LONG TERM POPULATION DYNAMICS AND THE EFFECTS OF PRESCRIBED FIRE ON THE WINTER RANGE OF THE YA HA TINDA ELK HERD

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Disclaimer

The information provided in this progress report represents preliminary results and are to be interpreted as such. Data collected over the summer will be used for graduate research theses and results are subject to revision.

Executive Summary

This report contains data collected as part of a long-term monitoring of the Ya Ha Tinda elk (*Cervus elaphus*) population dynamics and vegetation project, and the first season of a two year study on elk demography and winter range ecology. The main goal of this study is to provide Parks Canada with information on the current status of the Ya Ha Tinda Elk Herd and the dynamics of Upper Red Deer River Ecosystem as it applies to Banff National Park. Here, we list 3 main objectives proposed for the long-term monitoring and 2 year study as part of an ongoing graduate research project.

1.) Long-Term elk population demography and distribution.

Continue past monitoring efforts of elk population dynamics through collection of baseline demographic information and vital rates (adult survival, pregnancy rates, and calf survival) and cause specific mortality. Distribution will be monitored through regular VHF and GPS locations of radiocollared elk and biannual pellet plot surveys.

2.) Vegetation biomass and composition.

Using the established methods from previous studies we will continue to assess vegetation biomass and composition in response to changing grazing pressure. Our goal is to track changes in monthly and peak biomass and productivity of the grassland in response to the Aversive Conditioning program and reduced elk density.

3) Shrub and conifer encroachment on rough fescue grasslands of the Ya Ha Tinda

Contribution by Lindsay Glines of preliminary results for the final year of a two year Masters research project on shrub and conifer encroachment on the rough fescue grasslands of the Ya Ha Tinda.

4.) Discussion

Background

The primary purpose Ya Ha Tinda Elk Population Dynamics and Grassland Ecology Project is to provide reliable knowledge of current patterns of elk population dynamics, ungulate foraging ecology, and elk migration for a research area centered Ya Ha Tinda Ranch along the Red Deer River to the rivers upper headwaters in Banff National Park. Information gathered will provide Parks Canada and the Province of Alberta with information necessary for wildlife management and trans-boundary interagency ecosystem management.

1Long-term elk population demography and distribution

1.1 Observations

Elk observations were conducted each morning at first light along a transect route from the ranch compound to the eastern property boundary along the ranch road. We used 10× 42 Leopold binoculars and a 20 × 60 Bushnell spotting scope for visual detection. A total of 492 observations were recorded during 102 observation days between 10 May and 28 August of 2010. Each elk group or individual encounter is considered an observation. For each observation we recorded: date, time, and UTM location. If conditions permitted elk were classified by the number of individuals, sex and age class, individual ID, and whether or not a cow had a calf.

Following the methods already used in former studies (Hebblewhite et al 2003) calf survival was determined using standardized criteria to sex- and age-classify elk in groups and obtain cow: calf ratios (Smith and MacDonald 2002). Specifically, tagged and/or radio-collared elk observed with a calf were recorded. Successfully identified cow calf pairs will continue to be monitored at intervals throughout the year until 1 April to determine survival. If an identified calf survives to 1April then survival will be assumed to be 100 percent beyond that point. Similarly, migrant elk monitored during the summer will be recorded as having a calf present or not and periodically monitored during November and in winter to assess calf survival for migrant elk. A list of all marked adult females with calves is reported in the Appendix, Table 1.

For summer classifications we narrowed are observations to range from 15 June – 31 August to represent the period of highest vulnerability for calves starting from the biological year when calves are born (1 June) and accounting for a 15 day period when calves are hidden and separated from the herd (White et al.2010). During this period we had a total of 237 elk observations and classified a total of 2684 elk. Sex and ageclass ratios were: cow:bull 100:15, cow:yly male 100:4, cow:yly female 100:9, and 100:21for cow:calf ratios (Table 1).

Classifications	March 2009		Summer 2009		March 2010		Summer 2010	
	N	Ratio	N	Ratio	N	Ratio	N	Ratio
Cow	575	100	1213	100	155	100	1792	100
Bull	3	<1	38	3	10	6	275	15
YLY Males	11	2	63	5	3	2	78	4
YLY Females	12	2	48	4	18	12	155	9
Calves	94	16	477	39	52	34	384	21
Total	695		1793		238		2684	

Table 1. Elk sex and age ratios reported for March 2009 & 2010 and summer (15 June – 31 August) 2009 & 2010.

1.2 Biotelemetry and Migratory Behavior

Elk were monitored each morning from the same location using a handheld telemetry receiver (Model R1000, Communications Specialists Inc.) and an omni antenna. Presence data are used to discern migratory individuals based on the percentage of days each elk was detected on the ranch as a proportion of the number of days surveyed per summer field season. Individuals that were detected less than 20% of the time were considered migratory, 21-64% partial migrants, and 65-100% residents (Table 2). Presence telemetry was also used for detecting mortality signals within range of detection (~5km radius).

Table 2. Ratio of elk based on migratory status.

2010 Migrant ratios	N	Percentage
Resident	12	20
Partial Migrant	21	36
Migrant	26	44

Approximately 2-4 times per month elk telemetry transects were conducted along the ranch road from the eastern boundary of the ranch to Sundre, AB. We used detections of collared elk to supplement migratory information obtained from presence data. In addition, we triangulated locations for each elk detected along the transect route at a minimum of two times per month. Locations for each resident elk were obtained at least once per month using triangulation or by observation.

We located migrant elk by aerial telemetry (Cessna 337 Skymaster) on 18 June and 24 June7 for a total of ~7 hours. Our pilot was Sean Biesbroek of Wildlife Air Observation Services Inc., Springbank Airport, Alberta. A total of 34 migrant or partially migrant elk were located along the Red Deer River and within the Park Boundary to Banff and Lake Louise along the Bow River Valley (Fig. 1).

Two backcountry trips were conducted to track migrant elk and investigate mortality sites; the first from 29 June to 3 July and a second from 13 July to 21 July. We totaled 14 days in the backcountry. Six migrant elk were located (BL265, BL272, BL252, BL285, OR5, YL62) during backcountry trips and five mortalities were recovered (YL38, YL37, GR108, YL07, GR184). Only one collared elk located in the backcountry was observed with a calf (YL62).

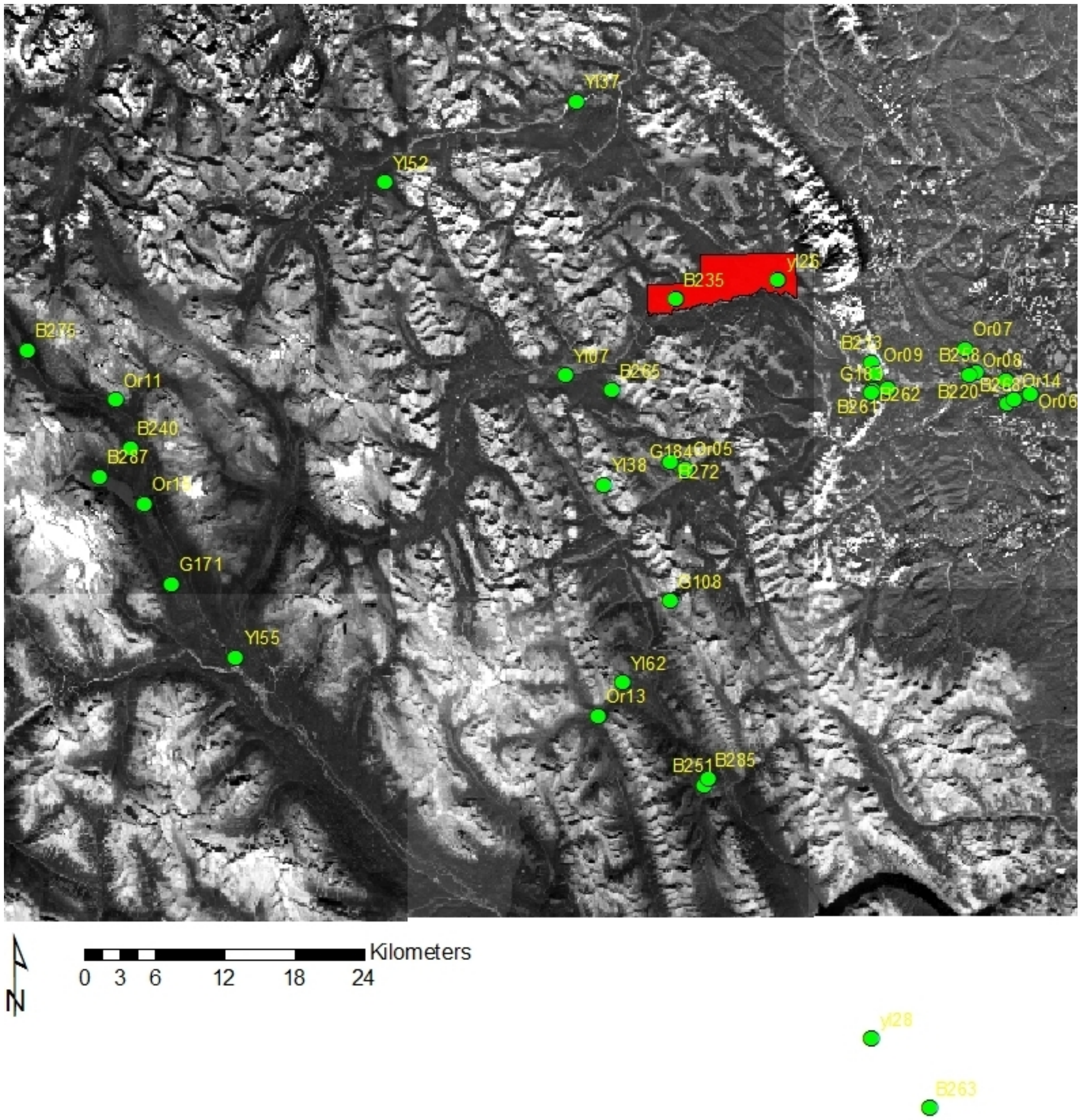

Figure 1. Locations of migrant elk from flights conducted on 17 and 24 June 2010.

1.3 Pellet Counts

We continued long-term pellet counts in the grassland (<60% canopy cover; McInenly 2003) of the Ya Ha Tinda. Spring pellet counts were conducted during the first two weeks of May and represented winter use of the ranch. Fall counts occurred between 9-12 September and represent summer use. Grassland plots were 25 m^2 circular plots located in a systematic grid at 250-m intervals across the grasslands (Fig. 2). Pellet groups were defined as containing at least 8 pellets and counted if >50% of a group was within the plot. Ungulate species recorded include elk, deer (*Odocoileus* *virginiana, O. hemonius*), horse (*Equis*), bighorn sheep (*Ovis canadensis*) and moose (*Alces alces*). Color, weathering, and shape of pellets was used to determine pellet species and age. Elk pellets deposited in the winter had a squared bullet shape, while summer pellets can transition to a soft coalesced or disc form (Murie and Elbroch, 2005). Deer pellets were similar but smaller, typically under 1 cm in length. Black pellets were considered recently deposited, where as grey or white color indicated pellets deposited last season or even a year earlier. The presence of wolf and coyote (*Canis latrans*) scat was recorded when encountered.

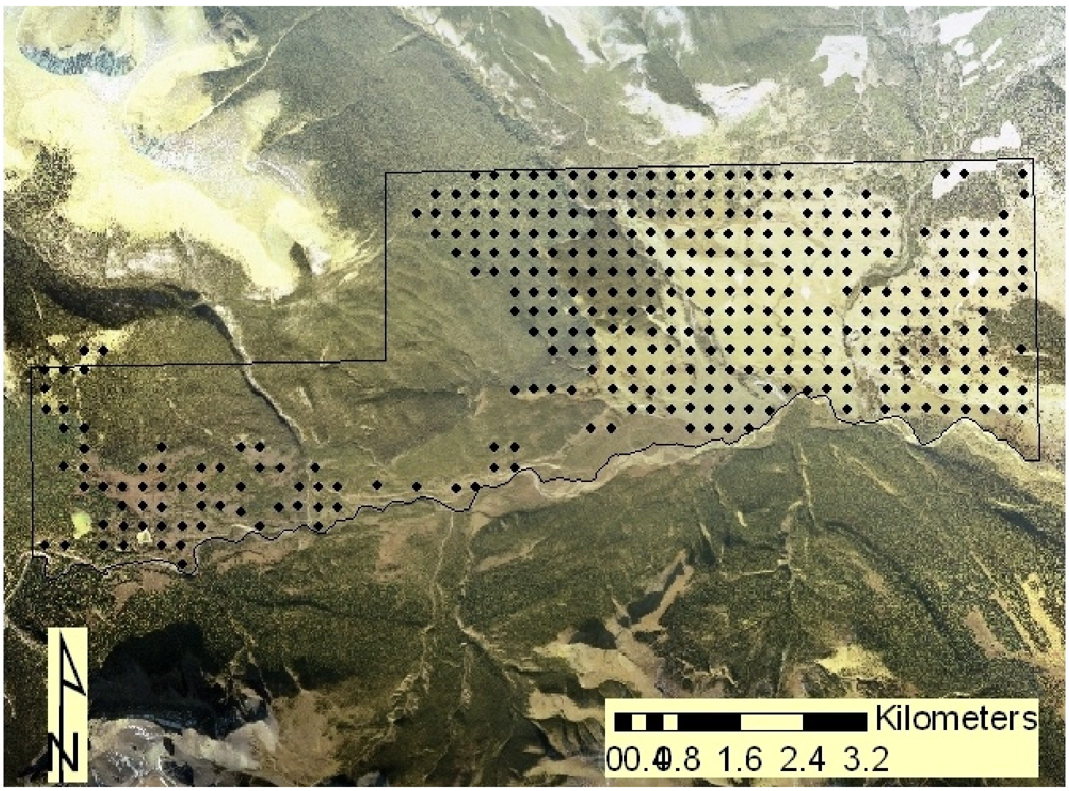

Figure 2. Locations of grassland pellet plots within different habitats across the Ya Ha Tinda ranch, AB.

1.4 Mortalities

Mortalities were detected from ground telemetry during morning presence/absence or aerial telemetry. Average time between detecting a mortality signal and locating the animal was 9.38 days. A total of 19 mortalities have been detected since the beginning of the calendar year, 17 of those were detected during the summer. We located 8 mortalities within the Park boundary and 11 were located on the ranch or along the front ranges (Fig.3). We determined 13 mortalities were predator related, 10 by wolves

(*Canis lupus*), 2 from grizzly bear (*Ursus arctos*), and 1 from cougar (*Puma concolor*). Causes for 3 mortalities were undetermined and one was by train (Table 3). The current number of collared elk remaining at the end of the 2010 summer field season was 60, however, two of those (Gr131 & GR 177) have been missing since 2008, and two other collars may no longer be working. Therefore we can verify only 56 working radiocollars (see Appendix, Table 2).

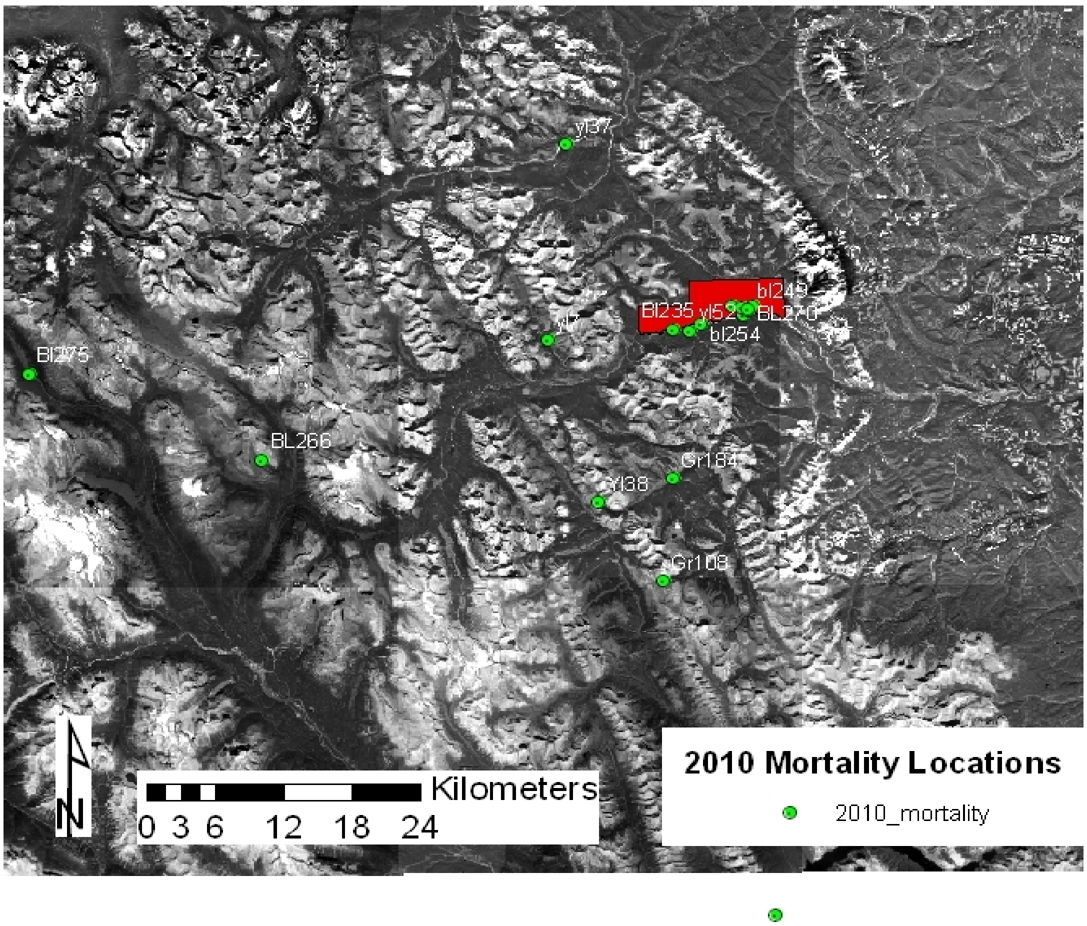

Figure 3. Map of mortality locations with ID numbers from summer 2010.

Table 3) Table listing mortalities found during 2010 representing mortalities from the current and previous year.

Date Found	Date killed	EASTING	NORTHING	MORTALITY CAUSE	Name/Ear Tag	Age Class	Date/Last Location	Migratory status
9/12/2010	9/1/2010	595961	5730842	Wolf	bl254	ADULT	8/19/2010	Resident
9/9/2010	8/25/2010	599556	5731768	Wolf		ADULT		Unknown
8/23/2010	8/16/2010	594911	5730227	Wolf	yl52	ADULT	8/12/2010	PM
6/24/2010	Unk	536901	5726102	Wolf	Bl275	ADULT	2/13/2010	Migrant
6/24/2010	Unk	557358	5717767	Unknown	BL266	ADULT	6/15/2009	Migrant
7/10/2010	7/9/2010	600084	5732100	Other	BL270	ADULT	6/29/2010	Resident
6/24/2010	6/1/2010	592645	5706127	Unknown	Gr108	ADULT	5/24/2009	Migrant
6/19/2010	6/1/2010	584037	5748114	Unknown	yl37	ADULT	5/13/2010	Migrant
6/19/2010	Unk	593526	5716015	Wolf	Gr184	ADULT	7/08/2009	Migrant
6/19/2010	6/5/2010	586886	5713738	Grizzly Bear	Yl38	ADULT	5/14/2009	Migrant
6/12/2010	6/12/2010	600447	5732647	Grizzly Bear		YOY		Unknown
6/19/2010	6/15/2010	582420	5729282	Wolf	yl7	ADULT	6/09/2010	PM
7/5/2010	6/7/2010	593409	5730338	Wolf	Bl235	ADULT	6/03/2010	PM
6/7/2010	6/1/2010	598595	5732596	Wolf		ADULT		Unknown
6/1/2010	5/26/2010	641226	5726093	Wolf	YL 50	ADULT	5/25/2010	Migrant
5/18/2010	5/17/2010	599476	5732465	Wolf		ADULT		Unknown
3/16/2010	3/15/2010	600004	5732286	Cougar	bl249	ADULT	3/15/2010	Migrant
1/22/2010	1/22/2010	602400	5674000	Railway	yl29	ADULT	1/12/2010	Migrant

2 Vegetation biomass and composition

2.1Long-Term Biomass

Based on the sampling design from McInenly (2003), 277 points were created on a systematic grid were created located at 250 m intervals. Each point was placed at the center of a $25m^2$ (5m*5m) plot, in which pellets were counted. The same grid was used, dropping every second plot, which created a grid with 500m spacing and 56 plots in total (Fig. 4). Each plot was flagged, using 20cm steel nails, wrapped with flagging tape, at all four corners to make re-visits easier and data collection more consistent.

Plots were visited once each per month between June and August, biomass was determined using a disc-pasture-meter (DPM) measurement, taken in all four corners of each plot. Average time The DPM consists of a $0.25m^2$ base plate (weight 222g) sliding over a 1m long calibrated aluminum rod (meter stick). After dropping the disc from the top of the meter stick, the settling height (accurate to 0.5cm) was recorded. This method has been described by Vartha and Matches (1977) and Dorgeloh (2002) and been used by Hebblewhite et al. (2006) at the Ranch in the years previous to this study. Biomass clippings were collected at ten randomly selected plot locations and dried in a drying oven at 50 Celsius for 48 hours to calibrate the drop disc measurements for each season.

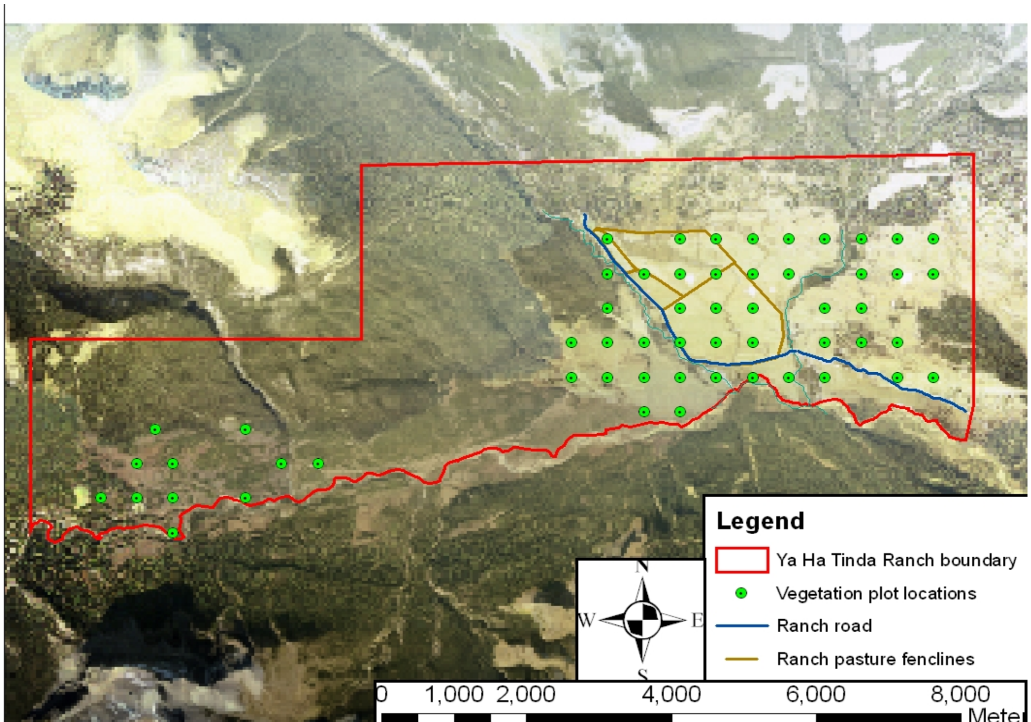

Figure 4) Map of 56 long-term biomass plots

For every disc measurement the average % species cover was determined (grasses, forbs, shrubs and bare ground). The phenological stage of the measured grass was recorded as old, newly emergent, flowering or cured. In addition the % of biomass grazed was assigned. This simple classification has been used by Hebblewhite et al. (2006) before and gives the ability to determine deviations between drop disc readings and grass height measurements. Results for the long-term biomass are reported in the annual Aversive Conditioning report submitted by Jodie Dunbar.

2.2 Peak Biomass

Forage biomass (g/m^2) at the peak of the growing season was statistically modeled within a landcover map derived from a supervised classification of LANDSAT TM imagery at a spatial resolution of 30m^2(Franklin et al. 2001, McDermid 2005,). Landcover types included: closed conifer, moderate conifer, open conifer, shrublands, upland herbaceous, mixed forest, deciduous, (see Franklin et al. 2001 for details). The landcover classification was expanded to include fires in three vegetation types (forest, grassland, and shrub). Cutblocks and salvage logged burns were important and were therefore included in our design (Munro et al. 2006).

Peak forage biomass was sampled randomly following a proportional allocation design (Thompson 1992) within strata designated by landcover type, fire cover types, slope, and aspect classes. Between 27 July and 21 August, 70 peak of biomass sites were sampled for a sampling intensity of .08/km^2. Average sampling date was ~August 10. At each site, plant cover was estimated within five 1m^2- quadrats systematically placed along a 30-m transect and clipped total (green + standing dead) herbaceous biomass in three 0.25m^2quadrats, which were averaged for one biomass estimate/site. Wet mass of forage biomass was weighed in the field; in the lab dry weight was obtained from n=210 samples oven dried at 50°C for 48 hours. Total shrub biomass was estimated using the basal diameter-biomass relationships (Visscher et al. 2006). Shrub biomass was converted to biomass of only forage species and leaf-forage biomass (g/m^2) using mean % conversions for both within each landcover type. Data from peak biomass sampling will be used in the future to inform Resource Selection Functions (RSF's) for Scott Eggeman's M.Sc. project.

3) Shrub and conifer encroachment on rough fescue grasslands of the Ya Ha Tinda
Lead: Lindsay Glines

Background

Over much of the past century, fire suppression in the eastern slopes of the Rocky Mountains has created an unnatural mean fire return interval and fire cycle. Rough fescue grasslands along the Red Deer River Valley provide high quality forage for the wintering Banff elk herd, and a reduction in area or quality of grassland habitat due to encroachment of trees and/or shrubs could alter the ability to support this partially migratory herd. Analysis of six (1952 ,1962, 1972, 1982, 1992, 2003) sets of photos was completed in July 2010 to evaluate the extent of vegetation change over a 50-year time period. A preliminary analysis of small-scale changes along grassland-woody vegetation ecotone has also been completed and can be found in: Glines L., Bohm, A., S. Eggemen, S., E. Merrill, M. Hebblewhite. 2009. Red Deer River Valley Ecotone and Elk Project: Second year progress report, June 2008. University of Alberta. 26pgs

Methods

Sites

This analysis focused specifically on grassland complexes at four sites (Ya Ha Tinda [YHT] West Lakes [WL] Tyrell Creek [TY], Scotch Camp [SC], and which establish an east (high) to west (low) grazing gradient with the Red Deer river drainage. Past high herbivory in areas such as YHT and WL, in combination with fire suppression at the YHT and WL would likely increase the rate or total amount of grassland loss. The west has experienced prescribed burns since 1983 (White 2001), and historically moderate herbivory, where encroachment might be expected to be moderate to low.

Analysis

Photographs were scanned at a high resolution (1000 DPI +), to provide pixel size of 1 m^2. Images were georeferenced using a minimum of 10 ground tie points to existing Parks Canada orthorectified images within an ArcGIS program. Vegetation classes (grassland, shrubland, mixedwood and coniferous) as well as other (water, buildings, bare ground, pasture, logged) landcover types were delimited using standard photo interpretation (PI) techniques. This process was repeated in each study site and photo year. The total area of vegetation types was reported for encroachment analysis, and a contingency table developed for assessing accuracy of PI relative to ground-truthed vegetation types.

Results

There has been a general decrease in grassland area for each study site except the YHT (Fig 1). Each study site photo series fits a linear decrease in grassland area well (WL; R^2=0.76, $P<0.05$, TY; R^2 =0.91, $P<0.05$, SC; R^2 =0.99, $P<0.05$), except the YHT. As expected, there has been moderate change in the western fire exposed sites, with more grassland loss in the WL fire suppressed region.

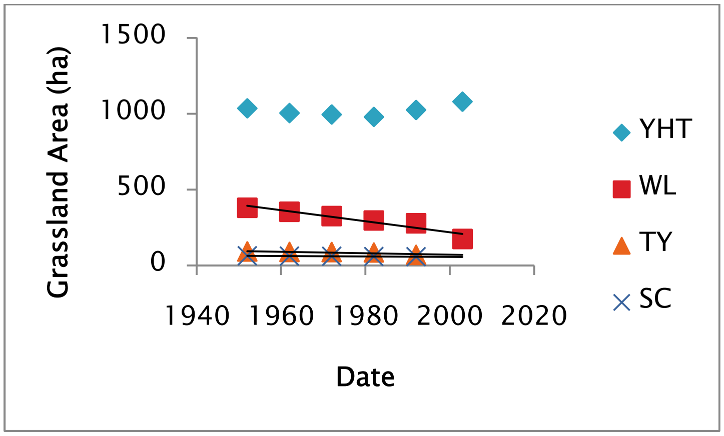

Figure 5 Reduction in grassland area over time for 4 study sites within the Red Deer River Valley. YHT= Ya Ha Tinda, WL= West Lakes, TY= Tyrrell Flats, SC= Scotch camp. Linear equations are as follows: WL($y = -0.4844x + 1039.3$), TY($y = -3.6365x + 7491.2$), SC ($y = -0.1439x + 343.86$).

The decrease, and subsequent increase in grassland area over time at the YHT is accompanied by a decrease in shrubland (Fig 6). While coniferous cover is also seen to increase, the most marked change is in shrub cover. While this could be the result of observer error in PI, a contingency table (table 4) was created to assess the reliability of the methods using to identify vegetation types. The overall accuracy of the 2003 cover map was 76.2% with the greatest error in shrubland indentification (57.7% accuracy). Most often, areas identified as shrubland on the ground were identified as grassland in the 2003 photoset.

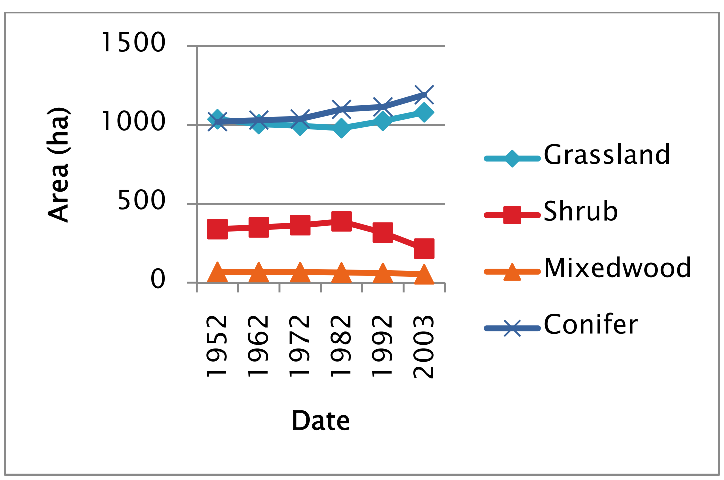

Figure 6 Change in aerial coverage of vegetation types within the Ya Ha Tinda over time.

Table 4 Contingency table for accuracy assessment using 94 ground truth points collected in 2009 with vegetation types described in the 2003 photo set. Overall map accuracy was 76.2%.

	Photo Vegetation Classes					
Field Varified	Grassland	Shrubland	Conifer	Mixedwood	TOTAL	PI Accuracy
Grassland	28	5	1	1	35	80
Shrubland	7	15	4	0	26	57.69
Conifer	0	2	18	0	20	90
Mixedwood	1	0	2	10	13	76.92

4) Discussion

Grassland loss has occurred within the Red Deer River valley since 1952. This loss has been more notable in the West Lakes region. Using repeat aerial photography, Rhemtulla et al. (2002) found a shift in grasslands to closed canopy forest over a 62-year period in Jasper Park. As a result of canopy closure and shrub invasion, forage production can be reduced by as much as 60% (Johnson and Smoliak 1968).

The Ya Ha Tinda exhibits an interesting pattern where an initial loss of grassland from 1952-1972 was offset by an increase from 1982-2003. While further analysis is required, this trend can be explained by the active mowing of shrub fields in the YHT region since 1982 (Hebblewhite 2006). While conifer encroachment has continued, it has not been great enough to reduce the grassland area when mowing has reduced the shrubland to a greater degree.

The population of the Ya Ha Tinda elk herd appears to be steady, based on counts from the previous two winters and sex and age ratios. However, fewer elk appear to be participating in their seasonal western migration into the park. Based on anecdotal information and past research (Hebblewhite et al. 2006), there has been a noticeable trend of eastward summer migration towards the Wildhorse and Panther Corners areas. This may be due to many factors including climate change, increased predation by wolves and bears in the higher elevation summer ranges, and predation avoidance along the Red Deer corridor east of the Park boundary.

To date, we have learned that migrants are declining faster than residents in this population, despite the nutritional benefits of migration, because of predation by wolves and grizzly bears on summer ranges (Hebblewhite 2006, Hebblewhite 2007). Declines seemed to have stabilized in recent years, and yet research has been unable to determine if wolves and elk have reached a balance, or whether other factors are halting declines. Understanding the role of wolves in regulating elk to low density is a key management question.

The goals of Scott Eggeman's Master's research will be to examine the general hypothesis that vital rates (survival, pregnancy and calf survival) of migrant and resident elk vary with changes in density and predation to determine a stable ratio of migrants to residents in a population. Specifically, we will test whether wolf predation has regulated elk to a low density equilibrium (i.e., that wolf predation is density-dependent with elk density; Sinclair 1989). Second, we will test the hypothesis that migrants are still being impacted more by wolf predation. We predict that 1) cause-specific mortality by wolves will decrease with decreasing elk density, and 2) survival rates will be lower for migrants and their calves compared to resident, we will test this hypothesis using a long-term dataset of over 300 adult female elk collected from 2001 through past and present field research. In addition, we will assess how changes to resource availability on the winter range due to prescribed fires differentially affects resource selection strategies of resident and migratory adult female elk. We will test the hypothesis that burning of winter range grasslands will enhance forage quality. We predict that elk will select for burned areas more often compared to non-burned areas. To test this hypothesis, we will use data from GPS collared elk and VHF telemetry since 2001, in addition to pellet data to compare pre- and post-burn resource selection.

Our goals for the 2011 field season remain relatively unchanged. We will attempt three backcountry packtrips in 2011 to locate mortalities and try to observe migrant elk with calves of the year. During the winter of 2011, we may trap and radiocollar and/or eartag 20-30 additional elk to maintain a target sample size of ~80 elk. A spring progress report in 2011 will elaborate on specifics for the summer season and developments over the winter field season.

Literature Cited

Dorgeloh, W.G. 2002. Calibrating a disc pasture meter to estimate above-ground standing biomass in mixed bush-veld, South Africa. African Journal of Ecology **40**:100-102.

Franklin, S.E., G.B. Stenhouse, M.J. Hansen, C.C. Popplewell, J.A. Dechka, and D.R. Peddle. 2001. An integrated decision tree approach (IDTA) to mapping landcover using sattelite remote sensing in support of grizzly bear habitat analysis in the

Alberta Yellowhead Ecosystem. Canadian Journal of Remote Sensing **27**:579-592.

Hebblewhite, M. 2006. Linking predation risk and forage to ungulate population dynamics.University of Alberta. Edmonton, Alberta. 256 pg

Hebblewhite, M. 2007 Predator-prey management in the National park context: lessons from a transboundary wolf-elk, moose, and caribou system. *Transactions of the North American Wildlife Conference* **72**, 348-365.

Johnson, A. and S. Smoiak. 1968. Reclaiming brush land in southwestern Alberta. Journal for

McDermid, G. J. 2005. Remote sensing for large-area, multi-jurisdictional habitat mapping. Dissertation. University of Calgary.

McInenly, L.E. 2003 Seasonal effects of defoliation on montane rough fescue (Festuca campestrisRydb.). University of Alberta, MSC.

Munro, R., M. Hebblewhite, and E.H. Merrill. 2006. Effects of post-fire logging on elk habitat during the first 3-years post burn. Forest Ecology and Management, In prep.

Murie OJ, Elbroch M (2005). Animal Tracks, Peterson Field Guide Series 3rd Ed. Houghton Mifflin Company, New York

Rhemtulla, J.M., R.J. Hall, E.S. Higgs, and S.E. MacDonalds. 2002. Eighty years of change: vegetation in the montane ecoregion of Jasper National Park, Alberta, Canada. Canadian Journal of Forestry Resources 32: 2010-2021

Sanchro L.L., W.L. Stronga, and C.C. Gates. 2005. Prescribed burning effects on summer elk forage availability in the subalpine zone, Banff National Park, Canada. Journal of Environmental Management 77:183-193

Spaedtke, H.R. 2009 Aversive conditioning of elk at the Ya Ha Tinda. University of Alberta, Msc.

Smith, L. B., and T.L. McDonald. 2002. Criteria to Improve Age Classification of Antlerless Elk. Wildlife Society Bulletin. 30:200-207.

Sinclair, A. R. E. 1989 Population regulation of animals. In *Ecological Concepts* (ed. J. M. Cherret), pp. 197-241. Oxford: Blackwell.

Visscher, D. R., E. H. Merrill, D. Fortin, and J. L. Frair. 2006.Estimating woody browse availability for ungulates at increasing snow depths. Forest Ecology and Management222:348-354.

White, C.A., E.G. Langemann, C.C. Gates, C.E. Kay, T. Shury, and T.E. Hurd. 2001. Plains bison restoration in the Canadian Rocky Mountains? Ecological and management 299 considerations. *In* Harmon, D., editor. Crossing boundaries to manage wildlife: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands. The George Wright Society, Hancock, Michigan.

White, C.G., P. Zager, M.W. Gratson. 2010. Influence of Predator Harvest, Biological Factors, and Landscape on Elk Calf Survival in Idaho. Journal of Wildlife Management 74(3):355-369.

Appendix

Table 1) List of all marked elk observed with an elk calf. An M designates migrant and PM designates partial migrant.

BL204	BL213	BL220pm	BL221pm	BL222	BL234	BL242	BL244
BL287m	Bl254	Bl256	BL257	BL264	OR3	BL267pm	Bl269
BL295	BL299	GR140	BL246	GR99	OR1	OR13	OR2
OR7pm	YL58	YL62m	YL80	OR6pm			

Table 2) All remaining radiocollared elk after 12 September 2010. Ear tag ID represents tag color: bl = blue, gr = green, or = orange, yl = yellow, and number. The letter G identifies elk with GPS collars.

	Ear Tag ID	Frequency	Comments
1	bl 201 G	150, 6519	
2	bl 204	150,710	
3	bl 211	149,922	
4	bl 213	148,331	
5	bl 220	152,060	
6	bl 221	148,786	
7	bl 226	149,586	
8	bl 234 G	150, 6716	
9	bl 236 G	151,029	
10	bl 240	152,990	
11	bl 243 G	150,992	
12	bl 244	152,695	
13	bl 245	148,532	
14	bl 246	148,641	
15	bl 250 G	148,160	
16	bl 251	150,754	
17	bl 256	152,802	
18	bl 258	152,240	
19	bl 260 G	152,889	
20	bl 261	152,071	
21	bl 262	148,312	
22	bl 263	151,071	
23	bl 264	149,545	
24	bl265	150,850	
25	bl267	150,430	
26	bl268	150,680	
27	bl269 G	152,859	
28	bl272	150,329	
29	bl284	150,539	
30	bl285	150,439	

31	bl287	150,649	
32	bl288	150,620	
33	bl290	150,640	
34	bl292	150,690	
35	bl295	150,729	
36	bl 622	152,790	
37	gr 131	152,706	missing since 2008
38	gr 133	148,970	
39	gr 177	148,501	missing since 2008
40	gr 183	152,750	
41	yl 1	152,464	
42	yl 2	148,980	
43	yl 42	148,796	probably dead collar
44	yl 55	152,125	
45	yl 62	149,206	
46	yl 88	150,609	probably dead collar
47	or 1	150,500	
48	or 2	150,629	
49	or 3	150,470	
50	or 5	150,669	
51	or 6	150,320	
52	or 7	150,560	
53	or 8	150,699	
54	or 9 G	150,800	
55	or 10	150,868	
56	or 11	150,929	
57	or 12	150,549	
58	or 13	150,839	
59	or 14	150,789	
60	or 15	150,858	