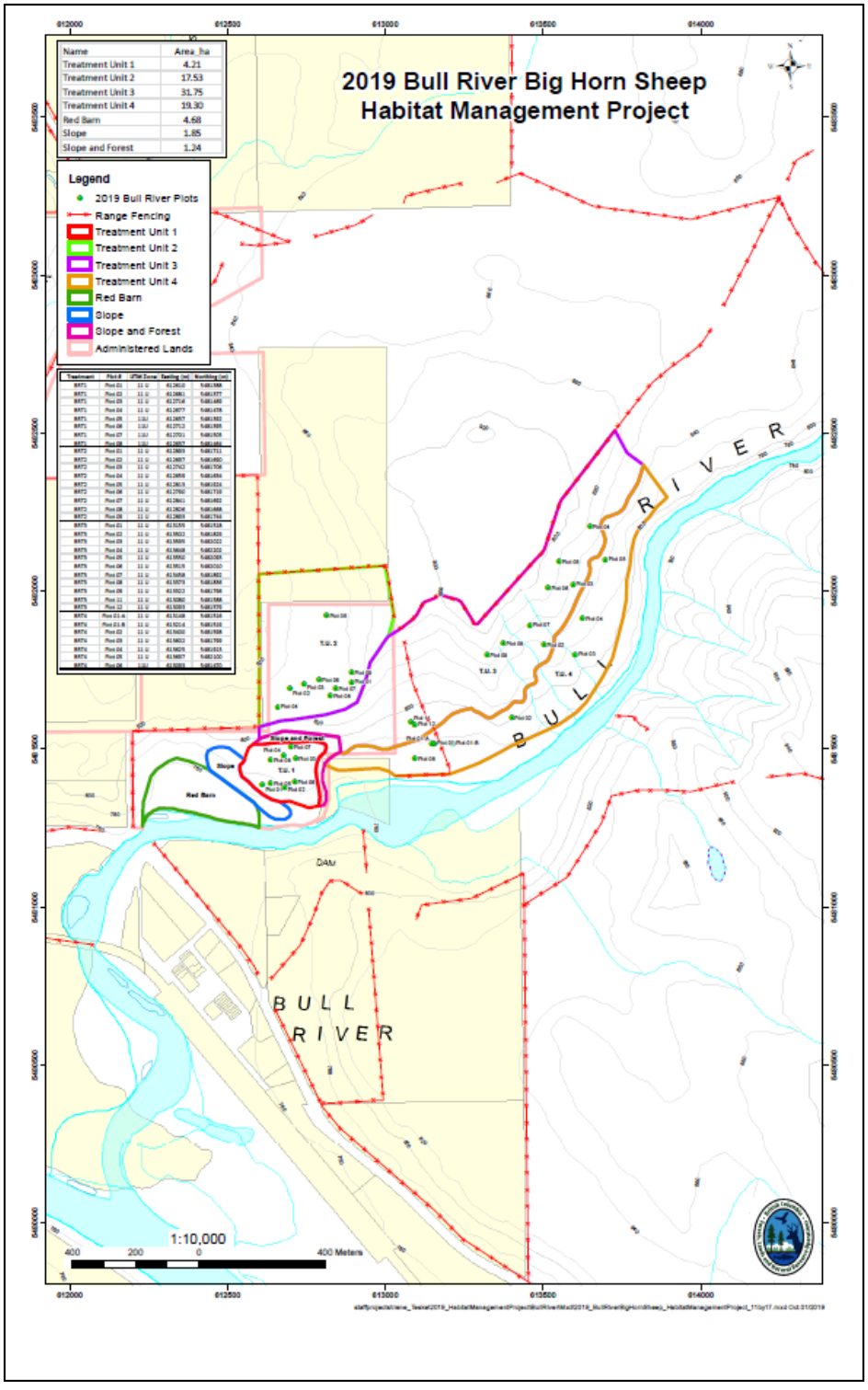

Figure 3: Map of treatment units and vegetation plot locations at Bull River

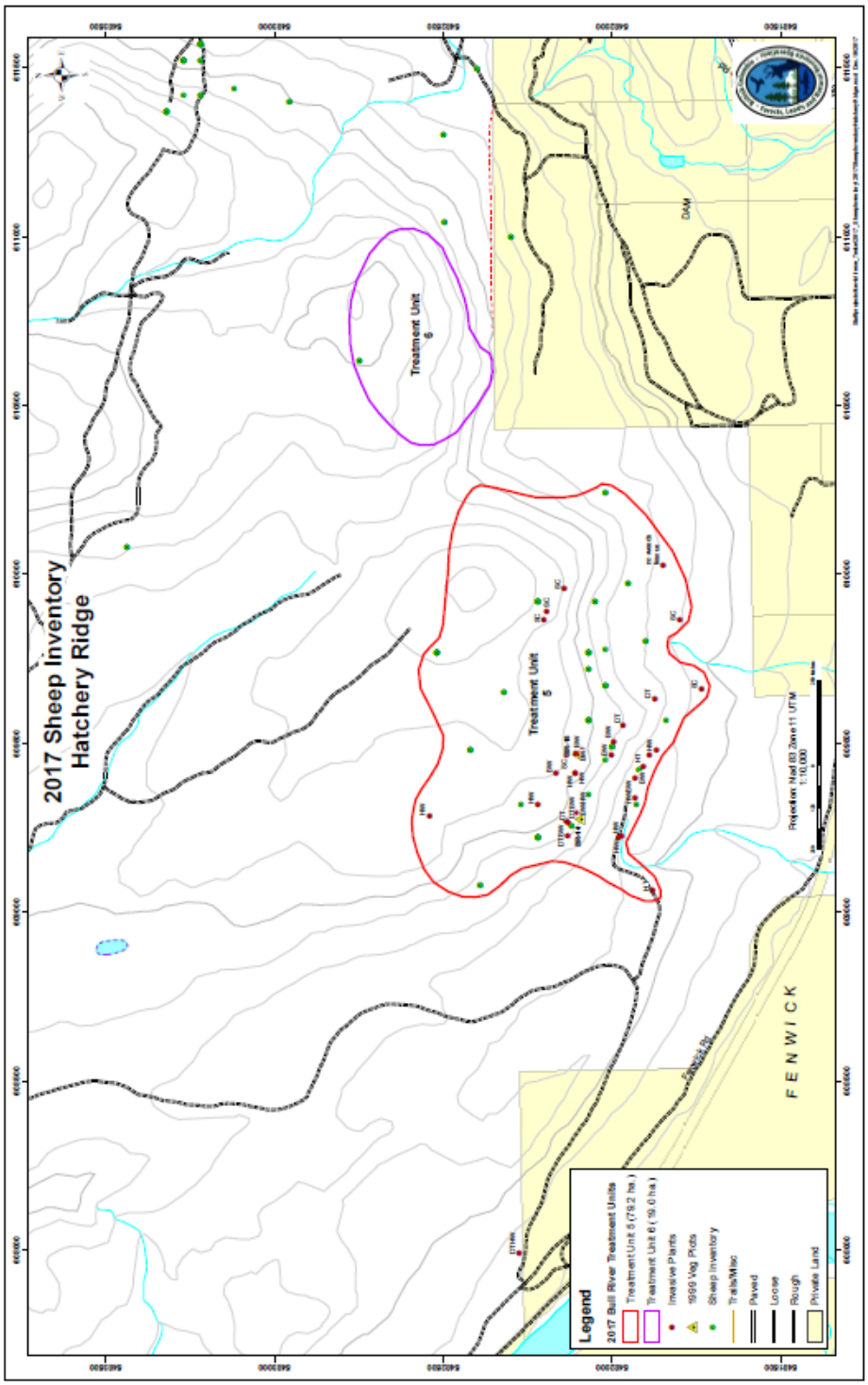

Figure 4. Map of Hatchery Ridge treatment units

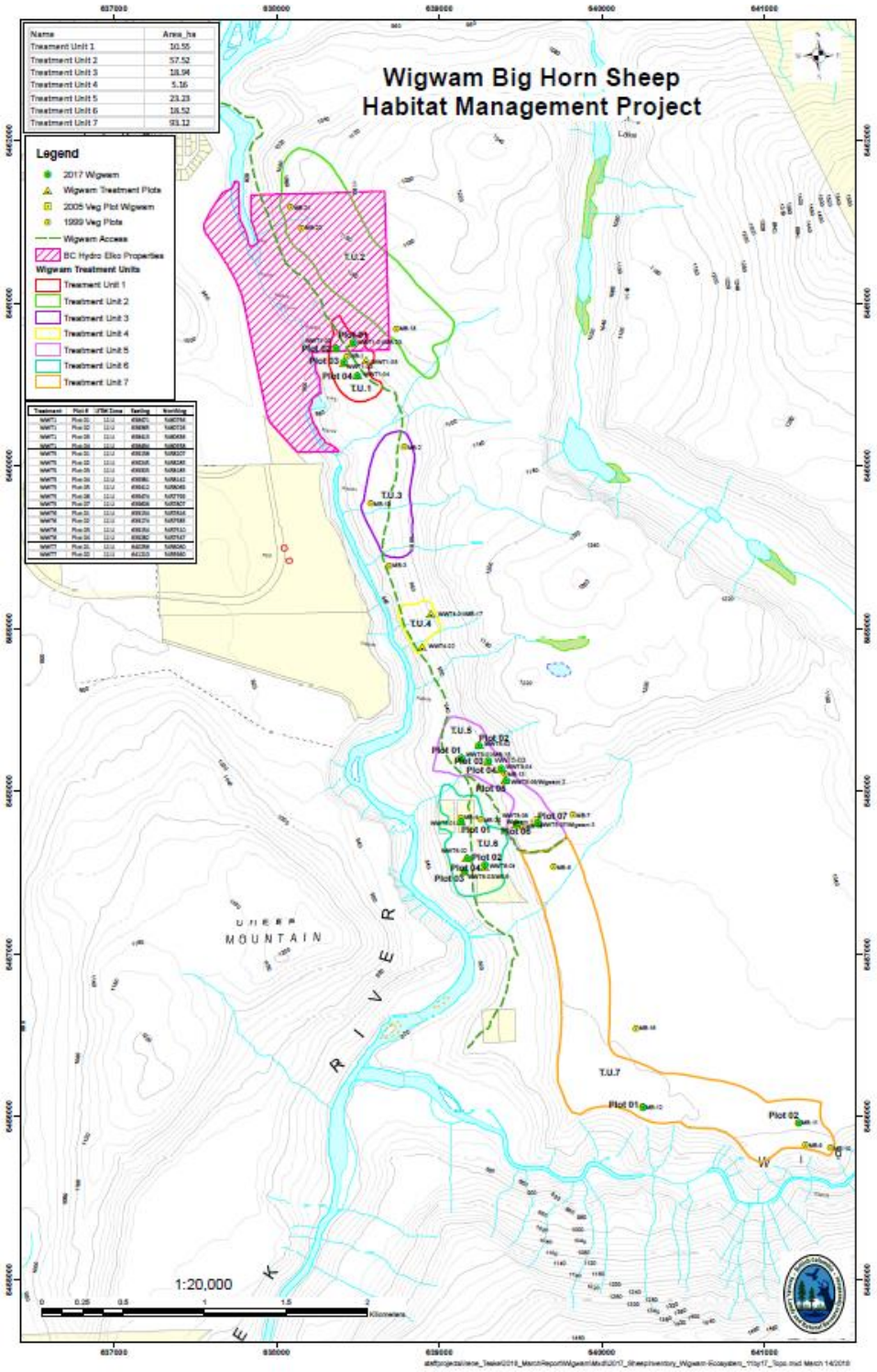

Figure 5: Map of treatment units and vegetation plot locations at Wigwam Flats

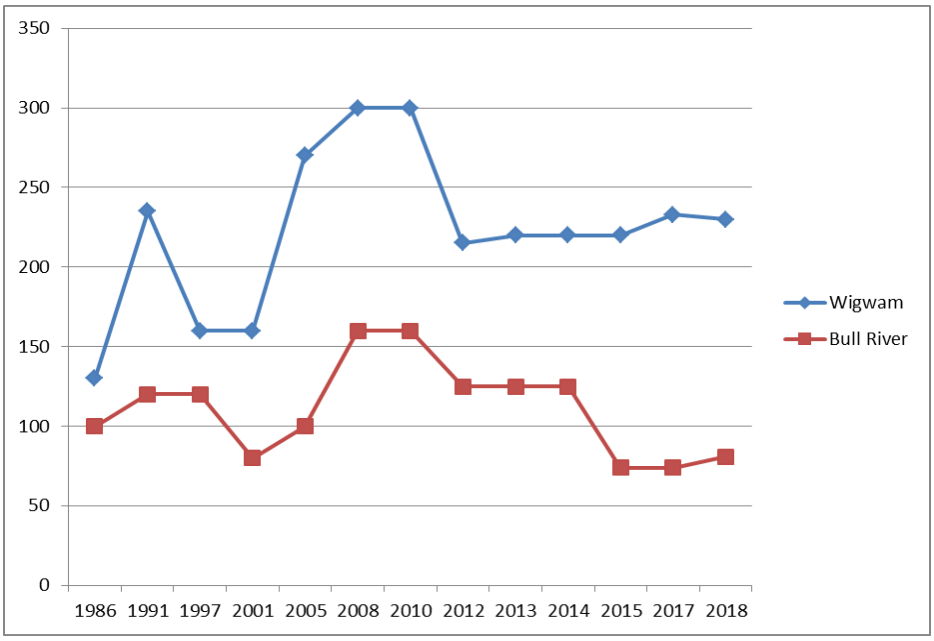

Figure 6: Bighorn sheep population estimates over time for Bull River and Wigwam Flats herds.

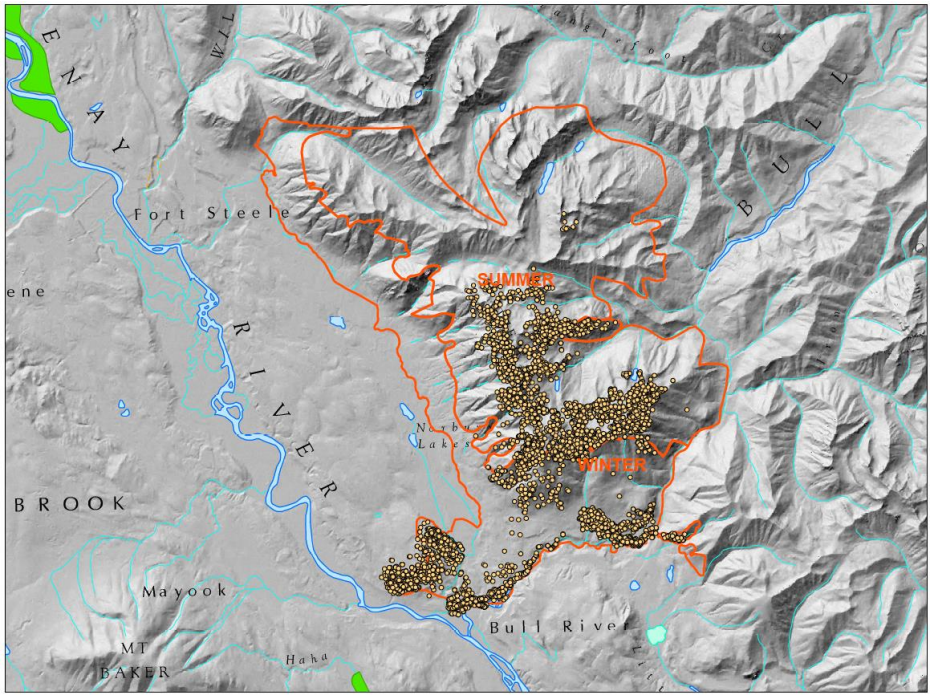

Figure 7: All season locations of GPS radio-collared bighorn sheep (HCTF project J. Ayotte): February 2017-March 2019.

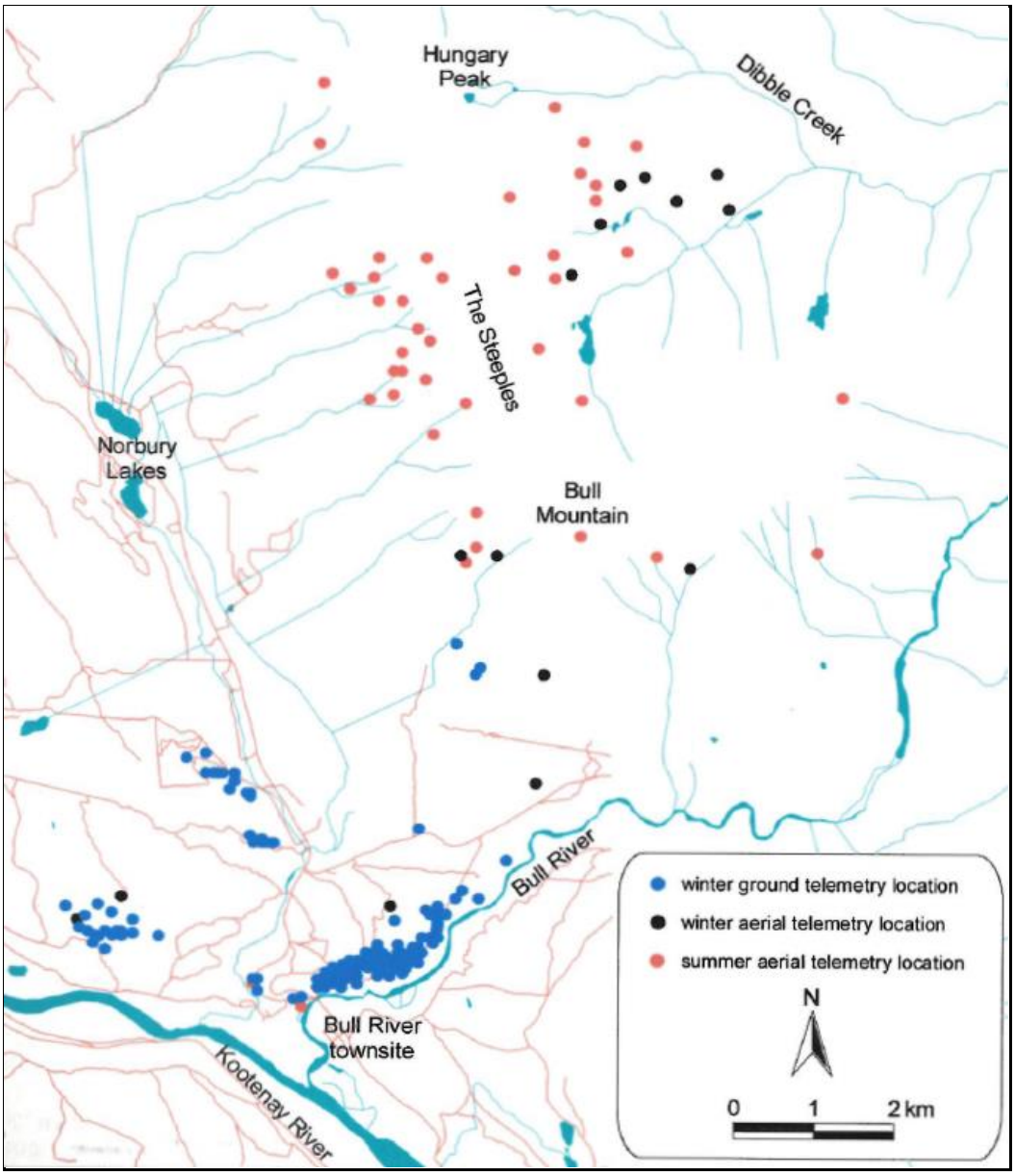

Figure 8: Winter (Dec-Apr) and summer (May-Nov) telemetry locations for bighorn ewes collared on Bull River winter range 1997-2000 (from Kinley 2007)

Vegetation monitoring 2020: Fertilizer trials (from Phillips 2021 report)

Six treatment units were delineated at Bull River covering a total of 166.1 hectares. At Bull River, 39 plots were established, 23 in 2017, 5 in 2018 and 11 in 2019. Seven treatment units were established at Wigwam Flats covering 227 hectares. At Wigwam Flats, 25 plots were established, 17 in 2017 and 8 in 2018. All plots were sampled prior to herbicide treatments.

At Bull River, both BRT1 and BRT2 are mostly flat sites and located within conservation land without cattle grazing. The western portion of BRT3 and BRT4 also exist within Conservation land without cattle grazing. The majority of BRT3 and BRT4 are located on Crown Land with cattle grazing. BRT3 is the largest treatment unit with the most plots and is located on a steep slope likely reducing cattle use. BRT4 is located downslope of BRT3 and is more gradually sloped and has access to water in a few locations. As BRT4 is likely more attractive for use by cattle, invasive species in this unit will only be treated at strategic locations or an attempt to obtain funding for treatment from agricultural sources will be explored. BRT5 and 6 are located to the west and are also on Crown Land and are lightly grazed by cattle.

Cattle grazing does not occur within Wigwam Flats. Portions of WWT1 and all of WWT6 and WWT7 are flat. WWT5 and WWT4 are located along steep slopes. WWT2 is on the ridge top which is mostly flat or gently sloping and WWT3 is on a gentler slope.

Bull River:

A total of 39 permanent vegetation plots were established within the treatment units at Bull River between 2017 and 2019 (Table 1). In 2019, 16 plots were sampled in BRT1 and BRT2 (Table 1; Table 2). In 2020, 17 plots were sampled in BRT1 and BRT2 in an attempt to monitor fertilizer use. Data analysis below only involves plots within these two treatment units. Of the 17 plots sampled, 8 were fertilized

Table 1. Summary of sampling and fertilizer treatments in treatment units BRT1 and BRT2 between 2017 and 2020.

TU BRT1	*Sampled in 2017*	*Fertilized in 2019*	*Sampled in 2019*	*Fertilized in 2020*	*Sampled in 2020*
Plot 1	*Yes*	*No*	*Yes*	*No*	*Yes*
Plot 2	*Yes*	*Yes*	*No*	*No*	*Yes*
Plot 3	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Plot 4	*Yes*	*No*	*Yes*	*No*	*Yes*
Plot 5	*No*	*No*	*Yes*	*No*	*Yes*
Plot 6	*No*	*Yes*	*Yes*	*No*	*Yes*
Plot 7	*N*	*Yes*	*Yes*	*No*	*Yes*
Plot 8	*No*	*No*	*Yes*	*No*	*Yes*

BRT2					
Plot 1	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Plot 2	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Plot 3	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Plot 4	*Yes*	*No*	*Yes*	*No*	*Yes*
Plot 5	*No*	*No*	*Yes*	*No*	*Yes*
Plot 6	*No*	*No*	*Yes*	*No*	*Yes*
Plot 7	*No*	*No*	*Yes*	*No*	*Yes*
Plot 8	*No*	*No*	*Yes*	*No*	*Yes*
Plot 9	*No*	*Yes*	*Yes*	*No*	*Yes*

Table 2: Total average percent cover of ground cover type for each treatment unit by treatment type (Pre-fertilizer, Year of Treatment, 1st year after treatment and no fertilizer) at Bull River study area, Spring 2017, 2019 and 2020.

Treatment	Year	Total Crypto	Total Shrub	Total Forb	Total Bunch Grasses	Total other grasses	Total Bare Ground	Total Invasive Forbs	Total Invasive Grasses *
BRT1									
Pre-treatment	2017	1.2	0	13.6	13.6	14.4	0.6	9.6	0
Year of treatment	2019	0.6	3.7	1.7	18.0	11.8	2.2	0	2
1st year after treatment	2020	14.0	8.9	0.6	12.4	20.3	0.5	0	0.3
BRT1									
No Fertilizer	2017	17.3	2.3	8.0	2.7	33.5	1.3	12.4	0
No Fertilizer	2019	0	3.5	1.7	17.3	7.2	0.4	0	0
No Fertilizer	2020	18.0	4.0	3.1	8.3	21.9	0	0	0
BRT2									
Pre-treatment	2017	9.9	2.3	2.6	10.1	2.8	12.1	19.6	1.1
Year of treatment	2019	0.2	5.8	3.2	28.4	7.5	4.5	0	0.6
1st year after treatment	2020	21.1	3.4	5.4	20.6	11.3	4.7	0	0
BRT2									
No Fertilizer	2017	8.4	8.0	17.0	9.8	7.0	2.4	9.4	0
No Fertilizer	2019	0.1	8.1	2.5	8.6	4.1	0.7	0	0
No Fertilizer	2020	15.8	13.3	6.5	10.5	8.8	0	0	0

***Invasive grasses = Cheat grass (*Bromus tectorum*)**

Percent Cover

Overall forbs decreased in cover after herbicide treatments occurred in 2017. In BRT1, the percent cover of forbs decreased in 2019 regardless of fertilizer treatment (Table 2). In 2020, percent cover decreased further in plots that received fertilizer treatment and increased slightly in the plots that did not receive fertilizer treatment. In BRT2, the percent cover of forbs that received fertilizer treatment increased in 2019 and again in 2020. In 2019, percent cover of forbs in plots that did not receive fertilizer treatment decreased; however, in 2020 percent cover increased slightly.

In BRT1, the percent cover of bunchgrasses increased in 2019 from pre-treatment coverage in plots that received treatment and plots that did not (Table 2). In 2020, percent cover of bunchgrasses decreased in all plots in BRT1. In BRT2, the percent cover of bunchgrasses increased in the plots that received treatment in 2019. Percent cover decreased in the plots that did not receive treatment. In 2020, percent cover decreased in plots after the first year of treatment and increased in plots that did not receive fertilizer treatment.

Percent cover of grasses in BRT1 decreased below pre-treatment coverage in 2019 and increased above 2019 coverage in 2020, regardless of fertilizer treatment or not (Table 2). In BRT2, percent cover grasses that received fertilizer treatment increased in 2019, and percent cover decreased in plots that did not receive treatment. In 2020, grass coverage decreased after the first year of treatment and percent cover increased in plots that did not received fertilizer treatment.

Percent cover of cryptogram decreased in all BRT1 and BRT2 plots in 2019 regardless of treatment. In 2020, percent cover of cryptogram increased above 2019 coverage in all BRT1 and BRT2 plots regardless of treatment.

In BRT1, percent cover of shrubs increased in 2019 and 2020 regardless of treatment or not. In BRT2, percent cover of shrubs in plots that received fertilizer treatment increased in 2019. Coverage decreased in 2020. Coverage in plots that did not receive treatment remained similar in 2019 and increased in 2020.

In 2019, bare ground in BRT1 increased in plots that received fertilizer treatment. However, bare ground was likely a result of reduced invasive plant and forb coverage due to herbicide treatments in 2017. However, in these plots, bare ground decreased in 2020, after the first year of treatment. In 2019, bare ground in BRT2 decreased in plots that received fertilizer treatment with coverage remaining similar in 2020. For plots that did not receive fertilizer treatment (in BRT1 and BRT2) bare ground decreased in 2019 and decreased further in 2020.

In BRT1 and BRT2, percent cover of invasive forbs decreased to zero in 2019 regardless of treatment and remained at zero in 2020 (Table 2).

In summary, results were different between treatment units. Fertilizer did not appear to increase vegetation cover in BRT1. However, in BTR2, it appears that fertilizer allowed for forbs, bunchgrasses, and other grasses to substantially surpass 2017 pre-herbicide treatment results. Invasive plants were not

detected in either fertilized or unfertilized plots. In general, herbicide treatments to remove invasive plants has increased the cover of bunchgrasses and other grasses. In BRT2, it appears that fertilizer assisted with increase in forage species coverage where amount of bare ground was high (result of removal of invasive plants).

Figure 9: Plot BRT2-01 prior to herbicide treatment in 2017. Sulphur cinquefoil and spotted knapweed extensive.

Figure 10: Plot BRT2-01 in 2019 after herbicide treatment and fertilizer treatment.

Wigwam Flats

A total of 25 permanent vegetation plots were established within the treatment units on Wigwam Flats between 2017 and 2019 (Table 3). In 2019, 20 plots were sampled. Of those 20 plots, five plots were in WWT1 and five were in WWT6. Between WWT1 and WWT6, five plots received fertilizer treatment in 2019 (Table 3 and 4). In 2020, 14 plots were sampled including five plots in WWT1 and five plots in WWT6. In 2020, all plots in WWT1 received fertilizer treatment as there was still a high percentage of bare ground. Bare ground was minimal in WWT6 so therefore was not fertilized in 2020. Data analysis below only involves plots in WWT1 and WWT6.

Table 3. Summary of sampling and fertilizer treatments in treatment units WWT1 and WWT6 between 2017 and 2020.

TU WWT1	Sampled in 2017	Fertilized in 2019	Sampled in 2019	Fertilized in 2020	Sampled in 2020
Plot 1	Yes	No	Yes	Yes	Yes
Plot 2	Yes	No	Yes	Yes	Yes
Plot 3	Yes	Yes	Yes	Yes	Yes
Plot 4	Yes	Yes	Yes	Yes	Yes
Plot 5	No	Yes	Yes	Yes	Yes
TU WWT6					
Plot 1	Yes	No	Yes	No	Yes
Plot 2	Yes	Yes	Yes	No	Yes
Plot 3	Yes	Yes	Yes	No	Yes
Plot 4	Yes	No	Yes	No	Yes
Plot 5	No	No	Yes	No	Yes

Table 4: Total average percent cover of ground cover type for each treatment unit by treatment type (Pre-fertilizer, Year of Treatment, First year after fertilizer and no fertilizer) at Wigwam Flats study area, Spring 2017, 2019 and 2020.

Treatment	Year	Total Crypto gram	Total Shrub	Total Forbs	Total Bunch Grass	Total Other grass	Total Bare Ground	Total Invasive Forbs	Total Invasive Grasses*
WWT1									
Pre-Fertilizer	2017	24.5	25.2	9.5	1.0	13.4	11.3	11.0	0
Year of treatment	2019	11.3	19.3	5.3	8.7	18.1	31.1	0	0
1st year after treatment	2020	22.0	34.2	8.2	7.9	26.9	7.3	0.3	0
WWT1									
No Fertilizer	2017	33.5	33.6	10.4	4.2	3.7	11.5	12.7	0
No Fertilizer	2019	6.4	27.3	3.1	11.6	8.5	44.5	0	0
No Fertilizer	2020	10.5	27.9	3.8	14.1	16.7	16.0	1.2	0
WWT6									
Pre-Fertilizer	2017	17.7	14.9	7.9	26.6	1.6	2.5	24.5	0
Year of treatment	2019	41.7	0	7.6	21.8	20.8	5.4	0	0
1st year after treatment	2020	33.5	22.1	5.7	20.5	14.6	0.2	0	0
WWT6									
No Fertilizer	2017	35.0	20.4	5.6	27.9	3.4	1.0	2.8	0.8
No Fertilizer	2019	38.7	17.6	1.6	21.1	15.1	8.5	0	0
No Fertilizer	2020	16.5	20.7	0.4	22.2	11.3	1.5	0	0

*Invasive grasses = Cheat grass (*Bromus tectorum*)

Percent cover:

Overall forbs decreased in percent cover after herbicide treatments occurred in 2017. Overall, percent cover of forbs in fertilized plots in 2020 is approaching pre-herbicide treatment values (Table 4).

In WWT1, percent cover of bunchgrasses increased in 2019 regardless of treatment (Table 4). In 2020, percent cover of bunchgrasses in plots that received fertilizer treatment decreased and in plots that did not receive treatment the percent cover increased. In WWT6, percent cover of bunchgrasses decreased in 2019 regardless of treatment. In 2020, percent cover of bunchgrasses in plots that received fertilizer treatment decreased and in plots that did not receive treatment the percent cover increased

Percent cover of other grasses in WWT1 increased in 2019 and again in 2020 regardless of treatment (Table 4). In WWT6, percent cover of grasses increased in all plots in 2019 and decreased in all plots in 2020 regardless of treatment. However, other grasses have increased substantially since herbicide treatments in 2017 in both WWT1 and WWT6 regardless of fertilizer treatment.

In WWT1, percent cover of cryptogram in 2019 was less than pre-treatment coverage regardless of treatment (Table 4). In 2020, percent cover of cryptogram increased from 2019 coverage, but remained less than pre-treatment coverage. Conversely, percent cover of cryptogram in WWT6 was greater than pre-treatment coverage regardless of treatment in 2019. In 2020, percent cover was less than 2019 coverage.

In WWT1 and WWT6, percent cover of shrubs decreased in 2019 regardless of treatment (Table 4). In 2020, percent cover of shrubs increased in plots that received fertilizer treatment in WWT1 and in all plots in WWT6. Percent cover remained similar to 2019 coverage in the plots that did not receive fertilizer treatment in WWT1.

Bare ground in WWT1 and WWT6 increased above pre-treatment coverage in 2019, then decreased in 2020 regardless of treatment (Table 4).

In WWT1, percent cover of invasive forbs species decreased to zero in 2019 regardless of treatment (Table 4). In 2020, percent cover of invasive forbs in WWT1 increased slightly regardless of treatment. In WWT6, no invasive forbs species were recorded in 2019 or 2020, only pre-treatment.

No invasive grass species were recorded in WWT1 over all three years (Table 4). In WWT6, Invasive grasses were recorded in 2017 and not again in 2019 or 2020.

In summary, fertilizer did not appear to increase percent cover of bunchgrass or other grasses but did positively affect forbs. Forbs did increase in percent cover in fertilized plots in both WWT1 and WWT6 and were now approaching 2017 values (before herbicide use). In WWT1, the percent bare ground decreased more so in fertilized plots than in unfertilized plots. Invasive plants were not detected in WWT6 but were found in WWT1 at low percentages (less than 1.2%). In general, herbicide treatments to remove invasive plants has increased the cover of bunchgrasses and other grasses. Fertilizer and seeding did decrease the amount of bare ground in WWT1.

Figure 11: Plot WWT6-02 prior to herbicide treatment in 2017. High percent cover of hawkweed

Figure 12: Plot WWT6-02 in 2020 after herbicide treatment and fertilizer treatment

Figure 13: WWT1 area post herbicide treatment (very high concentrations of spotted knapweed) Oct 2018

Figure 14: WWT1 after herbicide treatment, seeding, fertilizing June 2020.

Precipitation Data

Between 2017-2020, annual precipitation was highest in 2017 (~391.8mm), however 2017 had the lowest amount of precipitation fall during the growing season (Figure 15). The highest amount of precipitation that fell during the growing season was in 2019 (~197 mm), which was just over 50% of the annual precipitation. Annual precipitation was lowest in 2020 (~275 mm); however almost half of it fell during the growing season (~129mm). Annual precipitation in 2018 (~354 mm) was less than in 2017, but more than in 2019. Approximately 44% of the annual precipitation for 2018 fell during the growing season (~156 mm).

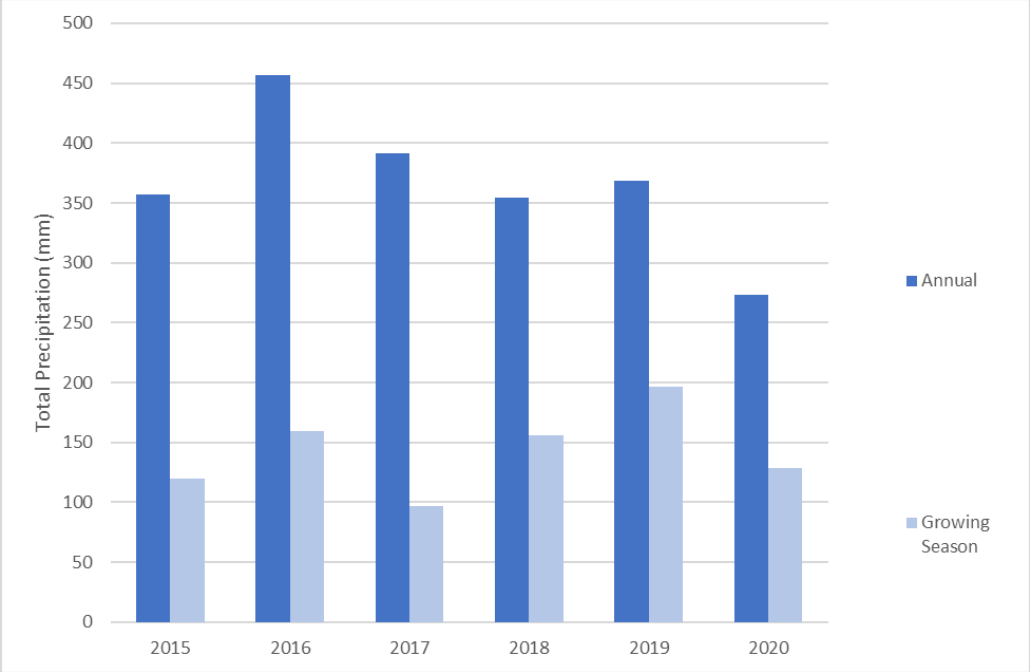

Figure 15. Total Annual Precipitation and Total Precipitation during the Growing Season (April 1 to August 31) at the Cranbrook Airport (YXC) for Years 2015 to 2020

Herbicide treatments

In May/June 2020, a total of 39 ha was covered by foot or ATV in Bull River and 93 ha in Wigwam Flats. A total of 3.7 ha was treated at Columbia Lake East. A total of 7.6 L of Milestone and 312 grams of Clearview were applied by backpack at Bull River. A total of 520 g of Reclaim was applied along roadways by ATV at Bull River. A total of 3.5 L of Milestone was applied by backpack at Wigwam Flats and a total of 54.2 L of Milestone was applied by ATV.

Efficacy of herbicide treatments at Bull River and Wigwam Flats was good for both methods. We used a combination of backpacking and boom spraying depending on terrain. Most of the ATV boom-spraying was cooperatively contracted by East Kootenay Invasive Species Council (EKISC).

Seeding/Fertilizing

In April 2019, in Bull River 400 kg of fertilizer was applied in 4.9 ha of BRT 1 and 2. In Wigwam Flats, 325kg was applied in 8.7 ha of WWT1 and 6. Fertilizer blend was 31-12-0-6.2S and nutrients per acre was 50 N- 20 P-10 S. In late April 2020, in Wigwam Flats, 1275 kg of fertilizer was applied in WWT1, WWT5 and small portion of WWT6 (outside plot area).

In late October 2020, 150 kg of orchard grass/sheep fescue/june grass/fall rye seed mix were placed in the Bull River primarily in the BRT5 area of Hatchery Ridge to try to outcompete persistent blueweed infestations. At Wigwam Flats, 100 kg of same seed mix was distributed in bare spots along the treated roadside and low slopes of WWT5.

Public education

Project goals, objectives and preliminary results have been communicated to BC Wildlife Federation, Wild Sheep Society of BC, local guide outfitters and interested members of the public.

Conclusions/Recommendations

Herbicide treatments targeted at invasive forb species in 2017 reduced the cover of native forbs as well (Phillips 2019). The herbicide used (Milestone) is not selective and affects all broadleaf plants. As a result, the percent cover of forbs in 2018 was much less than 2017 cover (Phillips 2019). However, native forbs showed some resilience to the herbicide treatments and the percent cover and species diversity started to increase in 2019 (Phillips 2020). A wet growing season and fertilizer treatments likely contributed to the recovery of native forbs in 2019. In 2020, percent cover of forbs continued to increase. It appears that in general native forbs responded to the fertilizer treatments.

Percent cover of bunchgrasses increased in 2020 regardless of treatment. It is likely the increase in bunchgrass cover is a response to the wetter growing season in 2019. There were many anecdotal reports of vigorous bunchgrass growth around the region during the 2019 growing season (Phillips 2020). This aligns with the results in Bull River and Wigwam. In 2020, bunchgrass cover was reduced from 2019 cover. Precipitation in 2020 was less than 2019, possibly contributing towards reduced cover of bunchgrasses.

The growth of other grasses differed between the two treatment areas; however, other grasses overall appeared to respond to the fertilizer treatment. In 2019, percent cover of other grasses decreased in many

of plots at Bull River but increased in some (i.e. BRT2-02 and 09). With the wetter growing season, the percent cover was expected to increase such as it did for bunchgrasses. Nonetheless, in 2020, coverage of other grasses increased in the plots that received fertilizer treatment coverage and exceeded 2017 pre-herbicide coverage. At Wigwam Flats, percent cover of other grasses increased in all plots in 2019 regardless of treatment. Wetter conditions during the 2019 growing season likely contributed to some of the increase. In WWT1, coverage in other grasses continued to increase and in WWT6 coverage decreased, regardless of treatment. To reduce bare ground, WWT1 was seeded in 2018 and 2019. Seeding is likely contributing to the increase in percent cover of other grasses in WWT1.

Growth of shrubs differed in 2019 between Bull River and Wigwam Flats. At Bull River percent cover increased in 2019 regardless of treatment and at Wigwam Flats percent cover decreased regardless of treatment. To increase the sample size for fertilizer monitoring additional plots were added at both treatment areas in 2019. With an increased sample size, the 2019 summary stats for shrubs may be more indicative of what is present on the landscape within the treatment areas as the 2017 sample size was low (based on one to two plots). In 2020, percent cover was more consistent between the two treatment areas and the percent cover increased in many of plots. This growth is likely a response to the wetter growing season in 2019 and not to fertilizer treatments. In addition, anecdotally medium to tall shrubs were unaffected by herbicide use while some low growing shrubs likely were adversely affected.

Percent cover of bare ground was reduced in all plots in 2020. The reduction of bare ground was a desirable outcome as less bare soil that is available provides less opportunity for invasive plant species to re-establish.

In 2019, coverage of cryptograms decreased in all plots except WWT6. The reason for the reduction of cryptogram is likely a result of ongoing herbicide application. Data from 2019 shows a correlation between herbicide treatment and reduced cryptogram (Phillips 2020). In 2020, cryptogram cover increased (with the exception of WWT6) indicating a resilience to the herbicide treatments. Fertilizer and wetter conditions may also be contributing to recovery of cryptograms. The recovery reduces bare soil which is desirable for preventing invasive species from re-establishing.

Invasive forb species responded positively to herbicide treatments and no invasive forbs species were recorded within the plots in 2019. In 2020, the majority of plots remained free of invasive forb species. WWT1 was the exception. Unfortunately, two invasive species were recorded in WWT1 plots in 2020- St John's wort and sulphur cinquefoil. Both species were present in 2017 prior to herbicide treatment. It is difficult to say why these plants are in the plots again (e.g. seed bank in soil, seeds transported by animal, human or wind, or if seeds responded to fertilizer treatment).

Invasive grasses (i.e. cheatgrass) were recorded within plots at WWT1, BRT1 and BRT2 in either 2017 or 2019. In 2020, no invasive grasses were recorded within the plots at Wigwam Flats or Bull River.

Other

These data were presented with some caution. Growing conditions vary between years due to climatic conditions. Conditions may allow species to flourish one year and not in another causing variation in the percent cover. Efforts were made to be consistent regarding timing of vegetation monitoring, however variations occur regardless. In addition, when determining percent cover surveyors may not be consistent when estimating cover year to year even with field crews calibrating their estimates at the beginning of each field season.

As mentioned in the methods, data comparisons were made with a small sample size for each treatment unit (ranging from one to six plots). The sample size used in these comparisons is small relative to the area of the study area and should be interpreted with caution.

General

The health of bighorn sheep herds depends on high quality winter ranges. Reducing the spread of invasive plants in bighorn sheep winter ranges will increase the value of these ranges by improving habitat quality. Using an integrated and coordinated approach to control and manage invasive plants improves the success of the project. Invasive plants will never be eradicated. Ongoing management is required to reduce the adverse impacts they are having to the environment. Without active and continued management, important ecosystems will be lost permanently. If the spread of invasive plants, especially new aggressive invaders, is not controlled, important winter ranges will become less productive and carrying capacity for bighorn sheep, elk and deer will be drastically reduced thereby resulting in reduced ungulate populations, reduced ecosystem function, and decreased biodiversity.

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