Ronald Lake Wood Bison Research Program: Annual Report

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Executive summary

In this annual report, we explore key knowledge gaps identified by the Ronald Lake Bison Herd Technical Team (RLBHTT) (Table 1). In collaboration with the RLBHTT, the University of Alberta and Royal Alberta Museum are investigating knowledge gaps related to the ecology of the Ronald Lake wood bison (*Bison bison athabascae*) herd that include examination of the Ronald Lake bison range and distribution, habitat use, forage quantity and quality, ecological drivers of habitat use, response to disturbance, disturbance predictions, habitat reclamation, population structure, and predation pressure. In addition to building on previous work, here we provide an overview of research objectives, methodologies, results, and outstanding work for the upcoming 2019 field season. Specifically, in this report we discuss the following knowledge gaps:

Knowledge gap #1b (bison range and distribution)

- Investigate spatial patterns in habitat supply (landcover types) at the northern limit of the Ronald Lake herd as it relates to limiting the interaction with bison from Wood Buffalo National Park.

Knowledge gap #2a, #2b, and #2c (habitat use)

- Estimate relative seasonal wildlife (e.g., bison, moose, and wolves) habitat use for a sample of landcover types including uplands, wetlands, and anthropogenic disturbances (energy & forestry industries) using dung counts. This work will contribute as a long-term monitoring tool that is not dependent on GPS radio-collar data and is useful for estimating relative habitat use for landcover types including anthropogenic disturbances.
- To increase accuracy of using dung counts as an index of bison relative habitat use, we begin work on quantifying the decay-rate of bison dung in different landcover types. Bison dung decay-rate estimates will be used as a correction factor for estimating seasonal bison habitat use of landcover types.

Knowledge gap #3c and #3e (forage)

- Identify the forage selected by the Ronald Lake herd. These data will be used to quantify changes in quality, quantity, and availability of forage throughout the year

Knowledge gap #4a, #4c (ecological drivers of habitat use), and #5a (response to disturbance)

- Assess how forage supply and physical characteristics influence bison's use of habitat. This investigation will contribute to our knowledge of forage as a mechanism of habitat use and how bison respond to forage in different landcover types including anthropogenic disturbances (energy and forestry).
- Monitor the movements and habitat use of wolves to assess spatial and temporal risk of predation to the Ronald Lake bison herd. In this study we monitor the movements of habitat use of wolves and bison to assess spatial and temporal risk of predation to the Ronald Lake herd. This work includes: 1) constructing resources selection functions for both wolves and bison and assessing areas of high risk for bison, and 2) determining the predation rate of wolves on the bison herd. These analyses will increase our understanding of predators as a factor that affects bison habitat selection as it relates to predation risk.

Knowledge gap #8c and #8g (herd age structure and calf-to-cow ratio)

- Estimate annual population structure and calf-to-cow ratio for the Ronald Lake herd. These estimates provide a preliminary understanding of population demographics until such time that a more rigorous study of population dynamics is undertaken by wildlife managers.

Table 1. Knowledge gaps identified by the RLBHTT. Shaded rows indicate knowledge gaps examined in this report.

Topic	Gap #	Gap description	Status
Bison range / distribution	1a	Delineation of Ronald Lake bison herd home range	DeMars et al. (2016)
	1b	Review of northern extent of Ronald Lake bison herd	Update in this report
	1c	Review of southern extent of WBNP herd	No results at this time
	1d	Define and map migration; quantify habitat composition	No results at this time
Habitat -Landcover	2a	Wetlands	DeMars et al. (2016), & update in this report
	2b	Current anthropogenic disturbance (energy industry)	DeMars et al. (2016), & update in this report
	2c	Current anthropogenic disturbance (forestry industry)	DeMars et al. (2016), & update in this report
	2d	Natural disturbance (fire)	DeMars et al. (2016)
Habitat - Forage	3a	Phenological succession (remote sensing)	No results at this time
	3b	Nutritional Carrying Capacity	No results at this time
	3c	Forage quantity and quality	Update in this report
	3d	Effects of weedy species	No results at this time
	3e	Different aged anthropogenic disturbances	Update in this report
Ecological drivers of habitat use	4a	Wallows & water	No results at this time
	4b	Insect refugia & ground firmness	Belanger et al. (2017)
	4c	Winter / snow & wolf predation	Update in this report
Bison response to disturbance	5a	Mechanisms of bison response to disturbance	Update in this report

Table 1 continued.

Topic	Gap #	Gap description	Status
Future disturbance predictions	6a	Spatial change in landcover (Frontier mine)	No results at this time
	6b	Temporal rates of change (Frontier mine)	No results at this time
	6c	Spatial and temporal trends in anthropogenic disturbance & past natural disturbance projected into future	No results at this time
	6d	Predicted trend in landscape change accounting for all disturbance types	No results at this time
Habitat - reclamation	7	Investigate success of reclamation in restoring bison habitat	No results at this time
Population	8a	Group size and population by season	No results at this time
	8b	Rate of herd increase	No results at this time
	8c	Herd age structure	No results at this time
	8d	Herd health, nutritional level	No results at this time
	8e	Predation rates	No results at this time
	8f	Harvesting rates	No results at this time
	8g	Cow-to-calf ratio	Update in this report
	8h	Calf recruitment	No results at this time
Predation	9a	Calving predation pressures	No results at this time

Background

Federally, wood bison (*Bison bison athabascae*) are designated as *Threatened* with twelve extant, free-ranging populations remaining in Canada (ECCC, 2018). In Alberta, there are six wood bison subpopulations with designations for each herd varying depending on the area of management. Under the *Wildlife Act* in Alberta, free-ranging wood bison do not have a status except for those in provincially designated management areas, and provincial and federal parks where they are designated as *At Risk*. Under Alberta's *Wildlife Regulation*, the Ronald Lake bison herd, located south of Wood Buffalo National Park (WBNP), is considered a *Subject Animal* (Shury et al., 2015; AEP & ACC, 2017). The Ronald Lake herd has been identified as a genetically differentiated herd from others in Alberta with a low probability of infection from brucellosis and tuberculosis (Shury et al., 2015; Ball et al., 2016). This herd is relatively small (~200 individuals). The herd's range extends from the west bank of the Athabasca River to the eastern edge of the Birch Mountains. Approximately 17% of their home range overlaps with WBNP (Tan et al., 2015). Research into the herd's ecology, habitat use, and response to landscape disturbances began in 2013 and is ongoing.

Previous studies on the Ronald Lake herd have examined bison movement, seasonal and annual range extents, habitat use/selection, and responses to natural and anthropogenic disturbances (Tan et al., 2015; DeMars et al., 2016; Belanger et al., 2017). Some key results from previous studies include: (1) low variation in annual bison habitat selection, but seasonal variation associated with areas having large quantities of graminoid biomass; (2) seasonal habitat use influenced by forage availability, biting flies, and ground firmness; (3) patterns of seasonal migration in spring during the period when bison are calving; and (4) marshes being the most productive in biomass of graminoids (i.e., potential forage for bison).

Key knowledge gaps that remain include information on range constraints, population demographics, habitat supply (in terms of forage quantity and quality), responses to natural and anthropogenic disturbances, and the effects of predation by wolves on bison. This report provides a summary of the work completed towards addressing these knowledge gaps and proposes methodology for further examination during the 2019 field season.

Research progress

Knowledge gap #1b: Northern range extent of the Ronald Lake bison herd

Research objectives

Discussion regarding the potential interaction between the WBNP and Ronald Lake bison herds continues to be of interest (AEP, 2014). The Ronald Lake herd's home range extends ~25 km into WBNP, with ~8% of the home range occurring inside WBNP (DeMars et al., 2016). Bison in the Ronald Lake herd are known to travel into WBNP, however, genetic differences between these two herds suggest either no or minimal interaction (Ball et al., 2016). Analyses of the GPS radio collar data in relation to landcover types suggest the Ronald Lake herd's movements northward may be constrained due to landscape features and landcover types that bison avoid (DeMars et al., 2016). Thus, adverse landscape conditions may be limiting interactions between Ronald Lake and WBNP bison. The objective of this research is to investigate the hypothesis that landcover types may be constraining the Ronald Lake bison's movement north further into WBNP.

Overview of research methods

Using all available Ronald Lake bison GPS radio-collar locations from 2013 – 2017 ($N >$ 350,000), and Enhanced Wetland Classification (EWC) data, we modeled the distribution of bison in relation to landcover types within minimum convex polygons (MCP) of the bison radio-collar data. To reduce large gaps of unused, available habitat, we constructed MCP's for each third of the Ronald Lake herd based on latitude, and later combined all three MCP's into one contiguous MCP. We constructed 30 east-west "bands" along a north – south gradient within the MCP to spatially characterize the distribution of bison and landcover types (Figure 1). Then, we calculated the number of bison GPS locations and percent area of landcover types for each band. To examine the relationship between bison radio-collar locations and landcover types, we constructed univariate, negative binomial models of total bison locations per band based on each landcover type (n = 24) within the MCP.

Progress / preliminary results

Of the 25 univariate, negative binomial models, bison GPS locations had a significant positive relationship (i.e., selected) with six landcover types (Table 2), a significant negative relationship (i.e., avoided) with six other landcover types (Table 3), and no significant relationship with the remaining 13 landcover types (Table 4). Higher quantities of avoided landcover types occupy northern regions of the Ronald Lake bison herd's range compared to central and southern regions (Figure 2 & 3). Here, we suggest that the combination of the dominance of avoided landcover types, and lower quantities of selected landcover types southeast of Lake Claire may limit the northward movement of the Ronald Lake herd and movement south by the WBNP bison, thus limiting potential interactions between WBNP bison and the Ronald Lake herd at the north end of their range.

In this analysis, we identified possible biases in the landcover data due to thematic inconsistencies between the landcover products for the WBNP and Lower Athabasca regions. Specifically, we observed inconsistencies for the landcover types upland pine and upland conifer. All other landcover types appear consistent across the two products.

Outstanding / upcoming work

In 2019, we will construct multivariate models to further investigate landcover types and landscape features that may limit interactions between the WBNP and Ronald Lake bison herds. Multivariate models will incorporate variables such as season, terrain ruggedness, distance to water, and landscape configuration.

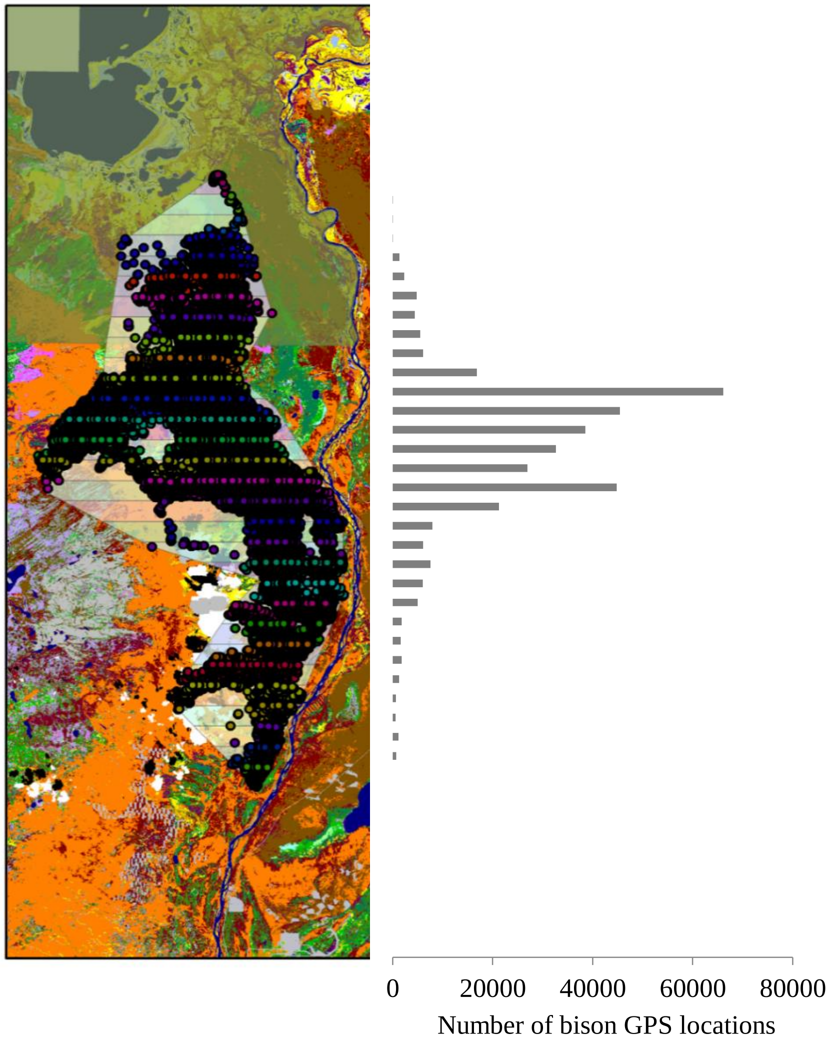

Figure 1. The distribution of Ronald Lake bison GPS radio-collar locations (*N* > 350,000) from 2013 – 2017. The background is Ducks Unlimited Enhanced Wetland Classification describing 25 landcover types, with WBNP highlighted in green. The colored dots above corresponding blacked areas represent bison GPS locations for individual bands.

Table 2. Normalized beta coefficients of selected (+) landcover types based on significant negative binomial models of bison GPS locations (*N* > 350,000) in relation to landcover types (EWC). Null model log likelihood = -305.65

Positive betas (selection)								
Landcover	**β**	**SE**	**t**	***p***	**95% C. I.**		**pseudo R^2**	**Log likelihood**
Emergent marsh	514.26	154.87	3.32	0.001	210.72	817.80	0.022	-298.75
Shrubby poor fen	179.05	52.29	3.42	0.001	76.57	281.53	0.023	-298.81
Upland deciduous	19.93	5.55	3.59	<0.001	9.06	30.80	0.015	-300.79
Graminoid poor fen	186.08	74.84	2.49	0.013	39.38	332.77	0.013	-301.42
Conifer swamp	44.83	17.93	2.5	0.012	9.69	79.97	0.011	-302.07
Meadow marsh	205.48	90.26	2.28	0.023	28.57	382.40	0.007	-303.22

Table 3. Normalized beta coefficients of avoided (-) landcover types based on significant negative binomial models of bison GPS locations (*N* > 350,000) in relation to landcover types (EWC). Null model log likelihood = -305.65

Negative betas (avoidance)								
Landcover	**β**	**SE**	**t**	***p***	**95% C. I.**		**pseudo R^2**	**Log likelihood**
Mixedwood swamp	-52.12	7.95	-6.56	<0.001	-67.70	-36.54	0.022	-298.73
Upland pine	-16.09	5.18	-3.11	0.002	-26.25	-5.94	0.010	-302.31
Shrub swamp	-38.84	14.90	-2.61	0.009	-68.05	-9.63	0.008	-302.93
Tamarack swamp	-57.04	28.20	-2.02	0.043	-112.30	-1.77	0.005	-304.08
Graminoid rich fen	-109.72	54.38	-2.02	0.044	-216.31	-3.13	0.004	-304.16
Mudflats	-4290.7	1919.49	-2.24	0.025	-8052.8	-528.5	0.003	-304.49

Table 4. Normalized beta coefficients of landcover types based on non-significant negative binomial models of bison GPS locations (N > 350,000) in relation to landcover types (EWC). Null model log likelihood = -305.65

Non-significant values								
Landcover	**β**	**SE**	**t**	***p***	**95% C.I.**		**pseudo R^2**	**Log likelihood**
Open bog	3476.83	1814.77	1.92	0.055	-80.06	7033.71	0.009	-302.86
Shrubby bog	352.37	209.89	1.68	0.093	-59.01	763.76	0.006	-303.63
Open water	85.88	56.33	1.52	0.127	-24.52	196.27	0.004	-304.29
Treed poor fen	-18.03	15.21	-1.19	0.236	-47.84	11.78	0.002	-305.02
Hardwood swamp	52.24	51.98	1.00	0.315	-49.65	154.12	0.001	-305.06
Cutblock	122.07	136.63	0.89	0.372	-145.72	389.87	0.002	-305.11
Treed bog	40.22	45.06	0.89	0.372	-48.09	128.53	0.002	-305.17
Anthropogenic	-379.40	606.28	-0.63	0.531	-1567.69	808.90	0.001	-305.44
Shrubby rich fen	-23.16	44.19	-0.52	0.600	-109.77	63.46	0.001	-305.50
Aquatic bed	-236.88	510.76	-0.46	0.643	-1237.96	764.20	0.001	-305.52
Upland conifer	-2.52	7.51	-0.34	0.738	-17.24	12.20	0.001	-305.57
Treed rich fen	-4.13	16.55	-0.25	0.803	-36.57	28.32	0.0001	-305.60

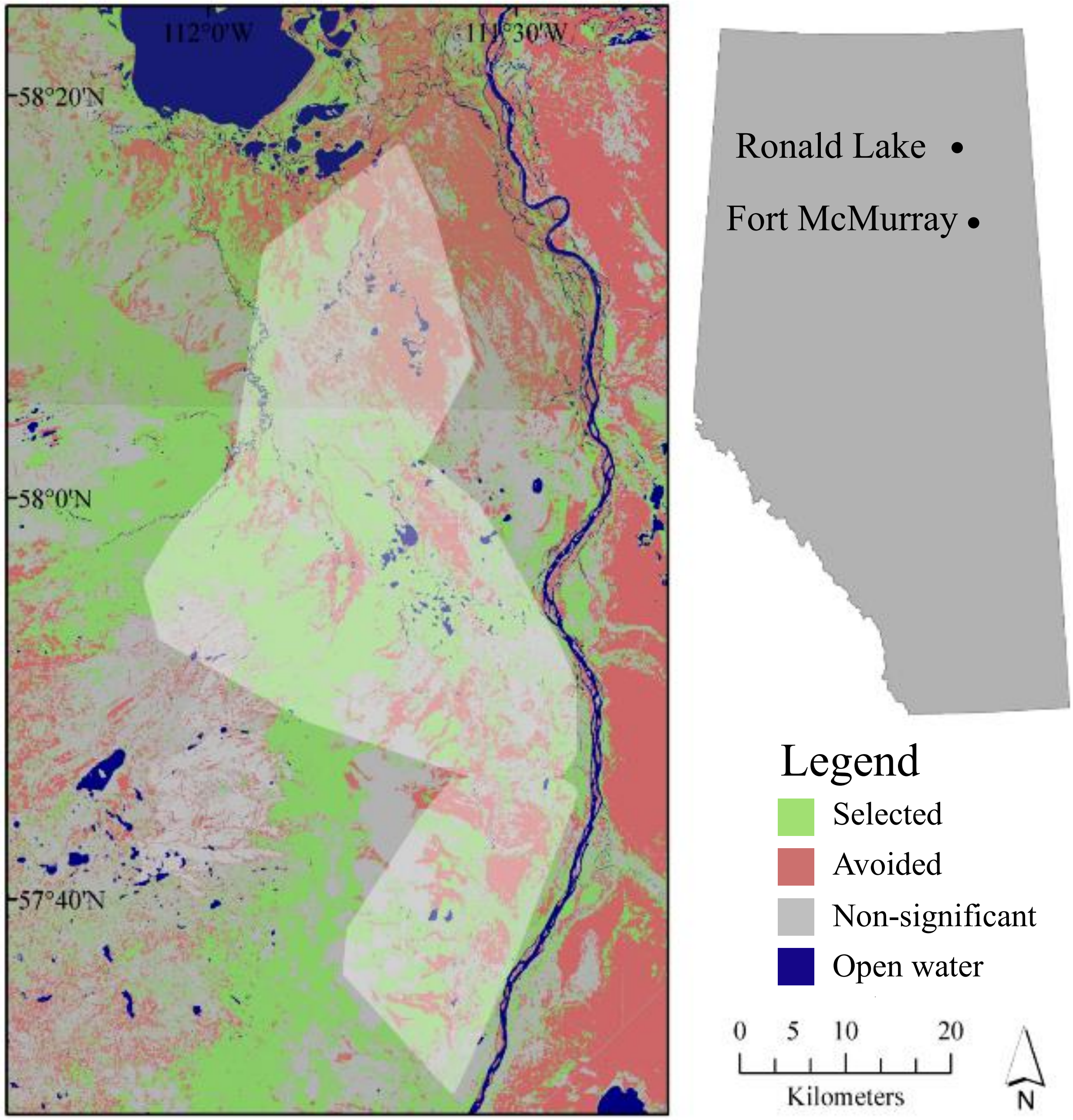

Figure 2. Map showing the distribution of selected and avoided landcover types (EWC) based on significant negative binomial models of bison GPS locations (n > 350,000) in relation to landcover types.

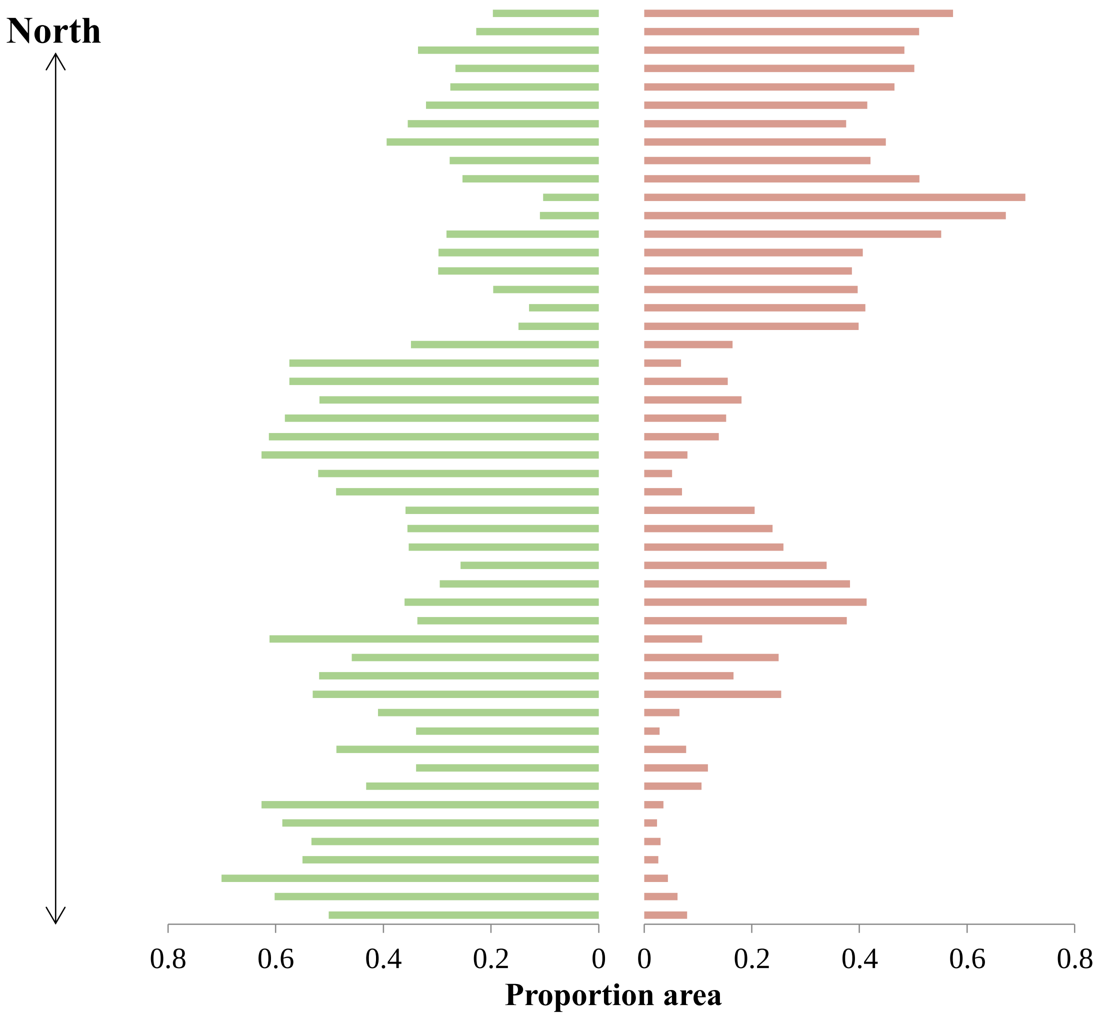

Figure 3. Graphic showing the distribution of selected (green) and avoided (red) landcover types (EWC) based on significant negative binomial models of bison GPS locations (N > 350,000) in relation to landcover types.

Knowledge gap #2a, #2b, and #2c: Habitat use of wetlands and anthropogenic disturbances

Wildlife plots

Research objectives

In addition to GPS radio-collar data, plot-based animal dung surveys can be used to estimate relative habitat use with less financial cost (Alves et al., 2013). The objective of this research is to estimate relative seasonal habitat use of different species in the Ronald Lake area with emphasis on bison. These surveys contribute as a long-term monitoring tool that is not dependent on GPS radio-collar data and is useful for estimating relative habitat use for landcover types including anthropogenic disturbances.

Overview of research methods

In the summer of 2018, we established permanent plots in seven different landcover types including three disturbance types: cutblock, seismic line, and wellpad by arranging six T-posts in a rectangular pattern encompassing a 500 m^2 area. Sites were accessed on the ground via quad and randomly selected within a 250 m buffer of accessible trails in the Ronald Lake area. Two observers surveyed the entire area of each plot twice with the second pass being perpendicular to the first. Dung/scat detectability rates for different species is likely to differ. We account for this by conducting multiple surveys using two observer counts and during snow-free periods: one survey in spring and one survey in fall before leaf-fall. During these initial surveys, all dung were identified to species, counted, and removed from plots. Bison dung was also categorized as either summer or winter dung (pers. comm. L. Carbyn). Plots will be completed twice per year to index winter versus summer use by re-visiting sites in early May to obtain winter counts, and again in late October to obtain summer counts. These counts will be used to calculate relative habitat use for bison and other wildlife.

Progress / preliminary results

In 2018, we established plots. In total, 17 plots were created, and initial dung counts recorded (Table 5). These initial counts are preliminary because the date of dung deposition and rate of decay for different species was unknown. However, these counts provide insight regarding relative estimates of wildlife habitat use. For instance, our preliminary results show that there is little overlap in wildlife habitat use of meadow marshes, with bison being the only species found using this landcover type (Figure 4).

Outstanding / upcoming work

As a preliminary investigation using dung surveys to calculate relative habitat use, our goal for 2019 is to establish five plots for each of the seven landcover types investigated in 2018, and re-survey existing plots to quantify actual use of landcover types since dung were removed in 2018 thus knowing actual rate of accumulation. Our goal of establishing five plots per landcover type is related to our ability to re-survey plots in a short period of time, thus to not bias seasonal estimates. To corroborate using bison dung counts as an effective method of estimating relative habitat use, we will use linear regression to investigate the relationship between bison dung counts and selection coefficients for the Ronald Lake bison herd.

Our research team is currently examining the method of pairing plots with trail cameras. Trail cameras can be a low cost (financial and effort) method of estimating relative wildlife habitat use (Manzo et al., 2012). In addition, detectability rates between dung and trail cameras may differ, and thus differences in relative wildlife habitat use estimates. We will investigate the efficacy of these methods.

Table 5. Landcover types (EWC) in which permanent wildlife plots have been established. Plots were established within Ronald Lake bison home ranges.

Landcover type	Date established	Number of plots
Meadow marsh	July 2018	2
Deciduous	July 2018	4
Pine	July 2018	4
Bog	July 2018	1
Cutblock	July 2018	4
Seismic line	July 2018	2
Wellpad	July 2018	0
	Total	**17**

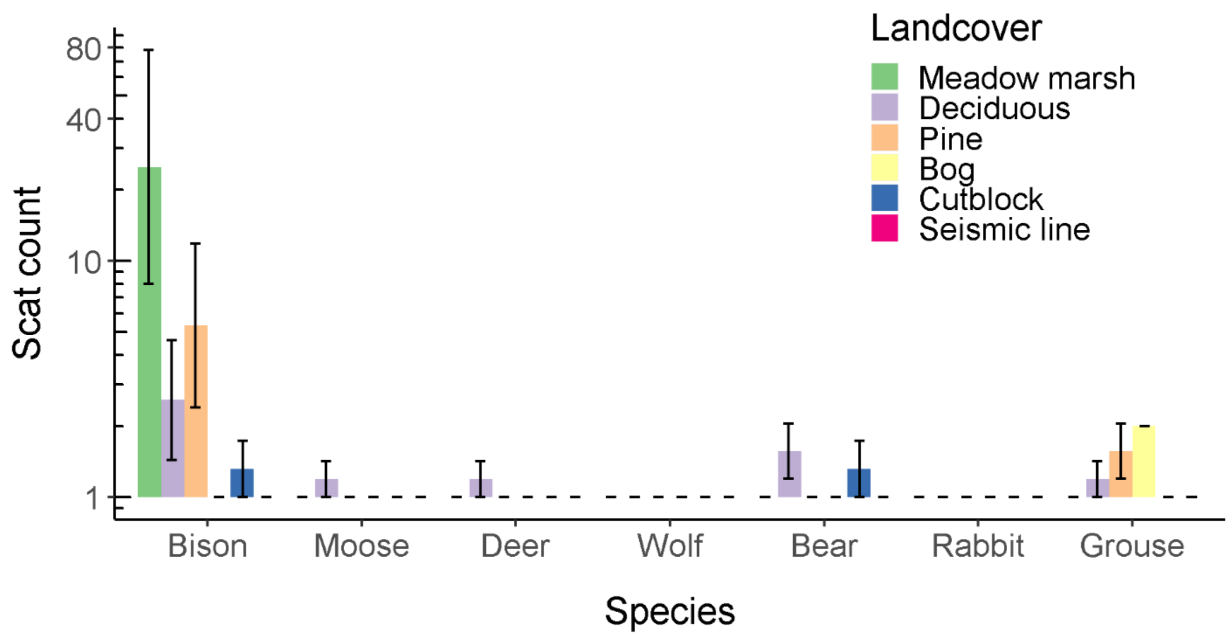

Figure 4. Scat/dung counts for seven observed wildlife species. Scat/dung counts were conducted in 500 m^2, rectangular plots (50 m x 10 m) in six landcover types (EWC) within Ronald Lake bison home ranges (n = 17 plots).

Dung decay rate

Research objectives

Wildlife dung decay rates vary between species, habitat types, and seasons (Brodie, 2006). Knowing the rate of dung decay is therefore needed to accurately estimate habitat use and population densities using single observed dung surveys (Theurerkauf & Rouys, 2008). The objective of this research is to estimate bison dung decay rate in different landcover types including both wetlands and uplands. The estimation of bison dung decay rate in different landcover types will be used as a correction factor to improve accuracy of bison dung counts as a long-term monitoring tool and index of bison relative use of landcover types including anthropogenic disturbances.

Overview of research methods

During the summer of 2018, rectangular enclosures were constructed around newly deposited dung that had not formed a crust and were believed to be less than one day old (Figure 5). An observer recorded the date dung was deposited, and dung average width and height. Enclosures will be revisited in spring of 2019 to re-measure dung state and at one month intervals thereafter during snow-free months. Using dung measurements, we will use linear regression and/or t tests to compare the rate of decomposition between landcover types and uplands and wetlands.

Progress / preliminary results

In total, 29 enclosures were constructed in six different landcover types including uplands and wetlands (Table 6).

Outstanding / upcoming work

Unless established dung plots are disturbed due to wildlife or human encounters, no further dung plots will be established in 2019. We will continue to monitor dung for decay and update our progress in 2019.

Figure 5. 'Fresh' bison dung (has not formed a crust) found on a linear disturbance (June 27) (left); dung enclosure constructed of 1.5" x 1.5" x 20 ga. galvanized steel (right).

Table 6. Landcover types (EWC) in which opportunistic encounters of 'fresh' bison dung (dung that has not formed a crust) occurred. Date indicates the time period in which field work was conducted and not the date dung was deposited, although dung were likely less than 1 day old. Age of bison dung in all opportunistic encounters is estimated to be about 1 day.

Landcover type	Date	Count
Meadow marsh	June 26 - July 13	10
Pine	June 26 - July 13	3
Deciduous	June 26 - July 13	5
Cutblock	June 26 - July 13	1
Linear	June 26 - July 13	6
Esker	June 26 - July 13	4
	Total	**29**

Knowledge gap #3c and #3e: Forage quantity and quality

Research objectives

A thorough understanding of available forage biomass and seasonal changes in quality and quantity of forage was identified as key knowledge necessary for informing management of the Ronald Lake herd (DeMars et al., 2016). Specifically, in this section our objective is to address the knowledge gap related to how the bison's habitat selection is influenced by the quantity and quality of forage and how these mechanisms change seasonally (Table 1, 3c). Eventually, we will use the information gained by addressing this objective to generate a forage-based carrying capacity model for the Ronald Lake herd (Table 1, 3b). We will address this issue by quantifying seasonal forage biomass available to the Ronald Lake herd for each landcover type within the herd's annual home range. Additionally, we will use samples of forage items from different seasons and assess their quality in terms of crude protein and the macronutrient composition.

Overview of research methods

We completed vegetation biomass surveys during the summers of 2016 – 2018, to estimate biomass for each landcover type, and natural and human disturbance class, as defined by the EWC and spatial disturbance layers, respectively. We classified anthropogenic disturbances as either legacy (> 5-years old) or recent (≤5 years old), and either wetland or upland. We obtained vegetation biomass estimates for landcover types by clipping vegetation in 0.5-meter^2, circular quadrats. We placed five, equally spaced quadrats along one, 60-meter transect. Quadrats were positioned 1-meter perpendicular to the transect line. Vegetation in each quadrat was dried at 60 °C for 24 hours, separated by forage class (i.e., grass, sedge, forb or shrub), and weighed to the nearest one-hundredth of a gram (Plumb and Dodd, 1993).

Next, to compare the quality and quantity of forage at use and available locations we used similar methods to clip and dry vegetation. At use and available locations three quadrats were deployed 10-meters apart along one, 30-meter transect that passes through each location (see "Ecological Drivers of Habitat Selection" for details on site selection). The cumulative weight of each clipped vegetation species will serve as a species-level biomass estimate for use and available locations. To assess forage quality, we will conduct a proximate analysis to calculate the macronutrient composition within each vegetation species (Coogan et al., 2018).

At all use locations, we searched for vegetation that showed signs of foraging. We used these observations in combination with our records of species cover at each use location to calculate statistics of relative frequency (RF) of observed foraging per species (Fracker & Brischle, 1944). We also collected fresh fecal samples at use locations, which will be used to determine the relative frequency and abundance of different forage items in the bison's diet.

Progress / preliminary results

Biomass estimates revealed high levels of graminoid, particularly sedge, biomass in wetlands of meadow marshes and graminoid rich fens, as well as legacy seismic lines in wetlands (Figure 6). Wood bison have been shown to select sedges, likely due to the relatively higher amounts of protein present in this forage item (Larter & Gates, 1991).

During the spring and summer of 2018, we surveyed 69 use locations and 109 available locations for a total of 178 locations. At 60 of the use locations, we observed evidence of foraging on 27 different species of vegetation. During the spring, the most frequently observed signs of foraging were on graminoid species and one shrub, prickly rose (*Rosa acicularis*). During summer, we observed a greater diversity of species foraged (Table 6). We did not observe evidence of foraging on thistle at any use or available location.

Outstanding / upcoming work

In the summer of 2019, we will complete our estimates of biomass by landcover type by surveying the six remaining landcover types (Table 7). Additionally, surveys of use and available locations will continue throughout 2019 and 2020. During these surveys, we will continue to clip vegetation, collect fecal samples, and record signs of foraging. Our goal is to have enough vegetation and fecal samples by the fall of 2019 to conduct our proximate and dietary analyses. Moving forward, we will characterize the intensity of foraging on specific species (Harvey & Fortin, 2013). These data will allow us to better estimate bison diet and determine how the quality of that diet changes throughout the year. Once biomass and forage quality estimates are complete, they will be used to assess the forage-based carrying capacity of the Ronald Lake herd's home range and determine how that will be affected by the proposed mine development (knowledge gaps 3b and 3c; Table 1).

Figure 6. Mean forage biomass (kg/ha) estimates for four forage classes (grasses, sedges, forbs, and shrubs) within each landcover type (EWC). For disturbances, legacy (L) refers to disturbances >5-years old, recent (R) refers to disturbances <5-years old, upland (U) are within upland landcover types, and wetland (W) are within wetland landcover types.

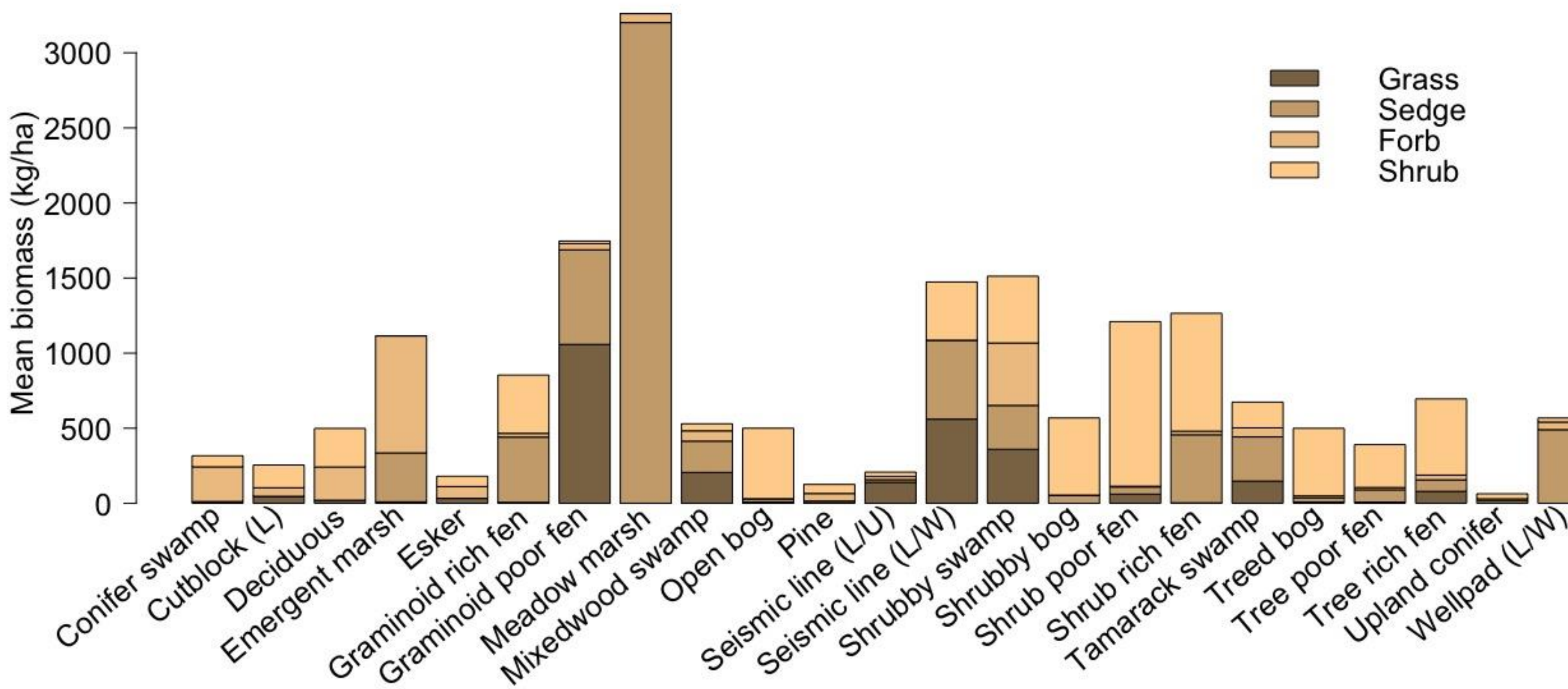

Table 6. The seasonal frequency of vegetation species foraged relative to the frequency they were observed at use locations regardless of landcover type (EWC). The species are listed in order of highest to lowest relative frequency (RF).

Common name	**Species name**	**Spring RF (%)**	**Summer RF (%)**	**Overall RF (%)**
Fireweed	*Equilobium angustifolium*	0.74	6.98	5.52
Grass spp	*Poaceae spp.*	10.37	3.26	5.16
Blueberry	*Vaccinium myrtilloides*	0.00	5.81	4.60
Prickly rose	*Rosa acicularis*	5.93	1.63	4.05
Saskatoon	*Amelanchier alnifolia*	2.22	3.02	2.95
NWT sedge	*Carex utriculata*	4.44	1.63	2.39
Low bush cranberry	*Viburnum edule*	0.74	2.56	2.21
Wheat sedge	*Carex atherodes*	3.70	0.93	1.66
Sedge spp	*Carex spp*	1.48	1.63	1.66
Willow spp	*Salix spp*	0.00	1.63	1.29
Quaking aspen	*Populus tremuloides*	0.00	1.40	1.10
Bunchberry	*Cornus canadensis*	0.74	0.23	0.74
Dogwood	*Cornus stolonifera*	0.00	0.93	0.74
Buffalo berry	*Spherdia canadensis*	0.74	0.70	0.74
Cattail	*Typha latifolia*	1.48	0.47	0.74
Sarsasparilla	*Aralia nudicaulis*	0.00	0.70	0.55
Water sedge	*Carex aquatilis*	2.22	0.00	0.55
Balsam poplar	*Populus balsamifera*	0.00	0.47	0.55
Pin cherry	*Prunus pensyvanica*	0.00	0.70	0.55
Calamagrostis spp	*Calamagrostis spp*	1.48	0.00	0.37
Ricegrass spp	*Oryzopsis spp*	0.74	0.23	0.37
Green alder	*Aluns crispa*	0.74	0.00	0.18
White birch	*Betula papyrifera*	0.74	0.00	0.18
Bebb's sedge	*Carex bebbii*	0.00	0.23	0.18
Bastard Toadflax	*Comandra umbellata*	0.00	0.23	0.18
Raspberry	*Rubus idaeus*	0.00	0.23	0.18
False Solomon's seal	*Smilacina stellata*	0.00	0.23	0.18

Table 7. The landcover types to be estimated in 2019.

Landcover Type
Cutblock (< 10 years old)
Seismic line active upland
Seismic line active wetland
Wellpad active upland
Wellpad active wetland
Wellpad legacy upland

Knowledge gap #4a and #4c: Ecological drivers of habitat use, and
Knowledge gap #5a: Bison response to disturbance

Distribution of water, snow characteristics, and landscape disturbances

Research objectives

Our objective is to determine why bison are using certain habitats and avoiding others to better define and understand bison-habitat associations and limitations. Through this research, we will be addressing knowledge gaps related to how bison's habitat selection is influenced by the distribution of water (Table 1, 4a), snow characteristics (Table 1, 4c), and landscape disturbances (Table 1, 5a). We will be investigating habitat characteristics within different landcover types, including disturbances, and bison's behaviour on these disturbances.

Overview of research methods

Considering "use" (locations where bison were present) locations to be a subset of the "available" locations within the Ronald Lake Herd's home range, we seek to find unique trends in the attributes of use locations that differentiates them from the locations that are available to bison. We use the term "available" to describe these locations because it is not possible to determine true absence of a species (Johnson et al., 2006). In the spring and summer for 2018, we surveyed use locations within two-weeks of bison presence based on GPS radio-collar locations provided by the Government of Alberta. We selected and surveyed available locations randomly within an individual bison's home range. We subset use locations by time of day (i.e., night, day, crepuscular) and individual bison, allowing for analysis of differential habitat selection throughout the day and by individual. Upon arrival at a use location, we searched the area for signs on bison presence such as, fresh dung, clipped vegetation, game trails, and bedding. We then considered the use location, which served as the center point for our surveys, to be the location of the observed sign nearest the provided GPS-collar location. If no sign was observed, we use the provided GPS-collar location as our center point and recorded the behavior as "unobserved." All locations were limited by accessibility to within 1-kilometer of a trail system in the study area.

At all locations, we established a plot that had a 15-meter radius around the location with a 30-meter transect running through the center of each plot. We then measured habitat characteristics likely to influence bison presence (Bruggeman et al., 2006; Nippert et al., 2013; DeMars et al., 2016; Belanger et al., 2017), such as:

- landcover type (defined by the Ducks Unlimited Enhanced Wetland Classification, EWC)
- canopy cover
- ground firmness
- distance to any water source
- distance to nearest marsh
- tree, shrub, and coarse woody debris densities.

Additionally, at use plots, we searched for signs behaviour (foraging, tracks/game trails, bedding, and wallows) to investigate how behaviour varies by time of day and across different habitat types. These measurements will allow for investigations of microhabitat selection and use.

Progress / preliminary results

During the spring and summer of 2018 (June – September), we surveyed a total of 178 use (n = 69) and available (n = 109) locations (Table 7). Of the use locations we surveyed, 36 were day locations, 18 were night locations, and 15 occurred during the crepuscular period. During the spring/summer of 2018, if sign of bison activity was observed at an available location (i.e., a false absence), we did not change that available location to a use location. We had false absences at 6% of our available locations. We are currently compiling our data and conducting preliminary analyses.

Outstanding / Upcoming work

We will continue to survey use and available locations throughout 2019 and 2020. Due to the relatively low percentage of false absences in our data we decided to not change the classification of these locations to use (Johnson et al., 2006). However, we are developing a set of criteria to decide when it is appropriate to reclassify an available location to a use location. We anticipate that by the end of 2020 will have surveyed enough use and available locations to generate a robust resource selection function that will describe the ecological drivers of habitat selection (knowledge gap 4; Table 1).

In the winter, we will focus on measuring snow characteristics and forage at use and available locations by surveying additional plots. During the summer of 2018, we deployed five measurement boards with graduated markings across from a time-lapse camera to estimate snow depth in five different landcover types (pine, deciduous, meadow marsh, esker, and cutblock). In addition, we will measure characteristics of snow at use and available locations including depth, volume, and density of snow as factors that may affect bison habitat selection. We will also note the presence of crust and measure curst thickness at use and available locations. Data from these surveys will then be used to quantify how snow influences winter habitat selection by individuals in the Ronald Lake herd. The winter research will help address knowledge gap 4c (Table 1).

During winter, we anticipate being able to access a greater amount of the Ronald Lake herd's home range as we should be able to cross wetland areas that should be frozen and covered by snow. This improved accessibility is important because we are potentially biasing our analysis by limiting our surveys to a 1-kilometer buffer surrounding the trail system, restricting our surveys to the most south-eastern parts of the herd's home range. During the spring and summer, we plan to offset this potential bias by using helicopters to access use and available locations throughout the herd's home range.

To turn our qualitative description of behaviour into a quantitative measure that can be used to differentiate habitat use within different landcover types we will measure intensity of behaviour at use locations moving forward. To accomplish this transition, we will follow the methodology of Harvey and Fortin (2103), which compares the area of the observed behavior within the plot radius. The continued work in 2019 related to bison behavior will help address knowledge gap 4a (Table 1).

Table 7. Summary of the use and available locations surveyed during the spring and summer of 2018.

	Spring	Summer	Total
Use	23	46	69
Available	31	78	109
Total	54	124	178

Wolf predation

Research objectives

The sustainable management of wildlife populations requires knowledge of their habitat preferences and the processes influencing selection and avoidance. Mortality risk is one of many biological factors that may influence habitat use (Nielsen et al., 2010). Investigating the factor of predation will allow us to develop models and maps that can provide estimates of risk-sensitive areas (Legendre et al., 1989) for the Ronald Lake bison herd and provide some insight on the influence predation may have on bison habitat selection.

Starting in 2019 we will study the effect of wolves, a known predator of bison (Carbyn & Trottier, 1988), on the survival and habitat selection of the Ronald Lake herd. Our first objective is to estimate the level of predation by wolves on the Ronald Lake herd and explore possible influences of winter conditions (e.g., snow depth) on predation rates. Second, we will examine the movement and habitat use of wolves and bison throughout the year to develop resource selection function models and maps to estimate predation risk and shed light on how wolves may shape the herd's use (selection) of habitats.

Overview of research methods

There are an estimated three to four wolf packs in the Ronald Lake area that occupy similar areas to that of the Ronald Lake bison herd (DeMars et al., 2016). To track wolf movements, we will deploy GPS radio-collars programmed at a four-hour acquisition interval (Webb et al., 2008) on one or two wolves per pack (n = 8, max) to increase the likelihood of receiving consistent data from each pack while minimizing the number of animals affected by the invasive nature of capture and collaring procedures. Prior to collaring, a team will be deployed to scout the study area for wolf activity to recommend locations for capture. The wildlife capture crew will then fly the area in search of wolves and will be able to further inform on number of packs within the herd's home range.

First, we will use wolf location data to identify kill sites using GPS cluster analysis (Webb et al., 2008). We will search these kill sites for available evidence to identify prey types and will collect wolf scat both at kill sites as well as opportunistically for diet content analysis. For this work, there will be an emphasis on the winter season when snow conditions can restrict ungulate movements and increase mortality rates (Telfer & Kelsall, 1979; Pruitt, 1959) and when there is greater access to the study area (frozen ground conditions).

Second, we will model wolf and bison movements using resource selection functions that will show the habitat characteristics (ie. forage biomass, crown cover, snow depth, elevation, disturbance) that are important to each species and the probability of each being found where those characteristics are present (Boyce et al., 1999). With the combination of location data from both wolf and bison collars, we can determine the spatial extent of habitat that each species utilizes, as well as when and where they are more likely to interact with one another (Legendre et al.,1989). Using this approach we can estimate encounter risk between bison and wolves within the Ronald Lake herd's home range.

Winter conditions generally impose higher energy outputs for bison, making them more vulnerable to predation, which may further influence bison habitat selection (Harvey & Fortin, 2013). Therefore, we will collect data on environmental conditions with a focus on snow characteristics such as depth, density and presence of crust. In order to gather this information from the closest approximate time of kill, we will use a combination of data from snow depth stations and data collected from bison sites.

Progress / preliminary results

The estimated three to four wolf packs that occupy portions of the Ronald Lake bison herd's home range is based on the average home range size for a wolf in Alberta as well as knowledge from local trappers, wildlife capture crews, and trail cameras. We will use this information in our upcoming scouting and collaring strategy to identify wolf capture areas.

Outstanding / Upcoming work

GPS radio-collars for wolves will be deployed in January or February of 2019. Once GPS collars are deployed and active, the locations will be monitored for potential kill sites (i.e., clusters) that will be prioritized and visited depending on accessibility beginning in February 2019.

Using previous research on bison habitat preferences from Tan et al. (2015) and DeMars et al. (2016a) for the Ronald Lake herd, and building a wolf resource selection function for the herd's home range, we can determine areas of spatial encounter risk for bison in 2020.

Knowledge gap #8c and #8g: Herd age structure and cow-to-calf ratio

Research objectives

Estimating mammalian population demographics can be used to monitor and assess population health and size trends (Brown, 2011; Cameron et al., 2013). High annual calf or cow mortality rates can result in decreased recruitment the following year and subsequent population decline (Cameron et al., 2013). The Ronald Lake herd is estimated at ~200 bison (AEP & ACA, 2018). Much less is known about the herd's demographics and long-term population trends. From 2015 to 2017, trail cameras were deployed in the Ronald Lake area to estimate calf:cow, yearling:cow and bull:cow ratios. These data, in conjunction with continued trail camera work, will contribute towards assessing variation in the annual population structure and trends for the Ronald Lake herd. The objective of this research is to estimate population demographics and observe long-term trends. Specifically, this research will document changes in the Ronald Lake herd's population structure and assess the potential impact of natural and human disturbances.

Overview of research methods

In March 2015 we deployed 16 trail cameras in a large, remote meadow in the northwest portion of the Ronald Lake herd's home range where the bison congregate in spring during the calving season (DeMars et al., 2015). In March 2016 we re-deployed these 16 cameras and deployed an additional 7 cameras in the same meadow (total cameras in meadow = 23). Cameras deployed in 2016 were setup in different locations than those in 2015 and in areas of observed wildlife activity (i.e., game trails and wallows). In addition to the 23 cameras deployed in the meadow, we deployed 10 trail cameras in central areas of the Ronald Lake bison herd's home range, south-east of Ronald Lake. Images from all cameras were used in analyses. Using Timelapse2, we identified sex, age group (i.e., bull, cow, yearling, or calf), and the number of individual bison (Greenberg, 2015). In a sequence of images (string of images with a similar time-stamp), individual bison were recorded only once. Bison were not identified to individual, thus in subsequent sequences of images, individual bison could have again been counted, thus double counting of bison may have, and is likely to have occurred. To avoid double counting of calves/yearlings, images were pooled for one year cycles that coincide with calving (01 May – April 30). We analyzed data for a full, one year cycle for the year 2015-2016, and a 10 month (01 May – 28 February) cycle for the year 2016-2017. Calves were identified as animals <1 year old, yearlings identified as animals between 1 and 2 years old, and mature bulls and cows identified as animals >2 years old. We calculated calf:cow, calf:adult, yearling:cow and bull:cow ratios for each year. In 2018, we re-deployed 17 trail cameras in the same meadow described above, and an additional 13 cameras in central areas of the Ronald Lake herd's range and in areas of high bison use (e.g., large sedge meadows and well-used game trails).

Progress / preliminary results

We analyzed images for the two annual time-periods: 2015 – 2016 and 2016 – 2017. We identified 564 and 3,039 unique images of individual bison in each time-period, respectively. We found that mature cows outnumbered bulls, yearlings, and calves in both years, with 229 and 1527 unique images of cows in respective years (Figure 7). Further, we found a lower number of bulls (38), yearlings (33), and calves (28) per 100 cows for the year 2016 – 2017, compared to 56 bulls, 57 yearlings, and 33 calves for the year 2015 - 2016 (Figure 8).

Outstanding / upcoming work

In 2019, we will collect data from trail cameras deployed in 2018 and conduct similar analyses to estimate population demographics. After gathering these data, we will redeploy cameras with additional units set in the southern region of the herd's home range. Due to large differences in bull:cow and yearling:cow estimates between 2015/2016and 2016/2017, and larger numbers of yearlings than calves in both years, we will re-examine and analyze these data, and compare with data from the most recent year.

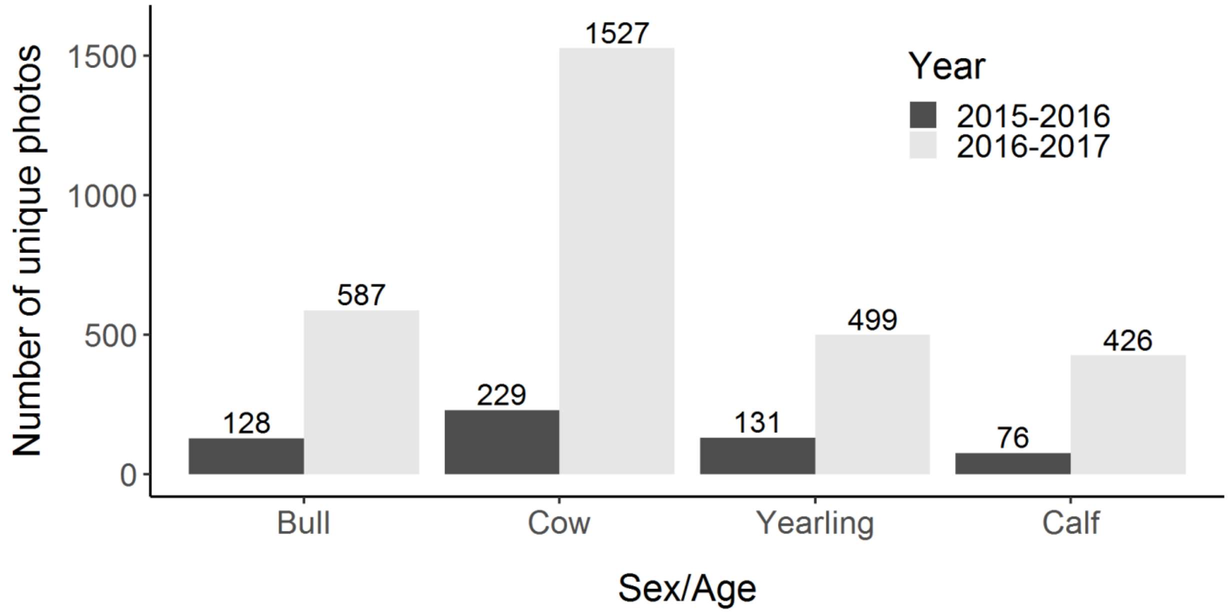

Figure 7. Number of unique individual bison identified in images captured by trail cameras within the Ronald Lake bison home range for two time-periods: 2015 – 2016 and 2016 – 2017. Time periods start 01 May and end 30 April.

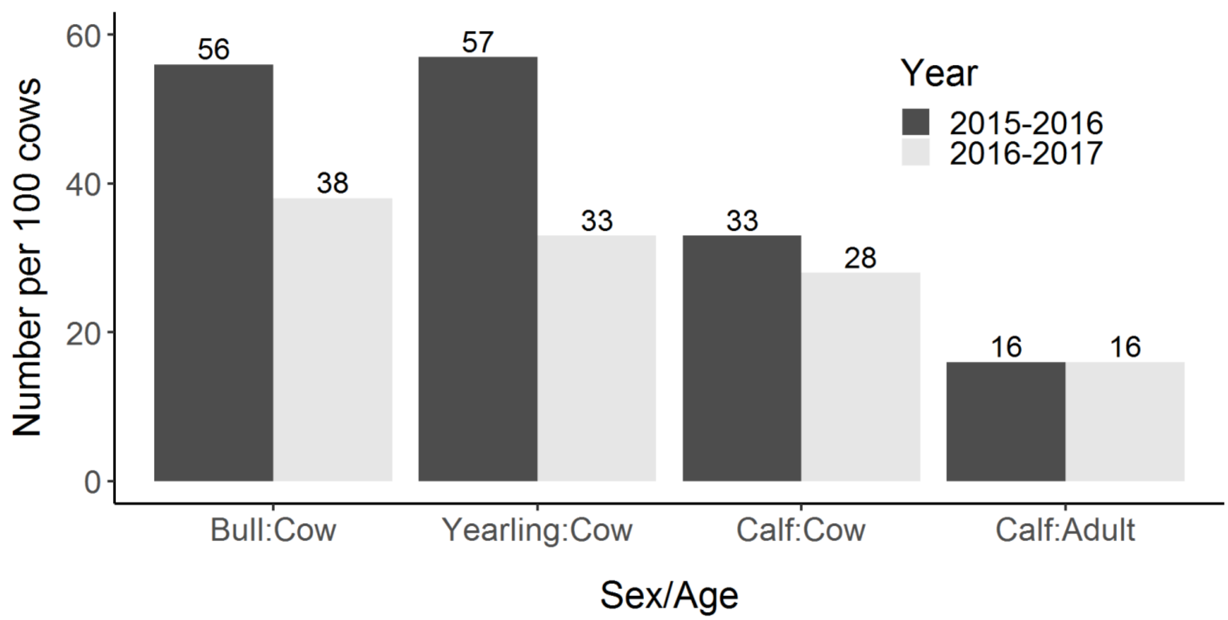

Figure 8. Bull:cow, yearling:cow, calf:cow, and calf:adult ratios derived from images captured by trail cameras within the Ronald Lake bison home range for two time-periods: 2015 – 2016 and 2016 – 2017. Time periods start 01 May and end 30 April. Adult category is the number of bulls, cows, and yearlings combined.

Closing

In this report, we discuss our current understanding of the ecology of the Ronald Lake herd based on research conducted to date to address knowledge gaps identified by the Ronald Lake Bison Herd Technical Team. We updated population demographic estimates using trail camera data of the Ronald Lake herd for two consecutive years. These are preliminary estimates that can be useful for comparing annual population structure. We summarized the ongoing research investigating the ecological drivers of habitat use and proposed methodologies for winter field research. Additionally, we outline the approaches we are taking to address top-down effects on the Ronald Lake herd's habitat selection as it relates to wolf behaviour and predation. We also described the deployment and planned use of dung plots to monitor habitat use of various large, mammalian species, including bison that occur within the Ronald Lake herd's range. Lastly, our investigation of habitat as a factor limiting the northern range boundary of bison suggests that a northward movement of Ronald Lake bison may be limited due to large areas of avoided landcover types in the far north just south of Lake Claire. Moving forward we will continue to advance our understanding of bison such as the herd's response to landscape disturbances and future scenario modeling.

Literature cited

Alberta Environment and Parks. 2014. Managing disease risk in Alberta's wood bison. Progress Report.

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., Alves de Silva, A., Soares, A. M. V. M., Fonseca, C. 2013. Pellet group count methods to estimate red deer densities: precision, potential accuracy and efficiency. *Mammalian Biology* 78:134-141.

Ball, M. C., Fulton, T. L., Wilson, G. A. 2016. Genetic analyses of wild bison in Alberta, Canada: implications for recovery and disease management. *Journal of Mammalogy* 97(6):1525-1534.

Belanger, R. J., DeMars, C. A., Hecker, L. J., Edwards, M. A., Nielsen S. E. 2017. Ronald Lake wood bison annual report: November 30, 2017. Ronald Lake Bison Report. 76 pp.

Boyce, M. S, McDonald, L. L. 1999. Relating populations to habitats using resource selection functions. *Trends in Ecology and Evolution* 14:268-272.

Brodie, F. J. 2006. An experimentally determined persistence-rate correction factor for scat-based abundance indices. *Wildlife Society Bulletin* 34:1216-1219.

Brown, G. S. 2011. Patterns and causes of demographic variation in a harvested moose population: evidence for the effects of climate and density-dependent drivers. *Journal of Animal Ecology* 80:1288-1298.

Bruggeman, J. E., Garrot, R. A., Borne, D. D., White, P. J., Watson, F. G., Borkowsi, J. 2006. Temporary variability in winter travel patterns of Yellowstone bison: the effects of road grooming. *Ecological Applications* 16:1539-1554.

Carbyn, L. N., and Trottier, T. 1988. Descriptions of wolf attacks on bison calves in Wood Buffalo National Park. *Arctic* 41:297-302.

Cameron, R. D., Griffith, B., Parrett, L. S., White, R. G. 2013. Efficacy of calf:cow ratios for estimating calf production of arctic caribou. *Rangifer* 33:27-34.

Coogan, S. C. P., Raubenheimer, D., Zantis, S. P., Machovsky-Capuska, G. E. 2018. Multidimensional nutritional ecology and urban birds. *Ecosphere* 9: 1:16

DeMars, C. A., Nielsen, S. E., Edwards, M. A. 2015. Ronald Lake bison (*Bison bison*): project update. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 26 pp.

DeMars, C. A., Nielsen, S. E., Edwards, M. A. 2016. Range use, habitat selection, and the influence of natural and human disturbance on wood bison (*Bison bison athabascae*) in the Ronald Lake area of northeastern Alberta. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 80 pp.

du Toit, J., Adler, P., Ranglack, D., Koons, D. N., Terletxky, P., Adler, P. B., Wolfe, M. L., Howe, F. P., Hersey, K., Paskett, W. 2012. Climate and density-dependent drivers of recruitment in plains bison. *Journal of Mammalogy* 93:475-481.

Environment and Climate Change Canada. 2018. Recovery strategy for the Wood Bison (*Bison bison athabascae*) in Canada. *Species* at *Risk Act* recovery strategy series. Environment and Climate Change Canada Ottawa. Viii + 59 pp.

Fracker, S. B., Brischle, H. A. 1944. Measuring the local distribution of ribes. *Ecology* 25: 283-303.

Greenberg, S. 2015. Timelapse2: An image analyser for camera traps.

Harvey, L., Fortin, D. 2013. Spatial heterogeneity in the strength of plant-herbivore interactions under predation risk: the tale of bison foraging in wolf country. *PLoS ONE* 8(9):e73324.

Johnson, C. J., S. E. Nielsen, E. H. Merrill, T. L. McDonald, and M. S. Boyce. 2006. *The Journal of Wildlife Management*, 70(2):347-357.

Kerr, J. T., and I. Deguise. 2004. Habitat loss and the limits of endangered species recovery. *Ecology Letters* 7:1163-1169.

Larter, N. C., and C. C. Gates. 1991. Diet and habitat selection of wood bison in relation to seasonal changes in forage quantity and quality. *Canadian Journal of Zoology* 69:2677-2685.

Legendre, P., Fortin, M. J. 1989. Spatial pattern and ecological analysis. *Plant Ecology*. 80(2):107-138.

Manzo, E., Bartolommei, P., Rowcliffe, J. M., Cozzolino, R. 2012. Estimation of populatin density of European pine marten in central Italy using camera trapping. *Acta Theriologica* 57(2):165-172.

Nielsen, S. E., McDermid, G., Stenhouse, G. B., Boyce, M. S. 2010. Dynamic wildlife habitat models: Seasonal foods and mortality risk predict occupancy-abundance and habitat selection in grizzly bears. *Biological Conservation* 143:1623-1634.

Nippert, J. G., Culbertson, T. S. F., Orozco, G. L., Ochletree, B. R., Helliker. B. R. 2014. Identifying water sources consumed by bison: implications for large mammalian grazers worldwide. *Ecosphere* 4: 23.

Plumb, G. E., Dodd, J. L. 1993. Foraging ecology of bison and cattle on a mixed prairie: Implications for natural area management. *Ecological Applications* 3:631-643.

Pruitt, W.O. 1959. Snow as a factor in the winter ecology of the barren ground caribou (Rangifer arcticus). Arctic 12(3):158-179

Steenweg, R., Hebblewhite, M., Gummer, D., Low, B., Hunt, B. 2016. Assessing potential habitat and carrying capacity for reintroduction of plains bison (*Bison bison bison*) in Banff National Park. *PLoS ONE* 11.

Shury, T. K., Nishi, J. S., Elkin, B. T., Wobesser, G. A. 2015. Tuberculosis and brucellosis in wood bison (*Bison bison athabascae*) in northern Canada: A renewed need to develop options for future management. *Journal of Wildlife Diseases* 51(3):543-554.

Telfer, E., Kelsall, J. 1979. Studies of morphological parameters affecting ungulate locomotion in snow. *Canadian Journal of Zoology* 57: 2153-2159

Theuerkauf, J., Rouys, S. 2008. Habitat selection by ungulates in relation to predation risk by wolves and humans in the Bialowieza Forest, Poland. *Forest Ecology and Management* 256:1325-1332.

Tan, T., Nielsen, S. E., Edwards, M. A. 2015. Ronald Lake bison (*Bison bison*) preliminary summary report: March 2013 – March 2014 telemetry data study. University of Alberta, Edmonton, Alberta, Canada T6G 2H1. 58 pp.

Travis, J. M. J., Palmer, S. C. F. 2005. Spatial processes can determine the relationship between prey encounter rate and prey density. *Biological Letters* 1:136-138.

Webb, N., Hebblewhite, M., Merrill, E. 2008. Statistical methods for identifying wolf kill sites using global positioning system locations. *Journal of Wildlife Management* 72: 798-807