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CARIBOU DATA SYNTHESIS—PROGRESS REPORT

Overview of the Status of Woodland Caribou in Insular Newfoundland: Research Methodology, Results, Interpretations and Future Projections

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Department of Environment and Conservation

Shane P. Mahoney & Jackie N. Weir

Newfoundland Labrador

For a hard copy or electronic version of this report please direct request to:

Manager of Communications/Outreach
Sustainable Development and Strategic Science Branch
Department of Environment and Conservation
P. O. Box 8700
St. John's, NL
A1B 4J6

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Overview of the Status of Woodland Caribou in Insular Newfoundland: Research Methodology, Results, Interpretations and Future Projections

Shane P. Mahoney
Executive Director, Sustainable Development and Strategic Science

and

Jackie N. Weir
Research Manager, Institute for Biodiversity, Ecosystems Science, and Sustainability

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EXECUTIVE SUMMARY

With the striking exception of insular Newfoundland, woodland caribou are listed as Threatened or Endangered throughout North America. In the last decade, however, insular Newfoundland has experienced a dramatic downturn in its caribou population. The *Caribou Data Synthesis* was initiated in 1996 in an effort to describe and understand the dynamics of caribou in insular Newfoundland. This systematic compilation, analysis and interpretation of all available data has revealed that caribou numbers are declining rapidly in association with changes in population sex and age structure and body size. In particular, calf survivorship has decreased dramatically over the past decade. The *Caribou Data Synthesis* is an ongoing project which continues to explore existing data and incorporate new information to enrich our understanding of the dynamics of caribou on the island of Newfoundland.

The *Synthesis* provides several significant conclusions:

1. Caribou herd distribution and fidelity to calving ranges changed significantly by the mid-1990s.
2. Population size has declined rapidly—overall a 60% decline in the past decade. Modeling indicates that this decline is likely to continue in the next five years, with or without harvesting.
3. Recruitment—the addition of young animals to the population—declined from 25–30% in the 1980s to less than 10% in most herds in recent years. Since 2003, over 80% of radio-collared calves died during the first six months of life and predation was the primary cause of death.
4. Calf production (birth rate) has declined marginally for some herds since the 1980s and requires continued monitoring.
5. The proportion of adult males has declined significantly since the late 1980s, likely exacerbated by our male-biased harvest regulations.
6. The population has aged as a result of very few young animals being recruited to the population.
7. Antler size in males, birth weight of calves, and adult jawbone size has declined, and in many cases significantly.
8. Hunter success rate has decreased from 80–85% in the late 1980s to less than 60% in 2005 and has resulted in harvest restrictions. Since 2005, success rate has improved slightly.
9. Both recreational human disturbance and industrial development have been intensively studied and confirm caribou avoidance responses believed sufficient to negatively affect caribou survival.
10. Island-wide compilations of historical weather data as well as long term climatic changes are indicating that climate may be contributing to changes in caribou body size.

Collectively, these demographic and morphological trends indicate that we are facing a serious situation. The current body of evidence clearly indicates that if declining trends in calf survivorship are not arrested or reversed, caribou of insular Newfoundland will fall through a predictable series of declines and designations, ultimately leading these populations to join those of the rest of the continent in being classified under federal and provincial statutes as Threatened or Endangered. The consequences for the sustainable development of resource-based economies of forestry, mining, outfitting, energy development, and adventure tourism are unknown but significant in magnitude to both the province as a whole and to rural Newfoundland especially.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PURPOSE

The intent of this document is:

1. To provide an accessible overview of the background and analytical findings of the *Caribou Data Synthesis*.
2. To provide current interpretation of long term patterns in caribou population dynamics, body morphology, and distribution.
3. To present a synopsis of five years of recent research into patterns of juvenile caribou mortality and compare this to historical trends, shedding light on the most influential and potentially redeemable cause of the current decline.

It is important to note that analyses and interpretations are released regularly as peer-reviewed publications in leading scientific journals (Product List). Work is ongoing, however, and figures and analyses are regularly updated as new data become available, and predictions are modified accordingly.

INTRODUCTION

Consistent with Sustainable Development and Strategic Science's mandate to explore sustainability issues within an empirical context, the *Caribou Data Synthesis* effort has followed the approach of data compilation, thorough analysis, determination of knowledge gaps, and stimulation of new research. Woodland caribou have been the focus of extensive research by the Government of Newfoundland and Labrador since the mid 1950s. The *Caribou Data Synthesis* was initiated in 1996 and involved a systematic compilation and evaluation of all data available for insular woodland caribou. Through these quantitative analyses, significant declines in caribou body size, numbers, and calf survival were evidenced. These findings led to new questions surrounding the causes of these patterns, rate and timing of calf mortality, and its role in the observed population decline.

To address these questions, the *Calf Mortality Study* was implemented in 2003 on three caribou herds. Consistent with the methodology of calf survival assessments conducted from the 1970s through the mid-1990s, calves were radio-collared to determine the cause, rate and timing of calf death. Synchronously, we continued to conduct Herd Composition Surveys, which provided an assessment of calf recruitment rates (indicative of calf survival and mortality rates) for other herds, verifying that all herds were subject to serious declines in calf survivorship.

In 2006, with confirmation from the composition surveys that while birth rates were only marginally reduced, calf recruitment was extraordinarily low and results from the *Calf Mortality Study* indicated that predation was the overwhelming proximate cause of mortality in all herds studied, we proposed a predator management strategy based upon the best scientific practices recommended by the National Resource Council (1997), and using protocols sanctioned by the international Wildlife Society. While

awaiting a funding decision, we continued the data analyses, report preparation, and field research in an effort to provide a basis for future management strategies. Furthermore, the Institute for Biodiversity, Ecosystem Science and Sustainability (IBES) engaged an elite academic team of wildlife specialists to lead and undertake a more detailed program of research on all aspects of predator-caribou interactions and predator ecology. This approach ensures that international scientific standards and objective evaluations are brought to bear on our current caribou problem, and provides further assurance to managers with respect to options they might choose in dealing with the issue. This program of research became a major component of Government's *Caribou Strategy 2008–2013*, announced in February 2008.

In the following sections we provide (1) a detailed explanation of the research components employed for the *Caribou Data Synthesis* and the *Calf Mortality Study*, including the herd composition surveys, (2) an overview of research findings and interpretations (up to 2007 where data exists) and (3) future projections for population abundance and demographic trends, and some of their predictable consequences.

RESEARCH COMPONENTS

Caribou Data Synthesis (1996-ongoing)

Insular Newfoundland caribou were extremely rare in the 20th century prior to the 1960s as a result of a massive decline in the late 1800s through early 1900s. From the 1970s until the mid 1990s caribou numbers increased dramatically, but in the last decade there is incontrovertible evidence that a serious reduction in numbers has occurred. Unless positive changes occur, the Newfoundland populations are headed towards Threatened or Endangered listing, similar to all other North American woodland caribou.

Due to the efforts of The Government of Newfoundland and Labrador, the insular woodland caribou population is among the best studied large mammal populations in North America. While considerable work has been done to gauge abundance and to understand the dynamics of these herds, no systematic evaluation of all research findings was previously attempted until the *Caribou Data Synthesis*.

Initiated in 1996, early efforts of the *Caribou Data Synthesis* involved gathering existing information stored in file cabinets and folders in various wildlife office locations, translating thousands of non-digital records from the 1950s through to the early 1990s (census maps and observations, herd compositions surveys, all radio-telemetry data and other herd distribution information, all jawbone and other body size data and age profile data, as well as hunting success rates, kill locations and field observations of caribou while hunting) to digital files, re-tabulating and error checking all data, and presenting the information in basic formats of tables, histograms, pie-charts and descriptive statistical treatments.

Following three years of attentive work, the first volumes of the Synthesis were provided in 2000 and, since then, other volumes have appeared on a regular basis (Table 1). To date, 13 hard-copy volumes have been published and copies have been distributed. In addition, digital cataloguing of more than 55,000 files ensures access to these databases by government departments and other user groups.

Table 1. Timeline of initial preparation and publication of the *Caribou Data Synthesis* volumes.

Year	Volume	Description
1996–1999		Data compilation and analysis
2000	2	Weather patterns in Newfoundland
	5–12	Distribution and movement of individual caribou herds
2001	3	Hunter Submissions: Biological specimens & observations
	4	Diet composition and body condition
2002	14	Population trends
2003	13	Survivorship patterns and causes of mortality

The *Caribou Data Synthesis* provides the only complete review, synthesis and interpretation of information available on woodland caribou on the island. It not only provides interpretation of demographic, morphometric and hunter trend information, but also reviews the impacts of increasing human disturbance and habitat alterations on caribou. Overall, the *Synthesis* provides (1) the supporting empirical evidence for understanding when and why the current decline occurred, (2) scientific assessment of future trends in populations and (3) the basis for developing and guiding possible interventions to assist population recovery.

Our approach has been to analyze both island-wide patterns and individual herd characteristics. By doing so we provide empirical rationale for herd specific management initiatives, while at the same time determining whether herds are synchronized in their spatial and demographic trends. Through these analyses we confirmed the decline in caribou numbers, and identified potential causes, and then initiated the *Calf Mortality Study* in 2003 which has allowed us to apportion the causes of juvenile mortality to various influences, confirming that predation is proximately responsible for the declining calf percentages seen in virtually all herds.

However, the final and certainly most important products of the *Caribou Data Synthesis* are conclusions published in the international scientific literature. To date, 16 peer-reviewed manuscripts are in preparation or have been published. This ongoing effort to extract empirical patterns and conclusions from the *Synthesis* and have them reviewed by international peers and subsequently published is critical to establishing objectivity in Government's approach to the current caribou situation we face. Having our results challenged via the highest scientific venues and standards ensures the best possible scientific bases are available for caribou management.

In addition to the hard-copy volumes, digital files and scientific publications, the preparation of a Comprehensive Report and Synopsis is ongoing. Its format will be as follows (progress indicated in parentheses):

Chapter 1: Introduction (completed)
Chapter 2: Study area and study populations (completed)
Chapter 3: Historical trends in insular Newfoundland caribou, 1860–1960 (draft completed)
Chapter 4: Demographic trends (analyses completed)
Chapter 5: Trends in body morphology (analyses being updated)

Chapter 6: Effect of multiple factors (density, weather, hunting) on demographic and morphological trends (analyses ongoing)
Chapter 7: Distributional patterns and range use (analyses ongoing)
Chapter 8: Population Modeling—forecasting the future of caribou (analyses ongoing).
Chapter 9: Conclusion

This Comprehensive Report and Synopsis will provide conclusions with respect to the reasons for population decline, future projections for the island caribou herds, and identification of information gaps and research needs.

It is important to realize that without the detailed data compilation, analysis and interpretation provided by the *Synthesis* and its related products, we would not have the historical context to understand, or possibly even detect, the current decline. For example, declines in calf survivorship and recruitment would not be evident from the recent collaring efforts without the radio-collaring program of the 1980s and 1990s (**Vol. 13**). The most recent herd sex and age observations would not inform us as to the changes taking place unless we had the historical data from the 1950s through to the 1990s (**Vol. 14**). Furthermore, recent efforts to determine the distribution and home range of caribou herds would provide little understanding of possible changes unless we had knowledge of their distribution prior to the population decline (**Vol. 5–12**).

While the *Synthesis* indicated a decline in caribou population numbers was underway by the late 1990s, neither the composition surveys nor the harvest records provided any evidence as to what was causing the decline in calves. To address this knowledge gap, the *Calf Mortality Study* was initiated in 2003.

Calf Mortality Study (2003–2007)

A. Radio-collaring

Initially launched in 2003, the *Calf Mortality Study* was designed to include several herds representing different ecological regions and their varying predator guilds. Such replicates are crucial in science. The goal was to determine the causes and timing of mortality and the survival rate of calves from Middle Ridge, Gaff Topsails and Mount Peyton herds. Longer term plans were to include the Northern Peninsula and La Poile herds as well. However, funding problems prohibited expansion to the other herds and necessitated elimination of the Gaff Topsails and Mount Peyton portion of the study by 2005. As part of the new *Caribou Strategy 2008–2013*, this work is now ongoing in La Poile, Middle Ridge and the Northern Peninsula. Here we report on the 2003–07 efforts for the Middle Ridge, Gaff Topsails and Mount Peyton herds.

We collared 221 calves in June from the Middle Ridge (2003–2007), Gaff Topsails (2003–2004) and Mount Peyton (2003) herds. Our intention was to assess calf survivorship to one year of age. However, because a large majority of collared calves died before reaching 6 months of age, it was impossible to determine the rate of calf mortality over-winter. There was some expectation that high over-winter mortality was occurring, based upon reports from recreationalists and others who observed coyotes feeding on recently killed caribou during the winter period.

In response to this, we collared additional 25 calves annually (76 calves total) from the Middle Ridge Herd in late fall 2005–2007 to determine the timing and causes of over-winter death. By doing so we hoped to discover whether calf mortality was restricted in time or occurred year round.

Annual reports on the *Calf Mortality Study* have been provided to the Wildlife Division, Parks and Natural Area Division and senior managers and executive of the Department of Environment and Conservation on a regular basis. To date, nine interim and annual documents have been available. We are currently preparing a summary report for the 2003–2007 research efforts for Middle Ridge, Gaff Topsails, and Mount Peyton.

B. Herd Composition Surveys

Herd composition surveys are an integral component of the *Calf Mortality Study* as they provide estimates of calf survival for herds for which it is not logistically or financially possible to conduct radio-collaring research. Previous to the development of radio-telemetry in the 1970s they were the only means of effectively assessing calf production and survivorship. These also serve as an independent measure to validate the accuracy of the radio-collaring results (confirm that the radio-collars themselves do not cause observed mortality).

We strive to assess populations three times annually: at calving, during the fall breeding season and in late winter. Calving composition surveys establish productivity (birth rate) and are used in combination with fall classification to determine calf survival to six months of age. Late winter surveys allow us to assess calf survival from fall through winter and help corroborate the more detailed over-winter mortality assessment undertaken in the Middle Ridge radio-collaring study (now expanded to include La Poile and Northern Peninsula study sites under the *Caribou Strategy 2008–2013*). This is especially relevant given the conspicuous, though unquantified, predation on caribou by coyotes in winter.

From the early 1950s until 1996 all composition data were compiled in Volume 14 of the *Caribou Data Synthesis*. As new data become available the historical trends are recalculated and these analyses are updated on a continuing basis as part of the Data *Synthesis* work.

WHAT HAVE WE LEARNED AND WHAT DOES IT MEAN?

In this section we present the most current information (to March 2009) and our interpretation of these data. While this information is available on an individual herd basis, we have also combined these data to project trends for all of insular Newfoundland. The Middle Ridge herd is presented throughout as an example of individual herd trends relative to island-wide trends.

Population size has decreased at an alarming rate

Caribou numbers on the island of Newfoundland increased exponentially from the 1960s to the 1990s reaching a peak abundance of nearly 100,000 animals. During this period the average annual rate of increase was near 8% for many herds. Beginning in the mid 1990s herds began to decline, many at a seemingly rapid rate. A variety of indices (census, survivorship, recruitment) have indicated that the island-wide population has decreased by 60% over the last decade, suggesting that the current island-wide population may number no more than 32,000 animals (**Fig. 1**). In the Middle Ridge Herd, a similar rate of decline from 19,765 animals in 1995 to 8,748 in 2006 (55.7% decrease) has been detected. However, some herds such as the Avalon and Grey River (not shown) have declined by over 90% in recent years which has resulted in the closure of these herds to hunting. If these current patterns of

reduced juvenile survivorship (see below) continue, we can only expect further significant declines in island-wide numbers of caribou. Populations of caribou, particularly those that exhibit rapid increase, often diminish quickly; a pattern well documented in the scientific literature.

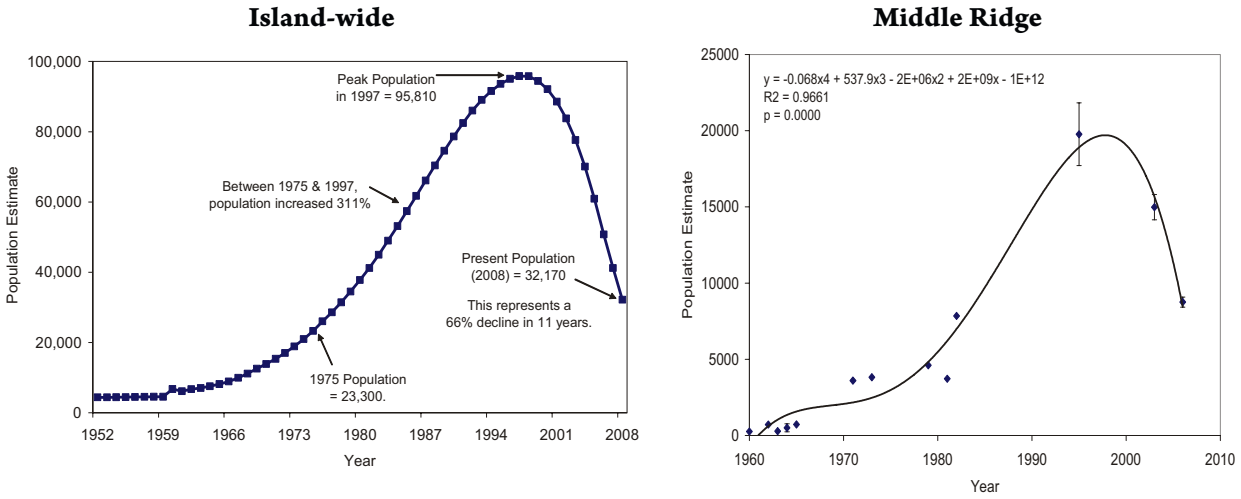


Figure 1. Caribou abundance island-wide (1952–2008) and for the Middle Ridge herd (1960–2006). Individual herd population estimates were based on intermittent aerial surveys. Mathematical models were fit to individual herd data and these equations were used to estimate data for years when a survey was not completed. The individual herd data were pooled to provide an annual island-wide estimate; these data were used to construct the island-wide population trajectory.

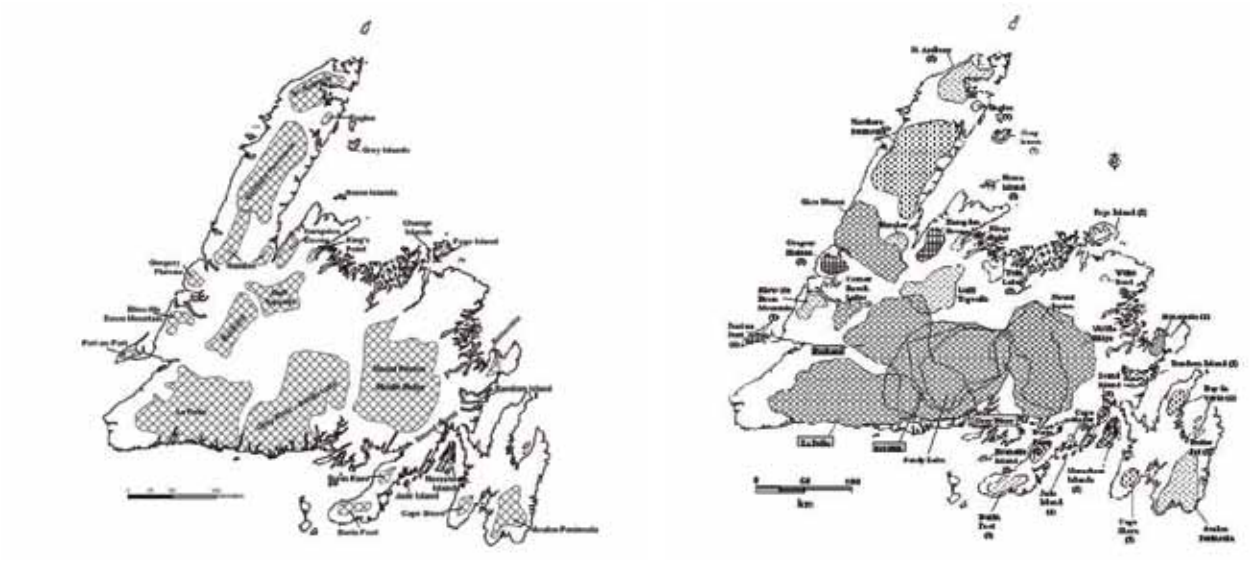
The question is—how low will populations fall? A similar pattern of rapid decline from high numbers has occurred in many caribou populations including many that were lightly hunted, or not hunted at all. One of the best known declines occurred in Newfoundland between the 1890s and 1920s when virtually all island herds dropped precipitously from about 100,000 animals to no more than 15,000, and perhaps considerably less. Despite the disappearance of the wolf, the absence of coyotes and closed hunting seasons, their numbers did not begin to recover until the 1960s.

It is tempting to infer from this pattern that the current decline is part of a natural cyclic process and, given sufficient time, population numbers will recover as they did historically. However, there have been many anthropogenic and natural changes to the island ecosystem, including changes to habitat and the predator guild of caribou, which may affect the capacity for caribou to recover. Therefore, the challenge to us as resource managers is to intervene to dampen such oscillations in population numbers. Harvest theory suggests maximizing the off-take of such populations at about 50% of the range carrying capacity, which assumes we have a good understanding of the maximum numbers of animals that the range can support. This is an ultimate objective for the *Synthesis*.

Caribou distribution has changed

Herds are the units of caribou conservation and are defined by fidelity of social aggregations to particular geographic regions for specific purposes; caribou herds are normally defined based on fidelity to calving and post-calving areas. As far back as the 1960s and 1970s ear-tagging and neck strapping studies had confirmed significant overlap of several herds on the south coast winter range, but it was the extensive radio-telemetry, population census, herd composition survey and observational data in the 1980s and 1990s that enabled clear delineation of annual and seasonal ranges for all herds on the island (**Fig. 2**).

These results are presented in considerable detail in the *Synthesis* (**Volumes 5–12**), which are entirely focused on this question of range use, and summarized all information available at the time of printing in 2000.



1984

(Schematic adapted from Mercer et al. 1985)

1996

(Figure derived from studies conducted in 1980s & 1990s)

Figure 2. Delineation of annual ranges for insular caribou herds. The comparison between decades shows the degree of overlap revealed from radio-telemetry, census, herd composition survey and observational data in the 1980s and 1990s. By 1996 extensive range overlap was confirmed.

Radio-telemetry more precisely indicated the extent of range overlap of many herds, significantly altering and refining our earlier understandings of herd spatial relationships. Intensive herd specific studies further confirmed these patterns:

- **Grey River, Sandy Lake and Pot Hill**
  The overlap between these herds was extensively studied and delineated during our investigation of the Upper Salmon hydroelectric development during the early 1980s *(Mahoney 1980, 1981, 1982, 1983; Russell & Mahoney 1985, 1986; Northcott, P.L. 1985.)*

- **La Poile and Grey River**
  The overlap/interchange between these two herds was documented during the investigation of the impact of the Hope Brook gold mine during the late 1980s and early 1990s *(Lane 1987; Lane & Berger 1989; Mahoney et al. 1991, 1989; Weir et al. 2007).*

- **Buchans and Grey River**
  Timing and extent of overlap between these two herds was identified during the investigation of the impact of the Star Lake hydroelectric development in the early 1990s *(Mahoney & Schaefer 2002).*

Given the evidence of herd overlap and mixing, particularly in fall and winter, and the relevance to hunting zones and seasons, these results were analyzed to find the mechanism behind such patterns. While the analyses and conclusions were restricted somewhat by the lapse of radio-collaring effort after

1996, we confirmed that individual caribou in the central and eastern region of the island were displaying lower fidelity to calving grounds and other traditional ranges beginning by the early 1990s, notably the Grey River, Pot Hill and Sandy Lake, and the Middle Ridge and Mount Peyton herds *(Bridges, Mahoney & Schaefer 2004; Bridges, Schaefer & Mahoney 2006).*

Indeed these trends were confirmed during annual herd composition surveys. It now appears that some calving ranges have been virtually abandoned, indicating a loss in herd identity. This is the case for the Grey River herd where in the last several years extensive searching in June of the entire range, not just the calving area, failed to identify any concentration of calving females, very few animals in total and exceptionally few calves. These results suggest this herd has not existed as such for some time.

Other changes have also been well documented through calving ground composition surveys. Major changes in calving (and other seasonal range) distributions were observed in the Avalon herd in the 1980s preceding the major decline. Changes in the La Poile, Middle Ridge and Northern Peninsula herds' calving distributions have been noted since the mid-1990s.

This circumstance is a dynamic one and requires continuing efforts to track and effectively address. New radio-telemetry efforts on adult females, ongoing since 2006 and continuing through the *Caribou Strategy 2008–2013*, will provide additional detail with respect to herd distribution.

Adult survival has remained stable

As part of an extensive radio-collaring program in the 1980s and 1990s, adult caribou from the nine major herds were radio-collared to determine causes, rates and timing of adult mortality. A comparison of this to the recent adult female radio-collaring (2004–2007; south coast and Northern Peninsula herds) indicated little change in adult female survivorship over the past four decades. On average, survivorship was high, at approximately 86%, throughout the entire time period (**Fig. 3**). Such rates are comparable to caribou populations elsewhere.

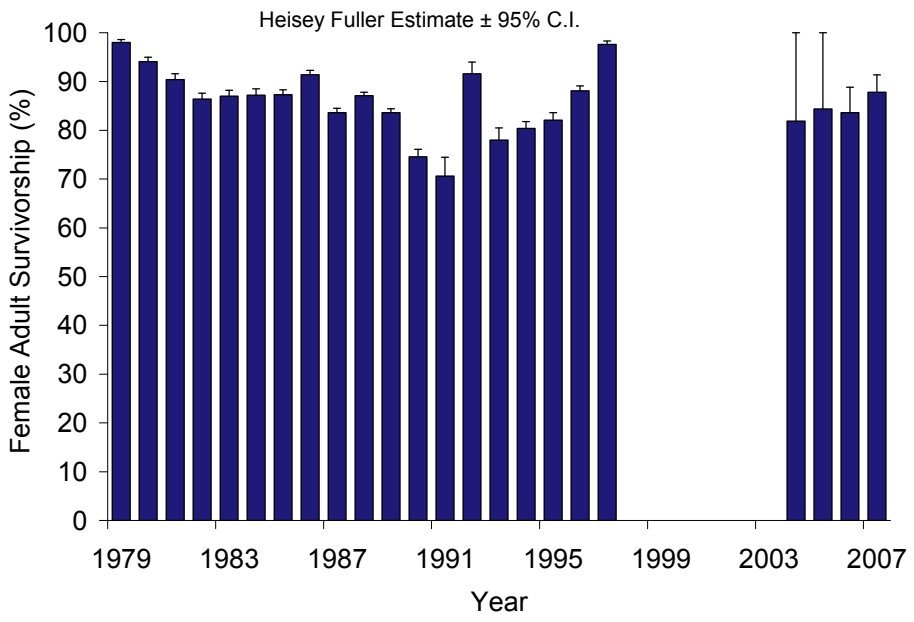


Figure 3. Annual (May 1–April 30) Heisey-Fuller survivorship estimates for adult female caribou from 1979–2007. Estimates for 1979–1997 were calculated from data available for nine major herds (*Caribou Data Synthesis*). 2004–2006 estimates were calculated from data available from five south coast herds; 2007 data included five south coasts herds and five herds from the Northern Peninsula.

Calf survival has decreased dramatically

Survivorship rate

As part of an extensive radio-collaring program in the 1980s and 1990s, 578 calves from nine herds were radio-collared to determine causes, rates and timing of calf mortality. A comparison to the recent *Calf Mortality Study* (2003–2007; 221 calves from three herds) revealed a dramatic decline in annual calf survivorship over the last decade. Island-wide annual calf survivorship from 1979–1997 averaged 66%; while our recent findings indicate that during this time for Middle Ridge, Gaff Topsails and Mount Peyton herds (2003–2007) calf survivorship dropped to less than 10% (**Fig. 4**).

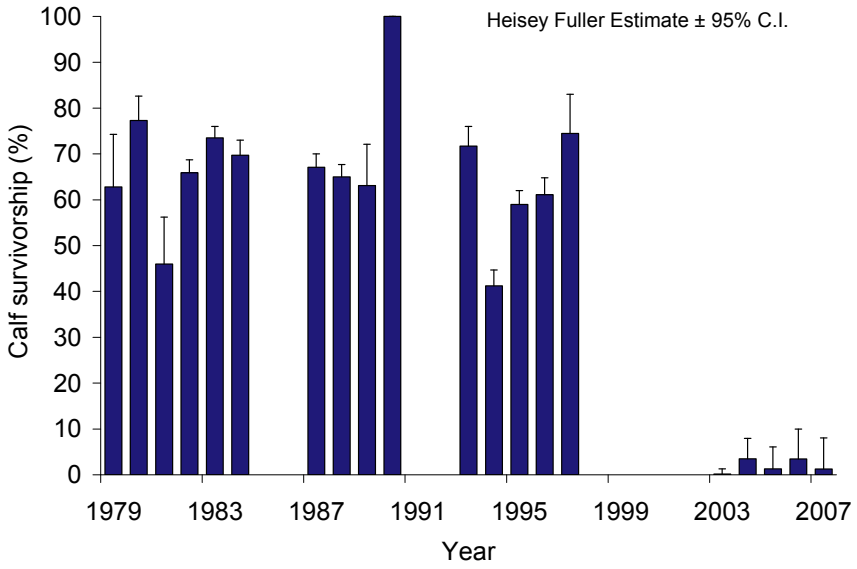


Figure 4. Annual Heisey-Fuller survivorship estimates for caribou calves from 1979–2005. Estimates for 1979–1997 (517 calves) were calculated from nine major herds (*Caribou Data Synthesis*). 2003–2007 estimates (221 calves) were calculated from Middle Ridge (2003–07), Mount Peyton (2003), and Gaff Topsails (2003–04) herds (*Calf Mortality Study*).

Cause of death

The dramatic decline in calf survivorship is correlated with a substantial increase in predation mortality. During both study intervals, predation was the major cause of mortality; however the percentage of mortalities due to predation increased from 59% in the 1970s–1990s to 83% in recent years (**Fig. 5**). The increased predation may be due to an increase in the numbers of predators, an increase in predator species, increased exposure of caribou to these predators, and/or increased vulnerability of calves to predators. Previously, it was primarily black bear and lynx which preyed on caribou calves, whereas we now record predation by black bear, lynx, coyotes, and bald eagles. While the proportion of calves killed by coyotes and eagles is new, the proportion of calves killed by black bears has decreased, suggesting possible competitive interaction between predators. Furthermore, during the 2003–2007 studies the percentage of death ascribed to individual predators varied between the Gaff Topsails, Mount Peyton and Middle Ridge herds (data not shown). Such variability means that efforts to reduce predation pressure may require herd specific strategies, with emphasis on the various predators proportionate to their relative impact on calf mortality. Understanding the interaction of these predators has been made a top priority for research in the *Caribou Strategy 2008–2013*, and an academic program and team have been assembled through the Institute for Biodiversity, Ecosystem Science and Sustainability (IBES) to assist in this effort.

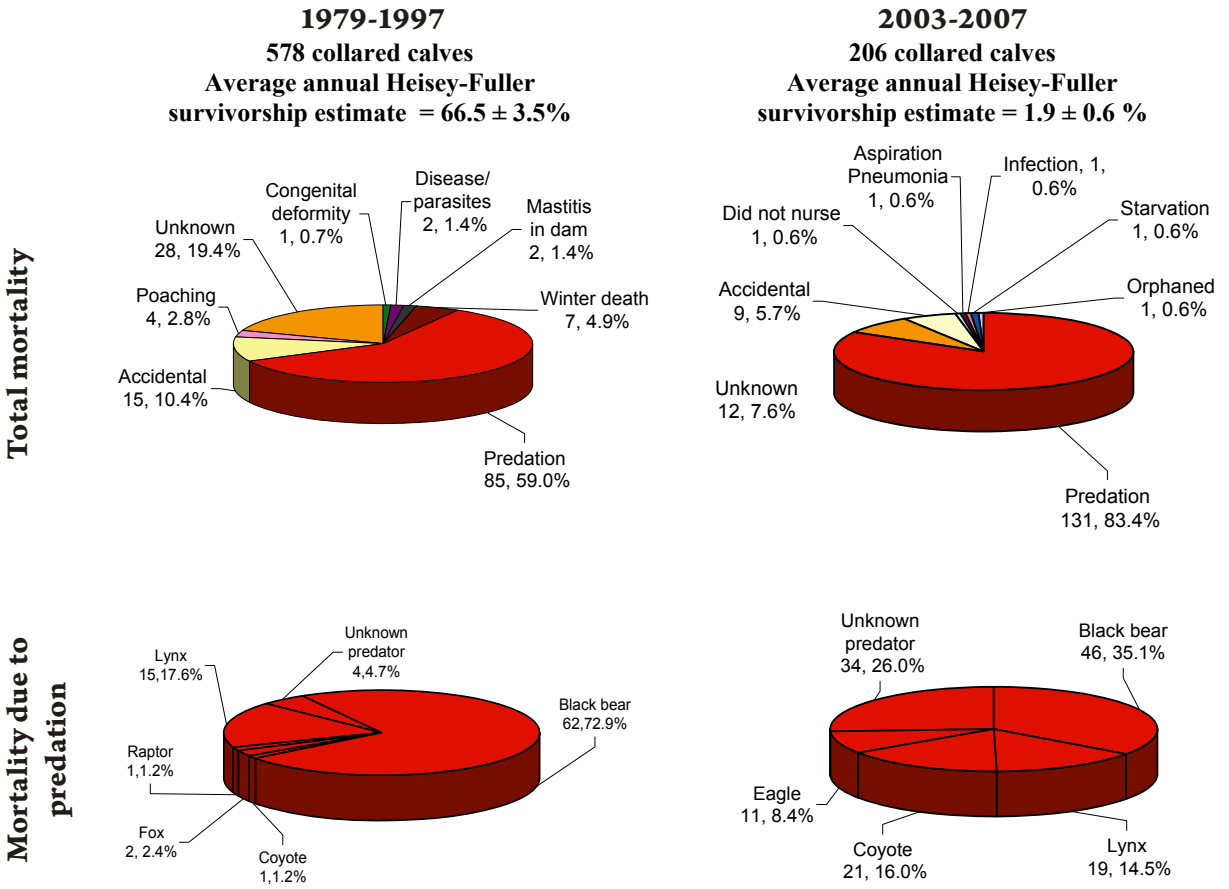


Figure 5. Causes of total calf mortality and predation mortality for two time periods. Data for 1979–1997 were for all nine major herds combined (*Caribou Data Synthesis*). Data for 2003–2007 were for Middle Ridge (2003–07), Gaff Topsails (2003–04) and Mount Peyton (2003) herds (*Calf Mortality Study*).

Schedule (timing) of mortality

There has been very little change in the timing of predation mortality; most calf predation still occurs during first 6–8 weeks of life (**Fig. 6**). This is especially interesting given the well-established coyote population. It might be reasonable to assume that coyotes would continue to prey on calves throughout the year. However, unlike during the 1980s and 1990s when a majority of calves survived to one year of age, during 2003–2007 very few calves survived beyond 12 weeks, making it difficult

to assess mortality causes during the post-summer period. Yet this is an essential issue, for while bears, lynx and eagles are restricted seasonally in their predation (either by body size constraints that limits their predation to only young calves or, in the case of bears, because of winter hibernation), coyotes operate year-round and are capable of hunting in groups, providing opportunity for over-winter predation of large animals.

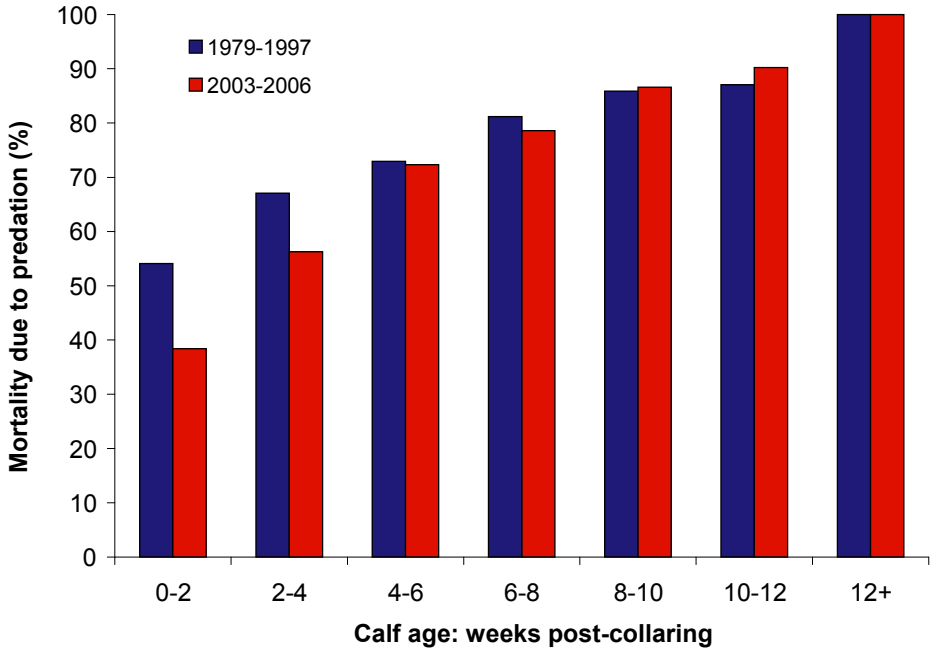


Figure 6. Chronology of cumulative percent predation mortality for two time periods. Data for 1979-1997 were for all nine major herds combined *(Caribou Data Synthesis)*. Data for 2003-2006 were for Middle Ridge (2003-06), Gaff Topsails (2003-04) and Mount Peyton herds (2003) from the *Calf Mortality Study*.

To address the problem of quantifying over-winter mortality, we collared Middle Ridge calves at six months of age (2005–2007) and monitored their survival. Over 70% of the calves collared at 6 months of age survived to one year of age whereas, on average, less than 10% of the calves collared at birth did so (**Fig. 7**). These results suggest that survivorship to 6 months of age is currently the primary factor limiting herd recruitment (see below). The observed pattern, though contrary to popular opinion regarding high coyote predation in winter is consistent with historic data from both composition surveys and calf mortality studies; the vast majority of calf mortality occurs in the first few weeks of life. An assessment of the over-winter survival of caribou calves is continuing for the Middle Ridge herd and has been expanded to La Poile and Northern Peninsula as part of the new *Caribou Strategy 2008–2013* efforts.

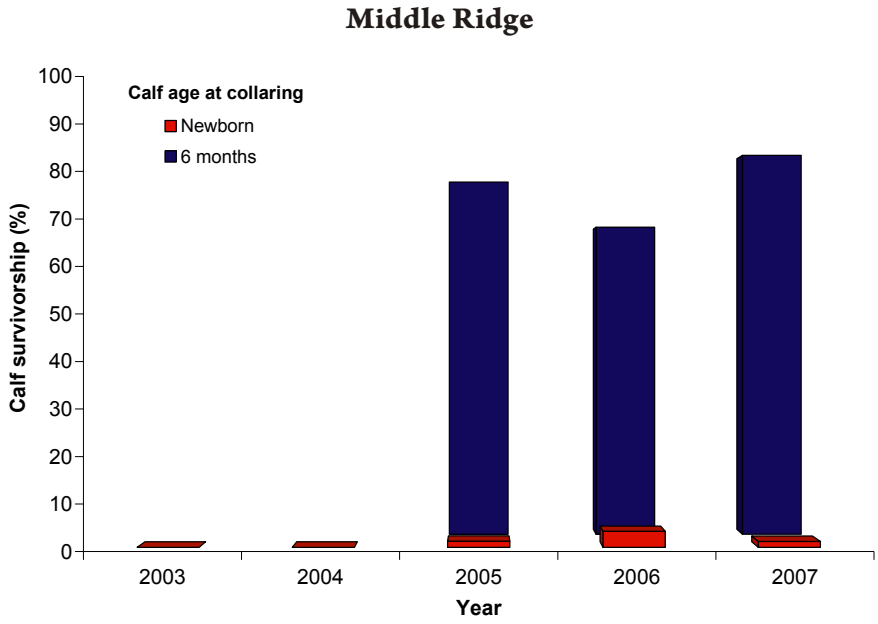


Figure 7. Heisey-Fuller survivorship estimates for Middle Ridge calves that were collared as newborns (June) and at 6 months of age (Nov.–Dec.). Estimates for newborn calves reflect annual survivorship to one year of age. Estimates for 6-month old collared calves reflect over-winter survivorship from 6 months to one year of age.

Despite many anecdotal reports regarding the presumed impact of coyote predation, the calf mortality data from Middle Ridge, Gaff Topsails and Mount Peyton do not support the hypothesis that coyotes are exclusively or even principally driving the decline in calf survival. Rather it is a combination of old and new predators that are collectively responsible. Nevertheless, the coyote mortality does appear to be additive and therefore contributing to the observed increase in predation mortality, at least among calves up to six months of age. In this sense, coyotes are very important in the continuing depression of calf survival and their impact should not be disregarded.

While these research results are alarming, one positive insight is that the window of greatest peril seems to be, for calves at least, the first 6–8 weeks of life. This suggests that intervention to protect these newborns could be effective in addressing the calf survivorship problem. More generally, of course, simply discovering the rate and role of predation in the decrease in calves was an important step forward.

Fewer calves are being recruited into the population

Recruitment is the addition of young into the adult population and is a sensitive indicator of population growth. The recruitment rate at 6 months (percentage of calves in the population in autumn) and 10 months (percentage of calves in late winter) has significantly declined island-wide with the steepest decline occurring in the past decade. For example, recruitment for the Middle Ridge herd declined from 25–30% during the increase phase of the 1980s to 5–10% in the 2000s (**Fig. 8**). A recruitment rate of 15% is considered the threshold for a stable caribou population.

Recruitment is currently insufficient to offset adult mortality. Future declines are inevitable if these trends continue. Indeed these calf recruitment patterns are so low that even if all hunting activity was prohibited, insular Newfoundland caribou could continue to decline rapidly into the foreseeable future.

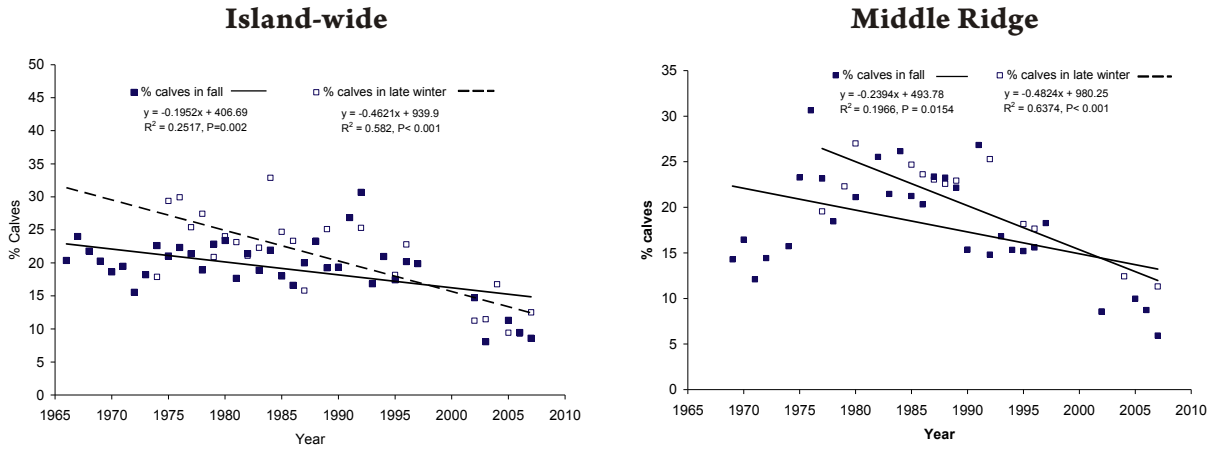


Figure 8. Trends in the percentage of calves in the population (fall and winter).

Reduced calf recruitment affects caribou populations in two ways. First, low recruitment limits the potential for population increase in the face of ongoing natural adult mortality. Secondly, as fewer young enter the population, the age structure shifts such that the majority of animals are older adults. It is well established that increasing age of ungulates contributes to declines in pregnancy and birth weight of calves. In combination, lower calf production, higher calf mortality, and adult senescence can have devastating effects. Indeed, given the increasing proportions of older animals the unexpectedly high over-winter survival of calves may be due in part to coyotes targeting older, less vital members of the herd.

Calf production has declined in some herds

Caribou productivity (proportion of adult females giving birth) declined island-wide, but there was much variability amongst herds **(Fig. 9)**. Most herds, such as Middle Ridge, show only slight declines. For other herds, such as Grey River, productivity has declined substantially and the trend is continuing. Furthermore, for herds such as Pot Hill, productivity declined steadily during the 1980s to 1990s but rebound again in the 2000s. These herd-specific trends may reflect the differential availability of forage resources resulting in differences in the female reproductive potential. Alternatively, or additionally, the high rates of early calf death from predation may have ameliorated pregnancy or productivity rates for some herds. By losing calves early, and thereby avoiding much of the physiological cost associated with raising a calf, females are more likely to maintain their nutritional reserves. This enables them to calve again the following year resulting in stable rates of calf production irrespective of (or indeed because of) higher juvenile mortality rates. The rebound in productivity for Pot Hill may provide circumstantial evidence for a release from nutritional restraints following drastic reductions in population density.

Downward trends in body size (P. 17) also suggest nutritional restrictions coincident with high population density. If true, such patterns will stabilize and then possibly reverse in response to the decline in caribou numbers, provided that resources are not depleted to a degree that population increase cannot be supported. Lichen is a primary food source for caribou, particularly during winter, but is an extremely slow growing source; if caribou population stabilization or recovery is primarily dependent on growth of lichen biomass, it could potentially take decades to observe improvement in caribou numbers. As analyses proceed and more data become available we will be better positioned to support/refute these hypotheses. These issues and related questions of habitat availability and quality, carrying

capacity, and density-dependence are the focus of ongoing analyses and will be addressed further with field research associated with the *Caribou Strategy 2008–2013*. Current measures of productivity may overestimate actual rates due to methods used. This does not affect our ability to interpret relative trends, but validation of the metric is required. Productivity of all herds will continue to be monitored through herd composition surveys and radio-collared females are now being monitored for calf production in order to improve our understanding of true productivity and caribou reproductive ecology.

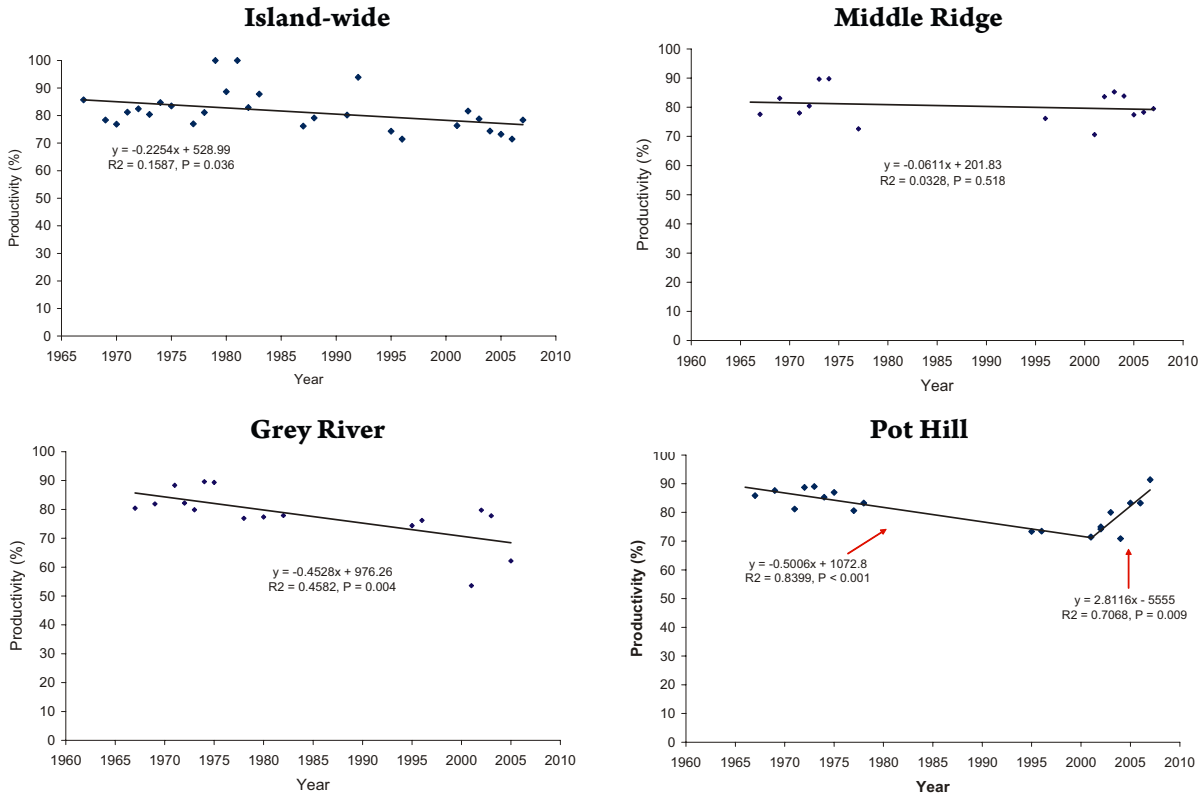


Figure 9. Trends in productivity rates for various caribou herds.

Percentage of adult males has decreased

The proportion of males in the adult population has decreased island-wide and for most herds, such as Middle Ridge (**Fig. 10**). A female-biased adult sex ratio has been reported, and is in fact managed for, in many hunted ungulate populations; but it can have a negative influence on productivity, birth synchrony, and body mass when the proportion of males in the population drastically declines, as is the case for Newfoundland caribou since the late 1980s. In some cases hunting is the primary cause of sex ratio distortion and must be carefully monitored to assess its effects. If the declining trend in the number of adult males and the increasing trend in the age of females continue (P. 16), negative consequences for female reproduction and population dynamics may ensue, exacerbating population decline. Although male caribou can inseminate more than one female in a breeding season, sex ratio thresholds do exist and must be carefully monitored and corrected where necessary. Given that in some herds stags have fallen below twenty percent of the adult population, management efforts to address this issue would be prudent.

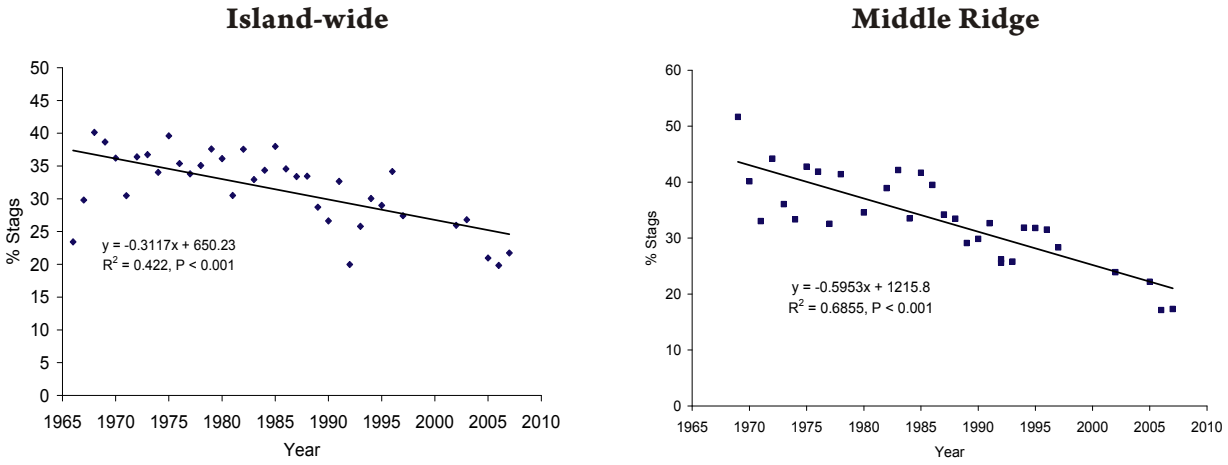


Figure 10. Trends in the proportion of adult males in the adult population in fall.

The caribou population is aging

The age structure of a population can be estimated from harvested animals. In Newfoundland, hunters voluntarily submit the lower jaw of their harvested caribou and the animal's age is determined from annual rings in tooth cementum, a process similar to counting growth rings of a tree. By examining the relationship between age at harvest and year of harvest we are able to detect changes in the population age structure.

Island-wide and for the Middle Ridge herd, the average age of male and female caribou has increased significantly from 3–4 years in the 1980s to 5.5–6.5 years in the early 2000s (**Fig. 11**). This large increase in mean age is no doubt strongly influenced by low recruitment of young animals into the population, and will have a negative impact on population size as a greater portion of caribou pass their prime reproductive phase. Furthermore, the inevitable die-off of older animals must eventually increase adult mortality rates. One might imagine a wave of older animals moving towards life span limits without any successive wave of young replacements.

This likely scenario again emphasizes the need to intervene quickly if the present regime of high calf mortality-low recruitment continues, before populations are squeezed by increased mortality at both ends of the age spectrum. Predators will be involved, of course, but whether their contributions will be more additive or compensatory when older age classes are involved is an open question.

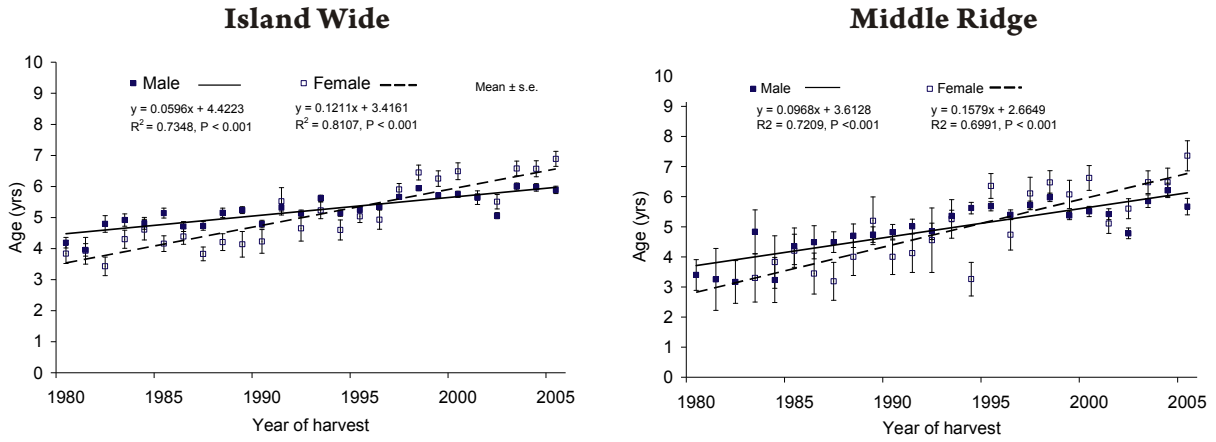


Figure 11. Trends in the mean age of harvested male and female caribou.

Body and antler size has decreased

Jawbone Length

Skeletal measurements (jawbone and antler size) are common indicators of adult herbivore body size. Exhaustive analysis of jawbone sizes, growth rates and residual comparisons have been a major focus of the *Caribou Synthesis* and have clearly indicated declines in the size of male and female caribou (**Fig. 12**). Island-wide, the decline in jawbone size was significant only for females. However, like Middle Ridge, many herds have shown significant declines in male jawbone size as well. Adult females from Middle Ridge lost an average of 1 mm per year of jawbone length from 1980–2003. Male jawbone size also declined but at a slower rate. Together, these trends suggest that reduction in body size may be more prominent for females than males. Jawbone collection and processing continue and body morphology will continue to be monitored.

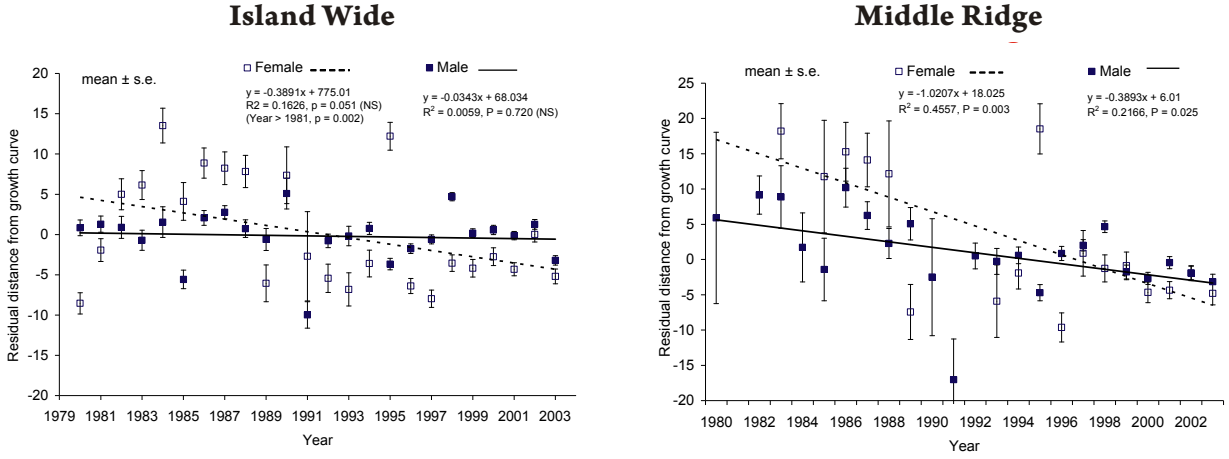


Figure 12. Trends in male and female jawbone length. Each datum represents the residual scores based on the Gompertz growth curve equation fit to all data for each year (analysis not shown here). Bars represent standard errors.

Antler Size

Antlers are grown and shed annually so the size and shape of antlers are dependent to a large extent on the current health of an individual and the accessibility of high quality nutrients. Male antler size in

autumn (number of points) reported by hunters decreased for every age class between the 1980s and the 1990s (**Fig. 13**). Island-wide, this reduction was significant for caribou 2–8 years of age. For Middle Ridge, the reduction was most evident for 5–6 year old males.

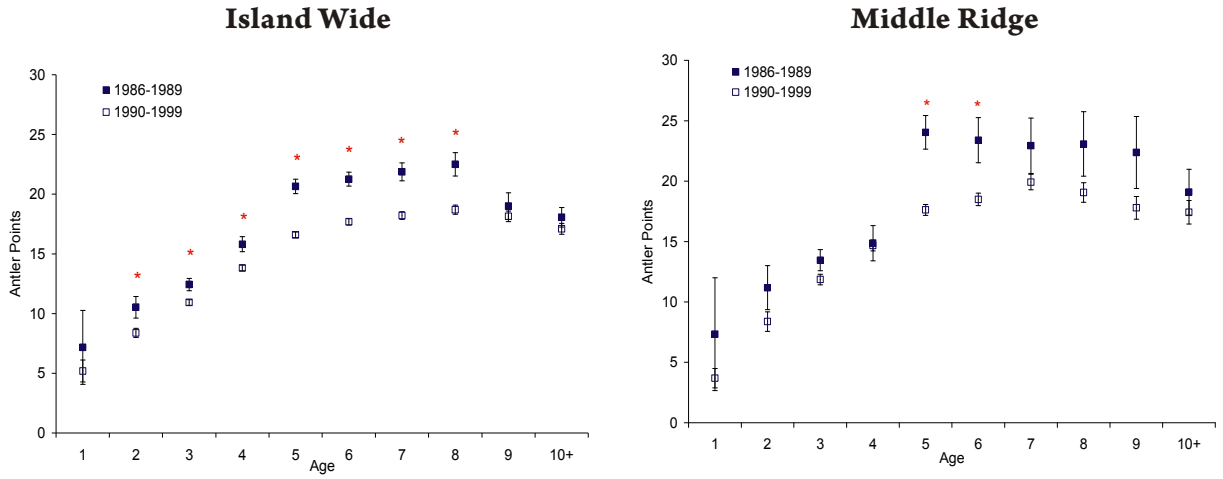


Figure 13. Decadal comparison between mean number of antler points on harvested adult male caribou by age. Asterisks indicate significant differences (t-tests, alpha = 0.05) between decades for each age. Bars represent standard errors.

Birth weight

Birth weight of calves captured 1–5 days post-partum has declined significantly since the 1970s (**Fig. 14**). The weight of male calves decreased nearly 10% from the 1970s to the 1990s and then stabilized in the 2003–2007 period. Female calf weight decreased 13% by the 2000s compared to the 1970s. Reduced birth weight could have implications for calf survivorship and could help explain the increased calf mortality.

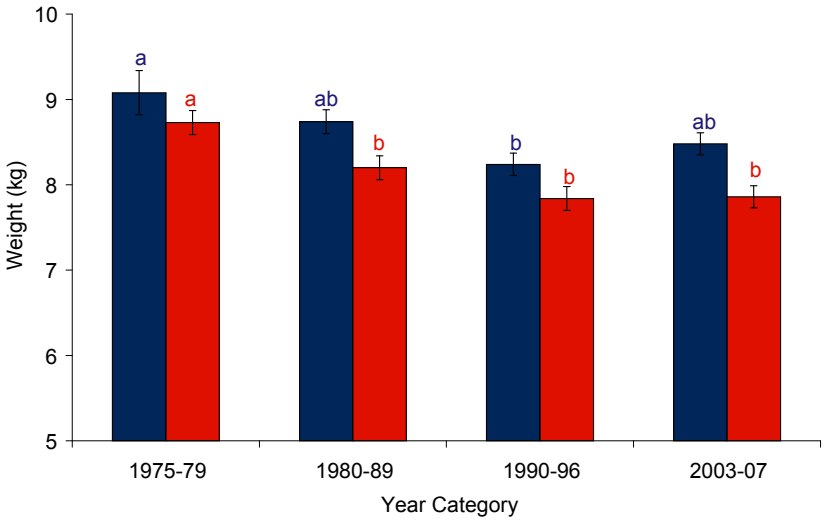


Figure 14. Mean ± S.E. mass of collared calves for each decade. Data for 1975–1997 were for all nine major herds combined (*Caribou Data Synthesis*). Data for 2003–2007 were for Middle Ridge, Gaff Topsails and Mount Peyton herds (*Calf Mortality Study*). Letters above bars denote significant differences in mean calf weight between year categories for males (blue) and females (red).

Potential causes of reduced size of caribou

Collectively, these trends in jawbone size, antler size and birth weight strongly suggest a nutritional influence is depressing caribou body size. Density-dependent nutritional effects are well documented in the scientific literature for many species, including caribou. The decline in calf weight is especially interesting as it introduces the probability of increased vulnerability of calves born in recent years. If such a density-dependent relationship holds, then given the significant decline in caribou numbers we can predict stabilization and perhaps reversal of these trends as caribou density-range relationships improve, although such changes would not be immediate. Regardless of such time lags, however, improvement in these indices will be a further test of the density-dependent hypothesis.

Indirect evidence points to deteriorated condition of caribou summer range. Compared to the early 1960s, the Buchans herd has now delayed its spring migration by one month, and advanced its fall migration by one month. This dramatic, 2-month reduction in time spent on the summer and calving range, coupled with diminished body size, implies that summer food resources are limiting. A potential consequence of nutritional stress is that females with calves may be feeding in riskier habitats where predators are more common. This suggests an intimate relationship between caribou, their food, and their predators. This is one of the issues to be addressed in the *Caribou Strategy 2008–2013*.

It must also be borne in mind that available habitat can be influenced by human activity, not only as a result of direct habitat alteration (e.g. timber harvesting) but also through induced avoidance by caribou of even preferred habitat, in response to human activity. While both processes represent quite different causal factors, their ultimate influence on caribou could be the same.

Despite such evidence we have no direct means of determining whether or how these changing body and antler sizes are influencing the numerical decline. To most effectively assess a nutritional influence on body size (and growth) we ultimately require measures of cause (habitat quality and abundance) and effect (changes in size etc.) We are much hampered in our evaluation of this problem by an absence of any detailed assessment of caribou range. This vacancy in our knowledge will be addressed in the *Caribou Strategy 2008–2013*. Nevertheless, density-dependent declines are generally associated with the trends in demography and morphology observed in the Newfoundland caribou population, including high rates of juvenile predation mortality. The concept of density-dependence is central to wildlife harvest theory and determining the population levels where such responses occur is critical for establishing optimal (versus maximal) population numbers the landscape can support. Ongoing analyses will help illuminate such relationships. Determining critical population thresholds remains a key focus of the *Caribou Data Synthesis* and involves the integration of numerous trends and indicators derived from nearly a decade of focused work.

Changes in caribou size can also reflect evolutionary (genetic) consequences of intense trophy hunting, whereby long term selection for larger animals with the biggest antlers results in decreased body size and antler size over time. While resident hunters of Newfoundland are not trophy hunters, 24% of the caribou harvested in Newfoundland from 1966–2007 were taken by non-residents who would generally select for large males. We are currently investigating the impact such hunting pressure may have had on these declining body size trends, keeping in mind that the greatest decline in jawbone length occurred in females, not males.

Most island herds have acquired brain worm immunity

Brain worm, *Elasphostrongylus rangiferi*, is a nematode parasite first introduced to caribou on the island of Newfoundland following translocation of infected reindeer from Norway in the first decade of the twentieth century. Symptoms of brain worm infection can range from no outward signs of disease, to unusual behaviour (caribou standing in one place for extended periods of time or appearing tame), to debilitating neurologic weakness (unsteady gait, walking in circles, hindquarter weakness, inability to stand). After the parasite's initial introduction, recorded outbreaks of brainworm occurred in Newfoundland in the mid-1980s in the Buchans and Gaff Topsail areas and more recently in 1996 on the Avalon Peninsula. The sudden decline of the Avalon Herd in the 1990s can be at least partially attributed to brain worm infection and exemplifies how the parasite can affect a naïve population. Caribou herds off the Avalon have acquired immunity to brain worm and generally do not develop disease from infection, although sporadic episodes can still debilitate small percentages of animals.

As the focus of a graduate thesis, fecal and tissue samples were collected through hunter submission and ground collection between 1998 and 2000, about the time of the recent caribou population peak and initial decline. *E. rangiferi* was found in seven of nine herds studied with a prevalence of 40–83% of fecal samples containing larvae in herds with brain worm presence (Ball et al. 2001). Prevalence of the parasite was highest in the Avalon herd where its arrival was relatively recent; the herds where brain worm was absent were Cape Shore and Bay de Verde herds, which were both established by translocation of uninfected animals from the Avalon herd in 1977 and 1989. Recent brain worm monitoring indicates the parasite was present in the Cape Shore and Bay de Verde herds by 2008.

The influence of brain worm on the current decline in many caribou herds in Newfoundland seems unlikely given low adult mortality, little outward sign of the disease in monitored animals, and evidence of immunity to brain worm in much of the island.

Hunter success has decreased

Hunter trends strongly confirm findings from the *Caribou Data Synthesis* and recent *Calf Mortality Study*. Hunter success declined drastically island-wide in the last decade, from 80–85% in the 1980s and early 1990s to 60% in 2005 (**Fig. 15**). For some herds, such as Middle Ridge, hunter success declined even more—to less than 45% in 2005. Success has improved slightly since then. These sharp drops in hunter success reflect declines in caribou numbers, and quite likely, the shifting patterns of range use and fidelity linked to the peak and fall in numbers. Places where hunters could predictably find caribou during the fall hunting season no longer have the same number of animals, or may be devoid of caribou altogether.

Hunter success may understate the decline of Newfoundland caribou. Because caribou are social animals of open habitat and are quite approachable, hunter success rate is relatively insensitive to decline in caribou abundance. Therefore the sharp decline in hunter success underscores the dramatic decline in population size. Furthermore, the reduced number of licenses issued in recent years may have contributed to the slight increase in success in the last two years.

The timing of the peak and ensuing phase of decline in hunter success suggests that caribou numbers peaked in the late 1980s to early 1990s a pattern slightly ahead of other indices of population change. Alternatively, prior to the population peak, caribou space-use and aggregative behaviour might have been more conducive to high hunting success.

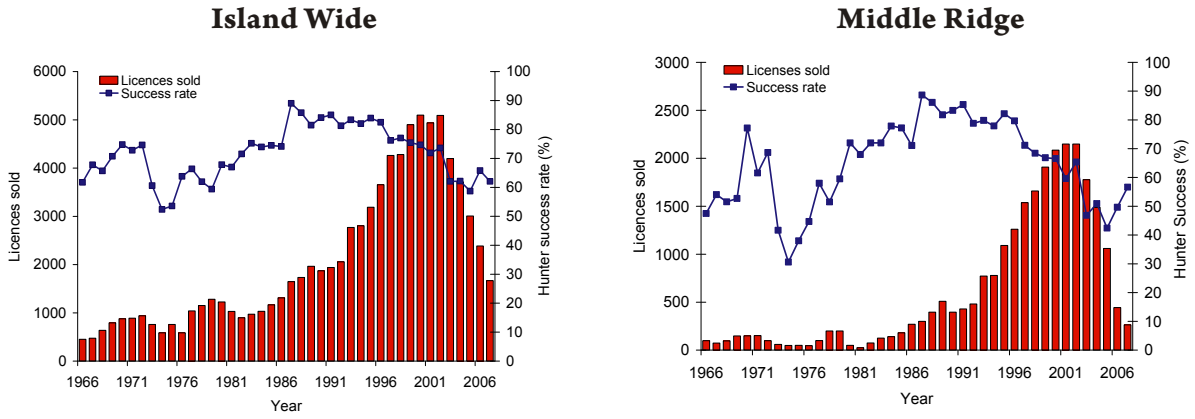


Figure 15. Trends in total (resident and non-resident) license sales and hunter success rate.

Population abundance will continue to decline

Population viability analysis (PVA) is a mathematical tool often used in wildlife biology to assess the probability that a population will go extinct in a given number of years and can be used to forecast population health and abundance under specific circumstances.

As part of the population modeling component of the *Caribou Data Synthesis*, we used PVA to forecast the prospects for insular Newfoundland caribou herds to 2013 (end date for the new caribou initiative). The model was loaded with the most current population estimates and demographic rates (calf and adult mortality rates, reproductive rates, and harvest rates) and we predicted population size under two scenarios (1) harvest rates set at 2008 levels and (2) no harvest. **(Fig. 16)** Results indicate that, unless current demographic trends and population limiting factors change, the caribou population will continue to decline with or without hunting pressure.

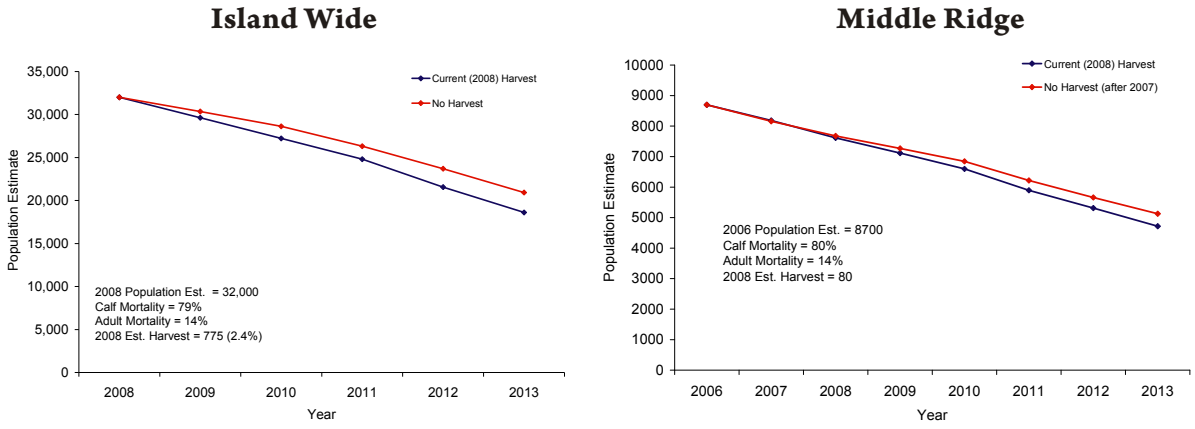


Figure 16. Population abundance of caribou projected to 2013 (with and without harvest). The model used to project future population size assumes that there are no changes to caribou vital rates (productivity, survival) except to the degree survival might improve if hunting were ceased.

Caribou avoid human activity

Human land-use activity has long been identified as a source of disturbance to caribou populations. Several long-term research studies conducted in Newfoundland have contributed significantly to this understanding. Furthermore, due to the comprehensive approach taken in the *Caribou Data Synthesis*

we are now able to evaluate the impact of human disturbance and human-induced alterations to caribou habitat within a wider population context. This research, using complementary data on population dynamics, demography, and morphology of Newfoundland's insular herds, is the foundation of a powerful tool giving the Government of Newfoundland and Labrador a unique perspective on the effects of human activity on caribou and making the Province a leader in understanding human influence on natural ecosystems.

To date, the effects of industrial resource use (forestry, hydroelectric development, and mining) and recreational snowmachine and pedestrian activity have been assessed for several of our herds. As reported elsewhere, Newfoundland caribou show an avoidance of infrastructure and activity associated with resource extraction and direct human disturbance. Resource extraction reduces caribou habitat directly by removing it or altering its composition, or indirectly by displacing caribou, often several kilometres beyond the precise footprint of development. In addition, direct disturbance through human encounter induces a flight response. All avoidance and flight responses have energetic consequences for caribou, potentially influencing productivity, survival and recruitment.

This province has been a leader in the scientific assessment of these disturbance effects on caribou with a research history extending back to the 1970s. Much of this research has entered the peer-reviewed literature and is being used by other jurisdictions to predict and assess human disturbance impacts. To follow are some of the principal studies and their findings to date.

- Following forest harvesting, the sedentary Corner Brook Lakes Herd displayed a tendency to avoid recently harvested forest stands, habitats which are associated with increased predator density, increased moose density, and reduced forage availability (Mahoney and Virgl 2003). These responses were predicted to lead to population decline.

- In a 12 year study, during forest harvest, in the range of the Middle Ridge Herd, male caribou did not appear to respond to harvest activity but females maintained an average distance of 9.2 km from active cutovers (Chubbs et al. 1992; Schaefer and Mahoney 2007). Adult females may be disproportionately affected by forest harvest disturbance.

- Hydroelectric development within the range of the Buchans Plateau Herd resulted in a disruption of migrational timing during construction activity and in caribou avoidance within 3 km of the site both during construction and for at least 2 years after the completion of construction (Mahoney and Schaefer 2002).

- During gold mine construction and operation, caribou of the La Poile Herd avoided areas within 4 km and were scarce within 6 km of the mine; avoidance of the mine site was most prominent in late winter, pre-calving and calving seasons, but was evident to some extent year round (Weir et al. 2007).

- When approached by snowmachines during winter, caribou from the Gros Morne Herd were displaced 60 to 237 m (Mahoney et al. 2001). Based on the sex- and age-specific reaction behaviour of caribou, and the estimated encounter frequency with snowmachines in Gros Morne National Park, energetic costs of this disturbance are high enough to affect caribou fitness. Based upon standard energetic models, snowmachine disturbance has the potential to cause mortality in calves, yearlings, and adult males, and to induce a decline in adult female productivity (Mahoney et al., *in prep*).

- When approached by a pedestrian during early summer, caribou from the Gaff Topsail Herd were displaced 50 to 135 m (Soulliere 2008). As when approached by snowmachine, interruption of other normal behaviour occurred prior to displacement. Energetic costs to caribou include both energy expenditure in running from direct disturbance, the loss of time for foraging, and reduced efficiency of rumination and digestion.

Climate oscillations correlate with trends in body size

In addition to assessing the role of predation, population density/forage interactions and hunting, the *Caribou Data Synthesis* has also included analyses of density-independent factors such as short term weather and large scale climate oscillations (e.g. North Atlantic Oscillation) and their effects on the observed trends in survivorship and body size. While preliminary analyses revealed few consistent relationships with short-term weather patterns, there was some indication that climatic oscillations may have played a role in changes in body size, but predominately at high population density. These analyses are continuing and form a large part of our population modeling (Chapter 8, *Synthesis* Report). Details on this component of the *Synthesis* will be provided in the next progress report.

SUMMARY AND INTERPRETATION

The *Caribou Data Synthesis* provides several firm and significant conclusions:

- Island-wide, the caribou population has declined rapidly and significantly—a 60% decline in the last decade. This numerical decline was underway by the late 1990s, but was first evidenced by a decline in recruitment that began in the mid-1980s.
- Radio-telemetry studies in the 1990s revealed complex herd relationships—extensive overlap in herd distributions, in some cases challenging existing management area boundaries and harvest quotas; some herds have abandoned their traditional calving grounds.
- Calf recruitment began to decline in the 1980s from 25–30%, eventually reaching less than 10% in recent years, levels which are insufficient for population stability.
- In many herds, over 80% of calves are dying during the first six months of life and most calves are being killed by predators, predominately black bear and coyotes, although lynx and bald eagles are involved. The most intense predation occurs in the first 6–8 weeks of life.
- For calves that do survive until late fall, over 70% survive over winter to reach one year of age.
- Virtually all caribou populations are aging as a result of the high calf mortality. A continuation of this trend can have only negative consequences for herd productivity and adult survival. Any intensified combination of high juvenile mortality, lowered pregnancy and increased adult mortality would hasten the caribou decline.
- Proportions of adult males in all populations have declined since 1980s and likely due in part to our male-biased harvest regulations. Too great a scarcity of males can potentially lead to declines in pregnancy rate, delayed impregnations and delayed birth leading to increased susceptibility of calves and eventually decline in population abundance.

- Productivity (pregnancy rate) has declined moderately for some herds, but not others. Continuous monitoring is essential to measure this important demographic index and to investigate the mechanism for these herd-specific trends.
- Birth weight of calves, adult jawbone size and male antler size have declined. These trends are consistent with impaired nutrition resulting from reduced availability of quality forage or increases in energy expenditure due to disturbance or some combination or both. Selective hunting practices may also have contributed.
- Hunter success rate has decreased dramatically since the late 1980s and has resulted in significant harvest restrictions.
- Using population viability analysis to model caribou population trends, if high rates of juvenile mortality continue, the population will continue to decline, even if all harvesting was suspended in the province.
- Both recreational human disturbance and industrial development have been intensively studied and confirm caribou avoidance responses believed sufficient to negatively affect caribou survival. As populations decline concerns for and remedial policies to address these issues will be of increasing importance.
- Utilizing island-wide compilations of historical data on weather as well as climatic changes associated with the North Atlantic Oscillation, evidence is indicating that climate and high population numbers may have contributed to changes in caribou body size.

While the cause of the caribou decline is undoubtedly complex, the phenomenon of fluctuating ungulate populations has been well studied and we are fortunate in having substantial scientific information available for the insular Newfoundland herds. Utilizing both the larger science and our provincial databases the *Caribou Data Synthesis* has shed considerable light on the causes of these patterns. Both density-dependent and density-independent influences have been implicated and the relationships and interaction of these factors is where the next phase of analysis is now focused. The conclusions presented in this Progress Report must be considered in this light and as subject to reevaluation. Nevertheless, we now stand better positioned than ever before to focus our efforts analytically and to design research to fill critical information gaps.

A number of these documented patterns are consistent with a density-dependent response to habitat. Specifically, we suggest that the long-term trends of reduced body size in adults, reduced antler points in males and the reduced weight of newborn calves are phenotypic consequences consistent with impaired nutrition at high population density. Although we do not have direct measures of changes in habitat quality and/or availability of forage, jawbone size, birth weight and antler quality are highly sensitive to changes in nutrient availability and are frequently used as indirect estimates of range quality and condition. Such range-related influences could be derived from the loss of range due to habitat alteration and disturbance as well as grazing effects of the animals themselves, especially on the summer range.

Hunting may contribute to these body size trends as well. We must acknowledge that our strongly male-biased hunting programs have influenced the female-biased sex ratio in our adult cohorts but hunting (especially non-resident hunting) may be contributing to reduced antler points and body size through selective mortality of the largest males. This effect has been cited to explain body size reductions in

populations with intensive trophy hunting programs involving small wildlife populations and for marine fisheries. The fact that percent harvest in our herds by non-residents (who select the largest males) is low, and that female body (jawbone) size has decreased more than the males appears at odds with this hypothesis. Nevertheless we cannot exclude hunting as a potential influence. We can however formulate an appropriate hypothesis to test between alternative explanations. If the forage limitation hypothesis is true than we predict that with lowered populations, now only at 1/3 of their former size, these antler and body size indices will improve.

Regardless of these underlying mechanisms, the high calf mortality (during first 6 months of life) due to predation is now the chief proximate limiting factor for our herds and is itself sufficient to drive population decreases. Furthermore, the demographic data are emphatic. Future declines are now inevitable, at least in the short term.

Unless these patterns are reversed, the decline of Newfoundland caribou will force cessation of hunting, sequentially in separate herds, but inevitably island-wide. Already hunting has been closed in the Avalon (2002) and Grey River (2008) herds, illustrating this pattern. Such closures can have dramatic social and economic implications. Certainly, given that the Newfoundland and Labrador outfitting industry alone contributes $40 million annually to the local (predominately rural) economy, the closure of caribou hunting will impact the already challenging sustainability of rural communities. Equally significant is the cultural impact for our recreational hunters, other outdoor enthusiasts, and the ecotourism economy generally.

Even if all hunting is prohibited, we will remain faced with the looming question of whether this population will fall to levels where recovery is unlikely or even impossible. Undoubtedly, before this time, the status of caribou under provincial and federal endangered species legislation will need to be addressed. The consequences for sustainable development generally, and for the economies of forestry, outfitting, energy development, mining, and adventure tourism specifically are deeply troubling. We cannot overlook the fact that once abundant caribou populations have disappeared from other regions of North America and nothing implicitly denotes insular Newfoundland to be any less susceptible. Indeed the predator guild that faces our herds is comprised of species which do not have an obligatory reliance on caribou. In other words, lynx, black bears, coyotes and eagles all pursue feeding strategies that will see them survive even in the total absence of caribou. Unlike the wolf, an obligate caribou predator, our carnivores will therefore not be expected to decline in lockstep with caribou. Under such circumstances, recovery from low numbers can be especially difficult. In this regard we should recognize that no reasonable alternatives exist for recovering these herds, except for intervention in the cycle of mortality that is currently depressing their numbers. This includes legal and illegal hunting mortality and the losses due to predation. We cannot improve habitat in any significant way directly, although we can expect improvement in the caribou-forage relationship given 60 percent fewer caribou than at their peak.

While we have confirmed the role of predation in calf survivorship, and should move immediately to reduce this, research is needed to clarify the predator-caribou dynamics, the inter-relationships of the predators themselves and their role in yearling and adult mortality, and to assess the efficacy of any predator intervention program. To this end we have, as directed, established a team of prominent academic

researchers from Memorial University, Trent University (Ontario), and the University of Massachusetts to lead a long-term predator ecology/predator-prey research program coordinated through the Institute for Biodiversity, Ecosystem Science and Sustainability (IBES).

This research, which forms a significant part of the science component of the new *Caribou Strategy 2008–2013*, will elucidate the nature of interactions between caribou and each predator species, as well as among the various predator species themselves. Knowing the ecology of the predators is essential if we are to prudently manage and conserve their populations through any predator intervention program to assist caribou, their prey. Even more importantly, however, it is an essential component of Government's public trust responsibility for the prudent and scientific conservation and management of all wildlife species.

FUTURE REPORTING

The *Caribou Data Synthesis* is ongoing and interpretations will continue to be revised based on the most recent information available. Further substantial progress towards the final report is anticipated over the next 12 months, and additional reporting is scheduled for fall 2010.

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PRODUCT LIST

This is a list of selected major products of the *Caribou Data Synthesis*. While not exhaustive, the list exemplifies the range of information synthesized, analyzed, interpreted and disseminated since the initiation of the project in 1996.

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