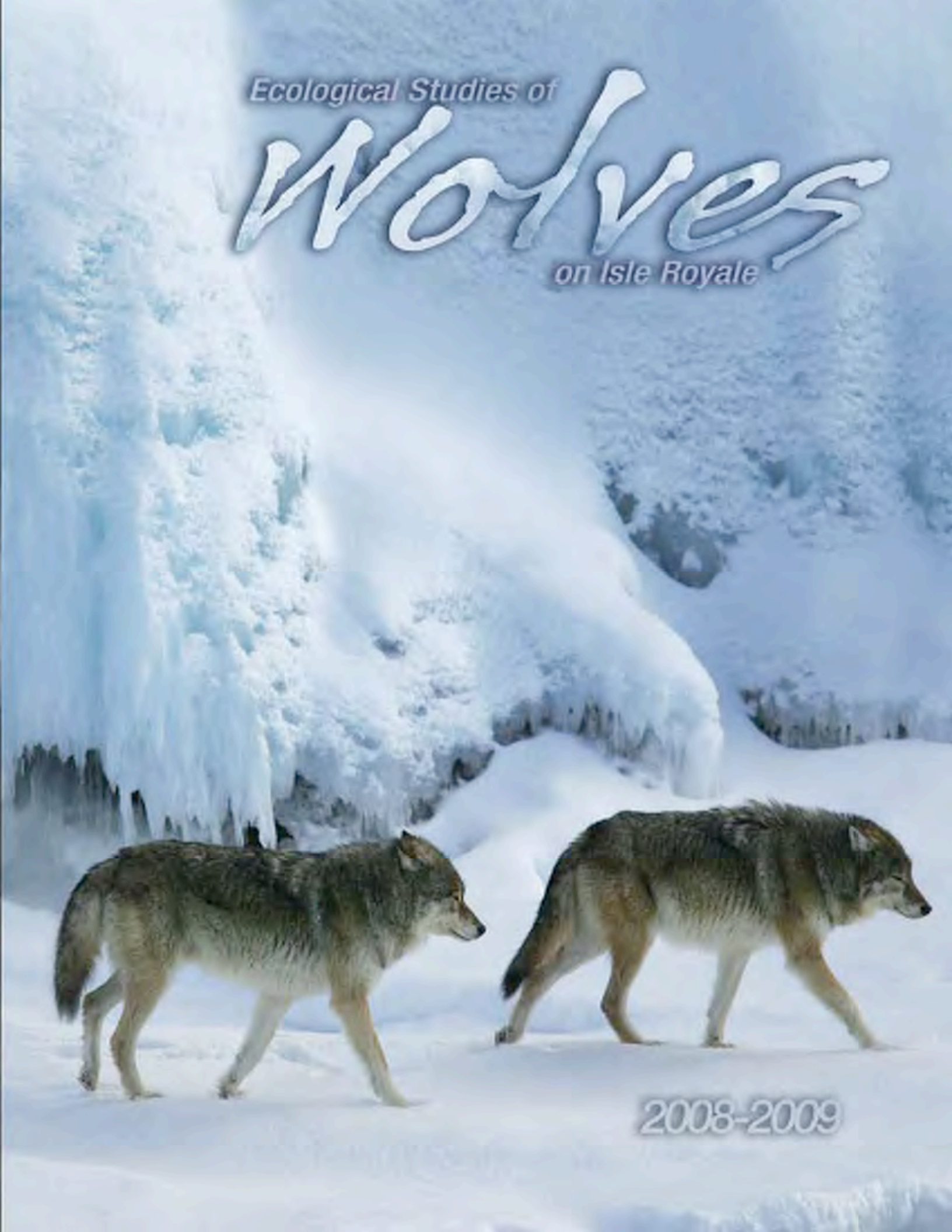
Ecological Studies of Wolves on Isle Royale



2008-2009

Ecological Studies of

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Annual Report 2008–2009*

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Results reported here are preliminary and, in some cases, represent findings of collaborators; please do not cite without consulting the authors.

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Ecological Studies of Wolves on Isle Royale

Without stories, places are desolate.

—Robert Archibald 1995

Personnel and Logistics

In summer 2008, ground-based fieldwork continued from late April through late October. Rolf Peterson and John Vucetich directed that field work with assistance from Dan Myers, Ben Betterly, Scott Larson, John Pfeiffer, Carolyn Peterson, and Leah Vucetich. During the course of the year many Isle Royale National Park staff and visitors contributed key observations and reports of wolf sightings and moose bones.

In 2009 the annual Winter Study extended from January 13 to March 2. Rolf Peterson, John Vucetich, and pilot Don E. Glaser participated in the entire study, assisted by Beth Kolb, Dieter Wiese, and Leah Vucetich and the following personnel from the National Park Service: Cam Trembath, Jon Spencer-Hudson, and Marshall Plumer. US Forest Service pilots Dean Lee, Tim Bercher, Wayne Erickson, and Pat Lowe flew several supply flights to Isle Royale from Ely, Minnesota. George Desort filmed and photographed our research activities in February 2009. A daily account of Winter Study's events and activities are recorded at www.isleroyalewolf.org/wsjournal.

Summary

In January and February, we conducted the 50th annual Winter Study of wolves and moose. The project's 50th anniversary was celebrated in Isle Royale National Park in July 2008 and at several other venues.

During 2008–2009, the wolf population increased slightly, from 23 to 24, and the moose population remained approximately stable at a relatively low level. During the past year, at least six (24%) wolves in the population died, and at least seven pups survived to their first winter. Per capita kill rates, which indicate how well-fed the wolves are, were lower than average (0.56 moose/wolf/month) during January and February 2009. East Pack experienced a dramatic decline during the past year, when four of its five adult wolves died and no pups survived.

In 2009, we estimated the moose abundance to be 530, with 90% confidence intervals of [375, 705] (Fig. 1). The ratio of moose to wolves remained low at ~22 to 1. For the past three years, wolf abundance has been near its long-term average, and moose abundance has been about half its long-term average. These conditions are similar to those observed 50 years ago, when this project first began.

One might not have expected the wolf population to maintain its abundance given the number of moose and given the decline of East Pack. Nevertheless, wolf numbers remained stable, in part, because of the ready availability of old moose (>14 years old). Changes to watch for in the future include the fate of East Pack and the young Paduka Pack.

The monthly mortality rate for moose during winter 2009, which is the proportion of moose that died per month, was relatively high (2.5%). Calves composed 10.5% of the moose population during winter 2009, somewhat lower than the long-term average. Although the intensity of ticks made the most significant decline in the past five years, prominent tick infestation on moose was still evident during spring 2008. The moose that wolves killed during the winter of 2009 were distinctive for being mostly bulls that were old, arthritic, and malnourished.

In the past year, we discovered high and increasing rates of congenital bone deformities among Isle Royale wolves. When these deformities occur in domestic dogs, they can have important health consequences. This is the first strong evidence of negative physical impacts to wolves attributable to inbreeding and prompts reconsideration of the appropriateness of introducing new wolves as means of genetically rescuing the Isle Royale wolf population.

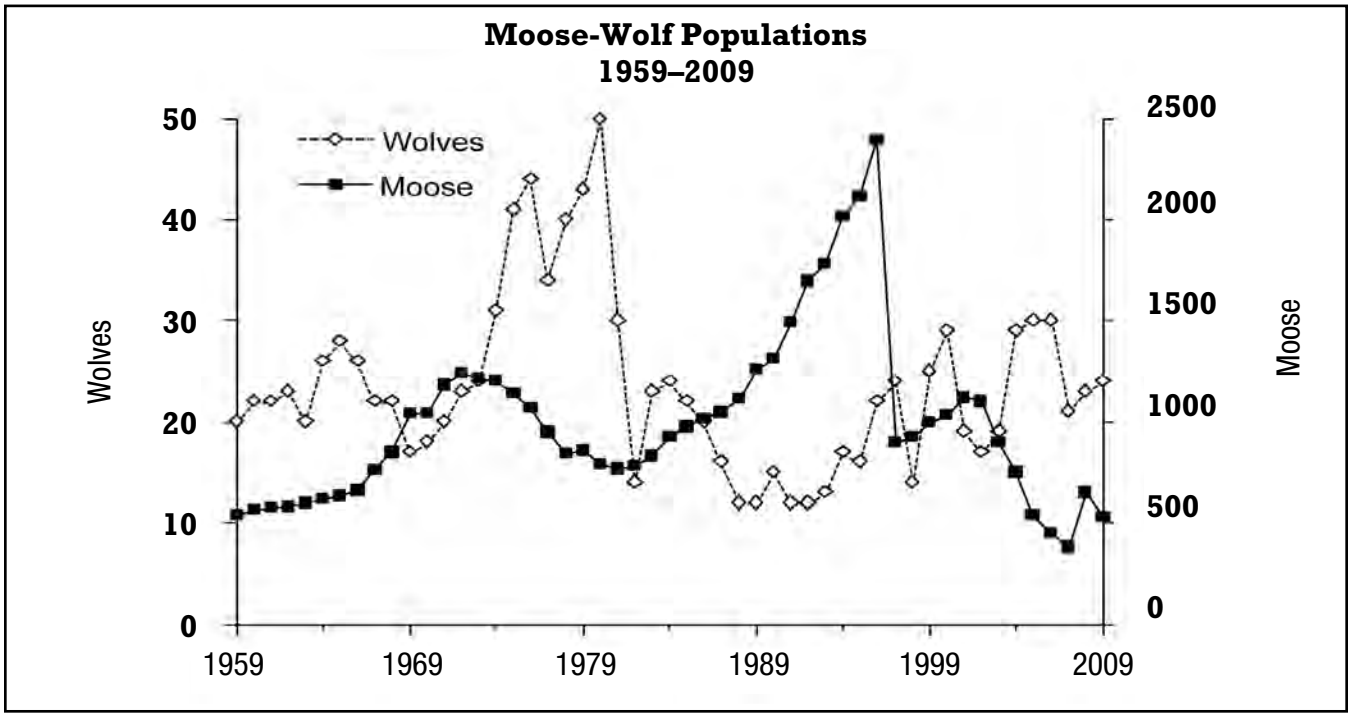


Figure 1. *Wolf and moose fluctuations, Isle Royale National Park, 1959–2009.* Moose population estimates during 1959–2001 were based on population reconstruction from recoveries of dead moose, whereas estimates from 2002–2009 were based on aerial surveys.

The Wolf Population

During the 2009 Winter Study, the wolf population contained 24 individuals, a 4% increase from last year's 23 wolves (Fig. 1). The wolf population was also comprised of four packs, as in the previous year. The number of wolves in each pack was as follows:

East Pack III (EP)	2
Chippewa Harbor Pack II (CHP)	8
Middle Pack II (MP)	9
Paduka Pack (PP)	3
Loners	2
2009 Total	24

At the beginning of Winter Study, the total wolf abundance could possibly have been 23 or 25, instead of 24. Specifically, on January 21 we found a wolf that had been killed the previous day. That dead wolf may have been one of the eight wolves in Chippewa Harbor Pack, or it may have been a 25th wolf. Also, we cannot rule out the possibility that the eighth wolf in Chippewa Harbor Pack is the same as the ninth wolf in Middle Pack. These pack sizes were observed just once for each pack, and those observations were separated by four days. If true, total wolf abundance would have been 23 wolves. Genetic screening of wolf scats may result in small adjustments in this year's estimate. The identities of the two loners are known with certainty because they wore functioning radio collars.

The wolf population killed at least 20 moose during the 46 days we observed them, for a per capita kill rate of 0.56 moose per wolf per month. Although this is significantly lower than the long-term average kill rate, it is not surprising given how few moose are in the population.

We conducted necropsies on 20 moose carcasses. All were old adults (7 cows, 13 bulls, 1 unknown sex), none were calves, and at least 13 suffered from arthritis. The wolf population seems to have been sustained primarily on the moose that were born before 1994, when the moose population was very high. Last year the most commonly killed moose were 14 years old.

It is likely that six wolves from the 2008 population died in the past year, for an annual mortality rate of 26% (Fig. 2). It is also likely that seven wolves born in 2008 survived to their first winter—a recruitment rate of 30%. These vital rates are near the long-term average for this population (Fig. 2).

East Pack experienced important changes during the past year. In February 2008, five wolves lived in East Pack (EP), and in mid-August the pack also included one or two pups. By January 2009, all the pups had died and four of the five adult wolves had died, including the pack's alpha and beta males. The alpha and beta males were known to have died because they wore nonfunctioning radio collars, and none of the surviving EP wolves were collared. The alpha male, who had been known by his ID number 670, was about 12

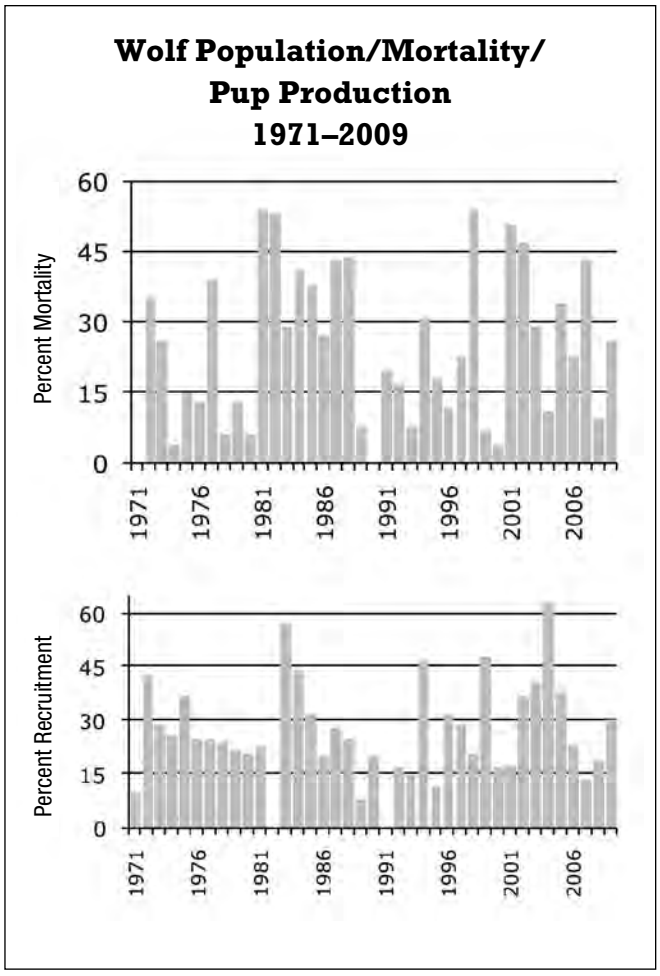


Figure 2. Percent mortality and recruitment for Isle Royale wolves, 1971–2009.

Figure 3. The alpha female of East Pack lost all the members of her pack during the past year. The new alpha male of East Pack mated with her on February 23.

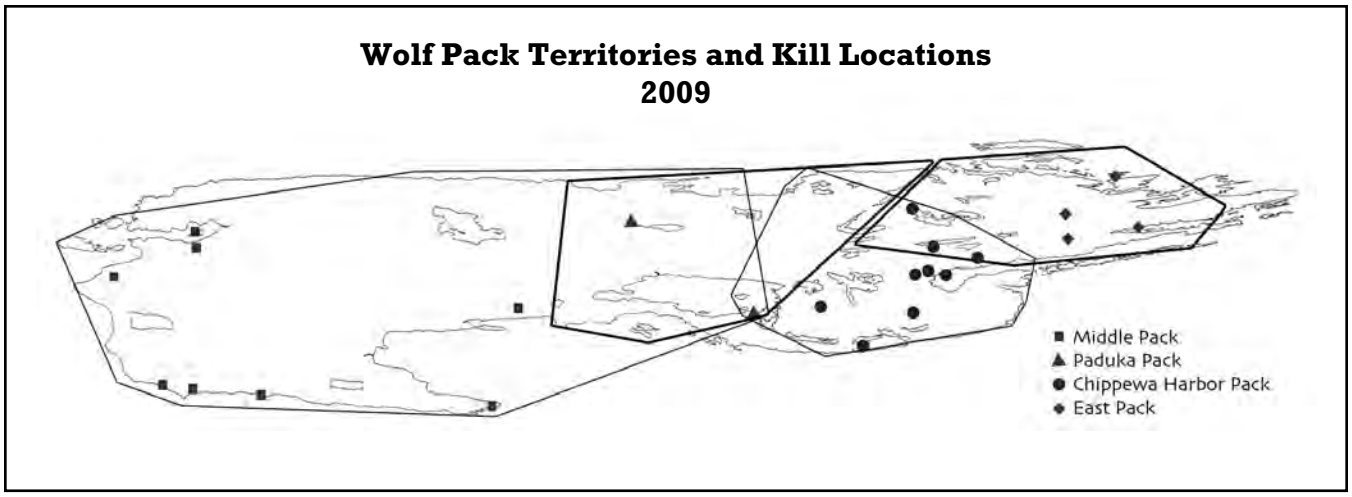


Figure 4. Wolf pack territorial boundaries and moose carcasses found during the Winter Study in 2009.

years old when he died, and the beta male was at least three years of age. Only the alpha female, collared in 2007, survived, and in 2009 she had found a new mate (Fig. 3). Analysis of fecal DNA revealed that this new alpha male originated in the Middle Pack.

The cause of the dramatic decline in the East Pack is unclear, but what is clear is that their prey base has dwindled in recent years. Starvation may have played a role, but seems unlikely to account for all the deaths—the current East Pack wolves seem able to kill moose at an adequate rate (four moose in 50 days). Perhaps the alpha male died of old age, and other deaths resulted from the social instability and threats from other packs that might have followed his death. Disease may also have played a role.

East Pack's decline began a few years ago. In 2004–2006, they numbered nine wolves, in 2007 there were six, and then five in 2008. For several years, East Pack had successfully encroached on the territory of the adjacent Chippewa Harbor Pack, killing that pack's alpha pair in the process. (e.g., see Fig. 7 of the 2007–2008 annual report). In 2009, with only two wolves, East Pack rarely traveled south of a line extending from McCargo Cove to Daisy Farm (Fig. 4), and yet numerous single wolves and small groups penetrated East Pack in mid-February, including visits to an East Pack kill (Fig. 5).

Paduka Pack (PP) had survived its second winter as a full-fledged pack by February 2009 (Fig. 6). This pack had its origins in winter 2007 when a newly formed pair began showing signs of territoriality and pair-bonding. They produced their first litter, with two surviving pups, in April 2007. In 2008, Paduka Pack seems not to have produced any surviving pups. By January 2009, Paduka Pack included just the alpha pair and one wolf who is likely a yearling born in 2007.

During the first half of the 2009 Winter Study, we consistently observed the three wolves of Paduka Pack on the south side of Isle Royale near the shore of Siskiwit Lake. In late January, Paduka Pack's territory

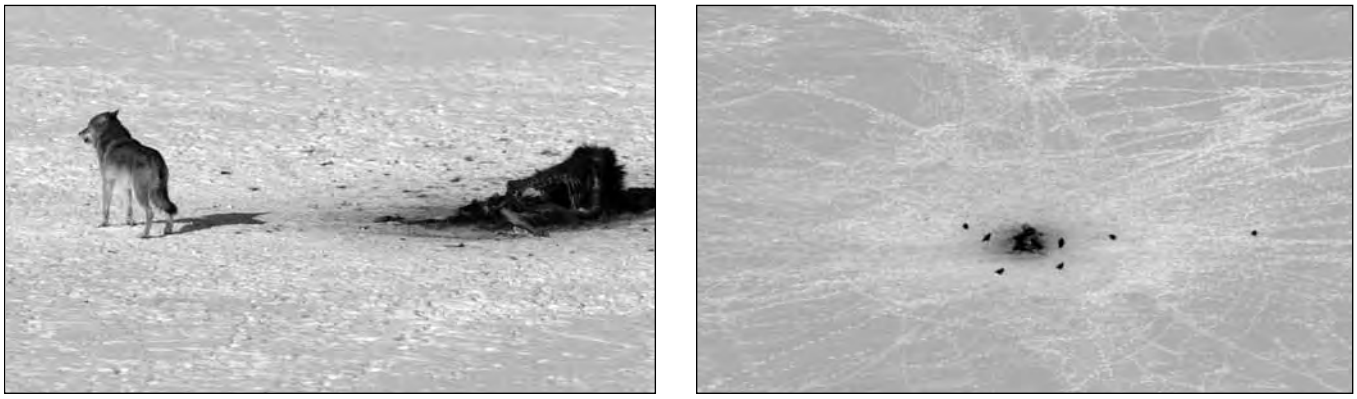


Figure 5. East Pack killed a moose near Dean Island, but that site was visited by a collared wolf that dispersed from Middle Pack and at least one unidentified wolf (pictured left). That kill was also scavenged by four foxes, two eagles, and more than a dozen ravens (pictured right).

was challenged by Middle Pack and Chippewa Harbor Pack, as the large packs freely traveled over PP country and visited a Paduka Pack kill near Wood Lake. After these challenges, we were unable to detect the uncollared Paduka Pack for the next two weeks. On February 14, we observed tracks on the north side of Isle Royale, on Hatchet Lake and near Todd Harbor—tracks we believe were made by Paduka Pack—and soon found the breeding pair on a new kill near Hatchet Lake. By early March, Paduka was likely adequately fed, but focused its travels in the central portion of its territory, far from the larger neighboring packs.

These territorial patterns are a departure from last year, when Paduka Pack spent most of its time on the north-central portion of Isle Royale and once made a deep foray into Middle Pack territory. This year and last, Paduka Pack territory includes the 75-year-old forests that formed after the forest fires of 1936. This portion of Isle Royale and other portions of Paduka territory contain relatively few moose.

We observed Paduka Pack too infrequently to reliably estimate their kill rate. However, we did observe two sites where Paduka Pack had killed a moose and two sites where they may have made a kill. Ground surveys planned for summer 2009 may yield more insight about these two possible kill sites.

Middle Pack continued to be a strong pack during the 2009 winter (Fig. 7). The gray, old alpha female, at least 10 years old, survived another year. Although the identity of the alpha male is uncertain, he is plausibly the same alpha that has been leading the pack since

Figure 6. The Paduka Pack male trailed his female mate closely on February 15, when she was in breeding condition.

Figure 7. Middle Pack wolves feed and rest near a kill made several days before on Houghton Point.

Figure 8. Only in recent years have we begun to observe wolves graying with age. The first was the alpha male of Middle Pack, who died in late 2006 or early 2007 (top). His mate, the current alpha female of Middle Pack, turned gray in the year following his death (middle). The current alpha male of Chippewa Harbor pack is also gray (bottom), and not very old—he may be just 5 or 6 years old.

Figure 9. During Winter Study we collected the remains of two wolves. Each had congenitally malformed vertebrae (see page 14). It took three days for Beth Kolb and Deiter Wiese to extract one of these wolves (left) from beneath the ice of a frozen beaver pond, several miles from where the research plane could bring the carcass to base camp. Pilot Don Glaser was joking when he walked up to this wolf carcass (right) to see if it was still warm. We were surprised; it had, in fact, died so recently that its carcass was not yet frozen.

2006 or 2007. Middle Pack probably suffered no deaths in the past year and probably produced three pups that survived to the winter.

The two Middle Pack wolves that we radio collared in May 2007 had, by winter 2009, been ostracized by the alpha wolves of Middle Pack. These wolves, probably brother and sister, spent their time at kill sites Middle Pack had abandoned, bedded 100 meters or more from where Middle Pack actively fed, or bedded far from any source of food. For a two-week period in January, the female loner didn't move more than one-half mile as she fed from the remains of two carcasses near Washington Harbor. Neither of these wolves is likely to be well fed. These wolves also appeared to have little interest in each other, as they were usually at different locations. By the final flight, March 1, signals from both wolves had disappeared, during a time when an ice bridge connected Isle Royale to the Ontario mainland.

Middle Pack spent most of their time on the south shore of Isle Royale and almost no time on the north side of their territory. In 40 days of observation they killed six moose. This kill rate is low, considering it supported nine pack members and two loners.

Of all the packs, Chippewa Harbor Pack seems to have fared best during the past year. They increased from five to eight wolves, produced four pups that survived to winter, and lost only one wolf. That wolf died sometime in late fall or early winter, and his carcass was recovered in late January (see above).

Last year Chippewa Harbor Pack endured territorial incursions from both East Pack and Middle Pack, but in 2009 Chippewa Harbor Pack seemed more secure, with a territory that includes the highest density of moose found on Isle Royale. This year, it was Chippewa Harbor Pack (CHP) that trespassed over neighboring packs, pushing their boundaries with East Pack and Paduka Pack. The kill rate for CHP was not especially high, at five moose in 37 days.

The current alpha female of Middle Pack has led the pack since 2002 and is now paired with the second in a succession of alpha males. She has turned progressively lighter with age, joining the Chippewa Harbor Pack alpha male as the most distinctively recognizable wolf in the current population (Fig. 8). Her first mate from Middle Pack also turned almost white with age. At present it is uncertain whether these alpha wolves have turned white just from old age or if stress levels or genetic predisposition have contributed to their coat color.

In winter 2009, we collected the carcasses of two dead wolves (Fig. 9). One was a subordinate male from

Figure 10. A Chippewa Harbor Pack wolf feeds on the carcass of an adult moose killed in front of a shelter in Moskey Basin Campground. This was one of at least three adult moose that this pack killed in lakes or ponds in the summer and autumn of 2008. A collared male wolf from this pack later died in a pond, perhaps attempting another such kill.

Chippewa Harbor Pack that had been collared as a young wolf (probably 2–3 years old) in May 2007. His carcass was fully intact beneath 14 inches of ice in a beaver pond. He had enough fat to suggest he was well nourished. He suffered trauma in the neck area and had blood in his mouth. This suggests that he was not killed by wolves, but may have been fatally wounded by a moose (see Fig. 10). He also suffered a congenitally deformed sacrum and had two severely arthritic vertebrae. The deformed sacrum may have contributed to the arthritis, unusual for such a young wolf.

The other dead wolf, a middle-aged male, was discovered on January 21 within 48 hours of its death. A necropsy indicated that the wolf was killed by other wolves. Analysis of its DNA suggests it may have been an East Pack wolf. Analysis of pack movements for the days when it likely died suggest that the new East Pack male was responsible for its death.

We also observed signs of reproduction for three of Isle Royale's four packs. We observed tracks in the snow on February 16 indicating that Middle Pack had mated and tracks on February 20 indicating that Paduka Pack had mated, and we observed East Pack mating on February 23 (Fig. 3). Though definite evidence was lacking, there is no reason to suspect that breeding did not also occur in the Chippewa Harbor Pack.

For the past two visitor seasons, fearless and curious wolves were less prominent than they had been during 2004–2006 visitor seasons, and we still do not understand the reasons for these changes. Nevertheless, Chippewa Harbor Pack did kill a moose in front of the shelters at Moskey Basin Campground, resulting in the closure of the campground for a week while the wolves fed. The deference to wolves seemed appropriate as this event occurred during the weekend of celebrations that marked the 50th anniversary of wolf research on Isle Royale.

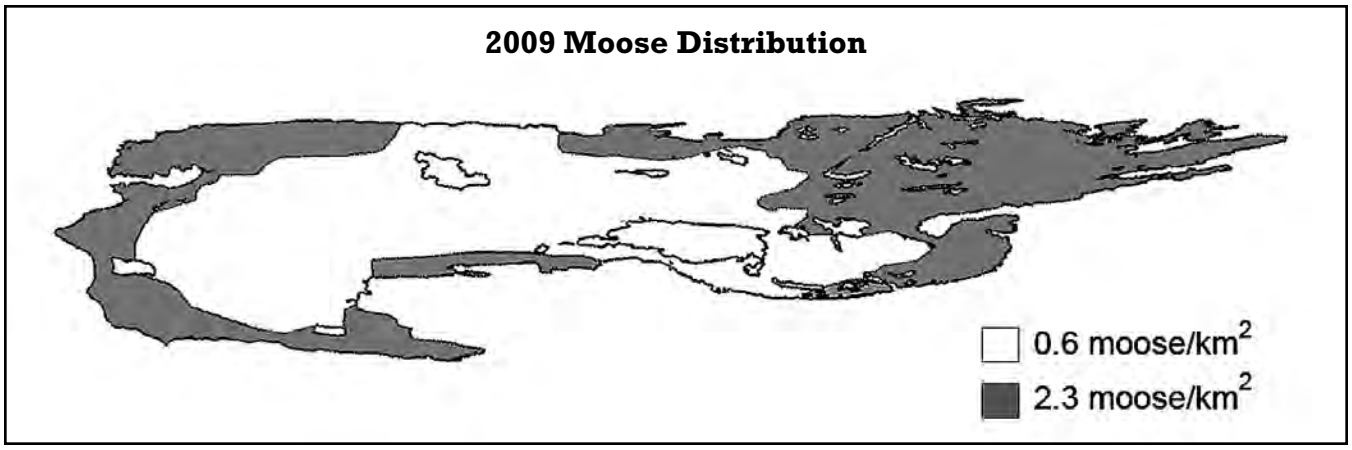


Figure 11. Moose distribution on Isle Royale in 2009 was relatively uniform, as it has been for the past several years. Only two strata were delineated, based on habitat types and results of the aerial counts on 91 plots that comprise 17% of the main island area.

The Moose Population

The 2009 moose survey began on January 21, under excellent conditions (calm wind, overcast skies, and deep, soft snow) and ended on February 16 under poor conditions (crusty snow that drove moose into thick cover where they are difficult to see). The survey resulted in an estimated moose abundance of 530. The 80% confidence intervals on this estimate are [420, 640]. Moose density throughout most of Isle Royale was 0.64 moose/km2, and there were 2.25 moose/km2 in some regions of the east and west ends of Isle Royale (Fig. 11). Last year, when conditions for counting moose were excellent, we estimated 650 moose, with an 80% confidence interval of [490, 770]; and in 2007, when conditions were very poor, we estimated 450 moose (with 80% CI of [370, 535]). Together with earlier counts, we infer that moose declined in 2002–2006, then stabilized or increased slightly in 2007–2009 (Fig. 1).

For many years we have estimated moose population size by two methods, aerial surveys and reconstruction. The reconstruction method involves three components: 1) an extensive database of moose for whom the year of death and age at time of death has been estimated, 2) calculations converting the database into a minimum number of moose alive in each age class during each year, and 3) aerial survey estimates of total moose abundance that are used to convert the minimum num-

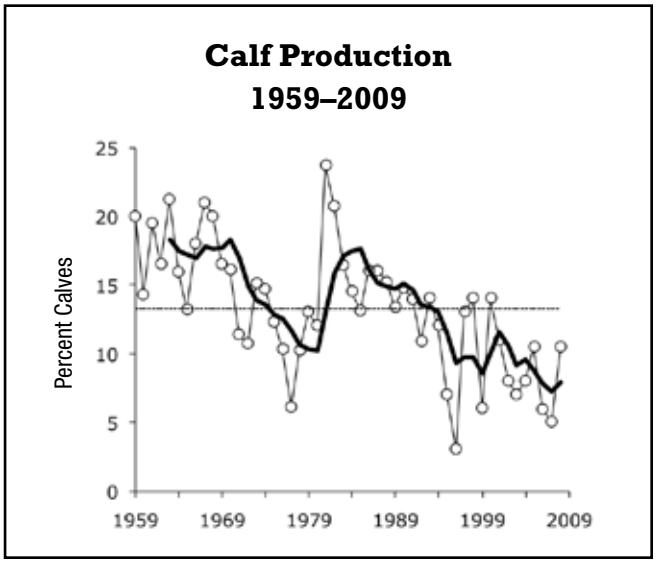


Figure 12. Long-term trends (1959–2009) in percent of the total moose population that are 8-month old calves. The 50-year average (13.3%) is marked by the light dotted line, and the curved line is a 5-year moving average.

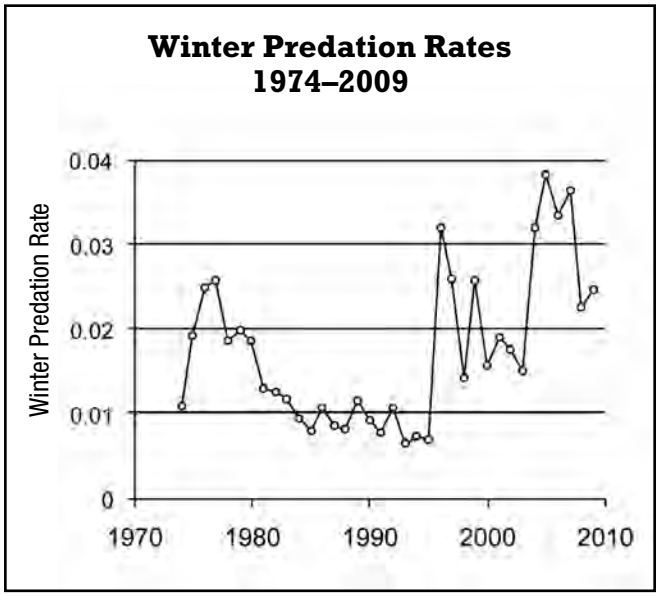


Figure 13. Winter predation rates (proportion of living moose killed per month) for Isle Royale moose, 1974–2009.

Figure 14. Moose usually lead solitary lives. However, they tolerate the presence of another when they congregate at mineral licks in the spring time. These moose have been heavily impacted by winter ticks. The moose on the left has a grapefruit-size tumor on its shoulder, actually a dermal papilloma, or wart. They may last for years and seem to cause no difficulties unless they grow to large size and get caught on trees or other objects that moose may brush up against.

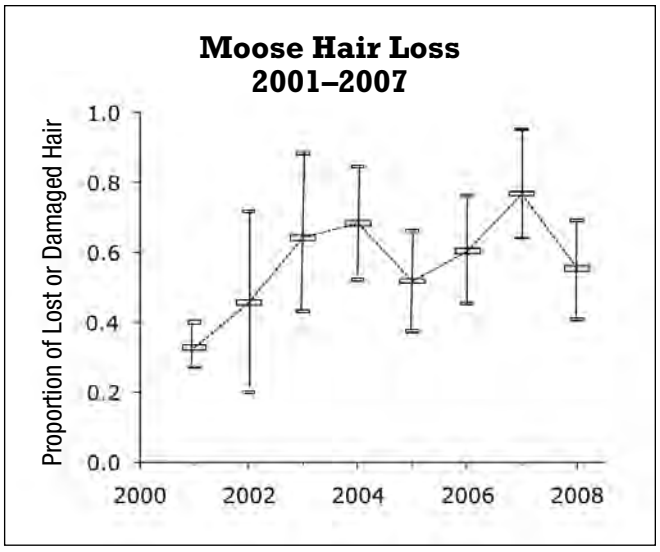


Figure 15. The extent of moose hair loss in spring, caused by winter ticks. Heavy bars are annual averages, and smaller bars mark interquartile ranges.

ber of moose alive into estimates of total abundance. The reconstruction-based estimate of abundance for any particular year is not available until most of the moose that were alive in that year have died. However, reconstruction-based estimates are more reliable and informative than aerial survey estimates.

Because we updated our reconstruction-based estimates in summer 2008, the moose time series in Figure 1 differs from previously published time series. Most importantly, previous publications showed the moose crash of the mid-1990s, which had been based on aerial surveys, to have occurred over a two-year period (1995–97). This had been a misleading impression caused by the fact that aerial surveys are conducted in mid-winter and that the crash occurred throughout winter and spring of 1996. The reconstruction-based estimates (Fig. 1) now give an accurate impression for the timing of that crash.

Of the moose that we observed on the census plots in 2009, 10.5% (10 of 95) were calves. This is slightly below the long-term average, but higher than expected when compared with the declining trend that has been observed during the past two-and-a-half decades (Fig. 12). The monthly mortality rate (percentage of living moose killed per month) was 2.5% during winter 2009 (Fig. 13). This rate is higher than the long-term average (1.7%), but not unexpected given the relatively high

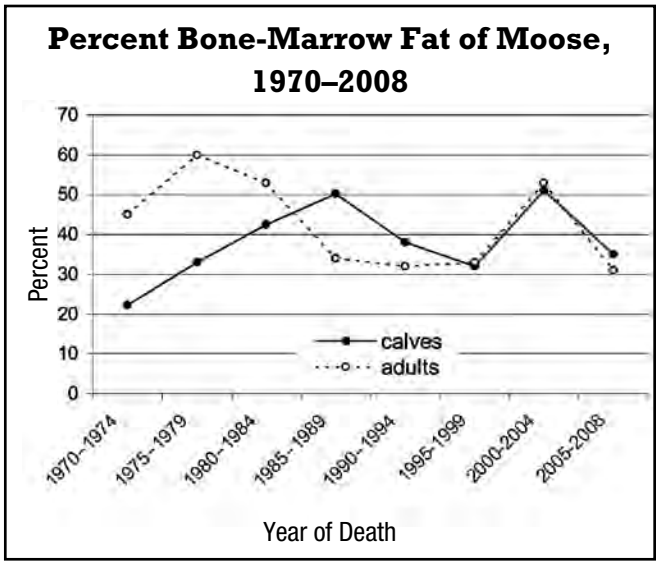


Figure 16. Long-term trends in bone-marrow fat for moose. The line for adults shows the proportion of adults with >70% fat in their bone marrow. The line for calves shows the mean value of percent fat in bone marrow.

Figure 17. Most of the wolf-killed moose that we necropsied so far in 2009 suffered from arthritis. Periodontal disease was less common. Examples of a normal hip socket (left), mild arthritis (middle), and severe arthritis (right).

ratio of wolves to moose (1 wolf for every 22 moose). For moose dying during the 2009 Winter Study, 16 were killed by wolves and one may have died from malnutrition. Because most of the deaths were wolf-caused, this year's mortality rate is an indication of the current impact of predation on the moose population.

Each spring we estimate the degree to which moose had been impacted by winter ticks (*Dermacentor albipictus*) during the preceding winter (Fig. 14). This is done by photographing moose and estimating how much hair they have lost during the preceding winter. In spring 2008, tick loads were high, but ticks also showed the largest decline (from 2007 to 2008) that we have documented in the past eight years. In 2007 the average moose had 77% hair loss, and in 2008 the average moose had 55% hair loss (Fig. 15). This could be the beginning of a multiyear decline in ticks, probably prompted by a long and cold winter in 2007–2008. The winter of 2008–2009 was similarly adverse for tick populations.

Compared to recent years (Fig. 16), a greater proportion of moose that wolves had killed showed signs of malnutrition. Specifically, the fat content of bone marrow was below 70% for 10 of the 20 moose that we had necropsied in 2009. The moose that wolves killed also showed a high incidence of arthritis. In a typical winter, about 30% of wolf-killed moose are arthritic (Fig. 17). This winter, 76% of the 17 moose that we necropsied with sufficient skeletal material were arthritic. For the first time in 50 years, we observed no calves among the moose that wolves killed; all of the wolf-killed moose were older adults. In most winters, between 20% and 50% of wolf-killed moose are calves.

Moose Move Nutrients Uphill

Everything flows downhill right? Not so, as long as moose are foraging in lakes and ponds. Moose are aquatic-terrestrial interface specialists, foraging extensively on aquatic vegetation during spring and summer (Fig. 18). Aquatic resources ingested by moose are either excreted as waste in urine and droppings or made into more moose biomass. Most excretion and mortality occurs on land; hence moose create what ecologists term a "biotic vector" for the flow of energy and nutrients uphill, from aquatic habitats to terrestrial habitats. Understanding the importance of biotic vectors that link different ecosystems is an area of ecology that has swelled over the past decade.

This past year we published a study (Bump, JK, K Tischler, A Schrank, R Peterson, & JA Vucetich. 2009. Large herbivores & aquatic-terrestrial links in southern boreal forests. J Anim Ecol., in press) quantifying the amount of nitrogen that Isle Royale moose move from interior lakes and ponds to the forests. We focused on nitrogen because it is a nutrient critical to animal physiology and most frequently limits primary production in the southern boreal forests found on Isle Royale. By using data on moose foraging and excretion we were able to estimate that each adult moose moves 8–10 kg (~20 pounds) of nitrogen from aquatic to terrestrial habitats each year. For comparison, that is nearly as much nitrogen as is found in a 100-pound bag of common 10-20-10 garden fertilizer. This means that at the landscape level moose are fertilizing riparian zones at a rate of 1-3 kg of nitrogen per hectare each year. This "fertilization" effect is particularly interesting because previous research has shown that moose can have negative effects on forest soil fertility when they only feed on terrestrial plants. By studying how moose link aquatic and terrestrial habitats, we have learned that moose can have opposite effects on the ecosystem depending on seasonal foraging. Given the circumpolar extent of moose, they constitute an important, unrecognized aquatic-terrestrial resource vector in boreal systems.

The overall effect that moose have on the cycling of important nutrients in aquatic systems is also interesting—and unknown. It may be that moose have a significant influence on lake and pond phosphorus cycling, which is most often the nutrient that limits aquatic productivity in this region. For example, the kicking up and turbation of lake sediments by moose while foraging for aquatic plants certainly releases phosphorus from the sediment waters, where concentrations are orders of magnitude greater than in overlying water. Therefore, lake phosphorus availability could hypothetically increase, producing a net positive effect on lake phosphorus cycling despite the phosphorus loss due to moose herbivory on aquatic plants. Testing such hypotheses is part of our future work.

Figure 18. Moose are drawn to feed in aquatic habitats by the high-protein forage, added security from wolves, and the cooling effect of water. Unknowingly, moose are fertilizing terrestrial habitats with nitrogen from aquatic habitats, and they may also influence phosphorus dynamics in the ponds themselves.

50th Anniversary

The wolf-moose project is the longest continuous study of any predator-prey system in the world. Throughout 2008 and into 2009, we celebrate the project's 50th anniversary. Some highlights of that celebration include the following:

- Many groups, including Michigan Technological University and the National Park Service, presented a multi-day celebration repeated in Duluth, Minnesota, Houghton, Michigan, and on Isle Royale National Park. More than 3,000 people attended, including Superintendent Phyllis Green, US Senator Carl Levin's senior aide Amy Berglund, Michigan State Representative Mike Lahti, NPS Associate Director for Science and Natural Resource Management Bert Frost, Midwest Regional Director of the NPS Ernie Quintana, and Assistant Secretary of the Interior Lyle Laverty. The celebration featured the premier of *Fortunate Wilderness*, a feature-length film by George Desort about the project, which has now been shown to more than 2,000 people. The celebration also featured *Minongers*, a lithograph depicting skulls of moose and wolves by the internationally recognized artist Gendron Jensen.

- Several publications were printed or re-released:

  - *The Wolves of Isle Royale, A Broken Balance* (Univ. Mich. Press, 2008) by R. Peterson, a popular account of the project's research findings

  - *A View from the Wolf's Eye* (Isle Royale Nat. Hist. Assoc., 2008) by C. Peterson describes how science and family life have been a rich mixture for the Peterson family, who have summered at the field site for the past 35 years.

  - *Winter Study* (Putnam, 2008) by Nevada Barr is a fictionalized, though informative, account of our winter field season. Barr spent a week in the field to research her book. In April 2008, *Winter Study* made the New York Times Best-Sellers list at #10 for hard-cover fiction.

  - *Notes from the Field* (Michigan Technological University, 2008) by J. Vucetich is a daily account of the happenings and discoveries that occurred during the 2008 Winter Study field season.

- More than 5,000 people visited a 1,000-square-foot traveling exhibit of the project's scientific discoveries at the Carnegie Museum in Houghton and, in Duluth, at the Hartley Nature Center and the Library of University of Minnesota.

- More than 1,000 people visited the summer field station on Isle Royale which also serves as a field museum featuring the world's largest collection of antlered bull skulls, other displays, and informal presentations by the investigators.

- *Thinking Like an Island*, a collection of 38 still images depicting our research from an artistic perspective, was exhibited at the Omphale Gallery (Calumet, Michigan) in November 2008 and at Michigan State University in April 2009. A portion of the exhibit was shown at The Gallery Project (Ann Arbor, Michigan) in October 2008. More than 2,000 visitors attended.

- The Isle Royale project was featured on the 2008 Wolf Awareness Poster; 35,000 copies were distributed nationally. The poster depicted a wolf image by Robert Bateman, which he agreed to share for the purpose of honoring the project.

- On July 21, 2008, Senator Carl Levin entered into the US Congressional Record a statement acknowledging the significance of the Isle Royale wolf-moose project.

- A variety of news and magazine articles were published, many of which can be found on the project's website.

Rolf Peterson and John Vucetich gave dozens of talks to thousands of people, and Val Bowen and Sean Currie from the staff of Isle Royale National Park gave a series of talks to more than 2,800 elementary school children. The events were a marvelous way to celebrate the first 50 years of the project.

Other Wildlife

The National Park Service conducts aerial surveys of known osprey and bald eagle nests each summer. For the past 20 years, these species have recovered to relatively low levels, after being wiped out by organochlorine pollutants in the Lake Superior watershed in the 1960s. In 2008 NPS staff counted 8 active eagle nests and 2 active osprey nests; both are low figures compared to most recent counts. At least 4-5 young eagles were fledged, but no young osprey were documented.

Snowshoe hare observations declined from 2007 to 2008, although local populations might be increasing (Fig. 19). Red fox continue to be relatively scarce, lagging behind any increase that might be occurring in hares and getting by as scavengers on what little remains of wolf-killed moose. Woodland deermouse populations were notably low in 2008, as they apparently were in much of Michigan's Upper Peninsula, perhaps in response to a relatively severe winter in 2007–2008. The river otter continued to be very abundant in the past year, with as many as seven otters at a time found beneath the summertime research headquarters at Bangsund cabin on Rock Harbor.

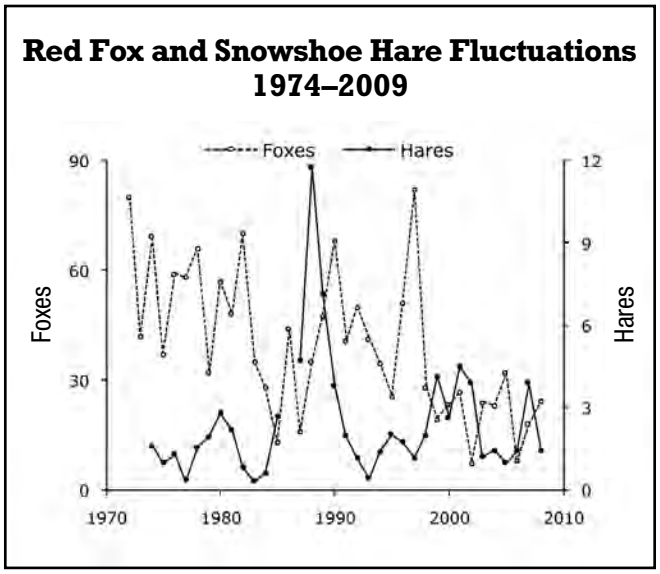


Figure 19. Indices of abundance for red foxes and snowshoe hares on Isle Royale, 1974–2008. The hare index is the number of hares seen per 100 km of summer hiking. The fox index is the number of foxes seen from the plane during Winter Study, the sum of the maximum number seen at kills and the number seen otherwise per 100 hr flight time.

For the past three years, an aerial count of beaver colonies (Fig. 20) using two aircraft in a double count was conducted in October by Rolf Peterson and Mark Romanski (Isle Royale Resources Management staff). Pilots during all three years were Jim Hummel, from Voyageurs National Park, and Donald Murray, from UpNorth Aerials, flying small, tandem-seat aircraft. This permitted a double count, which provides an estimate of sightability from the independent data provided by each observer-pilot team. The estimated total number of active beaver sites in 2006, 2007, and 2008 was 133, 124, and 128, respectively. These counts suggest that the beaver population, declining for the past two decades, has finally reached a low and relatively "stable" level. The word "stable" is misleading, because there was high turnover in individual sites over the three-year period. Successive annual counts allowed us to estimate annual turnover in lodge occupancy. In 2007, 65% (48/99) of the active sites were new, while 58% (65/112) of the active sites from 2006 were abandoned. A similar pattern continued in 2008: 52% (58/112) of the active sites were new while 55% (54/99) of the active sites from 2007 were abandoned. Of the 61 sites that were active in 2006 but not in 2007, 9 were recolonized in 2008. There were 32 sites with activity in all three counts, 2006–2008, and 41 sites with activity in two of the three years. An additional 149 sites had activity in only one of the three years. The emerging pattern is a core of about three dozen relatively secure beaver colonies, mostly on the eastern half of Isle Royale, and another 100 or so marginal sites that are being repeatedly colonized by 1-2 beavers that suffer high annual mortality.

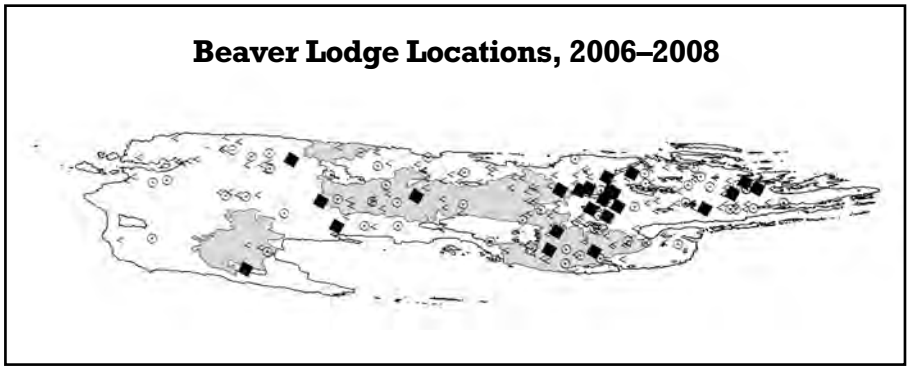


Figure 20. The locations of active beaver lodges for the years 2006–2008. The most stable lodges were active for all three years of the survey period (squares), and the most ephemeral lodges were present for just one year of the three-year survey period (triangles). Circles represent lodges that were present for two of the three-year survey period. The gray portion of Isle Royale highlights where forests had burned in 1936, a process that greatly affected habitat.

Bad Bones

In 2008, we collaborated with Jannikke Raikkonen from the Swedish Museum of Natural History, an expert in mammalian anatomy. Her observations of bones from the wolves of Isle Royale revealed an array of anomalies: 26% of the wolves had extra vertebrae; 58% had a malformation of one kind or another in the vertebral column (Fig. A). Some of these malformations were asymmetrical vertebrae. Others go by technical descriptions such as incomplete ossification of the cranial border of the first cervical vertebrae, thoracolumbar transitional vertebrae, intrasegmental transitional vertebrae, and lumbosacral transitional vertebrae (LSTV).

An LSTV is a single vertebra that possesses anatomical properties of both lumbral vertebrae and sacral vertebrae. LSTV are interesting because they are well-studied in dogs and wolves. About one-third of Isle Royale wolves have LSTV. By contrast, only 1% of wolves carry the malformity in populations that are not inbred, like those of modern-day Finland and Scandinavia before those wolves were extirpated by humans.

Even among modern-day Scandinavian wolves, which are highly inbred and suffer from inbreeding depression, just 10% have the LSTV malformation. LSTV malformities are also more common among domestic dogs that are particularly inbred.

The probability that an Isle Royale wolf will be born with one or more malformed vertebrae has increased dramatically over the past 50 years (dotted line in Fig. B). That increase corresponds with the continual genetic deterioration that Isle Royale wolves exhibit. We collected seven complete skeletons of wolves during 1995–2008; all of these had malformations. A wolf with completely normal skeleton has not been observed since 1993.

The consequences of these deformities have not been well studied in wild wolves (*Canis lupus*). However, the consequences are well understood among domestic dogs (*Canis lupus familiaris*). Domestic dogs with LSTV tend to suffer from a condition called cauda equina syndrome (CES), which entails injury at the end of the spinal cord and associated nerve roots. The consequences of CES are variable and include partial paralysis, deficits in placing reactions when walking, deficits in voluntary movement of the tail, loss of muscle tone causing weakness of the hind limbs and flaccidity of the tail, low back pain, and incontinence.

Several Isle Royale individuals exhibited asymmetries that would weaken the sacroiliac joint and may accelerate degeneration of the disc and result in disc protrusions. Dogs exhibiting disk protrusion also tend to suffer low back pain and lameness. Asymmetries like those observed in Isle Royale wolves can also be associated, in dogs, with irregularities in gait and detrimental development of the hip joints.

The effects of genetic deterioration might be mitigated by gene flow, that is, by introduction of unrelated wolves, possibly from Minnesota or Ontario, to Isle Royale. This raises the question: should such mitigation should be attempted? For a discussion of this topic see www.isleroyalewolf.org/overview/overview/wolf bones.html

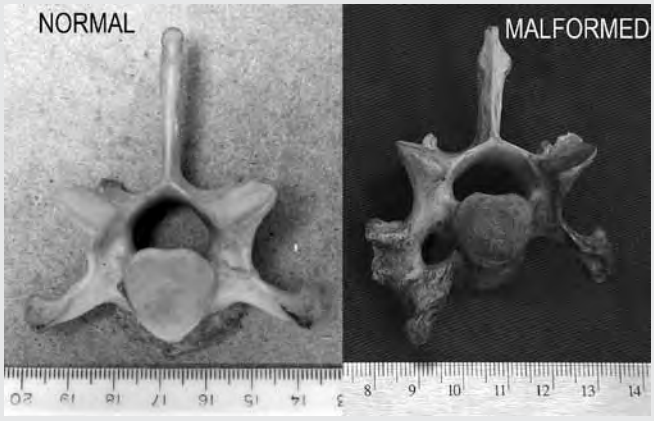


Figure A. The right photo shows the cranial view of wolf #3529 that exhibited a unilateral intrasegmental transitional vertebra at C7. One side of the vertebra resembles C6 with a transverse foramen. The left photo shows a normal C7 without transverse foramen.

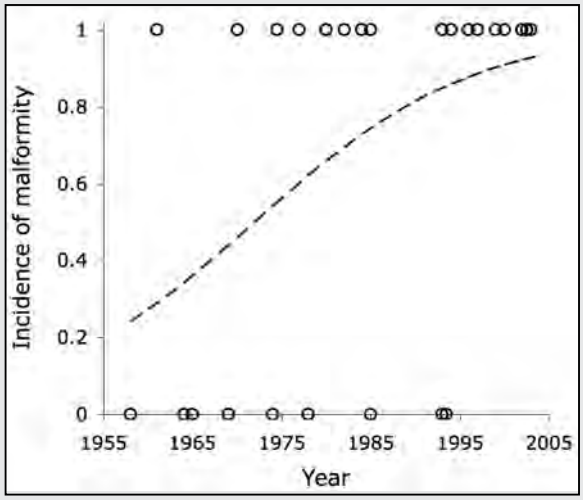


Figure B. In this graph, each dot indicates the year of birth for a wolf (read off the horizontal axis) and whether the wolf had a malformation (0=normal, 1=malformed). The dotted curve estimates the probability that a wolf would have the malformation, given its year of birth.

Weather, Snow, and Ice Conditions

During the 2009 Winter Study, average daily snow depth was 58 cm, which is above the long-term average of 44 cm (Fig. 21). By February 12 a thaw produced a moderate snow crust on top of 45 cm of snow, and this crust persisted in the snow profile through March 1, when our study ended. Snow depth and snow crusts are important because deeper, crusty snows hinder moose movements, and as a consequence impact their foraging and ability to escape prey. Because wolves can travel on top of even moderate crusts, their movements are favored which the snow is deep and crusty.

Winter temperatures (Fig. 21) were near the long-term seasonal average, but colder than most winters of the past decade, and ice extent was greater than it had been in a decade or more. During February and early March, ice extended to most of Isle Royale's outer islands, formed a bridge to Canada, and covered much of western Lake Superior.

Spring temperatures in 2008 were much cooler than average, and summer temperatures were closer to average (Fig. 22). This was a reprieve

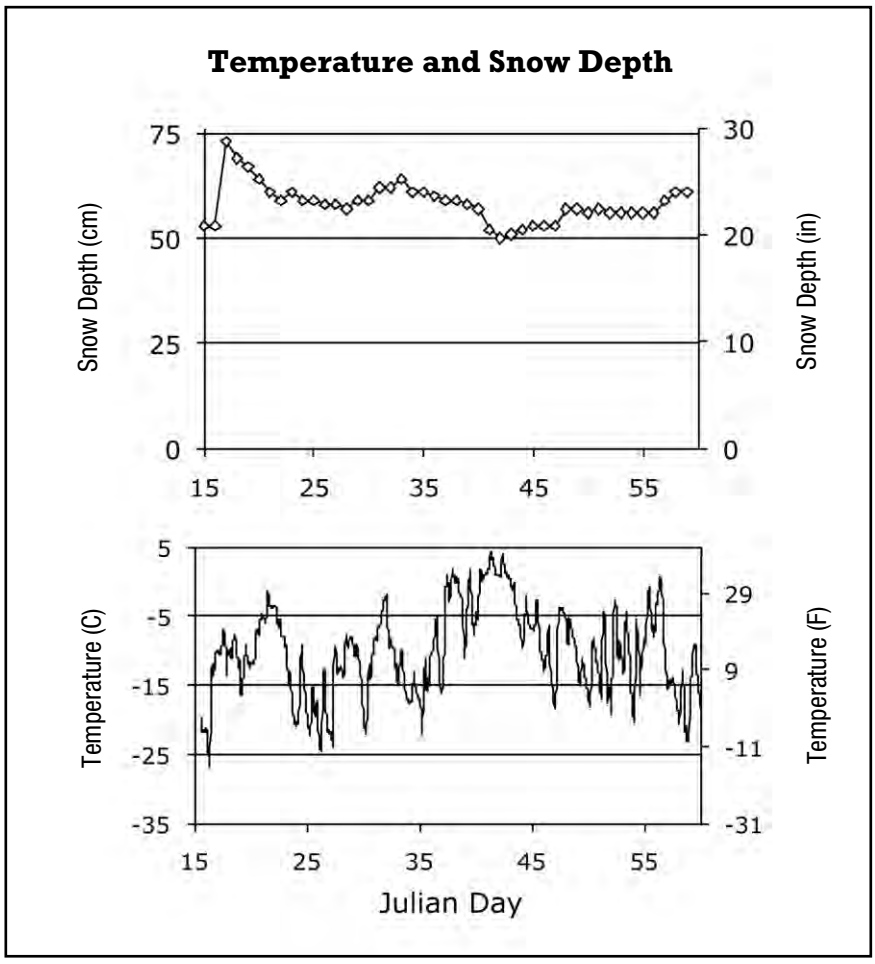


Figure 21. Snow depth (daily) and ambient temperature (hourly) during the 2009 Winter Study on Isle Royale.

from the previous decade, which brought mostly above-average summer temperatures. Although the summer of 2008 was only slightly drier than average, it was the sixth drier-than-average summer in a row (Fig. 22). Hot summers negatively impact moose because, in their need to stay cool, moose respond to hot weather by foraging less, and winter ticks are favored by early springs and possibly by hot summers. Although the effect of summer precipitation on forage quality is likely important, the details are poorly understood.

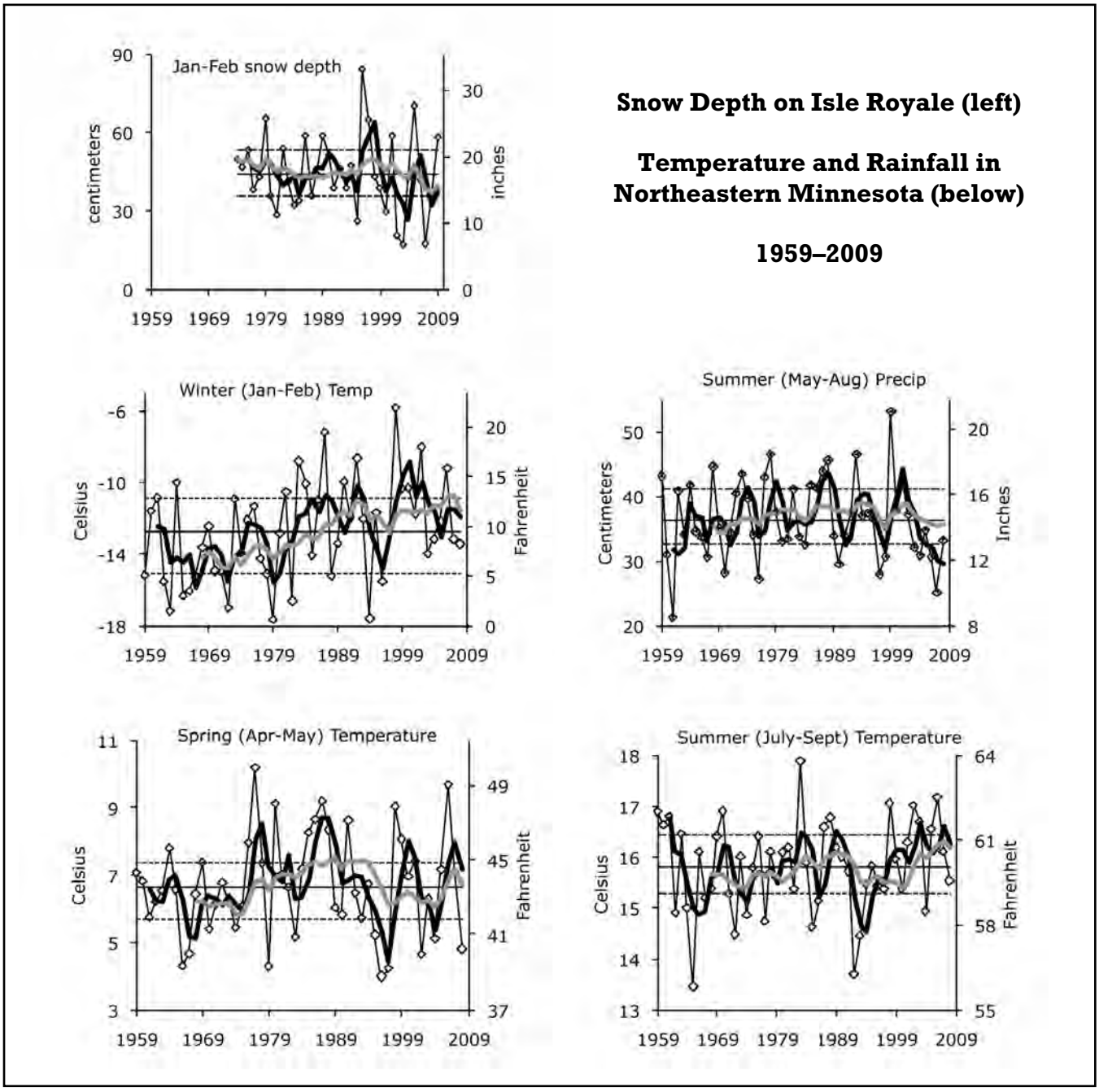
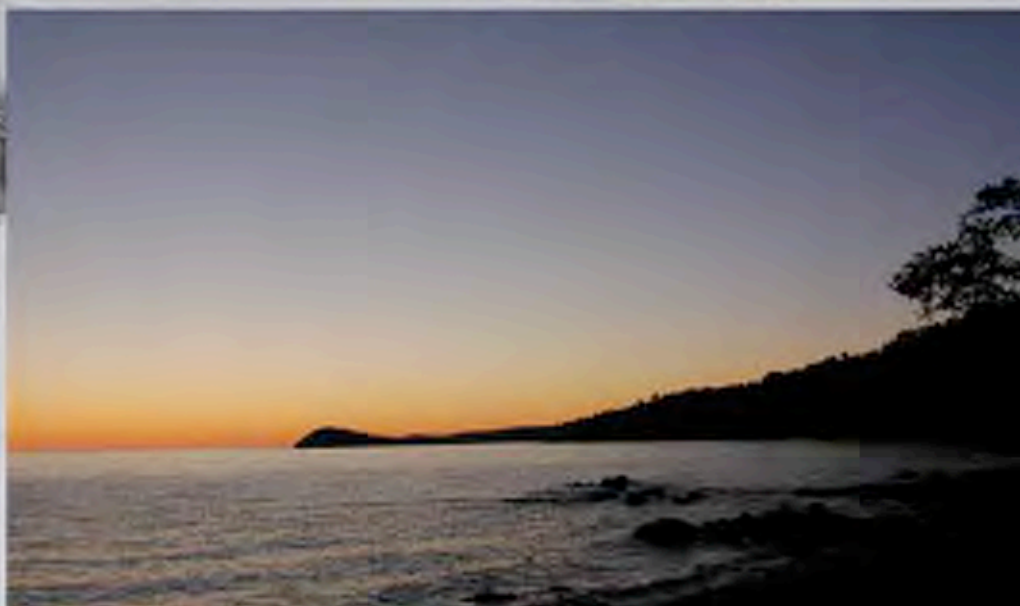


Figure 22. Climate data from Isle Royale (snow depth) and nearby northeastern Minnesota (temperature and precipitation). Climate data from www.wrcc.dri.edu/spi/divplot1map.html. Solid lines are long-term means and dotted lines mark interquartile ranges. Climate change is highlighted by the 10-year averages (heavy black line), and moose may be affected by a 3-year moving average (heavy gray line).





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