Ecological Studies of

WOLVES

on Isle Royale

2006–2007


"Wilderness hold answers to questions
men have not yet begun to ask."
Nancy Newhall

Ecological Studies of Wolves on Isle Royale

Annual Report 2006-2007*

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Team I—No team this year.
Team IIA—Tim Pacey (leader), Paul Janovicz, Barrett Warming, Erik Freeman, Anna Janovicz
Team IIB—Rolf and Candy Peterson (leaders), Ron Eckoff, Kim Thomas, Mike Thomas
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Results reported here are preliminary and, in some cases, represent findings of collaborators; please do not cite without consulting the authors.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

"And the end of all our exploring will be to arrive where we started and know the place for the first time."

—T.S. Eliot

Personnel and Logistics

In summer 2006, Rolf Peterson and John Vucetich directed ground-based fieldwork, aided by Matt Abbotts, Sam Gardner, Marcy Erickson, Dan Graham, Melissa Watkins, Erin Largent, Carolyn Peterson, and Leah Vucetich. Fieldwork continued from early May through late October. In 2007, the annual winter study extended from January 15 to March 5. Because temperatures were unseasonably warm during late December and early January, ice conditions were very uncertain just prior to the start of the winter field season. To accommodate the uncertain conditions, the U.S. Coast Guard (Lt. Mike Baker, pilot; Lt. Shawn Geragthy, co-pilot; Chief Warrant Officer Jeff Hansen) flew Mark Romanski and Rolf Peterson to the island by helicopter on January 11. They found only 1 in. of ice on Washington Harbor, but the research aircraft (PA-18 Supercub) was able to land safely on 4 in. of ice by January 15. The research aircraft was used to ferry arriving and departing people and supplies from Feldtmann Lake (13 in. ice) to Washington Harbor until January 23, when ice thickness had increased to 12 in. Rolf Peterson, John Vucetich, and pilot Don E. Glaser participated in the entire study, assisted in the field by Leah Vucetich and the following personnel from Isle Royale National Park: Mark Romanski, Valena Hofman, Beth Kolb, Dieter Weise, Cindy Glase, and Marshall Plumer. U.S. Forest Service pilots Wayne Erickson, Dean Lee, and Pat Lowe flew several supply flights to Isle Royale from Minnesota. George Desort participated in the winter study, shooting still photos and video. During the course of the year, many park staff and visitors contributed key observations and reports of wolves and moose bones.

Summary

During 2006-2007, the wolf population dropped from 30 to 21, while the moose population declined from 450 to about 385 (fig. 1). The ratio of moose to wolves remains very low, ~20 to 1. Three territorial wolf packs raised a total of four pups, and 43% of last year's wolves died. An additional group of two or three wolves formed at least temporarily in the middle of the island, exhibiting some territorial behavior and killing moose on their own. Wolves killed at a relatively low rate (on a per wolf basis), and consumed a greater proportion of what they killed than is usual. Moose calves were relatively rare this winter, and mortality rates among moose were high (~3.6% per month). Spring 2006 was the fourth year in a row that moose suffered from heavy loads of moose tick. The summer was also particularly hot (along with three of the four previous summers). Hot summers negatively impact moose because moose respond to hot weather by foraging less.

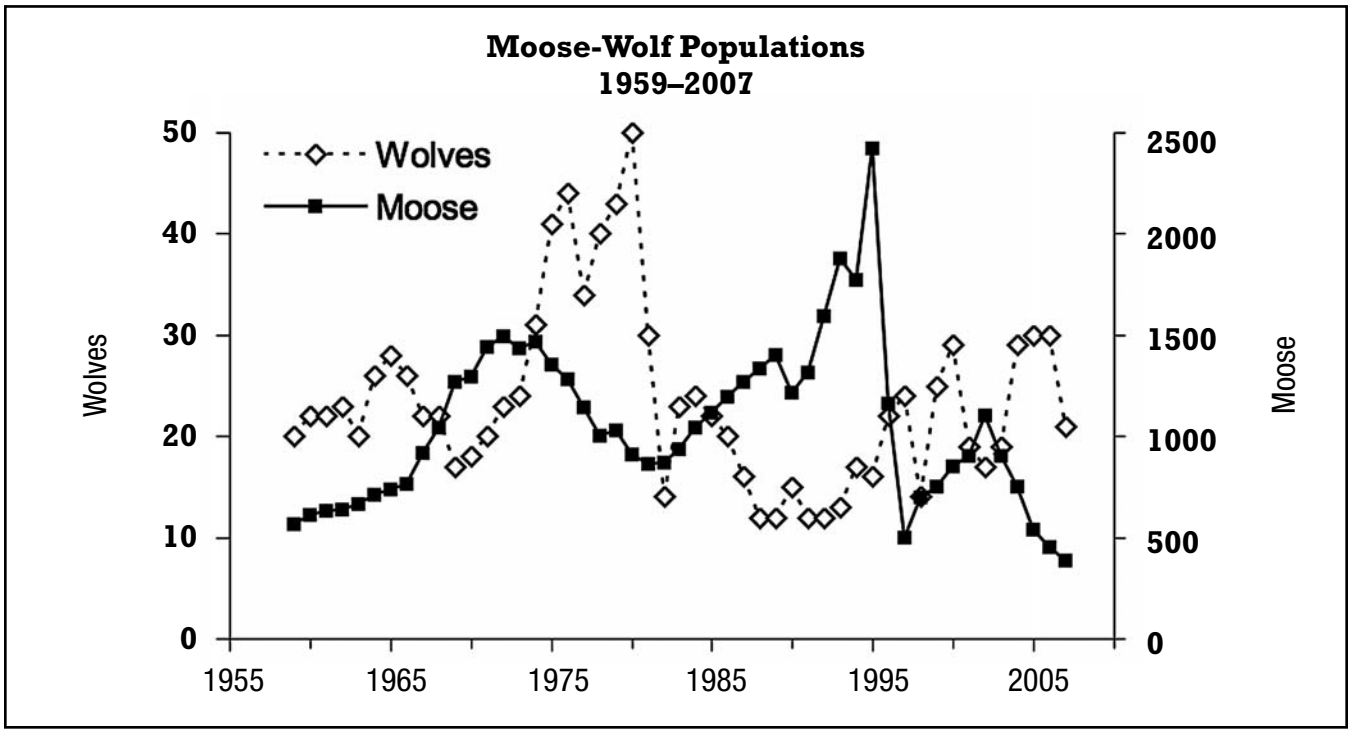


Figure 1. Wolf and moose fluctuations, Isle Royale National Park, 1959-2007. Moose population estimates during 1959-1993 were based on population reconstruction from recoveries of dead moose, whereas estimates from 1994-2007 were based on aerial surveys.

The Wolf Population

During the 2007 winter study, the wolf population contained 21 individuals, a 30% decline from last year's 30 wolves (fig. 1). The decline is ultimately attributable to lack of food. This challenge for wolves was compounded by a lack of snow, which makes moose more difficult to kill. The wolf population was comprised of the same three packs that have existed since 2000. Maximum pack sizes for all three packs were observed during an eight-day period, and this is our best estimate of population size. (We assume that all wolves were counted in one of the packs during this period.) Our count was:

East Pack III (EP)	6
Chippewa Harbor Pack (CHP)	7
Middle Pack II (MP)	8
2007 Total	21

Significant this winter study were the poor conditions for aerial observations, which arose from a combination of factors. First, only one wolf (in East Pack) wore a functioning radio collar. Second, because snow depths were very low, wolves were able to walk anywhere in the forest, so their travel was not concentrated as usual on lakes and shorelines. Third, when wolves did walk on frozen lakes, they did not leave tracks because of lack of snow. Fourth, for about one month, we received no snowfall. Consequently, the snow-covered landscape accumulated a dense maze of tracks that made it difficult to locate wolves or determine their travel routes. Finally, many days of high winds reduced the time we could spend flying.

We observed Middle Pack only twice (once with five wolves and once with eight wolves). CHP was observed eight times (on seven days), and only once with seven wolves. Although we observed the radio-collared East Pack many times, they were usually in the forest and we were often unable to make complete counts of the pack. Twice we observed East Pack with six wolves, and five times we observed five wolves in this pack. We observed loners on just a few occasions, including one wolf with a "rope tail" (fig. 2). Rope-tailed wolves were very common in the East Pack in the 1970s, but since then they rarely appear. Because of these poor circumstances, we will rely on DNA analysis of scats to confirm our winter count.

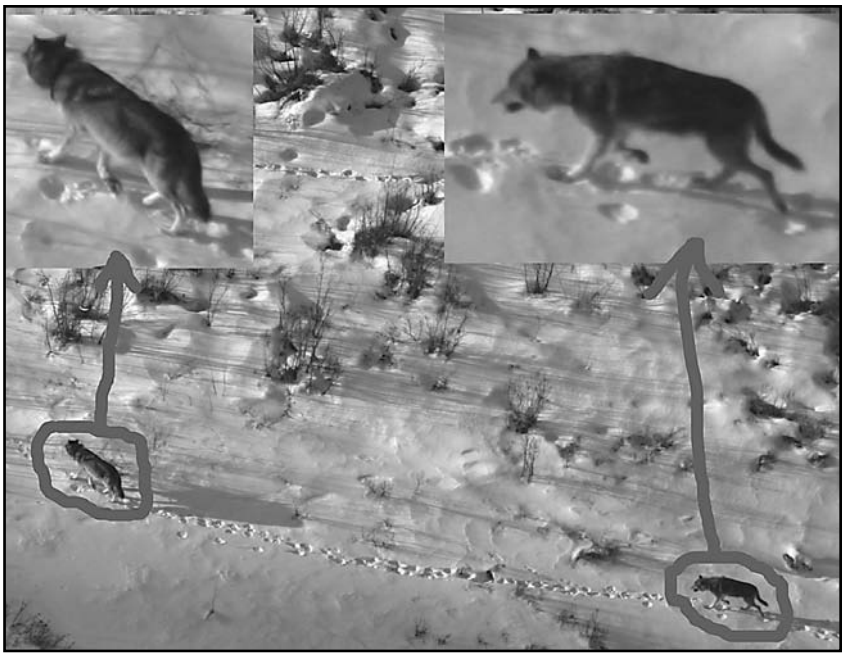


Figure 2. On January 23, the collared wolf from East Pack (left) was seen traveling briefly with a "rope-tailed" wolf (right) whose pack membership is unknown. The tail appears like a rope because it has short guard hairs.

This winter's wolf population included four pups, two each in the Middle and Chippewa Harbor packs. No pups were detected in the East Pack last summer, and winter observations suggested none were present. In early summer 2006, we recovered the remains of two wolves that were likely killed by wolves. In mid-January, we recovered the remains of the alpha female of Chippewa Harbor Pack (more details below). In total, 13 wolves died during the past year. The proximate cause of the past year's wolf decline was a low rate of reproduction (13%) combined with high rate of mortality (43%; fig. 3).

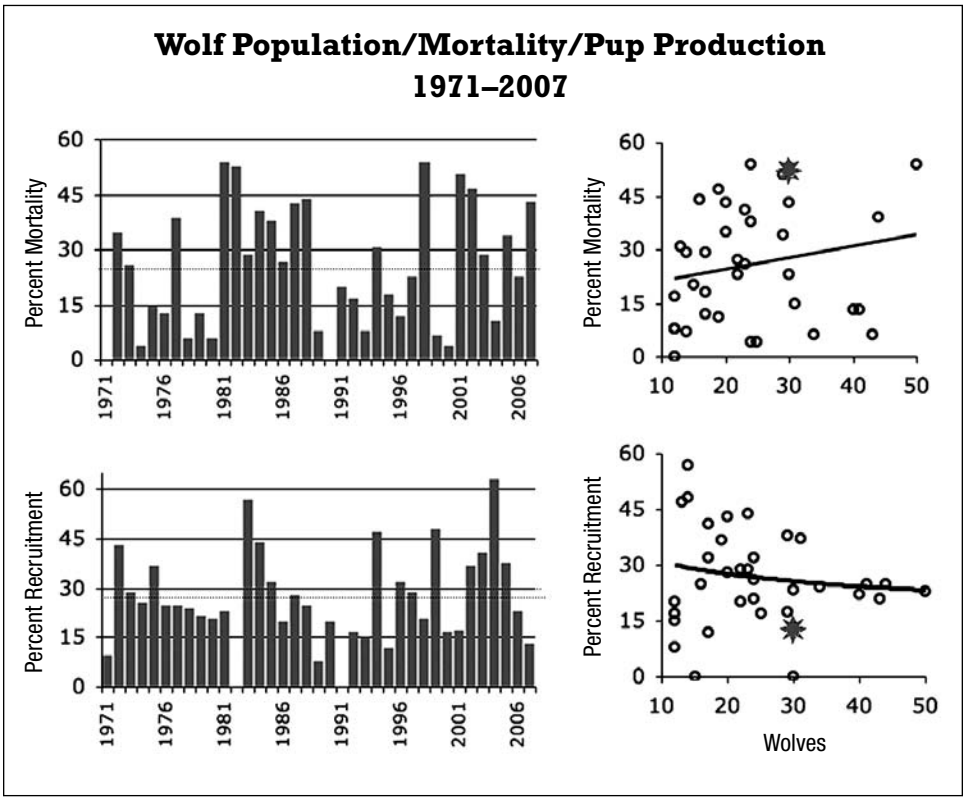


Figure 3. Percent mortality and recruitment for Isle Royale wolves, 1971-2007 (left panels), and relationships between wolf abundance and wolf vital rates (right panels). The dotted lines mark long-term averages. The stars in the right panels indicate abundance in 2007 and the past year's vital rates. The right-hand panels show that (i) mortality rates tend to decrease with increasing abundances, and (ii) that recruitment rate is lower when wolves are either particularly abundant or rare.

Because of limited observations and the difficulty of detecting tracks, our estimates of kill rate are fragmentary, especially for Middle Pack and Chippewa Harbor Pack. The East Pack of five wolves killed six moose in 40 days, a kill rate of 0.03 kills/wolf/day (fig. 4). This kill rate is higher than expected given the rarity of moose and the lack of snow. We were able to perform necropsies on 12 wolf-killed moose from

Figure 4. Members of the East Pack feed on an adult cow killed 20 minutes before. Aside from stomach contents, the entire moose was consumed, including the skull, hooves, leg bones, and almost all the teeth.

Figure 5. All that remained of this wolf-killed adult moose were a few bone fragments.

all three packs. Typically, wolf consumption was extremely high (fig. 5). From some adult moose kills we could find only portions of two or three bones—all the hide, hooves, teeth, and even skulls were completely consumed. Such complete consumption is quite rare.

This year, we observed several significant biological patterns among the wolves. First, the turnover in pack leadership that began two years ago continued. The alpha male of Middle Pack died sometime between late September and mid-January. He was probably at least eight–ten years old and his pelage had become very white. He was last seen on the Feldtmann Ridge Trail last October by Karena Schmidt, who works in our lab. The alpha female of Middle Pack, wearing a nonfunctioning radio collar (1072), is still alive and at least eight years old.

The alpha male (and a founder) of Chippewa Harbor Pack was killed by the East Pack in January 2006. In mid-January of 2007, we found and collected the remains of this pack's other founder, the radio-collared alpha female (and founder). She was likely between nine and eleven years old when she died. She died on the north shore of Angleworm Lake sometime in mid-December. The location of her death, just outside her recent territory, strongly suggests that she was killed by East Pack. Moreover, we observed East Pack visit the site of her death several times. The life of this alpha female is recalled in the sidebar on page 7.

The East Pack is led by a young female and large and old male (fig. 6). The alpha female began leading East pack in fall 2005 and reproduced for the first time in spring 2006. The alpha male of East Pack, radio-collared in 2001 and now probably about 10 years old, is not expected to live more than another year or two (fig. 7). We observed the alpha male tolerating courtship advances by younger males toward two females in winter 2007.

That second significant pattern observed this winter was a continuing shift in territorial boundaries between East Pack and Chippewa Harbor Pack. In previous years, this territorial boundary ran from Daisy Farm to McCargo Cove. Last year, East Pack showed signs of depleting the moose in the eastern portion of their territory, and subsequently challenged Chippewa Harbor Pack over a significant portion of their territory. This year, East Pack appeared to have complete control over areas formerly used by the Chippewa Harbor Pack on the north side of the island (fig. 8).

Figure 6. East Pack investigates a scent mark deposited by Chippewa Harbor Pack at Baker Point. The large wolves are the alpha male and the alpha female (third and second from left, respectively).

Figure 7. The old alpha male from the East Pack spent a lot of time bedded in 2007, but he was still a key leader in the pack. He had an infection or injury near his left eye.

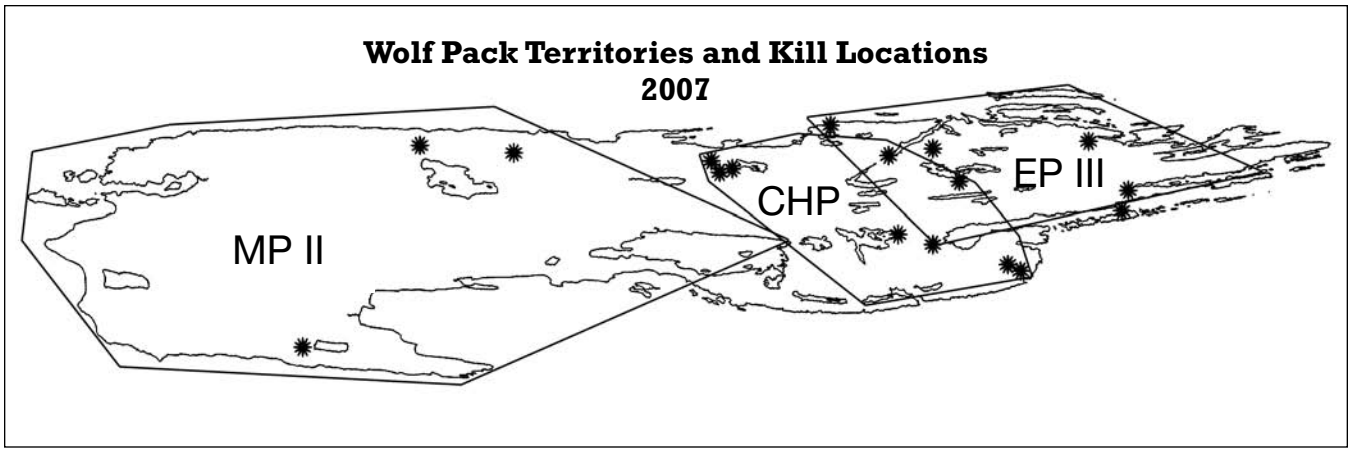


Figure 8. Wolf pack territorial boundaries and moose carcasses (all fresh kills) during the winter study in 2007.

The third significant change we observed this winter was the possible beginnings of a new pack in the middle of the island. We regularly observed tracks of a small group of two to three wolves in this area, and two wolves were observed scent-marking at the southwest end of Hatchet Lake in mid-January. This group killed at least three moose in about ten days in an area just southwest of Harvey Lake. One of these kills was aggressively taken over by the Chippewa Harbor Pack. The very next day, January 29, we observed Middle Pack on Lake Desor with eight wolves (three more than our observation from several days earlier). For this reason, and because this small group used a portion of the island that had traditionally been Middle Pack territory, it is likely that this group had its origin in the Middle Pack. In time, DNA analysis will confirm the identity of these wolves, and whether they succeed in becoming established as a reproducing pack.

We did not observe any copulation in 2007, but estrous blood on the snow or courtship behavior was observed in all three packs during February 10-19, (fig. 9). On this basis, we expect pups to be born in all three packs this year.

Fearless wolves were frequently reported by visitors during summer 2007, at a higher rate than in recent years when the phenomenon first became evident. Wolves killed a cow and calf on Minong Island in Tobin Harbor in late June, and to access this island they often traveled through heavily peopled Rock Harbor. Visitors watched wolves chase a fox down the asphalt lane in Rock Harbor, and wolves reportedly trailed backpackers on trails and confronted people in campgrounds. The number of wolves observed by Vucetich and Peterson on the ground in summer approximately tripled in 2007. Significantly, no aggressive behavior of wolves was reported, just curiosity and lack of fear. We are not aware that wolves obtained any food from people, and visitors were routinely warned by park staff that any feeding of wolves was illegal and dangerous.

The continuing loss of six long-term pack leaders may mean that the stable pack organization of 2000-2007 will change as new breeding wolves are recruited. The food supply for wolves has certainly declined in recent years as old moose, born in the early 1990s, are culled by wolf predation. Continuing decline in the wolf population is expected.

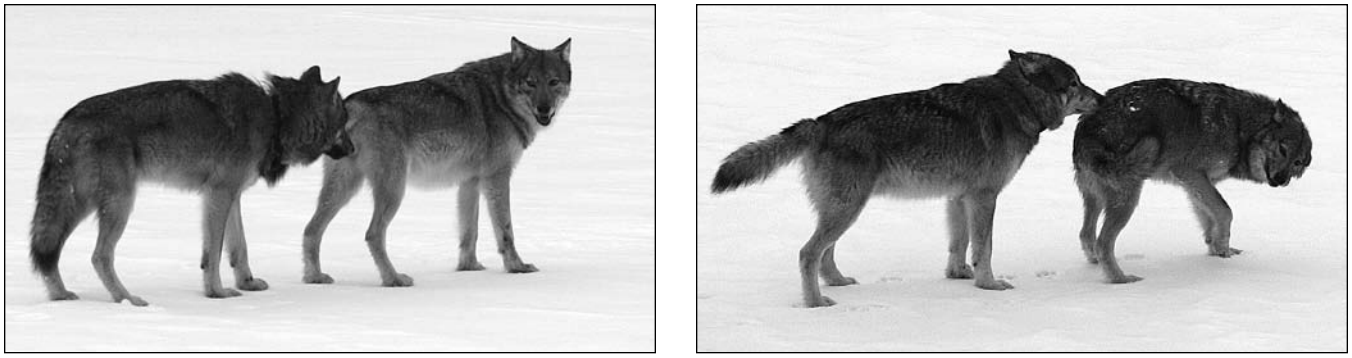


Figure 9. In the East Pack, a subordinate male courts a consenting alpha female (left) while the alpha male consorts with another female (right).

The End of the Story

Rolf Peterson

On the first research flight in 2007, the radio signal from alpha female 410 in the Chippewa Harbor Pack was on mortality mode. The next day we recovered her radio collar and skull from the heavily scavenged site on the north side of Angleworm Lake, and in the next week the East Pack made regular forays to the site. The East Pack had probably killed 410, as she died on the disputed territorial border between the packs, much as the Chippewa Harbor alpha male died in February 2006. Early in 2006, laboratory work confirmed that alpha female 410 in the Chippewa Harbor Pack was the same wolf that was chased into Lake Superior, attacked severely, and left for dead by the Middle Pack in February 2000. When live-captured in 2003, this alpha female had just borne pups and was in excellent condition even though one of her canine teeth had broken off.

The story of 410 and her mate is one of the most dramatic tales coming from over four decades of wolf research on Isle Royale. We think of it as an unusually compelling story, but probably all old wolves would have an equally unlikely story, if we only knew.

.....

On February 18, 2000, we followed the running tracks of the Middle Pack for six miles as they chased a foreign wolf…

"…We caught up to the 11-member pack at water's edge just before noon, vigorously shaking themselves dry, while 20 feet out in Lake Superior, standing on a submerged rock in 10 inches of water, stood a bedraggled wolf, cowering, its hindquarters almost underwater.

In 2000, a female wolf sought refuge in Lake Superior during an attack by the Middle Pack, but was beaten thoroughly and left for dead.

A Middle Pack male roused the female, and they eventually founded the Chippewa Harbor Pack.

"During the next hour we circled overhead. After several minutes of rolling in the snow to dry off, Middle Pack wolves either lay in the snow, watching the victim in the lake, or strutting stiffly back and forth along the shore in front of the hapless wolf. Suddenly, in quick succession, three wolves jumped into shallow water and leaped for the rock where their quarry stood quivering. Confronted by this snarling trio, it fought for its life, snapping furiously toward the lunging pack members. The lone wolf was forced backward into neck-deep

Continued on page 11

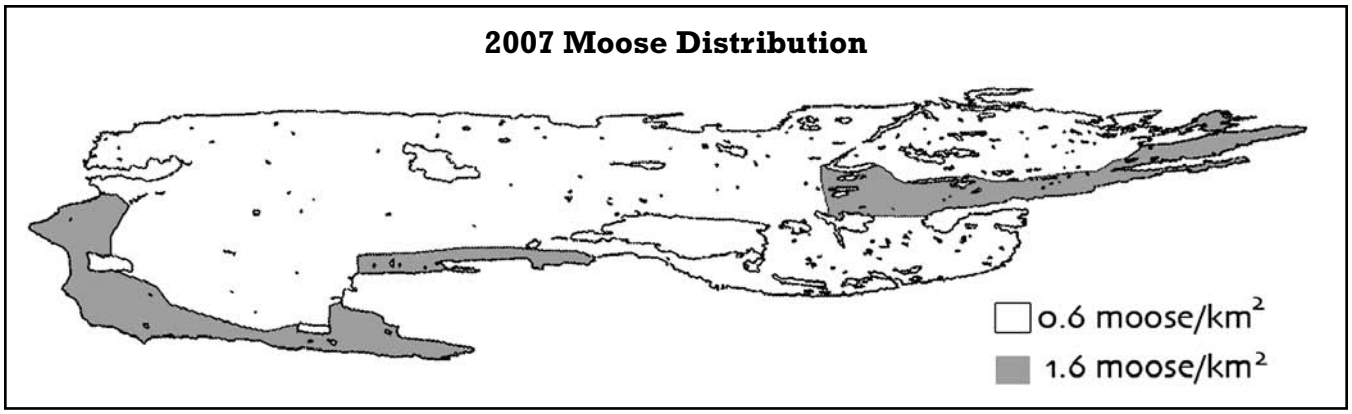


Figure 10. Moose distribution on Isle Royale in 2007 was relatively uniform, as it was in 2006. Only two strata were delineated, based on habitat types and results of the aerial counts on 91 plots that comprise 17 percent of the main island area.

The Moose Population

Over the past five years, moose abundance has declined by about two-thirds (i.e., in 2002 moose abundance was 1100). The moose census in 2007 was severely hampered by incomplete snow cover. After evaluating census results together with conditions known to affect moose abundance, we conclude that moose probably declined further from 2006 to 2007.

Last year, in 2006, we counted 92 moose on 91 one-km² plots, and estimated moose abundance at 450 (with a 80% confidence interval of [370, 535]; fig. 1). In 2007, we counted 51 moose on the same 91 plots. These counts and demographic considerations suggest that moose abundance was between 310 and 460. A more precise but less certain estimate for moose abundance is 385 moose (with an 80% confidence interval of [270, 500]) (fig. 10). The justification for this estimate requires a long explanation.

Typically, we assume we are able to see about 75% of the moose on a census plot, based on a previous radiotelemetry study conducted on Isle Royale under average winter conditions. If we take this standard assumption and the number of moose we counted this

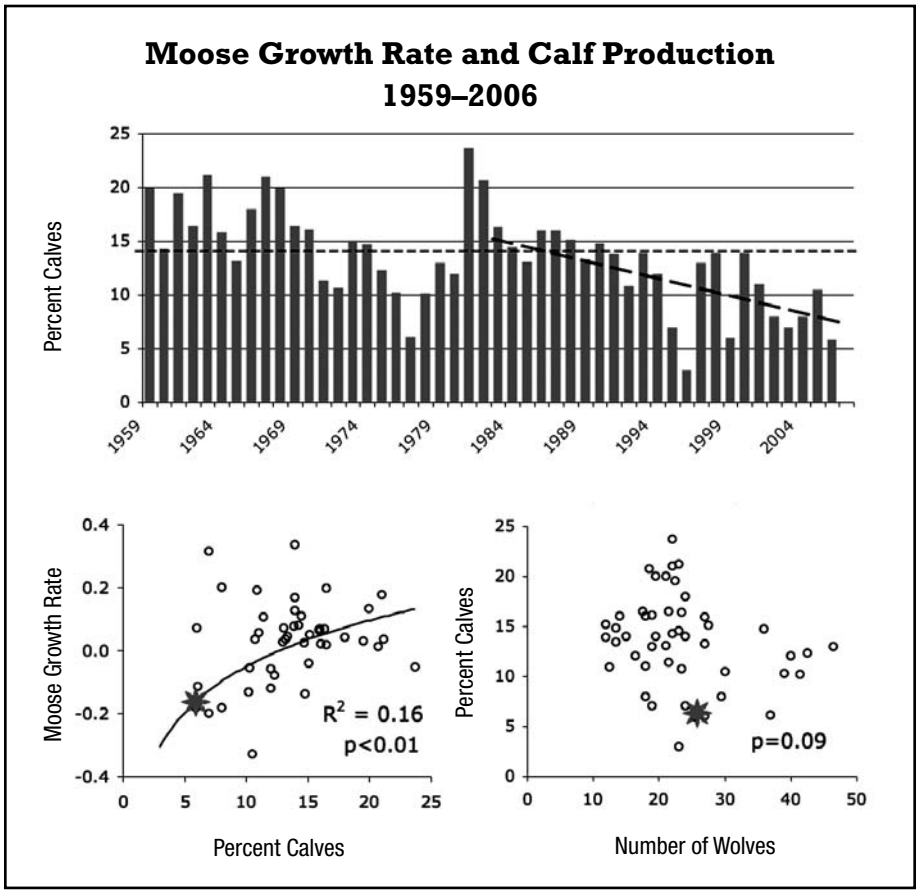


Figure 11. Long-term trends (1959-2007) in percent of the total moose population that are eight-month-old calves (upper panel). The 49-year average (13.7%) is marked by the light dotted line. The linear trend for the past 25 years is marked by the heavy dotted line. The lower left panel shows that calf production is an important determinant of moose population dynamics. The lower right panel shows that wolf abundance is not closely related to calf production. Calf production depends on the combined effects of many factors (predation, food, and climate), the details complex and poorly understood. The stars in the lower panels represent conditions during the past year. Number of wolves is the average of the current year and previous year. The lower panels include data from 1959-2007.

year, then the estimated moose abundance is 310, a significant reduction (31%) from last year's estimate of 450. However, conditions for counting moose were far below average this winter. There was so little snow that some portions of the ground were bare and brown (same color as moose) and the conifers had no snow on them (so the conifers were dark, just like moose). Without access to radio-collared moose in the population, it is impossible to empirically assess sightability of the moose census. However, experience suggests that sightability could have been as low as 50%. If we were to assume that sightability was 50%, then the best estimate of moose abundance would be 460. For the moment, take 310 and 460 to be a range of plausible estimates for abundance.

Independent, demographic considerations provide additional basis for judging moose abundance. Only three of the 51 moose we observed on plots in 2007 were calves. Six percent recruitment is quite low compared to the long-term average of 14% (fig. 11). The explanation for low calf recruitment is likely twofold: (i) During the summer of 2006 there would have been between 21 and 30 wolves, and scat analyses indicated they preyed primarily on moose calves; (ii) the summer of 2006 was extremely hot, probably causing moose to forage less and gain weight less quickly. This is likely the reason why calves in 2006 (and 2005) appeared to be particularly small. Small calves may be especially vulnerable to wolf predation.

In addition to low recruitment, the mortality rate of adult moose is likely to have been average (i.e., ~14%) or somewhat above average (fig. 12). Several factors affect moose mortality—food supply, winter severity, winter ticks, age structure, and wolf predation. During the past year, moose had plenty of food available to them, although hot weather probably reduced foraging rates. The winter of 2006-2007 was extremely mild (from the moose's perspective, this means low snow depths), but moose suffered from heavy loads of moose ticks (figs. 13, 14). The age structure of moose is probably dominated by middle-aged moose, which tend to

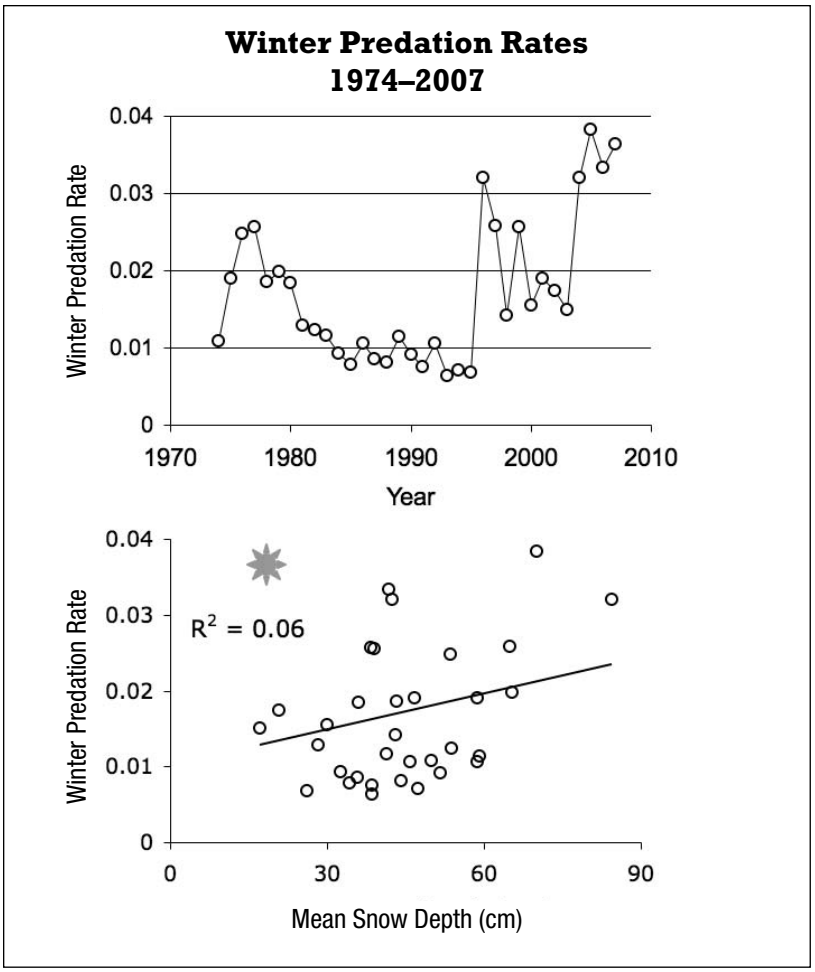


Figure 12. Winter predation rates for Isle Royale moose, 1974-2007 (upper panel). Predation rate (number of predation events per living moose per month) is influenced by average snow depth (lower panel).

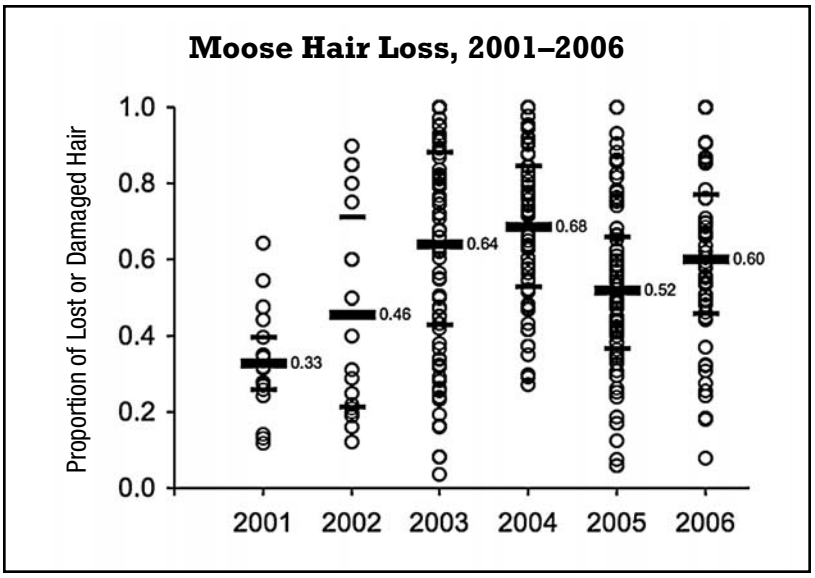


Figure 13. The extent of moose hair loss in spring, caused by winter ticks, remained high for the fourth year in a row. Circles represent individual moose, heavy bars are annual averages, and smaller bars mark interquartile ranges.

have relatively high survival rates. Yet, for the past year there have been only 15-20 moose per wolf, suggesting high predation pressure. From this combination of factors, we infer that mortality rate is likely to have been average or a bit higher.

These demographic considerations (low recruitment and normal to high adult mortality) suggest moose are likely to have declined from last year's 450 moose. If recruitment was low (say 6%) and mortality was average (i.e., 14%), then one would expect abundance to be 410 moose. If mortality were very high, say 25%, then one would expect abundance to be 360 moose.

Plausible point estimates for abundance are between 310 and 460 moose, based on census data, and between 360 and 410 moose, based on demographic considerations. The midpoint of both intervals is 385 moose, which seems a reasonable point estimate for abundance. The 80% confidence interval associated with this point estimate, from the observed variance in moose counts among survey plots and the negative binomial distribution, is 270 and 500. Ultimately, a less precise, but more reliable conclusion is that in 2007 moose abundance probably did not increase, and more likely declined further.

All the dead moose we discovered in winter 2007 were killed by wolves. Marrow fat levels in these moose exhibited the typical range of values, based on previous data (fig. 15). Wolves continued to rely heavily on very old moose, born in the early 1990s when the moose population was large and expanding rapidly. These old moose, with typical pathologies (fig. 16), are becoming very rare, and this change in age structure probably underlies the decline in the wolf population.

Figure 14. In the winter and spring of 2006, most moose suffered substantially from moose ticks and the hair loss that they cause.

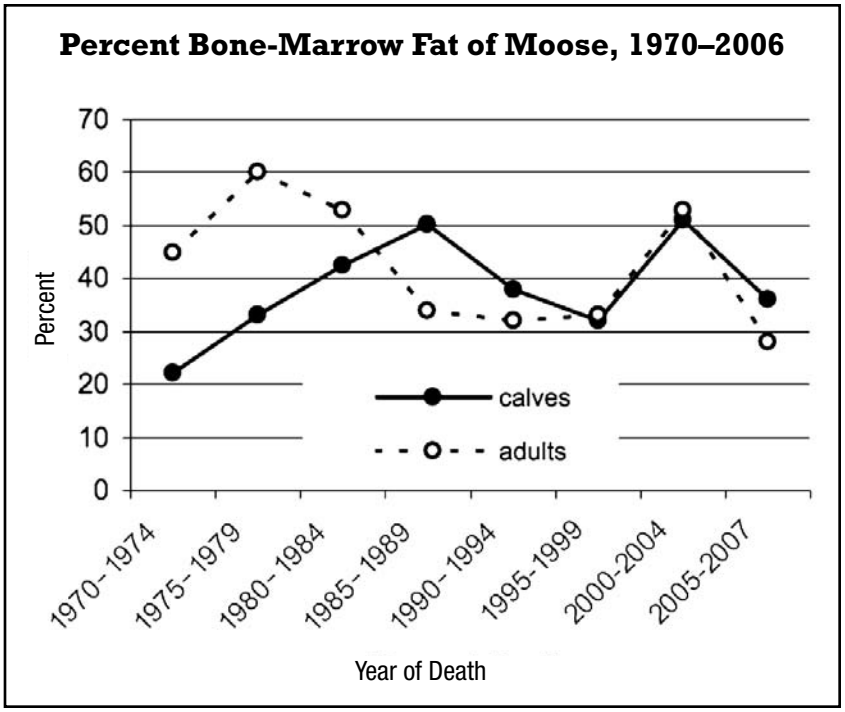


Figure 15. Long-term trends in bone-marrow fat for moose. The line for adults shows the proportion of adults with >70% fat in their bone marrow. The line for calves shows the mean value of percent fat in bone marrow.

The summertime weather in 2006 presented challenges for moose with its hot temperatures and continued drought. Many beaver ponds dried up completely. Although summertime observations suggested that a relatively high proportion of cow moose had calves, wolf predation was intensive, and few calves survived to face their first winter (fig. 17).

The combination of warmer weather and high predation pressure may lead to continued decline in the moose population, now at a historic low. A substantial decline in the wolf population may be necessary before the moose population stabilizes.

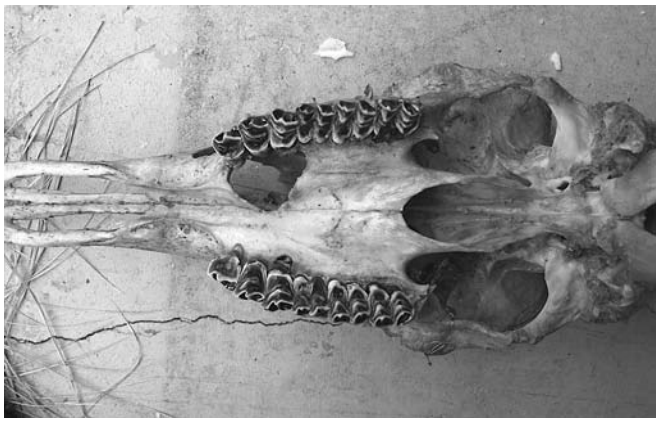


Figure 16. This skull is from a bull moose killed by the Chippewa Harbor Pack. The palate of this bull decomposed while the moose was alive, a result of a severe infection beginning along the tooth row. The cavity and nasal passage was impacted with a softball-sized wad of rotten vegetation.

Figure 17. A single wolf kept this cow moose and her crippled calf in Lake Superior for at least a half day as they traveled in tandem along the shoreline for over three miles. The outcome of this standoff was unknown.

The End of the Story *(continued from page 7)*

water, but it retained its footing and held the attackers at bay; they retreated to shore to shake and roll again in the snow…"

The lone wolf lost this battle, and was left for dead on the icy edge of Lake Superior. But a trailing male from the Middle Pack showed up and took an interest in the motionless victim, which turned out to be a female wolf in heat. Before the day was out the female managed to rise and make it 50m into the forest, where she lay all night as her bleeding wounds stabilized. The next morning we found that the male and female had walked out of the immediate area, and we picked up a few hairs from her bloody bed. Five days later we found the pair a half-mile from the attack site, the female standing shakily while the male alternately licked the wounds on her neck and frenetically tried to court the female.

The following summer a pup was born to the pair and the Chippewa Harbor Pack was established. Within two years this pack had killed two successive alpha males in the adjacent East Pack as it systematically took over a moose-rich portion of the east end of the island. The saviour male and courageous female thrived, reproducing each year and emerging as a territorial powerhouse. We radio-collared the female in 2003, and DNA from her blood matched that from the hair recovered from the attack site in 1999.

The East Pack and Chippewa Harbor Pack both flourished as long as there were plenty of moose. But by 2006, the East Pack had run short, and it began to make inroads on the edges of Chippewa Pack territory. In February 2006, the East Pack moved in on a recent kill of the neighboring pack. Finding the Chippewa alpha male feeding, the East Pack promptly killed him. Female 410 was then at greater risk, but she recruited a new alpha male, mated, and raised another litter of pups in 2006, her seventh successful season of reproduction. Against impossible odds, she survived and carved out, by wolf standards, a highly successful life. Her canine teeth were worn to small stubs (see photo), one canine tooth was badly infected and loose, and in the end life was simply wrung out of her.

The female died late in 2006, her worn teeth a testament to the rigors of her life.

Forest Vegetation

The forests of Isle Royale provide the context and foundation for long-term fluctuations in wolves and moose. The eastern, western, and middle regions of Isle Royale exhibit important differences in their vegetative communities. The middle of the island, burned in 1936, currently provides little winter forage for moose. The west end of Isle Royale supports very old forests with sparse but well-distributed balsam fir trees that are either in the forest canopy or less than two meters tall. These shorter trees have been browsed intensively for many years, and are prevented by herbivory from growing into seed-producing trees. The canopy trees on the island's west end are gradually dying without being replaced. Currently, only about 20% of the canopy balsam fir trees that existed in 1988 are still standing (fig. 18), and these survivors are projected to disappear by 2011. The ultimate implications of this forest change are not entirely clear. On a decadal time scale, moose are likely to decline at least somewhat on the west end of the island as the young fir trees die without replacement. However, a moose decline might be mitigated, at least partially, if moose switch to some other forage (e.g., cedar). Also, it may be that only a modest decline in moose is necessary to allow enough fir trees to reach into the canopy. We have already noticed that fir trees in the west end have been growing better in recent years, due to reduced moose abundance.

By contrast, the east end of Isle Royale is characterized by dense stands of balsam fir of all size categories (seedlings, samplings, pole-sized trees, and canopy trees). Moreover, east-end balsam fir trees are only lightly browsed. Until recently, east-end forests have supported greater densities of Isle Royale moose, which in turn have supported greater densities of Isle Royale wolves. More specifically, in 2001-2007 two wolf packs (with ~2/3 of the wolf population) shared the eastern one third of the island, with about half of the moose population.

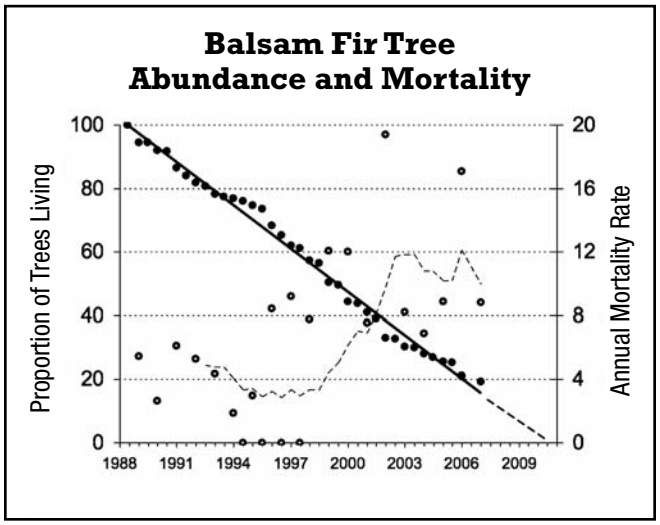


Figure 18. Abundance (filled circles) and annual mortality rate (open circles) of balsam fir trees in the forest canopy that were tagged in 1988. These trees are not being replaced by younger fir trees. The remainder of these sampled trees is expected to die by approximately 2011, an indicator of a dramatic reduction over 75% of Isle Royale in seed source for this species. The demise of this species is ultimately caused by moose herbivory.

However, in recent years intense wolf predation on the east end has reduced moose density substantially, outweighing abundant forage as a moose population determinant. The Blake Point peninsula at the northeast end remains largely vacant of moose, and the East Pack has shifted its attention in midwinter to other areas, including the territory formerly held by Chippewa Harbor Pack.

Other Wildlife

The National Park Service conducts aerial surveys of known osprey and bald eagle nests each summer. After regional declines in historic organochlorine pollutants in the Lake Superior watershed, both species reestablished at Isle Royale in the 1980s. Eagles and ospreys are both present at low numbers, and factors limiting further

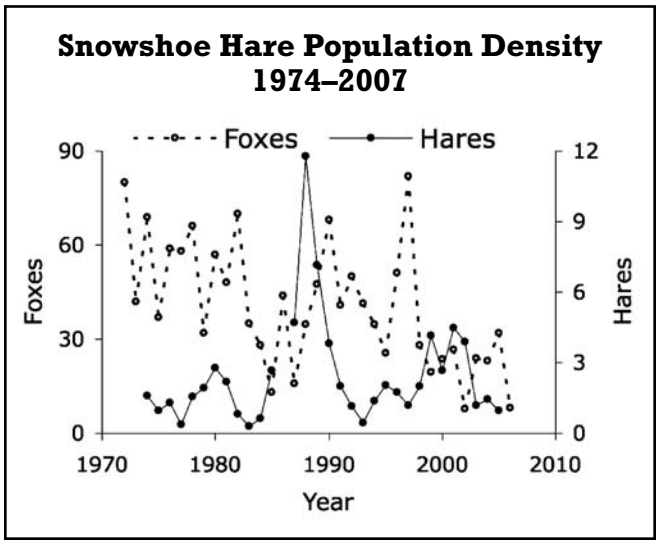


Figure 19. Indices of abundance for red foxes and snowshoe hares on Isle Royale, 1974-2007. The hare index is the number of hares seen per 100 km of summer hiking. The fox index is the number of foxes seen from the plane during winter study, the sum of the maximum number seen at kills, and the number seen otherwise per 100 hours of flight time. The hare population appears to cycle (albeit with a variable amplitude) but the fox population fluctuates in a more complex manner and the fox population appears not to cycle. Rather the fox population appears to be in long-term decline.

expansion are poorly understood. In 2007, active eagle nests numbered seven, with six eaglets fledged. The number of osprey nests was five, with three young fledged.

Snowshoe hare observations were still relatively low in summer 2007, consistent with a cyclical decline following a peak at the turn of the decade (fig. 19). Red fox, a major hare predator, have apparently declined to exceptionally low levels (fig. 19), probably a result of low food from scavenged moose carcasses and a low hare population (fig 20).

Active beaver colonies were estimated during 1974-2004 during biennial aerial surveys in autumn, conducted by Phil Shelton and Doug Smith (fig. 21). After reaching a historic peak in 1974, beaver declined, then recovered as wolves peaked and crashed. During 1986-2004, beaver numbers have slowly contracted as habitat deteriorated in successional forests recovering from fires in the nineteenth and early twentieth century. In October 2006, a double-count of beaver sites was made, for the first time, using two aircraft, with Rolf Peterson and Mark Romanski as observers. The search pattern was more intensive than in previous aerial surveys, and the number of active sites observed was more than twice as great as in the 2004 survey. The higher number reflects higher sightability rather than an increasing population. A followup survey will be conducted in 2007 to better clarify the population status and trend.

Figure 20. Two scavenging foxes compete agonistically over the sparse remains of a wolf-killed moose.

River otters continue to thrive in all parts of the island. The recently-established American marten is the subject of a study by park staff during 2006-2008. Although no marten were reportedly observed in the past year, a scavenged half-carcass was recovered on a trail last summer, and fresh tracks of several individuals were recorded in winter 2007 at the west end of Isle Royale.

Figure 21. Even with very low water and an aging forest, a few newly established beaver colonies could be found in autumn 2006.

A Small Safe Haven Leah Vucetich

June 5, 2006—I was awakened to the sound of moose grunts outside the yurt, at Windigo, where we live. My alarm had not gone off, so it had to be sometime before 6:00 AM. I was not prepared (mentally or logistically) to make observations on the foraging behavior of this moose. However, I can't seem to resist the sound of those burdened grunts! You cannot make these observations when *you* want; they have to be made when a moose decides to share its time with you.

So I crawled over my comatose husband, John Vucetich, and sprung out of bed. I pulled my baggie field pants on over my sleeping long undies, zipped on a fleece, and slipped on my red Crocs. Later, I realized that I pulled my field pants on backwards. I dug my binocs out of yesterday's pack and grabbed my notebook.

A cow moose was right outside the yurt, toward the Park Service junkyard that we live next to. She was foraging busily. The early morning light was still dim, so making observations was difficult. Nevertheless, I recorded several bites. As she moved deeper into the forest, I realized I was being swarmed with mosquitoes and blackflies, and I had forgotten an essential piece of equipment—my bug shirt. I noted her position and line of movement and headed back to the yurt. I changed into socks, boots, bug shirt, baseball hat, gloves, and citronella spray and headed back out. Despite the ruckus, John showed no signs of awakening.

I listened, but heard nothing. I proceeded carefully from where I had last seen her. Then I heard the crack of a hoof on a twig, and the methodical munching of leaves. I began to record more foraging observations. As the morning light became brighter, I noticed her pattern of hair loss (caused by winter ticks). The pattern was different from those which I had seen this year. This was our first meeting, this cow moose and I. I thought I knew all the moose who had been foraging in this area. Then I saw something I recognized—a tear on her left ear. I had met this moose before—two years before. In the summer of 2004, she and I had spent quite a bit of time together. That year, she had a calf, and I helped a German film crew video-record her at a nearby mud lick.

It was great to see an old friend, and it made me smile to know she was still doing well. She now carries a tumor on her right shoulder (these skin tumors are common and typically benign). I think that's new since we last met (I'll check my notes).

She continued to forage, and I continued to record. She is a moving browser—no standing in one spot and gorging. She takes a few steps and a few bites and a few steps. I'm sure this works for her, but it does make recording a challenge. This morning she eats lots of yellow birch leaves—both from branches on tall trees and from small suckers. Each birch bite is nearly matched with bites of lady fern and *Dryopteris*, and supplemented with hazel leaf here and a maple leaf there. After some time, she continued foraging, but began moving a bit more quickly—too quickly for me to handily follow, observe, and write notes. It is amazing how swiftly they can move while still appearing to be just meandering casually. I was disappointed that she was getting too far away from me to note her foraging.

Then she stopped suddenly and looked intently into the forest beyond her. She stood stock still for several seconds. Then she turned and bolted straight for me. In an instant, I felt that she was not charging me, or displaying any type of aggression toward me; but she was beating a rapid retreat from something she had heard, seen, or smelled ahead of her. She trotted toward me—all 800 pounds of brown fur and muscle—and then past me, just an arm's length to my left. She spun around and I could feel her looking over my shoulder from just behind me.

There we both stood, both looking intently into the forest. Then I saw it—just a fleeting glimpse of the dark form of a wolf as it ran through the trees just

Continued on page 16

Weather, Snow, and Ice Conditions

Snow depth was far below average during the 2007 winter study (fig. 22). Low snow depth had a significant impact on the wolves, moose, and researchers. Temperatures were close to average (fig 23). However, the lowest temperature that we recorded, -22°F (-30°C), was the lowest we have recorded for several years. An ice bridge was present between Isle Royale and mainland Ontario for about two weeks in early February. This past winter was particularly windy, which greatly limited flight time.

When moose get too hot during summer, they spend more time resting in the shade and less time foraging. Consequently, hot temperatures can make moose less prepared to survive winter. Moose are benefited by warm temperatures in early spring, because it causes plants to green-up more quickly, yet winter tick popula-

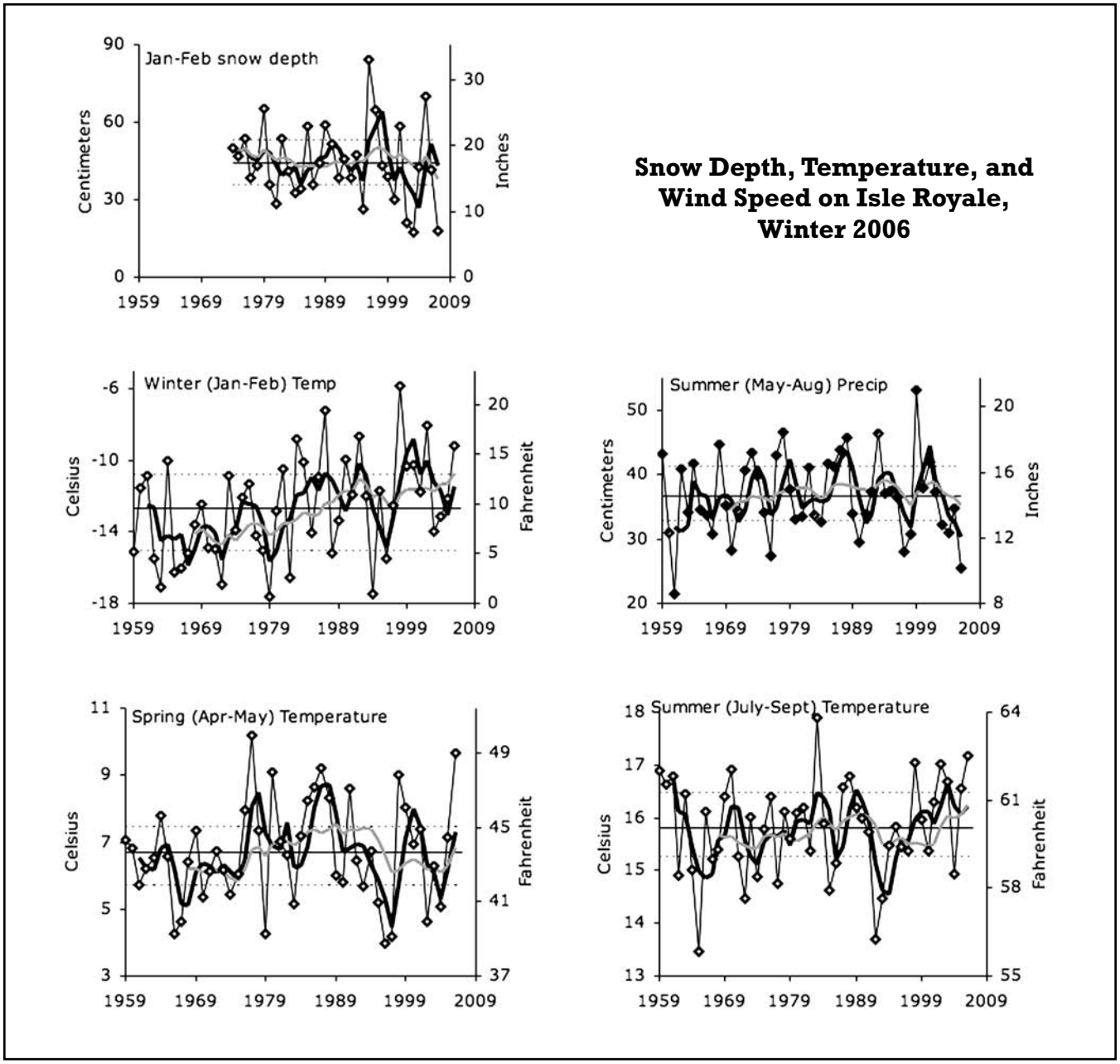


Figure 22. Climate data from Isle Royale (snow depth) and nearby northeastern Minnesota (temperature and precipitation). Climate data from <www.wrcc.dri. edu/spi/divplot1map.html>. Solid lines are long-term means and dotted lines mark interquartile ranges. Climate change is highlighted by the ten-year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

tions seem to thrive under these conditions. The effect of summer precipitation is liable to be important, but its effect is unknown. The effect of summer precipitation would be manifest through its impact on forage quality.

With this context, the summer of 2006 was extremely hot and dry. Moreover, seven of the past nine summers have been hotter than average, and the past four years have been drier than usual (Fig. 22). This past spring, green-up came earlier than usual. Although summer and winter temperatures are warming, there is little indication that spring green-up is occurring earlier.

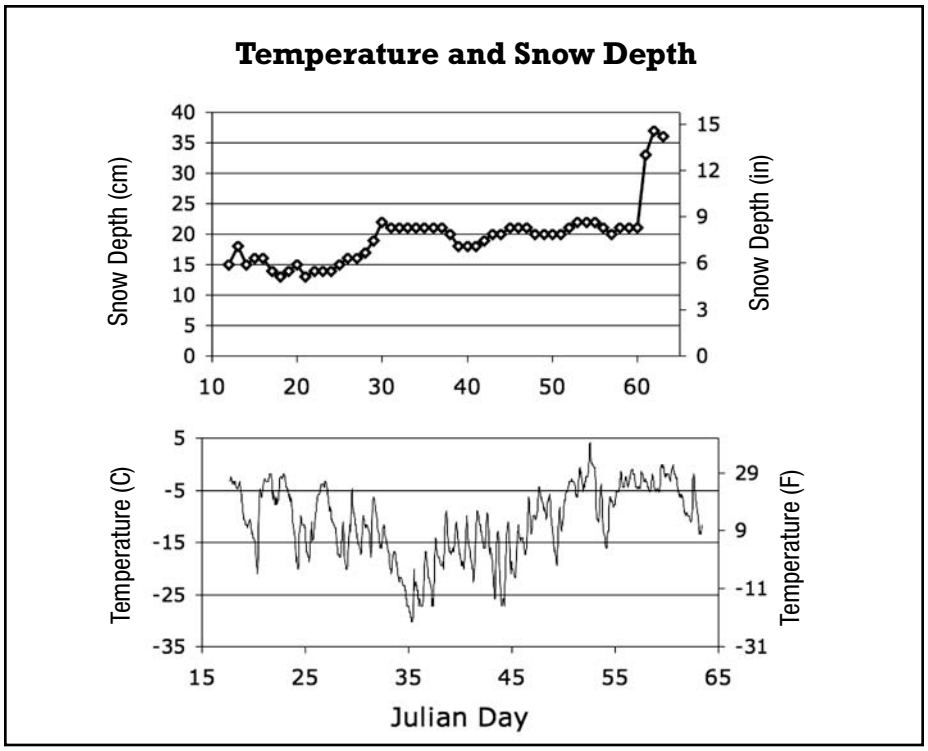


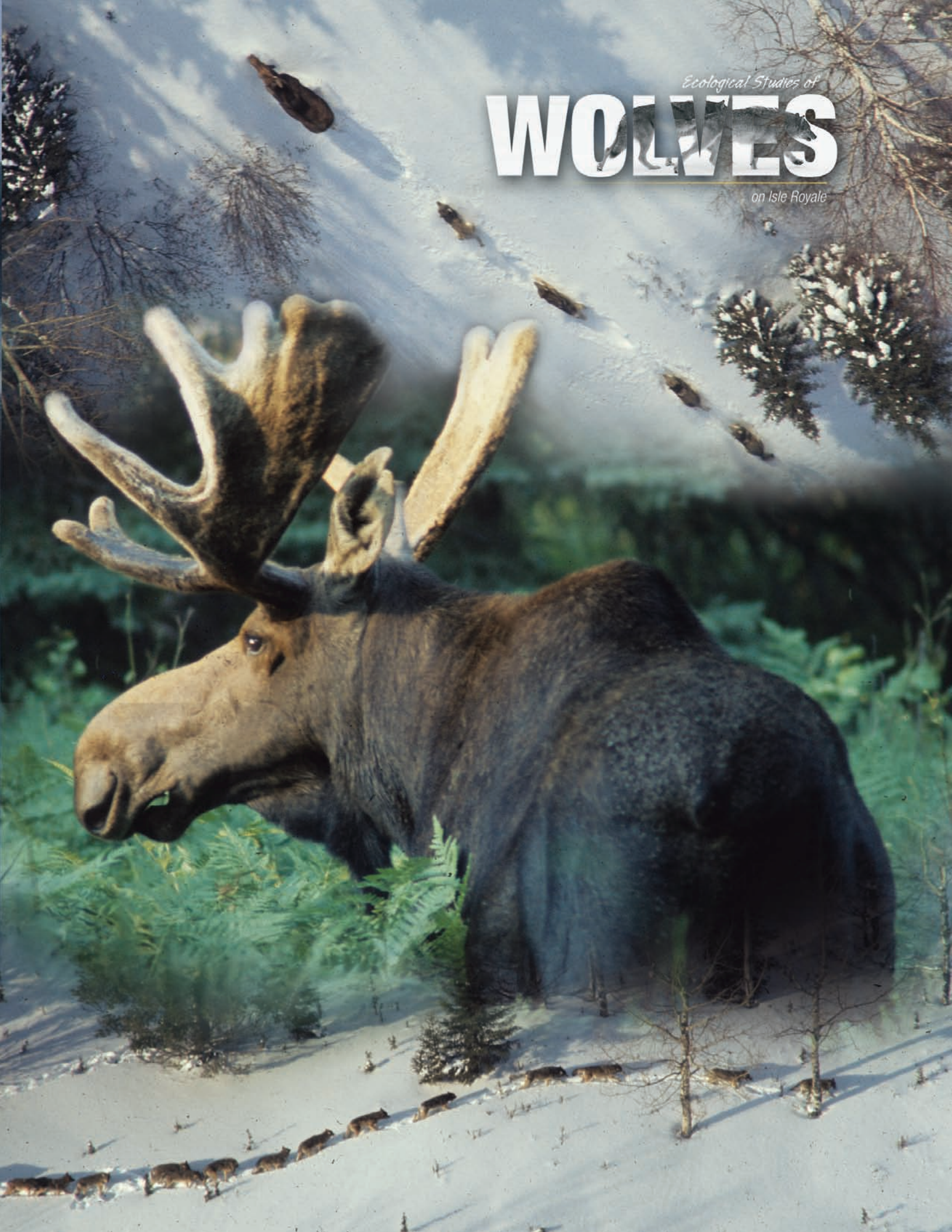
Figure 23. Snow depth (daily) and ambient temperature (hourly) during the 2007 winter study on Isle Royale.

A Small Safe Haven *(continued from page 15)*

beyond where she had been standing.

After her danger had passed, we stood near each other for what seemed a long time—perhaps two-three minutes. I spoke with her and we examined each other carefully. I asked if she remembered me from the mud lick. She leaned toward me, sniffing with ears cocked forward toward me. I stretched out my hand and spoke gently to her. She decided to move past me, and foraged a bit more. She never stopped looking where she had seen danger. She was no longer relaxed and leisurely in her foraging. After a couple of minutes, and just a few more bites, she left the area, walking too quickly for me to keep up.

I had been excluded from her moose world and was back into my own. But where exactly was I? I had no map, no compass, no GPS, no glasses or contacts, no sun, and had been on a moose trajectory through the forest. I decided to first look for tracks that may have been left by the wolf, but found no appropriate substrate to record the passing. I began to walk in the direction I thought was home. Eventually, I returned to the yurt, where John was still groggy—hadn't heard the alarm, didn't even know that I had been out, and had no idea that a moose decided that I was the safest thing to put between her and a wolf!



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