The purpose of this Annual Progress Report is to communicate progress and achievements of your research project over the funding period and identify impacts or outcomes of the project. Information from this progress report is required to assess the final progress of the project in relation to the Recipient Agreement and to provide information required for FII Ltd. to report on annual achievements and funding investments for the Forest Research Program. Complete the required information in the unshaded text boxes for **Parts A to C**, (text boxes will expand).

Part A: General Project Information

The information provided under Part A will be available for immediate posting on the Internet in a project repository on the Natural Resources Information Network (NRIN) website.

Project No:	R04-095, R04-025
Organisation:	Minsitry of Forests Research Branch
Project Contact:	Dr. Bruce McLellan
Address:	RPO#3, Box 9158, Revelstoke, B.C. V0E 3K0
Phone No.	(250) 837-7767
Email:	Bruce.mclellan@gems9.gov.bc.ca
Project Title:	
Quantifying forest stand and landscape attributes that influence mountain caribou habitat fragmentation.	
Final Project Abstract:	
Mountain caribou are considered threatened by COSEWIC and the Species at Risk Act has highlighted the significant implications of mountain caribou conservation. This project will address mountain caribou habitat fragmentation at two spatial scales. Using existing GPS collar data and data obtained from animals collared this year with FII funding plus snow trailing data, we will test if regenerating cut-blocks or other young forests block caribou movement and if so, what management prescriptions can reduce this barrier. At a larger scale of fragmentation, we will test if mountain caribou act as a meta-population and how does the level of fragmentation affect population viability. With last years FII funding we purchased ear-tag transmitters to put on 8-month-old caribou to quantify natal dispersal as well as mortality rates and causes. We also initiated the development of a mountain caribou nDNA database that will be used to estimate recent gene flow among subpopulations.	
Keywords:	
Mountain caribou, corridors, fragmentation, dispersal, GPS telemetry, GIS analyses, population viability, habitat selection, intensive forestry	

Part B: Project Impacts, Outcomes, Progress, and Extension

Information provided in Part B is used to evaluate and assess the completion of the project in relation to the terms and workplan outlined in the Recipient Agreement and assess the impacts and outcomes of the project.

B1: Workplan and Annual Progress Summary:

Using the table below, describe the extent to which the activities and objectives identified in the workplan (Schedule A Recipient Agreement) were achieved. Indicate any changes from the original plan in bold, and indicate date of approval and brief rationale for the change. Please list extension activities and deliverables in table B5 below("**Outputs, Deliverables, and Extension")**

Project Component or Objective	Activities (Tasks)	Extent to Which Activities have been Completed and Objective has been Achieved
Radio-collar and ear-tag transmitter deployment	Capture caribou and remove old GPS collars and put on new GPS and VHF radiocollars and ear-tag transmitters	In March 2003, 12 VHF ear tag transmitters were put on calves, 2 VHFcollars and 13 GPS collars were put on adult caribou and 3 GPS collars were removed. In March 2004, 8 expandable, VHF collars were put on calves, 8 VHF and 5 GPS collars were deployed on adult caribou and 5 GPS collars removed. Because of expanded objectives for the 2004-05, we also collared 17 moose and 6 wolves. nDNA from 165 caribou have been analysed and alleles from 10 loci identified. Tissue from the 16 animals newly captured in 2004 have been sent to the lab for analysis.
Telemetry data collection	Locate caribou from aircraft and investigate moralities	Caribou were located 850 times from aircraft and many thousands of GPS locations were also obtained. Ten animals died and the site of death was investigated.
Caribou use of young forest field work	When caribou are located in or near young forests from the aircraft, crews will be dispatched to investigate the sites on the snow	Data from 208 plots along 8 transects were recorded.

Paper – caribou site fidelity.	Has been submitted. Will need revisions	Postponed because other papers were thought to be more important at this time. Papers that were written include: 1. Underlying mechanisms of the decline of an endangered large herbivore, 2. The role of predation on the decline and extirpation of woodland caribou populations, and 3. A population viability analysis of mountain caribou: the effects of inverse density dependence.
Paper – demography on mountain caribou	Finish writing and submit paper and then review and modify	Has been submitted and waiting reviews.
Paper – Factors influencing fragmentation	Analysis and writing	Has been written, almost ready to submit.
Annual Report – Within home range fragmentation	Analysis and writing.	Initial analysis done, but because many GPS collars are still on caribou collecting data, a final analysis is premature.
Extension.	Be readily available to operational staff and agency executive and be on appropriate committees	Provided dozens on consultations, and participated in > 50 meetings related to landuse and mountain caribou in 6 Forest Districts.

B2: Research Question:

Restate the research question as per your original proposal and comment on the extent to which your research question has been answered during the current funding period.
Do forest plantations and other young forests block caribou movement and if so why, and do mountain caribou act as a meta-population? We have determined that, out of many competing models, that the amount and distribution of forests of 40 – 100 years of age best predicts low survival rates of adult females and where caribou once were, but no longer are found (two largely independent papers that we have prepared demonstrate this relationship). As we expected after one field season, our site investigations of caribou use of these younger stands (they rarely use these forests) have not yet provided conclusive results. Similarly, the movements of the 20 calves that have been radio-collared has not yet provided conclusive information on the metapopulation dynamics of mountain caribou. And, although we now have mico-satellite data from 165 caribou in our database, and a graduate student has been given the task of conducting a spatial analysis of these data, a detailed analysis of the short and longer-term metapopulation structure that has not yet been done.

B3: Impacts and Outcomes:

Describe the impacts and outcomes of the research and how the research has benefited or improved sustainable forest management. Where possible, provide quantifiable outcomes associated with this research (i.e., volume gain in terms of m^3; cost savings due to improved access, etc.).
Results of this years work has clearly shown the linkage between young forests and the increase in predation rates on mountain caribou and that predation is the proximate cause of caribou decline and extirpation. Forest managers from across the interior wet belt (Prince George to the US border) are now focusing more on silvicultural practices to discourage moose and deer population expansion. In addition, hunting regulations to decrease numbers of alternate prey and predators have been instated. The Kootenay-Boundary Landuse plan and the Kamloops LRMP have had major modifications based on the results of this years work. It is not possible to quantify the outcomes of this research in simple terms of m^3, but the management objectives of thousands of forest workers are being changed.

B4: Users and Application of Results:

List the user group and describe the realised or expected benefit of your research (eg, researchers, technical experts, planners, foresters,

practitioners, regulators, decision makers, public). If results or information derived from the research have been used, provide the name of the individual and organisation and describe how the information has been applied.

User/User Group	**Realised/Expected Benefit**
Researchers/Scientific Community	Contributed to the understanding of the extinction process and possible inverse density dependence at low population sizes. Our results have already changed the research paradigm in some areas from how to manage ungulate winter range to improve conditions for elk, deer, and moose to how to manage these ranges to reduce the numbers of these ungulates.
Forest Planners	Have contributed to the re-mapping and guideline modifications of the Kootenay Boundary Land-use plan, the Revelstoke, Minister's Advisory Committee Plan, and the Kamloops LRMP.
Operational Foresters	Have changed harvesting/silvicultural practices in many portions of the interior wet belt.
Environmental NGOs	Informed these groups on efforts being undertaken to ensure mountain caribou persistence
Public	Informed the public on the complex issue of mountain caribou conservation.
Forest Practices Board	Informed the FBP on the complexity of mountain caribou conservation and the efforts being undertaken to ensure their persistence
MOF, MSRM, WLAP Regional and Victoria Executive	Provided information on the complexity of mountain caribou conservation and the efforts being undertaken to ensure their persistence
Other industries and activities (snowmobliling, heli-skiing, hunting)	Have modified their behaviour in occupied mountain caribou habitat

B5: Outputs, Deliverables, and Extension

List the deliverables or extension products developed from the research during the 2003/04 funding period. Please identify a) the type of deliverable (TYPE), b) the deliverable citation, and c) whether it is (Y) or is not (N) included as part of this Annual Progress Report submission (INCL).

TYPE	CITATION	INCL (Y/N)
JOU	Wittmer, H.U., B.N. McLellan**,** D.R. Seip, J.A. Young, T.A. Kinley, G.S. Watts and D.H. Population dynamics of the endangered mountain ecotype of woodland caribou (*Rangifer tarandus caribou*) in British Columbia, Canada. *Submitted*. Canadian Journal of Zoology.	Abstract
TEC	Furk, K. 2004. Mountain Caribou Habitat Use in the Salmon Arm Forest District: 2000-2003: Preliminary Report #2	N
JOU	Apps, C.D, and B.N. McLellan. Factors influencing the dispersion and fragmentation of endangered mountain caribou populations. Conservation Biology. (in prep)	Abstract
TEC	Pearce, C., B.N. McLellan, and R.Serrouya. Compilation of Information Related to the Sub-populations of Mountain Caribou Inhabiting the Area North of Highway 1 within the Columbia Forest District	N
JOU	Wittmer, H.U., F.W. Hovey, and B.N. McLellan. Factors influencing variation in site fidelity of mountain caribou (*c*) (in prep)	Abstract
TEC	McLellan, B.N., J. Hooge, J. Flaa. Population censuses of caribou in the Columbia Forest District 1994-2004	N
JOU	Wittmer, H.U. and B.N. McLellan. The role of predation in the population decline and extirpation of woodland caribou, Canadian Journal of Zoology. (in prep)	N
JOU	Wittmer, H.U., A.R.E. Sinclair, and B.N. McLellan. Population decline and predation in woodland caribou: evidence for inverse density dependence (in prep, intended for Proceedings of the Royal Society of London)	N
OTH	Wittmer, H.U. Mechanisms underlying the decline of mountain caribou (*Rangifer tarandus caribou*) in British Columbia, Ph.D. Thesis, UBC	Abstract
POS	Wittmer, H.U., and B.N. McLellan. Viability of a declining mountain caribou population: the influence of population fragmentation (in prep)	N
ORA	McLellan, B.N. Mountain caribou ecology and forest management in British Columbia	N.
TEC	Lewis, D. Analysis of stand attributes associated with caribou foraging intensity from the 2001-2003 early winter caribou backtracking data	N
ORA	Wittmer, H.U. and B.N. McLellan. Cause & mechanism of decline of mountain caribou in British Columbia	N

Deliverable Type Legend

TYPE	OUTPUT DESCRIPTION	TYPE	OUTPUT DESCRIPTION
TEC	Technical Report	FGM	Field Guide or Manual
JOU	Peer Reviewed Journal Article	ORA	Oral Presentation

EXT	Extension Note or Newsletter Article	POS	Poster Presentation
NEW	Newsletter	WEB	Website
BOK	Book or Book Chapter	OTH	Other

Part C: Additional Project Information

Information provided in Part C will be used to report out on the overall investments of the Research Program during the 2003/04 funding period.

C1: Multi-year Projects: If the project is part of a multi-year research initiative, indicate in the statement below where the current funding period (2003/04) lies within the longer term research program:

The 2003/04 fiscal period represents year _1_ of a _6_ year research program/project.

C2: Research Focus: Select (by placing an X in the preceding box) the primary category that would best categorize the focus of research

	Silvicultural Systems - (harvesting systems – shelterwood, clear-cut, etc.)		Natural Disturbance Dynamics (fire, wind, etc.)		Site Rehabilitation and Restoration
	Growth and Yield (modeling, site index work)		Ecosystem Dynamics (classification, inventory, PEM, ecosystem research)		Forest Genetics
X	Biodiversity/Habitat Management (SAR, habitat requirements, habitat supply modeling)		Wood Quality (assessment, wood properties and potential applications)		Other – Please specify
	Forest health (pests and pathogens)		Soil Conservation, Health, and Productivity		
	Riparian and Aquatic Management (buffers, CWD)		Integrated Resource Management (land use planning)		

C3: Biogeoclimatic Ecosystem Classification: Identify (by placing an X in the preceding box) the BEC zone(s) to which the research applies.

X	Alpine Tundra	X	Engelmann Spruce-Subalpine Fir		Ponderosa Pine
	Boreal White and Black Spruce	X	Interior Cedar-Hemlock		Spruce-Willow-Birch
	Bunchgrass		Interior Douglas-Fir		Sub-Boreal Spruce
	Coastal Douglas-Fir		Montane Spruce		Not applicable
	Coastal Western Hemlock		Mountain Hemlock		

C4: FII's Objectives and Strategies: With respect to FII's objectives and strategies listed below, identify (by placing an X in the preceding box) which of the following strategies best represents the overall objective and approach of your research project.

Objectives and Strategies	
Objective: To support more effective policies, regulations, and guidelines	
x	Support policy, regulatory and guideline development, evaluation and adjustment
x	Enhance quality of decision making through improved knowledge base
x	Empowered decision makers to employ practical adaptive management approaches
x	Support greater certainty in planning and decision making for all forest resources values
Objective: To enhance the value of timber and forest land assets	
	More effective and efficient use of forest resources
	Reducing costs of timber production
	Reducing forest health risks through improved management practices
	Enhancing timber quality and resulting products
	Increasing available volume and value through productivity enhancements, increased utilisation and better realisation of inherent site potential
	Increasing available timber volume through management of access constraints
Objective: To improve stewardship and market acceptability of BC forest practices and forest products	
x	Promoting new or adapted forest practices which give BC an edge in the world forest product marketplace
x	Improving sustainable forestry practices in terms of planning, management, monitoring, analysis, reporting and adjustment
x	Enabling and accelerating certification practices

ABSTRACTS OF PAPERS

Population dynamics of the endangered mountain ecotype of woodland caribou (*Rangifer tarandus caribou*) in British Columbia, Canada

Heiko U. Wittmer, Bruce N. McLellan, Dale R. Seip, James A. Young, Trevor A. Kinley, Glen S. Watts and Dennis Hamilton

Abstract: We used census results and radiotelemetry locations of >350 collared individuals sampled over the entire distribution of the endangered mountain ecotype of woodland caribou (*Rangifer tarandus caribou*) in British Columbia, Canada, to delineate population structure and document the size and trend of the identified populations. We also describe the spatial pattern of decline, causes and timing of adult mortality and provide estimates of vital rates necessary to develop a population viability analysis. Our results indicate that the abundance of mountain caribou in British Columbia is declining. We found adult female annual survival rates below annual survival rates commonly reported for large herbivores. The major proximate cause of population decline appears to be predation on adult caribou. Spatial patterns of population dynamics revealed a continuous range contraction and an increasing fragmentation of mountain caribou into smaller, isolated populations. The population fragmentation process occurs at the outer boundaries of the current distribution as well as at the core of the population. Our results indicate that recovery strategies for mountain caribou should be directed at factors contributing to the fragmentation and isolation of mountain caribou populations as well as management strategies aimed to increase adult survival.

Mechanisms underlying the decline of mountain caribou *(Rangifer tarandus caribo*u) in British Columbia

Heiko U. Wittmer

Abstract: The distribution and abundance of mountain caribou *(Rangifer tarandus caribo*u) in British Columbia has declined. High predation rates as a consequence of forest management and associated changes to the relative abundances of alternate ungulate prey species have been proposed to cause the population declines. A direct link between changes in the forest age structure and declining caribou population trends, however, is lacking. Understanding the underlying mechanism of the population declines necessary to develop recovery strategies aimed at maintaining a viable mountain caribou population.

I synthesized demographic and radiotelemetry data from separate studies initiated over the entire distribution of mountain caribou between 1984 and 2002. My primary goal was to use a comparative approach among identified subpopulations to distinguish between three potential repercussions of forest management (food regulation, predation-sensitive foraging, and predation) that might explain the observed declining population trends. I used information on caribou density per area of forests >140 years within

subpopulation ranges and cause of mortality to differentiate between the potential repercussions. Predation was the primary cause of caribou mortality over the entire distribution of mountain caribou. In addition, I found increasingly negative rates of increase as caribou density per area of forests >140 years declined (i.e. inverse density dependence). Both results were consistent with the hypothesis that the decline of mountain caribou is caused by high predation rates.

I then quantified the influence of demographic parameters on subpopulation trends and identified environmental factors correlated with variation in these demographic parameters among subpopulations. My results indicated that differences in subpopulation trends were best explained by differences in female adult survival rates. Female adult survival rates were negatively associated with increasing amounts of young forest stands and thus high proportions of suitable habitat for alternate prey species. Thus, my data supports the mechanistic link between the amount of habitat characteristics suitable for alternate ungulates and decreased survival of adult female caribou.
Finally, I carried out a population viability analysis for mountain caribou. My results indicate that mountain caribou are likely declining to extinction over the majority of their distribution within <100 years.

Factors influencing the dispersion and fragmentation of mountain caribou populations

Clayton D. Apps and Bruce N. Mclellan,

Abstract: Mountain caribou, an ecotype of woodland caribou, are endangered due to the loss and fragmentation of old forests on which they depend. However, a wider array of natural and human factors may limit caribou persistence and isolate populations, and understanding these may help to stop or reverse population declines by forecasting risk and targeting core areas and key linkages for protection, enhancement or restoration. Across most of their historic range, we conducted a bi-level analysis to evaluate factors related to the persistence of, and landscape occupancy within, mountain caribou subpopulations. We used caribou location data from 245 radio-collared animals across 13 subpopulations to derive a landscape occupancy index, while accounting for inherent sampling biases. We analyzed this index against 33 landscape variables of forest overstory, land cover, terrain, climate, and human influence. At level 1, subpopulation persistence was explained by the extent of wet and very wet climatic conditions, the distribution of both old (>140 yr) forests, particularly of cedar and hemlock composition, and alpine areas. Other important factors were remoteness from human presence, low road density, and little motorized access. At level 2, caribou landscape occupancy within subpopulations was explained by the distribution of old cedar/hemlock and spruce/subalpine fir forests and the lack of deciduous forests. Other factors impeding population contiguity were icefields, non-forested alpine, hydro reservoirs, extensive road networks, and primary highway transportation routes. Model outputs at both levels were combined to predict the potential for mountain caribou population persistence, isolation, and restoration. We combined this output with the original occupancy index to gauge the potential

vulnerability of caribou to extirpation within landscapes known to have recently supported animals. We discuss implications as they pertain to range-wide caribou population connectivity and conservation.

Factors influencing variation in site fidelity of mountain caribou (*Rangifer tarandus caribou*)

Heiko U. Wittmer, Fred W. Hovey and Bruce N. McLellan

Summary

1. Movements and space use of large herbivores in mountainous and temperate regions enhance access to areas with high food quality and availability while reducing predation risk. Where predation is a major limiting factor, it has been postulated that woodland caribou (*Rangifer tarandus caribou* Gmelin) reduce movement rates to minimize contact with alternate prey species and predators and that reduced movements result in increased site fidelity.

2. We examined site fidelity of an ecotype of woodland caribou referred to as mountain caribou based on locations of 67 radiocollared individuals in a population in British Columbia, Canada. We used average linear distances between all possible pairs of radiolocations of individual caribou within and among years to assess seasonal site fidelity. Because mountain caribou are vulnerable to predation during calving, and when their ranges overlap with their main predators during summer, early winter, and spring but are not vulnerable during late winter, we tested the hypothesis that caribou site fidelity is correlated with predator avoidance.

3. Inter-year interlocation distances were similar to intra-year interlocation distances during calving, summer and spring, indicating that caribou did not shift their distribution during seasons where they are considered most vulnerable to predation. We did not find a correlation between intra-year interlocation distances and survival during the summer season when the majority of predator caused mortalities on adult animals occurred.

4. Inter-year interlocation distances were significantly greater than intra-year interlocation distances during both early winter and late winter indicating that individual caribou shifted their distribution among winters. The amount that an individual's distribution shifted among winters varied among individual animals and within individuals over different years. During early winter this behavioural plasticity was correlated with average seasonal snow accumulation with individuals moving further in years with high snow accumulation.

5. Our results indicate that site fidelity outside the calving and breeding season is unlikely solely influenced by predator avoidance. We suggest that seasonal shifts in the importance of limiting factors varies from predation to food, and, when combined with the social structure of caribou, results in variability of site fidelity in these large herbivores.