REGIONAL INDUSTRY CARIBOU COLLABORATION

2015 Annual Report

First Annual Report for the Regional Industry Caribou Collaboration

RICC January 31, 2016

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Executive Summary

This annual report outlines the goals and achievements of the Regional Industry Caribou Collaboration (RICC) from its inception in 2013, through to the end of the 2015 calendar year.

A single common concern, that of declining woodland caribou populations and the need to implement on-the-ground actions, has led to the formation of RICC. As a united group of energy, forestry, and pipeline companies, RICC has attempted to work across tenure boundaries within a portion of the Athabasca Oil Sands region and promote collaborative, range-based efforts aimed towards boreal caribou recovery.

So far, RICC has focused its efforts on the East Side Athabasca River (ESAR) and Cold Lake caribou ranges. Throughout 2013 and 2014, RICC developed its core objectives and created a foundation for what has become a strategic working group. Objectives are focused on coordinating functional habitat restoration, and ultimately, integrated planning of industrial disturbance activities in time and space while supporting scientific research and trials to assess the response of wildlife to restoration treatments. RICC currently includes seven active members, all of which have contributed experience and support in the spirit of collaboration.

In addition to the governance structure that has been implemented, RICC has developed a comprehensive inventory of digital data to support habitat restoration (hosted on an internal data portal), and initiated a series of "Contributing Projects" which are focused research and management projects. Major projects to date include: 1) graduate student support of wolf research; 2) predator radio collaring; and 3) the prioritization of linear features for restoration.

Wolf research revealed that wolves selected and travelled 2 to 3 times faster on linear features compared to the natural forest, increasing the potential for these predators to encounter caribou and their primary prey. Most types of anthropogenic linear features, except low impact seismic lines, increased travel speed. A continuation of this graduate work will use LiDAR (Light Detection and Ranging) data to determine the height of regenerating vegetation at which seismic lines are no longer selected by wolves. The LiDAR analysis will help identify which seismic lines are sufficiently regenerating such that restoration is not needed, allowing greater focus on lines that require treatment. Predator collaring fieldwork (completed between January and October, 2015) resulted in the deployment of 22 collars on wolves and 20 on black bears.

The data collected is being used to evaluate how these predators respond to restoration treatments that are beginning in winter 2015/16. The linear feature prioritization project used 6 criteria to rank seismic lines for restoration, including line density and avoiding areas that were slated for development in the near term. Line density was a key criteria for consideration, because selecting restoration areas with the lowest linear feature density will realize a greater ecological benefit for restoration activities, particularly to restore larger, contiguous patches of caribou habitat with the least effort possible. The analysis began with an initial 70,000 km of seismic lines in the RICC study area, and through prioritization was reduced to 1,854 km of candidate lines for restoration treatment - some of which will be restored this winter. The criteria used to select this initial set of candidate lines resulted in the identification of sites that had little overlap with planned development activities (low opportunity costs relative to development) while providing ecological benefits to caribou and their habitat.

Additional ongoing projects include monitoring existing radio collared animals, analysis of predator location data, linear feature restoration, and strategic engagement and communication ventures. RICC is in the process of developing a 5-year adaptive management plan to address hypotheses and knowledge gaps geared towards better understanding the response of predators to linear features and various approaches to restoring these features. Through adaptive management, RICC will integrate results from past and ongoing research efforts to design suitable habitat management solutions for boreal caribou.

In 2016, RICC is seeking increased member participation so that research activities may grow in both scope and spatial scale, and new, multi-stakeholder relationships can be built. New initiatives, such as a wolf census of the Cold lake caribou range and the Christina herd of the ESAR caribou range will validate current population estimates in the area and enable the measurement of their numerical response to restoration treatments. Long-term, RICC's primary outcome will be to make research-based conclusions, generating recommendations to move forward with recovery focused management actions and contributions to the development of provincial caribou action plans

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1.0 Introduction and Background

Boreal woodland caribou (*Rangifer tarandus caribou*) populations are declining rapidly in number (McLoughlin *et al.* 2003; Hervieux *et al.* 2013) and the species is currently listed as "threatened" under the federal Species at Risk Act (SARA). Two ultimate factors have been implicated with their decline: climate change and human disturbance (Dawe 2011; Wittmer *et al*. 2007). Both of these factors have been associated with an increased abundance and distribution of white-tailed deer (*Odocoileus virginianus*) and moose (*Alces alces*), which consequently increases the abundance of predators that also consume caribou. This process has been termed apparent competition (Holt 1977), because it *appears* as though caribou and other ungulates compete for a resource, but in reality their interaction is governed by a common predator.

Climate change has increased the distribution of white-tailed deer because winters have become less severe over time (Dawe 2011). Human disturbance that converts forest to early seral vegetation has also increased the abundance of both deer and moose because of the increased forage that early seral vegetation provides. Seismic lines can exacerbate this problem by increasing the foraging efficiency of wolves (McKenzie *et al*. 2012) and potentially bears as well (McNay unpublished data). By foraging more efficiently, predators are able to consume more caribou and other ungulates (McKenzie *et al.* 2012), which can also lead to increased predator numbers. Because moose, deer and predator populations have been associated with human disturbance (Schwartz and Franzmann 1991; Rempel *et al.* 1997; Serrouya *et al.* 2011), caribou decline can be indirectly linked to human development (Sorensen *et al*. 2008). These ecological pathways mean that companies operating within boreal caribou ranges have the potential to make a positive impact with respect to recovery of boreal caribou by undertaking efforts to restore caribou habitat.

The federal *Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population, in Canada* (2012) identifies the objective to achieve self-sustaining local populations in all boreal caribou ranges throughout their current distribution in Canada. Since the time this document was released, the Government of Alberta has been working to develop range plans and a provincial action plan that will outline recovery measures for boreal caribou in Alberta. Specifically, these plans will define how land-use activities will be managed to establish a minimum of 65% undisturbed habitat in a given range, where disturbance is defined as human footprint plus a 500-m buffer, along with areas that have been burned in the last 40 years (Environment Canada 2012). However, through ongoing research led by RICC and others, it is expected that these disturbance targets may be refined, and particularly what constitutes habitat that is no longer disturbed. As of 2012, boreal caribou ranges across Alberta are between 15% and 43% undisturbed (Environment Canada 2012).

Although led by government, the success of range-wide recovery efforts are recognized as a shared government, public and private-sector responsibility (Government of Alberta 2011). As range planning is to be completed by 2017, the provincial goal of stabilizing, recovering and sustaining woodland caribou populations will be achieved through joint efforts and considerations from provincial and federal departments, Aboriginal communities, industry and recreational stakeholders, and other organizations associated with caribou conservation (Government of Alberta 2011). Therefore, the formation of collaborative, range-based, conservation programs will be key in the recovery of boreal caribou.

The Regional Industry Caribou Collaboration (RICC) was formed in 2013, as a group of industry companies united to participate in coordinated research, habitat restoration, effectiveness monitoring and integrated land management where their industrial operations overlap with boreal caribou range. By definition, all RICC research is *applied research,* driven by the desire to resolve uncertainty around caribou conservation. Work conducted by RICC is intended to directly support the federal caribou recovery strategy and the pending Government of Alberta range plan and provincial action plan. The RICC forum will help to facilitate a shared vision with clear goals, ongoing engagement and commitment with respect to caribou recovery efforts.

2.0 RICC Mission and Objectives

A primary rationale for the formation of RICC is the recognition that wide-ranging animals such as caribou and wolves move beyond the tenure of any one company, region, or even provincial jurisdiction. Therefore, RICC's mission is to enable the conservation and restoration of caribou and their habitat through collaborative, range-based efforts. The goal of RICC is to coordinate research, integrated land management and active, science-based adaptive management that contributes to the mission within the defined RICC geographic scope of interest (Fig. 1). Defined objectives of RICC are to:

- Coordinate functional restoration of disturbance in priority areas of the geographic scope of interest;
- Coordinate land-use planning and industrial activity across companies and across sectors to minimize future disturbance across the geographic scope of interest;
- Support and lead scientific research on caribou ecology and on caribou-predator-landscape relationships to identify priority issues and/or priority areas; and
- Support and lead investigative trials on functional restoration methods and wildlife responses to assess the effectiveness of treatments, and to make recommendations for broader implementation.

3.0 Study Area

The RICC area of interest encompasses the Cold Lake and East Side Athabasca River (ESAR) woodland caribou ranges, parts of the contiguous boreal forest and Saskatchewan Boreal Plain Caribou Range to the east, along with a 20-km buffer to incorporate adjacent area that may have an impact on woodland caribou within their established ranges (Fig. 1).

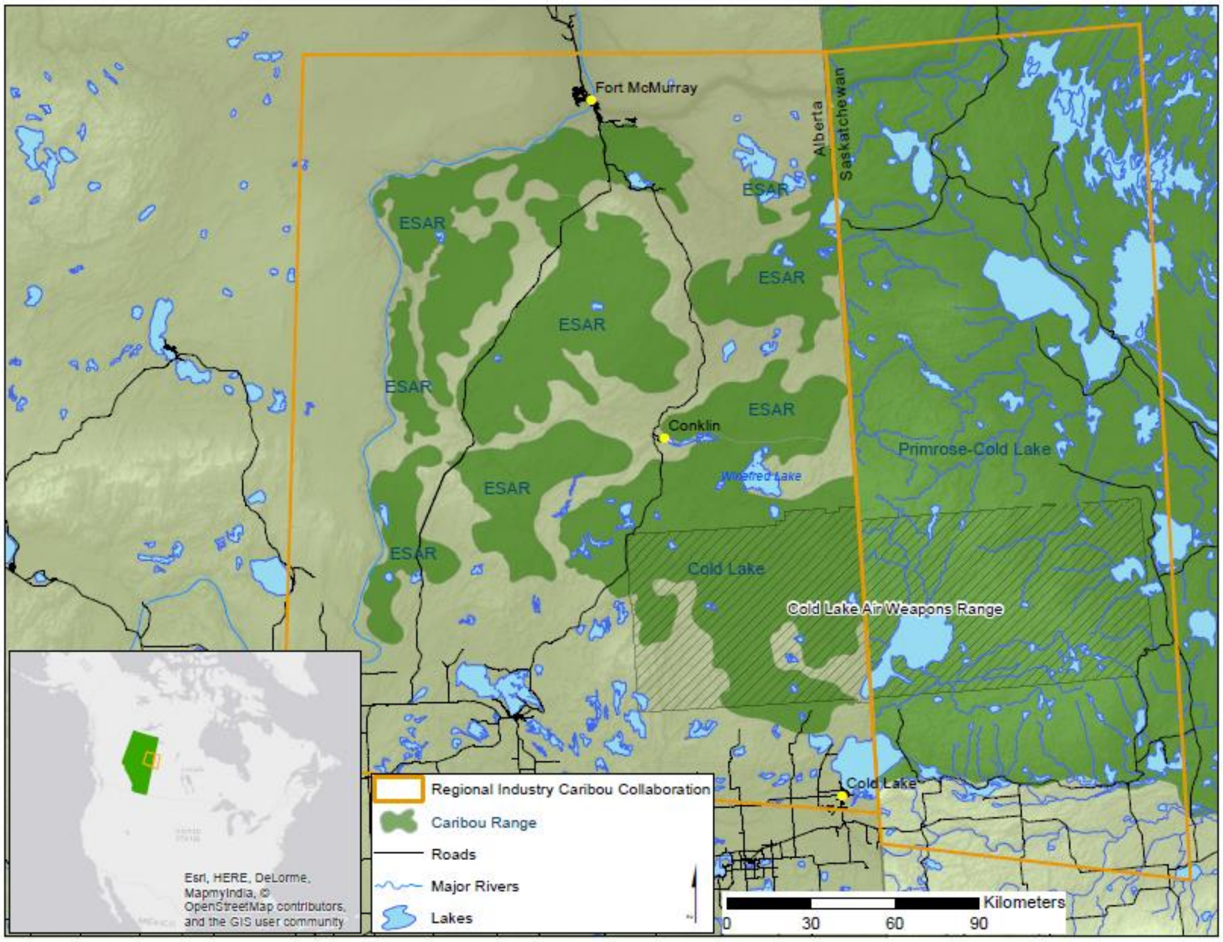

Figure 1 The RICC Study Area in Alberta and Saskatchewan. Indicates the boreal woodland caribou ranges on the Alberta side (Cold Lake and East Side Athabasca River ranges). Total study area is approximately 52,400 km^2 in Alberta, and 32,600 km^2 in Saskatchewan.

Movement is likely limited between these caribou ranges and between surrounding populations, where caribou reside in both large peatland mosaics and old lichen-pine forests. Both the ESAR and Cold Lake caribou ranges are currently in decline with 81% and 85% disturbed habitat[1], respectively, and the Saskatchewan Boreal Plain range is 42% disturbed overall[2] (Environment Canada 2012).

[1] Habitat disturbance includes anthropogenic and fire disturbance. As of 2012, fire disturbance accounts for 26% and 32% for ESAR and Cold Lake caribou ranges, respectively, and 26% in the Saskatchewan Boreal Plain range (Environment Canada 2012).

[2] This statistic is for the entire Saskatchewan Boreal Plain range which spans from the Alberta border to the Manitoba border, throughout the boreal plain ecozone. The RICC study area in Saskatchewan only overlaps with a small portion of this range.

4.0 Member Companies

RICC is currently comprised of five energy companies (Canadian Natural Resources Limited, Cenovus Energy Inc., Devon Canada Corporation, Imperial and MEG Energy Corp.), one forestry company (Alberta-Pacific Forest Industries) and one pipeline company (TransCanada Pipelines Limited). The Alberta Biodiversity Monitoring Institute (ABMI) performs the role as "Service Provider." RICC has also successfully collaborated with a number of organizations, including Alberta Innovates-Technologies Futures and the University of Alberta (through graduate student and academic sponsorship), and independent researchers. Plans to engage and directly collaborate with the Government of Alberta are underway, and RICC continues to encourage increased member participation. A process to engage other stakeholders and rights holders is in the early stages of development.

5.0 Structure

To ensure efficient operations, RICC established a Steering Committee and Technical Advisory Committee (TAC; Fig. 2). Together, the Steering Committee and TAC function to coordinate activities and make informed decisions for participation in collaborative industry caribou recovery efforts. In general, information flows from the TAC, where considered recommendations are made, and then passed on to the Steering Committee for decision.

Projects initiated by RICC may be identified as Contributing Projects, as defined under the RICC Joint Industry Project (JIP) Contract. Members are free to take part in a Contributing Project, if desired, but participation is not mandatory. Alternately, non-RICC members can participate in Contributing Projects, without the requirement to become a RICC member. Contributing Projects are research or management projects aligned with the mission, goal, objectives and scope of RICC, and must be sponsored by a RICC member. Contributing Projects are funded by a RICC member either solely or in collaboration with other member companies. Requests for proposals may be delivered throughout the year and are evaluated by the TAC, followed by the steering committee. Funds are allocated after approval is granted by the Steering Committee, member participation is determined, and a project budget is accepted.

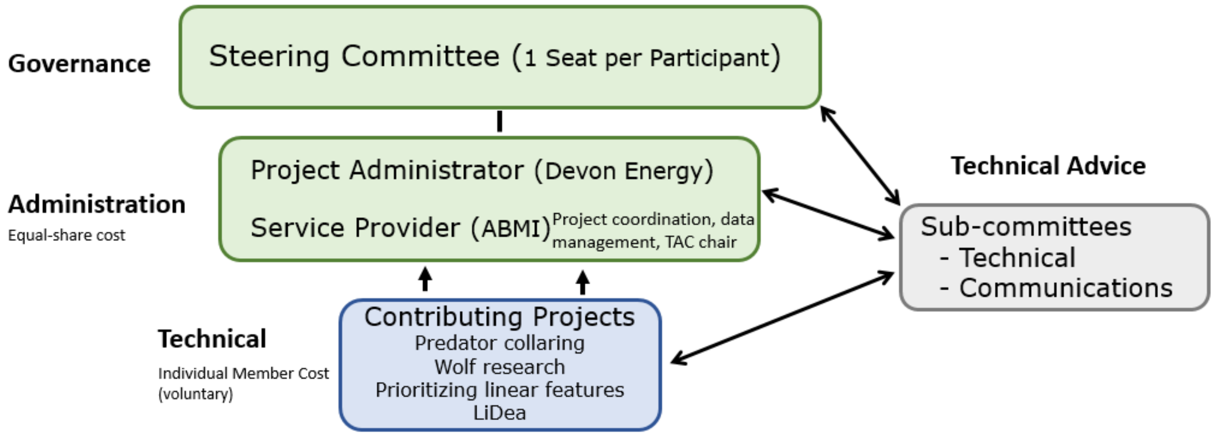

Figure 2 The RICC operating structure. RICC is governed by the Steering Committee, and receives technical advice and recommendations from the TAC on Contributing Projects and other technical matters.

5.1 Project Administrator and Service Provider

Devon Canada Corporation has been appointed as the Project Administrator for the purposes of the RICC legal agreement. The Project Administrator has all of the rights and obligations of other RICC members, and also participates in day to day administration and facilitation of projects.

The ABMI has been appointed as the Service Provider for RICC, and also serves the role as chair of the TAC. The primary responsibility as Service Provider is to administrate, coordinate, and direct research, management and monitoring activities, which may or may not be implemented through Contributing Projects.

5.2 RICC Committees

RICC is administered by a Steering Committee. This group, comprised of at least one representative appointed by each participating company, is responsible for duties such as project stewardship, reviewing and approving proposed projects, providing direction and feedback to RICC projects, and authorizing all communications and branding for RICC. A representative of the Project Administrator plays the role of chairperson of the Steering Committee.

The TAC's primary responsibility is to review, consider and make recommendations to the Steering Committee on technical matters related to Contributing Projects or as these technical issues pertain to guiding strategic direction of RICC. The TAC is supplemented by technical experts, as needed, to ensure sufficient expertise is present while making recommendations for the Steering Committee.

The Communications Sub-committee is responsible for developing a communications plan that is aligned and consistent with the RICC mission, goal, objectives and scope, including key communication opportunities and timelines. The Communications Sub-committee has initiated the development of a communications and engagement strategy, and are working with a representative from the Canada's Oil Sands Innovation Alliance (COSIA) to ensure RICC communications activities meet the COSIA Ways of Working Guidelines as well as address the communication needs of non-COSIA collaborators.

RICC typically holds meetings every two months, which may consist solely of the Steering Committee, or may have time set aside to discuss TAC-specific topics. Technical workshops are conducted on an as-needed basis, and are utilized to develop and review technical work completed by RICC or collaborating partners and facilitate knowledge transfer.

6.0 Collaboration and RICC

Research and conservation initiatives are often daunting tasks for individual companies or stakeholders to take on alone. Increasing operational costs, limited resources or space for research, species that range across tenures and political boundaries, and increased regulatory requirements for companies to collaborate, all have been pushing individual companies towards joint effort projects. Furthermore, as the number of species across Canada requiring research and management attention rises (e.g., grizzly bear, ferruginous hawk), the need for a collaborative approach to conservation is heightened.

Though collaboration in Alberta is not new (e.g., groups such as the ACC (Alberta Caribou Committee) and the EMCLA (Ecological Monitoring Committee for the Lower Athabasca)), RICC's aim is to apply a fresh, recovery-focused take on multi-stakeholder participation that will be highly successful to reach research and conservation objectives for caribou. Although multi-stakeholder participation has not been formalized, as mentioned above, a process to engage other stakeholders and rights holders is beginning.

7.0 Project Summaries

Since its inception in 2013, RICC has been dedicated to participating in research and monitoring the effectiveness of management that is geared towards recovery of boreal caribou. Throughout 2014, RICC focused on identifying a core group of companies to initiate collaborative efforts in NE Alberta, and developed both its working structure and core objectives. RICC determined its role in already established research projects (e.g., LiDea), and began construction of an online resource portal for members to house conservation and project planning-related data (RICC Data Portal).

Current research is helping to inform habitat restoration, and includes studies focused on predator-prey relationships that directly and indirectly affect caribou. In 2015 RICC members initiated a predator collaring program to contribute to a long-term adaptive management plan, focusing on determining how habitat alteration and subsequent restoration actions affects biological drivers of caribou population dynamics (see predator collaring project and the RICC 5-year plan). Substantial efforts were also put in to an analysis for identifying priority areas for linear feature restoration within caribou ranges. Plans for restoring additional linear features are underway.

Summarized below are specific projects RICC has worked on over the 2014 and 2015 calendar years.

7.1 RICC Data Portal

Working in partnership with ABMI, RICC has developed and refined an online data portal, which houses a suite of data and other resources for use by RICC member companies. The RICC Data Portal facilitates data sharing and collaboration among RICC affiliated researchers and managers by creating a common, easily accessible place for participating members to locate and utilize data associated with caribou conservation, and to facilitate planning for habitat restoration.

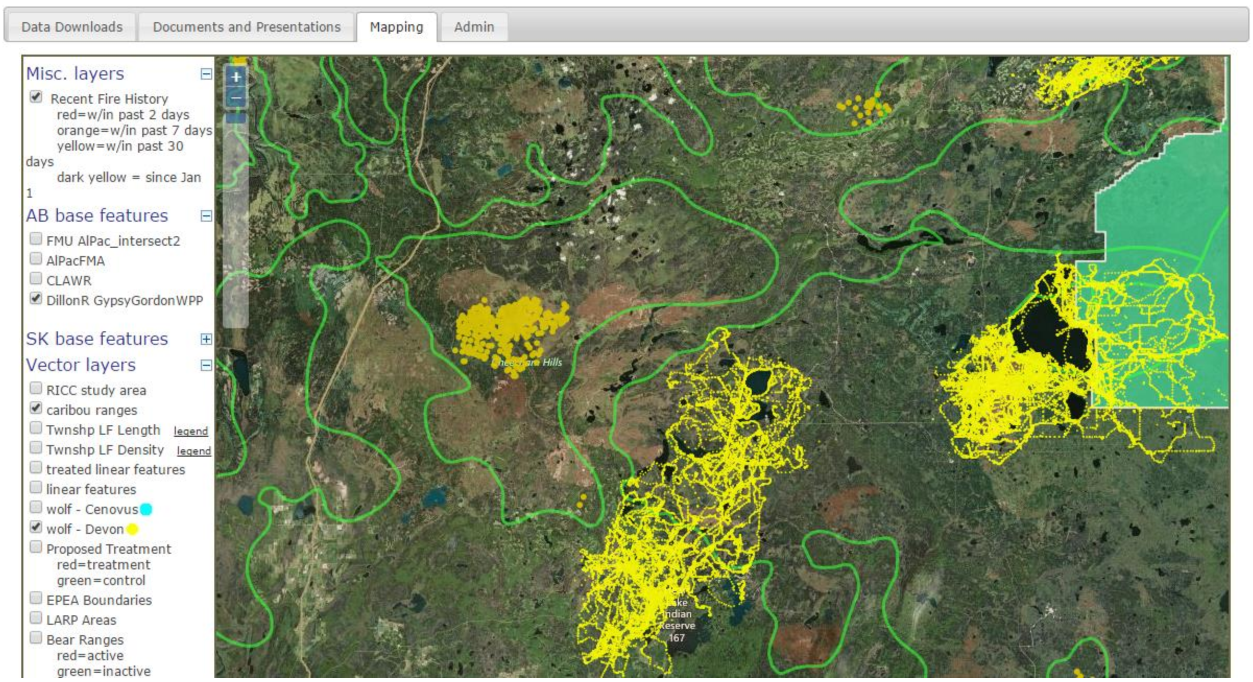

Figure 3 Screen capture of the RICC Data Portal mapping interface, displaying caribou range (open green polygons), Wildland Provincial Park (solid green), recent fire history (large, dark-yellow points), and wolf telemetry (small, light-yellow points). Visitors to the portal can select which layers they would like to view using the left-hand-side features bar.

Examples of data housed in the portal include an inventory of specific seismic lines that have been restored (and the method employed), predator telemetry data and estimated ranges, Geographic Information Systems (GIS) base layers for land cover, industrial footprint and linear features (e.g., seismic lines and roads), fire disturbance, Alberta caribou ranges and draft GoA restoration priority maps, and RICC member EPEA (Environmental Protection and Enhancement Act) approval boundaries and projected development plans. In addition, the portal houses a mapping interface for easy visualization of available data and scientific presentations by RICC affiliates (Fig. 3). This resource has been used extensively by RICC members, and will further increase in utility as more data and reference materials are appended and can contribute to land-use planning exercises.

7.2 How wolves interact with linear features

RICC directly supported the graduate research of Melanie Dickie, a student at the University of Alberta (U of A) under the supervision of Dr. Stan Boutin, during the 2013 and 2014 academic years. Melanie's research used fine-scale telemetry to determine if grey wolves selected for linear features, and if they increased their movement rates while on linear features (Dickie 2015). In addition, Melanie examined how the abundance and physical properties of linear features affect wolf selection of, and movement on, these features. Wolves involved in this project were captured within the RICC area of interest during the winters of 2013 and 2014, and were fitted with GPS collars programmed for 5-minute location fixes in summer and winter.

Within the study area, linear features were classified as conventional seismic lines, low-impact seismic lines, trails, roads, pipelines, transmission lines and railway using Government of Alberta specifications. One-dimensional line features were converted into polygons by assigning a buffer according to their average width.

In the study, wolves selected all linear features except low-impact seismic lines in summer, and truck trails in winter. Wolves travelled 2 to 3 times faster on linear features compared to the natural forest, excluding low-impact seismic lines year-round and transmission lines in the winter (Fig. 4). Wolves travelling on low-impact seismic and transmission lines moved 53% and 48% slower than in forests. To test whether linear feature use by wolves increased their search distance, Dickie evaluated whether overall daily wolf movements were increased by increased travelling speed on linear features as well as increased time spent on linear features. Increased average daily traveling speed while on linear features as well as increased proportion of steps spent traveling on linear features increased net daily movement rates. For example, a 1-km/hr increase in wolf travelling speed while moving on linear features, and a 1% increase to the number of steps travelling on linear features, corresponded to a 12% and 11% increase, respectively, in total distance moved per day in summer; translating to a 46% increase in daily distance moved for every hour wolves spent traveling on linear features. These results suggest that wolf use of linear features can increase their prey search rate.

Wolf selection of linear features was not related to overall linear feature density. However, for every increase of 1 km/km^2 of low-impact seismic lines in a wolf's home range, the odds of wolves selecting low-impact seismic lines in the winter increased by 14%. In summer, linear features in uplands increased wolf travelling speed relative to surrounding forest more than did linear features in wetlands, whereas linear features in wetlands exhibited a greater difference in winter. Wolves selected areas on linear features with shorter vegetation in summer, but not in winter. The effect of vegetation at reducing wolf use could be muted in winter because snow covers vegetation. Nonetheless, with every 1 m increase to vegetation height, the odds of wolves selecting that area of linear feature decreased by only 4%. However, increased vegetation height reduced movement rates (Fig. 5). For example, wolves moved 24% slower when vegetation reached 1 - 2 m compared to linear features with vegetation heights less than 1 m in summer. In winter, wolves did not move slower on linear features with taller vegetation until they exceeded 5 m, but travelled 44 % slower once vegetation exceeded 5 m, corresponding to nearly the same speed as natural forest.

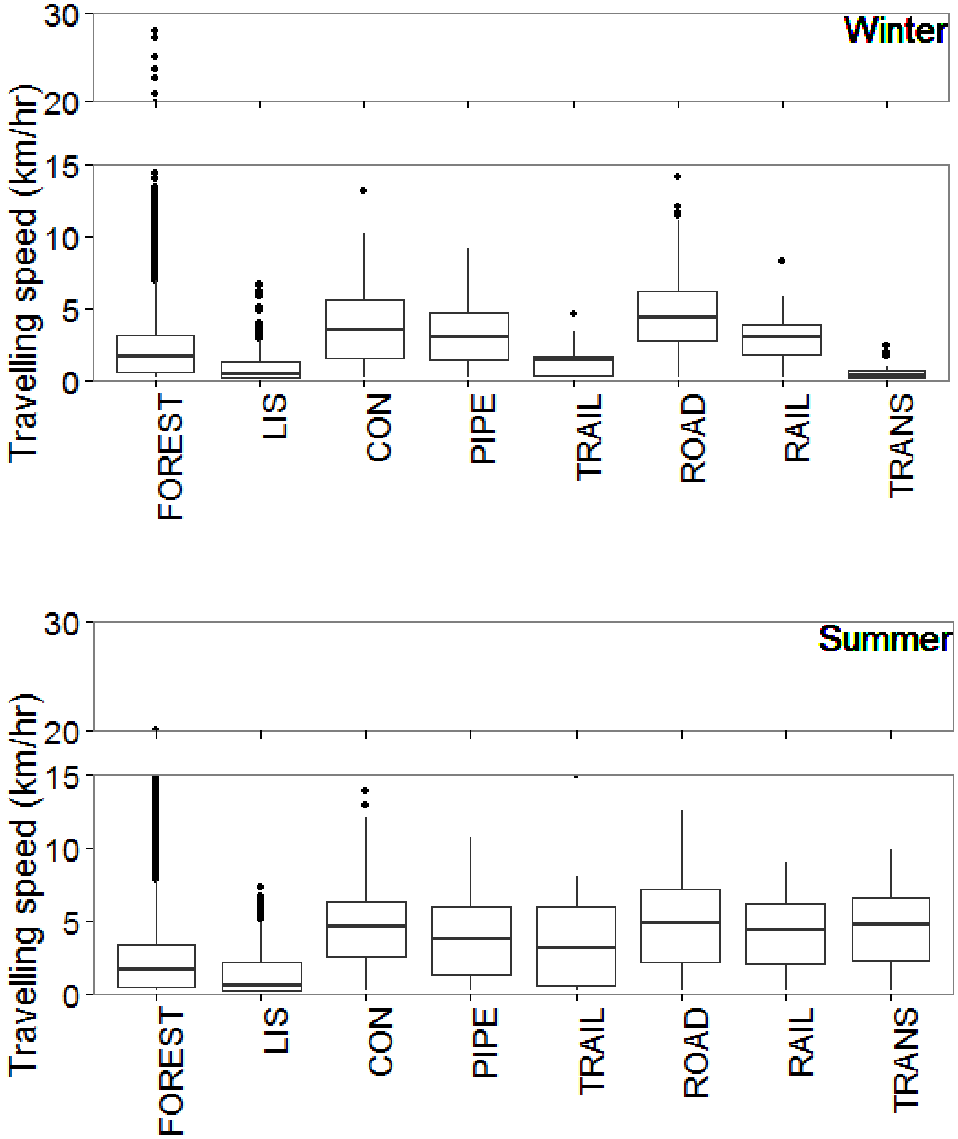

Figure 4 Median wolf travelling speed (km/hr) during 5 minute time travelling steps as a function of linear feature class, with undisturbed forest included for contrast, in summer and winter. Data from 20 wolves from 6 packs in summer and 13 wolves from 6 packs in winter were included. The upper and lower bounds of the boxplots correspond to the 1st and 3rd quartiles of the median, i.e., the 25th and 75th percentiles. Whiskers extend to the highest value within the inter-quartile range (distance between the 1st and 3rd quartiles) multiplied by 1.5. Data displayed as points outside of the boxplot correspond to outliers identified by a Tukey test. FOREST = undisturbed forest, CON = conventional seismic lines, LIS = low-impact seismic, PIPE = pipeline, RAIL = railway, ROAD = roads, TRAIL = trails, TRANS = transmission lines (Dickie 2015).

These findings will be used to both feed into hypotheses developed in the RICC 5-year work plan, and to help inform priorities for linear feature restoration and other mitigation strategies. For example, restoration plans can further be targeted to treat specific linear features, such as conventional seismic lines with vegetation regrowth that is < 1-m tall, so they are functionally restored to interfere with wolf movements.

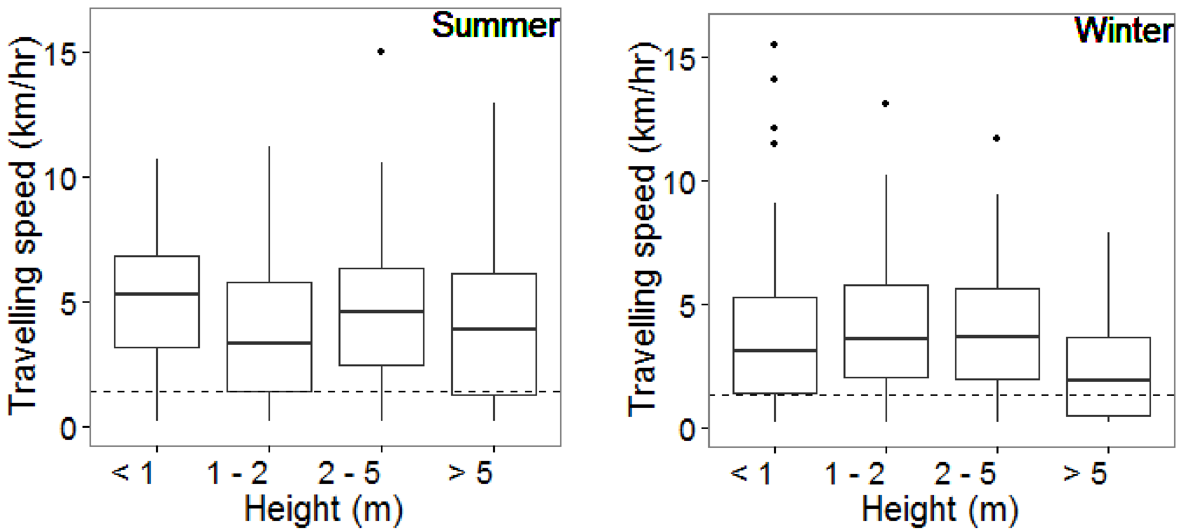

Figure 5 Median travelling speed (km/hr) of wolves travelling on linear features as a function of vegetation height (m) categories in summer and winter. A horizontal dotted line represents the average travelling speed of wolves in non-linear features forest. Data from 12 wolves from 4 packs in summer and 4 wolves from 3 packs in winter were included. The upper and lower bounds of the boxplots correspond to the 1st and 3rd quartiles of the median, i.e., the 25th and 75th percentiles. Whiskers extend to the highest value within the inter-quartile range (distance between the 1st and 3rd quartiles) multiplied by 1.5. Data displayed as points outside of the boxplot correspond to outliers identified by a Tukey test (Dickie 2015).

7.3 Comparing predator use of linear features

Preliminary analyses for telemetry data collected in 2015 by the RICC collaring project is underway. Below describes an initial analysis comparing how bears and wolves use linear features. This work includes locations from 2015 RICC collars, along with all previously collected location data from RICC Contributing Projects.

7.3.1 Methods

To evaluate the use of linear features for bears and wolves, the use of each linear feature class for each individual from April through July, inclusively, was extracted similar to the wolf analysis above (Dickie 2015). Linear features were visually classified using 2012 SPOT imagery (2-m resolution) as well as Valtus Views (0.5-m resolution), when available, at a 1:15 000 scale. Linear features were classified as above, and one-dimensional line features were again converted into polygons (Dickie 2015).

As above, each GPS location was assigned a linear feature class or was designated as being in the surrounding forest. Linear feature class was assigned to locations that were completely contained within a linear feature's buffer. If the location fell where multiple linear feature classes overlapped, the location was classified as the feature class with the largest buffer width. The proportion of locations that fell within each linear feature class was calculated for each individual, and then averaged to determine population-level use. Data from 39 bears in 2014 and 2015, as well as from 52 wolves in 2013 and 2014 were used.

7.3.2 Results

Wolves and bears used linear features similarly, with the mean use being 7.5% and 8.5% for bears and wolves, respectively (Fig. 6). The use of each linear feature class differed for both bears and wolves (Fig. 7); wolves tended to use low-impact seismic and conventional seismic more often than bears, whereas bears tended to use pipelines and roads more often.

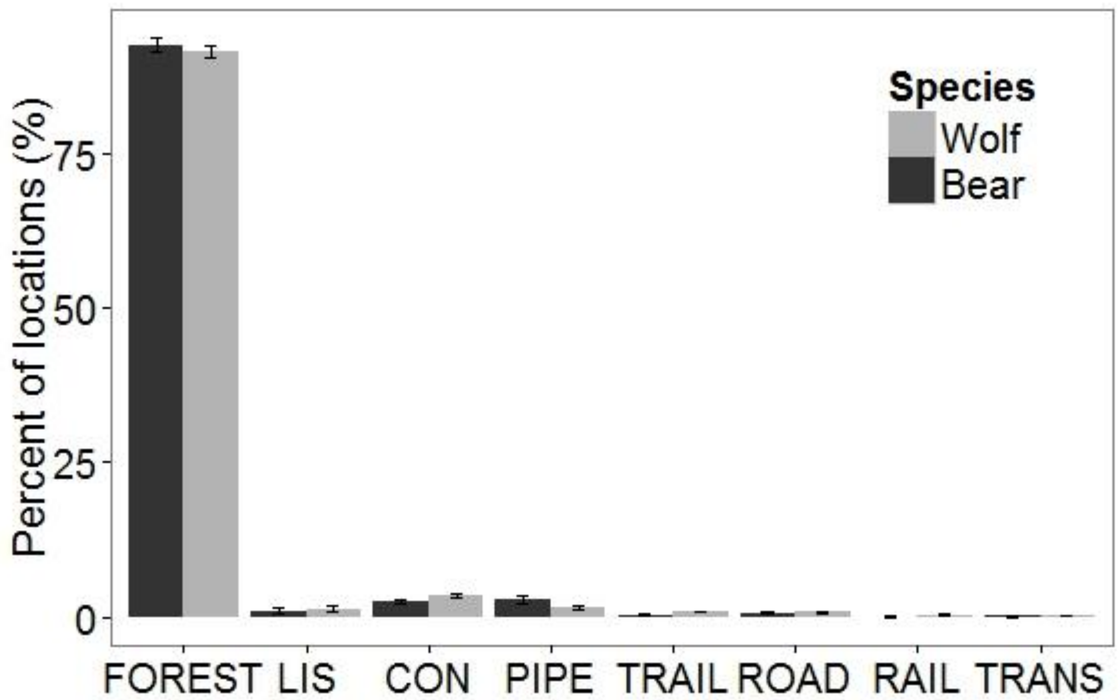

Figure 6 The average percent use (%) of wolf and bear locations, in the summer (April through July). The proportion of used locations in each class was calculated for each individual, and then averaged. Error bars represent standard error of the mean. CON = conventional seismic lines, LIS = low-impact seismic, PIPE = pipeline, RAIL = railway, ROAD = roads, TRAIL = trails, TRANS = transmission lines. Data from 39 bears in 2014 and 2015, as well as from 52 wolves in 2013 and 2014 were summarized. For comparison, the mean availability of forests within individual wolf home ranges was approximately 91.18% (Dickie 2015).

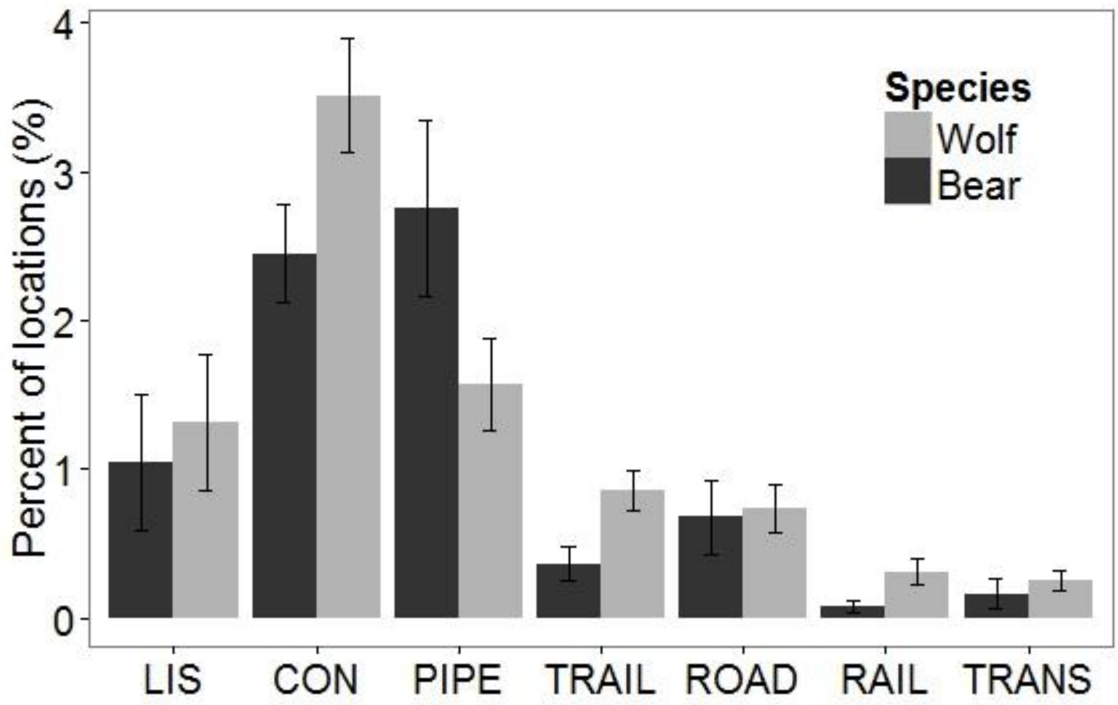

Figure 7 The average percent use (%) of wolf and bear locations, in the summer (April through July) of linear features only. The proportion of used locations in each class was calculated for each individual, and then averaged. Error bars represent standard error of the mean. CON = conventional seismic lines, LIS = low-impact seismic, PIPE = pipeline, RAIL = railway, ROAD = roads, TRAIL = trails, TRANS = transmission lines. Data from 39 bears in 2014 and 2015, as well as from 52 wolves in 2013 and 2014 were summarized. For comparison, the mean availability of forests within individual wolf home ranges was approximately 91.18% (Dickie 2015).

7.4 Linear Feature Restoration – the LiDea Forest and Habitat Restoration Project

In 2012, Cenovus Energy began a long-term adaptive management trial within the Cold Lake caribou range called the LiDea Forest and Habitat Restoration Project (LFHRP; Sutherland *et al.* 2015)[3]. Using a large-scale (~ 400 km^2) experimental landscape treatment area, Cenovus Energy has reduced the anthropogenic footprint within caribou habitat by restoring and deactivating disturbances associated with traditional industrial activities (e.g., seismic lines and well pads). One component of the LFHRP is a complimentary ecological monitoring program, developed to evaluate the effectiveness of restoration at improving conditions for caribou within the treated area in comparison to two control areas: one Business as Usual (BAU) area with untreated linear features; and a second Ecological Baseline (NAT) area that was relatively undisturbed and natural (Fig. 8). The initial LiDea (Linear Deactivation) project involved landscape level habitat restoration treatments upon linear features in the treatment area. The monitoring program is

[3] Data and interpretations from the LFHRP will be offered as a Contributing Project to RICC once the final legal document has been signed by all participants.

collecting 12 types of comparative metrics at three ecological scales: (1) site-level: vegetation and predator-prey responses to treated vs untreated linear features; (2) individual animal-level: rate of travel, encounters between predators (wolves, bears) and prey (moose, caribou), kills, diet composition, and prey condition; and (3) population-level: recruitment rates of prey, and predator prey population density changes after treatment (Sutherland *et al.* 2015).

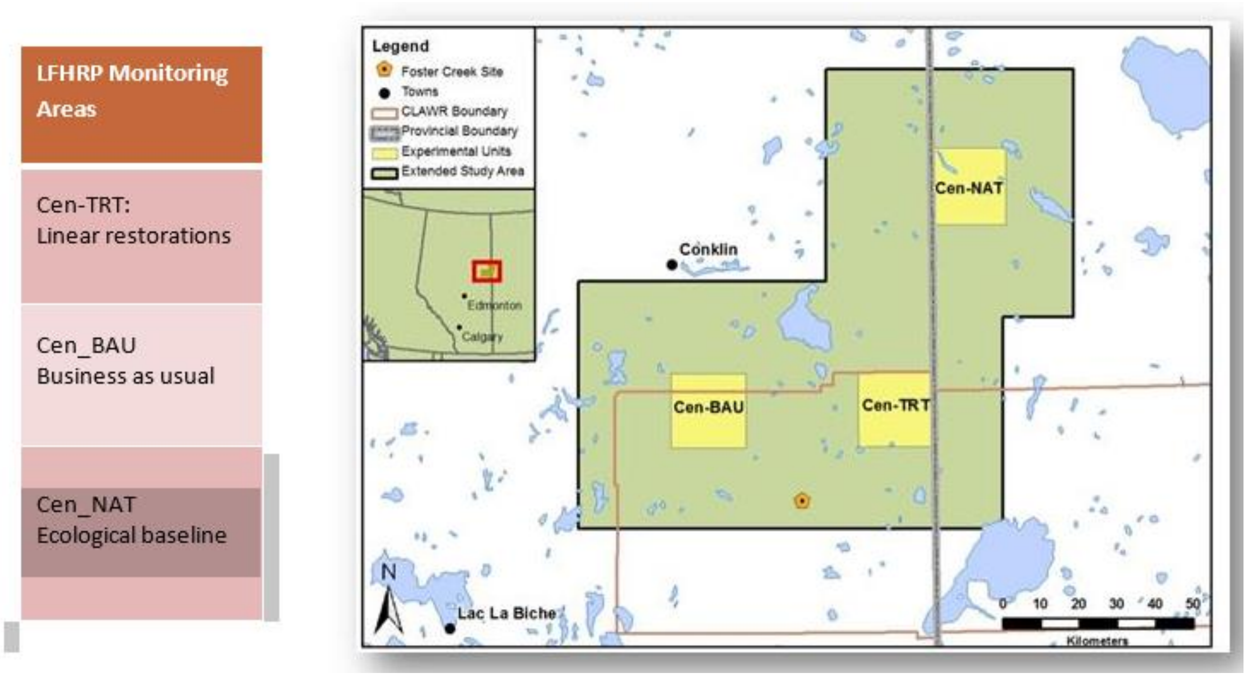

Figure 8 Locations of LFHRP study areas, and focal monitoring areas, chosen for implementation of an adaptive approach to restore caribou habitat in northeastern Alberta. TRT = treatment area, BAU = business as usual area where no treatment occurred and industry operations continued as usual, and NAT = natural area where industrial operations and human footprint are very low when compared to BAU and TRT.

The hierarchical nature of these scales reflect the expectation that the greatest magnitude and precision of effects will be observed at the site level, whereas the population level is most likely to be obscured by sampling and environmental variation. Yet, with an approach that relies on multiple lines of evidence across scales, the treatments' effects will be more likely to be evaluated. These metrics are intended to help inform a better understanding of the functional and numerical responses of predators to linear features and management actions (e.g., restoration) and help test *a priori* predictions made at each of the three ecological scales. Current LFHRP research activities include GPS collaring of predator and prey species, fecal pellet and scat sampling, kill site investigations, and habitat mapping and modelling (Sutherland *et al.* 2015). Throughout 2015, Cenovus Energy and other RICC members have worked together to continue LFHRP research activities in a collaborative manner.

It is important to also acknowledge the time and resources that other RICC members have invested in seismic line restoration trials, treatments, and monitoring. Devon Energy, MEG

Energy, CNRL, and Al-Pac all participated in restoration projects in 2013 and 2014, summing to over 150 km of treated seismic lines throughout the RICC study area. In addition, TransCanada Pipelines and Al-Pac collaborated on a project throughout 2014 and 2015 to restore approximately 200 km of linear features in the Dillon Wildlands, distributed across an area of approximately 6 townships.

7.5 Predator collaring project

Collaring of predators (grey wolves, black bears) was initiated as part of the LFHRP, and the U of A graduate research described above was eventually established as a RICC collaborative project. RICC therefore plans to continue leading this component of monitoring. In 2015, a total of 42 collars were deployed on wolves (n = 22)[4] and black bears (n = 20)[5] under the RICC Collaring Project (Table 1). The main objectives of this activity were to fill spatial gaps in the existing distribution of collared predators (including checking and replacing existing collars to maintain coverage), and to help obtain sufficient data on individual animals for the purposes of continued monitoring. The collaring activities brought the total number of functional collars on live predators to 47[6]: 20 wolves and 27 bears. Spatial distribution of these deployments and previous deployments is represented in Fig. 9.

Table 1 Capture information for collars deployed in 2015. General locations are based on original LFHRP study areas and 'Number Fixes' is the total number of location data points collected for each collar.

Animal ID	Species	Sex	Capture Date	General Location	Collar Status	Number Fixes
B001C	Bear	F	2015-05-21	Philomena/Imperial Mills	Normal	2759
B001D	Bear	F	2015-05-30	SE of Janvier/Bohn Lk	Normal	5536
B006F	Bear	M	2015-09-19	NE area of CLAWR	Normal	224
B007D	Bear	M	2015-05-28	NE area of CLAWR	Normal	5659
B010D	Bear	M	2015-05-19	E of Chard	Normal	6723
B010F	Bear	F	2015-09-20	N area of CLAWR	Normal	221
B011D	Bear	M	2015-05-21	E Behan, ~ 10 km S Conklin	Removed	700
B012D	Bear	M	2015-05-22	Margie, ~ 7km S Conklin	Normal	6308
B012F	Bear	M	2015-05-19	SK - E Chard	Normal	2081
B013D	Bear	M	2015-09-23	E of Chard	Normal	177
B027F	Bear	M	2015-05-18	NE area of CLAWR	Normal	1942
B028F	Bear	F	2015-05-27	E Winfred Lk	Normal	1759
B029F	Bear	F	2015-05-27	NE Winfred Lk	Normal	1738
B030F	Bear	M	2015-05-28	NE Winfred Lk	Normal	1725
B031F	Bear	F	2015-05-31	NE Christina Lk	Normal	1444
B032F	Bear	F	2015-09-19	NE area of CLAWR	Normal	198
B033F	Bear	F	2015-09-20	NE area of CLAWR	Normal	300

[4] One collar is VHF only, meaning location data is not collected via satellite.
[5] Includes one collar that was deployed twice in 2015.
[6] This number accounts for dropped collars, recaptured animals released without a new collar, and recent mortalities.

B034F	Bear	M	2015-09-20	SW Winefred Lk, near Kirby	Normal	255
B035F	Bear	M	2015-09-22	Near Primrose Airport	Normal	216
B036F	Bear	F	2015-09-23	E of Clyde Lk and Behran Lk	Normal	634
W001C	Wolf	F	2015-03-10	NW Conklin	Normal	3703
W001R	Wolf	F	2015-03-07	Waiu Lk	Normal	311
W002C	Wolf	F	2015-03-16	NW Conklin	Normal	3988
W002R	Wolf	F	2015-03-11	SK - East of Chard	Normal	231
W003D	Wolf	M	2015-03-13	South Winefred Lk	Animal dead	10321
W003R	Wolf	F	2015-03-17	NA	Animal dead	264
W004R	Wolf	M	2015-03-18	NA	Normal	276
W005R	Wolf	M	2015-03-19	North of Cowper Lk	Normal	254
W012F	Wolf	F	2015-03-09	East of Winifred Lk	Collar faded	7183
W015D	Wolf	F	2015-03-12	South Winefred Lk	Normal	125
W018F	Wolf	M	2015-02-03	W Waiu Lk	Normal	3130
W019F	Wolf	F	2015-02-03	W Waiu Lk	Normal	2816
W020F	Wolf	F	2015-02-08	N CLAWR	Normal	2777
W021F	Wolf	M	2015-02-09	SW Winefred Lk	Normal	219
W022D	Wolf	M	2015-03-16	Wiau Lk	Normal	2701
W022F	Wolf	M	2015-02-22	East CLAWR	Normal	3035
W023D	Wolf	M	2015-02-03	SW Winefred Lk	Normal	2602
W023F	Wolf	M	2015-03-07	E of Clyde Lk and Behran Lk	Normal	1993
W024F	Wolf	M	2015-03-11	SK - East of Chard	Collar faded	8872
W027D	Wolf	F	2015-03-19	South of Watchusk Lk	Collar faded	10569
W032D	Wolf	F	2015-03-20	NE of Lac La Biche	Normal	10540
W033D	Wolf	F	2015-03-20	S Conklin, W of Winifred Lk	Collar faded	2759

Data acquired from collars deployed in 2015, and those from previous years (which together contribute to upwards of 640,000 locations; Sutherland *et al.* 2015), will be used to help test a series of predictions that were collaboratively developed during initiation of the LFHRP and U of A graduate research. As with the LFHRP, the predictions are geared towards better understanding the functional and numerical responses of predators to linear features and management actions (e.g., restoration). For example: (1) a prediction at the site level is that predator use will be lower on treated versus untreated linear features; (2) a prediction at the individual level is that wolves and bears will travel slower along treated versus untreated linear features; and (3) a prediction at the population level is that survival and recruitment of predator species will be lower in treatment areas (adapted from McNay *et al.* 2014).

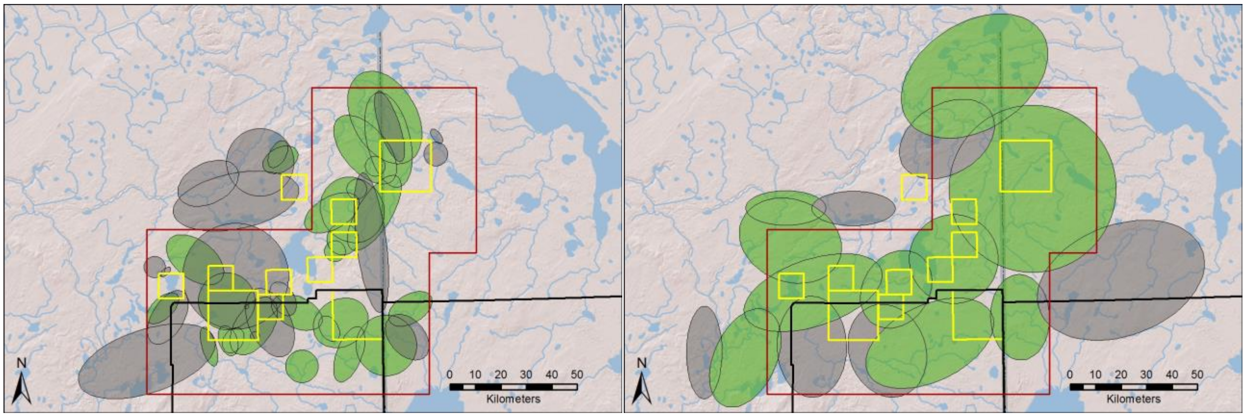

Figure 9 Distribution of radio-collared black bears (left) and grey wolves (right) forming the basis for monitoring the response of predators to management of linear features in northeastern Alberta. Green ellipses are active collars and grey ellipses are collars that have been removed or are no longer transmitting signals. Note: green wolf ellipses depict pack distribution.

Because GPS collars often malfunction or wolves are frequently killed, maintenance of an effective sample size requires that animal capture and collaring sessions occur on an ongoing basis. Therefore, RICC anticipates collaring efforts will be required through 2016, and in long term pulsed cycles which are recommended in the RICC 5-year Adaptive Management Plan (AMP; ABMI 2015). The project is also anticipated to expand to include restoring additional areas within caribou range. This would generate increased participation of RICC across research activities, including evaluation and monitoring of results.

7.6 Prioritizing linear features for restoration

Companies operating within boreal caribou ranges are responsible for reclaiming disturbed land that is under surface disposition. Restoration of disturbances associated with legacy seismic lines is not a regulated activity, but is a mitigation measure that has been incorporated into the Caribou Mitigation and Monitoring Plans of several EPEA approval holders. Habitat restoration is difficult, time consuming, and costly. It also requires long-term monitoring efforts to determine if individual metrics are responding to treatments, and overall, if management actions are effective in improving conditions for caribou. Unsuccessful or ineffective treatments may create additional liability for proponents, especially under regulated circumstances, if additional efforts relative to monitoring or re-treating features is required by regulators. RICC has recognized these challenges, and identified the need to take part in large-scale, collaborative restoration. RICC has worked-together with the ABMI to identify priority areas for linear feature restoration in the ESAR and Cold Lake caribou ranges.

Identifying priority areas is an important step in habitat restoration, as it allows project planners to increase efficiency by focusing resources where they will provide the most value. By setting a list of criteria and ranking them in importance, areas can be categorized from high to low priority. For example, if the top priority is completing restoration work within a caribou range, upland habitat, and low linear feature density, disturbances that best fit these parameters can be parsed out from the total inventory and targeted for restoration. Furthermore, this approach can be used both on a local scale (e.g., identifying a small set of lines within a limited area) or on a broader scale to identify larger patches for restoration treatments (by scaling the prioritization analysis up to sections, townships, or ranges).

7.6.1 Methods for prioritizing linear features for restoration

Prioritizing linear features for restoration required a series of net downs. This means seismic lines[7] that did not meet pre-defined criteria were successively eliminated as candidates for restoration. A workshop was held in Calgary on July 7 and 8, 2015, to identify, discuss and rank these criteria. This workshop included the majority of RICC steering committee members.

The prioritization analysis was conducted at two scales; the first was at the township scale and the second was completed at the scale of individual seismic lines. Most of the emphasis for prioritization was placed at the township scale, for two reasons. First, this coarser perspective provided a context for emphasising (minimum) patch sizes that would contribute to larger intact areas, increasing RICC's capacity to contribute towards the federal recovery target of 65% undisturbed caribou habitat within a range. Second, logistical considerations considered at the workshop suggested that once restoration equipment is transported to a location, it is more cost effective to treat multiple lines in that area (e.g., a township), rather than moving around the landscape to restore individual lines. Although restoration treatments are planned and implemented along individual linear features, it is necessary to think about opportunities to restore contiguous patches of caribou habitat at a landscape scale.

[7] Refers to wide 2-D seismic lines commonly used in Alberta in the past for oil and gas exploration.

Table 2 Criteria applied to the linear features prioritization exercise. Each rank represents an order of consideration, not a weighting.

Restoration Criteria[8]	**Rank**	**Sub-rank**
Caribou range	1	n/a
Conservation areas	2	a
Untenured lands	2	b
EPEA approved boundaries	3	a
Permanent features	3	b
Bitumen pay thickness	3	c
AlPac projected harvest	3	d
Density of linear features	4	n/a
Treated linear features	4	b
Caribou habitat quality	5	a
Deer habitat quality	5	b

Following the July 2015 workshop, initial analyses were conducted and the above rankings (Table 2) were adjusted to reflect practical considerations. For example, netting out areas outside of caribou ranges at the outset would negatively bias road density calculations at the edge of the caribou ranges, so road density had to be considered at the outset (see below).

[8] Restoration criteria are define as the following: caribou range is the current provincial boundary for woodland caribou ranges; conservation areas are identified in the Lower Athabasca Regional Plan (LARP); untenured land are areas which do not have current industrial tenure for future development (less likely to have industrial activity take place in the near term); EPEA (Environmental Protection and Enhancement Act) approved boundaries outline the areas in which construction, operation and reclamation activities associated with an in-situ oil sands or heavy oil processing plant and oil production site are most likely to occur; permanent features are human footprint features which are expected to remain on the landscape long term and not undergo restoration treatments (e.g., high grade roads and facilities); bitumen pay thickness is the predicted depth of bitumen deposits in an area, where high bitumen pay thickness areas are more likely to be industrially developed; AlPac projected harvest is the area in which future forest harvest activities by Alberta-Pacific Forest Industries may occur in the near term (e.g., 5-25 years) although all forest area within the polygons will not be harvested; density of linear features is the length (km) seismic lines per area (km^2) within a township; treated linear features are features previously restored by RICC member companies; caribou habitat quality is the best 20% of habitat used by caribou in summer or winter as determined by Resources Selection Function (RSF) modeling; deer habitat quality is the best 20% of habitat used by deer in summer or winter as determined by RSF.

The refined approach was as follows:

The **first** consideration was line density, because this criterion has the greatest influence on the amount of area considered to be disturbed by humans (due to the 500-m buffer defined by Environment Canada). Restoring a line that is isolated will provide much more benefit than restoring a line that is in close proximity to adjacent lines. Line density was also considered at the first step because had non-caribou range or EPEA boundaries been netted out beforehand, the line density analysis would have been compromised by edge effects.

The **second** consideration was caribou range – restoration would take place within caribou ranges as delineated by the Government of Alberta. Line density was summarized outside caribou ranges as well, so that the range boundaries would not subject the line density analysis to edge effects.

The **third** consideration was conservation areas – if there was a choice between restoring townships with similar or equal line density, priority would be given to townships that occurred within existing or planned conservation areas.

The **fourth** consideration was area to be developed for bitumen extraction in the near term. These areas were identified by the EPEA process, and EPEA boundaries were provided to us by each company. Any area within an EPEA boundary was removed from consideration as an area to be restored because the likelihood of imminent development and to minimize economic trade-offs.

The **fifth** consideration was treated linear features – restoration would not take place on seismic lines that had previously been treated by participating RICC members (inventory was completed by the ABMI as part of the RICC data portal data compilation process). The biggest contribution was linear features restored as part of the LiDea project, where seismic lines within four townships were netted out in the Cold Lake caribou range. In 2014-15 TransCanada Pipelines and Al-Pac collaborated on a project to restore approximately 200 km of linear features in the Dillon Wildlands distributed across an area of approximately 6 townships. However, because the spatial data of restored lines in the Dillon Wildlands was not available at the time of our analysis, they were not considered in this exercise.

The **sixth** consideration was provided by LiDAR (Light Detection and Ranging), a laser-based range finding sensor (also known as Airborne Laser Scanning), that produces accurate, high-resolution 3D models of ground and surface features. This level of analysis was focused at the scale of individual lines, rather than at the township, and was added as a criterion after the July 7-8 workshop. LiDAR was used to directly measure vegetative regeneration, based on an index termed 'roughness.' Roughness is the ratio of surface length (includes vertical displacement due to vegetation canopy along a least-cost path (i.e., path of minimum height)) to planimetric length (ground length with no vertical displacement). Roughness values per 100-m segment of lines within the area where LiDAR was collected by Devon in 2011 ranged from a minimum of 1.0 (unit-less) for non-vegetated lines to a maximum of 4.33 for heavily vegetated lines. Our hypothesis is that the roughness index along a least-cost path measures vegetation on game trails that exist within seismic lines, and reflects the functional recovery of lines in terms of their effect on predation efficiency on caribou. For the purpose of this analysis, lines with a roughness class of >2 were removed from consideration because it was assumed that this threshold would substantially reduce wolf use and travel speed. This assumption is currently being tested with empirical wolf data.

Finally, **ungulate habitat** was also taken into account. For caribou, a sensitivity analysis was conducted to determine the degree to which caribou habitat quality would affect the amount of lines selected for restoration. This was done by intersecting lines with a caribou resource selection function model to successively eliminate lines according to varying thresholds of habitat quality.

Habitat quality for white-tailed deer was not formally included in the analysis because the relative weighing of restoring deer vs caribou habitat is currently being determined. However, in anticipation of including deer habitat in this algorithm, work was completed with Alberta Innovates-Technology Futures (AITF) to develop a deer occupancy model and map the model across a small portion of RICC study area (see section 8.1).

One additional factor that has been discussed but not formally considered in this process includes the presence of burned areas. Areas that have burned within the last 30 years might be less likely to burn in the near future, providing an opportunity for long-term habitat recruitment and thus may increase the priority for restoration of lines within them. However, burns are still considered “disturbed habitat” and so they may confer adequate candidate sites for restoration.

7.6.2 Results

For the 353 townships or portions thereof that intersect the RICC study area within Alberta (Fig. 10), there are just over 69,000 km of conventional seismic lines, for a density of 1.32 km/km^2. The length of lines within only the Cold Lake and ESAR range boundaries is 26,850 km (1.35 km/km^2), and the length within current RICC focal areas (Cold Lake caribou range and the Christina herd) is 9,145 km (1.16 km/km^2). The EPEA boundaries encompass 3,980 km of lines (Fig. 10), all of which were precluded from treatment because of high likelihood of near-term future development, leaving 5,165 km of lines available for treatment (Table 3). 206 km of lines previously treated as part of LiDea project, other restoration efforts by individual companies, and isolated linear feature segments <20 m in length were removed, leaving 4,957 km available for restoration.

The RICC steering committee decided to focus on a core subsample of 30 complete or partial townships (2,340 km^2) that have the lowest linear density (0.87 km/km^2) and that are contiguous with areas that have been treated. These townships included the area adjacent to previously treated townships under the LiDea project (inside the Cold Lake caribou range), and extended south and west of Dillon River Wildland Provincial Park (inside the Christina herd). Focussing on these 30 townships left 2030 km of seismic lines as candidates to restore (Table 3). Then, 22 km of lines were removed because they were interspersed with previously treated lines and would be operationally difficult to access. Finally, 154 km of lines where roughness class was greater than 2 were also removed from consideration, leaving 1,854 km of lines as candidates to restore. This roughness analysis implies that a relatively low proportion of lines are naturally regenerated (i.e., only 154 km out of about 2,000 km) and that the rest would require active treatment.

Table 3 Steps used to determine the total length of treatable seismic lines for habitat restoration. CLESA refers to the Cold Lake and ESAR caribou ranges together, and CLCR refers to the Cold Lake and Christina Ranges (Christina is a sub-range of ESAR).

Step	**Length removed (km)**	**Remaining length (km)**
Total length of conventional seismic in the Alberta portion of the RICC study area	0	69,166
Length in caribou range (Cold Lake & ESAR)	42,316	26,850
Length in the Cold Lake caribou range and Christine herd	17,705	9,145
EPEA areas	3,980	5,165
Length of previously treated linear features	206	4,959
Remove segments ≤ 20m	2	4,957
Clip to 30 townships	2,927	2,030
Remove isolated segments in treated townships	22	2,008
Lidar of roughness class ≥ class 2	154	1,854

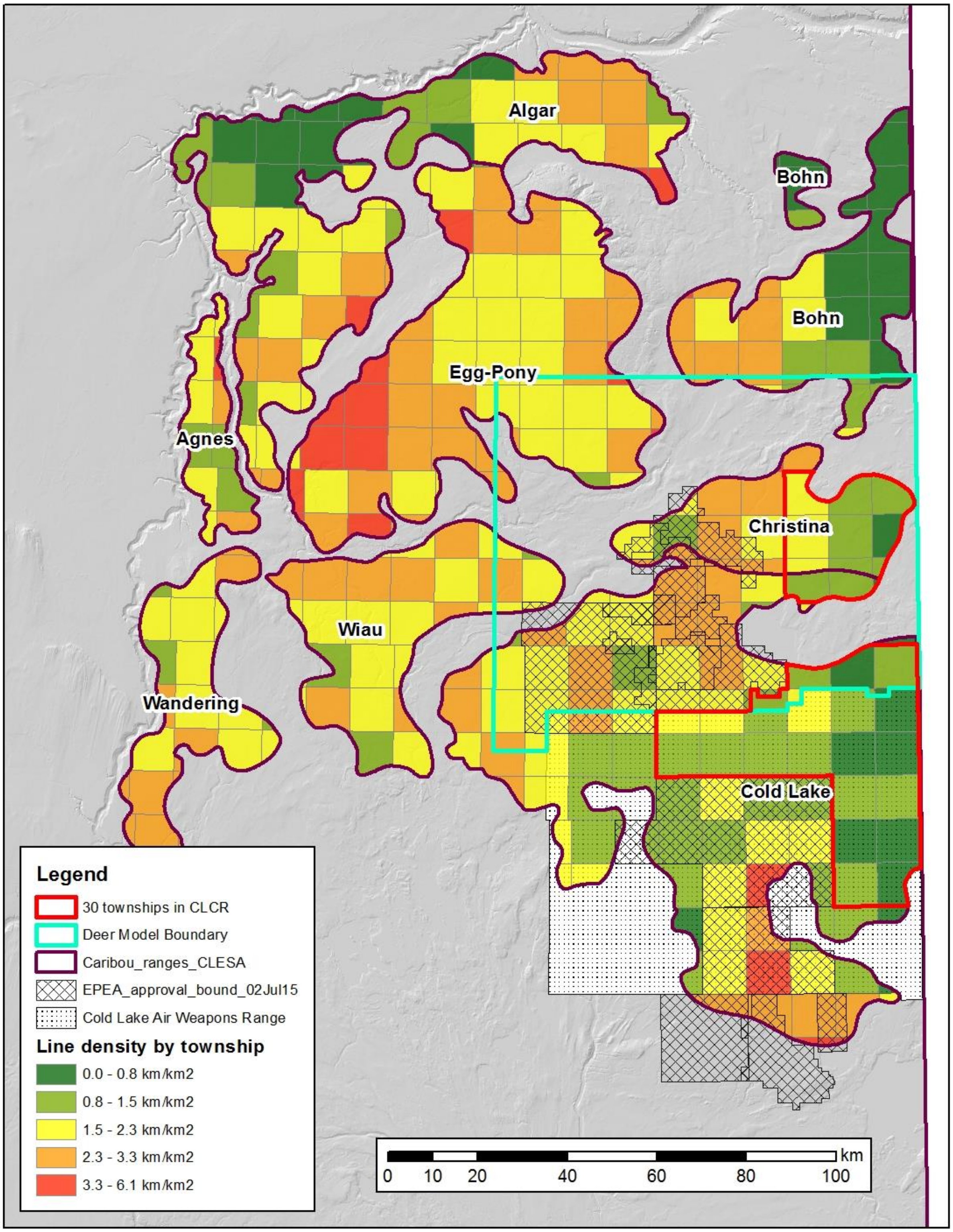

Figure 10 Townships displayed by priority for linear feature restoration in the ESAR and Cold Lake caribou ranges. Green (lowest linear feature density, in km/km^2) is highest priority and red (most dense linear feature density) is the lowest priority. Black cross-hatch indicates EPEA boundaries for RICC member companies.

8.0 Collaboration Outside of RICC

Outside of Contributing Projects, RICC engaged in successful collaborations with other stakeholders, including the University of Alberta and AITF. Outlined in the Project Summaries section, *How wolves interact with linear features* is an important collaborative project for RICC. Wolves involved in this project were captured and fitted with GPS collars within the RICC area of interest during the winters of 2013 and 2014. Telemetry data from these wolves continue to contribute to long-term predator monitoring. Below is a description of work RICC has engaged in with AITF to date. Collaboration with additional organizations and stakeholders operating within boreal caribou range will be encouraged in the following year.

8.1 Alberta Innovates-Technology Futures: Deer resource selection

Understanding caribou distribution and habitat use is important for identifying areas where conservation efforts should be focused. Because the proximate cause of caribou declines is apparent competition, it is also important to identify the specific predator-prey dynamics that are taking place. Essential to this is understanding deer (a primary prey species of grey wolves) habitat use and movement.

To address this component, the ABMI and RICC collaborated with AITF to map deer habitat within the RICC study area. AITF has been conducting intensive research on white-tailed deer habitat use in relation to human footprint, using camera traps and radio collared deer as the response metrics.

AITF deployed a Reconyx Hyperfire PC900 camera at each of 62 sampling sites in the northeast boreal forest between the Cold Lake Air Weapons Range and Bohn Lakes, from October 2011 - October 2014. From the resultant > 100,000+ images, *deer relative abundance* was calculated by counting the total number of independent camera-detection events, and the number of deer observed in each event. Land cover was measured in a 1-km^2 radius around each camera site, including (i) AVI (Alberta Vegetation Inventory) digital forest inventory data, collapsed into 12 classes; (ii) ABMI human footprint layer[9] data reclassified into 3 classes; and (iii) a high-resolution linear features layer[10] to classify anthropogenic linear features on the landscape.

Deer relative abundance was modelled against land cover variables using generalized linear models (square root-transformation, Gaussian errors, identity link), in *R* ver. 3.1.1 (R Foundation for Statistical Computing 2014). To determine the most parsimonious model describing deer relative abundance, the step-AIC function in R package MASS[11] was used. The function ranks different possible variable combinations based on AIC scores.

[9] 2010 Provincial Human Footprint layer downloaded from: http://www.abmi.ca/abmi/rawdata/geospatial/gisdownload.jsp?categoryId=3&subcategoryId=7
[10] University of Alberta, Integrated Landscape Management Lab
[11] http://cran.r-project.org/web/packages/MASS/MASS.pdf

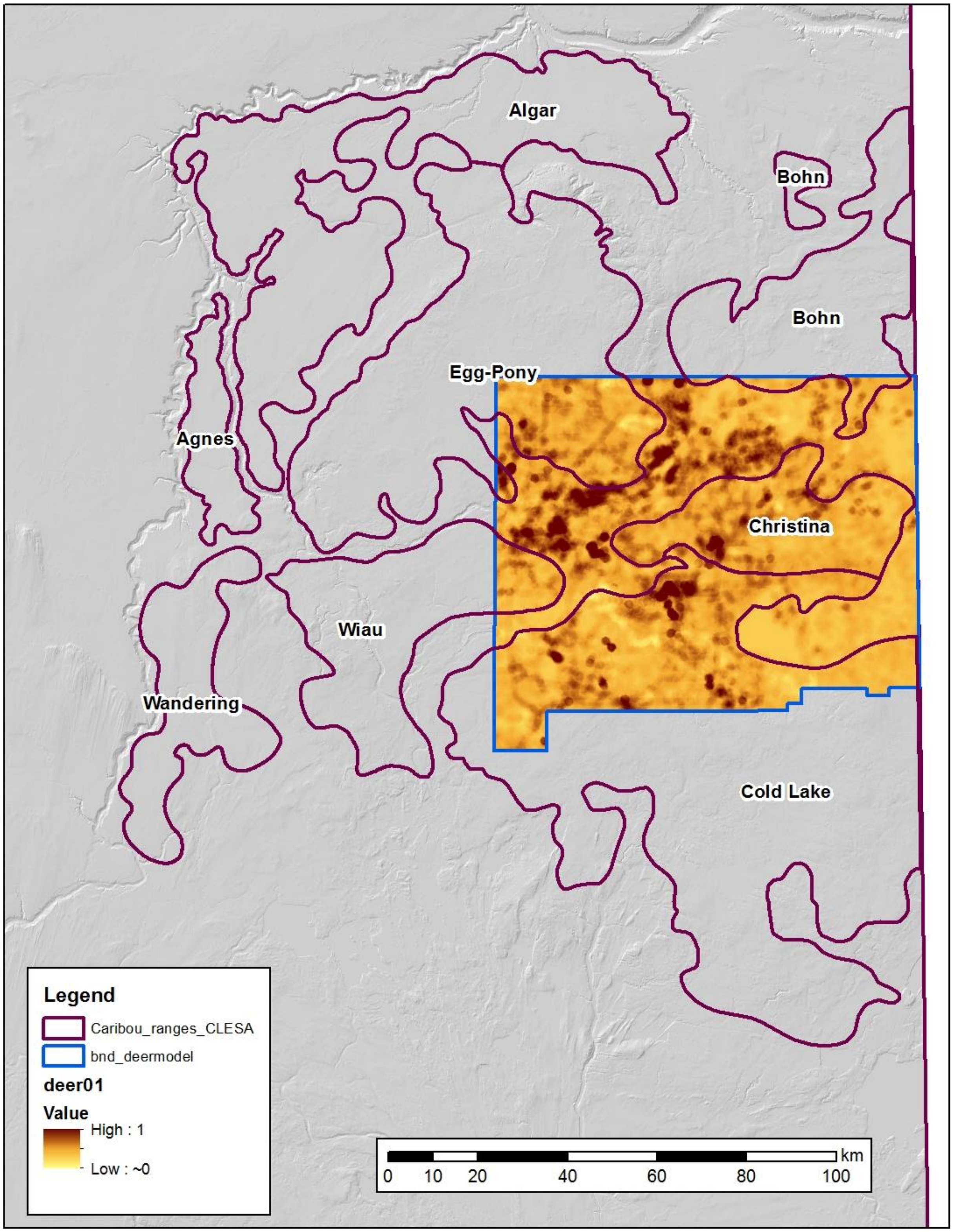

Figure 11 The deer model shown overlaid on caribou ranges. The model boundary is 7020 km^2. Dark orange refers to high deer habitat quality (highest = 1) and light orange refers to low quality deer habitat (lowest = ~ 0).

Coefficients of the deer resource selection model were published by AITF (Fisher *et al*. 2015), and then ABMI acquired the relevant GIS layers to theme the coefficients in a GIS. The process required substantial collaboration between all parties, and provided mutual benefit. AITF staff can use the themed model for model validation, and the ABMI and RICC will use the model for future prioritization efforts. The deer model essentially highlights that upland areas and deciduous forests have the highest quality deer habitat (Fig. 11).

9.0 Plans for 2016

Various RICC projects will continue through 2016 (e.g., prioritization of linear features, restoration). Moreover, RICC plans to top-up a portion of its collaring program (to maintain active collars), and conduct an aerial wolf census over the RICC study area before subsequent habitat restoration takes place. As RICC carries on with research activities, substantive amounts of data will continue to be collected and used to answer the important questions outlined in the RICC 5 year plan (ABMI 2015). Data will be used to establish home ranges for wolves and bears, and assist in measuring the functional response of wildlife to management practices such as habitat restoration. Finally, RICC will develop communications and outreach materials, including a strategy for engagement with the GoA and potential RICC participants, and remains open to exploring other research opportunities.

9.1 LF prioritization refinement and restoration

In 2016, RICC will use learnings from the 2015 restoration prioritization project to further refine and improve the analysis, and inform subsequent restoration plans in areas of the Cold Lake and ESAR caribou ranges. Habitat restoration will aim to append to existing areas with restored linear features (e.g., LiDea, 2016 winter treatments), in order to build larger patches of undisturbed caribou habitat.

9.2 Analysis of wildlife data

Detailed analysis of data collected through RICC research is anticipated to take place, and will include bolstered data management and collaboration with external researchers. For example, RICC currently has access to hundreds of thousands of location data points for predator and prey species within the study area, collected by 2015 collaring activities and contributed from other research projects (e.g., Devon, LiDea). These data will be used to address specific questions developed in the RICC 5-year Work Plan (ABMI 2015), such as how linear features contribute to the numerical response of predators, and if indicators (e.g., wolf use of linear features) are responding positively to restoration treatments.

For more information, see the *Long Term Vision* section and the RICC 5-year Plan (ABMI 2015). For a list of anticipated peer-reviewed research papers, see Appendix 3.

9.3 Wolf census

Plans are currently underway for a wolf census to be conducted in the Cold Lake caribou range and Christina herd during the 2015/2016 winter. The census will involve a new method that was piloted last year in NE British Columbia. Monitoring how restoration will affect key components of the ecosystem such as numbers of alternate prey, predators, and caribou is a key step in assessing success of restoration. Wolf density is an important ecosystem component linked to the abundance of seismic lines. Ideally, wolf density would be tracked before and after ecosystem restoration is implemented across a broad area.

The primary objectives of this project are to obtain a baseline estimate of wolf density prior to the broad scale implementation of seismic line restoration, validate the method by estimating the number of collared wolves that are missed during the census, and to expand the range of ecological conditions to further test human-induced apparent competition, compared to natural habitat drivers that affect caribou-moose-wolf interactions. Furthermore, this project will continue to test associations between wolf and moose abundance, and the abundance of human footprint.

9.4 Development of communications materials

Moving forward, RICC will construct a communications work plan through the Communications Sub-Committee. The committee will be responsible for developing a communications strategy that is aligned and consistent with the mission and objectives of RICC and the COSIA Ways of Working Guidelines. Short-term plans include measures to increase awareness of RICC's research activities, thereby promoting engagement with stakeholders, encouraging additional member participation from industry companies and facilitating discussions with the Government of Alberta about alignment of RICC activities with priorities of the pending caribou range plans and provincial action plan. Materials currently being discussed are a basic RICC website, an annual newsletter, and resources to ensure consistent messaging and formatting is used across communications materials.

10.0 Long Term Vision

RICC's long-term monitoring is based on the RICC 5-year work plan (ABMI 2015). This document outlines objectives and timelines over the short (1 year) and long term (5 years), and an Adaptive Management Plan (AMP) that will adjust practices once new information is acquired. The AMP addresses both proximate (e.g., predation) and ultimate (e.g., climate change, habitat alteration) drivers of caribou population decline.

Through adaptive management, RICC is proposing the results from past and current intensive research efforts will be integrated to design management actions, such as restoration of linear features. Over time, the RICC's monitoring role may change (i.e., increase or decrease), so the process must incorporate the possibility of involvement from other agencies. It is also acknowledged that the ultimate response metric is caribou abundance and demography, and this component is monitored by the Government of Alberta. It is the intent that the results of these actions will be monitored and synthesized to determine efficacy, triggering further targeted, strategic research to address remaining questions or unexpected outcomes. This adaptive management cycle approach will foster efficient development of pragmatic management solutions. Table 4 summarizes the initial steps of the AMP, which would run in a cyclical fashion to address different research aspects.

Table 4 Timelines for AMP research and management steps.

	Timing of AMP Steps						
AMP Step	Prior years	2015	2016	2017	2018	2019	Long term
Step 1: Initial research							
Step 2: Plan							As needed
Step 3: Manage							As needed
Step 4: Monitor							Pulsed
Step 5: Evaluate							Pulsed
Step 6: Strategic research							As needed

To determine how factors such as habitat alteration and subsequent restoration actions affect proximate biological drivers including predator use of linear features, predator-prey dynamics, and ultimately, caribou population dynamics, the AMP as presented will address multiple ecological scales (i.e., at the site, individual, and population level; McNay *et al.* 2014).

Although RICC aims to contribute to caribou conservation (e.g., restoring large patches of linear features, or concluding important predator-prey hypotheses through analyses of extensive data sets), the primary long term outcomes will be sound, scientific conclusions based on research and improved confidence with future recommendations regarding recovery focused management actions.

Finally, because caribou recovery in the long term will likely depend on management levers in addition to habitat restoration (e.g., management of the predator-prey system, actions related to climate change), goals associated with restoration of habitat may be considered successful, but may not result in recovery of boreal caribou with respect to the federal recovery strategy. Therefore, RICC will actively solicit multi-stakeholder collaboration on range wide, multi-scale projects.

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13.0 Appendices

Appendix 1 List of Acronyms

Abbreviation/ Acronym	Description
ABMI	Alberta Biodiversity Monitoring Institute
ACC	Alberta Caribou Committee
AITF	Alberta Innovates – Technology Futures
AMP	Adaptive Management Plan
BAU	Business as Usual scenario
CL	Cold Lake caribou range
CLAWR	Cold Lake Air Weapons Range
CMU	Caribou Monitoring Unit
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSIA	Canadian Oil Sands Innovation Alliance
CR	Christina caribou range
DND	Department of National Defense
EMCLA	Environmental Monitoring Committee for the Lower Athabasca
EPEA	Environmental Protection and Enhancement Act
ESAR	East Side Athabasca Range
GIS	Geospatial Information System
JIP	Joint Industry Project
LAR	Lower Athabasca Region
LiDea	Linear Deactivation (project, Cenovus Energy)
LMP	Landscape Management Plan
NAT	Natural, ecological baseline scenario
RICC	Regional Industry Caribou Collaboration
RSF	Resource Selection Function
SARA	Species at Risk Act

TAC	Technical Advisory Committee
U of A	University of Alberta
WII	Wildlife Infometrics

Appendix 2 Glossary of Terms

Action plan: A document that demonstrates to the public and stakeholders how a boreal caribou recovery strategy will be implemented; not necessarily range-specific.

Adaptive management: An evidence-based approach to managing complex systems in which a management objective is addressed through a complimentary combination of research and management experimentation.

Alternative prey: Prey that do not generally support predator populations, but may be predated on through mechanisms such as apparent competition or when primary prey populations decrease quickly.

Apparent competition: An increase in predation on alternative prey species, caused by growing predator populations supported by an increased abundance of primary prey.

Contributing Project: A project with multi-company participation, as defined through COSIA guidelines. RICC specific Contributing Projects work towards meeting the goals, objectives and scope of RICC.

Disturbed habitat: As per federal recovery Strategy: habitat with anthropogenic disturbance visible on Landsat (at a scale of 1:50,000) including habitat within a 500 m buffer of the anthropogenic disturbance; and/or fire disturbance in the last 40 years, as identified in data from each provincial and territorial jurisdiction (without buffer).

Functional response: The relationship between average number of prey consumed and density of prey.

Integrated Land Management: As per Alberta Environment and Parks: strategic planned approach to managing and reducing the human-caused footprint on public land. Goals of ILM are to reduce land-use disturbances relative to what would occur in the absence of integrated efforts, and to foster a stewardship ethic in all land users.

Linear deactivation: Treatment of anthropogenic linear features to reduce use by wolves for travel and hunting. Deactivation techniques include line blocking, tree felling, mounding or fencing.

Linear restoration: Reclamation and land management activities that return anthropogenic linear features to functional caribou habitat. Restoration techniques include tree planting and mounding.

Low impact seismic: Methods use GPS technology to navigate, requiring a much smaller corridor to be disturbed, and can also navigate around large trees easily and use smaller equipment. Can be as narrow as 2 m wide.

Numerical response: The change in predator population in response to change in prey densities.

Primary prey: The primary prey supporting predator populations. Primary prey for grey wolf include moose, deer, and beaver.

Proximate cause: The immediate factors associated with population decline (e.g., predation).

Range plan: A document that outlines how land and resource activities within a specific range will be managed to ensure protection of boreal caribou critical habitat.

Self-sustaining population: A population of boreal woodland caribou that over a short timescale (≤20 years), demonstrates a stable or increase in numbers, and is large enough to persist over the long-term (≥50 years) without active management.

Traditional seismic: Method of seismic exploration where line-of-site is used to navigate line. This requires a wider corridor to be created, and created a larger linear feature than low-impact does. Generally > 5m wide.

Ultimate cause: The fundamental factors associated with population decline (e.g., change of climate, change of habitat availability and/or quality).

Undisturbed habitat: As per federal recovery strategy: habitat without anthropogenic disturbance visible on Landsat (at a scale of 1:50,000) including habitat within a 500 m buffer of the anthropogenic disturbance; and/or fire disturbance in the last 40 years (without buffer).

Appendix 3 Anticipated Publications

Title	Preliminary authors	Contributing Project	Target Journal	Expected submission date
Comparing population growth rates between census and recruitment-Mortality models: implications for monitoring cryptic species	Serrouya, McNay, Boutin, other	LiDea, predator collaring	Journal of Wildlife Management	To be determined
A validated method to count wolves in boreal forests	Serrouya, van Oort, DeMars, other	Wolf census	Journal of Wildlife Management	To be determined
Predicting the population-level response of boreal caribou to seismic line restoration	Serrouya, DeMars, Dickie, Gilbert, Boutin	LiDea	Eco Model, Eco Apps	2016-09-30
Wolf selection and movement on anthropogenic linear features	Dickie, Serrouya, McNay, Boutin	Wolf research, predator collaring, LiDea	Eco Apps	2016-11-15
Effect of linear feature abundance and physical structure on wolf selection and movement	Dickie, Serrouya, Cranston, Boutin	Wolf research, predator collaring, LiDea	Journal of Applied Ecology/ Eco Apps	2016-01-01
Ecological factors influencing spatio-temporal relationships between multiple predators and prey in a modified boreal landscape	Wildlife Infometrics	LiDea, predator collaring	Journal of Applied Ecology	2016-01-31
Behavioural Interactions between Prey and Predators in Response to Disturbance Features	Wildlife Infometrics	LiDea, predator collaring	Journal of Applied Ecology	Spring 2016

Responses of kill and consumption rates by predators to habitat factors in a modified boreal landscape	Wildlife Infometrics	LiDea, predator collaring	Journal of Wildlife Management	Summer 2016
Population responses of multiple predators and prey to restoration of linear disturbance features	Wildlife Infometrics	LiDea, predator collaring	Journal of Wildlife Management	December 2016 – Jan 2017
Using multiple lines of evidence to assess response of a predator/prey system to restoration of linear disturbance features	Wildlife Infometrics	LiDea, predator collaring	To be determined	Bear Wolf Caribou Moose
Summer movement and utilization patterns of predators and prey on treated and untreated seismic lines	Wildlife Infometrics	LiDea, predator collaring	To be determined	May 2016