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Recommended Citation

Vucetich, John A. and Peterson, Rolf O., "Ecological Studies of Wolves on Isle Royale, 2007-2008" (2008).
Ecological Studies of Wolves on Isle Royale. 14.
[10.37099/mtu.dc.wolf-annualreports/2007-2008](https://digitalcommons.mtu.edu/wolf-annualreports/2007-2008)

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Ecological Studies of

Wolves

on Isle Royale

2007-2008

"The more you know, the less sure you are."

Voltaire

Ecological Studies of Wolves on Isle Royale

Annual Report 2007–2008

by

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and

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March 31, 2008

Major support for the 2007–2008 studies was received from the National Park Service (Co-op Agreement No. J631005N004/0003), the National Science Foundation (DEB-0424562), Earthwatch, Inc., and the Robert Bateman Endowment of the Michigan Tech Fund.

Additional contributions were received from the following organizations and individuals: James and Carol Applegate, BP Foundation, Dorthey L. Behrend, Pippin and Janice Brehler, Sheri A. Buller, Alison J. Clarke, Donald C. Close, the Complete Battery Source, Robert and Ray Dumas, Clay Ecklund, Ronald and Barbara Eckoff, Ronald L. Felzer, Milwaukee Zookeepers Association, Robert and Sally Irmiger, Timothy W. Gifford, Edith N. Greene, Charles and Elizabeth Hambrick-Stowe, H. Robert Krear, William and Diane Kuhlmann, Warren and Patricia Kuhlmann, Warren and Patricia Larsen, Frances R. LeClair, Dana and Donna Lowell, Robert and Janet Marr, Brian E. McLaren, Paul S. Mueller, Richard and Bea Ann Murray, Michael Nelson and Heather Varco, Patsy Ophaug, Michael and Kari Palmer, Janet L. Parker, Christopher and Nan Parson, Tony and Thelma Peterle, Rolf and Carolyn Peterson, Frederick Rogers and Jeanette Harley, Jenny Rogers, Robert and Grace Rudd, John and Linda Schakenback, Fred and Joyce Scharringhausen, Betty L. Schnaar, Joan Silaco, Marion R. Stoddart, Caesar Sweitzer, William and Cynthia Veresh, Linda M. Williams, Dorothy D. Zeller, and Bruce Zuraw.

Unless otherwise noted, all photographs are by Rolf O. Peterson, John A. Vucetich, or George Desort.

Important contributions, personal time, and financial assistance from the following Earthwatch volunteers are gratefully acknowledged:

Team IA—Tim Pacey (leader), Clay Ecklund, Laura Hickman, Philipp Krupcynski, Kari McDonald

Team IB—Mike Clark (leader), Benjamin Betterly, Julian Noble, Joe Royer, Vivien Tartter

Team IIA—Philipp Krupcynski (leader), Terry Birk, Fred Braun, Pam Davidson, Katie Eckert, Dan Stermac-Stein

Team IIB—Rolf and Candy Peterson (leaders), Andrew Sorenson, Kim and Mike Thomas, Alan West

Team IIIA—Jeff Holden (leader), Stefan Anderson, Kevin Keogh, Terry Schaich, Dick Skarecky, Dane Warming

Team IIIB—Jeff Plakke (leader), Laquita Crow, Maria Maschauer, David Norris, Charles Queen, John Warming

Team IIIC—Brian Rajdl (leader), Ron Eckoff, Karen and Michael George, Barrett Warming, Ted Soldan

Team IVA—Lynda Thompson (leader), Kerry Galson, Polly Knudsen, Therese Pieper, Leonard Sheehy, Joseph Young

Team IVB—Brian Rajdl (leader), Natalie Bladis, Danica Brunker, Michael Egan, Justin Sutera, Nancy Sutera

Team IVC—Ted Soldan (leader), Lee Coopridge, Natalie and Tim Gifford, Eric Guise, Kristin Harrison

Steven Rettke, an Earthwatch volunteer from Team III in 2006, was inadvertently omitted from last year's report.

Tax-deductible donations to support continuing research on Isle Royale wolves and moose can be sent to Wolf-Moose Study, Michigan Tech Fund, Michigan Technological University, 1400 Townsend Drive, Houghton, Michigan 49931-1295. *Thank you to all who help!*

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

... it is not ours to own because it already owns itself.

—Barbara Kingsolver

Personnel and Logistics

In summer 2007, ground-based fieldwork continued from late April through late October. Rolf Peterson and John Vucetich directed that fieldwork with assistance from Brittney Wedgewood, Derek Eckstrom, Philipp Krupczynski, Rick Gworek, Carrie Klehm, Carolyn Peterson, and Leah Vucetich. During the course of the year many park staff and visitors contributed key observations and reports of wolf sightings and moose bones.

In April 2007, we radio-collared six wolves. Veterinarians Jenny Powers, Robert Irmiger, and Kevin Castle assisted with wolf handling. Cindy Glase, Superintendent Phyllis Green, Sally Irmiger, Beth Kolb, Mark Romanski, and Dieter Wiese all helped with logistics of collaring. In 2008 the annual winter study extended from January 17 to March 3. 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: Alex Egan,

Valena Hofman, Larry Kangas, Mark Romanski, and Karena Schmidt. Superintendent Phyllis Green and John Flesher, a correspondent with the Associated Press, also shared a few days on site during winter study. USDA Forest Service pilots Wayne Erickson and Pat Lowe flew several supply flights to Isle Royale from Ely, Minnesota.

Pilot Donald Murray also participated in winter study for the first two weeks of February. Murray's effort provided the opportunity for a double count of moose census plots (see "The Moose Population"). Donald Murray, the grandson of Don Murray (project pilot from 1959 to 1979), flew the same plane that his grandfather used on Isle Royale during 1968–79.

George Desort filmed and photographed our research activities in May 2007 and February 2008. A daily account of winter study's events and activities are recorded at www.isleroyalewolf.org/wsjournal.

Summary

During 2007–2008, the wolf population increased slightly, from 21 to 23, and the moose population remained approximately stable at a relatively low abundance. In 2008, we estimated the moose abundance to be 650, with 90% confidence intervals of [430, 850] (Fig. 1). The ratio of moose to wolves remained low at ~28 to 1. For the past two 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 began.

During the summer of 2007, wolves showed signs of experiencing food shortage by scavenging moose bones from the winter of 2006–2007. Signs of food shortage persisted during January and February 2008, when wolf packs frequently made forays into other pack territories. Nevertheless, from the perspective of food acquisition by wolves, kill rates were nearly typical (0.65 moose/wolf/month) during January and February 2008. Moreover, a fourth territorial pack formed during the past year. During the past year, at least two (10%) wolves in the population died, and at least four pups survived to their first winter.

For the second consecutive winter, moose calves were relatively rare, and mortality rates among moose were somewhat higher than average (2.3% per month). Spring 2007 marked the fifth consecutive year that moose suffered from heavy infestations of moose ticks. The summer of 2007 continued a decade-long trend of hotter-than-average summers. Hot summers negatively

impact moose because, in their need to stay cool, moose forage less, and moose ticks are favored by early springs and possibly by hot summers.

During summer 2008 we will celebrate the 50th anniversary of wolf and moose research on Isle Royale. A centerpiece of that celebration will be the world premier of a feature-length documentary about the research, *Fortunate Wilderness* (Fig. 2). Activities associated with these celebrations are described at www.wolfmoose.mtu.edu.

Figure 2. George Desort, independent film-maker, has been working for the past five years on the development and production of *Fortunate Wilderness*, a feature-length documentary celebrating 50 years of research on Isle Royale's wolves and moose. The film will be released in June 2008. For more information, visit www.isinglasspictures.com.

Figure 1. Wolf and moose fluctuations, Isle Royale National Park, 1959–2008. Moose population estimates during 1959–93 based on population reconstruction from recoveries of dead moose, whereas estimates from 1994–2008 were based on aerial surveys.

The Wolf Population

During the 2008 winter study, the wolf population contained 23 individuals, a 10% increase from last year's 21 wolves (Fig. 1). This increase had not been expected because food for wolves seemed particularly scarce during the past year. The wolf population was comprised of four packs. Three of the packs have existed since 2000. A fourth pack, Paduka Pack, formed from a pair of wolves that mated and raised two pups in 2007. The number of wolves in each pack was as follows:

East Pack III (EP)	.5
Chippewa Harbor Pack (CHP)	.5
Middle Pack II (MP)	.8
Paduka Pack (PP)	.4
Loners	.1
2008 Total	.23

Between April 20 and May 9, 2007, we live-captured and radio-collared six wolves: a subordinate male and female from both Middle Pack and Chippewa Harbor Pack and two females from East Pack (see Fig. 3 and Table 1). Analysis of blood samples collected at the time suggests that two of the six wolves had previous exposure to West Nile virus, while three had been exposed to canine parvovirus.

During the summer, the collared female of Chippewa Harbor Pack had been detected via telemetry in the territories of all three packs, and the East Pack subordinate female likewise traveled widely. Both of these dispersed wolves died within the year (see Fig. 6).

Conditions during the winter field season for observing wolves were exceptionally good in two respects. First, for the entire duration of the winter field season, three of the four packs had wolves with at least one working radio collar. It has been more than seven years since more than two packs have had functioning radio collars. Second, we flew on more days and for more hours compared to an average year. We observed each of the packs with collared wolves on more than 24 different days. However, we observed the uncollared Paduka

Figure 3. Robert and Sally Irmiger were among several people who provided valuable assistance and expertise in our effort to live capture, handle, and radio-collar wolves in spring 2007.

Table 1. Summary of wolves collared in spring 2007 and the results of blood tests for various pathologies

Sex	Weight (lbs)	Estimated age* (yrs)	Pack membership	Status as of March 2008	Pathology test results †
female	70	4-6	East Pack	subordinate	antibodies indicate a protection against adenovirus
female	56	4-6	East Pack	dead	antibodies indicate a protection against parvovirus and previous West Nile virus infection; positive for antibodies against <i>Anaplasma phagocytophilum</i>
female	70	4	Chippewa Harbor Pack	dead	antibodies indicate a protection against parvovirus and previous West Nile virus infection
male	62	2	Chippewa Harbor Pack	subordinate	all negative
female	58	2	Middle Pack	subordinate	all negative
male	83	4	Middle Pack	alpha	antibodies indicate a protection against parvovirus

* Age estimates are based on tooth wear.
† All tests results were negative, except those noted in the column. Each wolf was tested for the following: West Nile virus, blastomycosis, bratislava, canicola, grippotyphosa, hardjo, ichterohaemorrhagiae, pomona, leptospirosis, ehrlichiosis, *Anaplasma phagocytophilum*, rickettsiosis, canine parvovirus, canine adenovirus, canine distemper, heartworm.

Pack on just six occasions (Fig. 4). One of these occasions represented a seven-day period during which Paduka Pack did not travel, but tended a moose that they had wounded and eventually killed.

Births and Deaths—The past year's change in abundance from 21 to 23 wolves is most likely accounted for by the birth of four wolves (20% recruitment) and death

Figure 4. Paduka Pack is Isle Royale's newest pack. They include two adult wolves that mated for the first time in February 2007 and two pups that were born in April 2007.

of two wolves (10% mortality) (Fig. 5). During the summer, there was no evidence that East Pack or Chippewa Harbor Pack had produced any pups. In October, Rolf Peterson observed two or three pups in Middle Pack. This winter's wolf population included at least four pups, two each in the Middle and Paduka packs. The estimated recruitment rate (19%) is near the population's long-term average, but quite high given the number of moose per wolf. If there are in fact just four pups in the population, then, by arithmetical reasoning, just two wolves died during the past year. This corresponds to an estimated mortality rate of 10% ($=2/21$), which is quite low given the declining food supply for the wolf population.

During the past year, we learned some details concerning the circumstances surrounding the deaths of two wolves. First, on June 23, the carcass of the collared Chippewa Harbor female washed onto the shore of

Figure 6. We collected the remains of two wolves that died during the past year. One wolf, a female, belonged to Chippewa Harbor Pack and died in Middle Pack territory (left panel). Presumably she drowned. The second wolf, a female belonging to East Pack, also died in Middle Pack territory. At some point in her life she suffered from a severely broken forelimb (right panel), which eventually healed. This wolf presumably was killed by Middle Pack or perhaps drowned.

Figure 5. Percent mortality and recruitment for Isle Royale wolves, 1971–2008 (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 abundance, and (ii) that the recruitment rate is lower when wolves are either particularly abundant or rare.

Grace Island, deep within Middle Pack's territory (Fig. 6). It likely drowned the day before. A couple of days before learning of this dead wolf, park personnel reported observing a dead calf floating in Grace Harbor. It is possible that the death of this wolf, with a freshly broken rib, was somehow linked to the dead moose calf.

We became aware of a second wolf death on January 20, our first winter flight, when we detected the mortality

signal from the radio collar of the East Pack female along the shore of Siskiwit Bay, also in Middle Pack territory. From her scavenged remains, we recovered only a skull, both front legs, and a few vertebrae. One of her front legs had been severely broken but had re-healed by the time of her death (Fig. 6). This wolf probably died within the previous month from a wolf attack or a fall through the ice.

Pack Leadership and Social Structure—East Pack seems to be led by two males and a female (Fig. 7). Last year, the long-standing alpha male of EP (670), who is now about 11 years old, allowed wolf 1393, a young male, to make courtship advances toward female pack mates. This year, we observed wolf 1393 to be leading East Pack travels about as often as we observed male 670 doing the same. Both wolves can be identified by the nonfunctioning collars that they wear. East Pack's alpha female is likely, but not certainly, the same wolf that has been alpha since the fall of 2005.

Though the precise identities of this year's alpha wolves for Chippewa Harbor Pack are uncertain, we know the pack is led by two wolves that have each held the alpha position for just one or two years. We know this because the former alpha female died last year—she was probably killed by East Pack—and the previous alpha male of Chippewa Harbor Pack's was killed by East Pack in January 2006.

The alpha female of Middle Pack, estimated to be at least nine years old, has survived another year, and she was much whiter in color (Fig. 8). This winter, in contrast with last winter, she was often not leading the pack's travels. We can identify her from the nonfunctioning radio-collar that she continues to wear. Middle Pack's current alpha male has been in the alpha position for at least one year, but more likely two years.

In January and February 2007, we observed the early sign of pack formation, i.e., scent-marking and moose-killing by a pair of wolves in the middle of Isle Royale. In 2007, this pair reproduced and successfully raised two pups that survived to their first winter (Fig. 4). We named this

Figure 7. East Pack is comprised of five wolves (upper panel), a relatively young alpha female (in lead), an aging alpha male (second wolf in foreground), a young male that appears to be in the process of eclipsing the alpha's leadership (second wolf in background), and two subordinate adult wolves. East Pack spent much of a week in late February bedded on Moskey Basin (lower panel). Their time there was probably intended to let Chippewa Harbor Pack know that they were in possession of Moskey Basin.

Figure 8. Five of Middle Pack's eight wolves traveling toward Lake Halloran. The leading wolf is Middle Pack's alpha female, and the trailing wolf is a subordinate adult male. On February 26 and 27, this large male dispersed from Middle Pack, probably looking for opportunities to mate, and subsequently returned to Middle Pack, without signs of success.

Figure 9. In late January, Chippewa Harbor Pack attacked and wounded, but did not kill, five moose during a five-day period. One of these attacks is depicted in the left panel. Of the three packs monitored, Chippewa Harbor Pack had the highest kill rate on a per-wolf basis.

group Paduka Pack in honor of the means by which wolves make their living—their feet. Hunting moose and territorial defense both entail a great deal of walking. Paduka is a Sanskrit word that means sandal, but also connotes respect, protection, and power of the foot.

Paduka Pack territory seems focused on the north side of Isle Royale between Lake Harvey and Lake Desor. However, tracks indicate they had traveled freely through Middle Pack territory to Washington Island, at the southwestern end of Isle Royale, and to other points along western shorelines. These forays and similar observations from last year (see the *2006–2007 Annual Report*) suggest former ties with Middle Pack. Forthcoming analysis of DNA, obtained from fecal samples collected during summer and winter, will be required to clarify and confirm the identities and origins of the alpha wolves and to confirm whether our current estimates of survival and recruitment are accurate.

Kill rates and food supply—We determined kill rates for three wolf packs for 43 days, January 19–March 1. During this period, the five wolves of Chippewa Harbor

Pack killed eight moose, and the eight-member Middle Pack killed seven moose. Although East Pack, with five wolves, killed only four moose, they scavenged from a fifth moose that had died from wounds inflicted by another of Isle Royale's packs. We observed Paduka Pack on two fresh kills, but this is likely an underestimate of their kill rate. These kill rates are approximately what would be expected given low moose abundance, low moose-to-wolf ratio, and less-than-average snow depth. Chippewa Harbor Pack wounded at least five moose in five days in late January, and we were able to confirm that two of these moose died near the site of attack within a few days (Fig. 9).

We were able to perform necropsies on 16 wolf-killed moose from all four packs. Five of these were calves born in 2007, while the others were old adult moose, probably born in the early 1990s when the moose population was very high. Packs typically spent many days at their kills, or returned frequently to feed later. Cold temperatures probably slowed their rate of consumption after the initial feeding.

During the summer of 2007, we observed wolves on

Figure 10. Wolf pack territorial boundaries and moose carcasses (all fresh kills) during the winter study in 2008

Figure 11. Two of several conspicuous wolf-human interactions during the past year include (left, photographed with a remote camera) a wolf that spent several weeks in close proximity to people at Daisy Farm campground eating apples from an apple tree and (right) a wolf that had to be chased off of Washington Harbor, near our bunkhouse, so that our research plane could land.

several occasions scavenging kill sites that had been made during the previous winter, chewing on nothing but old bones. It seemed that food in summer was in very short supply, with beavers in decline and moose calves very scarce.

Another possible sign of food shortage this winter was the substantial amount of time and energy that packs spent on incursions into foreign territories and territorial defense (Fig. 10). For example, in late January one pack (either Chippewa Harbor Pack or Paduka Pack) wounded a moose that later died on the southwest end of East Pack's territory. Upon discovering the incursion, East Pack spent nine days at that site, perhaps waiting for the perpetrators to return—to our knowledge, they never did. During this time, East Pack made a couple of kills, but rather than feeding on those kills, they repeatedly returned to the violated site. Later, in mid-February, East Pack spent two days traveling through Chippewa Harbor Pack territory, south of Moskey Basin. This incursion represents the third year in a row that East Pack has pushed into Chippewa Harbor Pack's territory. Also in mid-February, Middle Pack made three separate trips, each two or three days long, deep within Chippewa Harbor Pack's territory. On one trip they scavenged a moose at Lake Mason, and on the second trip they seem to have confronted and injured the alpha male in the Chippewa Harbor Pack. Although Chippewa Harbor Pack has experienced the most incursions, it may not be the most underprivileged pack. Their territory contains the most moose, and their kill rate has been the highest of the packs. Also, on February 13, Chippewa Harbor Pack traveled into Paduka Pack territory, where they spent a night and part of a day bedded at the southwest end of Lake Harvey. Also, East Pack posted themselves on their border with

Chippewa Harbor Pack for several days at the end of February (Fig. 7). These territorial disputes have been continuing at elevated rates for the past three years and represent the general condition of wolf packs that face chronic food limitation.

On February 22 we observed estrus blood associated with East Pack, and similar evidence of breeding was observed in three packs during the final week of February. While it seems there is insufficient food for four packs to successfully reproduce and flourish, future change is likely but can't be predicted. The wolves' slight increase in abundance, high survival rate, and relatively high recruitment rate were all unexpected, given the continued shortage of moose and snow conditions that favor moose. The wolf population has likely been fueled by killing a large proportion of the calves that have been born in each of the past two springs (see "The Moose Population"), and high predation pressure on moose will probably continue.

Fearless wolves were not as prominent during the visitor season in 2007 as they had been in 2006, but we don't understand the reasons for such differences. Visitors are repeatedly reminded to keep all food away from wolves, and as far as we know wolves have not acquired any food from people. However, in early September 2007 apple trees, dating from 19th-century mining activity near the Daisy Farm Campground (the largest back-country campground in the park), produced a bumper crop of green apples, and wolves began to appear on a daily basis to take advantage of this "windfall." To protect both wolves and visitors, the National Park Service closed the campground for the remainder of the season, and wolves consumed undisturbed about 120 pounds of apples over the next month (Fig. 11).

2008 Moose Distribution

Figure 12. Moose distribution on Isle Royale in 2008 was relatively uniform, as it has been for the past two 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 2008 moose survey, conducted under excellent conditions (calm wind and overcast skies), resulted in an estimated moose abundance of 650. The 80% confidence intervals on this estimate are [490, 770]. Moose density throughout most of Isle Royale was 0.8 moose/km², and there were 2.7 moose/km² in some regions of the east and west ends of Isle Royale (Fig. 12). Last year, when conditions for counting moose were very poor, we estimated the population to have between 310 and 460 moose (50% sight-ability), with an 80% confidence interval of [270, 500]. The percentage of the population made up of calves has been very low for the past two years, 6% in 2007 and 5% (=7 of 143 the moose counted during the moose census) in 2008. In retrospect, the moose population probably declined between 2002 and 2006, and since then moose numbers have probably stabilized.

Our annual estimate of moose abundance is derived from an extrapolation of the number of moose counted from our research aircraft on 91 plots, each about 1 km² in size. Moose are sometimes not visible while standing or bedded under thick vegetation. Research conducted in the mid-1980s, with the use of radio-collared moose, indicated that we typically see about 75% of the moose present on census plots. Our annual estimates of moose abundance usually include this level of sight-ability.

In 2008, we aimed to re-assess sight-ability using a different method. Between February 1 and 14, we used two planes, each with a single pilot and single observer, to count 52 plots

Figure 13. Winter predation rates for Isle Royale moose, 1974–2008 (upper panel) The predation rate (the number of predation events per living moose per month) is influenced by snow depth (lower panel).

twice. In most cases, the two counts of a single plot were conducted within 30 minutes of each other. For each double-counted plot, each team recorded where each moose had been observed within each plot. We estimated sight-ability using statistical methods that account for the number of moose observed by both teams or by one or the other team. Because snow depth was low, moose were in relatively open terrain, and because we were always able to count moose under excellent conditions, we expected sight-ability to be higher than average. In fact, our efforts indicated that sight-ability was 89% during the 2008 moose census.

Although the predation rate this winter was relatively high (Fig. 13), about one-third of the predation events involved calves. Several observations suggest that the mortality rate among adult moose during the past year was probably about average. More specifically, the past two years (May 2006 through March 2008) have been similar: moose had plenty of food available to them, although hot weather probably reduced foraging rates. The winter of 2007–2008 was mild (i.e., with lower-than-average snow depths), but moose suffered from heavy loads of moose ticks (Figs. 14, 15). Also, the age structure of moose is dominated by prime-aged moose (3–8 years of age), which tend to have relatively high survival rates.

Figure 14. The extent of moose hair loss in spring, caused by winter ticks, has been generally increasing. Heavy bars are annual averages, and smaller bars mark interquartile ranges. The spring of 2007 was the worst documented season for tick infestations. A quarter of the 56 moose we observed had >95% hair loss, and nearly every moose had >40% hair loss.

For the second consecutive year, recruitment was far below average (Fig. 16). Observations of moose calves in summer have typically declined steadily through the season, and wolf predation pressure is undoubtedly very high. Low calf abundance during the winter months and apparently stable moose population abundance for the past two years may be explained by

Figure 15. *Dermacentor albipictus* is also known as the moose tick or winter tick (left panel). A heavily infested moose can carry tens of thousands of ticks throughout the winter. By spring, these moose suffer severe loss of hair and blood (right panel).

intense wolf predation on calves and relatively light predation on adults.

Only 6 of the 22 kills that we observed were made near shorelines (Fig. 10). This is an indication that moose had little trouble traveling through the snow, and thus were not restricted to shoreline areas. This also suggests that wolves worked harder as they traveled inland more frequently, where snow is deeper.

Figure 16. Long-term trends (1959–2008) in the percentage of the total moose population made up of 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.

All the dead moose we discovered in winter 2008 were killed by wolves. Marrow fat levels in these moose exhibited the typical range of values, based on previous data (Fig. 17). 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, are increasingly rare, so wolves will likely face a declining supply of food.

Figure 17. 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.

Black Gold

In the late 1990s the toolbox of molecular biologists improved, and we began to collect and save scats, or droppings, from wolves, hoping for new scientific methods that would allow us to extract and analyze DNA from wolf scats. This quickly became a reality about five years ago, and in 2007 we hired a postdoctoral research associate, Jen Adams, to fully develop our ability to gain new insights from DNA in wolf scats. Already Adams has enlarged the agenda to include moose, and it is evident that we can obtain useful DNA from moose droppings and from the bones of dead animals. We anticipate using wolf fecal DNA to monitor the survival, reproduction, and pack affiliation of every wolf in the population. In addition, we expect to use DNA from wolf bones collected over the past 50 years to document genetic changes over time and any new individuals as they arrived. For example, preliminary evidence suggests the wolf population had one female and two male founders, and stored bones may provide information on when each of these three founders became established. For moose, the potential new data from bones, feces, and urine seems endless: urine and feces collected in winter will tell us something of the nutritional condition of individual moose, the pregnancy status of females, and what they have been eating; and stored bones may provide important clues on the number of founders and how isolation has produced moose with unique genetic characteristics.

Forest Vegetation

In recent years, we have been monitoring several aspects of the vegetation as it relates to moose forage. The forests of Isle Royale provide the context and foundation for long-term fluctuations in wolf and moose abundance. For example, the Chippewa Harbor Pack has recently been under threat of takeover from its neighbors because its territory is moose-rich, a result of abundant balsam fir regeneration in successional forests that followed fires set by copper prospectors in the middle of the 19th century.

The west end of Isle Royale supports older 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 are prevented by intense herbivory from growing into seed-producing trees, and the canopy trees on the island's west end are gradually dying without being replaced (see 2006–2007 Annual Report).

However, as the moose population has declined in recent years, browsing pressure on the plants they eat has lessened and balsam fir trees have exhibited increased growth (Fig. 18). With fewer moose and more balsam fir, fir has also become an increasingly larger component of moose diet during the winter. The increased importance of balsam fir in moose diet may also be related to lower-than-average snow depths, which give moose easier access to balsam fir branches growing nearer to the ground.

One natural process that can dramatically change moose habitat is forest fire, which can rejuvenate forests and result in abundant forage in the short term. However, if moose browse heavily in recent burns, it may result in long-term detriment for the moose as only inedible trees grow into the burned areas. There has not been a significant fire on Isle Royale for about 75 years. Since the 1970s the National Park Service's policy has been to allow fires to take their natural course should they be started by natural causes and not threatening to human life or property. In August 2008, following strict guidelines imposed by the US Congress following the Yellowstone fires in 1988, the National Park Service extinguished a naturally ignited wildfire in the eastern portion of Isle Royale where a volatile fuel layer of regenerating fir and spruce has been emerging for the past 30 years (Fig. 19).

Figure 18. The mean annual height growth of balsam fir trees that are between one and three meters tall (upper panel) These trees are an important source of food during the winter for moose. The annual browse rate (middle panel) is the proportion of measured trees upon which moose have eaten the terminal branch. The browse rate indicates the pressure moose place on balsam fir. The proportion of balsam fir in the moose diet (lower panel) is measured by microhistological analysis (see 2004–2005 Annual Report for details on that method) and is an indication of how important balsam fir is to moose diet on an annual basis.

Figure 19. In August 2008 the National Park Service extinguished a naturally ignited forest fire near Lake Richie. Even on a wilderness island in the largest lake in the world, it is apparently difficult to let a “natural” fire burn. Image by Larry Kangas

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 re-established at Isle Royale in the 1980s. Eagles and ospreys are both present at low numbers, and the factors that limit further expansion are poorly understood. In 2007 active eagle nests numbered 10, with 8 eaglets fledged. A count of osprey nests was not conducted in 2007, but typically they are fewer in number and less permanent than eagle nests.

Snowshoe hare observations were slightly more abundant in summer 2007, perhaps signaling the beginning of recovery from the mid-decade low population level (Fig. 20). Red fox, a major hare predator, continue to be relatively scarce (Fig. 20), probably a result of low food in recent years from scavenged moose carcasses and a low hare population (Fig. 21).

An aerial count of beaver colonies using two aircraft in a double count was conducted in October of both 2006 and 2007 by observers Rolf Peterson and Mark Romanski (Isle Royale Resources Management staff). Previous beaver population estimates during 1974–2004 were based on biennial transect counts from one aircraft, and these counts suggested that beavers declined steadily since 1986 as habitat deteriorated in successional forests recovering from fires in the 19th and early 20th century. Of course, wolf predation pressure is intensified when beavers have to travel longer distances from their lodges to forage. In 2006–2007, the aerial counts employed a low-altitude, intensive circling pattern, (pilots were Jim Hummel, from Voyageurs National Park, and Donald Murray, from UpNorth Aerials) resulting in a higher number of active beaver sites recorded. The final estimate is based on the number of active sites seen only by one of the two observers, plus the number of sites that both observers recorded, and it includes sites that *neither* observer saw but are probably present. In 2006 a total of 111 active sites were documented in the combined effort, and the estimate of the total number of sites was 133. These numbers declined in 2007, to 98 seen and 124 estimated to be present (Fig. 22). Even with two teams flying an intensive search pattern, sight-ability of the combined effort was only 80%. But the slight decline from 2006 to 2007 is consistent with the long-term trend identified in previous counts.

Figure 22. Active beaver lodges, shown here with a food cache, have been on the decline in recent years. Forest succession is an important influence on beaver population dynamics. Wolf predation also likely plays an important role.

Red Fox and Snowshoe Hare Fluctuations 1974–2008

Figure 20. 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.

Figure 21. Foxes depend greatly upon the carcass remains left by wolves.

The Bush Pilot Saga

For 50 years two pilots have done virtually all the winter research flying on Isle Royale, Don Murray (1959–1979) and Don Glaser (1979–present). This amounts to thousands of hours of accident-free flying under the most challenging of conditions. It is impossible to overemphasize the importance of their contribution, and the long-term nature of the research would likely have fallen apart without them. Our work, which is a benefit to fellow researchers, the National Park Service, and the public, has depended critically on their skill and effort. *Our thanks to both Dons!*

And for about 30 years, the USDA Forest Service pilots based in Ely, Minnesota, have flown the periodic supply flights between the mainland and Isle Royale. These shuttle flights bring people, food, and gear to and from the island. In recent decades, pilots Dean Lee, Pat Lowe, and Wayne Erickson have flown ski-equipped Beaver aircraft for all of these flights, also with incident. *We extend our appreciation to them for navigating the “Bermuda Triangle” of Lake Superior.*

Weather, Snow, and Ice Conditions

At the beginning of winter study, the ice on Washington Harbor was 14 inches thick. An ice bridge between the Isle Royale and mainland Ontario was present intermittently between February 20 and March 3. During the 2008 winter study, temperatures were close to average, and snow depths were below average (Figs. 23, 24).

Below-average snow depth benefits moose, because they can travel more easily.

Moose population dynamics are affected directly and indirectly by summer weather conditions. Hot summer temperatures cause moose to spend more time resting in the shade and less time foraging. Consequently, hot

Figure 23. Figure 23. Climate data on Isle Royale (snow depth) and nearby northeastern Minnesota (temperature and precipitation) 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 gray line), and moose may be affected by a 3-year moving average (heavy black line).

temperatures can make moose less prepared to survive winter. Although moose benefit by warm temperatures in early spring, because it causes plants to green-up more quickly, winter tick populations seem to thrive under these conditions, an important indirect influence. Although the effect of summer precipitation on forage quality is likely important, the details of its effects are poorly understood.

Within this context, spring and summer temperatures in 2007 were slightly warmer than average (Fig. 23), and 8 of the past 10 summers have been hotter than average. The summer of 2007 was the driest summer in the past 45 years (Fig. 23).

Figure 24. Snow depth (daily) and ambient temperature (hourly) during the 2008 winter study on Isle Royale

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