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CircumArctic Collaboration to Monitor Caribou and Wild Reindeer

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ABSTRACT. Caribou and wild reindeer (*Rangifer*) are integral to ecology and Aboriginal lives and culture in circumArctic regions. Since reaching peak size in the 1990s, most herds have been declining, while their ranges are changing as the footprint of people's activities expands and the climate warms. More than ever, then, people need to share information and experience on *Rangifer* management and conservation. In recognition of this need for a circumArctic approach to monitoring, the CircumArctic *Rangifer* Monitoring and Assessment (CARMA) network, a relatively informal group of scientists, community representatives, and management agencies, was established in 2004. CARMA emphasizes collaborating and sharing information on migratory tundra *Rangifer* and developing tools to deal with the impacts of global changes on these herds.

Key words: caribou; circumpolar; CircumArctic *Rangifer* Monitoring and Assessment (CARMA); monitoring; management

RÉSUMÉ. Le caribou et le renne sauvage (*Rangifer*) jouent un rôle intégrant dans la vie et la culture autochtones des régions circumarctiques ainsi que dans l'écologie de ces régions. Depuis que la taille des troupeaux a atteint son summum dans les années 1990, la taille de la plupart des troupeaux diminue et leur parcours naturel se modifie en raison de l'expansion des activités humaines et du réchauffement climatique. C'est pourquoi plus que jamais auparavant, il est important de partager information et expérience au sujet de la gestion et de la conservation du *Rangifer*. Dans cette optique, un réseau de surveillance circumarctique a été établi en 2004, soit le réseau CircumArctic *Rangifer* Monitoring and Assessment (CARMA), dirigé par un groupe relativement informel de scientifiques, de représentants de la communauté et d'organismes de gestion. Le réseau CARMA met l'accent sur la collaboration et le partage d'information concernant le *Rangifer* migrateur de la toundra ainsi que sur la mise au point d'outils pouvant faire face aux incidences des changements planétaires qui ont un effet sur ces troupeaux.

Mots clés : caribou; circumpolaire; CircumArctic *Rangifer* Monitoring and Assessment (CARMA); surveillance; gestion

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INTRODUCTION

Caribou and wild reindeer (*Rangifer*) are a keystone large mammal in Arctic ecology, characterized by peaks of abundance in the millions and seasonal migrations of hundreds and thousands of kilometres across the tundra and northern boreal forests. The frequency and methods of national observing systems for the trends in *Rangifer* abundance vary between countries and even within countries. The precision and accuracy of measured trends are variable, and the frequency of estimates for some herds is at the decadal scale, which means that some declines have not been recorded until they exceeded 50%. Observing systems that record landscape changes also vary greatly between countries and regions even though trends are often widespread.

The need to monitor caribou and wild reindeer is rapidly increasing because the herds themselves are declining and the landscapes of their seasonal ranges are also changing rapidly. Of the 23 herds monitored, at least 19 remain at low numbers after severe declines of 70%–97% or have continued to decline, while only four herds are increasing or have remained stable at high numbers (Russell and Gunn, 2013; unpubl. updates; Fig. 1). It is uncertain whether the current low numbers are lower than historical numbers, but for some herds, their current ranges, especially winter ranges, are significantly contracted compared to historical ranges. Large migratory *Rangifer* herds are nutritionally regulated, and climate plays a major role in the interannual availability and quality of forage for the species. Further, cycles in large migratory caribou herds have been linked to global climate oscillations (Post and Forchhammer, 2002; Joly et al., 2011). Both vegetation shifts driven by climate warming and expansion of industrial development are rapidly modifying the landscapes of *Rangifer* seasonal ranges although their signals vary regionally around the Arctic (Gunn et al., 2009). The concerns of the people who depend on *Rangifer* and whose cultures are built on the ancient relationship with *Rangifer* are strong across all circumArctic countries (Ulvevadet and Klokov, 2004).

The need for a circumArctic approach to monitoring *Rangifer* was first recognized in 1999 when the International Arctic Science Committee (IASC) and the U.S.

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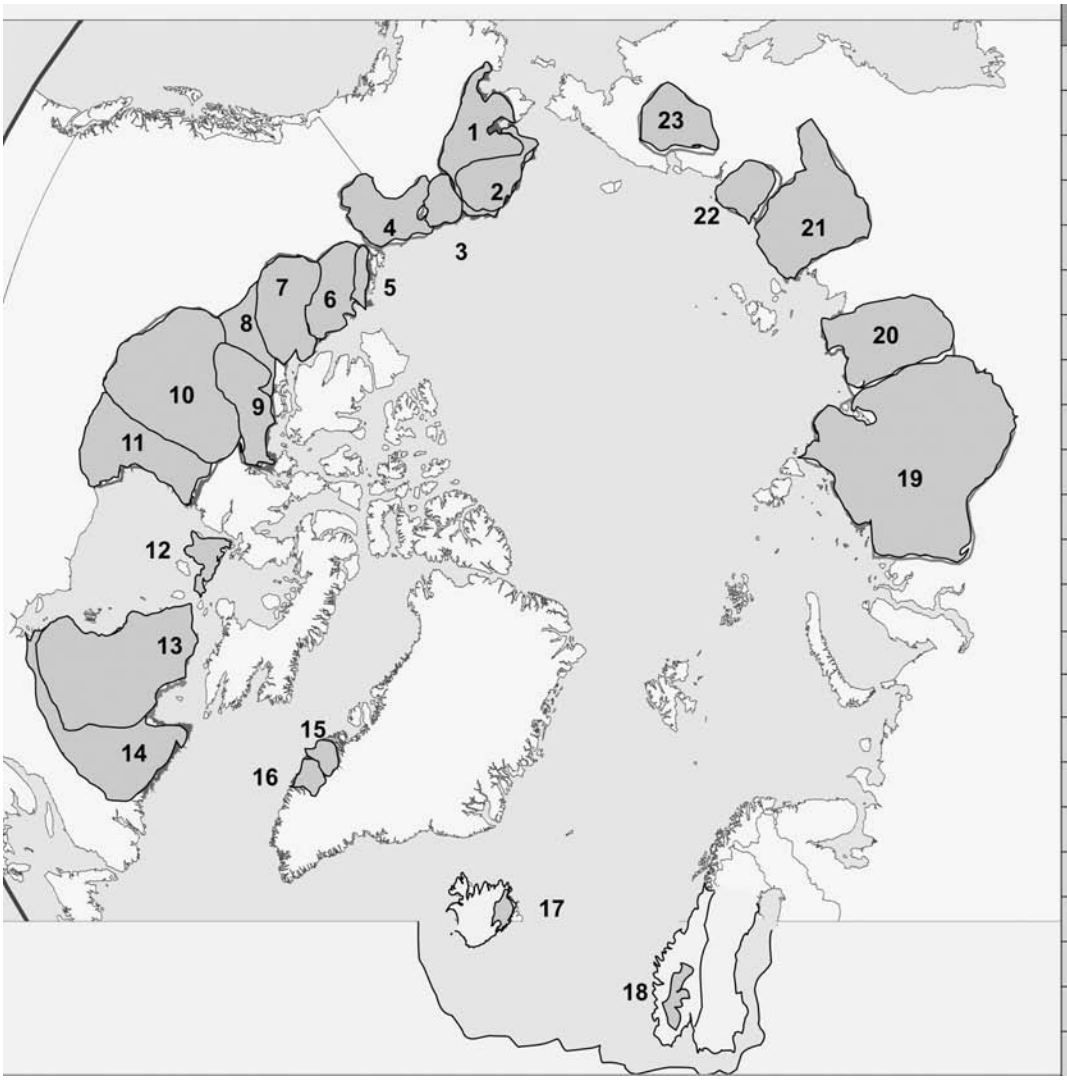

#	Herd name
1	Western Arctic
2	Teshekpuk Lake
3	Central Arctic
4	Porcupine
5	Cape Bathurst
6	Bluenose West
7	Bluenose East
8	Bathurst
9	Ahiak
10	Beverly
11	Qamanirjuaq
12	Southampton
13	Leaf River
14	George River
15	Kangerlussuaq-Sisimiut
16	Akia-Maniitsoq
17	Iceland
18	Norwegian
19	Taimyr
20	Lena-Olenyk
21	Yana-Indigurka
22	Sundrunskya
23	Chukotka

FIG. 1. Circumpolar herds included in the CARMA network.

National Science Foundation (NSF) funded an interdisciplinary conference of *Rangifer* managers, users, and scientists to discuss a circumpolar monitoring and assessment network for human-*Rangifer* systems (Russell et al., 2000). To implement the monitoring plan, a relatively informal network of scientists, community representatives, and management agencies, called CircumArctic *Rangifer* Monitoring and Assessment (CARMA), was established in 2004. The focus was on collaborating and sharing information on migratory tundra caribou and developing the tools to deal with impacts of global changes on caribou herds (Russell et al., 2013a).

This paper follows the major themes that were defined for the 2013 Arctic Observing Summit in Vancouver, British Columbia. We summarize (1) the status of the current observing system, 2) its design and organizaton, and 3) the mechanisms for coordination, implementation, and operation of a sustained Arctic observing system. Lastly, we offer some recommendations for continued support and adaptability of the monitoring system for *Rangifer*.

STATUS OF THE CURRENT OBSERVING SYSTEM

The current monitoring for *Rangifer* at the national and regional scales is typically driven by formal or informal management plans. Those plans (and of course, budgetary constraints) have led to aerial surveys, often with photography, to track the abundance of individual herds. Currently about 23 herds are assessed at intervals varying from 2–3 years to 10+ years, but the information these assessments produce tends to be scattered in unpublished reports.

In 2005, CARMA was invited to become an official network under the Circumpolar Biodiversity Monitoring Program (CBMP), which in turn reports to the Conservation of Arctic Flora and Fauna (CAFF) and the Arctic Council (Russell et al., 2013a). CARMA's network is well supported in Alaska, Canada, Greenland, Iceland, Norway, and Russia. With the end of the International Polar Year (IPY) funding in 2010, CARMA turned to other government programs and industry to fund priority activities that its members had identified as meeting their needs. CARMA

currently has a small organizing committee and decided in 2012 to switch from annual to biennial meetings, with 40–70 people from Aboriginal organizations, government agencies, and universities attending. The emphasis is on exchange of information about the status of *Rangifer* and their seasonal habitats. A priority has been for CARMA to develop tools (models) for the assessment, monitoring, and mitigation of cumulative effects on migratory tundra caribou. CARMA also maintains a database on *Rangifer* abundance and condition and provides input to the annual Arctic Report Card from the National Oceanic and Atmospheric Administration.

THE OBSERVING SYSTEM'S DESIGN AND COORDINATION

CARMA has a small organizing committee coordinated through the Yukon College in Whitehorse, Canada. In 2005, two large grants, one through the Canadian IPY program and the other through the NSF, provided support. CARMA's Canadian IPY project, "Starting the Clock for the CARMA Network: Global Change, Resilience and Human-*Rangifer* Systems of the CircumArctic," aimed to develop protocols for monitoring caribou at individual and population levels and funded a number of projects to either initiate standard monitoring programs or develop new methods that could be incorporated into monitoring manuals. The funding also gave us an opportunity to 1) develop a communications website (www.caff.is/carma), 2) develop policies for sharing and handling data, 3) initiate programs that will help us better understand how change is affecting communities across the North, 4) document local knowledge about changes in human-caribou relationships, 5) provide educational tools to schools, 6) provide materials and training for hunters to participate in monitoring the health of caribou, and 7) further our capability to synthesize data and assess herd-specific vulnerability and resilience to global change through modeling. Considerable effort was focused on building a common understanding, and the CARMA membership and secretariat collaborated on monitoring techniques captured in online databases, manuals, and videos (Russell et al., 2013a).

The design of the monitoring is constrained by national programs, but all programs have elements in common that are facilitated by CARMA's manuals and shared databases. The national and regional programs track trends in *Rangifer* abundance and distribution, as well as vital rates, typically adult and calf survival, and parturition. Habitat inventory and monitoring are conducted across the circumpolar North, primarily through remote sensing of vegetation types (CAVM Team, 2003) and changes in vegetation (Epstein et al., 2004). CARMA contributes through a climate database at the scale of seasonal ranges that includes derived indices for factors such as insect harassment (Russell et al., 2013b).

MECHANISMS FOR COORDINATION

While CARMA is well established and accepted for its role in circumArctic *Rangifer* monitoring, it has been driven by the efforts of a few people. We are now at a stage where CARMA needs to implement a knowledge-to-action plan to further coordinate and support *Rangifer* monitoring. The next step is to find the funding to implement the plan, which aims to move CARMA from describing what is happening to caribou (symptoms) to understanding why it is happening (causes). Implementation of this plan should help us understand how we can manage in the future. At CARMA's annual gatherings, Aboriginal communities and co-management boards ask similar questions: 1) Why have our herds declined, and what should we be doing to foster recovery? 2) How are climate change and development affecting our herds? and 3) Are caribou safe to eat?

A common thread throughout CARMA's knowledge-to-action plan is our vision of fostering youthful leadership and cross-generational learning. CARMA recognizes the need to have at least one early-career scientist, with mentoring support, to lead and produce a "repository of lessons learned" from caribou declines over the past 15 years. The second priority of the knowledge-to-action plan is to use existing knowledge to assess herd-specific vulnerability and resilience to human-related change in the Arctic. The CARMA network will develop a user-friendly interface for the climate database, a demonstration application of climate data to calving grounds, and online resources that will enable people to use the CARMA cumulative effects models to assess impacts of development and climate change on individual herds. The third knowledge-to-action priority will be to invite a second early-career scientist to lead in developing a caribou health monitoring plan, with guidelines for community-based monitoring of caribou health. Online and practical teaching aids will be developed for youth, hunters, and elders in order to test and improve the health monitoring protocols.

Caribou herds experience a cycle of abundance that lasts about 40 to 60 years (Gunn, 2003). Over the last 15 years, most caribou herds around the circumpolar world have experienced rapidly declining populations, a phenomenon not experienced since the 1950s and 1960s (Russell and Gunn, 2013). The major difference between the latest declines and earlier declines, particularly in Canada, is that management of the herds now depends on recommendations of co-management institutions created under land claims (Kofinas and Russell, 2004). What is also different is the unprecedented rate of global Arctic changes: 1) increased industrialization and transportation corridors, 2) sophisticated technology that gives hunters unprecedented access to caribou, and 3) climate change (Gunn et al., 2009).

During the last caribou cycle (1970 to 2014), a clear "management" pattern emerged: essentially, herd abundance was not actively managed until numbers of caribou had peaked and then declined to the point of near-crisis. In some cases,

delayed monitoring resulted in the almost total disappearance of once-large herds. Some herds, including the Bathurst and George River herds, lost more than 90% of their peak numbers. Although at least one herd, the Porcupine caribou herd, is recovering, others such as the George and Leaf River herds are still declining (Russell and Gunn, 2013).

CARMA collaborators identified a clear need to develop a strategy for monitoring and management through the entire cycle of abundance. Management actions and monitoring are just as important when herds are rapidly increasing as when they are declining. We can use monitoring data to address two key questions: 1) What lessons did we learn during the recent period of decline? and 2) How should we monitor and manage our herds during the next cycle of abundance?

Lessons learned from caribou declines over the last 15 years compared to peak caribou numbers include how to monitor changes in peak numbers; how to manage the land for recovery when it is devoid of caribou; and which management actions worked, which did not, and why. When the knowledge-to-action plan is implemented, an online repository of these monitoring data will be immediately accessible to managers facing declines in the near future and will remain a legacy for future managers.

All co-management boards have expressed the need for a coordinated, credible approach to assessing the cumulative impacts of development on their caribou herds. Boards and agencies also wonder both 1) how climate change will factor into impact assessment and 2) how to factor in the cycles of caribou abundance. We hear the same message directly from communities as people recognize the need to determine how herds will be affected by incremental development not only during the "good times" of herd expansion, but also during the "bad times," when herds are in rapid decline.

CARMA has already begun to address the challenges posed by cumulative effects and has a workable and tested approach (Russell, 2012, 2013, 2014a, b; Gunn et al., 2011, 2013, 2014; White et al., 2013, 2014). CARMA uses a modeling approach to project a caribou's forage intake and then determines the growth and fattening of an individual female caribou and her calf as they "walk through" their environment. Climate is a major factor that affects how well a caribou will do throughout the year. The model can incorporate climate change or human activity as the caribou moves through its seasonal ranges, so different scenarios can be imposed on the caribou to assess cumulative impacts of human activity. From modeling scenarios in the energy-protein model, output of key indicators such as fall fat weight of cow and fall condition of calf can then be used to link condition with herd productivity at the population scale. When modeling impacts on the population, the impact of management policies, such as harvesting strategies, can also be explored.

To ensure that CARMA's knowledge base is available and accessible for users, CARMA will develop demonstration applications and online manuals for climate modeling and cumulative effects. Users have expressed a strong need for a user-friendly interface to make the climate database more accessible. With an online manual to introduce and explain the climate database, co-management boards and other users can access data to predict annual risks to their herds. Applying the climate database will provide input into cumulative effects modeling. We will build herd-specific datasets required to run the models, combined with generic runs to demonstrate herd vulnerabilities and resilience to global change. Further, for a few herds with extensive monitoring data (e.g., Porcupine and Bathurst caribou herds), we will run a current and potential analysis of cumulative impacts. From the results of these first two actions, we will develop a manual and provide access to expertise for users to apply the CARMA cumulative effects models in order to assess development and climate change on a herd-by-herd basis.

Traditional food security is a concern throughout the North. The rapid and unprecedented Arctic climate change is already influencing diseases and parasites in caribou (Bradley et al., 2005; Kutz et al., 2012). During IPY, we developed, and implemented for the first time, standardized protocols to measure the biodiversity of pathogens in caribou across a broad geographic range. CARMA, with the University of Calgary's Faculty of Veterinary Science, established a database (biodiversity, effects, and geographic, seasonal, and age-related patterns of pathogens in caribou) that will now allow us to explore the effects of climate change on host-pathogen dynamics, and ultimately, on host population dynamics. We also recognize and share the concern of users that they need more information about diseases and parasites—especially new and emerging ones. CARMA will seek to ensure the flow of useful information and effective training on caribou health monitoring through a collaborative health-monitoring plan and through development of teaching aids and delivery of training.

Much of CARMA's knowledge-to-action plan is about communication: bringing data, experience on management, and tools from both community knowledge holders and scientists to co-management agencies. Building sustainability is a collective process and requires communication to keep team members and other participants working together. CARMA communicates through its website, email distribution lists, announcements, online conference calls, and participation in co-management board and council meetings.

It is CARMA's aim for the next few decades to play a role in ensuring that herds will recover to previous high numbers, that we will emerge from the current low numbers with a better knowledge of the dynamics and effective management of migratory tundra caribou and wild reindeer, and that the species will continue to be a critical part of the North's ecology and cultural identity.

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