



Ronald Lake Wood Bison Research Program: 2020 Semi-Annual Report

May 20, 2020

Lee J. Hecker^{1,2}, Lindsey T. Dewart^{1,2}, Darren M. Epperson^{1,2},
Garrett Rawleigh^{1,2}, Aidan C. Sheppard¹, Scott E. Nielsen¹,
and Mark A. Edwards^{1,2}

¹University of Alberta, Department of Renewable Resources

²Royal Alberta Museum, Department of Mammalogy



ROYAL ALBERTA
MUSEUM



UNIVERSITY OF
ALBERTA



APPLIED
CONSERVATION
ECOLOGY LAB

Table of Contents

Executive summary	2
Background	4
Research progress	7
Knowledge Gap 2a – How are wetlands used by bison in the winter?	7
Knowledge Gaps 2a, 2b, & 2c - How are different habitats used by bison within their range?	10
Knowledge Gaps 3c & 3e – What is the herd’s diet and how does it change seasonally?	12
Knowledge Gaps 4a, 4b, & 5a – How do anthropogenic and natural disturbances affect habitat selection?	16
Knowledge gap 4c - How do winter conditions influence bison movement and habitat selection?	18
Knowledge Gap 4c & 8e – How does potential wolf predation influence bison habitat selection?	22
Knowledge Gap 8c & 8G – What is the demographic structure of the RLBH?	28
Conclusions	31
Acknowledgements	32
Literature cited	33

*Cover photo credit to Lindsey Dewart (top) and Lee Hecker (bottom)

Executive summary

The Ronald Lake bison herd (RLBH) is a small population of wood bison (*Bison bison athabasca*) that is of cultural and ecological significance, and of management concern. Located on the northern fringe of the Alberta oil-sands region, the RLBH range falls within an area of ongoing and proposed increases in natural resource exploration and extraction. With the mandate to ascertain what information is needed for the sustainable management of the RLBH and its habitat, the RLBH Technical Team was formed. The Technical Team consists of representative members from regional Indigenous communities, industry, and federal and provincial governments. As part of their mandate, the Technical Team identified a series of knowledge gaps related to the herd's ecology that are needed for management. In 2013, researchers from the University of Alberta and Royal Alberta Museum were invited to develop a research program to help fill some of these knowledge gaps. Here, we provide an update on research activities conducted within this program since December 2019 (i.e., the semi-annual report), and describe methodologies related to research activities scheduled for 2020. Specifically, the knowledge gaps we report on here are:

- 2a – *How are wetlands used by bison in the winter?*
- 2a, 2b, & 2c – *How are different habitats used by bison within their range?*
- 3c & 3e – *What is the herd's diet and how does it change seasonally?*
- 4a, 4b, & 5a – *How do anthropogenic and natural disturbances affect habitat selection?*
- 4c – *How do winter conditions influence bison movement and habitat selection?*
- 4c & 8e – *How does wolf predation influence bison habitat selection?*
- 8c & 8g – *What is the demographic structure of the bison herd?*

Our investigations into these questions yielded several interesting results. Firstly, our examination of winter wetland forage sites reinforced the bison's preference for a suite of sedges (e.g., *Carex atherodes*, *C. utriculata*, *C. aquatilis*) as their primary winter forage. A seasonal breakdown of protein procurement revealed that the bison's primary source of protein was browse, although the percent of browse changed seasonally. Snow depth and temperature affected bison movement rates, with deeper snow inhibiting movement and warmer temperatures facilitating movement. Finally, bison kills were recorded for one of the three radio collared wolf (*Canis lupus*) packs occupying the RLBH range. Pooling data across all three packs, bison made up for 40% of the wolves' diets. Moose (*Alces Alces*) or white-tail deer (*Odocoileus virginianus*)

were the dominant prey items for each pack with wolf and black bear (*Ursus americanus*) also found in the wolves' diet.

In the spring and summer of 2020, we are proposing to conduct fieldwork related to: (1) the monitoring of water dynamics in wetlands that bison forage in versus others that they do not; (2) the long-term examination of habitat use by bison using scat surveys; and (3) investigating the influence of bottom-up mechanisms (i.e., forage quality and quantity) on bison habitat selection. Throughout 2020, we will also continue to analyze wolf diets, quality of bison forage, and wolf/bison habitat overlap as an indicator of potential predation pressure. Please note, that with the COVID-19 pandemic, the proposed fieldwork described within this semi-annual report is conditional of meeting safety precautions outlined by the University of Alberta and in accordance with the Alberta Health Services protocols and the Government of Alberta. An update on COVID-19 adaptations will be provided in the 2020 fall Annual Report.

Background

Located in northeastern Alberta, Canada, the Ronald Lake wood bison (*Bison bison athabasca*) herd (RLBH) is of cultural and scientific significance. This herd is small in number (ca. 200 individuals) and named after a large lake approximately in the center of their annual range. A genetic inventory of bison herds in northern Alberta and Northwest Territories found that the RLBH is distinguishable among the populations in these regions with less genetic introgression from plains bison than the neighboring bison herds in Wood Buffalo National Park (WBNP; Ball et al. 2016). The RLBH is further distinguished from neighboring WBNP herds by the apparent lack of diseases from domestic animals like brucellosis and bovine-tuberculosis, which are present in WBNP herds (Shury et al. 2015). Due to its significance, the RLBH holds a status of *Subject Animal* under Alberta's Wildlife Act along with the *Threatened* status wood bison hold in Canada (AEP & ACA, 2017).

The RLBH has a range that expands from the southeast corner of WBNP south into the Alberta oil-sands region bounded by the Birch Mountains and Athabasca River to the west and east, respectively. In addition to natural disturbances like wildfire, the RLBH range experiences active timber harvesting and oil exploration operations. To improve the ecological understanding of the RLBH and its habitat, which is essential to guiding the sustainable management of the herd, the RLBH Technical Team was established. This team consists of representative members from regional First Nations and Métis communities, industrial parties, and provincial and federal government agencies.

The RLBH Technical Team identified a number of important ecological knowledge gaps (Table 1), which at the request of the Technical Team are being addressed by University of Alberta and Royal Alberta Museum researchers under a grant supported from matching funds from industry and the federal government (NSERC). Using data provided by Alberta Environment and Parks from GPS radio-collars fitted to 63 bison (5 male, 58 female), the researchers have investigated (1) seasonal/annual ranges, (2) seasonal changes in habitat quality, (3) bison movements, (4) elements regulating the herd's range, (5 & 6) mechanisms influencing habitat selection, and (7 & 8) reactions to anthropogenic disturbances (Tan et al. 2015, DeMars et al. 2015, DeMars et al. 2016, Belanger et al. 2017, Belanger et al. 2018, DeMars et al. 2019, Hecker et al. 2019a, Hecker et al. 2019b, Belanger et al. 2020). Notable conclusions from this work include:

1. The same annual range is used regularly with predictable, seasonal changes;
2. The use of habitats in the spring (western range) coincide with areas of higher quality forage when compared to the rest of their range;
3. A spring migration of all females in the herd using two distinct corridors, likely coinciding with calving, to a western range that is generally not used in other seasons;

4. The region separating WBNP herds and the RLBH is dominated by landcover types generally avoided (e.g., mixedwood, shrubby, and tamarack swamps) by the RLBH during all seasons;
5. Habitats rich in graminoids (i.e., grasses, sedges) are especially selected during winter;
6. Summer habitats with high forage biomass have less stable footing and more biting insects creating trade-offs between forage and predation;
7. Females avoid disturbances with ongoing industrial activity (i.e., oil sands exploration and forestry), but not those without activity, while the small sample of males assessed were unaffected by anthropogenic activity; and
8. Movement rates are marginally faster on linear disturbances compared to other habitats suggesting use of these features for movements and thus possibly less value as forage.

In this semi-annual report, we summarize the research conducted since December 2019 (Hecker et al. 2019b), build upon earlier results, and describe the research planned for the remainder of 2020. As stated in the Executive Summary, an update on research conducted over the spring and summer 2020 and any adaptations based on the COVID-19 pandemic response will be provided in the 2020 Annual Report.

Table 1: Knowledge gaps identified by the Ronald Lake Bison Herd Technical Team that are reported on here, completed, or are ongoing as conducted by the University of Alberta and Royal Alberta Museum researchers.

Theme	Gap #	Project	Status	Citation
Bison range	1A	Season & sex-specific ranges	Complete (future updates)	DeMars et al. 2016
Bison range	1B	Northern extent (limits)	Complete	Hecker et al. 2019b
Bison range	1D	Migration routes	Complete (future updates)	Hecker et al. 2019b
Habitat - Landcover	2A	Wetlands	Update in this report	Hecker et al. 2019b
Habitat - Landcover	2B	Human disturbances (energy)	Update in this report	DeMars et al. 2019
Habitat - Landcover	2C	Human disturbances (forestry)	Update in this report	Belanger et al. 2018
Habitat - Landcover	2D	Natural disturbances (fire)	Complete (future updates)	DeMars et al. 2016
Forage (bottom-up)	3A	Greenup/phenology	Ongoing	Hecker et al. 2019b
Forage (bottom-up)	3C	Forage quantity/quality	Update in this report	Hecker et al. 2019b
Forage (bottom-up)	3E	Anthropogenic changes	Update in this report	Hecker et al. 2019b
Habitat use	4A	Wallows & water	Update in this report	Belanger et al. 2018
Habitat use	4B	Trade-offs (insects/ground)	Complete	Belanger et al. 2020
Habitat use	4C	Winter snow	Update in this report	Hecker et al. 2019b
Habitat use	5A	Anthropogenic disturbances	Update in this report	Hecker et al. 2019b
Popln ecol (top-down)	4C/8E	Wolf predation	Update in this report	Hecker et al. 2019b
Popln ecol (top-down)	8C/G	Cow-calf & age structure	Update in this report	Belanger et al. 2018
Future scenarios	6A/C	Habitat supply forecasts	Ongoing / future work	

Research progress

Knowledge Gap 2a – How are wetlands used by bison in the winter?

Research objectives

The objective of this section is to understand what environmental factors influence bison use of wetlands and the selection of forage within those wetlands. Winter in northern ecosystems is a period when wood bison rely almost exclusively on graminoid-dominated wetlands for sustenance due to a shortage of alternative forage (Jung 2015). In winter, wetlands become more accessible because of the frozen ground, and have the highest available biomass, which results in an increased selection by wood bison (Strong and Gates 2009). Here, we examine this relationship for the Ronald Lake wood bison herd (RLBH).

Overview of research methods

We visited clusters of bison locations provided by GPS-collared bison and searched for recent craters, areas where bison have pushed snow aside to access the forage beneath. These clusters were selected by examining recent (less than 7 day old) GPS locations and choosing points accessible by trail or snowmobile. After locating craters, we measured a suite of environmental factors to understand how they influence foraging site selection by bison. These factors include snow characteristics (i.e., depth, density, crust hardness), crater size, distance to cover, wetland area, and vegetation characteristics. We measured snow depth to the nearest 0.5-cm beyond the crater edge in undisturbed snow, and for large craters, we took the average of up to three snow depth measurements (Fortin 2005). Crater area was measured by walking the perimeter of craters with a handheld GPS unit. Using a snow-metrics snowboard sampler, we recorded the density of snow at each site using the same locations as the depth measurements. Snow crust hardness was recorded as the presence or absence of a crust, and when present, hardness was measured using the hand-hardness test (Höller and Fromm 2010). Daily changes in snow depth are being measured using trail-cameras that take two pictures per day, around noon, of two to three snow gauges per camera (Figure 1). We visually identified vegetation at the foraging site to the species level when possible and recorded the intensity of grazing for each species observed, while also collecting vegetation clippings to confirm identification in the lab. As a comparison, the same variables were measured at non-use sites located near each distinct crater, selected by availability of vegetation and absence of crater evidence or grazing.



Figure 1: An example of a station for monitoring snow depth in a marsh. The yellow and white boards are our snow gauges, measuring snow depth to the nearest 5-centimeters.

Progress / results

We collected data from 86 forage (used) sites and 86 non-used wetland sites between January and March 2020 and are now in the preliminary stages of analysis. Early patterns suggest that bison prefer to forage on specific sedge species such as, slough sedge (*Carex atherodes*), water sedge (*C. aquatilis*), and common yellow lake sedge (*C. utriculata*), as they occurred most often as primary or secondary forage types in craters and were grazed more intensely than any other available forage species including: cattail (*Typha* spp.), willow (*Salix* spp.), and Canadian reedgrass (*Calamagrostis canadensis*) (Figure 2).

Outstanding / upcoming work

During the summer of 2020, we will install water monitoring stations in several wetlands within the Ronald Lake area. These stations will be used to better understand how seasonal hydrology affects the plant species available to bison within wetlands.

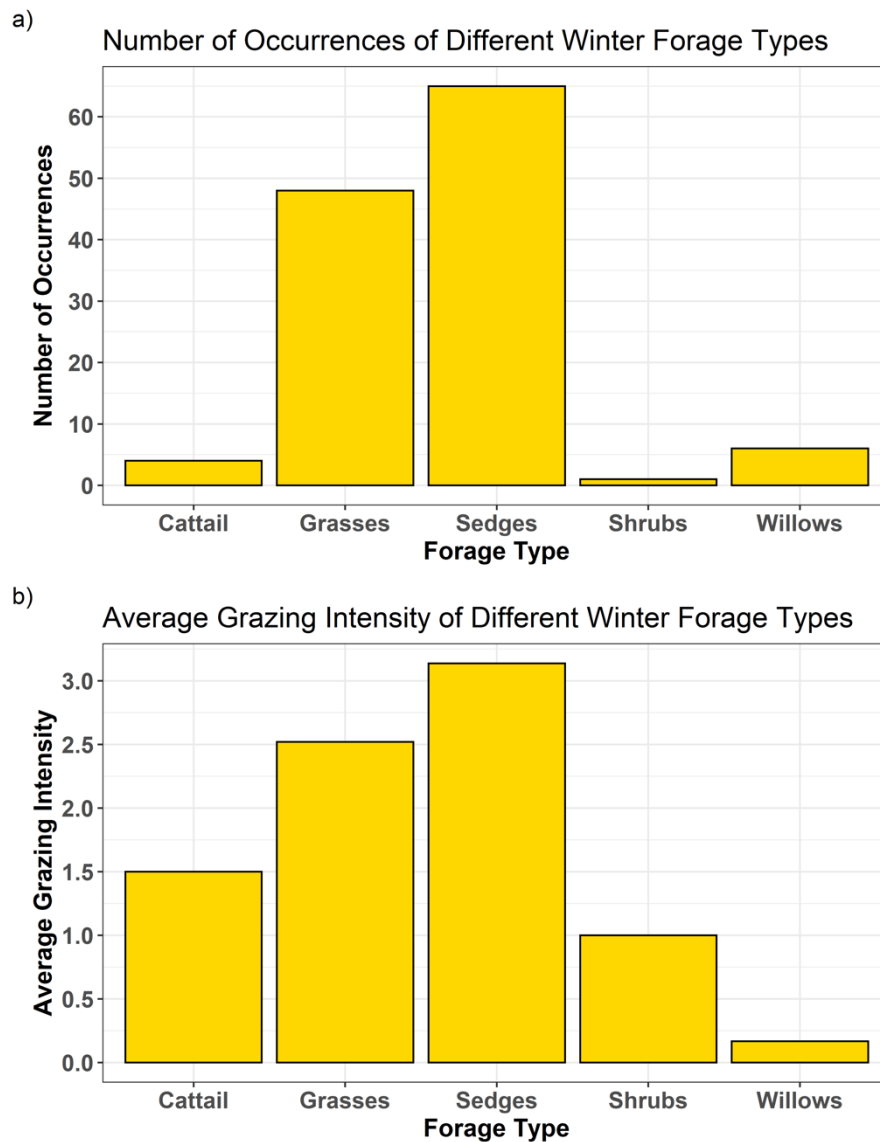


Figure 2: Summary graphs showing (a) the number of encounters of each forage type as either the primary or secondary vegetation in wetland craters of wood bison (*Bison bison athabasca*) during the winter of 2020 in the Ronald Lake area, and (b) average grazing intensity of each forage type encountered as the primary or secondary forage type in a wetland craters of wood bison in the winter of 2020.

Knowledge Gaps 2a, 2b, & 2c - How are different habitats used by bison within their range?

Research objectives

Our objective here is to estimate and monitor seasonal habitat use of different landcover types, including anthropogenic disturbances, by bison and where present other wildlife. Specifically, by using plot-based animal scat surveys, we test an approach for long-term, non-invasive monitoring of the RLBH. Plot-based scat surveys that are independent of GPS radio-telemetry are non-biased regarding herding behaviour of animals and, in case of collar failure, are a low-cost method for long-term monitoring habitat use by the bison and possibly trends in their numbers (Alves et al. 2013).

Overview of research methods

In 2018, we established 17 permanent plots located in four different landcover types (i.e., marshes, upland deciduous, upland pine, and bogs), and one anthropogenic disturbance type (i.e., cutblock). Plots were created by arranging six T-posts in a rectangular pattern encompassing a 500-m² area that is open, allowing free movement of wildlife. To establish the initial count, we counted, recorded, and removed all scat deposits within the plots. Surveys were conducted annually at two different times, each representing a six month season. The first being the snow-free periods measured between late September to early October prior to full leaf fall and the second in late April to obtain counts over the winter period (October – April) and before the start of the growing season (i.e., snow-free period). Two observers surveyed each plot, counting individual scat deposits and identifying them to species. All scat encountered in the plot are then removed from the plot. Thus, we measure scat accumulation per unit area for each habitat for each 6-month season (winter vs. growing season). Because detectability rates of scat differ between landcover types and seasons (Alves et al., 2013), we increased our detectability and thus accuracy by resurveying each plot twice using two observers each time, with the second pass being perpendicular to the first. These counts are used to calculate relative habitat use of bison by landcover types and overlapping use by other species.

Progress / preliminary results

The 2018 – 2019 scat counts exhibited a small seasonal shift in the use of landcover types by bison. While the dominant winter habitat used was marsh, we also observed winter use of bogs, cut-blocks, and upland pine forest habitats. We observed an increase of summer bison activity within the upland deciduous habitats, while no summer use for the other land cover types of pine, cutblocks, and bogs (Figure 3). In addition to using GPS locations and scat surveys, our plot-

based scat monitoring record habitat use for five landcover types, as well as the overlap with other species (e.g., moose, and bear). Bison, moose, and bear overlapped their use in pine, deciduous, marsh, cut block, and bog, with marshes predominantly used by just bison (Hecker et al. 2019b).

Outstanding / upcoming work

We plan to conduct our annual spring and fall surveys of the 17 long-term plots in May and October of 2020, respectively. Results will be reported in the 2020 annual report.

Knowledge Gaps 3c & 3e – What is the herd’s diet and how does it change seasonally?

Research objectives

The objectives of this research are to define seasonal and annual diets of bison and to assess corresponding changes in diet quality. Previously, we had conducted a review of bison diets across North America, which revealed a positive correlation between latitude and browse, lipid, and protein quantities in bison diets (Hecker et al. 2019b). Therefore, we hypothesized that high energetic requirements associated with living in the boreal forest will lead the RLBH to forage more on items like forbs (i.e., herbaceous vegetation) and browse that have higher levels of proteins and lipids, rather than strictly consuming graminoids (i.e., sedges and grasses).

Overview of research methods

We collected 129 fecal samples from bison to quantify seasonal diets for spring (n = 38), summer (n = 45), and winter (n = 46). For each season, we combined three to five fecal samples randomly to create 10 composite samples. Annual diets were estimated by amalgamating the results of all three seasons. Then, we shipped two replicates of each composite sample to the Jonah Ventures laboratory (jonahventures.com) for analyses of dietary composition using DNA barcoding techniques (Craine et al. 2015). Results report diet content based on a read count of unique DNA sequences, the number of times each unique DNA sequence was found in the sample. Each DNA sequence is associated with a unique plant species or a specific assemblage of plants in a genus or family. For the latter, we used data on forage biomass and observations of bison foraging (Belanger et al. 2018) to select the species most likely consumed by bison to represent that DNA sequence (King and Schoenecker 2019). The results of the DNA analysis of diet should be interpreted as what plants bison are acquiring protein from, not dry matter intake (Jorns et al. 2019). Therefore, the results are likely biased towards plants with higher protein content (e.g., forbs; Hecker et al. 2019b). Despite this potential bias, studies comparing diet analyses conducted using DNA barcoding and classic methods, like microhistology, yielded consistent results between methods (King and Schoenecker 2019).

In the spring and summer of 2018 and 2019, we collected samples of plants foraged by bison in the field. We visited locations provided by GPS collared bison within 14 days of the animal being there and searched the area within 15-m of the GPS location for signs of foraging activity. When foraging signs were observed, we clipped each vegetation sample in a fashion that mimics how bison foraged the plant. These samples will be analyzed for crude protein content and metabolizable energy to assess forage quality.

Progress / preliminary results

Annual diets contained 134 unique DNA sequences. Bison acquire 48% of their annual protein from browse items, 28% from forbs, 16% graminoids, and 9% “other” items such as mosses, horsetails, and lycopods. Less than 1% of the DNA sequences could not be identified (Figure 3). Prickly rose (*Rosa acicularis*), Bebb’s willow (*S. bebbiana*), and low bush-cranberry (*Viburnum edule*) were the dominant browse species across their annual diet. The dominant forbs included common fireweed (*Chamaenerion angustifolium*) and bur-reed (*Sparganium angustifolium*), while the dominant foraged graminoid was slough sedge (*C. atherodes*).

In spring, bison acquired 39% of their protein from browse items, 23% from graminoids, 23% from other sources primarily bogmoss (*Sphagnum* spp.), and 14% from forbs (Figure 4). Slough sedge was the single most dominant species. We observed the highest levels of “other” forage items, like bog moss and stiff clubmoss (*Spinulum annotinum*), and a coniferous browse item, jack pine (*Pinus banksiana*), during the spring. We interpret this as bison foraging lower to the ground on new growth, particularly in rich fens, which are landcover types that these bison select in the spring (DeMars et al. 2016), and in doing so are consuming these species incidentally.

During summer, bison acquired 53% of their protein from browse items and 45% from forbs. Graminoids and other forage items combined to contribute 3% of the protein (Figure 5). Prickly rose and common fireweed were the dominant species in the summer diets.

Protein in winter diets also primarily came from browse items contributing to 49% of the protein in the diet. Forbs contributed 25% of the protein, graminoid added 23%, and other forage items add an additional 2% (Figure 6). However, at the species level, bur-reeds and slough sedge dominated the RLBHs diet.

Outstanding / upcoming work

With the diet analysis complete, we are now turning our attention to forage quality. Vegetation samples are currently being prepared for shipment and analysis of quality in terms of crude protein and digestible energy. Results of the diet composition, forage quality, and habitat selection analyses will be used to generate models of nutritional carrying capacity for the RLBH.

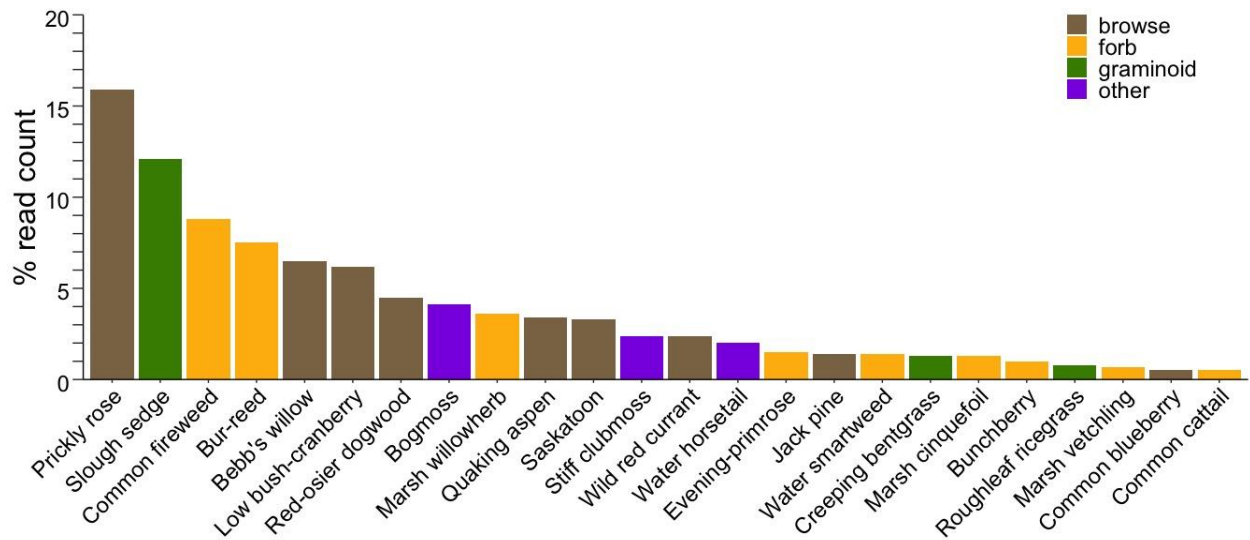


Figure 3: Annual diets of the Ronald Lake wood bison as analyzed using DNA barcoding techniques. Browse items are woody plants, forbs are herbaceous plants, graminoids are grasses and sedges, and other is a category of miscellaneous plants including mosses, lycopods, and horsetails.

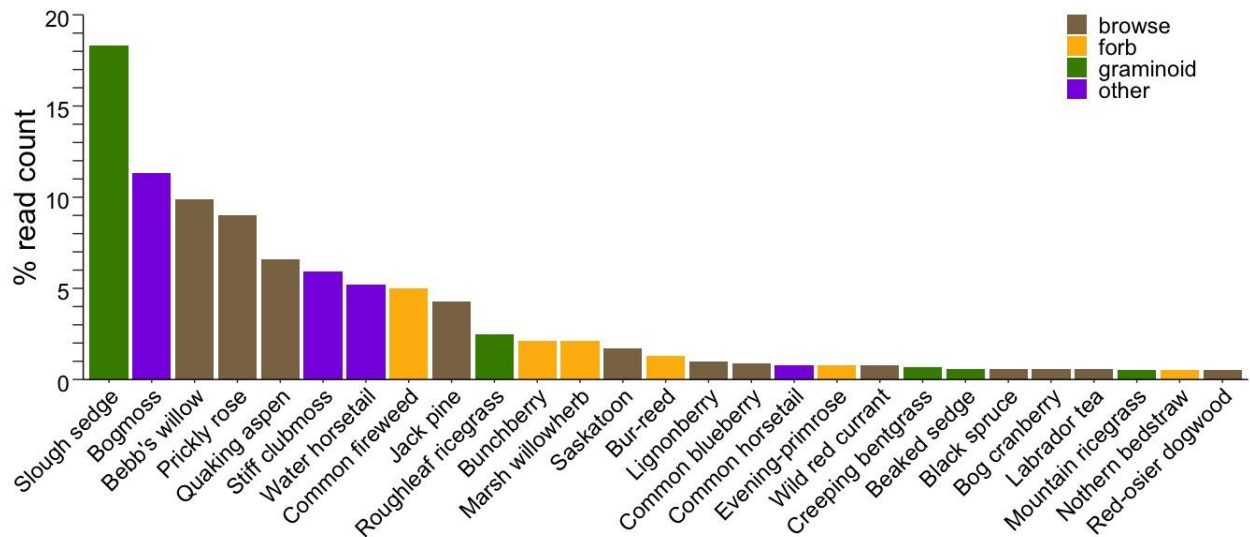


Figure 4: Spring diets of the Ronald Lake wood bison as analyzed using DNA barcoding techniques. Browse items are woody plants, forbs are herbaceous plants, graminoids are grasses and sedges, and other is a category of miscellaneous plants including mosses, lycopods, and horsetails.

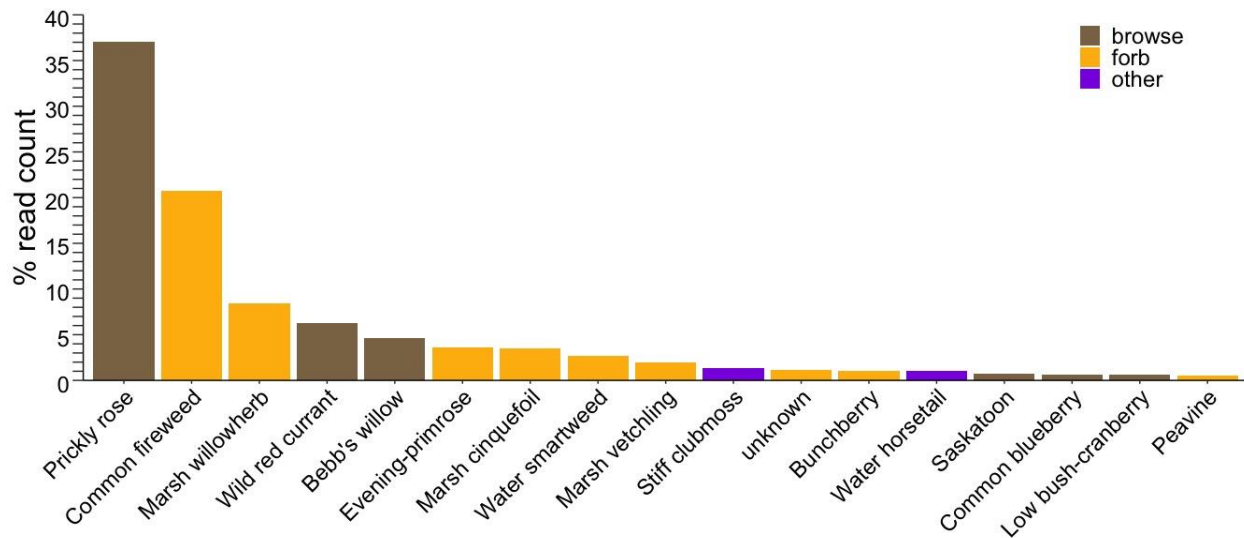


Figure 5: Summer diets of the Ronald Lake wood bison as analyzed using DNA barcoding techniques. Browse items are woody plants, forbs are herbaceous plants, graminoids are grasses and sedges, and other is a category of miscellaneous plants including mosses, lycopods, and horsetails.

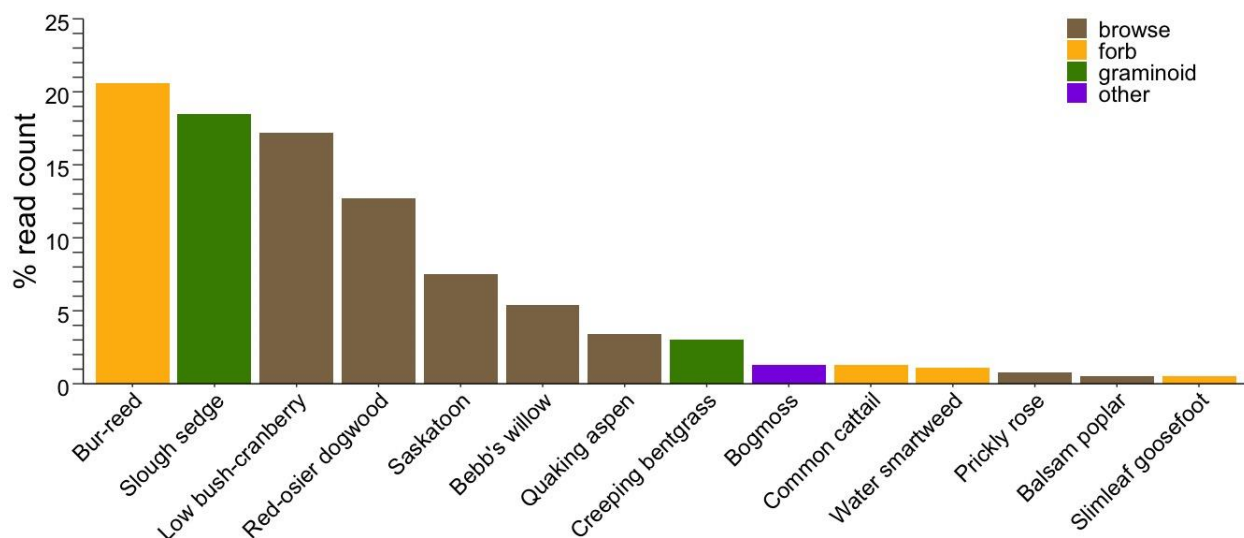


Figure 6: Winter diets of the Ronald Lake wood bison as analyzed using DNA barcoding techniques. Browse items are woody plants, forbs are herbaceous plants, graminoids are grasses and sedges, and other is a category of miscellaneous plants including mosses, lycopods, and horsetails.

Knowledge Gaps 4a, 4b, & 5a – How do anthropogenic and natural disturbances affect habitat selection?

Research objectives

Here, we seek to understand how bison habitat selection is influenced by changes in forage quality and quantity, and physical characteristics of the microhabitat. We are interested in how bison respond to changes in these habitat characteristics, in areas that have been disturbed by resource extraction-related activities (i.e., cutblocks, seismic lines, and well pads) and wildfires. Bison are known to select habitats with higher biomass of preferred forages (Fortin 2002), therefore we hypothesize that forage-related habitat characteristics will be the primary factor influencing habitat selection.

Overview of research methods

To explore habitat selection at the level of the herd, we are using third-order resource selection functions (RSFs) to assess differences between habitat characteristics at locations used by bison and random locations available to bison within the RLBH's range (Johnson 1980). We are stratifying bison use and available locations by landcover and disturbance type (Hecker et al. 2019b). A sample of bison use locations are being surveyed in the field within 14 days of the bison presence with a similar number of available (random) locations within each landcover group (i.e., an amalgamation of Duck Unlimited Enhanced Wetland Classification landcover types based on forage biomass; Hecker et al. 2019b) and disturbance type combination (e.g., seismic lines within upland deciduous forests). At all locations we are measuring biomass of functional forage groups (i.e., grass, sedge, forb, and browse), time since most recent burn, intensity of most recent burn, slope, aspect, ground firmness (substrate type + soil moisture), distance to nearest water source (lentic and lotic), distance to nearest graminoid-rich landcover group, canopy cover, tree density, shrub/sapling density, and coarse woody debris (CWD) density (Hecker et al. 2019a). We are also quantifying five bison behaviours (i.e., grazing, browsing, traveling, bedding, and wallowing) by measuring the area within each survey plot that contains signs of each behaviour.

We will analyze these data collected in the field using logistic regression treating the landcover groups and disturbance types as grouping factors.

Progress / preliminary results

In the spring and summer of 2018 and 2019 a total of 214 locations (i.e., 102 bison use, 112 available) were characterized in the field. RSF models generated from these data revealed that

bison selected habitats that lacked physical obstructions, such as coarse woody debris, shrubs/saplings, and trees (Hecker et al. 2019b). However, these models were not stratified by landcover group and disturbance type, which will require more data collection in the field.

Outstanding / upcoming work

We are proposing to finish habitat surveys at bison use and available locations through August of 2020, but may be limited due to COVID-19 restrictions. If surveys are completed, we will finalize analyses examining the influence of disturbances on bison habitat selection.

Knowledge gap 4c - How do winter conditions influence bison movement and habitat selection?

Research objectives

Our objective here is to describe how bison respond to winter conditions (i.e., snow and temperature). One key element of this is understanding how variations in snow dynamics differ spatially among landcover types and disturbances. Bison in other regions have been shown to have slower movement rates with greater snowpack, and while there is evidence that some northern ungulates are limited by cold temperatures, there are several examples of how bison are tolerant to the cold (Jung 2015). We therefore hypothesized that bison would not be cold-limited, but rather snow-limited in their movement activity. Additionally, we expected that warmer temperatures may increase their activity in any particular depth of snowpack and thus interact with snow depth to promote movement. Results from this study will be used to determine the influence of winter conditions on bison movement rates thus improving our understanding of winter movement ecology of wood bison.

Overview of research methods

We acquired location data from eight collared female bison from the winter of 2018/2019 as this is the first winter we have on-the-ground snow depth data (Hecker et al. 2019b). We removed records with no coordinate information or low fix accuracy with a dilution of precision value greater than 10-m (Bjørneraas et al. 2010). We defined winter as occurring from the first day of continuous snow cover (10 November 2018) to the last day of continuous snow cover (26 March 2019). We then split the winter in half and defined early winter as 10 November 2018 to 13 January 2019 (72 days), and late winter as 13 January 2019 to 26 March 2019 (72 days). For each individual we calculated mean daily movement rate in meters per minute (m/min) to standardize temporal comparisons of movement (Gurarie and Palm 2018; Johnson et al. 2002).

We used mean snow depth data from four of our winter snow camera stations dispersed across the Ronald Lake study area (Hecker et al. 2019b). We collected data on minimum and maximum temperature from the nearest available weather stations (Aurora and Mildred Lake; Alberta Agriculture and Forestry, 2020) and then calculated the average daily maximum and minimum temperature recordings from these two stations for our analyses (Figure 7).

We used Linear Mixed Models (LMMs) to assess the influence of snow depth, minimum temperature, and maximum temperature on movement rates during the early, late, and full winter periods of 2018 – 2019. We fit LMMs using the lme4 package (Bates et al., 2014) in R (R Core Team, 2019), with individual as a random effect to account for general variations in movement rates between individual bison. We modelled interactions between fixed effects to test the

hypothesis that it is the multiplicative effect of snow and temperature that is the important determinant of bison daily differences in movement rates.

Progress / preliminary results

For the full winter model, every 10-cm increase in snow depth resulted in a movement rate that decreased by 9.86-m/min when assuming temperature is equal to 0 °C. In contrast, a 1 °C increase in maximum daily temperature increased bison movement rates by 1.03-m/min when snow depth is equal to zero (Figure 8). A significant interactive effect between snow depth and maximum temperature predicted that the effect of snow depth on bison movement rates changed depending on temperature (Figure 8). At low temperatures, movement rates remained relatively low regardless of snow depth, but increased faster in shallow snow as daily maximum temperature increased.

In the early winter, every 10-cm increase in snow depth resulted in bison movement rates decreasing by 9.89-m/min, similar to the overall winter average. Additionally, for every one-degree C increase in maximum daily temperature, bison movement rates increased by 1.21-m/min, a rate that was higher than the overall average winter period. In the late winter, every 10-cm increase in snow depth resulted in bison movement rates decreasing by 9.77-m/min, similar to early winter. Unlike early winter, temperature was not important in predicting differences in movement rates in the late winter.

Outstanding/upcoming work

This work concludes our investigation of the influence of winter conditions on the RLBH's movement. Further research on bison movement rates could improve our understanding of the relationship between bison movement and the winter environment, especially that of male bison, which likely respond differently than females to snow and temperatures and overall may have different average activity (movement rates).

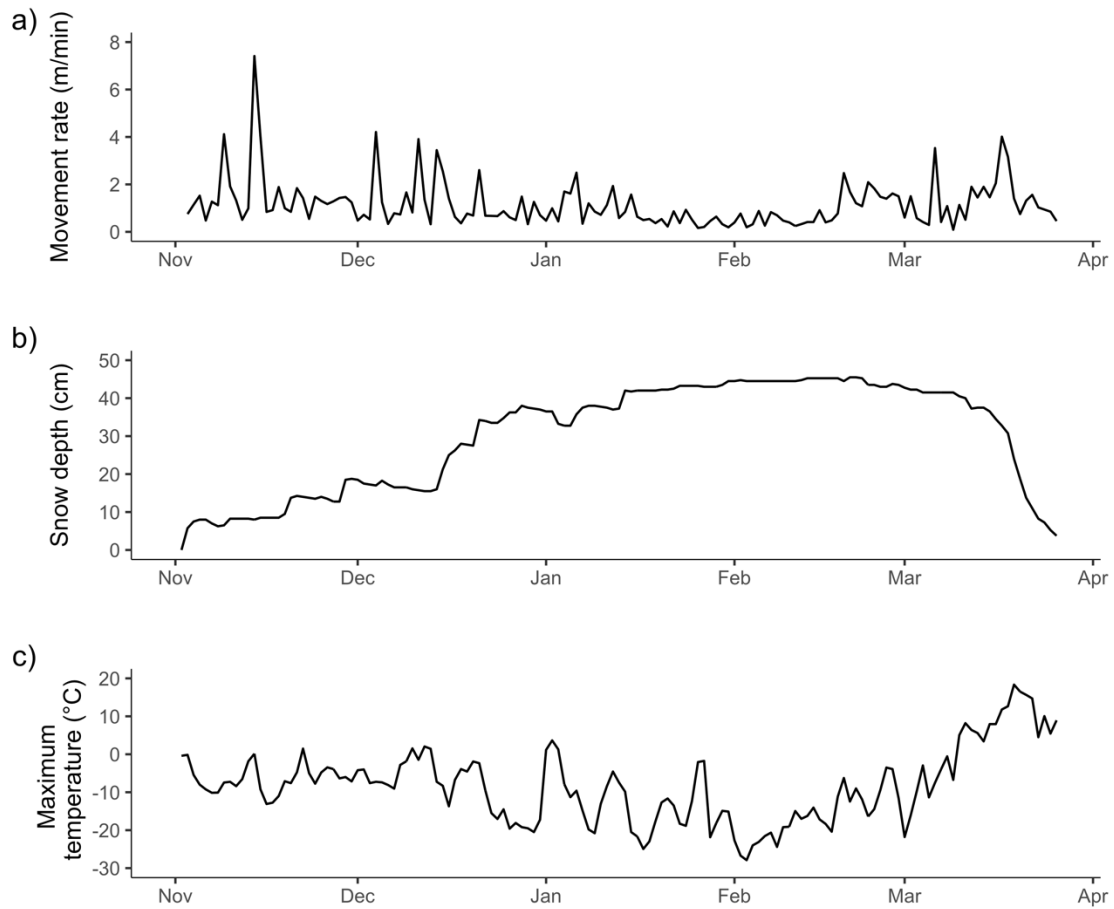


Figure 7: Summary graphs showing (a) example daily movement rate (m/min) for wood bison (*Bison bison athabasca*) individual 23277, (b) snow depth (cm), and (c) maximum temperature (°C) in the Ronald Lake study area, Alberta, Canada, during the winter of 2018 – 2019.

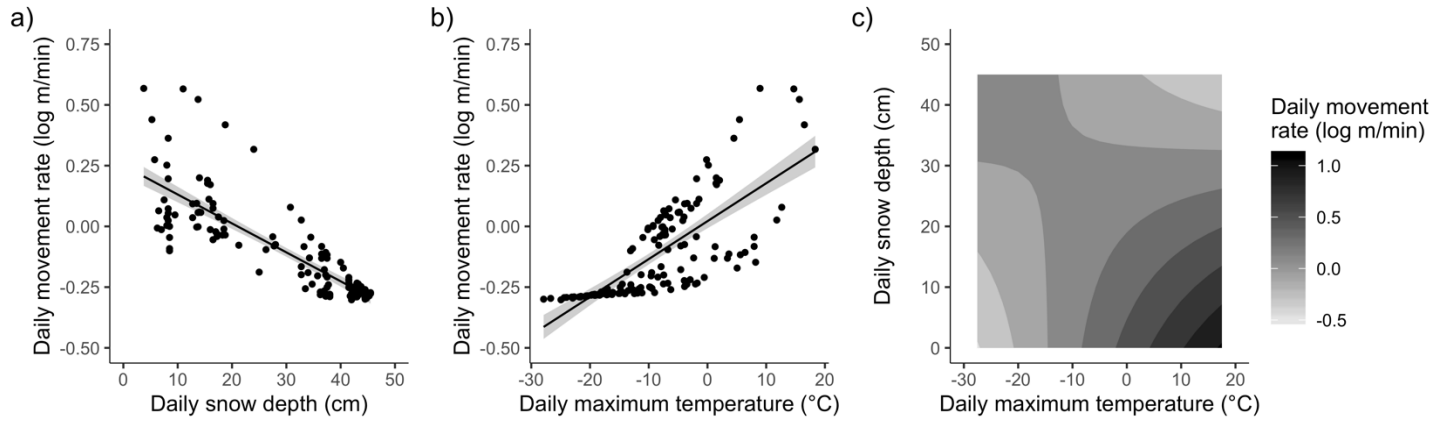


Figure 8: Predicted movement rate (log m/min) for (a) snow depth (cm), (b) maximum temperature (°C), and (c) the interaction between snow depth and maximum temperature for wood bison (*Bison bison athabasca*) individual 23277 from the Ronald Lake herd in Alberta, Canada, during the winter of 2018 - 2019.

Knowledge Gap 4c & 8e – How does potential wolf predation influence bison habitat selection?

Research objectives

The objective for this project is to better understand top-down (i.e., predation) influences on wood bison habitat selection. By studying the predator-prey dynamics between wolves (*Canis lupus*) and bison, we can better understand the spatial and temporal components of predation risk for bison. The investigation into this relationship includes determining the diet of wolf packs whose territories overlap with the herd's range. Environmental conditions and landscape features at wolf sites will be used to develop seasonal resource selection functions (RSF) to identify habitat characteristics that are important to wolves (Boyce and MacDonald 1999). Collectively, the wolf RSF, kill sites, and bison location data will be used to develop a predation risk model for the RLBH that will aid our understanding of where and when bison are most at risk.

Overview of research methods

We programmed GPS radio-collars at a 4-hour fix interval (Webb et al. 2008) and deployed them on wolves whose pack territories overlap the range of the bison, by use of aerial net-gunning in the winter and foothold-trapping in late summer. We determined the ranges of wolf packs using 95% utilization distributions (UDs) and compared their ranges overlap with the bison's 95% UD for the same time period (Worton 1989). Cluster analysis was used to identify potential kill sites that were prioritized by handling time (i.e., continuous time spent within a 150-m radius) and visited on the ground. Site investigations consisted of identifying the type of prey species and determining age, sex, and health if possible. Snow depth, density and crust layer were measured at the sites to formulate a continuous timeline of snow conditions throughout the season and habitat classifications (i.e., dominant tree/vegetation, water presence and type, habitat edge presence, cover, disturbance presence and type) were assigned to each site. Movements and habitat use of wolves and bison were monitored throughout the year and seasonal wolf RSF models are being developed to estimate encounter risk. The RSF models are developed by comparing habitat characteristics at wolf kill and use sites with random, available sites (Manly et al. 1993) broken into the summer (1 May – 31 Oct 2019) and winter (1 Nov 2019 – 31 April 2020) seasons. Results will allow us to estimate the spatial and seasonal pattern of predation risk for bison by wolves within the study area.

We also collected scat both opportunistically and at cluster sites to estimate wolf diet. The same number of collected scat samples were selected randomly from each wolf pack. To quantify wolf diets, prey remains, such as hair, feathers or small bones, were extracted from each sample and a subsample of these items were selected using the point-frame method (Ciucci et al. 2004). This

method assumes a random distribution of each item in the sample and requires a systematic selection of items that represent the overall contents of the sample. This method was found to reduce processing time by 85% and reduce observer subjectivity while producing the same level of accuracy in diet analysis compared to other methods (Ciucci et al. 2004). Impressions of the prey hair and feathers were made in a clear medium to easily view cuticle scale patterns through a microscope. These scale patterns were used to identify prey species by comparing to a reference collection and the use of “A Manual for the Identification of Hairs of Selected Ontario Mammals” (Adorjan and Kolenosky, 1969).

Progress / preliminary results

Five GPS radio-collars were deployed on wolves in January 2020 using aerial net-gunning, adding to the two existing wolves in the sample from the previous year (Note: one wolf died during capture operations; a necropsy performed by the provincial disease specialist and wildlife pathologist found blood in the lungs, however, no associated signs of trauma were identified). To date, collared wolves have provided movement data for three packs. These are the West, East, and South Packs named for their position relative to the study area. Monitoring for these packs has been continuous for 10, 11, and 3 months, respectively.

From aerial visuals and trail camera photos, we estimated the West Pack to have five to six adults with an annual range size of 1,759-km². They remained west of Ronald Lake and moved in and out of WBNP throughout the year (Figures 9, 10). The East Pack was estimated to have three adults and two pups in the summer season and two adults with no pups in the winter season with an annual range size of 1,901-km². Initially, their range was located between Ronald Lake and the Athabasca River and remained consistent in size throughout the summer season (Figure 9). However, during the winter, this pack moved south along the Athabasca River, through the South Pack territory, to settle just north of the Horizon oilsands mine (75-km north of Fort McMurray) in February 2020 (Figure 10). The South Pack was estimated to have nine to ten adults in the winter season and had a range spanning over 2,500-km². They moved extensively in and out of the other wolf pack territories (Figure 10). However, this range is only based on three months of location data and should be considered a preliminary estimate.

In summer, the West Pack’s home range of 1,112-km² overlapped with 58% of the bison’s range and the East Pack’s home range of 303-km² overlapped with 27% of the bison’s range. The combined total territory size of the two packs was 1,420-km², which overlapped 78% of the bison’s range (Figure 9 & Table 2). During winter, the West Pack territory of 1,600-km² overlapped with 79% of the bison’s range, the East Pack territory of 1,973-km² overlapped with 56% of the bison range, and the South Pack’s home range of 2,518-km² overlapped with 94% of the bison’s range. The combined territory size of the three wolf packs was 3,161-km², which overlapped 98% of the bison’s home range (Figure 10 & Table 2).

A total of 60 wolf cluster sites were visited this winter, 32 (53%) of which were confirmed kill sites. Of these 32 kill sites, remains of bison were only discovered at West Pack sites (one adult cow, one adult bull, one calf, and another suspected calf) that constituted 40% of the West Pack winter diet (Figure 11). Combining data from all three packs, moose consisted of 40.6% of the winter diets, while white-tailed deer consisted of 34.4%, wolf at 6.3%, and black bear at 6.3% (Figure 11). On average, the collared wolf packs killed one large mammal every nine days.

Scat content identification from the summer season has been completed and analysis is underway. The majority of the prey remains were identified as beaver (*Castor Canadensis*), followed by muskrat (*Ondatra zibethicus*) and to a lesser extent white-tailed deer (*Odocoileus virginianus*).

Outstanding / upcoming work

Identification of winter scat sample remains will be completed by mid-May to incorporate into the winter diet analysis. Summer season scat analysis is nearing completion and seasonal wolf resource selection functions are being developed to formulate bison predation risk models. To maintain monitoring of packs in the RLBH range, we plan to deploy collars on wolves in the summer of 2020, but see note on COVID-19 restrictions at the start of this document.

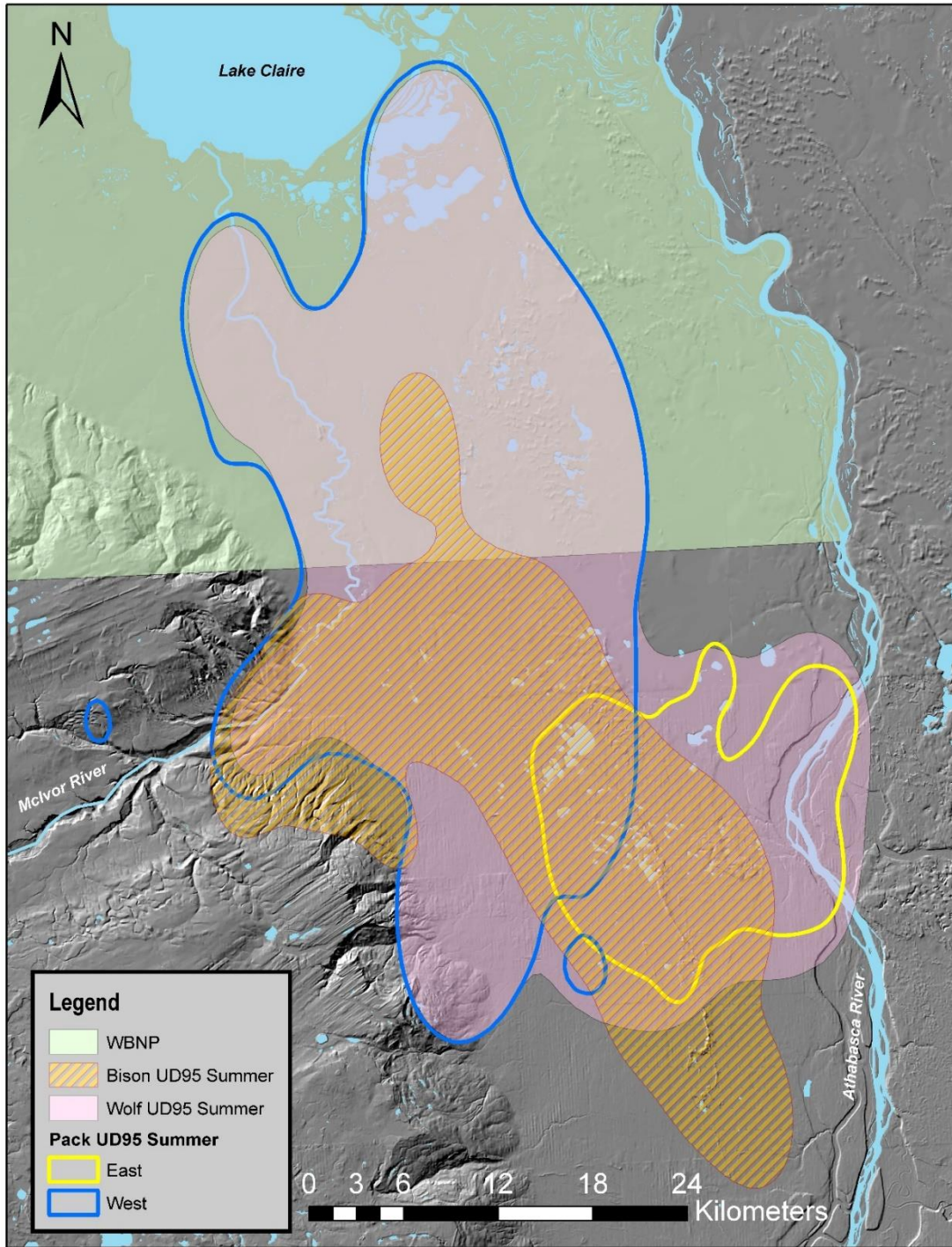


Figure 9: Summer season home ranges as 95% utilization distributions (UD95) of the Ronald Lake bison herd (orange scored), the West wolf pack (blue outline), East wolf pack (yellow outline) and both wolf packs combined (solid pink) based on locations between 1 May – 31 October 2019.

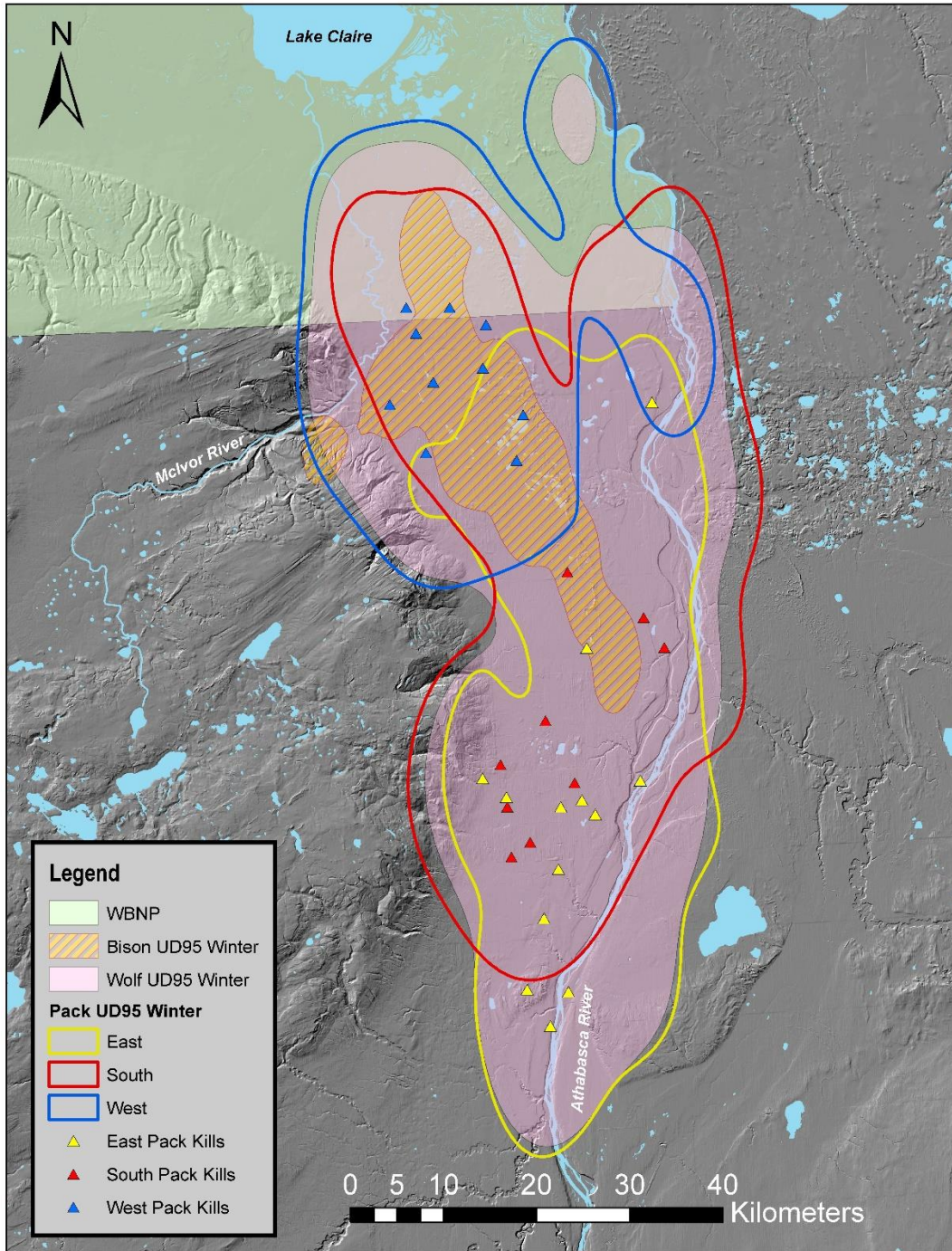


Figure 10: Winter season home ranges measured as 95% utilization distributions (UD95) for the Ronald Lake bison herd (orange scored), the West wolf pack (blue outline), East wolf pack (yellow outline), the South wolf pack (red outline) and all wolf packs combined (solid pink) based on locations between 1 Nov 2019 –30 March 2020. Triangles represent 32 kill sites visited from the West pack (blue), East pack (yellow) and South pack (red).

Table 2: Seasonal wolf pack home range (95% utilization distribution) sizes and percent overlap percentage of Ronald Lake bison herd's range in northeastern Alberta, Canada. The East and West wolf packs were monitored during the summer (1 May – 31 Oct 2019) and winter (1 Nov 2019 – 30 March 2020) seasons, while the South pack was only monitored for a portion of the winter.

	East	West	South*	Total
Summer 95% UD	303 km ²	1,112 km ²	NA	1,420 km ²
Summer % Overlap	26.7%	57.8%	NA	77.8%
Winter 95% UD	1,973 km ²	1,600 km ²	2,518 km ²	3,161 km ²
Winter % Overlap	56.4%	79.2%	93.6%	97.7%

* South pack only monitored from 22 Jan – 17 April 2020.

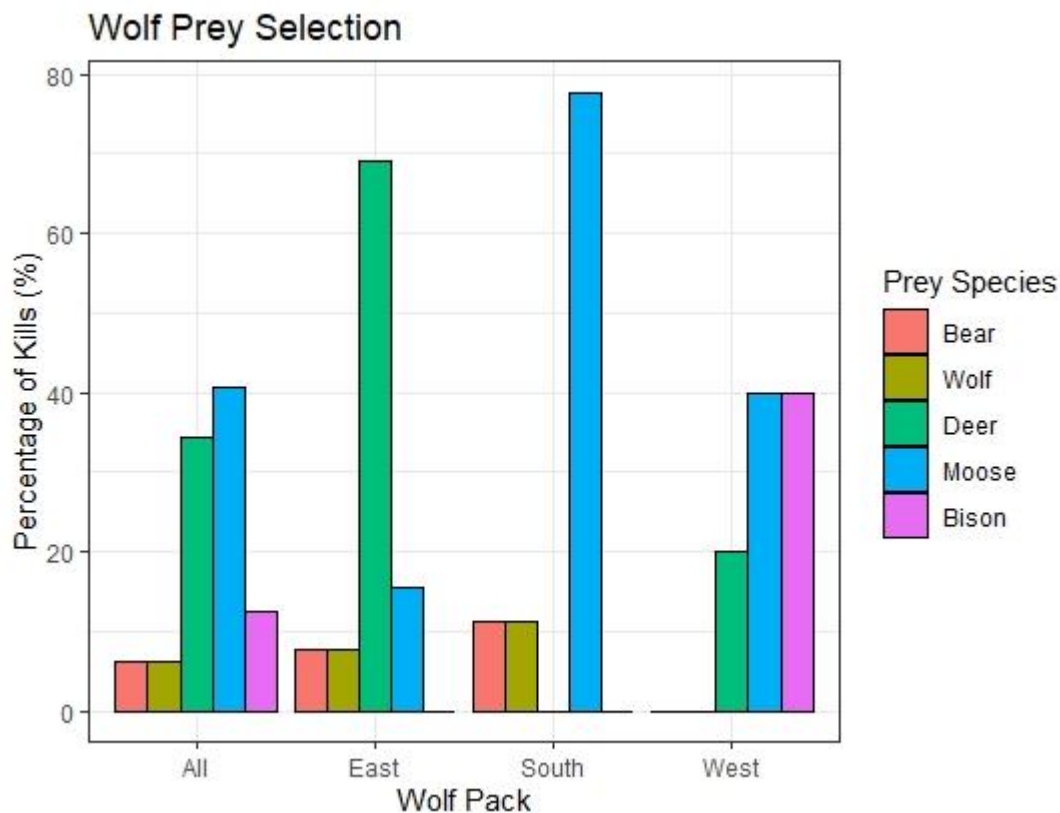


Figure 11: Wolf pack prey selection (percentages) estimated from a total of 32 kill sites visited between 1 Nov 2019 – 30 March 2020 through GPS collar cluster formations developed from three wolf packs in the Ronald Lake area of northeastern Alberta, Canada. Thirteen East pack kills sites were visited, along with ten West pack kill sites and nine South pack kills.

Knowledge Gap 8c & 8G – What is the demographic structure of the RLBH?

Research objectives

We conducted an exploratory analysis to determine if it was feasible to use camera traps from a large meadow at the center of their western, spring range (i.e., calving meadow) to estimate population demographics of the RLBH (Hecker et al. 2019a). Specifically, we attempted to estimate calf:cow, yearling:cow, and bull:cow ratios to infer fecundity, recruitment, and survival within the herd, respectively.

Overview of research methods

To account for temporal autocorrelation between photo events, we tested a series of independence intervals and quantified their influence on observed demographic patterns (Meek et al. 2014). For each independence interval, we systematically removed photographs of bison between events of interval size n , resulting in a subset of photos from which demographics could be estimated. We used 60 seconds as our baseline event interval during image processing. This meant that any bison recurring within the same event were not recounted, but any “new” bison entering the image frame in photos a minimum of 60 seconds after the last event, were counted as new individuals. We categorized bison into four age classes (calf, yearling, juvenile, adult) and sex. We classified events based on the change in time (ΔT) from the first photo of an event to the last photo of the previous event (e.g., all images within an event that starts 200 seconds after the end of the last event would therefore be classified as “ $\Delta T = 200$ ”). We then filtered events in our yearly dataset of images based on their ΔT class, returning varying bison abundance values. There were a few special cases that we included in our analyses regardless of their ΔT classification. These included: (1) the first bison event for a camera; (2) a bison event occurring after a wind event; and (3) a bison event occurring after another species event. We hypothesized that age ratios would be inversely related to the independence interval, as an increased number of excluded photographs would return fewer age classes with low detection probabilities (i.e., calves, yearlings, and juveniles).

Progress / preliminary results

Due to the high density of camera traps in this area, repeated captures of unmarked individuals in high numbers made it difficult to readily apply a method of calf:cow ratio estimation. The highly social nature of wood bison and close proximity of camera traps within the intensely used calving meadow violated assumptions of spatio-temporal independence necessary for a robust and systematic assessment of herd population parameters (Meek et al., 2014). Calf:cow ratios

varied considerably between camera stations, and no reliable trends were observed from temporal resampling of data from which we could have inferred demographic patterns (Figure 12).

Outstanding / upcoming work

We relocated camera traps to movement corridors (Hecker et al. 2019b) outside of the calving meadow in March 2020 to contribute to future estimations of herd demographics. A comprehensive study design that accounts for the unmarked and social nature of the RLBH is necessary to attain an accurate estimate of herd demographics and population trends. In the future, camera traps should be deployed with the specific intention of estimating population parameters. Additionally, systematic and consistent camera deployment techniques should be implemented and recorded accurately to ensure the viability of future camera trap analyses.

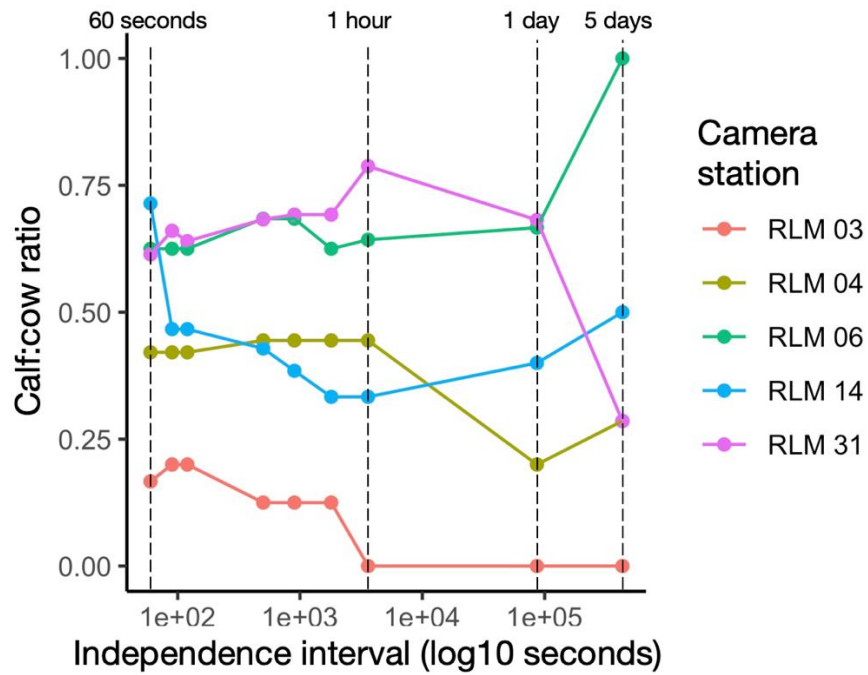


Figure 12: Cow:calf ratios as a function of camera independence interval for the Ronald Lake wood bison from 2016 to 2018. Camera independence interval represents the threshold applied under each scenario to systematically remove photos to avoid temporal autocorrelation among bison detections on cameras.

Conclusions

In this report, we build on our current understanding of the ecology of the Ronald Lake wood bison herd (RLBH) with the work conducted to date addressing knowledge gaps identified by the RLBH Technical Team. We started an investigation of the herd's winter foraging behaviour by visiting recently foraged craters and measuring the environmental characteristics present. The preliminary analysis of these sites reinforces bison's preference for sedge species during the forage-limited winter season. We continued monitoring our previously established wildlife plots to continue understanding relative use of different landcover types by bison and, secondarily, by other wildlife in the Ronald Lake area. Through analysis of fecal samples, we quantified the seasonal change in bison diet, focusing currently on where bison acquire protein in different seasons. Bison protein sources primarily came from browse items in all seasons, but showed shifts in diet content through spring, summer, and winter. We discussed plans to continue the examination of bottom-up influences (i.e., forage quality and quantity) on habitat selection at the herd level during spring and summer of 2020. We found bison movement rates in winter were significantly affected by winter conditions (i.e., snow and temperature). As predicted, deeper snow decreased winter movements of bison, while warmer temperatures facilitated increases in movement. Through kill site visits and scat analyses of wolf diets, we are quantifying wolf predation on the herd. During the winter, bison made up 12.5% of the wolf's diet, with the remaining 87.5% of their diet composed of moose, white-tail deer, other wolves, and black bear. However, only one of the three wolf packs killed bison. Lastly, we attempted to understand the demographic structure of the RLBH using camera traps in a meadow within the western spring range during the calving season. However, the high density of traps within a small area intensely used by bison did not provide clear answers about the herd's structure. We recommend a shift in focus of camera traps to the key migration corridors associated with the spring range; this is currently being implemented. Throughout the remainder of 2020, we are continuing work to address the knowledge gaps outlined in this report.

Acknowledgements

There are a number of people and organizations we would like to thank for making this research possible. We thank our partners Craig Dockrill, Joann Skilnick and Troy Hegel from Alberta Environment and Parks, and Karen Halwas and Neil Sandstrom with Teck Resources Ltd. We would like to acknowledge the following local community members and trappers for their assistance: Roy Ladouceur, Mike Berdinski, and Chuck Shovelup. We are also thankful for all the field technicians that have helped with data collection: Alex Coley, Melissa Dergousoff, Ashley Hillman, Neal Josephs, and Adam Scharnau. We are thankful for the support of the Ronald Lake Bison Herd Technical Team. Further, we are especially grateful to the Treaty 8 First Nations that sit on the Technical Team, including Athabasca Chipewyan First Nation, Mikisew Cree First Nation, Fort MacMurray First Nation #468, and Fort McKay First Nation, and for the Métis Indigenous groups that are involved with the Technical Team, including Fort Chipewyan Métis Local 125, Fort McMurray Métis Local 1935, Fort McKay Métis 63, and Lakeland Métis Local 1909. Finally, we would like to thank our funders Teck Resources, the Natural Sciences and Engineering Research Council (NSERC), the Alberta Conservation Association, the Northern Scientific Training Program, and the University of Alberta's Northern Research Awards.

Literature cited

- Adorjan, A.S, and G.B. Kolensosky. 1969. A manual for the identification of hairs of selected Ontario mammals. Department of Lands and Forest Research Branch 90 pp.
- Alberta Agriculture and Forestry. 2020. Alberta Climate Information Service (ACIS). Alberta Government. <https://acis.alberta.ca>
- Alberta Environment and Parks and Alberta Conservation Association. 2017. Status of the American Bison (*Bison bison*) in Alberta: Update 2017. Alberta Environment and Parks. Alberta Wildlife Status Report No. 38 (Update 2017). Edmonton, AB. 134 pp.
- Alves, J., A.A. da Silva, A.M. Soares, and C. Fonseca. 2013. Pellet group count methods to estimate red deer densities: Precision, potential accuracy and efficiency. *Mammalian Biology*. 78(2):134-141.
- Ball, M.C., T.L. Fulton, and G.A. Wilson. 2016. Genetic analyses of wild bison in Alberta, Canada: implications for recovery and disease management. *Journal of Mammalogy*. 97(6): 1525-1534.
- Bates, D., M. Mächler, B. Bolker, and S. Walker. 2014. Fitting Linear Mixed-Effects Models using lme4. *ArXiv:1406.5823 [Stat]*. <http://arxiv.org/abs/1406.5823>
- Belanger, R.B., C.A. DeMars, L.J. Hecker, M.A. Edwards, and S.E. Nielsen. 2017. Ronald Lake wood bison annual report: November 30, 2017. Ronald Lake Bison Report. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 76 pp.
- Belanger, R.J., L.J. Hecker, L.T. Dewart, S.E. Nielsen, and M.A. Edwards. 2018. Ronald Lake Wood Bison Research Program: Annual Report 21 December 2018. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 30 pp.
- Belanger, R.J., M.A. Edwards, L.N. Carbyn, and S.E. Nielsen. 2020. Evaluating trade-offs between forage, biting flies, and footing on habitat selection by wood bison (*Bison bison athabasca*). *Canadian Journal of Zoology*. 98(4):254-261.
- Bjørneraas, K., B. Van Moorter, C.M. Rolandsen, and I. Herfindal. 2010. Screening global positions system location data for errors using animal movement characteristics. *Journal of Wildlife Management*. 74(6):1361-1366.

- Boyce, M.S., and L.L. McDonald. 1999. Relating populations to habitats using resource selection functions. *Trends in Ecology and Evolutions*. 14(7):268-272.
- Ciucci, P., E. Tosoni and L. Boitani. 2004. Assessment of the point-frame method to quantify wolf *Canis lupus* diet by scat. *Wildlife Biology*. 10(1):149-153.
- Craine, J. M., E. G. Towne, M. Miller, and N. Fierer. 2015. Climatic warming and the future of bison as grazers. *Scientific Reports*. 5(2015): 16738.
- DeMars, C.A., S.E. Nielsen, and M.A. Edwards. 2015. Ronald Lake Bison (*Bison bison*): Project Update. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 26 pp.
- DeMars, C.A., S.E. Nielsen, and M.A. Edwards. 2016. Range use, habitat selection and the influence of natural and human disturbance on wood bison (*Bison bison athabasca*) in the Ronald Lake area of northeastern Alberta. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 80 pp.
- DeMars, C.A., S.E. Nielsen, and M.A. Edwards. 2019. Effects of linear features on resource selection and movement rates of wood bison (*Bison bison athabasca*). *Canadian Journal of Zoology*. 98(1):21-31.
- Fortin, D. 2002. Optimal searching behaviour: the value of sampling information. *Ecological Modelling*. 153(2002):279-290.
- Fortin, D. 2005. Elk winter foraging at fine scale in Yellowstone National Park. *Oecologia*. 145(2):335- 343.
- Gurarie, E., and E. Palm. 2018. Modern Tools for Spatial Modelling and Animal Movement Analysis. University of Maryland, College Park, Maryland, 20742. https://terpconnect.umd.edu/~egurarie/teaching/SpatialModelling_AKTWS2018/index.html
- Hecker, L.J., L.T. Dewart, R.J. Belanger, S.E. Nielsen, and M.A. Edwards. 2019a. Ronald Lake wood bison research program: Semi-annual progress report 2019. University of Alberta, Edmonton, Alberta, Canada, T6G 2H1. 19 pp.
- Hecker, L.J., L.T. Dewart, D. Epperson, M.A. Edwards, and S.E. Nielsen. 2019b. Ronald Lake wood bison research program: 2019 annual report. University of Alberta, Edmonton, Alberta, Canada, T6G 2H1. 46 pp.

- Höller, P., and R. Fromm. 2010. Quantification of the hand hardness test. *Annals of Glaciology*. 51(54):39-44.
- Johnson, C.J., K.L. Parker, D.C. Heard, and M.P. Gillingham. 2002. Movement parameters of ungulates and scale-specific responses to the environment. *Journal of Animal Ecology*. 71(2):225–235.
- Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology*. 61(1):65-71.
- Jorns, T., J. Craine, E.G. Towne, and M. Know. 2019. Climate structure bison dietary quality and composition at the continental scale. *Environmental DNA*. 2(1):77-90.
- Jung, T.S. 2015. Winter diets of reintroduced bison (*Bison bison*) in northwestern Canada. *Mammal Research*. 60(4):385–391.
- King, S.R.B., and K.A. Schoenecker. 2019. Comparison of methods to examine diet of feral horses from noninvasively collected fecal samples. *Rangeland Ecology & Management*. 72(4):661-666.
- Manly, B.J., L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P. Erickson. 1993. *Resource Selection by Animals*. Chapman & Hall, London, United Kingdom.
- Meek, P.D., G. Ballard, A. Claridge, R. Kays, K. Moseby, T. O'Brien, A. O'Connell, J. Sanderson, D.E. Swann, M. Tobler, and S. Townsend. 2014. Recommended guiding principles for reporting on camera trapping research. *Biodiversity and Conservation*. 23(9):2321–2343.
- R Core Team. 2019. R: A language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria. <https://www.R-project.org/>
- Shury, T. K., J. S. Nishi, B. T. Elkin, and G. A. Wobeser. 2015. Tuberculosis and brucellosis in wood bison (*Bison bison athabasca*) in northern Canada: a renewed need to develop options for future management. *Journal of Wildlife Disease*. 51(3):543-554.
- Strong, W.L., and C.C. Gates. 2009. Wood bison population recovery and forage availability in northwestern Canada. *Journal of Environmental Management*. 90(1):434-40.

- Tan, T., S.E. Nielsen, and M.A. Edwards. 2015. Ronald Lake bison (*Bison bison*) preliminary summary report: March 2013 – March 2014 telemetry data study. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 55pp.
- Webb, N.F., M. Hebblewhite, and E.H. Merrill. 2008. Statistical methods for identifying wolf kill site using global positioning system locations. *Journal of Wildlife Management*. 72(3):798-807.
- Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology*. 70(1):164-168.