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NATIONAL COUNCIL FOR AIR AND STREAM IMPROVEMENT

AN INVENTORY OF CARIBOU RESEARCH PROGRAMS IN CANADA

SPECIAL REPORT NO. 11-02

JULY 2011

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PRESIDENT'S NOTE

The woodland caribou has become an iconic symbol of the boreal forest in which it lives, and of the Canadian north as a whole. Concerns about the conservation and persistence of caribou in the boreal have been raised as populations have experienced range retraction in some areas, and some local populations have experienced population decline.

In many places, the fate of the woodland caribou remains closely linked to levels of industrial and natural disturbance. Habitat conversion in some areas has resulted in altered predator/prey dynamics, and the development of natural resources has fragmented some populations and introduced new pressure in the form of hunting and poaching. Mitigating negative effects has taken on a heightened imperative for the forest industry, and much effort has been put into research efforts across Canada.

Previous efforts have been made to document and summarize the findings of the significant research efforts to date on woodland caribou, and to highlight research gaps. As a complement to these efforts, this document inventories the ongoing research programs in Canada, with the aim of identifying the focal points of current research efforts. Doing so may help researchers to better coordinate their efforts, allow the forest industry to anticipate where potentially useful results may arise, and better support conservation efforts on the ground.

This is the second such inventory conducted by NCASI. In contrast to the findings of our 2007 report, significantly more projects are ongoing in 2011. In spite of this overall increase, most jurisdictions have shown a level- or decreased effort, while the provinces of Quebec and Newfoundland/Labrador have shown marked increases in effort. While most research areas have shown a proportional increase in research effort, two areas—predation and energetic—have shown decreases in effort.

It is anticipated that this research inventory will be updated from time to time in the future, providing an ongoing tool for use in coordinating and targeting caribou-related research towards areas that will help optimize conservation efforts.

Ronald A. Yeske

July 2011

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MOT DU PRÉSIDENT

Le caribou des bois est devenu le symbole de la forêt boréale, forêt dans lequel il vit, et de tout le Nord Canadien. Bien des gens ont exprimé leurs préoccupations au sujet de la conservation et de la persistance du caribou dans la forêt boréale en raison de la diminution de l'aire de répartition des populations de caribous et du déclin de certaines populations locales.

Dans bon nombre d'endroits, le sort du caribou des bois demeure étroitement lié à l'intensité des perturbations naturelles et industrielles. À certains endroits, la transformation de l'habitat a eu pour effet de modifier la dynamique prédateur-proie, et le développement des ressources naturelles a morcelé certaines populations et a introduit de nouveaux points de pression (chasse et braconnage). Cette situation a obligé de plus en plus l'industrie forestière à identifier des mesures d'atténuation de ces effets négatifs, ce qui a donné naissance à de nombreux projets de recherche au Canada.

De nombreux travaux ont permis de documenter et de résumer les résultats des immenses efforts de recherche réalisés jusqu'à ce jour sur le caribou des bois et de faire ressortir les avenues de recherche peu exploitées jusqu'à maintenant. Pour compléter tous ces efforts, NCASI a produit le présent rapport. Celui-ci contient un inventaire des programmes de recherche présentement en cours au Canada afin d'identifier les principaux axes de recherche actuels, ce qui aidera possiblement les chercheurs à mieux coordonner leurs efforts, à permettre à l'industrie forestière de déterminer d'où peuvent provenir les résultats potentiellement utiles et à mieux soutenir les efforts de conservation sur le terrain.

Le présent document constitue le deuxième inventaire de ce genre préparé par NCASI. Dans ce document, nous notons qu'en 2011 il y a beaucoup plus de projets en cours qu'en 2007. Malgré cette augmentation, la plupart des juridictions ont maintenu ou diminué le niveau d'effort, tandis que le Québec et Terre-Neuve/Labrador ont augmenté considérablement leurs efforts de recherche. Bien qu'il y ait eu une augmentation proportionnelle au niveau d'effort dans la plupart des domaines de recherche, les efforts ont diminué dans deux domaines : la prédation et l'énergie.

NCASI prévoit mettre à jour périodiquement cet inventaire sur les travaux de recherche dans le but d'offrir un outil permanent de coordination et d'orientation des travaux de recherche sur le caribou vers des domaines qui aideront à optimiser les efforts de conservation.

Ronald A. Yeske

Juillet 2011

AN INVENTORY OF CARIBOU RESEARCH PROGRAMS IN CANADA

SPECIAL REPORT NO. 11-02
JULY 2011

ABSTRACT

Caribou or *Rangifer tarandus* is a species of deer that lives in tundra, taiga, and forest habitats at high latitudes in the northern hemisphere, including Russia and Scandinavia; Alaska, Idaho, and Washington states; and Canada. The woodland caribou (*Rangifer tarandus caribou*) has been listed under Schedule 1 of the Species at Risk Act (SARA) and is a high profile subspecies as it relates to forested environments across Canada. Further, the decline of this emblematic species has been linked to forest management practices throughout its range, and as a result, conservation of the species is a high priority for many forest products companies. As research on this subspecies is important to aid in its conservation and management, researchers from across Canada were surveyed to document the current research effort within the species' range. These findings are a follow-up to a similar NCASI project in 2007, and show a notable increase in caribou-related research since that time. While some research topics have shown decreases in effort, most have seen increased effort. Overall, the number of research programs across the country has increased since 2007, with several jurisdictions showing significant increases in research projects. It is hoped that this inventory will be useful for coordinating research efforts on woodland caribou, and in helping delineate future research efforts with an eye to long-term caribou conservation.

KEYWORDS

boreal, disturbance, ecology, forest management, predation, *Rangifer tarandus*, research effort, woodland caribou

RELATED NCASI PUBLICATIONS

Special Report No. 10-02 (October 2010). *Compendium of long-term wildlife monitoring programs in Canada*.

Technical Bulletin No. 939 (September 2007). *State of knowledge and analysis of current caribou research on woodland caribou in Canada.*

Technical Bulletin No. 934 (June 2007). *A review of ungulate nutrition and the role of top-down and bottom-up forces in woodland caribou population dynamics*.

Technical Bulletin No. 893 (December 2004). *Ecological interactions among caribou, moose and wolves: Literature review*.

UN INVENTAIRE DES PROGRAMMES DE RECHERCHE SUR LE CARIBOU AU CANADA

RAPPORT SPÉCIAL N^{O} 11-02
JUILLET 2011

RÉSUMÉ

Le caribou ou *Rangifer tarandus* est une espèce de la famille des chevreuils qui vit dans la toundra, dans la taïga et dans des habitats forestiers situés à des latitudes nordiques de l'hémisphère nord, notamment en Russie, en Scandinavie, dans les états de l'Alaska, de l'Idaho et de Washington et au Canada. Le caribou des bois (*Rangifer tarandus caribou*) est inscrit à l'Annexe 1 de la *Loi sur les espèces en péril* (LEP) et est une sous-espèce qui fait l'objet de beaucoup d'attention car elle est liée à des environnements forestiers situés partout au Canada. De plus, il existe un lien entre le déclin de cette espèce emblématique et les pratiques d'aménagement forestier dans l'ensemble de son aire de répartition. La conservation de cette espèce constitue donc maintenant une très grande priorité pour de nombreuses sociétés de produits forestiers. Puisque la recherche sur cette sous-espèce est importante pour contribuer à sa conservation et à sa gestion, NCASI a interrogé des chercheurs partout au Canada afin de documenter les efforts de recherche actuels à l'intérieur de l'aire de répartition du caribou des bois. Les résultats de cette enquête, qui fait suite à un projet similaire réalisé par NCASI en 2007, montrent une importante augmentation dans le nombre de travaux de recherche sur le caribou depuis ce temps. Bien qu'il y ait eu une diminution du nombre de travaux dans certains domaines de recherche, il y a eu augmentation du niveau d'effort dans la plupart des domaines. Dans l'ensemble, le nombre de programmes de recherche au Canada a augmenté depuis 2007. Dans plusieurs juridictions, le nombre de projets de recherche a même augmenté considérablement. Il y a lieu de croire que cette inventaire sera utile pour coordonner les efforts de recherche sur le caribou des bois et pour contribuer à définir les efforts de recherche futurs avec un objectif de conservation à long terme du caribou.

MOTS-CLÉS

aménagement forestier, caribou des bois, écologie, effort de recherche, forêt boréale, perturbation, prédation, *Rangifer tarandus*.

AUTRES PUBLICATIONS DE NCASI

Rapport spécial n^{o} 10-02 (octobre 2010). *Recueil des programmes de suivis à long terme des espèces fauniques au Canada*.

Bulletin technique n^{o} 939 (septembre 2007). *État des connaissances et analyse de la recherche sur le caribou des bois du Canada.*

Bulletin technique n^{o} 934 (juin 2007). *Revue des effets du régime alimentaire saisonnier sur les dynamiques des populations de caribous des bois*.

Bulletin technique n^{o} 893 (décembre 2004). *Les interactions écologiques entre le caribou, l'orignal et le loup : une revue de la littérature*.

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AN INVENTORY OF CARIBOU RESEARCH PROGRAMS IN CANADA

1.0 INTRODUCTION

Caribou or *Rangifer tarandus* is a species of deer that lives in tundra, taiga, and forest habitats at high latitudes in the northern hemisphere, including Russia and Scandinavia; Alaska, Idaho, and Washington states; and Canada. The common name is caribou in North America and reindeer in Europe and Asia. Several populations of barren-ground caribou, comprised of three sub-populations (*R.t. groenlandicus* and *R.t. pearyi* and *R.t. granti*), inhabit Canada's far north. Five populations of woodland caribou (*Rangifer tarandus caribou*), a subspecies of caribou, occupy the northern boreal forest, and south through the Rocky Mountains to, and just extending beyond, the US border into Idaho.

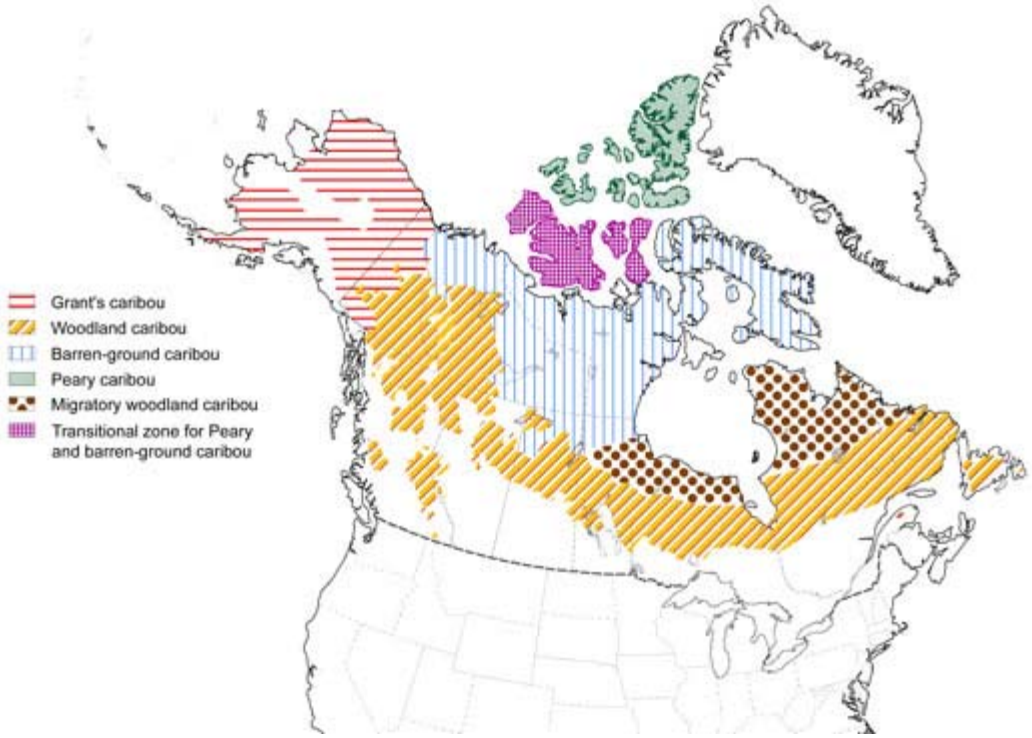

Figure 1.1 Distribution of Caribou in Canada, by Sub-Population (CWS 2005)

The woodland caribou (*Rangifer tarandus caribou*) has been listed under Schedule 1 of the Species at Risk Act (SARA) and is a high profile subspecies as it relates to forested environments across Canada. Further, the decline of this emblematic species has been linked to forest management practices throughout its range, and as a result, conservation of the species is a high priority for many forest products companies that operate in caribou range or companies that purchase fibre from those who do.

A good deal of research has been undertaken related to woodland caribou in Canada, some of which is focused on the interaction between forest management and caribou population dynamics. Boreal populations of woodland caribou are known to be sensitive to human disturbance (Racey et al. 1991; Cumming 1992; Courtois et al. 2004; Vors et al. 2007). Understanding the effect that

disturbance and fragmentation may have on caribou populations is challenging because of the complex ecology of the species and the variety of factors thought to play a role in that ecology.

Because of concerns about the roles of forest management and fragmentation in the decline of woodland caribou, control of fragmentation is emphasized in boreal forest management strategies. For example, this is both implicit and explicit in the measures advocated for Quebec (Courtois et al. 2004) and northwestern Ontario (Racey et al. 1999) for integration of caribou habitat concerns into forest management. For Quebec, suggested practices include 1) delimiting large (100–250 km2) habitat blocks and planning harvest strategies that maintain such blocks on the landscape in old forest conditions; 2) maintaining connectivity between seasonal habitats through the provision of wide (2 km) corridors; and 3) concentrating forest harvesting in contiguous blocks so as to avoid creating forest fragments. Similar strategies are advocated for northwestern Ontario.

The role that predation plays in limiting woodland caribou populations has received considerable attention, as reviewed by NCASI (2004), and forest fragmentation has been hypothesized to be a contributory factor in predation effects (Bergerud 1974; James 1999; Rettie and Messier 2000; Voigt et al. 2000; Dyer et al. 2001; Courtois et al. 2004). The basic hypothesis is that in areas where caribou are the only ungulates, they do not exist at sufficiently high densities to support large predator populations and can thus maintain viable populations. However, in areas where commercial-scale logging or other large-scale disturbance has occurred, the younger forest matrix and fragmentation of habitats has increased habitat for other ungulates, primarily moose, but also white-tailed deer and elk. It has been hypothesized that these changes have resulted in increased ungulate densities, which is thought to be the cause of increased predator populations and predation pressure on caribou (Simkin 1965 in Bergerud 1974; Bergerud 1974; Darby et al. 1989; Racey et al. 1991, 1999; Chowns 2003; Schaefer 2003).

Caribou populations may also be negatively affected by the existence and use of forest roads. Several studies of caribou behaviour in response to forest roads have suggested that while the evidence is not conclusive, caribou appear to use linear features to facilitate movement, but are inhibited by vehicular traffic, possibly as a result of increased noise disturbance (Banfield 1974; Bergerud, Jakimchuk, and Carruthers 1984; Curatolo and Murphy 1986; Murphy and Curatolo 1987; Cumming and Hyer 1998; Yost and Wright 2001; Dyer et al. 2001, 2002). Very lightly traveled roads may not pose a disturbance, or may even provide some benefits, but use of the roads by vehicles above some relatively light, but as yet unidentified, threshold may act as a deterrent for use and potentially present an ecological barrier. Hunting, facilitated by northern access roads, may also have an effect on populations of woodland caribou (Johnson 1985; Dyer et al. 2001; Chowns 2003; Courtois et al. 2004).

In 2007, NCASI produced a state of knowledge report on the current state of woodland caribou research in Canada (NCASI 2007a). Part of this Technical Bulletin involved documenting the approximately 50 woodland caribou-related projects that were occurring across the country at that time, along with information regarding the principal investigators, students, and objectives for each project.

Since 2007, significant changes have occurred on the Canadian caribou research landscape. To better track the woodland caribou research effort in Canada on an ongoing basis, a caribou research inventory has been compiled in this document, and in an accompanying electronic spreadsheet. It is anticipated that this inventory will assist the research community and other stakeholders in better coordinating research programs across caribou range and to enhance the researcher networks across concurrent projects. The inventory is similar in format to that compiled in 2007, and a similar methodology was employed in its compilation.

2.0 RESEARCH NEEDS

In 2007, existing research on forest-dwelling caribou had provided a substantial body of scientific information. Indeed, a substantial body of peer-reviewed literature had been published on various aspects of caribou biology, ecology, and conservation. That said, it is apparent that much remains poorly understood. Increasing the depth and breadth of scientific information about caribou will improve conservation programs and our ability to forecast future threats from changes in climate, ecosystems, and disturbance regimes. Therefore, there is a continual need for improved knowledge across the entire spectrum of the species' ecology, and research gaps persist. The following is a list of important research needs for caribou, some of which were previously identified (NCASI 2007a):

- The reliability and availability of current population estimates vary by herd, sub-population, and population. Estimates of both population numbers and demographics are available for only less than half of the defined herds in Canada (NCASI 2007a). The population status of many herds is essentially unknown. Ontario is thought to be home to roughly 15% of the boreal population of sedentary forest-dwelling caribou in Canada but has neither an estimate of population trend, nor a measure of the reliability of their provincial population estimate. Lack of data makes it difficult to assess the current status of caribou populations in forested landscapes.

- Mortality through wolf predation, other predator action, vehicle collisions, or disease and parasite action has resulted in the decline of caribou in forested environments. However, most research has focused on proximate drivers of those factors (e.g., habitat disturbance) rather than actual mortality rates generated by these factors. Estimates of mortality rates for radio-collared animals in managed forest landscapes are informative, but mortality rates are needed for caribou in unmanaged forests to facilitate comparisons with those on manipulated landscapes.

- Research on the medium- and long-term effects of the extensive mountain pine beetle epidemic on caribou habitat in British Columbia and Alberta is lacking, and the epidemic is poised to extend further east across the boreal range. It could be argued that salvage logging of suitable pine stands may exacerbate the problem of late-seral habitat loss, but the fundamental value of beetle-killed stands as habitat for caribou is still unknown. Additionally, the subsequent effects on other species, notably alternate wolf prey such as deer, may also play a substantial role. Overall, these issues point to a need for better understanding of caribou habitat selection/use as it relates to forest structure, particularly in conditions of high coarse woody debris loadings.

- Various reports, recovery documents, and primary sources have documented a variety of factors that may contribute to declines of caribou, but few have examined the interplay and relative effect size of these factors. Research is needed not only to assess their relative contributions, but in many cases to test and quantify the direct causal link between specific factors and caribou demography.

- Substantial research from around the world has documented that spring, summer, and fall forage quantity and quality have significant effects on reproduction, survival, and population growth for a wide range of ungulates. However, detailed studies on woodland caribou forage and nutritional dynamics are almost non-existent. Much of our understanding on this topic comes from work on barren-ground caribou, which may or may not be relevant to the forested environment. Understanding the relationships between

preferred forage items and forest structure can only be examined once foraging ecology is better understood.

- Detailed, realistic, and tested models for caribou demographics as they relate to both natural and anthropogenic factors are lacking. Recent attempts at modeling caribou persistence and forestry have met with some success, but remain untested in the long-term. Understanding and adapting such models to field conditions are vital to managing caribou over the medium- and long-term.

- Following an increased understanding of foraging needs through all seasons, research into silvicultural practices that promote winter and summer caribou forage, and which discourage the proliferation of less desirable forage species and habitats for alternative ungulates, would be helpful in leading to increases in the fitness of individuals and populations of caribou.

- There has been much speculation that population dynamics of other ungulates (e.g., moose and deer) in the immediate geographical region of caribou populations have indirect consequences for caribou population dynamics. These hypotheses, which link to forest management and to other factors such as climate change and parasitic loading, could be tested through predictions about increases or decreases in alternate ungulate species. Given that most ungulates (e.g., moose, deer, and elk) are legally harvested, research to test such causal links would be useful.

3.0 INVENTORY METHODOLOGY

To optimize woodland caribou conservation efforts, both past research findings and current research efforts may shed new light on management and recovery approaches, increasing their chances of success. While numerous reviews and summaries of caribou research have been published, including several by NCASI (2004, 2007a, 2007b), the need for an updated inventory of current research projects was identified by signatories to the Canadian Boreal Forest Agreement (CBFA). This report and accompanying spreadsheet are designed to meet that need.

NCASI identified relevant research projects through a combination of internet searches, discussions with researchers in the field, attendance at caribou-related conferences and meetings (e.g., the 13th North American Caribou Workshop in Winnipeg, Manitoba), and execution of an informal survey of researchers. Projects and researchers were identified in each province and territory and, where available, in each of four primary research sectors: academia, industry, governments (provincial and federal), and non-governmental organizations, although many projects are collaborative and multi-sectoral (e.g., industry/academic collaborations). Once projects were identified, the primary contacts, principal investigators, and graduate students were contacted regarding the details of each project. Researchers were asked to provide abstracts for their project, if possible, key areas of focus, and timelines for completion.

The objective of this project was to document all research underway concerning caribou subspecies in Canada. That said, it is very likely that some projects have been missed. Further, several kinds of caribou-related projects that do not constitute research *per se* were not included, e.g., long-term monitoring programs, recovery planning efforts, educational material development projects, and outreach programs.

4.0 RESULTS

Despite important limitations mentioned above, almost 100 researchers were contacted regarding their work, with representation from every jurisdiction in Canada. As such, the projects identified in this report likely constitute a significant majority of ongoing research concerning caribou in Canada, and therefore are a good representation of the scope and nature of current research. A total of 73 woodland caribou projects were identified, an increase of 50% since the publication of NCASI (2007a). A majority of the projects focus on the woodland caribou subspecies, including all recognized populations in Canada, and are grouped in Appendix A by jurisdiction (National, Provincial, or Territorial). Further, we documented a number of barren-ground caribou projects, located in Canada's north. These 11 projects are grouped together at the end of the inventory.

It is important to note that the number of ongoing projects does not directly correlate to the total dollars spent on research, but may serve as a general indication of research effort. Within Canada, seven provincial and two territorial jurisdictions include woodland caribou range. While there has been an overall increase in woodland caribou research effort across the country (in terms of numbers of projects), some jurisdictions have reduced their number of projects as previous projects have been completed. Other jurisdictions have either continued existing programs or initiated new projects. Notably, the province of Quebec has shown a substantial increase in projects, from 7 in 2007 to 24 in 2011 (Figure 4.1).

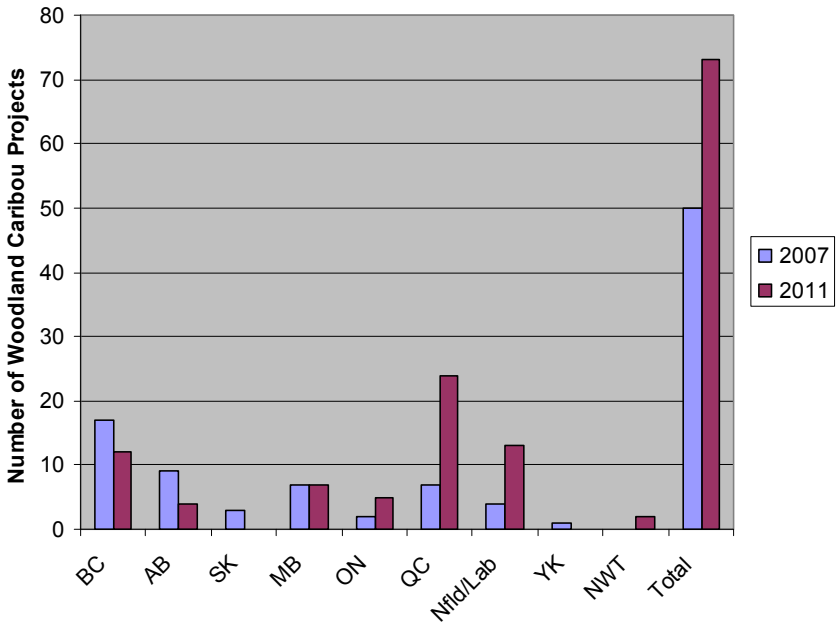

Figure 4.1 Number of Woodland Caribou Projects by Provincial Jurisdiction
[Total also includes six Canada-wide projects that have been developed since the 2007 report.]

For comparison with the results of the 2007 inventory, researchers were either asked to self-identify which research category best represented their work, or categories were selected by the inventory administrator and researchers were asked to confirm correct classification. Projects were categorized into the following seven categories to describe the focus of the research:

- **Basic Ecology** – Any project in which the primary research question examines the basic relationships between woodland caribou and the abiotic or biotic environment. Metrics of interest may include population demographics, habitat selection or behaviour.
- **Disturbance Driven** – Any project in which the primary research question examined any woodland caribou-related parameter as it directly relates to various disturbance factors (e.g., roads and other linear features, harvesting, wildfire, insect infestation, sensory disturbance, etc.).
- **Predation Driven** – Any project in which the primary research question examined altered or increased predation rates on caribou, the causes of such changes, and/or the underlying causes of changes to predator/prey dynamics.
- **Energetics/Nutrition** – Any project in which the primary research question examined the use and availability of forage resources and the physiological relationship between individual and population-level demographics.
- **Genetic** – Any project in which the fundamental research question examined genetic information (e.g., genetic diversity, allelic frequency) or methods (e.g., sample capture techniques).
- **Administrative** – Any project in which the primary research question examined the use of mitigative or best management practices to minimize effects of human activity on woodland caribou, and the related effects on those activities of such actions (including cooperation between organizations).
- **Other** – Any category of research that (in the opinion of the authors) does not fit into the previous six categories.

According to this classification, the majority of research projects (80%) deal with predation, disturbance, or another element of basic distribution and ecology of the subspecies (Figure 4.2). Under "Other" (4 projects), researchers self-identified the topics "Traditional/local knowledge," "Techniques/methodology," or "Economic analysis" (1 project each). One project remained classified simply as "Other".

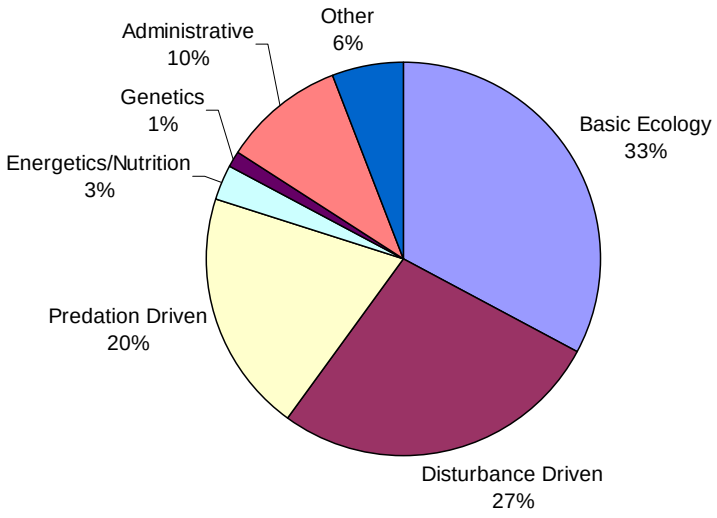

Figure 4.2 Breakdown of Research Projects from across Canada by Research Category (as identified by contacted researchers)

A similar classification scheme was used in the NCASI (2007a) report, with percentages reported as 32% for basic ecology, 26% for disturbance-driven, 25% for predation-driven (for a total of 83%), 2% for energetics and nutrition, 6% for genetics, and 8 % for administrative projects. Based on the 2011 results, there has been an increase in research effort in all categories except predator driven research (down 6%) and genetics work (down 4%; Figure 4.3).

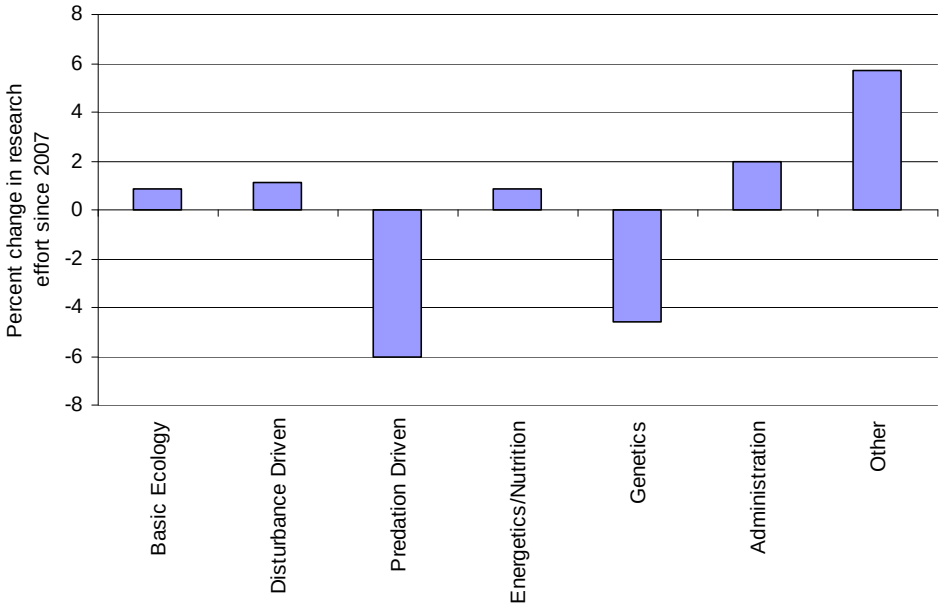

Figure 4.3 Percent Change since 2007 in Research Effort, as of 2011, per Research Category (as identified by contacted researchers)

5.0 CONCLUSIONS

Based on the number of research projects reported, there has been a significant increase in the number of projects focusing on woodland caribou across Canada. Notably, the province of Quebec has shown a dramatic increase in the number of ongoing projects focusing on this subspecies. Further, increases in research have been distributed across most of the subject categories described here, with the exception of predator-based work and genetics. Whether or not this is indicative of perceived research need, or is simply a reflection of researcher interest or funding availability, is uncertain.

It should be noted that it is uncertain whether all relevant research projects were identified through this survey, and it is probable that some were missed. Nonetheless, as in 2007, this inventory is an effective snapshot of the majority of current research projects related to woodland caribou in Canada. As such, it is reasonable to suggest that the comparison between inventories (2007 and 2011) is valid, and that increases (or topic-specific decreases) in research effort, in terms of the number of projects if not research dollars, are likely real.

As mentioned, this inventory did not attempt to assess research project scope or scale (e.g., project budget, number of personnel involved), nor did it attempt to evaluate the likelihood of the projects achieving their stated goals and objectives based on their study design. In addition, there was no evaluation made as to whether the research subcategories, nor the research effort level

within each, are sufficient. Finally, it is unclear whether or not the research highlighted here is sufficient to address the knowledge gaps needed to be filled to address the conservation and recovery objectives for this species in the near future. An assessment of those research needs would be valuable in determining the direction and sufficiency of future caribou research efforts in Canada.

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Note: Many of the items in the reference list contain digital object identifiers (DOIs). DOIs allow for persistent links for electronic objects. More information is available at www.doi.org.

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APPENDIX A

PROJECTS IDENTIFIED

The following projects were identified using the methodology described above. Projects are listed as national (Canada Wide) or under the province/territory in which the research is primarily taking place, irrespective of the location of the primary contact or sponsoring institution. Abstracts were either available from various online sources, or were provided directly by primary contacts or graduate students, and appear here as received, unedited or reviewed, except for spelling or grammatical errors.

Canada Wide (6)

Title: Scientific Assessment to Support the Identification of Critical Habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada (2011 Update).

Principal Investigators: Jason Duffe, Cheryl Johnson, Christian Malouin, Cathy Nielsen, Fiona Schmiegelow, Glenn Sutherland, Ian Thompson, Stephen Virc

Contributing Researchers: Vince Crichton, Marie-Josée Fortin, Daniel Fortin, Mark Hebblewhite, Dave Hervieux, Nic Larter, John Nagy, Tom Nudds, Richard Pither, Jean Polfus, Gerry Racey, Justina Ray, Dale Seip, Jim Schaefer, Tim Trottier

Affiliated Organizations: Environment Canada; University of Alberta; Canadian Forest Service; Sustainable Resource Development, Government of Alberta; University of Montana; University Laval; Wildlife Conservation Society; University of Guelph; BC Ministry of Environment and Ministry of Forests; Trent University

Sponsoring Institution: Environment Canada

Region: Canadian distribution of boreal caribou

Research Category: Other

Anticipated date of completion: August 31, 2011

Abstract: The Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population (herein referred to as boreal caribou) has been listed under the Schedule 1 of the Species at Risk Act (SARA). The Minister of the Environment must prepare a Recovery Strategy for a listed species that includes an identification of its "critical habitat", based on the best available information, where recovery is deemed feasible.

In 2007, Environment Canada launched a scientific initiative that culminated in a report entitled '*Scientific Review for the Identification of Critical Habitat for Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada'* (Environment Canada, 2008; available at www.sararegistry.gc.ca*)*. The report provided scientific information and a decision analysis framework to support the identification of critical habitat (i.e., habitat conditions required for recovery of boreal caribou under SARA).

Environment Canada identified several areas requiring further investigation to address key questions raised as a result of the analyses developed for the 2008 report, and resultant description of critical habitat. They included a more complete understanding of: 1) the

implications to critical habitat identification of variation in range delineation approaches across jurisdictions; 2) the relative impact of different disturbance types and their configuration, as well as other habitat types, on range assessment and critical habitat description; 3) the identification of disturbance thresholds for self-sustaining local populations, and; 4) how future range conditions might influence disturbance thresholds given the dynamic nature of disturbance and recovery within a given range. Updated best available information (demographic, disturbance) and a suite of additional analyses (e.g., resource selection functions, buffer analyses, enhanced meta-analysis, habitat-based PVA, Bayesian Decision Network) were used to explore these questions. Key findings from the update report will include: 1) a revised boreal caribou range delineation national map; 2) an assessment of the range to support a self-sustaining local population based on multiple lines of evidence; 3) a proposed methodology to assess where each range sits in relation to a disturbance threshold reflecting the desirable level of risk as informed by science and decided by management, and; 4) a list of key bio-physical attributes of boreal caribou habitat by ecozone.

Title: Conservation by Coincidence: Woodland Caribou, Surrogacy and Biodiversity in the Boreal Forest of Canada

Principal Investigators: C. Ronnie Drever, Mark C. Drever, Daniel Fortin, Cheryl Ann Johnson, Yolanda F. Wiersma, Michael Palmer

Affiliated Organizations: The Nature Conservancy, University of British Columbia, Université Laval, Environment Canada, Memorial University

Region: Boreal forest of Canada

Research Category: Basic Ecology

Anticipated Date of Completion: Unknown

Abstract: Woodland caribou is an at-risk species often portrayed as emblematic of functional boreal wilderness, partly because its principal threats include habitat loss and increased predation facilitated by extensive industrial activity. Since large protected areas are frequently proposed to maintain its persistence, caribou's emblematic status may have functional value for conservation of other species. We estimate the surrogacy value of the boreal population of woodland caribou by (i) evaluating co-occurrence of native taxa with caribou distribution for mammals (n=101), birds (n=338), at-risk mammals (n=8) and at-risk birds (n=28); and (ii) conducting systematic conservation planning to identify representative reserve networks, comprised of planning units deemed large enough (10,000 km^2) to enable persistence, both at the extent of woodland caribou range and the entire boreal forest. Our analyses indicate strong anisotropy in the surrogacy of woodland caribou for overall mammal and bird diversity partly due to the pronounced latitudinal gradient in richness. Surrogacy values for at-risk species did not follow expected latitudinal patterns, suggesting priority areas for biodiversity conservation need to carefully consider a range of patterns, and not overall richness gradients. This information can help prioritize caribou management and planning in areas of high surrogacy for other taxa of conservation importance.

Title: Nutritional and Habitat Influences on Woodland Caribou Populations

Principal Investigators: Perry Barboza, John Cook, Rachel Cook, Katherine Parker, Darren Sleep

Contributing Researchers: Larry Irwin, Kirsten Vice

Affiliated Organizations: The National Council for Air and Stream Improvement, Inc., University of Alaska Fairbanks, University of Northern British Columbia

Sponsoring Organization: AbitibiBowater, Domtar, Forest Resource Improvement Association of Alberta (FRIAA), LP Canada, Tolko Industries, Verso Paper

Region: Canadian distribution of Woodland Caribou

Research Category: Energetics and Nutrition

Anticipated date of completion: Fall 2017

Abstract: The Woodland Caribou (*Rangifer tarandus caribou*) has been listed under Schedule 1 of the Species at Risk Act (SARA) and is a high profile species as it relates to forested environments across Canada. Further, the decline of this emblematic species has been linked to forest management practices throughout its range, and as a result conservation of the species is a high priority for many forest products companies that operate in caribou range or companies that purchase fibre from those who do. Many studies to date have focused in the causal links between habitat alteration, natural and anthropogenic disturbance, alternate ungulate species and predators on caribou populations. Such "top-down" influences have been found to have significant negative effects on caribou distribution and abundance. In contrast, very little research has been directed to "bottom-up influences" such as forage quality and quantity, availability, and the subsequent nutritional status among wild populations. In species such as elk and deer, nutrition dynamics have been found to influence key demographic factors, such as probability of breeding, timing of breeding and parturition, birth weight, juvenile growth and development, susceptibility to predation, and long-term survival, none of which has been examined in woodland caribou.

This program is based on two overarching, working hypotheses:

(1) Across Canada, the suitability of habitat for woodland caribou undoubtedly varies in relation to broad-scale patterns of climate, soils, topography, vegetation type, successional trajectories, and land use. The influences of habitat on caribou populations undoubtedly vary as well. We hypothesize that at least in some settings, habitat has limiting effects, mild in some areas and perhaps ranging to severe in others. There may be potential to benefit caribou by improving habitat in many of these areas through application of more effective forest management and through more effective selection of areas for protection or conservation.

(2) We hypothesize that judicious forest management may provide valuable opportunities to benefit woodland caribou and thus may provide opportunities to the forest products industry to play a positive and proactive stewardship role for this species in areas where the industry continues to operate.

Phase 1 of this research program involved the establishment of a research herd to develop baseline data on nutritional needs and influences through the use of controlled feeding trials at the R.G. White Large Animal Research Station (LARS) at the University of Alaska, Fairbanks. This work was initiated in 2009, with controlled feeding trials initiated in 2010. The purpose of the work is to determine and quantify the relationship between digestible protein and energy content in forages and performance measures of the animals. Phase 2 will begin in 2013 when the tame caribou are moved to Canada where they will be used in experiments of foraging dynamics and nutrition in managed and unmanaged natural habitats across caribou range in Canada. These data will improve understanding of habitat attributes, and how management of these attributes, influence foraging efficiency and nutrition. Estimates of body condition, reproduction, and habitat use of wild caribou will be linked with data of nutritional resources from the foraging experiments to evaluate extent of nutritional limitations, habitat correlates of nutritional status,

and nutrition's role in affecting distribution and habitat use of caribou in wild herds. Integrating data of captive and wild caribou offer a unique and powerful approach to understand how habitat influences population dynamics that should enhance conservation of woodland caribou.

Title: Conservation Assessment and Analysis of Critical Habitat of Mountain Caribou (*Rangifer tarandus caribou*).

Principal Investigators: James Bergdahl, Glada McIntyre

Affiliated Organizations/ Sponsoring Institutions: Conservation Biology Center, University of the Wilderness; Applied Ecological Stewardship Council of British Columbia

Region: Geographic range of mountain caribou

Research Category: Disturbance Driven

Anticipated Date of Completion: Ongoing

Abstract: Our research focuses on habitat and wildlife population analysis of the Pacific Northwest of North America, including salmonids, bears, mountain caribou, rare and little known insect species, and *Sphagnum* bogs. Our work on mountain caribou is focused on the impacts of forest and recreation management policy on conservation of caribou populations and their habitats.

Title: Use of Space by Caribou in Northern Canada

Principal Investigator/Graduate Student: John Nagy

Affiliated Organization: University of Alberta

Region: Northwest Territories, Nunavut, and northern Alberta

Research Category: Basic Ecology/Disturbance Driven

Anticipated Date of Completion: 2011

Abstract: Understanding how populations are structured and use natural and anthropogenic spaces, is essential for effective wildlife management. A total of 510 barren-ground (*Rangifer tarandus groenlandicus*), 176 boreal (*R. t. caribou*), 11 mountain woodland (*R. t. caribou*), and 39 island (*R. t. groenlandicus x pearyi*) caribou were tracked with satellite collars in 1993-2009 in the Northwest Territories, Nunavut, and northern Alberta. Using these satellite location data with hierarchical and fuzzy cluster analyses I verified that Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Qamanirjuaq, and Lorillard barren-ground subpopulations were robust; the Queen Maude Gulf and Wager Bay barren-ground subpopulations were distinct. Dolphin and Union island caribou formed one subpopulation and boreal caribou formed two distinct subpopulations. Females in robust subpopulations were structure by strong annual spatial affiliation; those in distinct subpopulations were spatially independent and structured by migratory connectivity, movement barriers, and/or habitat discontinuity. The subpopulation structure identified for migratory barren-ground caribou was supported by an east-west cline in annual-range sizes and path lengths. I analyzed satellite location data to determine parturition dates and activity periods for most caribou ecotypes. For parturition dates I found a north-south cline for boreal caribou, west-east cline for migratory barren-ground caribou, and ecotype and

subspecies clines for boreal and barren-ground caribou. Based on annual changes in movement rates I identified eight activity periods for boreal and tundra-wintering, 10 for mountain woodland, and 12 for migratory barren-ground caribou. Based on changes in their distribution and movement rates I found that boreal caribou avoided seismic lines during periods when females and calves were most vulnerable to predators or hunters. They crossed fewer seismic lines and travelled faster when they crossed them than expected. Where they could space away from seismic lines they avoided areas near them up to 400 m suggesting that they perceive these as risky areas. I defined secure habitats as those areas that were >400 m from anthropogenic linear features. Population growth rates were greater in areas where they had access to secure unburned habitat and where most of this was in patches >500 km^2. Critical habitat for boreal caribou is a habitat state that provides "security" from predation risk and facilitates the effectiveness of their anti-predator strategies.

Title: Subpopulation Structure of Caribou (*Rangifer tarandus L.*) in Arctic and sub-Arctic Canada.

Principal Investigators: John Nagy, Deborah Johnson, Nicholas Larter, Mitch Campbell, Andrew Derocher, Allicia Kelly, Mathieu Dumond, Danny Allaire, and Bruno Croft.

Affiliated Organizations: University of Alberta, Government of Northwest Territories, Government of Nunavut

Region: Arctic and Sub-Arctic Canada

Research Category: Basic Ecology

Anticipated Date of Completion: 2011

Abstract: Effective management and conservation of species, subspecies, or ecotypes requires an understanding of how populations are structured in space. We used satellite-tracking locations and hierarchical and fuzzy clustering to quantify subpopulations within the behaviorally different barren-ground (*Rangifer tarandus groenlandicus*), Dolphin and Union island (*R. t. groenlandicus x pearyi*), and boreal (*R. t. caribou*) caribou ecotypes in the Northwest Territories and Nunavut, Canada. Using a novel approach, we verified that the previously recognized Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Qamanirjuaq, and Lorillard barren-ground subpopulations were robust and the Queen Maude Gulf and Wager Bay barren-ground subpopulations were organized as individuals. Dolphin and Union island and boreal caribou formed one and two distinct subpopulation, respectively, and were organized as individuals. Robust subpopulations were structured by strong annual spatial affiliation among females; subpopulations organized as individuals were structured by migratory connectivity, barriers to movement, and/or habitat discontinuity. One barren-ground subpopulation used two calving grounds and one calving ground was used by two barren-ground subpopulations indicating that these caribou cannot be reliably assigned to subpopulations solely by calving ground use; they should be classified by annual spatial affiliation among females. Annual-range size and path lengths varied significantly among ecotypes, including mountain woodland caribou (*R. t. caribou*), and reflected behavioral differences. An east-west cline in annual-range sizes and path lengths among migratory barren-ground subpopulations likely reflected differences in subpopulation size and habitat conditions and further supported the subpopulation structure identified.

British Columbia (12)

Title: Parsnip Caribou Recovery Trail

Principle researchers: Doug Heard, Mike Gillingham

Affiliated Organizations: Fish and Wildlife Compensation Program, University of Northern British Columbia and BC Ministry of Natural Resource Operations

Region: Central British Columbia

Research Category: Predator/Prey

Anticipated Date of Completion: Spring 2011

Abstract: The Parsnip caribou herd in central BC is the northernmost population of the mountain caribou ecotype. This project is examining the change in Parsnip caribou herd numbers resulting from an increase in moose hunting. Moose hunting regulations were changed to allow hunters to kill more moose in the hope that increased hunting would reduce moose numbers and there would then be a decline in wolf numbers and a decline in wolf predation on caribou.

Title: Assessing Spatial Factors Affecting Predation Risk to Boreal Caribou Calves: Implications for Management

Principal Investigator: Stan Boutin

Contributing Researcher: Conrad Thiessen

Graduate Student: Craig DeMars

Affiliated Organizations: University of Alberta, BC Ministry of Natural Resource Operations

Sponsoring Institutions: Alberta Upstream Petroleum Research Fund (Petroleum Technology Alliance Canada); BC Ministry of Natural Resource Operations; BC Oil & Gas Commission Science, Community, and Environmental Knowledge Fund; Canadian Natural Resource; Canadian Wildlife Federation; ConocoPhillips; Devon; EnCana; EOG Resources; Imperial Oil/ExxonMobil Canada; Nexen; PennWest; Progress Energy; Quicksilver;

Region: Boreal caribou ranges in northeastern BC near the community of Fort Nelson. Specific caribou ranges include Maxhamish, Parker, Prophet, and Snake-Sahtaneh.

Research Category: Predator/Prey

Anticipated Date of Completion**:** Fall of 2013

Abstract: Low rates of calf recruitment (survival to 1 year of age) are a key demographic factor limiting populations of boreal caribou, an ecotype of woodland caribou (*Rangifer tarandus caribou*) *Red-listed* in British Columbia and federally designated as *Threatened* under the *Species at Risk Act*. Predation is the primary cause of calf mortality and increasing predation of caribou has been linked to increasing levels of landscape alteration from industrial activity. By facilitating access to caribou habitat, landscape alteration impacts the spatial separation of caribou from other ungulates and their associated predators. For boreal caribou, spatial separation is a key mechanism for reducing predation risk, particularly during the calving season when females become more highly dispersed to further decrease predation risk. Consequently, in altered

landscapes, an inability of parturient females to spatially separate from predators can result in above-normal mortality rates of neonate calves (0-6 weeks of age). In BC's boreal caribou ranges, which have been significantly impacted by industrial activity, rates of neonate mortality for the past 7 years have been particularly high (e.g. >70%), causing calf-cow ratios at the end of the neonate period to fall below those associated with population stability (e.g. < ~29 calves: 100 cows) and increasing extinction risk to these populations.

To effectively conserve boreal caribou populations in increasingly altered landscapes, novel and comprehensive management strategies are needed to reduce predation risk to caribou during the calving season. Reducing predation risk solely by predator control is unsustainable long-term without concurrent management actions to maintain or restore functional caribou habitat. To that end, our project's objective is to develop new management recommendations for reducing predation risk to caribou calves by assessing the relative importance of spatial factors thought to influence predation risk, specifically: calving site selection, larger-scale characteristics of landscape pattern, and predator habitat use during the critical neonate time period. To achieve this objective, we will use a model selection approach with data developed from aerial surveys of radio-collared female caribou, radio-collaring of wolves and black bears – the main predators of caribou calves – and GIS analyses. Given current and projected impacts of landscape alteration on BC's boreal caribou ranges, our project's outcomes will provide important information to wildlife managers seeking to minimize development impacts within caribou ranges.

Title: Influence of Heli-skiing on Mountain Caribou in Columbia Mountain, BC

Principal Investigators: Tom Dickinson, Bruce McLellan

Graduate Student: Katarina Hubel

Affiliated Organizations: Thomson Rivers University, British Columbia Ministry of Forests

Region: Columbia and Cariboo Mountains, BC

Research Category: Disturbance Driven

Anticipated Date of Completion: unknown

Abstract: Unavailable

Title: The Influence of High Elevation Timber Harvest and Transmission Lines on Moose: Do high elevation logging and power lines reduce the spatial separation between moose and caribou?

Principal Investigators: Stan Boutin, Bruce McLellan

Graduate Student: Meagan Anderson

Affiliated Organizations: University of Alberta, British Columbia Ministry of Forests, Columbia Mountains Caribou Project

Region: Columbia Mountains, BC

Research Category: Disturbance Driven

Anticipated Date of Completion: Unknown

Abstract: Unavailable

Title: Columbia Mountain Caribou Project

Principal Investigators: Bruce McLellan, Robert Serrouya, Stan Boutin

Graduate Student: Robert Serrouya

Affiliated Organizations: University of Alberta, British Columbia Ministry of Forests, Columbia Mountains Caribou Project

Regions: Columbia Mountains, BC

Research Category: Predator/Prey, Energetics/Nutrition, Genetic

Anticipated Date of Completion: Research ongoing

Abstract: After a decade of studying caribou ecology, the evidence became overwhelming that the main cause of their decline was unsustainable predation due to "apparent competition" with moose and deer, with wolves and cougar being the primary predators. In 2003 the number of moose hunting permits in the Revelstoke area was increased and the moose population rapidly declined. In an adaptive management framework, our primary research goal at this time is to document how this dramatic shift in the ecosystem is affecting the predator-prey system including caribou.

Here are some of the projects we are currently working on:

1. "Developing a population target for an overabundant ungulate for ecosystem restoration." In this paper we developed a statistical population target for moose in the Columbia Mountains. We estimate how many moose would have been in the ecosystem in the absence of forest harvesting and transmission lines.
2. "Fragmentation, dispersal, and metapopulation function in remnant populations of endangered mountain caribou" In this paper we asked if mountain caribou function as a metapopulation with sufficient dispersal to rescue the smaller and declining subpopulations. Since 2005, we collared 27 calves and additional adults. We found that the 18 subpopulations were more fragmented than previously thought, actually consisting of 41 breeding ranges with very little movement among these.
3. "Genetic analysis reveals historic fragmentation and unique signature correlated with ecotype of an endangered herbivore" In this paper we ask: Are the 18 subpopulations delineated using telemetry reflected using genetic analyses? This work is significant because if genetic signals mirror these subpopulations, then the fragmentation has existed for a relatively long time, and is less related to recent human activity. In contrast, if the genetic patterns show no structuring, then the fragmentation observed by Wittmer is recent.
4. "Factors influencing bone marrow content of endangered Mountain caribou". Here we further test the hypotheses that predation is at unsustainable levels because caribou are in poor nutritional condition and consequently make risky foraging decisions. We amassed a dataset across the range of mountain caribou of bone marrows from 79 dead caribou. So far, we found no relationship between the amount of old growth in a caribou's home range, or subpopulation, and marrow fat. Caribou killed by predators have the same level of marrow fat as those killed in accidents. The subpopulation with the highest marrow

content (Columbia South) has among the fastest rate of decline. Nutrition, as indexed by marrow fat, does not seem to explain why caribou are declining.

5. "Spatial factors related to mortality and population decline of endangered mountain caribou". This paper examines landscape patterns (roads, cut-blocks, edges) associated with caribou mortality sites. All analyses were stratified by cause of death and predator species. Landscape pattern did not seem to influence where caribou die (with the notable exception of roads, which seem to influence where caribou are killed by wolves, but not other predators). The implication is that it is the numbers of alternative prey and predators that matter, and less so how landscape patterns affects the distribution of alternative prey or the foraging efficiency of predators. Also, bears were found to be a more important cause of death than previously thought.
6. "Caribou movement paths in managed landscapes: the influence of edges and road density". Based on snow trailing data collected in winter, we noticed that caribou were strongly selecting roads and edges for foraging. This may be problematic because some predators forage along edges and roads, thus roads may create "ecological traps" for caribou. We are expanding this analysis to include snow-free seasons using existing GPS movement data. Caribou are killed more often during the snow-free season, so before concluding that roads and edges created traps, it is important to conduct this analysis using summer data.

Title: Impacts of Industrial Development on Habitat Selection and Movement Ecology of Wolves (*Canis lupus*) and Woodland Caribou (*Rangifer tarandus caribou*) in the South Peace Region of British Columbia.

Principal Investigators: Chris J. Johnson, Dale R. Seip, Katherine Parker

Graduate Student: Libby Williamson

Affiliated Organizations: University of Northern British Columbia, Ministry of Environment

Sponsoring Institutions: Habitat Conservation Trust Fund, Canadian Association of Petroleum Producers, University of Northern British Columbia, British Columbia Ministry of Forests and British Columbia Ministry of Environment

Region: The South Peace region of British Columbia (~12,000 km^2)

Research Category: Predator/Prey

Anticipated Date of Completion: Fall 2011

Abstract: Since the early 1990's, regions surrounding the Peace River in north eastern British Columbia have experienced rapid land-use change from resource extraction activities, in addition to large-scale agriculture and forestry. Landscape change has altered a once stable relationship between woodland caribou (*Rangifer tarandus caribou*) and wolves (*Canis lupus*); caribou are now threatened by increased predation through apparent competition. My research goal is to understand factors influencing wolf distribution relative to high-quality habitat for caribou. I used resource selection functions (RSFs) to quantify the spatial relationships between 27 collared caribou to variables that are hypothesized to influence seasonal distribution. For wolves, I used a statistical model based on counts to relate the number of locations within a habitat selection unit (HSU) to a number of covariates representing environmental or industrial features that might

explain seasonal distributions. Because caribou herds within the study area prefer wintering in a variety of habitats, I also quantified the seasonal variation in wolf distributions in the context of herd-specific wintering strategies. Lastly, I will be investigating movement ecology of wolves relative to anthropogenic disturbances. This study will provide insights on wolf-caribou interactions that may be applicable to other wildlife negatively influenced by increasing human disturbances.

Title: Quesnel Highland Alternative Silvicultural Systems

Principle investigators: Michaela Waterhouse, Harold Armleder, Teresa Newsome, Pat Teti, Robert Sagar

Affiliated Organizations/Sponsoring Institutions: Ministry of Natural Resource Operations, Province of British Columbia

Region: East Central British Columbia (Quesnel Highland) (Southern Mountains National Ecological Area)

Research Category: Disturbance Driven

Anticipated Date of Completion: ongoing long-term research installation

Abstract: In British Columbia, Mountain Caribou are provincially 'red-listed' and under the federal *Species at Risk Act* they are designated as threatened. The objective of this long-term project, established in 1990, is to develop and test group selection silvicultural systems to maintain caribou habitat, while allowing for some timber harvesting in high elevation Engelmann spruce – subalpine fir forests. The group selection system is based on 33% area removal and a cutting cycle of 80 years. The project has a pilot trial, a replicated trial and an adaptive management phase. The response of arboreal lichen (main winter forage) has been measured pre- and post- harvest in response to treatments based on opening size between 0.03 - 1.0 ha in the older forest matrix. This is an inter-disciplinary project that includes regeneration, snow melt and ablation, vegetation, stand structure, microclimate, bird and small mammal studies. The study has resulted in many publications to facilitate management of caribou habitat in the Quesnel Highland and elsewhere in British Columbia.

Title: Itcha-Ilgachuz Alternative Silvicultural Systems

Principal Investigators: Michaela Waterhouse, Harold Armleder, Bill Chapman, Adam Wei, Robert Sagar

Affiliated Organizations/Sponsoring Institutions: Ministry of Natural Resource Operations, Province of British Columbia, University of British Columbia

Region: West-Central British Columbia (Chilcotin) (Southern Mountains National Ecological Area)

Research Category: Disturbance Driven

Anticipated Date of Completion: Ongoing long-term research installation

Abstract: In British Columbia, Northern Caribou are provincially 'blue-listed' (vulnerable) and under the federal *Species at Risk Act* they are designated as threatened. The objective of this long-term project, established in 1994, is to develop and test irregular group shelterwood and group

selection silvicultural systems to maintain caribou habitat, while allowing for some timber harvesting in dry, high elevation, lodgepole pine forests. The group selection system is based on 33% area removal and a cutting cycle of 80 years, while the shelterwood system is planned on a 50% area removal and final cut at 70 years. The project has a pilot trial, a replicated trial and an adaptive management phase. The response of both terrestrial and arboreal lichens (main winter forage) has been measured pre- and post- harvest in response to a range of treatments based on opening sizes up to 0.15 ha, and silvicultural system in the older forest matrix. The study has become more complicated and valuable since the area has experienced 60% tree mortality due to Mountain Pine Beetle. This is an inter-disciplinary project that includes regeneration, long-term site productivity, vegetation, stand structure, microclimate, bird and mushroom studies. The study has resulted in many publications to facilitate management of caribou habitat in the Chilcotin and elsewhere in B. C.

Title: Assessing Predation Risk by Wolves to an Augmented Mountain Caribou Herd in Southeast BC

Principal Investigators: Dennis Jelinski, Gerald Kuzyk, Leo DeGroot

Graduate student: Cary Gaynor

Affiliated Organizations/Sponsoring Institutions: University of Victoria, British Columbia Ministry of Natural Resource Operations

Region: This study is being conducted in the South Purcell Mountains in southeast British Columbia.

Research Category: Predator/Prey

Anticipated Date of Completion: 2014

Abstract: The Purcells South caribou herd in southeast British Columbia that numbers only 15 individuals distributed in two groups is geographically isolated from neighbouring herds and hence is at high risk of being extirpated. The BC Government plans to augment this herd with 40 caribou over the next two years, in an attempt to establish a long-term, demographically-viable herd. However, the present and future augmented herd are at risk of predation by wolves (and other predators). Forest harvesting has altered the landscape creating extensive early-successional habitat that supports a moderately dense population of moose and a highly dense population of elk and deer. In the presence of elevated predator and multi-species prey populations, the risk of opportunistic predation on caribou by wolves is unknown. This information and any resulting management implications are critical to successful herd augmentation.

We seek to understand spatial and temporal movements of wolves by using GPS cluster analysis to locate and examine their kill sites, and use the resultant information to assess predation risk to caribou. Additionally, we will examine wolf behaviour in relation to anthropogenic disturbance such as roads and high-elevation cut-blocks, which may attract alternative prey species adjacent to caribou habitat.

We will fit three female caribou, from two groups, and one or two wolves with GPS radio collars in each of five to six resident packs. From the GPS location data and field kill-confirmation data, we will assess wolf kills, by locating “cluster” data and delineating the proximity to nearest anthropogenic disturbances, predicting the degree of risk to newly augmented caribou.

Title: Adaptive Restoration of Northern Caribou Range in North-central British Columbia

Principal Investigator: Scott McNay

Affiliated Organization: Wildlife Infometrics INC

Region: British Columbia

Research Category: Administrative

Anticipated Date of Completion: Unknown

Abstract: This multi-year project will complete a historic path from the preliminary investigation of habitat use by northern caribou (*Rangifer tarandus*) to the applied work of the Omineca Northern Caribou Project. With over $7 Million invested since 1998, we have moved from investigative research, through adaptive management (AM), to recovery planning, and propose work that will be applied to the development of a longer-term restoration strategy of caribou range. At a time when caribou populations are in decline an opportunity exists to ensure their conservation, and potential enhancement, in north-central BC near to historical levels. Annually, caribou utilize multiple seasonal ranges including: low (PLWR) and high elevation winter range, calving and summer range, movement corridors, and post rut range (PRR). This project aims at improving, developing, and implementing restoration techniques to maintain and/or enhance habitat in PLWR and PRR areas, which in its simplest form means managing the range to provide forage/foraging cover (terrestrial lichens) that is relatively free of predation risk. In the Omineca Region of north-central BC, legislated ungulate winter ranges (UWR) provide a primary tool for achieving such a goal, but because strategies specified in the policy were developed on interim research data they require further assessments to ensure the policy is effective. Through the collection of new information and implementing habitat management treatments, using an adaptive management framework this project will reduce uncertainty and progress with the restoration of PLWR and PRR. We are proposing tasks as three different project elements that will be addressed through the achievement of 5 objectives. Collected information will guide effective management and restoration of terrestrial lichen range by: evaluating previously implemented trials (objectives 1), undertaking restoration treatment activities at multiple treatment sites (objective 3 and 5), and initiating additional restoration activities by completing site level reconnaissance for new treatments (objectives 2 and 4). Given the multi-task nature of this proposal, successful completion of objectives will be varied. For monitoring oriented objectives, success will be evaluated as a function of validating, and updating of UWR policy and implementation of recovery plan strategies. For treatment oriented objectives, completion of treatments will be the base measure of success, although where treatments are designed to reduce predation risk for caribou, a reduction of moose presence within the vicinity of caribou range is also an expected outcome that will be used as a measure of success.

Title: Conservation Measures for Liard Plateau Caribou

Principal Investigator: Scott McNay

Affiliated Organization: Wildlife Infometrics INC

Region: British Columbia

Research Category: Administrative

Anticipated Date of Completion: Unknown

Abstract: The Liard Plateau caribou herd (henceforth the herd) is a small, isolated population of woodland caribou (*Rangifer tarandus caribou,* Northern ecotype) north of the Liard River in British Columbia (BC). Although relatively remote, the herd still provides opportunities to hunt caribou in reasonable proximity to Fort Nelson. However, the rationale for hunting caribou is precarious since caribou populations are in decline globally, nationally, and provincially. Knowledge about the condition of the Liard Plateau herd is weak and what data does exists, suggests the herd is also in decline or at least suffering from poor juvenile recruitment, a low number of bulls per 100 cows, and the average age of harvested males appears to be less than some other northern herds. The herd is remote and, aside from man-induced forest fires, is relatively unaffected by anthropogenic disturbance. Pending industrial development is likely to change all that in a number of ways and, with very limited ecological understanding about the herd, it will be difficult to manage the potential impacts other than by precautionary measures such as reducing or even eliminating the current hunt. In an effort to avert such measures, our proposal is to conserve this wildlife resource value and the sustainable flow of benefits to people by using a science-based (data collection on population vital rates and habitat use) and traditional-knowledge based (modeling ecological information collected from aboriginal people and domain experts) approaches to: i) determine sustainable harvest levels and habitat quality, ii) develop recommendations for range protection measures (currently there is no designated protection), and iii) develop an effectiveness monitoring program. Outcomes of the work are expected to positively affect the herd, the provincial status of northern caribou, working relationships with aboriginal people, the provincial oil and gas industry, the guide-outfitting industry, and hunters and others who gain benefit from healthy populations of caribou.

Title: Herd Boundary Refinement for the Chase, Spatsizi, Horseranch, Rabbit, Frog and Finlay Caribou Herds in Northern British Columbia

Principal Investigator: Scott McNay

Affiliated Organization: Wildlife Infometrics INC

Region: British Columbia

Research Category: Administrative

Anticipated Date of Completion: Unknown

Abstract: Woodland caribou (*Rangifer tarandus caribou*) populations are in decline in many places around British Columbia (BC) with the largest and most stable populations existing in northern BC. Even so, caribou are considered to be of only “trace occurrence” (i.e., no designated herd) in a large area of north-central BC and yet observations show that caribou numbers exceed 3/4 of the herd sizes in BC. Our ultimate objective is to collect data that will help us understand how the observed caribou contribute to the provincial inventory (i.e., what herds do they belong to) as a means to: i) identify proper herd boundaries and hence management units, ii) update the numbers and density of affected herds, and iii) make preliminary recommendations for designated protection through the Forest and Range Practices Act and the Oil and Gas Activities Act. Our objectives for this project are to: i) collect spatial data that would allow us to model caribou seasonal ranges in the area, ii) run the models, iii) review literature for a list of historic inventories and their results, iv) work collaboratively with our aboriginal partners in the area, v) confirm the engagement of other potential partners that have already expressed interest (e.g., guide outfitters, Wildlife Conservation Society, Canadian Parks and Wilderness Society, WilburForce). This work would lead off from, and continue work started in 2009-2010 by two

partners who continue as partners in the new project: 1) the Muskwa-Kechika Advisory Board (MKAB) and 2) the Tsay Keh Nay (TKN -- a collaboration of three aboriginal associations – Tsay Keh Dene, Kwadacha, and Takla Lake First Nations). The MKAB funded a survey in the southwestern portion of the MK Management Area and TKN funded a second and much larger survey in the area between the Spatsizi, Frog, and Chase herds (Sulyma et al. in prep). Ultimately, we will propose to use automated recovery of relocations of collared caribou collected through the Iridium satellite system as the approach to understand associations of individual animals to specific herd areas. The MKAB have confirmed they will provide funds to purchase the necessary collars. Five herds (the Chase, Spatsizi, Horseranch, Rabbit, Frog and Finlay) are potentially implicated and there is the possibility of an entirely new herd being discovered. Relocations will be assessed for different seasonal and levels (life, seasonal, daily) of movement to infer herd association. Outcomes of the work are expected to positively affect the 5 herds, the provincial status of northern caribou, working relationships with aboriginal people, the guide-outfitting industry, and hunters and others who gain benefit from healthy populations of caribou.

Alberta (4)

Title: Wildlife Management and Conservation of Ecological and Genetic Variation in Caribou

Principal Investigators: Marco Musiani, Mark Hebblewhite

Graduate Students and Postdoctoral Fellows: Nick DeCesare, Christina Semeniuk, Byron Weckworth

Affiliated Organizations: University of Calgary, University of Montana

Sponsoring Institutions: PTAC - Petroleum Technology Alliance Canada, Parks Canada, NSERC- Natural Science and Engineering Research Council

Region: Canadian Rockies and surrounding regions

Research Category: Predator/Prey

Anticipated Date of Completion: ongoing

Abstract: We are comparing the influence on caribou mortality of predators and, indirectly, of prey that are favoured by Forestry vs. Oil and Gas development and provide practical recommendations for mitigation. Modelling and implementation of such mitigation strategies at a regional scale is especially needed. The project will: 1. Improve our understanding of (a) the role of summer predation to caribou declines, (b) the effects of forestry vs. oil and gas development on predation. 2. Provide recommendations on how to mitigate predation on caribou (e.g. through management of predation-enhancing factors). 3. Assess the contribution to caribou mortality by predators other than wolves, and provide recommendations on management (e.g. through management of other predators). 4. Assess the relative importance of forestry (e.g. through moose) and oil and gas (e.g. though wolves) on caribou declines, with implications for mitigation and protection strategies to recover caribou. 5. Describe ecological and genetic variation in caribou populations. 6. Use molecular ecology tools and telemetry to delineate Evolutionary Significant Units and Management Units for caribou. 7. Develop habitat selection models that provide quantitative and rigorous spatial mitigation strategies at regional scale.

Title: Use of Location Data to Inform Conservation of Woodland Caribou in Alberta

Principal Investigators: Fiona Schmiegelow

Graduate Student: S. Slater

Affiliated Organization: University of Alberta

Sponsoring Institutions: Alberta Sustainable Resource Development, NSERC, University of Alberta, Weyerhaeuser

Region: Alberta woodland caribou range

Research Category: Administrative

Anticipated Date of Completion: December 2012

Abstract: Woodland caribou (*Rangifer tarandus caribou*) are the most broadly distributed threatened species in Canada. In a time of increasing land use activities on many landscapes, there is a need for effective management of ecosystems to maintain biodiversity, including species at risk. Development of effective conservation initiatives for rare or threatened species requires reliable knowledge in an appropriate decision-support system. To gather such knowledge, researchers often rely on radio telemetry technology to collect animal location data. However, the sampling regime used to collect the data, the analytical technique applied, as well as variation in woodland caribou ecology can have significant effects on the results. This project is studying how inferences from common analytical techniques may be confounded by how animal location data is acquired and analysed. Using woodland caribou location data from Alberta, the strengths and limitations of different approaches are being evaluated relative to issues of spatial and temporal resolution of data, the ability to inform (or misinform) general questions of distribution and abundance, as well as more specific questions regarding habitat use and determination of critical habitat. Results from this study will support the development of standardized sampling and analysis protocols to inform conservation strategies for woodland caribou in Alberta, and in other jurisdictions across Canada.

Title: Economic Analysis of Species at Risk Recovery Plans: Integrated Assessment of Benefits and Opportunity Costs

Principal Investigators: Fiona Schmiegelow, Stan Boutin, S. Cumming, P. Boxall and M. Weber.

Graduate Student: W. Adamowicz

Affiliated Organizations/Sponsoring Institutions: University of Alberta

Region: Alberta

Research Category: Other: Economic Analysis

Anticipated Date of Completion: Unknown

Abstract: Canada's Species at Risk Act states that socio-economic costs and benefits should be identified in formulating an action plan for endangered species recovery. The incorporation of economic costs and benefits into species at risk planning helps identify recovery plan options that are cost effective and that provide net benefits to Canadians. However, the economic assessment of costs and benefits is challenging. The determination of economic benefits of endangered species in particular has been lacking. Most current assessments simply state that computation of the benefits is difficult or undefined. Many significant species at risk in Canada do not have

market values. Their value is *non-market* in nature and must be estimated using environmental valuation techniques. In addition, economic values associated with endangered species are usually not related to activities that are linked to markets (e.g. nature tourism, recreation, etc.) but are so-called *existence* or *passive use* values that rely on highly structured surveys to identify economic value. Nevertheless, in order to identify the benefits of species protection, and examine the costs of protection in terms commensurate with the benefits, measurement of the value of species protection is important for public policy analysis.

This research project attempts to identify estimates of the economic benefits of endangered species by linking two previously distinct areas of research – empirical production possibility frontier analysis and environmental valuation. Empirical production possibility frontier analysis, in this context, examines the amount of economic activity that can occur under different recovery planning options. In doing so the tradeoffs between species conservation and economic activity are identified. However, this approach only identifies the opportunity cost of alternative levels of conservation or acceptance of risk. It does not provide an assessment of the benefits of species recovery or indicate which of the set of recovery options provides the highest net benefit.

Environmental valuation, in the endangered species context, attempts to identify the public's willingness to pay for recovery plans or species conservation. These methods attempt to assess whether certain levels of cost are acceptable or not. The costs are framed in terms of direct impacts on an individual's income. The literature identifies several challenges associated with these approaches – problems that we hope to overcome by incorporating increased realism into the presentation of tradeoffs and by eliciting values in a context that recognizes that conservation targets and preferences are uncertain.

In this project we will examine the opportunity costs and benefits of Woodland Caribou recovery plans in Alberta. Woodland caribou populations across much of Canada are hypothesized to be declining because industrial development and resulting landscape disturbances have increased predation (e.g. by wolves) through simultaneous mechanisms: increased access by predators; increased populations of alternate prey species (e.g. moose) which increases the predator population; and increased spatial overlap between caribou and alternate prey which increases the frequency of interactions with predators. Woodland caribou are chosen because they are at risk in a number of Canadian jurisdictions and are particularly sensitive to industrial activity. Because the most prevalent such activities are energy exploration and forestry, the opportunity cost of caribou recovery plans are potentially very high.

This study will contribute directly to resolution of a highly visible, controversial and consequential public policy issue in Alberta and inform the ongoing land-use framework discussions that are intended to balance social, economic and ecological objectives. It will also provide an assessment of a particular approach to incorporating economic analysis into endangered species conservation that may serve as a model for other species and other jurisdictions.

Title: Development of an Agent-Based Model of Woodland Caribou Winter Habitat Selection in West-Central Alberta

Principal Investigator: Christina Semeniuk

Contributing Researchers: Danielle Marceau, Marco Musiani, Mark Hebblewhite, Scott Grindal

Affiliated Organizations/Sponsoring Institutions: University of Calgary, University of Montana, ConocoPhillips Canada

Regions: West-central Alberta, Little Smoky Region

Research Category: Basic Ecology

Anticipated Date of Completion: August 2011

Abstract: Alberta woodland caribou (*Rangifer tarandus*) are classified as threatened in Canada, and a local population in the province's Foothills Region, the Little Smoky herd, is at immediate risk of extirpation due, in part, to anthropogenic activities such as oil, gas, and forestry that have altered the ecosystem dynamics. While much is known about caribou ecology, the behavioural mechanisms by which resource-extraction industries contribute to caribou population decline are less clear. Traditional approaches to studying wildlife-human-environment interactions do not typically consider individual-level information, or integrate cross-scale and cross-discipline data and methods, and can result in a loss in predictive or explanatory power. To address these issues, we have developed a spatially explicit, agent-based model (ABM) to simulate winter habitat selection and use by woodland caribou in the face of intense land use by resource-extraction industries in west-central Alberta.

Our ABM is composed of simulated individual caribou-agents that interact with their environment. The ABM incorporates two critical ecological theories involved in habitat selection: animal movement ecology and behavioural ecology, as it is these adaptive responses of individuals to environmental conditions that give rise to population- and community-level phenomena. The overall objective of our research is to investigate how woodland caribou coexist with industrial activities within their home range in west-central Alberta. Specifically, we aim to: 1) Simulate and recreate the movement behaviours of caribou to explore how they select and use their winter habitat; 2) Determine the relative impacts of different industrial features on caribou habitat-selection strategies in winter; and 3) Build upon the first two objectives to explore how caribou spatial distribution and fitness will be altered under differing resource-extraction development and mitigation strategies. The model outputs will be evaluated and statistically tested against actual caribou movement data from the Little Smoky herd. Because the simulated caribou agents are goal driven and will make realistic, optimizing tradeoffs between factors constraining fitness such as energy reserves, resource distribution and abundance, energetic cost of movement, and predation risk and disturbance, we will gain an understanding of the processes that govern caribou movement, distribution, and selection. As a result, we will increase our ability to predict how animals might respond to habitat loss and other environmental change.

Manitoba (7)

Title: Monitoring of the Forest Tundra Ecotype Caribou of Pen Island/Cape Churchill Manitoba

Principal Investigator: Vicki Trim

Affiliated Organizations: Manitoba Conservation NE Region, Fox Lake, York Factory and Split Lake RMBs

Sponsoring Institutions: Manitoba Hydro (Transmission), ANA, NSERC, Trent University

Region: Pen Island/Cape Churchill caribou ranges

Research Category: Basic Ecology

Anticipated Date of Completion: 2014

Abstract: This study focuses on the development of conservation strategies and range specific action plans for the forest tundra ecotype caribou of Pen island/Cape Churchill. This will be a four year study beginning in February of 2010. One of our main objectives in this study is to increase communications and cooperative management with northern communities, Ontario MNR and industry. Throughout the duration of the study there will be key components being recorded and monitored in this population. Project components include: GPS collaring, summer and winter recruitment surveys, habitat mapping, and biological sample collections. Our goals are to determine pregnancy status in the sampled population and determine estimates of calf recruitment by doing seasonal recruitment surveys. We will also be monitoring for various diseases and parasites from a sample of the population. Biological samples will allow us to create a genetic profile of ranges for comparison with other ranges. By completing the habitat mapping of this population we will be able to determine their current seasonal range use, identify areas of important habitat and period of use including calving and calf rearing areas, migration corridors, rutting sites and wintering areas. We will also be able to determine habitat site selection, availability and quality on existing range and to assess any changes between current and historical range use and distribution.

Title: Anticipated Effects of Human Development, Natural Disturbances and Forest Succession on Potential Future Habitat for Woodland Caribou in the Wadowden Caribou Range

Principal Investigator: Vicki Trim

Affiliated Organizations: Northeast Region Woodland Caribou Advisory Committee, Manitoba Conservation NE Region

Sponsoring Institutions: Vale, Crowflight Minerals, HudBay Minerals Inc., Tolko, Manitoba Hydro, Special Conservation Fund, Enhancement Fund, Manitoba Conservation NE Region

Region: Wabowden boreal caribou range

Research Category: Disturbance Driven

Anticipated Date of Completion: 2012

Abstract: This study aims to identify current and potential future habitat for woodland caribou in the Wabowden caribou range based on anticipated effects of human development, natural disturbance and forest succession. To accomplish this we will start by putting GPS collars on a sample of the individuals in the population and mapping their habitat. This will allow us to assess changes between current and historical range use, determine current seasonal range and habitat use, and identify important habitat areas and fidelity to calving and calf-rearing sites, wintering areas, migration corridors and rutting sites. We will also be able to assess use or avoidance of naturally or anthropogenically disturbed areas and linear corridors. We will determine habitat type selection, availability and the quality of habitat on the existing range and between adjacent ranges. Throughout this study we will work to increase communications and cooperative resource management with local northern communities, industry and resource user groups.

Title: Habitat Selection of Woodland Caribou on a Managed Landscape: the Owl-Flintstone Range

Principal Investigator: James Schaefer

Graduate Student: Mark Basterfield

Affiliated Organizations: Trent University

Sponsoring Organizations: Trent University, Eastern Manitoba Woodland Caribou Advisory Committee, Manitoba Conservation

Region: Owl-Flintstone Range, Manitoba

Research Category: Basic Ecology

Anticipated Completion: August 2011

Abstract: The purpose of this project is to test the hypotheses that (a) summer habitat is the most limiting factor for caribou and that (b) the geographical separation that has been maintained between the spring and summer calving and post calving areas and human disturbance has allowed for the continued persistence of a caribou population at the southern limit of the caribou range in Manitoba.

Title: Validating and Refining a Calving Habitat Model for the Owl Lake Range

Principal Investigator: Rick Baydeck

Graduate Student: Daniel Dupont

Affiliated Organization: University of Manitoba

Sponsoring Organizations: University of Manitoba, Eastern Manitoba Woodland Caribou Adivory Committee, Manitoba Conservation, Habitat Stewardship Program

Region: Owl Lake Range, Manitoba

Research Category: Basic Ecology

Anticipated Completion: August 2011

Abstract: Determining used and potential calving habitat across the Owl Lake range will provide an opportunity to protect calving habitat on a managed landscape. Having collected ground vegetation data through transect surveys, a predictive calving habitat model will be attempted to be validated.

Title: Population Dynamics and Habitat Use/Availability of the Atikaki-Berens Range

Principal Investigator: Dennis Brennan

Affiliated Organizations: Eastern Manitoba Woodland Caribou Advisory Committee, Manitoba Model Forest, Manitoba Hydro, Centre for Forestry and Interdisciplinary Research (University of Winnipeg), Time to Respect Earths Ecosystems, Manitoba Trappers Association, Manitoba Floodway and Eastside Road Authority, Lac du Bonnet Game and Fish Association, Manitoba Conservation

Sponsoring Organizations: Manitoba Model Forest, Manitoba Conservation, Manitoba Hydro, Manitoba Floodway and Eastside Road Authority

Region: Atikaki-Berens Range, Manitoba

Research Category: Basic Ecology

Anticipated Date of Completion: ongoing

Project Components:

- GPS/VHF collaring
- Summer/winter recruitment surveys
- Adult female survival study
- Pregnancy rates
- Habitat use/availability modelling
- Seasonal movement patterns
- Calving habitat modelling
- Parasite/disease assessment
- Predation in calving areas

Abstract: The Atikaki-Berens range is the largest woodland caribou range in Eastern Manitoba. Since 2000, limited collaring efforts have collected some baseline data, in the southern and western portions of the range. However, little is known about caribou distribution across the northeast portion of the range. Starting in February 2011, two new projects were initiated that will provide new information about caribou movements in the northern and northeast parts of the range. These 3 year projects along with continued monitoring of collars in the southern part of the range will provide a more comprehensive understanding about habitat use/availability, population dynamics and movement patterns across a larger portion of the range.

Title: Population Dynamics and Habitat Use/Availability of the Owl Lake Range

Principal Investigator: Dennis Brennan

Affiliated Organizations: Eastern Manitoba Woodland Caribou Advisory Committee, Manitoba Model Forest, Manitoba Hydro, Centre for Forestry and Interdisciplinary Research (University of Winnipeg), Time to Respect Earths Ecosystems, Manitoba Trappers Association, Manitoba Floodway and Eastside Road Authority, Lac du Bonnet Game and Fish Association, Manitoba Conservation

Sponsoring Organizations: Manitoba Model Forest, Manitoba Conservation, Manitoba Hydro

Region: Owl Lake Range, Manitoba

Research Category: Basic Ecology

Anticipated Date of Completion: ongoing

Project Components:

- GPS/VHF collaring
- Summer/winter recruitment surveys
- Adult female survival study

- Pregnancy rates
- Population viability analysis
- Habitat use/availability modelling
- Calving habitat modelling
- Parasite/disease assessment

Abstract: The Owl Lake population exists at the southern edge of boreal caribou range in Manitoba. As such, the population was listed as a high conservation concern. Initially, the data collected across this range focused on habitat use and movement patterns. More recently, focus has been shifted to better understand the population dynamics of the Owl Lake population. While the collaring data will continue to provide data for habitat use and availability analysis, the adult female survival study, calf recruitment surveys and pregnancy rates will produce data that will be used to better understand the viability of the population.

Title: Range Alteration of Boreal Woodland Caribou due to Wildfire in West Central Manitoba

Principal Investigator: Kent Whaley

Contributing Researcher: Doug Schindler

Affiliated Organizations: Manitoba Conservation, Joro Consultants

Sponsoring Institutions: Manitoba Hydro, Manitoba Conservation, Hudson Bay Mining and Smelting Inc

Region: Manitoba

Research Category: Disturbance Driven

Anticipated Date of Completion: 2013-2015

Abstract: Manitoba Conservation identified range boundaries for a population of boreal woodland caribou in west central Manitoba through a telemetry collar project over the period 1997-2006. The area of occupation by this population is referred to as the Naosap range and a provincial action plan was in development to provide recommendations for protection of critical habitat as required by provincial policy. In June 2010, a large wildfire consumed approximately 25% of the northern extent of this range, an area used intensively by the herd and representing the core of critical habitat for the population. In anticipation of caribou displacement from the affected area over a 3-5 year horizon, *Iridium* satellite collars were equipped on 22 female caribou within or in near proximity to the fire boundary to monitor fidelity/ abandonment rates over a 5 year period. Survival of collared animals and recruitment of calves will be also monitored as will changes in range boundary arising from animal dispersal.

Ontario (5)

Title: Influence of Post-Harvest Silviculture on Understory Vegetation in Northwestern Ontario: Implications for Moose Forage and Woodland Caribou.

Principal Investigators: Brian. E. McLaren, J.R. Malcolm

Graduate Student: Julee J. Boan

Affiliated Organizations: Lake University, University of Toronto

Sponsoring Institutions: Ontario Ministry of Natural Resources Species at Risk Stewardship Fund, Natural Sciences and Engineering Research Council, AbitibiBowater Inc., Ontario Nature, Wildlife Conservation Society Canada

Region: Northwestern Ontario

Research Category: Disturbance Driven

Anticipated date of completion: August 2011

Abstract: The range of woodland caribou in northern Ontario, Canada has receded considerably over the past century, and a proposed contributing cause is higher predation brought about by increases in moose and white-tailed deer populations attracted to early successional, forage-rich forests associated with timber harvesting. Research has shown that woodland caribou use habitats that spatially and temporally separate them from other ungulates and their predators. Aggregation of harvesting and roads is proposed as a management strategy to ensure woodland caribou can maintain this predator avoidance strategy. However, evaluation of the impact of different post-harvest silvicultural approaches in regenerating vegetation that supports ungulate separation is lacking. We studied understory vegetation at 10 and 30 years after disturbance in conifer-dominated forests in the English River and Caribou forest management units, as well as parts of Wabakimi Provincial Park, in northwestern Ontario. Treatments included: (1) natural post-fire regeneration, (2) natural post-harvest regeneration (including seed tree retention), and (3) intensive regeneration (planted, herbicide-sprayed, or both). We hypothesized that harvesting would increase forage availability for moose and white-tailed deer in the short and medium terms when compared to similar-aged fire-origin sites. Trees, shrubs and herbaceous vegetation and soils were sampled in three plots in each of 20 stands per treatment (n = 360). Using non-metric multidimensional scaling (NMS), we found that abundance of hardwoods, shrubs, and herbaceous plants was greater in natural post-harvest sites than fire-origin and intensive post-harvest sites at both 10 and 30 years post-disturbance. We compared direct lines of sight through the understory and found significantly shorter lines in the intensive treatment compared to the two natural treatments in 10-year-old sites, but the opposite in 30-year-old sites. When pooled, 30-year-old sites had significantly greater lines of sight than 10-year-old sites. In spite of increased forage abundance in post-harvest, regenerating sites, we did not find these sites to be significantly associated with moose use, based on pellet counts. This study suggests that post-harvest silviculture can influence a sites' suitability for ungulates, but management considerations in vegetation regeneration need to occur at a scale greater than the stand level.

Title: Movements of Caribou in the James Bay Lowlands

Principal Investigators: Megan Hazell, Mark Taylor

Contributing Researchers: Dave Simms

Affiliated Organizations: AMEC Earth and Environmental

Sponsoring Institutions: DeBeers Canada

Regions: James Bay Lowlands

Research Category: Disturbance Driven

Anticipated date of project completion: 2001 – ongoing

Abstract: Little is known about the movements and home range of boreal woodland caribou (*Rangifer tarandus*) in the James Bay lowlands, northern Ontario. Our study was initiated as part of the Victor Diamond Project Environmental Assessment process and will be continued during the operation and closure phases of the Victor Mine. Our research is focused on the use of GPS collars with Argos satellite system uplink to monitor movements of caribou to characterize seasonality in movement rates and habitat use as well as information from Attawapiskat First Nations including tissue sampling and subsistence hunting.

This data is used to assess potential interactions between mine activities and local caribou behavior as well as provide detailed baseline information on caribou for this region of Ontario. We have investigated site fidelity of calving and over-wintering areas, seasonality in movement rates, spatial distribution and dynamics in the selection and home ranges, calving and over – wintering areas and habitat characteristics of preferred areas. The caribou in the James Bay lowlands tend to display behaviours that are characteristic of both the forest-tundra and forest-forest ecotypes.

Title: Demography of Ontario Woodland Caribou in Relation to Predation Risk and Landscape Disturbance

Principal Investigators: John Fryxell, Ed Iwachewski, Ian Thompson, Brent Patterson, Art Rodgers, Jim Baker, Glen Brown, Ajith Perera, Bruce Pond, Merritt Turetsky, Steve Newmaster.

Graduate Students and Postdoctoral Fellows: Anna Mosser, Tal Avgar, Morgan Anderson, Scott Moffatt, Neil Webster, Robin Kucyk

Affiliated Organizations: University of Guelph, Ontario Ministry of Natural Resources, Canadian Forest Service, Ontario Forest Research Institute, Lakehead University

Sponsoring Institutions: Forest Ecosystem Science Cooperative Inc, NSERC CRD program, NSERC Strategic Grant Program, NSERC Fellowship Program, Canadian Forest Service, Ontario Ministry of Natural Resources

Region: Pickle Lake, Auden, and Cochrane regions of Ontario. Each site is ~20,000 km^2 in size

Research Category: Predator/Prey

Date of completion: December 2014

Abstract: Forest-dwelling caribou have experienced declining abundance and range retraction throughout large parts of the boreal zone in Ontario, resulting in the designation of woodland caribou as “threatened” under the Endangered Species Act in Ontario and nationally under the

federal Species at Risk Act. Anthropogenic landscape disturbances have been suggested as the primary cause of declining caribou in Ontario, mirroring patterns seen in other parts of the country. There are multiple interests' in future economic development within and north of the current limit for commercial forestry activities in Ontario (termed the AOU). Potential economic development activities in northern Ontario are likely to involve roads, forestry, mining, and hydro development, all of which could potentially influence persistence of woodland caribou, through habitat alteration.

A key uncertainty is how much habitat is enough to manage caribou extinction risk at an acceptable level. Population Viability Analysis, hereafter termed PVA, can be very useful in estimating how extinction risk should vary in relation to habitat composition at the landscape scale over time horizons that are meaningful for resource managers. By identifying complex ecological linkages and trade-offs between habitat-based factors influencing demographic rates, the risk of extinction can be reduced to tolerable levels when balanced against other land uses. For the most reliable application, however, PVA models require system-specific estimates of parameters for key processes.

We propose to test the effects of forest successional stage, source of forest disturbance, road density, and densities of predators and other herbivores on the rate of energy gain, predation risk, movement rate, patterns of habitat association, and vital rates for woodland caribou equipped with GPS radio-collars in 3 large (22,500 km^2) landscapes in northern Ontario. The proposed field study has the following specific objectives:

- Use GPS radio-telemetry data for 150 woodland caribou and 36 wolves to determine patterns of movement, home range use, predation risk, survival, and offspring recruitment.
- Develop mechanistic movement models for woodland caribou and wolves on the basis of energy gain and predation risk.
- Use mechanistic movement models from ½ the radio-telemetry data to predict patterns of home range use, habitat selection, and predation risk and test those predictions against field observations from the other ½ of the data.
- Test the effects of forest stand composition, forest source of origin (fire vs. harvesting), food plant availability, road density, herbivore density, and carnivore density on caribou diet, net energy gain, survival and offspring recruitment.
- Link the movement, energy-gain, predation risk, and vital rates sub-models with a spatially-explicit population viability model for woodland caribou (already funded by NSERC Strategic Grant STGP 380926-09).
- Use the PVA model to predict the long-term effect of competitor density, predator density, road density and forest disturbance from natural and anthropogenic causes on the probability of population persistence by woodland caribou and the potential caribou response to alternative management policies available to the government of Ontario.

The resultant PVA model will be used to assess the effectiveness of alternate policies for land use and wildlife management. This model is an essential element in the adaptive management framework proposed in the recently tabled conservation plan for woodland caribou in Ontario as well as helping to resolve the critical habitat needs for woodland caribou across Canada.

Title: Using Caribou Fecal DNA to Characterize the Genetic Relationships among Caribou of the Boreal Forest

Principal Investigators: Paul Wilson, Micheline Manseau

Contributing Researchers and Postdoctoral Fellows: Mark Ball, Laura Finnegan, Bruce Pond, Ken Abraham, Glen Brown, Neil Arnason, Robert Weladji, Doug Schindler, Fiona Sccurah, Dale Cross, Vicki Trim, Kent Whaley, Darryl Hedman, Tim Trottier, Al Arsenault, Mark Bradley

Graduate Students: Paul Galpern, Laura Thompson, Karen Smith, Michael Hurley, Pete Hettinga

Affiliated Organizations: Trent University, University of Manitoba, Parks Canada, Government of Alberta, Ontario Ministry of Natural Resources, Concordia University, Manitoba Hydro, Manitoba Conservation, Saskatchewan Environment

Sponsoring Institutions: NSERC, Canadian Research Chair, Manitoba Hydro, Manitoba Department of Conservation, Ontario Ministry of Natural Resources, Parks Canada, University of Manitoba, Trent University

Region: Boreal forest from Ontario to Saskatchewan, Northern Ontario and Manitoba, specifically areas occupied by the tundra ecotype Jasper National Park

Research Category: Genetic

Anticipated Date of Completion: Research On-going

Abstract: The listing of boreal caribou as a Threatened species under the Species at Risk Act (SARA) (2007) has required federal, provincial and territorial governments to develop a recovery strategy for the species. To support conservation initiatives and assist industry in their monitoring obligations, we have advanced a research program based on the non-invasive sampling of caribou fecal DNA and developed techniques allowing us to delineate genetic populations and demographic herds, to assess the level of landscape connectivity among these units, and to develop a toolkit for monitoring population sizes and survival through time. The use of non-invasive sampling and genetic profiling, specifically DNA from winter-collected fecal pellets, has allowed us to monitor different subspecies, ecotypes and populations at different scales. More specifically, we are currently characterizing the genetic relationships among the caribou of the boreal forest and investigating the effect of potential changes in habitat type or fragmentation on natural gene flow using a range of landscape genetic approaches at broad- and fine-scales. We are also addressing the question of boreal caribou ecotypes using these data. Two ecotypes of caribou occur in the boreal forest: 1) the dispersed calving ecotype occurs in the forest year round; and 2) the aggregated calving ecotype that only spend their winter range in that area, with summer migrations to the Hudson Bay coast. Currently only the dispersed calving ecotype is protected under SARA legislation, however, delineation between these two ecotypes, and so protection status of specific caribou, is important due to increasing mining and anthropogenic activities in the north. We are applying mitochondrial sequencing and genomics in combination with nuclear microsatellite data to assess the differences among ecotypes. We are assessing whether the ecotype behavior is 'hard-wired' or changeable from year-to-year and to estimate levels of gene flow between ecotypes. We will use this data to determine whether these ecotypes can be separated geographically, and, if this is the case, where this line occurs.

Title: Monitoring Boreal Forest Caribou Occupancy in Large and Remote Areas: Maximizing Detectability and Survey Efficiency

Principal Investigators: Justina C. Ray, Bruce A. Pond, Devin S. Johnson

Contributing Researchers: Glen Brown, James Schaefer

Affiliated Organizations: Wildlife Conservation Society Canada, Ontario Ministry of Natural Resources, National Oceanic and Atmospheric Association National Marine Mammal Laboratory, Trent University

Sponsoring Institutions: Ontario Ministry of Natural Resources, Wildlife Conservation Society Canada, Limited Brand

Region: Far North of Ontario

Research Category: Other: Techniques/Methodology

Anticipated Date of Completion: late 2011

Abstract: A linchpin of wildlife conservation and adaptive management is the ability to monitor populations and assess the effectiveness of management actions. In the case of boreal forest caribou, we are handicapped by a lack of cost-effective means for broad-scale population monitoring. Obtaining information on population dynamics of this species is only feasible in relatively small areas; however, accurate knowledge of caribou distribution, probability of occurrence and identification of core areas (and their changes over time), can serve as practical indicators of boreal caribou recovery. We are developing techniques that estimate area and distribution of winter occupancy over large geographical extents using aerial surveys of tracks in snow and hierarchical spatial modelling. Surveys undertaken from 2008-2010 in a 7 million ha area in northern Ontario by two types of fixed-wing airplanes are allowing for comparisons of various co-varieties, e.g. speed, altitude, time of day and land cover type, to gain an understanding of what extrinsic and intrinsic factors influence detectability. Simulated reductions in survey effort are yielding further results to inform design of future surveys and monitoring programs to maximize efficiency and the ability to detect changes in caribou occupancy parameters over time. This project will also produce an R-package for estimation of probability of occurrence and of accompanying standard errors of estimate to be applied to the observations from past and future surveys for caribou, wolverine, and additionally wolves and moose undertaken in Ontario. This will permit statistically valid, repeatable estimation of geographically referenced probabilities of occurrence of these species and over the long term offer the possibility of monitoring change in the geographic range of these species.

Quebec (24)

Title: Population Dynamics of Migratory Caribou in Northern Quebec and Labrador in the Context of Climate Change

Principal Investigators: Steeve D. Côté, Marco Festa-Bianchet, Christian Dussault, Jean-Pierre Tremblay

Graduate Students and Post Doctoral Fellow: Joelle Taillon, Mael Le Corre, Emilie Champagne, Melanie Pachkowski, Glenn Yannic

Organization: University Laval, Ministry of Natural Resources and Wildlife/UQAR

Sponsoring Institutions: NSERC/CRSNG; Ressources Naturelles et Faune Quebec; ArcticNet; Fonds de recherché sure la nature et les technologies Quebec; Hydo Quebec; XSTRATA nickel; FPO Federation des pourvoiries du Quebec Inc; Federation quebecoise des chasseurs et pecheurs; FIRST AIR The Airline of the North; Societe Makivik/Makivik Corp; CircumArctic Rangifer Monitoring and Assessment Network (CARMA); International Polar Year; Canada Foundation for Innovation; Institute for Environmental Monitoring and Research; Fondation de la faune du Quebec; OURANOS

Region: Nunavik and Nunatsiavut

Research Category: Basic Ecology

Anticipated Date of Completion: 2014 for phase 1

Abstract: The aim of our research program is to identify the factors influencing population dynamics and space use by migratory caribou in a context of climate change. With our partners, we seek to understand what factors influence variations in caribou abundance to improve the management of their populations and to understand the impacts of industrial activities on their ecology. Caribou play a central role in the ecology of the North, where it is at the heart of the culture and the economy. In Québec, sport hunting for caribou each year generates $30 million in revenues. The subsistence harvest is very important for the Aboriginal people. The limited knowledge of caribou population dynamics and of the impacts of industrial activities, notably hydroelectric and mining developments, makes the management of this population problematic. Population numbers have varied dramatically in the past and the effects of climate change are unpredictable. We are documenting the spatial, demographic and genetic structure of the two herds of Northern Québec and Labrador. Our approach involves monitoring cohorts of caribou of known age and the analysis of existing data. We quantify the reproductive success and survival of radio-collared animals and identify which variables have the greatest influence on the dynamics of the populations and on the annual changes in migration routes and location of calving grounds. Our study is measuring how caribou and climate affect the vegetation, and documents the interactions between industrial activities, climate, habitat productivity and space use by caribou. The knowledge acquired will allow a sound management of caribou and help understand the impacts of climate change and artificial disturbances on this species.

Title: Variation in Seasonal Onset Behaviour and Potential Consequences for Studies of Seasonal Habitat Selection

Principal Investigator: Pierre Drapeau

Contributing Researcher: Vincent Brodeur

Graduate Student: Tyler Rudolph

Affiliated Organizations: University of Québec Montréal, Ministry of Natural Resources and Wildlife (Ministère des Ressources naturelles et de la Faune)

Sponsoring Institutions: FQRNT – Partnership in Environmental Management and Forestry, Ministry of Natural Resources and Wildlife of Quebec (Partenariats en aménagement et environnement forestiers, Ministère des ressources naturelles et de la faune (MNRF) du Québec)

Regions: The study area comprises a 109,116 km^2 tract of boreal forest in northern Quebec situated between 49°52’ and 51°46’ N and 71°17’ and 79°31’ W.

Research Category: Basic Ecology

Anticipated date of completion: January 2011 – Thesis is under evaluation

Abstract: The biology of terrestrial mammals is strongly influenced by seasonal changes in environmental conditions. Studies of animal space use behaviour are therefore inherently seasonal in nature. We develop an individual-based quantitative method for identifying seasonal shifts in caribou movement behaviour and we demonstrate its use in determining the onset of the winter, spring dispersal, and calving seasons. Using pooled data for the population we demonstrate an alternate approach using polynomial regression with mixed effects. We then compare the onset dates obtained using the individual-based method with a) those estimated using the population-based model and finally b) those adopted by expert consensus for our study area. Distributions of individual-based onset dates were normally distributed with prominent modes. However results revealed considerable variation in individual onset times even for calving which varied the least. Population-based estimates were closer to the peaks of individual estimates than were expert-based estimates, which fell outside the 90 % and 95% sample confidence intervals of individual-based estimates for spring and winter, respectively. Both expert- and population-based estimates were late for winter and early for both spring and calving. We discuss the potential consequences of neglecting to corroborate conventionally used dates with observed seasonal trends in the movement behaviour of sample animals. We conclude by recommending researchers adopt an individual-based quantitative approach and a variable temporal window for data set extraction.

Title: Spring dispersal and habitat selection of boreal caribou in northern Quebec

Principal Investigators: Pierre Drapeau

Contributing Researcher: Vincent Brodeur

Graduate Student: Tyler Rudolph

Affiliated Orgainzations : University of Québec Montréal, Ministry of Natural Resources and Wildlife (Ministère des Ressources naturelles et de la Faune)

Sponsoring Institutions: FQRNT – Partnership in Environmental Management and Forestry, Ministry of Natural Resources and Wildlife of Quebec (Partenariats en aménagement et environnement forestiers, Ministère des ressources naturelles et de la faune (MNRF) du Québec)

Regions: The study area comprises a 109,116 km^2 tract of boreal forest in northern Quebec situated between 49°52’ and 51°46’ N and 71°17’ and 79°31’ W.

Research Category: Disturbance Driven

Anticipated date of completion: January 2011 – Thesis is under evaluation

Abstract: While much is presently known about caribou space use behaviour during the winter and calving periods, relatively little is known about migratory phases of its annual life cycle. We investigate spring movement parameters and habitat selection of boreal caribou. Individual movements were directional overall but there was no predominant direction at the population level. There was little interannual overlap in travel routes used although caribou did exhibit fidelity to traditional calving site locations. Caribou traveling within 30 km on average of highly roaded areas (> 0.5 km/km^2) were more likely to circle about extensively with little net displacement (i.e. random movements), whereas caribou beyond the 30 km threshold were more likely to exhibit quasi-linear (i.e. directed) movements. This indicates that roads may represent semi-permeable barriers to caribou dispersal. Second, we use a Brownian bridge movement

model to estimate the probability of occurrence of boreal caribou during spring dispersal and conducted linear regression with mixed effects to estimate a Resource Selection Probability Function. Caribou space-use patterns revealed trade-offs between optimal foraging, predator avoidance and energy conservation. In general caribou stayed close to waterways when they were within 500m and were slightly less likely to be found at higher elevations. Caribou selected lichen woodlands and all forms of wetlands, particularly herb-dominated, and they were less likely to be found in zones of higher road and cut-block densities. This being said caribou were less selective during spring dispersal that they are known to be at other times of the year. Our primary recommendation for forest management is to reduce harvesting and road network development in areas still occupied by caribou. Where harvesting is permitted we recommend partial or selective cutting with permanent retention using temporary winter roads. Road deactivation and rehabilitation is of critical importance in conserving caribou on managed landscapes.

Title: Caribou Responses to the Loss and Fragmentation of the Boreal Forest and the Permanent Anthropogenic Structures

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Christian Dussault, Jean-Pierre Ouellet, Claude Dussault, Réhaume Courtois, Daniel Fortin

Affiliated Organizations: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, Université Laval

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Fondation de la faune du Québec, Canada Economic Development, Québec Forest Industry Council, Essipit First Nation, Aboriginal Funds for Species at Risk (Environment Canada)

Region: Quebec

Research Category: Disturbance Driven

Anticipated date of completion: 2011

Abstract: The objective of this study is to better understand, at a macroscopic level, how the loss and fragmentation of mature canopy and the permanent anthropogenic disturbances (e.g. roads, cottages) impact how forest-dwelling caribou uses their environment in dispersed cut stands. We studied the spatial use patterns of forest-dwelling caribou herds in three separate areas of the Quebec boreal forest (Charlevoix, Saguenay and Lac Saint-Jean) along a decreasing south-to-north forest management intensity gradient. Thirty-four (34) females were surveyed by GPS telemetry between 2004 and 2006, and the data collected were linked to forest ecosystem maps from the Quebec Ministry of Natural Resources and Fauna (*Ministère des Ressources naturelles et de la Faune du Québec*). The positions of each caribou were compared to random points that were homogeneously distributed within the animal's home ranges. For each point, variables such as topography (e.g. altitude, slope), density (e.g. clearcut edges, buildings, roads), distance to various attributes on the forest ecosystem map (e.g. clearcut edges, lake), and habitat proportion (e.g. clearcuts, mature forests, lichen tundra hereinafter referred to as "dry barren area") were extracted from the forest ecosystem map. The available data on the variables were then grouped in four categories ("Natural", "Loss", "Fragmentation", "Permanent Structures") and candidate conditional logistic regression models were assessed using the BIC criterion to determine which

ones were the most parsimonious on a seasonal basis (spring: April 15 to May 15; calving: May 21 to June 20; summer: June 21 to September 14; rutting: September 15 to October 30; winter: November 1 to April 14).

Title: The Impact of the Managed Forest on the Long Term Stress Response of the Forest-Dwelling Caribou

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Christian Dussault, Jean-Pierre Ouellet, Claude Dussault, François Vézina, Fanie Pelletier

Graduate Student: Limoilou-Amélie Renaud

Affiliated Organizations: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, Université de Sherbrooke

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Fondation de la faune du Québec, Canada Economic Development, Québec Forest Industry Council, Essipit First Nation, Aboriginal Funds for Species at Risk (Environment Canada) , Hydro-Québec

Region: Quebec

Research Category: Disturbance Driven

Anticipated date of completion: 2012

Abstract: The management of the boreal forest results in habitat changes in several ways, including forest rejuvenation, increased access to the land for road building and increased cottage development. For the forest-dwelling caribou (*Rangifer tarandus caribou*), these disturbances can induce responses at both the population level and individual level, i.e. at a finer scale. Our study proposes to explore the response of the forest-dwelling caribou at a fine scale, i.e. at the physiological level, in order to improve our understanding of the mechanisms that link habitat use to caribou condition within a managed landscape. To do so, we are studying the stress response, i.e. the cascade of physiological changes that allow an animal to cope with a source of stress linked to an unpredictable stimulus. This cascade of changes results in the secretion of glucocorticoids, in particular cortisol, a stress-related hormone used as an indicator of stress in mammals. It is accepted in the literature that a stress response maintained over a long period of time can adversely affect an animal's energy reserves and inhibit the activities needed to maintain its physical condition. The primary objective of this study is to compare the average cortisol levels in four herds of forest-dwelling caribou. A second objective is to link the levels of cortisol to the habitat characteristics found within a caribou's home range. Our research hypothesis is that the levels of disturbances are linked to the intensity of the stress exerted on the caribou on a long term basis. The study is taking place in four regions of the Province of Quebec, i.e. North Shore, Charlevoix, Saguenay and Lac Saint-Jean, four areas located along a south-to-north gradient of anthropogenic disturbances that become less marked as the study moves from the south (Charlevoix) to the north (Lac Saint-Jean). A total of 169 caribous were sampled by MRNF, UQAR and Hydro-Québec teams in connection with the monitoring of four caribou herds between 2004 and today.

Title: Influence of Different Barrier Types on the Use of Landscapes by Forest-Dwelling Caribou

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Jochen A.G. Jaeger, Jean-Pierre Ouellet, Claude Dussault

Graduate Student: David Beauchesne

Affiliated Organizations: Université du Québec à Rimouski, Concordia University, Ministère des Ressources naturelles et de la Faune

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Natural Sciences and Engineering Research Council of Canada, Fondation de la faune du Québec, Canada Economic Development, Québec Forest Industry Council, Essipit First Nation, Aboriginal Funds for Species at Risk (Environment Canada)

Region: Quebec

Research Category: Disturbance Driven

Anticipated date of completion: 2012

Abstract: The objective of the study is to show how various anthropogenic and natural barriers can affect the movement patterns of the caribou in the boreal forest. The study will take place in the Saguenay – Lac St-Jean region, in an area that has a strong north-to-south gradient of anthropogenic disturbance. Approximately 80 females were monitored with a GPS collar between 2004 and 2010. The data on their positions will be used to estimate their seasonal home ranges using Minimum Convex Polygons, which will include all points (100% MCP), and to conduct movement patterns analyses. The animals were monitored during the spring season (April 15 – May 14), the calving period (May 15 – June 14), the summer season (June 15 – September 14), the rutting period (September 15 – November 14), the beginning of winter (November 15 – February 21) and the end of winter (February 22 – April 14). The density (km/km^2) was calculated for three groups of variables: “Roads” (i.e. primary, secondary, tertiary, quaternary and winter roads), “Clearcut Edges” and “Natural Borders” (i.e. streams and natural disturbances). Candidate models will be selected to determine habitat characteristics and anthropogenic barriers that have the greatest influence on caribou home range size and that influence animal movements in a managed boreal forest at a fine scale.

Title: Assessment of the Forest-Dwelling Caribou Habitat Management Strategy: Factors Underlying the Use of Residual Forest Masses

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Jean-Pierre Ouellet, Claude Dussault

Graduate Student: Rémi Lesmerises

Affiliated Organizations: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Fondation de la faune du Québec,

Canada Economic Development, Québec Forest Industry Council, Essipit First Nation, Aboriginal Funds for Species at Risk (Environment Canada)

Region: Quebec

Research Category: Administrative

Anticipated date of completion: 2011

Abstract: The objective of this study is to better understand the factors underlying the use of residual forest masses by forest-dwelling caribou, in terms of probability of occurrence and use intensity, in order to assess the effectiveness of the forest-dwelling caribou habitat management strategy supported by the Province of Quebec, which favours maintaining protected and replacement masses of forest of 50 to 250 km^2. Our team tracked a number of forest-dwelling caribou by GPS telemetry between 2004 and 2010 in a northern area of the Saguenay – Lac St-Jean region. The boundaries of residual masses of mature forest stands (all species) at the scale of our study were defined by eliminating linear strips of forests that had a width of less than 120 m, which resulted in masses of between 4 and 72,000 ha. We tracked 11 to 26 females per year by telemetry to determine whether the animal was absent or present (occurrence) in a forest mass as well as the number of times it occupied the mass. In order to determine how the surrounding landscape influenced the use of a forest mass, the proportion (or density) of several types of habitat and anthropogenic structures was calculated within several buffer zones (radius varying from 100 to 7,500 m) around each mass. The most representative radius was then used to model the occurrence and use intensity of various forest masses on a seasonal basis (i.e. spring, calving, summer, rutting and winter).

Title: Assessing Terrestrial Lichen Biomass Using Ecoforest Maps: A Useful Decision-Making Tool in the Conservation of the Forest-Dwelling Caribou Habitat

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Jean-Pierre Ouellet

Graduate Student: Rémi Lesmerises

Affiliated Organizations: Université du Québec à Rimouski

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean

Region: Quebec

Research Category: Basic Ecology

Anticipated date of completion: 2011

Abstract: Terrestrial lichens are an important part of the winter diet of forest-dwelling caribou (*Rangifer tarandus caribou*; Gmelin 1788), and developing forest management guidelines to support high lichen biomass could enhance both individual- and population-level health of this threatened species. Our objective was to develop an index to assess terrestrial lichen biomass available to caribou at the landscape scale using ecoforest maps based on forest characteristics (age, density, and height) and geographical variables (slope, altitude, and latitude). We sampled 439 sites within 8340 km^2 of the spruce–moss domain located >100 km north of the Saguenay River (Quebec, Canada). Since they are known to support terrestrial lichen, we sampled only

spruce-dominated stands older than 50 years, representing 41.8% of the study area. Using a two-step approach, we first modeled lichen occurrence and thereafter lichen biomass in sites where lichens were found. Lichen occurrence was positively correlated with latitude but negatively with stand age, height, and density. Lichen biomass was primarily a function of altitude and tree density. Using this index could prioritize conservation of areas that are most likely to contain high lichen biomass, thus favoring caribou population maintenance in logged landscapes.

Title: The Impact of Land-Use Planning on the Survival of Forest-Dwelling Caribou Calves

Principal Investigators: Martin-Hugues St-Laurent, Christian Dussault

Contributing Researchers: Jean-Pierre Ouellet, Claude Dussault, Jochen Jaeger

Graduate Student: Martin Leclerc

Affiliated Organizations: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, Concordia University

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean

Region: Quebec

Research Category: Predator/Prey

Anticipated date of completion: 2012

Abstract: The objective of this study is to understand the impact of land-use planning on habitat selection and calf survival in the range of the forest-dwelling caribou. This will be done by studying the links between female caribou habitat selection and calf survival. More specifically, the study will measure survival rates, determine the main causes of death, characterize the calving sites at two spatial scales (home range and micro-habitat) and identify the habitat selection patterns that are most suitable to calf survival. This study will include capturing a group of female caribou and their calves in a northern area of Saguenay – Lac St-Jean, then tracking them by telemetry from calving to the end of summer, i.e. the period when the calves are the most vulnerable. It will also include land surveys and GIS analysis at several scales. This study will allow us to identify the best strategies for successful caribou reproduction in a managed forest environment. The results of this study will provide guidance to forest managers not only on the conservation of the habitats selected by the caribou, but also on the conservation of the habitats where survival is optimal.

Title: Function Responses of the Forest-Dwelling Caribou to Landscape Alteration: Behavioural Variability and Demographic Implications

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Christian Dussault, Jean-Pierre Ouellet, Claude Dussault, Jochen Jaeger

Graduate Student: **(**to be determined, start date is September 1st, 2011)

Affiliated Organizations: Université du Québec à Rimouski , Ministère des Ressources naturelles et de la Faune, Concordia University

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Fondation de la faune du Québec, Canada Economic Development, Québec Forest Industry Council, Essipit First Nation, Aboriginal Funds for Species at Risk (Environment Canada)

Region: Quebec

Research Category: Basic Ecology

Anticipated date of completion: 2015

Abstract: The objective of this project is to improve our knowledge on the links between spatial use patterns and habitat selection (and subsequent demographics) at several spatiotemporal scales, while taking into account the inherent variability of individuals, herds and populations. The preliminary objectives of this project are 1) to better understand and characterize the functional responses of forest-dwelling caribou to habitat heterogeneity and to model the demographic implications using behaviour at different spatial, temporal and biological scales and 2) to simulate long term responses to various disturbance patterns in the forest environment in order to establish the most favourable scenarios to caribou conservation. We are currently studying two herds of caribou in Saguenay – Lac St-Jean since 2004 and have collected a significant amount of telemetry locations on ~80 adult females (GPA collars) and ~30 calves (VHF collars) along a gradient of natural and anthropogenic disturbances.

Title: The Impact of the Managed Forest on Black Bear in Terms of Abundance, Spatial Use Patterns and Habitat Selection: The Implications on the Survival of the Forest-Dwelling Caribou in Saguenay-Lac-Saint-Jean

Principal Investigator: Martin-Hugues St-Laurent

Contributing Researchers: Jean-Pierre Ouellet, Claude Dussault, Jochen Jaeger

Graduate Students: Rémi Lesmerises, Christine Chicoine

Affiliated Organizations: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, Concordia University

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Natural Sciences and Engineering Research Council of Canada

Region: Quebec

Research Category: Predator/Prey

Anticipated date of completion: 2013 (MSc) and 2015 (PhD)

Abstract: It is becoming increasingly evident that caribou conservation is linked to a better understanding of its predators' ecology and a better understanding of how the managed forest impacts these predators in terms of habitat selection, spatial use and population dynamics. Our team has started to document these three aspects of forest-dwelling caribou ecology in Saguenay – Lac St-Jean, in a forest area that has been managed using new harvesting techniques. Our research on calf survival has shown that black bear is the main predator and is a deterrent to herd recruitment in a managed forest. However, we still need to better understand the impact of these

new management approaches on the ecology of the black bear. The objectives of this project are as follows: to characterize black bear habitat selection and spatial use patterns at various spatial and temporal scales in the continuous range of the forest-dwelling caribou; to characterize black bear response to various types of anthropogenic structures (e.g. logging activities, roads, buildings and power lines); to model the black bear's response to various spatiotemporal harvest patterns (including the forest management strategy supported by the Province of Quebec) in order to propose forest management strategies that are unfavourable to the black bear but compatible with the needs of the caribou; and finally, to improve our techniques on how to estimate black bear density in the boreal forest using CMR-hair genotyping. The project will make use of the data collected by our team by telemetry on 80 female caribou and 30 calves in Saguenay – Lac St-Jean between 2004 and 2011. We will also install GPS/Argos satellite collars on 24 bears (target : 12 males and 12 females) in a study area that provides a good representation of cuts with regeneration and soil protection, partial cuts and various configurations and sizes of residual forests, including 19 caribou protected blocks (100-250 km^2).

Title: Monitoring Program of Woodland Caribou in Hydro-Québec's Hydroelectric Development Complexe de la Romaine (North Shore, Québec)

Principal Investigators: Alexandre Beauchemin, Marie-Claude Richer

Contributing Researchers: Yves Leblanc, Serge Couturier

Affiliated Organization/Sponsoring Institution: Hydro-Québec

Region: Romaine River, North Shore of Québec

Research Category: Disturbance Driven

Anticipated Date of Completion: 2025

Abstract: Woodland caribou of the forest-dwelling ecotype is recognized as an animal sensitive to disturbances. Industrial developments located in caribou habitat thus have the potential to affect this species and particular efforts must be made to understand their effects on caribou in order to better design future projects and mitigation measures. The construction of the Complexe de la Romaine hydroelectric project on the Romaine River on the North Shore of Québec started in 2009. The project development includes four generating facilities with a combined power of 1550 MW (8.0 TWh of total annual production), four reservoirs of 279 km^2 total surface area and a 150 km access road. In addition to the generation project, four sub-stations and two power lines (500 km total length) will be built. The construction period will span from 2009 to 2020. Given the presence of woodland caribou in the project area, Hydro-Québec launched an important monitoring program for this species in 2009.

The monitoring program has three main objectives: 1) evaluate the effects of construction and operation of the Complexe de la Romaine and its power lines on caribou, 2) evaluate the potential cumulative effects on caribou and 3) determine habitat use by caribou. The program will span from 2009 to 2025, enabling data collection before, during and after the project completion. Two methods will be used to gather data: aerial winter surveys every three years until 2025 (started in March 2009) and a telemetry study for a 10-year period (started in March 2009). An additional study estimating availability of lichen biomass and winter habitat carrying capacity has also been conducted in 2009.

In addition to a better understanding of the effects of hydroelectric development on caribou, the results of the monitoring program are being used to identify areas of special interest for woodland

caribou. Hydro-Québec, as much as possible, will then try to avoid implementing project infrastructures within identified areas of special interest. The results of the monitoring program are also being used to design and implement appropriate mitigation measures for woodland caribou.

Title: Woodland Caribou's Functional Response to Habitat Selection in a Managed Boreal Forest

Principal Investigators: Daniel Fortin, Serge Couturier

Contributing Researcher: Thierry Duchesne

Graduate Student: Guillaume Moreau

Affiliated Organizations: Université Laval, Ministère des Ressources naturelles et Faune du Québec

Sponsoring Institutions: National Sciences and Engineering Research Council of Canada, University Laval, AbitibiBowater, Ministère des Ressources naturelles et Faune du Québec (MNRF), Forintek Canada, Feric, Boisaco, Arbec, CRÉ – Côte-Nord, Rémabec, Cégep de Baie-Comeau, FPInnovations, CEDFOB, Natural Resources Canada, Essipit Community, Fondation de la faune du Québec

Region: Quebec's North Shore

Research Category: Disturbance Driven

Anticipated Date of Completion: This research project will end in 2011.

Abstract: In the boreal forest, both the forest industry and woodland caribou look for dense and mature conifer stands. In order to understand to what extent it is possible to harvest trees and still maintain the caribou populations, it is essential to document the factors that affect the spatial distribution of this large mammal. Habitat selection is one of the main processes that influence the spatial distribution of animals. Most studies assume that habitat selection remains the same, despite changes in the availability of various components in the habitat. In reality, an increasing number of studies show that some species change their preference based on the composition of their environment, a behavioural plasticity called functional response. The objective of our project is to determine whether the abundance of logging activities and forest roads on Quebec's North Shore generates a functional response by the caribou in the selection of dense and mature conifer stands.

Title: The Impact of Managing the Woodland Caribou's Habitat on the Biodiversity of the Boreal Forest

Principal Investigators: Daniel Fortin

Contributing Researchers: Christian Hébert and Serge Couturier

Graduate Student: Orphé Bichet

Affiliated Organizations: University Laval, Laurentian Forestry Centre, Natural Resources Canada and ministère des Ressources naturelles et Faune du Québec

Sponsoring Institutions: National Sciences and Engineering Research Council of Canada, University Laval, Abitibi-Bowater, Ministère des Ressources naturelles et de la Faune du Québec, Forintek Canada, Feric, Boisaco, Arbec, CRÉ – Côte-Nord, Rémabec, Cégep de Baie-Comeau, FPInnovations, CEDFOB, Natural Resources Canada, Essipit Community, Fondation de la faune du Québec

Region: Quebec's North Slope

Research Category: Disturbance Driven

Anticipated Date of Completion: This research project will end in 2012.

Abstract: Because the woodland caribou is listed as a vulnerable species since 2005, a recovery plan has been proposed for the species. The forest managed according to this plan will inevitably have an impact on several species found in the areas where the plan is implemented. Nevertheless, the focus is essentially on caribou. However, it is inherently assumed that the conservation measures used for this large mammal should also maintain biodiversity. The objective of our project is to assess this hypothesis. We will study the long term impact of managing the woodland caribou's habitat on the biodiversity in an area of the Quebec North Shore. The biodiversity index will be based on beetle, ant, bird, and micro-mammal species. These species will be sampled along successional gradients following harvesting. The subsequent modelling will allow us to propose additional measures to maintain the integrity of the managed boreal forest.

Title: Impact of Habitat Loss and Fragmentation on the Home Range Fidelity of the Forest-Dwelling Caribou in a Managed Boreal Forest

Principal Investigators: Jean-Pierre Ouellet, Christian Dussault

Contributing Researchers: Martin-Hugues St-Laurent, Claude Dussault, Réhaume Courtois, Daniel Fortin

Graduate Student: Geneviève Faille

Affiliated Organizations: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, Université Laval

Sponsoring Institutions: Université du Québec à Rimouski, Ministère des Ressources naturelles et de la Faune, AbitibiBowater Inc., Fonds québécois de recherche sur la nature et les technologies, Natural Sciences and Engineering Research Council of Canada, Fonds de la recherche forestière du Saguenay-Lac-Saint-Jean, Fondation de la faune du Québec, Canada Economic Development, Québec Forest Industry Council, Essipit First Nation, Aboriginal Funds for Species at Risk (Environment Canada)

Region: Quebec

Research Category: Disturbance Driven

Anticipated Date of Completion: This research project will end in 2011.

Abstract: Conservation of forest-dwelling caribou (*Rangifer tarandus* caribou) is of great concern across most of its range. Anthropogenic disturbances, primarily logging activities, have been identified as the most important cause of caribou decline, although the mechanisms underlying this decline are not fully understood. Caribou commonly display fidelity to calving sites or

seasonal ranges, but the potential role of this life history trait has been largely overlooked in research and conservation planning. This is surprising because sites and ranges with high inter-annual use should have high conservation value. We investigated the relationship between habitat disturbances and home-range fidelity of forest-dwelling caribou across three study sites in Québec, Canada, using a broad range of natural and anthropogenic disturbances. Between 2004 and 2007, we tracked 47 adult female caribou using GPS collars. Home-range fidelity varied between seasons, being higher during calving and summer, and lower during winter. Caribou reduced fidelity following natural and anthropogenic disturbances, the latter having a stronger negative influence. Anthropogenic disturbances had a strong negative impact on home-range fidelity during annual, summer and winter periods, whereas natural disturbance was the dominant factor during calving. Despite this negative influence on fidelity, caribou tended to demonstrate range fidelity even in study sites most impacted by human activities. Habitat disturbances could produce two possible outcomes for caribou conservation: (1) a trend for females to reduce home-range fidelity which could translate into lower calf and female caribou survival through reduced familiarity with food distribution, escape cover and predation risk and (2) a global tendency to maintain range fidelity even in a drastically modified landscape which could turn into an ecological trap, particularly for calves when predation risk increases due to increased black bear density in early successional forests. Taking range fidelity behavior into consideration during forest management planning could direct conservation efforts toward the best available sites and therefore facilitate caribou persistence in managed landscapes.

Title: The Functional Responses of Gray Wolves in a Managed Boreal Forest: A Study of Movement and Predation Patterns

Principal Investigators: Christian Dussault, Martin-Hugues St-Laurent

Contributing Researcher: Daniel Fortin

Graduate Student: Solène Tremblay-Gendron

Affiliated Organizations: Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski, Université Laval

Sponsoring Institutions: Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski, Natural Sciences and Engineering Research Council of Canada

Region: Quebec

Research Category: Predator/Prey

Anticipated Date of Completion: This research project will end in 2011.

Abstract: The objective of this study is to better understand the movement and predation patterns of gray wolves (*Canis lupus*) in a managed boreal forest. The specific objectives are to understand the relative importance of biotic factors (occurrence of different preys and different vegetation cover) and abiotic factors (topography, roads, etc.) on wolf movement and to characterize predation sites and hunting patterns that will result in a successful hunt. In terms of forest-dwelling-caribou conservation, this study will allow us to determine if the wolf adapts its hunting strategy to caribou or moose availability, to understand the impact of anthropogenic disturbances on wolf movement and predation patterns and, ultimately, to verify whether caribou predation is an opportunistic or a targeted event.

Title: Calf Predation and the Influence of a Mother's Behaviour on Calf Survival

Principal Investigators: Christian Dussault, Jean-Pierre Ouellet

Contributing Researchers: Daniel Fortin, Réhaume Courtois

Graduate Student: Véronique Pinard

Affiliated Organizations: Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski, Université Laval

Sponsoring Institutions: Ministère des Ressources naturelles et de la Faune , Ministère des Transports du Québec, Fondation de la faune du Québec, Endangered Species Recovery Fund, Université du Québec à Rimouski, Natural Sciences and Engineering Research Council of Canada

Region: Quebec

Research Category: Predator/Prey

Anticipated Date of Completion: This research project will end in 2011.

Abstract: The increased human use of the boreal forest has an impact on the abundance and distribution of several wildlife species. Some predators benefit from the changes in habitat caused by logging, which can increase predation on some species of special concern such as the forest-dwelling caribou. Given that the survival of very young calves is an important component governing population dynamics, we have described the life cycle traits of the forest-dwelling caribou and how it selects its habitat in a managed boreal forest during calving, a period when calves are highly vulnerable to predation. We hypothesized that the caribou would avoid habitat conditions that would attract wolves and moose during that critical period. We monitored 22 female caribou from the Charlevoix population as well as their calves by GPS telemetry between 2004 and 2007. We measured the annual calving rate as well as the calf survival rate and identified the death causes. We assessed habitat selection at the calving site at two spatial scales (home range and micro-habitat). Although the annual rate of calving was high, the majority of the calves did not survive more than four weeks mainly because of bear predation. At the larger spatial scale (home range scale), the caribou chose calving sites located on hill tops and in a landscape with few roads. These conditions contributed to the spatial segregation of caribou and wolf. At the finer spatial scale (micro-habitat scale), the caribou chose forested habitats that had low side protection cover and avoided forested habitats that had high side protection cover. We believe that the females chose these sites because they provided them with better visibility and allowed them to possibly detect predators more easily. At the micro-habitat scale, the calving sites were also located at high altitude in an area where the basal area of spruce was relatively small. Food abundance was not an important variable at the calving site. Our results suggest that the caribou's anti-predator strategy during calving was adequate to keep the wolves away, but not the bears. An increase in the number of bears could have a significant impact on the forest-dwelling caribou populations.

Title: Monitoring How the Improvements to Highways 73/175 Impact Habitat Selection and Space Use By the Forest-Dwelling Caribou

Principal Investigators: Christian Dussault, Jean-Pierre Ouellet

Contributing Researchers: Yves Bédard, Réhaume Courtois, Daniel Fortin

Graduate Student: Mathieu Leblond

Affiliated Organizations: Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski (UQAR), Ministère des Transports du Québec (MTQ), Université Laval

Sponsoring Institutions: Ministère des Transports du Québec (MTQ), Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski (UQAR), Fonds québécois de recherche sur la nature et les technologies

Region: Quebec

Research Category: Disturbance Driven

Anticipated Date of Completion: This research project will end in 2013.

Abstract: The main objective of this project is to increase the knowledge on the effect of linear disturbances on the behaviour of the forest-dwelling ecotype of woodland caribou. This project is part of the work done to address caribou conservation concerns in Quebec and is aimed at better understanding how a road affects the persistence of a population and what mechanisms are involved (e.g. dispersion, survival). These are relevant questions for which answers are expected. The specific objectives are: 1) to assess the impact of road construction work and a wider road on how the forest-dwelling caribou selects its habitat and uses the space; 2) to identify the changes in caribou movement patterns during spring migration and the changes in habitat selection during the post-calving period once road construction work is completed; and 3) to assess the impact of a major road on survival and reproduction parameters.

Title: The Use of Open Habitats by the Forest-Dwelling Caribou of Charlevoix

Principal Investigators: Christian Dussault, Jean-Pierre Ouellet

Graduate Student: Jo-Annie Charbonneau

Affiliated Organizations: Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski (UQAR)

Sponsoring Institutions: Ministère des Ressources naturelles et de la Faune (MRNF), Ministère des Transports du Québec, Fondation de la faune du Québec, Fonds québécois de recherche sur la nature et les technologies, Aboriginal Funds for Species at Risk (Environment Canada), Université du Québec à Rimouski (UQAR)

Region: Quebec

Research Category: Basic Ecology

Anticipated Date of Completion: This research project will end in 2011.

Abstract: In this project, we studied the relationship between the forest-dwelling caribou and open habitats. To do so, we monitored twenty caribou female by GPS telemetry between 2004 and 2007 in the *Réserve faunique des Laurentides* region located in Quebec, Canada. In order to explain the influence of limiting factors on habitat selection and the potential trade-offs made by the caribou in a managed boreal forest, we tested the effect of the annual period (season) and the effect of the calf presence (parental status) on the open habitat use patterns of the forest-dwelling caribou. Habitat selection analyses conducted at three spatial scales showed seasonal changes and intra-individual variations among the observed patterns. All caribou monitored in this project selected open habitats at the three spatial scales. Because of the seasonal changes observed in the

open habitat selection patterns of females accompanied by calves and females without calves, our results suggest that the use of open habitats by the caribou is a trade-off between the risk of predation and food. The risk of predation seems to be the limiting factor that governs the observed use patterns. At a larger scale, it appears that the caribou selects habitats that are less likely to be used by moose and wolves while, at a finer scale, the caribou selects habitats characteristics that contribute to heighten its alertness and increase its detection and escape capabilities. When the risk of predation is higher, i.e. when there is a calf, food seems to be less of a priority. However, we believe that this trade-off may vary according to the level of opening in the landscape and the dynamics of the moose, wolf and bear populations.

Title: Environment-Based Model of Caribou, Wolf and Moose Movements for the Development of a Management Planning Decision-Making Tool

Principal Investigators: Lael Parrott, Daniel Fortin

Graduate Student: Guillaume Latombe

Affiliated Organizations: Université de Montréal, Université Laval

Sponsoring Institutions: Natural Sciences and Engineering Research Council of Canada, Université Laval, Abitibi-Bowater, Ministère des Ressources naturelles et de la Faune, Forintek Canada, Feric, Boisaco, Arbec, CRÉ – Côte-Nord, Rémabec, Cégep de Baie-Comeau, FPInnovations, CEDFOB, Natural Resources Canada, Essipit First Nation, Fondation de la faune du Québec

Region: Quebec

Research Category: Administrative

Anticipated Date of Completion: This research project will end in 2013.

Abstract: Forest-dwelling caribou conservation in Quebec requires a better understanding of the relationships between the caribou and its environment, which includes other animal species. The relationships between caribou distribution and landscape characteristics are complex and non-linear and are characterized by many feedback loops. As a result, it becomes difficult to study the factors that control species distribution. An individual-based model (IBM) was developed to better understand this complex system. This approach provides a way to represent individuals from each species separately (caribou, wolf or moose) in a virtual environment. The model allows each individual to move in a dynamic environment, while reacting to different habitat components, including the other individuals. An individual is therefore defined by its attributes (the internal variables), its perceptual capabilities (the external variables) and its capacity to react (which can modify the two types of variables). With this type of model, it is possible to test different cut scenarios that will produce, on the long term, different environment configurations, which will generate different responses from the system: the movement patterns of the individuals will be affected and also their encounter rate. This type of model has the advantage of letting the feedback loops emerge from the overall individual behaviours. It then becomes easier to represent the complexity of the system.

Title: Habitat and Space Use Strategies Adopted By Caribou, Moose and Wolves and the Modelling of the Interactions between These Species in a Managed Forest of the Quebec North Shore

Principal Investigators: Daniel Fortin, Christian Dussault

Contributing Researchers: Réhaume Courtois

Graduate Student: Nicolas Courbin

Affiliated Organizations: Université Laval, Ministère des Ressources naturelles et de la Faune (MRNF)

Sponsoring Institutions: Natural Sciences and Engineering Research Council of Canada, Université Laval, Abitibi-Bowater, Ministère des Ressources naturelles et de la Faune (MRNF), Forintek Canada, Feric, Boisaco, Arbec, CRÉ – Côte-Nord, Rémabec, Cégep de Baie-Comeau, FPInnovations, CEDFOB, Natural Resources Canada, Essipit First Nation, Fondation de la faune du Québec

Region: Quebec

Research Category: Predator/Prey

Anticipated Date of Completion: This research project will end in 2011.

Abstract: Because of increased logging activities in the boreal forest, the forest-dwelling caribou (*Rangifer tarandus caribou*) must deal with the increased loss and fragmentation of its habitat. A conservation-based management strategy on caribou habitat aimed at protecting large masses of forest was implemented on the Quebec North Shore. Although these protection blocks were established for the caribou, wolves (*Canis lupus*), the main caribou predator, are also likely to benefit from them. Our goal was to assess if establishing protection blocks adjacent to a logging area had an impact on the wolf-caribou interactions in winter. From 2005 to 2007, we monitored a number of adult female caribou and two packs of wolves by GPS telemetry. The monitoring work showed that the caribou were very sensitive to anthropogenic disturbances. The probability of caribou occurrence decreased with an increase in cut density, regardless of the age of the cut. The probability of wolf occurrence also decreased in areas where cuttings were recent (< 5 years). The two species selected the protection blocks. Our results show that the current management approaches could increase the caribou predation risk from wolves because they increase the probability of co-occurrence in small areas such as the protection blocks.

Title: Foraging Strategies By Omnivores: Are Black Bears Actively Searching for Ungulate Fawns or Are They Simply Opportunistic Predators?

Principal Investigators: Daniel Fortin, Christian Dussault

Contributing Researchers: Jean-Pierre Ouellet, Réhaume Courtois

Graduate Student: Guillaume Bastille-Rousseau

Affiliated Organizations: Université Laval, Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski (UQAR)

Sponsoring Institutions: Ministère des Ressources naturelles et de la Faune (MRNF), Ministère des Transports du Québec, Fondation de la faune du Québec, Fonds québécois de recherche sur la

nature et les technologies, Endangered Species Recovery Fund, Université Laval, Université du Québec à Rimouski (UQAR)

Region: Quebec

Research Category: Predator/Prey

Anticipated Date of Completion: This research project will end in 2011.

Abstract: Omnivores feed on animals that have a dynamic distribution and on plants that have a more static distribution. The search strategy that they adopt defines the risk, not only for the usual preys, but also for the preys that might be consumed during a fortuitous encounter. The potential impact of an omnivore on a system that includes several preys depends on the resources chosen and the strategies used to find them. We present a simple approach to help clarify the foraging decisions made by an omnivore, by combining analyses on resource selection, residence time, and interpatch movements. We used this approach to evaluate if black bear predation on ungulate fawns is the result of an active search or of fortuitous encounters. We monitored 12 black bears, 22 forest-dwelling caribou and 36 moose by telemetry during the calving period. We estimated the relative probability of an encounter between a black bear and ungulate fawns by using a resource selection function. We carried out field inventories to assess plant abundance. We defined a resource selection function that evaluates the spatial relationship between bear distribution and the abundance of the three types of bear food (plants, caribou and moose fawns). To evaluate the bear's food search strategy in order to explain the bear's selection, we analyzed its residence time and its interpatch movements. Our results show that bears did not select areas where the probability of an encounter with young ungulates was higher, but rather selected areas heavily filled with plants. We observed that bears spent the least amount of time in the patches that provided the greatest amount of plants. Plant selection was therefore determined by frequent movements, preferentially to patches heavily filled with plants. Such movements could result in a higher rate of fortuitous encounters with young ungulates, even if a bear is not actively searching for them. In order to reduce the negative impact of logging operations on the forest-dwelling caribou, the areas that are heavily filled with plants should be spatially separated from the mature coniferous masses that attract caribou.

Title: Maintaining the Caribou in Managed Boreal Forests in Spite of the Presence of Gray Wolves and Black Bears

Principal Investigators: Daniel Fortin, Christian Dussault

Contributing Researchers: Jean-Pierre Ouellet, Réhaume Courtois

Graduate Student: Mathieu Basille

Affiliated Organizations: Université Laval, Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski (UQAR)

Sponsoring Institutions: Ministère des Ressources naturelles et de la Faune (MRNF), Ministère des Transports du Québec, Fondation de la faune du Québec, Fonds québécois de recherche sur la nature et les technologies, Endangered Species Recovery Fund, Université Laval, Université du Québec à Rimouski (UQAR)

Region: Quebec

Research Category: Predator/Prey

Anticipated Date of Completion: This research project will end in 2012.

Abstract: Forest-dwelling caribou populations are declining almost everywhere in North America; it is even considered a threatened species in Canada and in Quebec. Black bear and wolf predation would be the main cause of decline of the caribou populations in Quebec. It is thought that forestry practices might be one of the reasons for the high predation rate because they create favourable conditions for caribou predators, as well as for moose, which increase the predation effect through an apparent competition mechanism. In this context, the FQRNT project will identify the overall impact of forest management in the caribou-moose-wolf-bear multi-predator and multi-prey system, in particular in terms of spatial interactions between the four species. The ultimate objective of this study is to develop a spatially explicit simulation model that can assess several forest management plans to allow long term caribou persistence in the boreal forest. This project will make use of existing data (2005-2010) collected at sites located on the Quebec North Shore and in Charlevoix on the four species monitored by GPS telemetry. The work will be carried out in several steps aimed at synthesizing current knowledge and, where required, at filling the gaps according to final needs. In the first step, the project will determine how the four species use the space on a seasonal basis in order to define the periods during the year when there are homogeneous patterns in habitat use and movements. Next, the caribou predation risk assessment, conducted at a fine and large spatio-temporal scale, will be used to develop a mechanistic caribou movement model that will be based on the environmental characteristics (in particular cuts and roads generated by logging activities) and that will also include the predation factor. The influence of this factor will then be refined for the females that were monitored by studying the impact of the predators on calf survival and the capacity of the females to limit that impact by adapting their movements. Finally, the integration of all these data on caribou movement and recruitment, in addition to all existing information on adult survival and fertility, will be used to develop a spatially explicit model to assess the potential effects of various forest management scenarios using long term simulations.

Title: The Influence of Predation and Management of the Boreal Forest on the Movements of the Forest-Dwelling Caribou *(Rangifer tarandus caribou)*

Principal Investigators: Daniel Fortin

Contributing Researchers: Christian Dussault, Jean-Pierre Ouellet, Réhaume Courtois

Graduate Student: Marie-Claude Labbé

Affiliated Organizations: Université Laval, Ministère des Ressources naturelles et de la Faune (MRNF), Université du Québec à Rimouski (UQAR)

Sponsoring Institutions: Ministère des Ressources naturelles et de la Faune (MRNF), Ministère des Transports du Québec, Fondation de la faune du Québec, Fonds québécois de recherche sur la nature et les technologies, Endangered Species Recovery Fund, Université Laval, Université du Québec à Rimouski (UQAR)

Region: Quebec

Research Category: Predator/Prey

Anticipated Date of Completion: This research project will end in 2012.

Abstract: The objective of the study is to identify the factors that influence the movements of the forest-dwelling caribou in a managed boreal forest. Our goal is to identify the intrinsic and

extrinsic characteristics of habitat patches that influence the propensity of caribou to go to these patches, and to evaluate the changes in these characteristics during the year. More specifically, we will determine the influence of predation (wolf and bear) and the influence of forest management (roads and forest cuts) on the accessibility of these patches for the caribou. Our study will allow us to better understand the behavioural decisions made by the caribou that result in a heterogeneous distribution of the forest-dwelling caribou in a managed forest. The outcome of this study will allow us to evaluate how the caribou uses the various patches under predation risk and anthropogenic disturbances. This approach will then become applicable to several other species for which a more complete understanding of their movements and distributions is required.

NWT (2)

Title: Gwich'in Traditional Knowledge: Woodland Caribou, Boreal Population

Principal Investigator: Kristi Benson

Contributing Researcher: Billie Lennie (Interviewer)

Affiliated Organization: Gwich'in Social and Cultural Institute

Sponsoring Institutions: Environment Canada, Gwich'in Renewable Resource Board, Gwich'in Social and Cultural Institute

Region: Gwich'in Settlement Area, Northwest Territories

Research Category: Other: Traditional Local Knowledge or Traditional Ecological Knowledge

Anticipated Date of Completion: Mid-2011

Abstract: The Gwich'in Social and Cultural Institute and the Gwich'in Renewable Resources Board conducted a study to gather and present Gwich'in Traditional Knowledge on Woodland Caribou – Boreal population (woodland caribou). There is a stable population of woodland caribou in the Gwich'in Settlement Area and surrounding regions which are harvested by Gwich'in living in the NWT communities of Inuvik, Aklavik, Fort McPherson, and Tsiigehtchic. However, the Canadian population is classified as threatened under the federal Species at Risk Act. Environment Canada supported the project in order to integrate Gwich'in Traditional Knowledge in the recovery planning process for woodland caribou. The study involved searching the digital archives of GSCI for relevant primary and secondary data, and conducting 20 interviews with Gwich'in hunters and Elders. Study results and maps will be presented in a detailed report.

Title: Dehcho Boreal Caribou Study

Principal investigators: Nicholas Larter

Contributing researchers: Danny Allaire, John A. Nagy

Affiliated Organizations: Environment & Natural Resources, Government of the Northwest Territories; University of Alberta

Sponsoring Institutions: Government of Northwest Territories Department of Environment & Natural Resources; NWT Western Biophysical Program, Environment Canada; Cumulative Impacts Monitoring Program (INAC)

Region: The Dehcho Region, south western Northwest Territories

Research Category: Basic Ecology

Anticipated Date of Completion: This is an ongoing study which will continue monitoring for 3-5 years, longer if the Mackenzie Gas Pipeline project commences.

Abstract: An ecological study on boreal caribou in the Dehcho Region of the Northwest Territories was initiated in March 2004 when 10 boreal caribou females were equipped with Telonics ST-20 satellite collars. Subsequently, additional annual deployments of satellite and GPS-ARGOS collars resulted in 83 collared females and about 100,000 GPS locations collected over 6 years which are currently being analyzed. Location data were used to verify and document calving events, and for a variety of other analyses utilizing digital linear development data, National Earth Observation Sustainable Development vegetation cover data, wildlife history data, forest inventory data, and wildlife distribution data for the area.

Mean annual home range size of female boreal caribou (n=50) is 2824 km^2 (range 205-11,485 km^2). Female boreal caribou space out during calving and space away from disturbances to reduce predation risk. Peak calving is 7-24 May. Boreal caribou females actively avoid seismic lines during 15 April to 24 July (the pre-calving, calving and summer periods). During this time period, caribou also use areas with fewer alternative prey and fewer predatory species. Movement rates increase when female boreal caribou have to cross seismic lines (3-7 times faster). Female boreal caribou selected forest stands ≥100 years of age, with open conifer land cover, and that had not been burned by wildfires during the last 50 years, suggesting that it may take 100 years for boreal caribou habitat to regenerate after wildfires. Secure habitat, defined as areas >400m from linear features, remains relatively abundant in the Dehcho but most of it is in small patches; less than 30% of the Dehcho occurs as secure, unburned habitat of patch size ≥500km^2.

Annual adult female boreal caribou survival was estimated by tracking a number of collared females. Aerial surveys were conducted each March to determine annual survival of calves. These data were used to estimate annual population growth rates or lambda (λ). From 2004/05 to 2009/10 the population has shown an overall decline, however higher overwinter survival of calves in recent years is encouraging and resulted in annual $\lambda > 1$. The relatively high availability of alternate prey species (moose, deer, bison, beaver), and of key predators (wolves, black bears) in this region may reduce adult female survival more than in some other regions of the Northwest Territories where boreal caribou numbers are increasing.

Newfoundland and Labrador (13)

Title: Genetic & Genomic Structure of Newfoundland Caribou (*Rangifer tarandus terranovae*) and its Phylogeographic Implications for the Evolution of Caribou and Reindeer (*Rangifer* ssp.)

Principal Investigators: Steven M. Carr, H. Dawn Marshall, Shane P. Mahoney

Graduate Student: Corrine Wilkerson

Affiliated Organizations: Memorial University, Department of Environment and Conservation, Government of Newfoundland and Labrador

Sponsoring Institutions: NSERC; Newfoundland government

Region: Island of Newfoundland

Research Category: Genetic

Anticipated Date of Completion: Unknown

Abstract: Caribou on the island of Newfoundland on the eastern seaboard of Canada are a distinctive form of Woodland Caribou (*R. tarandus caribou*), whose range of post-glacial ecological adaptations spans that of other populations throughout the subspecies. Genetic analysis of 223 Newfoundland caribou from 14 herds over a 2,223 bp region spanning the mtDNA Cytochrome *b* and Control Regions identified 32 haplotypes. Hierarchal Analysis of Molecular Variance partitions 0.03 ~ 0.07 of the genetic variance to geographically-defined regions or hunting compartments. Nested Clade Analysis identified significant phylogeographic associations due to restricted gene flow with isolation by distance, contiguous range expansion and long-distance colonization, coupled with fragmentation followed by range expansion. Clade diversity is greatest on the Northern Peninsula, whereas caribou on the Avalon Peninsula in the southeast are genetically depauperate, consistent with re-population across the northern Straight of Belle Isle rather than from southern coastal refugia. Analysis of complete mitogenomes (16Kbp) from 80 animals assigns individuals in the 32 haplotypes to four clades, three of which are endemic to the island, consistent with Newfoundland caribou as a distinct subspecies, *R. tarandus terranovae* (Bangs, 1896). The fourth, basal clade is more closely related to animals from Labrador as a persistent ancestral lineage rather than a recent migrant. Re-analysis of previous single-locus data in the genomic context suggests re-evaluation of the Flagstad & Roed (2003) biogeographic hypothesis of Reindeer / Caribou evolution: we suggest the Beringean-Eurasian reindeer clade (including Svalbard) is basal and the Nearctic caribou clade derived. Implications for a pan-*Rangifer* genomic investigation are discussed.

Title: The Impact of Forest Harvesting Activities on Caribou in Areas Utilized on the Island of Newfoundland.

Principal Investigators: Paul Saunders

Graduate Student: TBD

Affiliated Organization: Department Environment and Conservation, Wildlife Division; Department Natural Resources

Region: Newfoundland and Labrador

Research Category: Disturbance Driven

Anticipated Date of Completion: Unknown

Abstract: Three years into the Newfoundland and Labrador Caribou Strategy enough telemetry data has been collected to provide a delineation of caribou range utilization. In some cases areas identified as important to caribou overlap those proposed for current and future forest harvesting. This has created the need to quantify the characteristics of these areas and to determine the possible impacts of timber harvesting in these areas on resident caribou populations. The main goal of this research is the creation of guidelines that can be used to direct activities in areas deemed important to the long term survival of caribou on the island of Newfoundland.

Title: Delineation of Land Cover Boundaries in Areas Utilized or Avoided by Female Caribou during Calving and Post-Calving Using Publicly Available Spatial Datasets

Principal Investigator/Graduate Student: Paul Saunders

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Newfoundland and Labrador

Research Category: Basic Ecology

Anticipated Date of Completion: Unknown

Abstract: The availability and utility of spatial datasets, at no cost to the end user, directly impacts the ability of government and non-governmental wildlife management agencies to delineate land cover utilization or avoidance for targeted wildlife species. The availability and utility of four datasets; Canada Land Inventory for Ungulates, Earth Observation for Sustainable Development of Forests, Provincial Forest Inventory for the Island of Newfoundland, and the Landsat 7 ETM+, were evaluated for their usefulness in delineating land cover boundaries in areas utilized by caribou during calving and post-calving. To perform this evaluation a representative sample of land cover features, in both utilized and avoided areas, were selected through the use of space-time scan statistics and maximum step length calculations, then land cover boundaries were recorded using spiral transects based on the Fibonacci sequence. The location of all land cover boundaries intersected during the completion of ground based transects were recorded and provided a baseline dataset for comparison to those depicted using the selected datasets. Object-oriented segmentation had to be completed for the Landsat ETM+ dataset before a comparison could be conducted. Root mean square error (RMSE) values were calculated for all datasets and compared with the ground based results. In addition, RMSE values were also calculated for a set of randomly generated boundary locations for each completed transect. For all datasets errors of omission were taken into account on an independent basis. Upon completion of the evaluation it was determined that all datasets, except the Earth Observation for Sustainable Development of Forests, where both the RMSE for random (r) and actual (a) boundary points (r=22.89, a=14.93, error 25 m) was below the associated positional error of the dataset, would be useful for the delineation of land cover boundaries. The Canada Land Inventory (r=86.60, a=30.43, error 35 m) was deemed useful only for its ability to provide information on historical location and permanence of boundaries at the landscape scale. To provide land cover delineation for the island of Newfoundland a combination of both the forest inventory (r=64.71, a=39.47, error 35 m) and landsat datasets (r=37.02, a=27.92, error 30 m) must be utilized along with a variety of ancillary data sources.

Title: Land Cover Characteristics of Areas Utilized By Caribou during Fall Rut and Winter Time Periods.

Principal Investigator/Graduate Student: Paul Saunders

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Topsail study area in Newfoundland

Research Category: Basic Ecology

Anticipated Date of Completion: Unknown

Abstract: Our objectives are to identify areas utilized or avoided by caribou during the fall rut and winter time periods, collect attribute data on land cover features in these areas, and utilize

attribute data to provide a delineation of areas suitable for rutting and wintering in the Topsail study area. A comprehensive examination of land cover utilization by caribou during the fall and winter has not been completed for the island of Newfoundland. This information is required for the effective management of land cover at the landscape scale as it is related to the requirements of caribou during these time periods. This work represents an extension to work conducted during the calving and post-calving period under the Caribou Strategy. Sampling methods for the calving and post-calving period have been developed and will be adopted for use during the rut and wintering periods. This will involve the survey of a representative sample of transects for both periods. Attribute associations will then be determined and a study area delineation of land cover features completed. This will later be translated into maps displaying areas available to be utilized and those deemed to be avoided by caribou.

Title: GPS Collar Data Retrieval and Collar Redeployments (240 Argos and 100 GPS collars) on Caribou in Newfoundland

Principal Investigator: John Neville

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Newfoundland

Research Category: Basic Ecology

Anticipated Date of Completion: unknown

Abstract: The purpose of this project is the retrieval of caribou telemetry data, investigation of mortality sites, and the redeployment of collars. Our goal is to maintain a continuous spatial dataset for caribou on the island of Newfoundland. Our objective is to obtain one complete download of GPS locations from collared caribou in 2010/2011. We would like to maintain a full complement of collared caribou as required under the Insular Newfoundland Caribou Strategy and to maintain a record of caribou mortalities and where possible to determine the cause of death. At present our GPS downloads have been completed and the redeployment of collars has been completed for 2009/2010 and will continue in 2010/2011. Spatial databases will be updated on a monthly basis.

Title: Caribou Population Surveys and Fall Classifications

Principal Investigator: Casidhe Dyke

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Newfoundland

Research Category: Basic Ecology

Anticipated Date of Completion: unknown

Abstract: The purpose of this project is to conduct population surveys on all managed insular Newfoundland caribou herds on a five-year rotation schedule using the most appropriate survey methodology, and conduct annual fall classification surveys on all managed caribou herds. Our goal is to maintain up-to-date information on the status and demographic parameters for all managed Newfoundland caribou herds for use in population assessment and modeling. Our

objective is to Assess demographic parameters needed for establishment of sustainable quotas in the fall of each year for all managed herds and to conduct population surveys, using the most appropriate survey methodology, on a maximum five-year rotation frequency. This information will be used, in conjunction with hunter trend information, other research information and age structure information from hunter submitted jawbones to monitor caribou populations in Newfoundland.

Title: Studies on the Caribou Lichen Stands of Newfoundland: A Reassessment of Teuvo Ahti's Field Sites

Principal Investigator: Mac Pitcher

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Newfoundland

Research Category: Basic Ecology

Anticipated Date of Completion: unknown

Abstract: The purpose of this study is to compare lichen species diversity and biomass with a 1956 Island-wide survey with the objective of determining whether lichen range depletion has occurred and to estimate winter range quality for Newfoundland Caribou populations. Our goal is to depict the species composition, distribution and abundance of winter forage lichens for caribou in Newfoundland and describe temporal changes that have occurred since Ahti (1959). Our objective is to resample 50 plots and identify species of lichen and total lichen biomass for each plot. We will accomplish this by revisiting plots originally sampled 50 years ago; this will allow for a comparison of change in biomass and species composition on caribou ranges in Newfoundland. The lichen plots are being sampled using a rigorous, repeatable methodology.

Title: Integration of Remotely Sensed Information and Field Data for a Determination and Assessment of Ecological Communities and Caribou Critical Habitat in Central and Western Labrador

Principal Investigators: Isabelle Schmelzer, Lindsay Notzl, Jeri Graham, Jean-Francois Senécal

Affiliated Organizations: Department of Environment and Conservation, Wildlife Division; NCC; Department of Environment and Conservation, Parks and Natural Area Division;

Region: Lac Joseph area of Western Labrador

Research Category: Basic Ecology

Anticipated Date of Completion: Unknown

Abstract: The purpose of this study is to review remotely-sensed and mapped environmental and landscape information, including information on ecoregion boundaries and ecological communities, and design and implement a field verification program within the Lac Joseph caribou range in Western Labrador. Our goal is to gather field-based site descriptions, to use these to validate community delineations and boundaries, and where appropriate, propose changes (at a scale of 1:50 000) for both habitat classes used in critical habitat for Woodland caribou and ecoregion boundaries for central and western Labrador. Our objectives are to assess

the accuracy of community delineations (e.g. Lapoukhine land districts) within the range of the Lac Joseph caribou populations using a field-based validation, to delineate caribou-specific habitat classes, and to map these throughout the Lac Joseph caribou range. The ability to identify important caribou habitat and accurately depict ecological communities on the landscape is pivotal for the assessment of current and future developments on caribou and other wildlife. Available baseline information either occurs at scales too coarse to permit analyses of wildlife-habitat relationships and/or is limited to areas with commercially viable forests (e.g. the Forest Resource Inventory) which exclude important wildlife habitats such as wetlands and lichen-rich areas. This project will cross-validate a classified satellite image which can be used as a base map for caribou critical habitat and numerous other applications. A prior complementary study ("A compilation of landscape and environmental features of the Lac Joseph Caribou herd range in Labrador") will provide the base data (remotely-sensed environmental information) used in this study. An unsupervised classification was performed (using ISODATA) on 4 LANDSAT images which span the Lac Joseph caribou herd. These were aggregated into clusters by comparing them to available landscape data and Quickbird satellite images, and further pooled into 12 classes. Field validation is required to assess the accuracy of these classes. The present study will require the planning and implementation of a two-tier field validation program: one course-scale through the study area (flight lines) and the second using ground-based sampling at a series of at least 40 stations.

Title: Lichen Biomass and Snow Pack Characteristics of Winter Ranges in the Red Wine Mountain Caribou Herd

Principal Investigators: Isabelle Schmelzer, Mac Pitcher, Philippe LeBlanc

Affiliated Organization: Department of Environment and Conservation, Wildlife Division; Memorial University

Region: Labrador

Research Category: Basic Ecology

Anticipated Date of Completion: Unknown

Abstract: The purpose of this study is to assess the richness of winter forage (lichens) on Red Wine Mountain(RWM) caribou winter ranges in relation to land cover type and snow pack characteristics to determine trade-offs between richness and availability. Our goal is to depict the species composition, biomass and site characteristics, including snow depth and icing, of winter ranges for RWM caribou.

Objectives:

1. To document the biomass of terrestrial fruticose lichens in land cover types used during winter;
2. To estimate biomass of terrestrial lichens for at least 30 plots
3. To compare, using field data on biomass, the available forage in winter habitats used by caribou and randomly selected sites.
4. To document snow conditions, including depth, icing, and snow pack characteristics, in different winter habitats used by RWM caribou.
5. To assess potential trade-off between lichen availability (biomass) and accessibility (snow conditions) by RWM caribou.
6. To identify high value winter habitats throughout the range of RWM caribou.

7. To create a baseline inventory (including floristic measurements and photographs) of bryophytes, fungi and lichens for central Labrador and to contribute toward assessments of biodiversity, status and distribution of these groups within Atlantic Canada.

This study is part of a suite of projects assessing land cover utilization by sedentary Woodland caribou in Labrador. The ability to identify important caribou habitats and accurately depict ecological communities on the landscape is pivotal for the assessment of current and future developments on caribou and other wildlife. The bulk of monitoring (surveys, classifications) occur during the winter, and the identification of areas throughout the range with a high probability of caribou occupancy is an important management tool. Terrestrial lichens are an important component of the winter forage for woodland caribou. This project will allow for a quantitative comparison of biomass in relation throughout the winter ranges of RWM caribou. Since caribou concentrate in lichen-rich areas in which snow characteristics facilitate foraging, identification of these areas will assist in identification of core winter habitats. These will be mapped and will be an essential component of caribou management in Labrador. To accomplish this, sampling methodology was developed and lichen biomass, abundance and species composition was measured at 30 sites throughout the RWM winter ranges during September 2009. Data was entered into a database and differentiated into 7 classes on the basis of multi-dimensional scaling analyses. Samples were cleaned and prepared for kiln-drying for explicit measurement of biomass. Samples will be processed May to July 2010. Snow pack characteristics were measured at 20 sites during March 2010. Data remains to be entered into a database and analyzed and this will be completed as time permits early in the 2010 fiscal year.

Title: Compilation and Screening of Telemetry Data for Sedentary Caribou Populations in Labrador

Principal Investigators: Isabelle Schmelzer, David Elliot

Affiliated Organization: Department of Environment and Conservation, Wildlife Division

Region: Labrador

Research Category: Basic Ecology

Anticipated Date of Completion: unknown

Abstract: The purpose of this study is to consolidate spatial data holdings for Lac Joseph, Red Wine Mountain and Mealy Mountain caribou herds. Our goal is to bring all datasets up to date to permit analyses and provide an access point for their efficient dissemination. Our objectives are to catalog identified spatial datasets and the creation of associated metadata and the filtering of all spatial datasets and the production of shapefiles pertaining to seasons, populations, and extended populations. Data accumulation for these 3 populations has been ongoing for 20 years, and upcoming field work and deployment of GPS collars with a frequent relocation schedule will add to the amount of data that needs to be processed. Due to range overlap with George River caribou herds, and associated legal and illegal hunting activities, this information must be current to within the week to allow for appropriate enforcement, mitigation and management.

Data filtering, analysis and information generation is currently required to guide future field related research activities. This requires the cataloging, filtering, and preliminary production of secondary spatial data products for use in the effective management of all three populations. To date all three populations have been updated to the end of 2009, but only basic screening has been completed for the 2010 data received for approximately 70 collared caribou.

An inventory of frequencies and animal identification has been completed for each population. Currently these are filed in folders linked to the target population as the data are downloaded from the satellite (every 4 days). Pre-determined filtering exercises need to be applied to all of these and the resulting screened locations can be added to existing (screened) data.

Title: Identification of Critical Habitat for Red Wine Mountain and Lac Joseph Caribou

Principal Investigators: Isabelle Schmelzer, Shelley Pardy-Moores

Affiliated Organization/Sponsoring Institutions: Department of Environment and Conservation, Wildlife Division; Woodland Caribou Recovery Team

Region: Labrador

Research Category: Basic Ecology

Anticipated Date of Completion: unknown

Abstract: This project uses environmental and landscape information compiled over the past 3 years for the Red Wine Mountain (RWM) and Lac Joseph (LJ) caribou populations and combines it with caribou location information to determine seasonal habitat selection and to formally identify critical habitat for these Threatened populations. Our goal is to systematically analyze selected datasets through comparison with a known location and classification dataset.

Objectives:

1. Complete resource selection functions relating environmental variables to use locations (GPS and class 3 ARGOS) by caribou.
2. To identify the site characteristics of wintering and calving/post-calving areas.
3. To map these throughout the range of RWM and LJ caribou
4. To quantify natural (fire) and anthropogenic levels of disturbance on the range
5. Determine relative abundance of preferred and avoided habitats throughout the RWM and LJ caribou ranges.
6. To propose areas for formal consideration as Critical Habitat for RWM and LJ caribou populations.

Sedentary caribou populations in Labrador have been assessed by COSEWIC and the SSAC as threatened populations, and have been formally listed as such under Provincial Endangered Species Legislation since 2001. Identification of critical habitat for caribou is a requirement of both Provincial and Federal Endangered Species legislation. This project builds on companion projects related to classification and validation of remotely-sensed imagery and the compilation and screening of telemetry data.

Remotely sensed landscape information has been compiled and grouped into classes which reflect caribou habitat use. It will be validated for the LJ range during late summer 2010. Telemetry data has been compiled and screened for hundreds of animals from 1984 to 2009 for both RWM and LJ populations. The 2010 data will be added to the analyses. A remote-sensing specialist has extracted environmental features for use and random locations at 5 different spatial scales. Resource selection functions (RSFs) comparing use and random locations at 5 different spatial scales will be run in late 2010 once the final site validation has been completed.

Title: Impact Assessment of the TLH3 on the Mealy Mountain Caribou Population

Principal Investigator: Isabelle Schmelzer

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Labrador

Research Category: Administrative

Anticipated Date of Completion: unknown

Abstract: This is a long-term project designed to assess and assist in the mitigation of potential impacts of the construction and use of the 3rd phase of the Trans-Labrador Highway on caribou from the Mealy Mountain caribou population. Our goal is to assess the impacts of, and mitigate appropriately for, the TLH 3 on movements, distribution, range use and demography of female Mealy Mountain caribou (MMC).

Objectives:

1. Determine risk faced by animals/subpopulations within MMCH by evaluation i) the proportion of individual ranges which contain the TLH3 and ii) proximity of winter and calving ranges to TLH.
2. Determine the proportion of collared individuals within different zones of impact which have been defined based on seasonal travel rates (e.g. 20 of MMC females were within 24 hours travel distance of TLH during winter etc).
3. Evaluate subpopulation structure in MMCH caribou and assess whether certain subpopulations are more likely to be affected than others
4. Calculate the probability that an MMCH female will occur within different zones of influence adjacent to the road by assessing spatial and temporal range overlap within these zones.
5. Identify areas of the MMC range in which additional radio collars need to be deployed, and identify animals which should have their collar replaced in order to complete the objectives of the study.
6. Describe risk posed to calving and winter ranges during the construction and use of TLH and propose appropriate mitigation
7. Improve knowledge of the space and use and general ecology of this population
8. Determine survival rates for adult females and assess calf recruitment
9. Conduct late winter classifications.

A requirement of the environmental assessment of the Trans Labrador Highway (phase 3) was the initiation of a research project which assesses the impact of the road during the construction and implementation stages of this development, with comparisons made to information collected prior to initiation of construction. This year marks the first year of the post-construction phase. There are currently 45 active collars. Preliminary analyses conducted during 2009/10 have indicated that not all animals in the MMC will be affected equally, and the impacts are limited to 2 subpopulations in particular. As a result, additional collars were deployed or replaced on caribou within these areas to permit enhanced monitoring of affected individuals.

Twenty-four ARGOS collars were either replaced or deployed on MM caribou during April 2009 and March/April 2010. Telemetry data from 2004 to 2009 was compiled, screened and prepared for analysis. A priority list of collar replacements/ areas to collar was developed on the basis of preliminary analyses and used to plan 2010 field operations. The analysis of remaining questions posed in objectives is underway. A preliminary report for the 2009/10 year is almost completed. A new employee will need to be hired for 2010/11 in order to complete the remaining assessment.

Title: Caribou, Moose and Wolves in Southern Labrador: An assessment of predator-prey dynamics in a multi-prey boreal ecosystem.

Principal Investigators: Isabelle Schmelzer, Shannon Crowley, David Elliot

Affiliated Organization: Department Environment and Conservation, Wildlife Division

Region: Labrador

Research Category: Predator/Prey

Anticipated Date of Completion: unknown

Abstract: This study aims to assess interactions between caribou, moose and wolves in central Labrador. In multi-prey systems, predator numbers can remain high as alternate prey decline. Forest-dwelling woodland caribou can be considered an alternate prey species in moose-caribou-wolf-systems which characterize much of the boreal forest. Several studies have suggested that where wolf numbers in these systems exceed a threshold value, caribou populations decline. Our goal is to estimate predation rates on moose and forest-dwelling caribou by resident wolves (those not strictly associated with the migratory George River herd) within the ranges of the sedentary caribou populations in Labrador (Lac Joseph (LJ); Red Wine Mountain (RWM); Mealy Mountain (MM)); and to clarify the implications of increasing moose densities to caribou.

Objectives:

1. Estimate wolf kill rates and variance during winter (November-May) in a multi-prey system.
2. Examine the effects of various covariates on kill rate, including pack size, prey sex and age, snow depth and time of year.
3. Derive a statistical model to predict the probability of an individual cluster of wolf locations being a kill of a large-bodied prey species, a small-bodied prey species, a non-kill site, or a resting site.
4. Estimate survival rates of radio-collared caribou in the Red Wine Mountain and Lac Joseph caribou populations, and determine cause of death for mortalities of radio-collared caribou.

Wolf predation rates on Boreal caribou have been linked to presence of moose or other ungulates which occur at higher densities or offer a greater biomass to wolves. Moose, although not historically resident in Labrador, have increased their distribution and numbers over the past 5 decades. Similarly, large numbers of migratory caribou have over wintered within the northern portions of the winter ranges of LJ and MM populations, and throughout the entire range of the RWM population (which numbers less than 100 individuals) over the past 10 years. These two factors could be problematic for forest-dwelling caribou if they result in higher levels of predation. Wolf predation accounts for approximately 50% of radio-tagged caribou of known fate. In spite of this, little is known regarding the abundance and basic ecology of wolves in Labrador. Given the importance of wolf predation to caribou demography, and the association with wolf kill rates to landscape change and presence of other ungulates elsewhere, this limitation will affect our ability to manage caribou populations in the future, or to adequately assess implications of proposed developments and/or associated changes in moose or wolf abundance and distribution on caribou persistence.

Four GPS/ARGOS hybrid collars for wolves; 5 VHF transmitters for wolves; and 8 GPS/ARGOS hybrid collars for caribou have been ordered and programmed. A survey delineating moose abundance and distribution has been completed. Currently, sites with high potential for wolf activity are being delineated using field observation, surveys, and local knowledge. Wolf collar deployments were attempted throughout the winter (2010) but snow conditions constrained

capture opportunities. Further capture attempts are planned for winter 2011. Once collars have been deployed, a graduate student may be identified to take on the project.

Barren-Ground Caribou (11)

Alaska, Yukon, Northwest Territories, Nunavut, Northern Quebec and Greenland

Title: Living With Caribou: Sahtu Region Traditional Knowledge Program

Principal Investigator: Deborah Simmons

Contributing Researchers: Micheline Manseau, Ken Caine, Robert Ruttan, Dawn Ostrem, Walter Bayha, Michael Neyelle, Roger Odgaard, Leon Andrew, Anne Marie Jackson

Graduate student: Erin Freeland Ballantyne

Affiliated Organizations: University of Manitoba

Sponsoring Institutions: University of Manitoba, Sahtu Renewable Resources Board, NWT Environment and Natural Resources, NWT Education, Culture and Employment, NWT Cumulative Impact Monitoring Program, Deline Renewable Resources Council, Fort Good Hope Renewable Resources Council, Colville Lake Elders Council, Tulita Renewable Resources Council, Norman Wells Land Corporation

Region: Sahtu Region, Northwest Territories

Research Category: Other: Traditional Knowledge

Anticipated Date of Completion: March 2012

Abstract: In 2006, a multi-year study was initiated in the five communities Sahtu Region, Northwest Territories to understand Dene and Métis relationships with barren-ground caribou. The study was a response to community concerns about news that caribou populations were in decline. The study was collaborative, allowing each community to define the specific research tools used. Activities included focus groups, on-the-land trips, and a school program. Three regional meetings were held to provide opportunities for community Renewable Resources Council delegates to share knowledge and validate the research.

Title: Interrelationships between Weather, Parasitic Insects, and Barren-ground Caribou (*Rangifer tarandus groenlandicus*) Behaviour in Northwest Territories and Nunavut

Principal Investigator and Contributing Researchers: Chris J. Johnson, Bruno Croft, Anne Gunn, Lisa M. Poirier, & Michael P. Gillingham.

Graduate Students: Leslie A. Witter

Affiliated Organizations: University of Northern British Columbia, Government of Northwest Territories

Sponsoring Institutions: CircumArctic Rangifer Monitoring and Assessment Network (CARMA), Government of the Northwest Territories Department of Environment and Natural Resources

(GNWT ENR), Natural Sciences and Engineering Research Council of Canada (NSERC), and University of Northern British Columbia (UNBC).

Region: Post-calving/summer range of the Bathurst barren-ground caribou herd; 46 386 ± 13 725 km^2 of the Slave Geological Province and Southern Arctic Ecozone in Northwest Territories and Nunavut, Canada.

Research Category: Basic Ecology

Anticipated date of completion: Completed fall 2010; further publications in prep/review.

Abstract: The Bathurst barren-ground caribou (*Rangifer tarandus groenlandicus*) herd decreased by 90% from 1986-2009. Increased intensity of insect harassment due to climatic warming is hypothesized as a factor contributing to the decline. We monitored weather, trapped insects, and recorded caribou behaviour during 2007-2009. Oestrid fly (*Oestridae*) presence, and mosquito (*Culicidae*) and black fly (*Simuliidae*) activity/abundance were best explained by temperature, wind speed, light intensity, barometric pressure, relative humidity, vegetation, topography, and location. Time of day and growing degree days also affected mosquito and black fly levels. Conditions favouring mosquito activity declined, while those favouring black and oestrid fly activity increased since the mid 1980s. Mosquitoes had relatively little effect on caribou behaviour. Insect avoidance increased when oestrids were present or black flies were active at moderate-high levels. Understanding differential effects of macroparasites on *Rangifer* behaviour is necessary to predict herd dynamics in the context of a changing climate across northern Canada.

Title: Monitoring and Understanding Distribution of Bathurst Barren-ground Caribou (*Rangifer tarandus groenlandicus*) During Winter

Principal Investigators: Chris J. Johnson, Jan Adamczewski, Phil J. Burton, Katherine L. Parker, and Bruno Croft

Graduate Student: Tara A. Barrier

Affiliated Organizations: University of Northern British Columbia; Wildlife Division, Environment and Natural Resources, Government of the Northwest Territories; North Slave Region, Environment and Natural Resources, Government of the Northwest Territories

Sponsoring Institutions: Government of the Northwest Territories Department of Environment and Natural Resources, Natural Sciences and Engineering Research Council of Canada, Northwest Territories Cumulative Impact Monitoring Program, and University of Northern British Columbia

Region: Winter range of the Bathurst barren-ground caribou herd; approximately 297,000 km^2 of the Taiga Shield and Southern Arctic ecozones in Northwest Territories, Canada.

Research Category: Disturbance Driven

Anticipated Date of Completion: April 2011

Abstract: A downward trend in *Rangifer* herds is echoing across the circumpolar north. In the Canadian central Arctic, the Bathurst barren-ground (*Rangifer tarandus groenlandicus*) herd declined from 472,000 (±72,900) caribou in 1986 to 31,897 (±6,092) caribou in 2009. A

reduction in winter forage due to an increased frequency and severity of forest fires has been implicated as a factor contributing to the decline. We employed a multi-scale approach to identify the influence of ecological variables related to vegetation, fire history, snow cover, and predation risk on the occupancy of winter habitats by caribou. Between 2008 and 2009, we collected forest stand and understory data at habitats used by caribou, as well as paired unused sites. At one scale higher, we used animal location data recorded from 1996 to 2009 to characterize the spatial and temporal distribution of Bathurst caribou on winter range. At the scale of the feeding patch, caribou foraged in habitats with a high ground cover and biomass of lichen and few or small trees. Similarly, the consensus among the models of habitat selection by collared caribou was that they avoided areas of the winter range densely populated with burns and favored older patches of forest characterized by a high ground cover of lichen and herbaceous forage and a close proximity to lakes and rivers. However, there was considerable use of habitats adjacent to the burn boundary, and some individuals occupied early-seral habitats significantly more than expected. Although the abundance of fruticose lichens was relatively high (2464 kg/ha), our results suggest that an increased incidence and severity of forest fires due to climatic warming could cause a short-term decrease in the winter habitat available to the Bathurst herd.

Title: Risk Factors Associated with *Besnoitia tarandi* Infection in Barren-Ground Caribou (*Rangifer tarandus*)

Principal Investigators and Contributing Researchers: Guy Beauchamp, Susan Kutz, Manon Simard, Brett Elkin, Bruno Croft, Joëlle Taillon, Steeve D. Côté, Vincent Brodeur, Mitch Campbell, Dorothy Cooley, Christine Cuyler and Stéphane Lair

Graduate Student: Julie Ducrocq

Affiliated Organizations: Université de Montréal; University of Calgary; Makivik Corporation, Nunavik Research Center; Government of the Northwest Territories, Nunavik Research Center; Université Laval, Ministère des Ressources naturelles et de la Faune; Government of Nunavut, Department of Environment; Yukon Department of Environment, Greenland Institute of Natural Resources

Sponsoring Institutions: CircumArctic Rangifer Monitoring and Assessment Network (CARMA)

Regions: Rivière-aux-Feuilles (Northern Québec) and Rivière-George (Northern Québec and Labrador), Akia-Maniitsoq and Kangerlussuaq-Sisimiut (Greenland), Bathurst (NT and NU), Bluenose West (NT and NU), Porcupine (AK and YT) and Southampton Island (NU)

Research Category: Other: Health and Disease

Anticipated Date of Completion: April 2010

Abstract: Although *Besnoitia tarandi* has been described in *Rangifer* sp. for over 80 years, its ecology and distribution remains poorly understood. We evaluated the prevalence and intensity of *B. tarandi* infection in eight barren-ground caribou herds and identified some biotic and abiotic risk factors associated with this infection. Densities of *B. tarandi* cysts were determined by microscopic examination of formalin-fixed sections of skin from the anterior aspect of the metatarsus of caribou opportunistically collected from each herd. *Besnoitia tarandi* was not observed in the two Greenland herds (n=96), but was found in approximately a third of the caribou sampled from six North-American herds (n=1004). The median density of cysts observed in the infected skin examined was 1.1 per mm^2. Caribou sampled following the summer months (September to December) and during the winter (January to April) had greater prevalence *of B.*

tarandi, compared to caribou sampled in June. Male caribou also had a slightly higher apparent prevalence compared to females while cyst density was similar between genders. Results of this survey suggest that caribou from Rivière-aux-Feuilles and Rivière-George, Nunavik, harbored higher *B. tarandi* burden compared to the other sampled herds. The impact of this parasitic disease on the fluctuations of caribou abundance remains unclear. Nevertheless, the relationship between *B. tarandi* and caribou merits further investigation, specifically in light of a changing Arctic environment with increase temperatures, hence of potential vectors.

Title: Anatomic Distribution of Besnoitia tarandi Cysts in Barren-Ground Caribou (*Rangifer tarandus*): Implications for Diagnosis and Monitoring

Principal Investigators and Contributing Researchers**:** Guy Beauchamp, Susan Kutz, Manon Simard, Brett Elkin, Bruno Croft, Joëlle Taillon, Steeve D. Côté, Vincent Brodeur, Mitch Campbell, Dorothy Cooley, Christine Cuyler and Stéphane Lair

Graduate Student: Julie Ducrocq

Affiliated Organizations: Université de Montréal; University of Calgary; Makivik Corporation, Nunavik Research Center; Government of the Northwest Territories, Nunavik Research Center; Université Laval, Ministère des Ressources naturelles et de la Faune; Government of Nunavut, Department of Environment; Yukon Department of Renewable Resources, Greenland Institute of Natural Resources

Sponsoring Institutions: CircumArctic Rangifer Monitoring and Assessment Network (CARMA)

Regions: Rivière-aux-Feuilles (Northern Québec) and Rivière-George (Northern Québec and Labrador), Akia-Maniitsoq and Kangerlussuaq-Sisimiut (Greenland), Bathurst (NT and NU), Bluenose West (NT and NU), Porcupine (AK and YT) and Southampton Island (NU)

Research Category: Other: Health and Disease

Anticipated Date of Completion: April 2010

Abstract: Although *Besnoitia tarandi* appears to be a significant parasite in reindeer and caribou populations worldwide, the monitoring of this parasite has not been standardized. Our objectives were to (i) determine which of four anatomical sampling sites had the highest probability of detecting parasitic cysts in caribou and (ii) to evaluate the relative sensitivity and specificity of *in-situ* macroscopic assessment of these areas compared to their microscopic evaluation. The conjunctiva and skin sections from the rostrum, metatarsus and thigh were sampled from 312 harvested caribou. Tissues were fixed in buffered 10% formalin and analyzed microscopically to determine the density of *B. tarandi* cysts in the submucosal or dermal region. *In-situ* macroscopic evaluation of all four sites was performed on 244 of these caribou. Likelihood of detecting *B. tarandi* infection by microscopic examination of the skin from the metatarsus and from the rostrum was statistically similar but higher than for the conjunctiva and thigh. However, *B. tarandi* cyst density was higher in the metatarsus skin section than in all three other tissues (multivariate logistic regression models). The cyst density observed in the metatarsus area was representative of the overall cyst density. Even if macroscopic assessment for *B. tarandi* cysts is not a sensitive method compared to the microscopic analyses, it can still provide some indication of the occurrence of this parasite. Our results suggest that the microscopic evaluation of skin sampled from the metatarsal region could be used as a standardized comparative indicator of the density of *B. tarandi* infection in *Rangifer*.

Title: Population Ecology of Migratory Caribou in Nunavut

Principal Investigators: Mark Boyce, Don Thomas

Contributing Researchers: Mitch Campbell, John Nagy, Andrew Derocher, Mark Lewis

Graduate student: Liv Vors

Affiliated Organizations: University of Alberta

Sponsoring Institutions: Government of Nunavut

Regions: Beverly and Qamanirjuaq caribou herd ranges in Nunavut and NWT

Research Category: Energetics/Nutrition

Anticipated date of project completion: 2011-2012

Abstract: Our research seeks to understand factors that drive changes in the abundance of barren-ground caribou, with a focus on herds in Nunavut, Canada. Our research foci include mechanisms that influence global changes in caribou and reindeer abundance, interrelationships of caribou body condition, environmental factors and population change, and using simulation models to forecast future changes in caribou abundance. We have investigated the influence of pre- and post-conception environmental factors and maternal condition on fetus size in the Beverly herd, and are determining how environmental factors such as insect harassment and winter weather conditions differentially affect body condition of male and female caribou of the Beverly herd.

Finally, we built a stage-structured, stochastic, female-only model for the Qamanirjuaq caribou herd based on vital rates collected via radio telemetry from the early 1990s to present to project population change under climate change scenarios and explore different harvest scenarios.

Title: Blood-on-filter-paper for Monitoring Caribou Health: Efficacy, Community-based Collection, and Disease Ecology in Circumpolar Herds

Principal Investigator: Susan Kutz

Contributing Researchers: Carl Ribble, Brett Elkin, Wendy Hutchins, Klaus Nielsen, Robbin Lindsay, Alasdair Veitch, Mitch Campbell, Debbie Jenkins

Graduate Student: Patricia Curry

Affiliated Organizations: University of Calgary; Environment and Natural Resources, Government of NWT; Canadian Food Inspection Agency, Ottawa; Public Health Agency of Canada, Winnipeg; Dept of Environment, Government of NU; CircumArctic Rangifer Monitoring and Assessment Network (CARMA)

Sponsoring Institutions: NSERC IPY, NSERC Northern Research Internship,CIHR – Nasivvik Centre for Inuit Health and Changing Environments, Alberta Innovates Technology, CircumArctic Rangifer Monitoring and Assessment Network, INAC - Northern Scientific Training Program, Arctic Institute of North America, U of Calgary

Region: Circumpolar North – in particular, barren-ground caribou ranges of North America and Greenland Fieldwork: Baffin Region, NU and Sahtu Settlement Region, NT

Research Category: Other: Health and Disease

Anticipated Date of Completion: 2012

Abstract: Several barren-ground caribou (*Rangifer tarandus* ssp.) herds in North America are in severe, concurrent decline. A complex of drivers is likely involved and infectious disease may be contributing, but there are major scientific knowledge gaps regarding disease in caribou. Caribou are a valued affordable food source and icons of hunting culture for many Northerners; thus, human health is tied to caribou health and zoonotic diseases (those transmissible to humans, such as brucellosis) are of concern. This project examines blood collected on filter paper (FP) as a method for pathogen detection and monitoring in caribou. FP blood sampling is established in human medicine and seems ideal for the punishing field conditions that wildlife researchers face, yet validation for wildlife species is lacking.

This research has three goals:

1) Evaluate the efficacy of dried caribou blood on FP for detecting pathogen exposure;
2) Implement and assess uptake of hunter-based FP sampling in northern communities;
3) Conduct epidemiological analyses on herds using blood samples and a multi-herd dataset collected by the Circum Arctic Rangifer Monitoring and Assessment Network (CARMA) during International Polar Year.

In Phase I, blood on FP has been validated for detection of exposure to nine pathogens in *Rangifer*. In Phase II, hunter FP collection was introduced to communities in Baffin Region, NU in 2008. This built on an earlier pilot program that was initiated with hunters in Sahtu Region NWT in 2003-2005. To evaluate perceptions and uptake of caribou FP sampling and to compare regional differences, 30 semi-structured interviews have been conducted with harvesters and other stakeholders in the Western, Eastern, and High Arctic. In 2011-12, interview data will be analyzed and diagnostic results for hunter-collected FPs will be reported back to communities in person. In Phase III, results of testing for nine pathogens in seven circumpolar barren ground caribou herds will be analyzed. The seroprevalence data will provide current baseline disease information, and epidemiological analysis incorporating abiotic and biotic factors will generate new knowledge about disease ecology in arctic caribou. FP sampling could potentially facilitate caribou disease surveillance throughout Canada and the world. This would inform caribou management, help safeguard public health for Northerners, and help gauge impacts of climate change and other anthropogenic disturbances.

Title: Identity, Distribution and Life History of the 'Serendipity Worm' (Nematoda; Protostrongylidae): a New Parasite of Ungulates in High Latitudes of North America

Principal Investigator: Susan Kutz

Contributing Researchers: Eric P. Hoberg, Manon Simard, John S. Gilleard

Graduate Student: Guilherme G. Verocai

Affiliated Organizations: US National Parasite Collection, US Department of Agriculture; Makivik Corporation; University of Calgary; Biologists and veterinarians from across Canada, Alaska, and Greenland for contributing fecal samples

Sponsoring Institutions: NSERC, NSERC IPY, CircumArctic Rangifer Monitoring and Assessment Network (CARMA), Faculty of Veterinary Medicine, University of Calgary

Regions: Range distribution of caribou, muskoxen and northern range of moose in North America, as well as introduced reindeer in Alaska and Northwest Territories

Research Category: Other: Health and Disease

Anticipated Date of Completion: August 2013

Abstract: In 2007, a previously unknown nematode species in the family Protostrongylidae was serendipitously discovered infecting three caribou subspecies (*Rangifer tarandus caribou, Rangifer tarandus groenlandicus, Rangifer tarandus grantii,*), the Yukon-Alaska moose, and muskoxen from Alaska to Labrador, including the Yukon, Northwest Territories, Nunavut and Quebec. This novel parasite was molecularly characterized based on the second internal transcript spacer (ITS-2) sequence of larvae from faeces of those ungulates and was proven quite distinct from other protostrongylid species. Pathological effects caused by the novel species on definitive hosts are still unknown, but other protostrongylid species are important parasites of wild ungulates and can cause significant pulmonary, muscular and neurological diseases. Protostrongylids have an indirect life cycle, requiring gastropod intermediate hosts for development, a temperature-dependent process proven to be highly influenced by climate change.

This project has three objectives:

1) Provide the taxonomical description of the new species;
2) Establish its lifecycle in captive reindeer;
3) Delineate geographic and host distribution; and
4) Explore parasite population structure and phylogeography.

In 2010, adult worms were isolated from lungs of muskoxen in Kuujjuaq (QC). The material was examined, and the new species was assigned to the genus *Varestrongylus.* A manuscript on the new species description is in preparation. Preliminary results on geographic distribution have shown that this parasite is present in five additional barren ground or migratory woodland caribou herds in Canada and a muskox population on an Arctic island, resulting in a broader geographic range than originally described. We hypothesize that it is present in woodland caribou populations from various Canadian provinces and territories.

This study will provide a better understanding of geographic and host range of this and other protostrongylids parasitic on North American ungulates. Knowledge on its biology is essential to determine its potential role in host health and, ultimately, implications of climate change on host-parasite interactions. Finally, information on its phylogeography will provide insights on its co-evolution with different mammal hosts, and potentially on caribou historical distributions.

Title: Impact of Climate Change on the Transmission Dynamics of *Ostertagia gruehneri,* an Abomasal Parasite of Barren-Ground Caribou

Principal Investigator: Susan Kutz,

Contributing Researchers: Kathreen Ruckstuhl, Bruno Croft, Brett Elkin, Peter Molnar, Andy Dobson

Graduate Student: Bryanne M. Hoar

Affiliated Organizations: University of Calgary; Environment and Natural Resources, Government of Nortwest Territories, Princeton University;

Sponsoring Institutions: NSERC, NSERC IPY, NSERC Northern Internship, Alberta Innovates Technology Arctic Institute of North America, Canadian Northern Studies Trust, Faculty of Science, University of Calgary, CircumArctic Rangifer Monitoring and Assessment Network (CARMA)

Region: Focus on Bathurst caribou herd. Field work was completed at the Tundra Ecosystem Research Station (TERS), Daring Lake, NT

Research Category: Other: Health and Disease

Anticipated Date of Completion: 2011

Abstract: This research will investigate the impacts of climate and climate change on the transmission of *Ostertagia gruehneri* in barrenground caribou. *Ostertagia gruehneri* is the most common gastrointestinal nematode in caribou and can cause decreased food intake, weight loss, and reduced pregnancy rates in reindeer. Adult parasites in the abomasum produce eggs which are shed in the feces and development and survival of eggs to the infective third larval stage (L3) depends on climatic conditions, primarily temperature and humidity. A combination of laboratory and field experiments quantified the impact of different climatic conditions on the development and survival of the free-living stages of *O. gruehneri*. Experimental infections of captive reindeer and a muskox with *O. gruehneri* investigated the impact of different conditions on the development of larvae once ingested by the host. This data will be used to develop and validate transmission models for this parasite

This project has three objectives:

1) Determine development and survival rates of *O. gruehneri* under natural conditions on the tundra;
2) Quantify development and survival rates of *O. gruehneri* through a series of laboratory experiments;
3) Determine factors contributing to the development of larvae once ingested by the host; and
4) Develop and validate transmission models for *O. gruehneri*.

The results from this study will further our understanding of the transmission dynamics of *O. gruehneri* in barren ground caribou herds and will identify potential impacts of climate change on this host-parasite system. These results will be transferrable to other caribou and reindeer herds across the globe and the methodologies and concepts developed from this work will be applicable to other host-parasite systems.

Title: Climate Change and Parasitic Invasions of High Latitude Ecosystems: the Winter Tick as a Model

Principal Investigator: Alessandro Massolo

Contributing Researchers: Susan Kutz, Brett Elkin, Alasdair Veitch, Greg McDermid, Tim Lysyk, Doug Colwell

Graduate Students: Cyntia Kayo Kashivakura, Rachel Cullen, Tracy Wyman

Affiliated Organizations: University of Calgary; Environment and Natural Resources, Government of NWT; Lethbridge Research Centre, Agriculture and Agri-Food Canada

Sponsoring Institutions: Cumulative Impact Monitoring Program, Indian and Northern Affairs Canada, Sahtu Renewable Resource Board, University of Calgary

Region: Northwest Territories, with a particular focus on the Sahtu Settlement

Research Category: Other: Health and Disease

Anticipated Date of Completion: 2015

Abstract: The Canadian North is changing at an unprecedented rate because of climate change, increased resource exploration and development, and rapid social change. Climate warming at approximately twice the global rate is implicated in the northward advancement of shrubs and the tree line, changing plant communities, earlier onset of spring vegetation phenology and lengthened growing season. Climate change can directly affect the ecology and phenology of ticks, ectoparasites of species such as moose and woodland caribou. Ticks feed on blood and tissue fluids and, in large numbers can cause debilitating disease, with the potential to transmit a wide range of pathogenic agents to animals and humans. Because tick distribution is strongly affected by environmental conditions, gaining a better understanding of their ecology and distribution can provide information about the impact of climate change at these latitudes. In this research program the Winter Tick (WT) *Dermacentor albipictus* will be used as a model for investigating climate change and parasitic invasions. This tick is typically distributed at high latitudes and has a relatively simple life cycle (one host). Although the WT is not a known vector for any disease, severe WT infestation, as is the case for the moose, can lead to mortality due to anemia, hair loss and skin exposure during winter. With our work we aim to use the WT as a model to study the effects of climate change on ectoparasite ecology and on host-parasite dynamics at high latitude ecosystems by:

1. Delineating the northern limits of WT distribution;
2. Modelling climate change impacts on WT ecology and distribution in northern latitudes; and
3. Assess the impact of climate change on WT host communities.

We believe that using the relatively simple WT system as a model, and an inter-disciplinary approach (parasitology, climatology, geography, math modelling) will allow a better understanding of how climate may affect host-parasite-habitat relations at these latitudes, and the potential risk of new parasitic invasions, particularly for keystone species such as barren-ground caribou, which are of tremendous socio-economic value in northern communities where they are relied upon for survival.

Title: Season and Temporal Variation in Bone Density in Caribou (*Rangifer tarandus*)

Principal Investigator: Douglas Whiteside

Contributing Researchers: Steven Boyd, Eva Szabo, Susan Kutz, Brett Elkin, Ryan Brooks

Affiliate Organizations: Calgary Zoo, University of Calgary

Sponsoring Institutions: CircumArtic Rangifer Monitoring & Assessment Network (CARMA), Devon Energy, Calgary Zoo

Region: Northwest Territories, Greenland

Research Category: Other: Health and Disease

Anticipated Date of Completion: December 2011

Abstract: Caribou are a keystone species in the northern Canada, serving as an important biological indicator for climate change, and an important source of food for carnivores and people. Observations by biologists and veterinarians working with free ranging caribou populations indicated female caribou with calves have a perceived higher prevalence of fractures compared with other females, young caribou or males, which has prompted this research project. Osteoporosis has been reported in other cervid species, and has been associated with malnutrition in moose calves and mineral deficiencies in Tule elk. In other mammalian species, osteoporosis

is linked to malnutrition (especially protein and calcium), vitamin C deficiency, mineral imbalances (especially copper), and exposure to organochlorines. In human women, bone mineral density decreases 1-4% during pregnancy independent of calcium intake

Utilizing metatarsal bones that are collected at harvests, this research will assess for temporal and seasonal variations in bone density in caribou. This collaborative project will evaluate bone density via a number of methods including quantitative microcomputed tomography and absolute bone mineral compositional analyses on the collected metatarsal bones from caribou from all age classes and gender, and at different stages of lactation in females. Bone bending stiffness will be computed based on the CT data. Regional variation also will be assessed by comparing samples from the Northwest Territories and Greenland, which may lead to further exploration of native habitat nutrients.