The Adaptable Caribou

They survived the tremendous environmental upheaval that accompanied their transition out of the last ice age and they continue to adjust today...

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When Dr. Mark Steffen, section editor of *Fair Chase*, recently called to ask, "Why haven't we seen many B&C-class barren-ground caribou from northern Canada or Alaska submitted during recent years?" I had to admit that I wasn't aware that was the case. A quick perusal of the Boone and Crockett Club web site showed there were 82 entries from 1981-1983, while from 2005-2007, there were only 14.

After more than 20 years working as an area management biologist for the Alaska Department of Fish and Game in the northwest portion of the state, and as lead biologist for the Western Arctic Caribou Herd, I've spent thousands of hours looking at caribou, thinking about their population dynamics and working on management issues. But like most other management biologists, I've not had much reason to focus specifically on their antlers. I suspected the answer to Mark's question was probably related to nutrition but I wasn't ready—and still am not—to pronounce that caribou range is in decline across North America. Even so, our brief conversation quickly made me realize the potential value of B&C records for showing long-term, broad-scale trends in wildlife populations that would be impossible for any individual management agency to collect.

A several-year gap in submissions of B&C-class barren ground caribou does not constitute a long-term trend, and only time will tell whether this is the beginning of such a trend. In Alaska, several small caribou herds, numbering only hundreds of animals, have produced some tremendous bulls in recent years.

Ask any wildlife biologist who's been in the business for more than 15 minutes and they'll tell you that there are rarely any simple answers to questions regarding wildlife biology. Such is the case with antler growth. Entire books have been published describing the evolution and physiology of antlers, the effects of antlers on male and female behavior, reproductive success, etc. The answer to Mark's question lies in the balance between nature and nurture—the effects of genes and environment—in determining the body size and condition of caribou and, hence, the size of their antlers.

Body Size, Antler Size, and Nutrition

The genus *Rangifer*, to which all species and subspecies of caribou worldwide belong, is a survivor from the last ice age. It's the only member of the deer family in which both males and females carry antlers. Like most species that existed then and now, caribou were 10-20 percent larger during the Pleistocene period (roughly 10,000 to 1.8 million years ago) than

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the caribou we see today. Paleontologists attribute the large body size of Pleistocene herbivores to environmental conditions that produced tremendously productive grasslands: cold, dry, windy winters with generally shallow snow cover; wet springs; warm, dry summers; and wind-transported loess—a product of glaciers grinding rock to the size of silt that constantly rejuvenated mineral soils.

As a result, grazers such as horses, wooly mammoths, and steppe bison thrived as did the predators and scavengers that ate them. In addition to having large bodies, many animals present during the Pleistocene—including caribou—had disproportionately greater secondary sex characteristics, such as horns, antlers, dewlaps and manes, with greater sexual dimorphism (the tendency for males to be larger and gaudier than females). Pleistocene caribou with bodies 20 percent larger than those alive today may have had antlers that were 30 percent larger. Paleontologists think that the superabundance of food available during the Pleistocene enabled animals to invest heavily in showy traits that gave them a competitive advantage during breeding without compromising their ability to escape predators or survive during winter.

Warming temperatures at the end of the Pleistocene changed the highly productive grasslands to less productive forests, shrubs, and tundra. As food became limiting, two things happened. First, the body size of grazers became smaller. For example, the last mammoths in existence were less than half the size of those present during the height of the ice age. Second, some species eventually disappeared completely. Those species that survived into modern times, which included caribou, did so by virtue of their adaptability while more specialized species, such as mammoths, died out. The price paid by those species that survived was a more conservative growth strategy that resulted in smaller bodies and smaller horns or antlers.

You don't have to go back to prehistoric times to show the link between caribou body size and nutrition, though. In what is now considered a classic study of the rise and fall of a food-limited population, Dr. Dave Klein found that both body and antler size of a wild reindeer population introduced to St. Matthew Island varied in relation to range quality. Virgin, high quality range initially produced large-bodied individuals that grew large antlers, but as range condition declined, so did each of these characteristics. Since then, many other studies in North America and Europe have shown similar results for caribou and other members of the deer family.

Biologists have collected jaws from Western Arctic Herd caribou several times since the 1950s which allowed us to look for trends in body size. We found that the body size of bulls was smaller during 1965-1968, a period of relatively high and possibly declining numbers, compared to 1977-1989 when numbers were increasing following a dramatic population decline. Based on the growth curves of bulls during these two periods, it appeared that poor nutrition during the period of decline resulted in small calves, and that those calves did not compensate for their poor start in life by rapid or prolonged growth later on. It is unlikely that predation, hunting, or disease selectively eliminated large caribou during the period of decline.

An alternative to abundance-based management is to enjoy population highs when they occur, do all we can to prevent man from further depressing populations during naturally-occurring periods of low abundance, and accept that some wildlife populations, like caribou, will cycle up and down.

Density-Dependent vs. Density-Independent Limitation

Caribou populations are limited by a myriad of factors. Biologists lump these into two broad categories: density-dependent and density-independent factors. Density-dependent factors affect populations in proportion to the number of animals on their range. That is, the more caribou there are, the greater the impact on their environment. For example, if caribou numbers increase more rapidly than the size of their range, they will: 1) reduce range quality by feeding and trampling vegetation, and may increase chemical defense mechanisms that plants use to reduce herbivory; 2) increase numbers of predators—including man; and 3) be more susceptible to disease as opportunities for transmission of bacteria, viruses or parasites increases with greater direct or indirect contact among caribou and their predators.

In contrast, the severity of density-independent factors is irrespective of population density. Examples of density independent factors include weather, such as icing events or severe storms, or resource-development projects that reduce the quality of caribou range or restrict their movements. A rain-on-snow event during mid-winter can create a killing coating of ice on the vegetation that would be fatal to many caribou regardless of whether their population was high, low, increasing or decreasing.

Density-dependent and -independent factors can affect caribou populations simultaneously. There were over 400,000 caribou in the Western Arctic Herd from about 1990 through 2007. During this same time, Bureau of Land Management range ecologists documented roughly a 15 percent decline in lichen cover with corresponding increases in shrubs and sedges on portions of this herd's winter range. This was probably a density-dependent response to grazing by caribou. It may also have been due to warming temperatures and vegetative succession, density-independent factors that have caused similar trends in other portions of Alaska. Despite this change, we saw no trend toward declining caribou body condition during this time.

Apparently, although winter range was changing, there was still enough food for caribou to maintain their overall body condition through time. However, an icing event during December 2005 resulted in the highest mortality of adult cows that we've ever measured (32 percent). It's possible that the long-term changes in vegetation prior to this event rendered caribou more vulnerable to the effects of this icing event. To further complicate things, the effects of density-dependent and -independent factors may act synergistically; that is, their combined effects may exceed the sum of the individual factors. I tend to think of density-dependent factors as primarily influencing long-term population oscillations, and density-independent factors as those that cause rapid deviations—both up and down—from those long-term trends.

Weather: Short-Term Effects

In addition to long-term trends that can span decades, seasonal and annual variability in weather can substantially affect vegetation and caribou over a scale of weeks or months.

Barren Ground Caribou Boundaries and Records Book Entries

The various varieties of caribou, which vary widely in size and antler configuration, have required subdivision of the species into five different trophy categories: mountain, woodland, barren ground, Central Canada barren ground, and Quebec-Labrador. Prior to 1960, the classification of the different species and subspecies of the world was in disarray. At that time, Frank Banfield (a Canadian wildlife biologist) reviewed all of the available museum specimens of the world's caribou and reduced the number of valid subspecies. Among his conclusions were that the new world caribou and the old world reindeer should all be classified as one species, but that northern barren ground caribou differ from the more southerly distributed woodland caribou, both in Eurasia and in North America.

The largest antlered caribou from North America are the Grant's variety from Alaska and northern Yukon Territory. These caribou, called barren ground caribou for records-keeping purposes, have long, rounded main beams with very long top points. They also have the highest all-time records book minimum entry score of 400 points.

Central Canada barren ground caribou occur on Baffin Island and the mainland of Northwest Territories and Nunavut, as well as in northern Manitoba and northern Saskatchewan. Caribou from other Arctic islands north of the mainland of Northwest Territories/Nunavut are ineligible for entry in B&C's records books. The geographic boundaries in the mainland of Northwest Territories are: the Mackenzie River to the west; the north edge of the continent to the north (excluding any islands except Baffin Island); Hudson's Bay to the east; and the southern boundary of Northwest Territories to the south.

YEAR TAKEN	BARREN GROUND CARIBOU	CEN. CAN. BARREN GROUND CARIBOU
2006 Entries	3	8
2007 Entries	4	8
2008 Entries*	2	0

** We may still receive more entries taken during the 2008 season. We will be receiving entries for the 2008 hunting season for the remainder of this year, especially the next two months.*

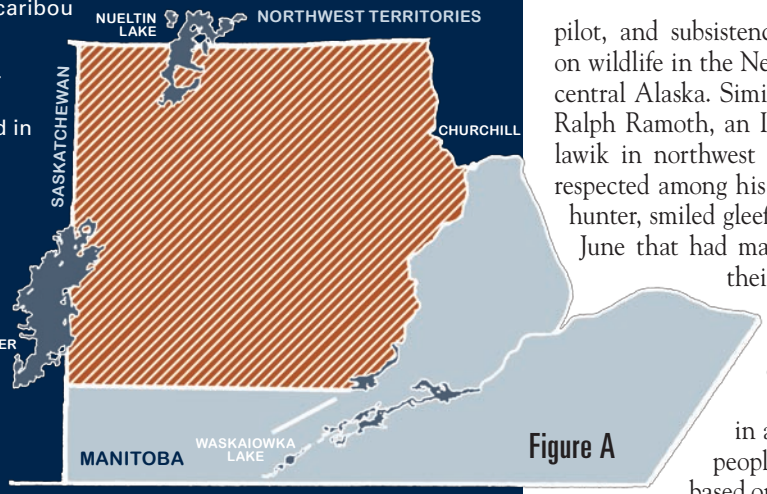

Figure A

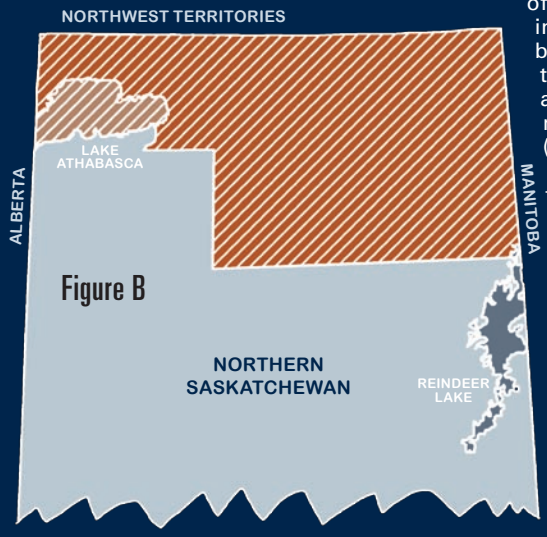

Figure B

Figure A indicates the boundary for Central Canada barren ground caribou in Manitoba, while **Figure B** demonstrates the boundary in northern Saskatchewan. For more detailed boundary descriptions, visit the Club's web site (www.booneandcrockettclub.com) or pick up a copy of our newest book, ***Measuring and Scoring North American Big Game*** (Associates $23.95) available in April.

AWARDS PROGRAM	BARREN GROUND CARIBOU	CEN. CAN. BARREN GROUND CARIBOU
20th Awards Program 1986-1988	119	46
21st Awards Program 1989-1991	74	68
22nd Awards Program 1992-1994	147	53
23rd Awards Program 1995-1997	108	102
24th Awards Program 1998-2000	53	72
25th Awards Program 2001-2003	44	46
26th Awards Program 2004-2006	19	36
27th Awards Program 2007-2009	16	26

Over 20 years ago at his Meier's Lake hunting camp, I recall long-time big game guide Cleo McMahan remarking that a cool, wet spring often produced large antlers on moose and caribou. Cleo didn't have a speck of data to support that statement. But instead of formal biological surveys, he had over 40 years of experience as a guide, trapper, bush pilot, and subsistence hunter, all focused on wildlife in the Nelchina Basin of south-central Alaska. Similarly, several years ago Ralph Ramoth, an Inupiaq elder from Selawik in northwest Alaska who is highly respected among his peers as a subsistence hunter, smiled gleefully over a cold, foggy June that had many people bemoaning their continued need for long johns, remarked, "Good for berries and caribou, fall time!"

Ralph grew up in a time and place when people ate or went hungry based on their ability to secure food from their surroundings. People like Cleo and Ralph had a comprehensive understanding of animals, their habitats and weather with a depth through time that most scientists—constrained by things like funding cycles, publication requirements, career advancement and agency procedures—usually cannot approach.

Science has its strengths, though, and is now quantifying what people who live close to the land have conceptually understood for generations. Dr. Greg Finstad recently published several manuscripts that are consistent with Cleo and Ralph's observations: the timing of moisture availability and air temperature during spring through summer affect both the amount of biomass and nutritional content of vegetation that caribou rely on for food. A warm, dry spring followed by a hot summer reduces the quantity and quality of plants that caribou eat which, in turn, can reduce fat deposition and antler growth.

It's not enough for caribou to merely have access to adequate amounts of high-quality forage to put on enough fat to get through the fall rut and subsequent winter. Caribou are particularly vulnerable to the effects of insect harassment during summer. Mosquitoes, nose bots, warble flies, and biting flies cause caribou to gather in large, dense aggregations along coastlines and on windswept ridges. In addition to forcing

caribou to compete with each other on small areas that often have little food, insect harassment increases energy expenditures by causing them to move continuously, sometimes at a dead run. If caribou cannot feed or ruminate, their bodies cannot replenish fat stores or grow large antlers. These 'buggy' summers can increase infestations of fly larvae that lodge in caribou nasal cavities or beneath their skin and sap their energy and nutrient stores. Hot, dry, and calm conditions that reduce the quality and quantity of caribou food are favorable for insects: a double whammy if ever there was one.

Each September, we collect blood samples from up to 175 caribou and deploy radio collars on 25-40 individuals at a river crossing in northwest Alaska. In addition to the animals we actually handle, we're close to thousands of caribou as they swim the river. I recall one year in the late 1990s when we were struck by the large size of antlers on bulls and cows, and by the preponderance of large calves. Similar observations were reported by many guides and transporters operating in northwest Alaska that fall. Phil Driver, a guide that has worked this area for almost 40 years, stole the words right out of my memories of Cleo: "That's because it was such a lousy spring!"

Short-term effects of weather on caribou are notoriously difficult to quantify. A weather event that occurs during early winter may have no measureable effect on caribou for months. The effects of weather on caribou can be cumulative: a moderately deep snow that falls in early winter may be harder on caribou than an unusually deep snowfall that happens just prior to breakup. In areas where caribou range abuts coastlines, weather can substantially vary on a daily or even hourly basis. Caribou are also famously unpredictable. All of these things produce what biologists term "noisy" data. In addition, for many herds there are few or no weather stations in large, remote portions of their range: no data is even worse than noisy data! Although biologists have generally not yet been able to mathematically model comprehensive, predictive relationships regarding the effects of climate and weather on caribou populations, models can be useful to identify gaps in data and evaluate how changing conditions might affect caribou and their environment.

Caribou Populations: Large-Scale, Long-Term Trends

The past 30-40 years were generally good for barren ground caribou across North America. Most populations increased, and some populations in Canada and Alaska

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reached very high levels. This situation may have begun to change around the year 2000. The three largest barren ground caribou herds in Alaska—the Mulchatna Herd, Porcupine Herd and Western Arctic Herd—all began to decline within several years of that time. During the same period, some of the largest caribou herds in Canada and Russia declined as well. The fact that these large caribou populations are declining across the north with some degree of synchrony may be merely coincidence. Alternatively, they may indicate that large-scale environmental processes that biologists do not yet completely recognize or understand are affecting caribou populations similarly over the circumpolar north.

You can't read a newspaper now without seeing some reference to climate change: specifically, global warming. The theme of the Tenth North American Caribou Workshop held in Girdwood, Alaska, in May 2004 was "Caribou and Climate." Many of the papers that were presented (reported in the journal *Rangifer*, Special Issue No. 16, 2005), including the keynote address by noted climatologist Dr. Gunter Weller, presented a large body of evidence indicating that global warming is real and is being caused by elevated levels of CO_2 in the atmosphere generated from burning fossil fuels. Regardless of whether you accept or dispute man's role in climate change, there is now an abundance of climatological data that unequivocally show air temperatures have increased in the Northern Hemisphere during the 20th century, and most strikingly in the Arctic.

These data also show that the rate of warming was most rapid after about 1970. This may partially explain the increase in shrubs throughout portions of Alaska that has occurred since the mid 1900s. A short-term consequence of rising temperatures for caribou and other northern animals will likely be an increase in the frequency of mid-winter thaws. Warm temperatures accompanied by rain can create the deadly icing conditions I mentioned above. In October 2003, freezing rain contributed to the death of roughly 20,000 musk oxen on Banks Island. Animals struggling to simply survive will probably not produce trophy antlers. Over the long term, warming temperatures are predicted to cause significant changes in ocean water temperatures and ice cover that drive weather patterns on land, resulting in shifts in the species composition of plants and changes in plant biomass.

In addition to affecting caribou body condition, antler size, and population dynamics, climate change may also influence their seasonal movements and distribution. Canadian researchers speculate that this could affect hunter access to the Porcupine and Bathurst herds in western Canada. Since about 2000, the fall migration of the Western Arctic Herd has begun two to six weeks later than during the 1980s and 1990s, and has been unpredictable in terms of numbers and distribution of migrating caribou. This has reduced hunting success in some years during early fall when most trophy hunting occurs.

Even though browsers such as moose and generalists like caribou successfully replaced specialized grazers at the end of the Pleistocene, this time around they may not fare as well. There are limits to the adaptability of caribou, and ecological reasons why elk now occur in Wyoming instead of caribou.

Some researchers speculate that caribou populations may cycle on a somewhat regular basis, like snowshoe hares, and that these cycles are driven in part by periods of good and bad weather similar to the well-known El Nino and La Nina cycles. How these weather patterns will interact with global climate change is unknown, although the impact of these changes in each weather pattern are already starting to be measured. Instead of an average seven to nine-year oscillation period characteristic of hares, caribou populations may fluctuate over periods spanning decades. Indeed, caribou numbers reached very low levels throughout much of Alaska by the mid 1800s and disappeared completely from large areas where the fossil record shows they had previously occurred. The human population in Alaska then was small, hunting equipment was primitive, large-scale resource development was nonexistent, and animals were taken by man only for sustenance. It's hard to imagine that man caused this tremendous population contraction. Techniques commonly employed today to monitor caribou populations, such as aerial surveys and radio telemetry, have only been around about 50 years. If caribou populations do indeed cycle, there hasn't been enough time for modern scientists to have experienced enough complete oscillations to recognize or understand this pattern.

What Does It All Mean?

Climate change will likely not be a steady slide toward warmer conditions. Instead, temperature will probably vary through both space and time. For example, a recent long-term forecast by the National Weather Service suggests that Alaska may be in for a period of cool, dry weather due to decreasing water temperatures in the north Pacific. However, if global warming continues far into the future, I can't help but think that northern adapted species like caribou will be at a disadvantage compared to those species adapted for more temperate conditions. Even though browsers such as moose and generalists like caribou successfully replaced specialized grazers at the end of the Pleistocene, this time around they may not fare as well. There are limits to the adaptability of caribou, and ecological reasons why elk now occur in Wyoming instead of caribou.

In the meantime, though, during years when weather conditions are favorable, caribou could benefit from periods of high plant productivity and produce large individuals with large antlers. In contrast, during years when icing events occur, the results could be disastrous for caribou. In other words, caribou and the people who depend on them could be in for a roller coaster ride of good times and bad in coming decades.

Many people think that with good science and active management it's possible to maintain relatively stable populations of moose and caribou at moderate to high levels indefinitely. That is, actively manage harvest levels, predator numbers, and habitat to lower population peaks and shore up their lows. The concept of managing wildlife to maximize abundance for human use is an objective in Alaska and probably other states and provinces as well. Unfortunately, it may be wishful thinking—at least with regard to caribou. Caribou, their predators, and their range have been around much longer than scientists, administrators, and politicians, and they did just fine biologically—albeit with large swings in abundance—without

modern management. Indeed, it's often the collective activities of man that necessitate modern, intensive management of wildlife.

During 1976 through 1990, when the Western Arctic Herd was increasing at its maximum rate, there was nothing managers could have responsibly done to limit its growth and prevent it from overshooting the carrying capacity of its range. Even if we had wanted to stabilize this herd before it peaked, who would have decided what that level should be? If we had somehow managed to do so, we would have precluded access to this herd by some communities that hadn't hunted caribou for generations. People in those communities were understandably overjoyed when thousands of caribou returned to nearby portions of their range that had not been used for over 100 years. Of course, at the other end—the low end—of the population spectrum, it's imperative for users and managers to do everything possible to conserve caribou and their environment for the future.

With an unprecedented human population, increasing habitat loss and fragmentation from development, and highly sophisticated hunting technology, managers will face tremendous challenges in the future to simply prevent man from driving caribou populations even lower than would naturally occur, or prolong naturally-occurring periods of low abundance. Even so, it may not always be in the best interest of caribou to artificially maintain their populations at high or even moderate densities indefinitely. I'm speculating here, but it may be important for the long-term health of caribou range to have extended periods of time when caribou density is low to recover from intense use during population peaks. Lichens, which caribou depend on for energy during winter, grow very slowly and can take 50 years to recover from disturbances like fire or overuse. An alternative to abundance-based management is to enjoy population highs when they occur, do all we can to prevent man from further depressing populations during naturally-occurring periods of low abundance, and accept that some wildlife populations, like caribou, will cycle up and down.

A several-year gap in submissions of B&C-class barren ground caribou does not constitute a long-term trend, and only time will tell whether this is the beginning of such a trend. In Alaska, several small caribou herds, numbering only hundreds of animals, have produced some tremendous bulls in recent years. It's possible that these small herds have not felt the effects of density dependent limitation as severely as the larger North American herds. Unfortunately, these small herds provide only limited hunting opportunity, and the fate of most caribou hunters will ride with that of the large herds that can sustain liberal hunts.

So, the answer to Mark's question still eludes me. I suspect there is no single answer. Instead, complex interactions among long-term factors, such as climate change, and the short-term effects of weather on caribou and their environment may be driving the recent declines of large caribou herds across the circumpolar north. If these declines are indeed related and not just coincidence, then their causes are beyond our current understanding of large-scale environmental effects on caribou. Given the complexity of balancing resource development versus maintaining the integrity of natural systems—even locally, not to mention globally—such factors would likely be difficult to change.

Even so, caribou have proven their adaptability. That's how they survived the tremendous environmental upheaval that accompanied their transition out of the last ice age. There are also many people, including sportsmen, subsistence users, environmentalists, scientists, and non-consumptive users, dedicated to conserving caribou and their habitats now and in years to come. I'm hopeful that caribou will continue to thrive, and that 'The Book' will bulge with new entries in the future. ■