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Ecological Studies of the Wolf on Isle Royale, 1971-1972

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ECOLOGICAL STUDIES OF THE WOLF ON ISLE ROYALE*

Second Annual Report

(Covering the Fourteenth Year in the Isle Royale Studies)

1971-72

Wolves probably 23

by

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THE WOLF ON ISLE ROYALE

This report summarizes the second year of study on Isle Royale by Rolf O. Peterson, who began work in June 1970. During his anticipated three-year project, the research effort will be directed primarily towards wolf ecology and continue to feature the wolf-moose relationship.

James M. Dietz arrived on the island on May 18 to begin the summer field work. Dietz, a graduate student in wildlife biology at Purdue, participated during both the winter and summer periods in 1971 while on a temporary research assistantship. Peterson and his wife arrived on June 8. Dietz left the island on August 20 to resume his graduate program at Purdue. Peterson stayed until September 7, then returned to campus for his last semester of course work.

The 1972 winter study extended from January 23 until March 10. Allen was on the island from January 23 until February 29, and Peterson remained for the entire period. Fred H. Montague, who is studying the red fox in Indiana, assisted in opening up the camp and made intensive fox observations at our Windigo headquarters until February 5. Dr. Erich Klinghammer (Department of Psychology, Purdue), a member of Peterson's advisory committee, participated in the winter work from February 22 to 29. Dr. P. A. Jordan, (Yale School of Forestry), who did post-doctoral research on Isle Royale during the years 1964-1966, spent February 19-24 on the island, collecting browse samples for nutrient analysis as part of his continuing research on moose-vegetation relationships.

Pilot Donald E. Murray, in his fourteenth winter on the island, made his customary excellent contribution to the project. William J. Martila made seven flights in the Cessna 180, transporting personnel and supplies to and from the island. Six park staff members gave valuable assistance during the winter study: William E. Dohrn, 23-28 Jan.; Frank J. Deckert, 28 Jan. - 5 Feb.; Alan D. Eliason, 5-19 Feb.; (Superintendent) Hugh P. Beattie, 19-22 Feb.; Arnold Long, of Grand Portage National Monument, 22 Feb.-2 March; Richard Hoffman, 29 Feb. - 10 March.

Summer Observations, 1971

In contrast to the hot and dry summer of 1970, precipitation and temperature were nearly normal in 1971. Fruit crops generally were successful, including an especially heavy blueberry crop. After a high yield in 1970, mountain ash fruit failed completely in 1971, both on Isle Royale and the north shore of Lake Superior.

During the summer emphasis was placed on extensive coverage of the island, including as much off-the-trail hiking as possible in order to locate fresh wolf sign and to record moose observations without excessive repetition. A total of 605 miles was hiked, 350 miles on park trails, and 255 miles off the trail. Efforts were made to cover known winter and summer travel routes of the wolves. All moose carcasses found during these travels were examined, with appropriate specimens collected. Notes were taken on beaver, snowshoe hare, birds, and other wildlife as they were encountered.

Wolf-related work

Wolf activity was inferred through indirect means such as the study of fresh tracks, scats, scent-posts, and howling.

A total of seven wolf observations were reported during the summer months, two of which are significant in light of our findings this winter. On May 28, while on a routine flight over the island, Chief Ranger Robert W. Rogers and District Ranger Frank J. Deckert saw 7 wolves, including one black animal, near Lake Halloran. This was the "Big Pack" (called the West Pack this winter), which usually numbered 7 or 8 animals during the winters of 1971 and 1972. This pack had no recognizable pups this winter, and no signs of successful wolf reproduction within its usual winter range were found last summer. The second observation involved six grey wolves seen crossing the Daisy Farm trail, as reported by a park visitor on July 28. From the description, the wolves seemed uniformly small. In the winter study we found a new pack of 8-10 animals occupying the eastern half of the island (the "East Pack"), with strong evidence that as many as five pups were present in this pack, and it is possible that these were the wolves seen that day.

During the summer months it appeared that wolves were avoiding the Greenstone Trail, which was heavily used by hikers. A considerable number of wolf scats were cleared from this trail in May, but when it was checked again in August not a single additional scat was found. The park trails where fresh sign and tracks were seen frequently were those showing less visitor usage.

Recorded wolf howls (or human imitations thereof) have been used in this and other studies to stimulate responses from nearby wolves. This technique met with limited success during the summer of 1971. Howls were broadcast 113 times from June 8 until August 26, at locations over the

entire island. Only four responses were heard, all of which were made by several wolves, and all in the vicinity of Island Mine. Three of the responses were on one day, suggesting that the potential for response is good. It is believed that lack of proper amplification is partially responsible for our lack of success in this area, so a portable loudspeaker will be used during the coming summer.

Moose observations

During the past two summers we have recorded routine information (sex, calf or adult, location, etc.) on all moose encountered during travels on the island. These figures are intended to furnish information on population characteristics, including reproductive success. Some of these data are summarized in Table 1.

Table 1 - Summer moose observations and hiking mileage, 1970 and 1971.

June 9 to Sept. 4, 1970

MILES HIKED:

50.0 off trail
391.7 on trail

441.7 total

MOOSE OBSERVATIONS:

Total	mm	ff	calves	?
192	64	91	35	2

Sex ratio: 70mm/100ff
Calves per 100 adult ff*: 38.5
Percent calves in total pop.: 18.2%

5 sets twins (20% of 25 ff observed with young)
27.5% of observed ff had young

MOOSE SEEN PER 100 MILES HIKED**:

36.2 ± 21.3 (95 percent conf. int.)

May 18 to Sept. 7, 1971

MILES HIKED:

256.3 off trail
349.2 on trail

605.5 total

MOOSE OBSERVATIONS:

Total	mm	ff	calves	?
141	47	64	19	12

Sex ratio: 73mm/100ff
Calves per 100 adult ff*: 29.7
Percent calves in total pop.: 13.5%

1 set twins (5.5% of 18 ff observed with young)
28.1% of observed ff had young

MOOSE SEEN PER 100 MILES HIKED**:

×18.2 ± 8.5 (95 percent conf. int.)

* Yearling females are here designated as "adult females" because they could not always be reliably distinguished from adults.

** excludes observations from airplane, boat or canoe.

Cow-calf counts are biased to a certain extent by the "hiding" of young calves and the increasing independence of older calves. Nevertheless, similar methods of travel and observation were followed during the summers of 1970 and 1971, and thus the figures summarized in Table 1 should reveal trends in population parameters. It appears that the production of young in 1971 declined somewhat from the previous year.

From Table 1 it is evident that fewer moose were seen in 1971, even though the study period was longer and hiking mileage was greater. There was no significant difference in the relative number of moose seen on and off the trails. The figure "moose seen per 100 miles hiked" was calculated for the last two summers, using successive 100-mile totals to calculate the variance for each summer. The 95 percent confidence interval for the difference between the 1970 and 1971 figures is 18.0 ± 10.0, indicating that the difference is significant. During the winter study of 1971 the wolves had killed more moose than in any previous winter study, and during summer 1971 some moose were examined that appeared to have died of malnutrition. Since it appeared that a significant reduction in the moose population had taken place, an aerial census of moose was planned for the winter of 1972, the results of which are reported here. According to the winter census, there was no significant change in the moose population since the last census in 1970. Only a partial census was completed, however, so the confidence limits for the population estimates are rather large.

Moose mortality

The remains of 64 moose were examined during the summer. Data from these carcasses are presented in Table 2.

Table 2 - Moose remains examined during summer, 1971

			Cause of death	
Date of death	No.	Wolves*	Other natural mortality	Unknown
Winter, 1971	19	12	5	2
Adults	10	7	2	1
Calves	9	5	3	1
Other times	45	17	6	22
Adults	22	7	6	9
Calves	19	9	0	10
Unknown	4	1	0	3

* Includes known wolf kills and carcasses utilized by wolves.

We have now examined a total of 44 moose that were killed by wolves during the winter of 1970-1971, including the 33 "wolf-kills" recorded during the winter study. Twenty-four (53%) of these moose were calves, born in 1970. Deep and fluffy snow during much of last winter undoubtedly increased the proportion of calves killed.

Of the 64 carcasses examined, 29 were of moose that had died since the summer of 1970 (including 19 from winter 1970-71). Evidently 10 of these animals died of causes other than wolf predation. Of the 10, 5 were found early in the summer floating in bays around the island. Four were males 3, 3, 4, and 5 years old, respectively. The fifth moose was an 8-year-old female carrying a fetus, which indicated that death had occured in late April. All five of these animals may have broken through thin ice. It is interesting to note that most of them belonged to an age class not preyed upon extensively by the wolves.

Four moose carcasses (3 calves and a 7-year-old) were found for which there was no evident cause of death. These succumbed during winter, and malnutrition or complications therefrom may have been involved.

The majority of the moose killed by wolves last winter were not cleaned up immediately to the extent usually observed. If a carcass is completely utilized by the wolves, nearly all the bones are clean, with the softer parts gnawed. The skull and legs are pulled off and the vertebral column left in two or more pieces. In 1971 the skeleton usually was found intact, except that the head and one or more legs might be removed. Commonly much hide was left on the legs, back and rump. Sometimes only the viscera had been eaten. This striking degree of non-utilization obviously resulted from the unusual snow conditions, which significantly increased the vulnerability of moose. It should be noted that if the bones of such an animal were found at some future time, they would bear little evidence that the moose had been killed by wolves.

Other summer observations

Beaver continued to thrive in suitable locations on Isle Royale, although no systematic survey was carried out this summer. Three well-established beaver ponds (below Mt. Franklin on the trail from Tobin Harbor; north of Chickenbone Lake (T66N, R35W, S. 35) on the trail to McCargoe Cove; on Siskiwit River tributary (T64N, R37W, S. 32) which had been known for years, were found drained this summer, apparently washed out by heavy rains in late spring. None of the washed-out dams was being rebuilt as of August.

All identifiable bird species that were either seen or heard each day were recorded, and by the end of the summer 87 species were listed. Noteworthy observations included the first nesting record of the bobolink on Isle Royale, a pair of ospreys in the Washington Harbor area, and sightings of a peregrine falcon (possibly a pair) near Chippewa Harbor.

For the second year, a majority of the aspen trees on Isle Royale were defoliated by the great aspen leaf roller (Archips conflictana). The infestation was not quite as extensive as last year in the Moskey Basin area, but it was quite noticeable along the Greenstone Ridge, along the north shore of Siskiwit Lake, in the Island Mine trail area, and along Coyote Ridge. Most of the affected trees managed to leaf out before the end of the summer, but not as vigorously as normal. In August, total defoliation of mountain ash trees in small, localized areas was observed. Specimens of the caterpillar causing the defoliation were collected by Park Naturalist Robert Janke for identification. This defoliation had little, if any, effect on the total population of mountain ash trees this summer. Tent caterpillars were present in some areas, but nowhere abundant. It is interesting to note that there were several black-billed cuckoos seen and heard this summer. The cuckoo has been considered rather rare on Isle Royale in years past. These birds are well known for their preference for caterpillars, and their apparent increase in 1971 may have been due to increased caterpillar populations, particularly the aspen leaf roller.

Winter Conditions, 1972

Winter conditions this year were characterized by deep snow and a high incidence of windy days, similar in both respects to 1971. Temperatures were slightly below normal, with an average daily maximum and minimum of 18.1° F and -2.7° F, respectively. The highest daily minimum was 23° F, on February 14, while the lowest temperature was -21° F, recorded on March 3.

Flying was attempted on 30 out of a total of 48 days, though good flying conditions (little or no wind and good light) prevailed on only 13 days. Gusting winds often precluded low level work. Deep snow frequently created slushy ice conditions and this, together with the wind, limited our landing opportunities and hence the number of wolf-killed moose that could be examined on the ground. A total of 92 hours of flight time was logged this year, which is considerably below the average figure for the previous 13 winters. This makes the third consecutive year of less than 100 hours flown.

We arrived on the island just after a heavy snow, with 35 inches on the ground. Little new snow fell during the first two weeks of February, and the snowpack settled to about 28 inches in that time. Frequent snows thereafter increased snow depth to a maximum of 40 inches on March 10, the day we left the island. Thus, 1972 ranks with 1969 and 1971 as a year of unusually deep snow. An attempt was made to measure various physical characteristics of the snowpack in order to assess more precisely its effect on wildlife. Preliminary results of the study are included in this report.

There was little shelf ice around Isle Royale when we arrived on January 23, and no ice bridge existed at that time between the island and the mainland. By February 9 considerable ice had moved in, but winds kept leads open as late as February 18. However, by late February a solid ice bridge had formed, which persisted beyond the close of the winter study.

Winter birds

An abundant yellow birch seed crop was utilized heavily by small, mixed flocks of redpolls and pine siskins. This winter no goldfinches were seen at all. Other birds commonly seen in the Windigo area included downy and hairy woodpeckers, red-breasted nuthatches, chickadees, Canada jays and blue jays. We also had a resident pair of pine grosbeaks. A pileated woodpecker and a great-horned owl were heard occasionally at Windigo.

Small flocks of goldeneyes and a few old-squaws could be seen along the south shore, and one juvenile herring gull was sighted near open water by Washington Island.

One mature bald eagle was seen soaring near Mt. Desor on March 6, and a red-tailed hawk was observed on February 15.

Secondary species of mammals

After a population peak in 1970, the number of snowshoe hares declined somewhat by winter 1971, based on relative track abundance. In 1972 hare numbers appeared to be similar to 1971. Hare tracks were quite abundant in areas of suitable habitat, indicating that the population is not unusually low. High-density hare populations were observed on Mott Island in summer 1971, and on South Government Island in Rock Harbor during winter 1972.

Otter sign was observed this winter at Malone Bay, Booth Island, Little Todd Harbor, Cumberland Point, and Card Point (Grace Harbor).

In years past, relative fox densities have been inferred from the number of foxes observed per 100 hours of flight time. From 1961 through 1968 this figure ranged from 17 to 52, averaging 29. In 1971, 141 foxes were seen in 99 hours. Foxes evidently were rendered unusually visible by the fact that they were feeding on the abundant mountain ash fruit and wolf-killed moose along the lakeshores. It appeared also that the fox population was very high. When this figure is calculated for 1972 in the same manner as 1971 (totaling the foxes seen each day, avoiding repeats on the same day) we come up with 167. Most of the foxes observed this winter were on or near moose carcasses, as the mountain ash fruit crop was practically nonexistent. Thus the same fox probably was seen repeatedly from day to day as we routinely checked the old kills. To offset this bias, in part, the maximum number of foxes seen on or near each carcass at one time was determined. This figure ranged from one to ten, averaging 2.2. The sum of these maximum figures is 47. In addition, 23 observations were made of foxes not associated with a "kill". Thus, 70 foxes in 92 hours (or 76 in 100 hours) would be the adjusted index figure.

Five foxes (2 males, 3 females) frequented our headquarters at Windigo, including the dominant female that was present last year. A litter was born to this female last spring, and it appeared that a female and possibly a male from that litter were still included in the "resident population" at Windigo this winter. The young female was courted by an unfamiliar male during late February and early March,with one observed copulation on February 29 lasting for 2 minutes. Fox copulation was observed also at Houghton Point on March 8, this pair remaining tied for 31 minutes.

A single silver fox was seen in 1970 at Windigo and in 1971 at Lake Whittlesey. This year a silver fox was again seen several times in the Lake Whittlesey area, and another silver fox occupied a range along the north shore, between Todd Harbor and Hawk Island.

Two cases of fox mortality were recorded this winter. One of these occured when a pack of 10 wolves (East Pack) caught a fox on the ice of Malone Bay. It was killed and left uneaten. The other was an old male fox (missing several teeth) who literally died on our doorstep. This was a fox new to the headquarters area, and though there were three other foxes within 20 feet when it died, they apparently inflicted no injury. Its stomach was empty, though intestinal contents indicated the fox had fed on snowshoe hare. The frozen carcass was brought to Purdue's Animal Disease Diagnostic Laboratory for post-mortem analysis. The preliminary findings included "white streaks throughout the myocardium" and "a marked gastritis characterized by red rugae in the fundus of the stomach." A routine check for rabies was negative. The intestine contained but a single parasite, an ascarid. The lack of any serious pathology suggests that an old and decrepit animal may have succumbed, literally, to the social shock of an unusual situation.

The Moose Population, 1972

Moose distribution was highly stratified this winter, as in previous years with deep snow. Large areas of the island, notably the burns of 1936 and 1948, received little usage, while areas of heavier conifer cover, especially along lakeshores, were utilized extensively.

Heavy winds in late fall and early winter caused considerable blowdown in many scattered areas of the island. Moose were frequently seen browsing on fallen balsam fir, often feeding on such a tree until it was stripped of all desirable browse. Windblown balsam fir undoubtedly served as a significant source of food for many individual moose this winter.

With the exception of last year, an aerial moose census based on a stratified random sampling system has been flown every year since 1965. This year, due to the low total number of hours flown, only 43 of 70 plots could be flown. Counting was usually attempted only when optimum or near-optimum counting conditions prevailed. Although counting was

extended over a rather long period of time (January 31 to March 6), it is believed that no changes in moose distribution occurred which would significantly alter the results. Total snow depth did not vary more than 10 inches during the period of counting. The island was divided into four strata of moose density, based on counts of previous years and subjective observations of moose distribution this winter. There was no significant difference between the moose density of the two lowest density strata, so these were combined into one. The results are summarized in Table 3.

Table 3 - 1972 Midwinter aerial moose census

Stratum	Area (sq. mi.)	No. of plots	Percent of stratum counted	Moose counted	Moose per sq. mi.	Estimated total
1	120.29	17	~~4.8~~ 6.4	5	0.7	~~84~~ 78
2	57.39	8	~~6.4~~ 6.8	19	~~5.2~~ 4.9	~~300~~ 279
3	35.07	18	~~19.1~~ 20.2	93	~~13.9~~ 13.1	~~488~~ 461
Isle Royale	212.75	43	-	117	~~4.1~~	~~871~~ 818

The 95 percent confidence interval for the estimated total population is 871 ± 233. On the basis of the aerial census, the moose population in 1972 is not significantly different from the population in 1970.

This winter a total of 39 moose carcasses were located from the air, including 31 that were killed by wolves during the study period. Because of poor landing conditions and wind, only 11 carcasses were examined on the ground. The age distribution of nine of these animals, together with data from the winters of 1969 through 1971, is given in Table 4.

The percentage of calves killed in winter for the years 1959 through 1968 averaged 23.8, while the mean age of the adults killed during this period was 10.6 years. It is undoubtedly significant that snow depths have been higher than average in 1969, 1971 and 1972.

Though sample size for any given year is relatively small, it is evident that the percentage of calves in the winter kill has been higher than "normal" in the last four years. This could be due to an increased proportion of calves in the population, or increased vulnerability of calves. Thus far, the percentage of calves in the winter kill is not well correlated with the percentage of calves in the population during the previous summer, so the latter explanation seems more reasonable. The vulnerability of a calf is chiefly dependent on the protection provided by its mother. If a calf is temporarily left behind because of its inability to cope with deep snow conditions, as suggested in 1971, it would be extremely vulnerable to attack by wolves. It is probably that the vulnerability of the mother or her degree of mobility in protecting her calf is adversely affected by unusually deep snow conditions.

Table 4 - Age distribution of Isle Royale moose killed by wolves[1] in winter, 1969 - 1972.

	Frequency			
Age (years)	1969	1970	1971	1972[2]
Calf	14	7	24	4
Yearling	1	0	0	2
3 - 5	2	4	7	2
6 - 7	0	0	2	0
8	1	0	2	1
9	4	1	3	0
10	0	0	1	0
11	3	0	3	0
12	0	0	1	0
13	0	0	0	0
14 - 17	3	4	1	0
Total	28	16	44	9
Percent calves	50.0	43.7	53.4	40.0
Mean age (adults)	9.8	8.8	7.7	3.6

[1]includes both known wolf kills and carcasses utilized by wolves (examined in both summer and winter).

[2]partial listing to be completed after summer, 1972.

It is perhaps significant that two of the eleven moose examined this winter were yearlings. The calf crop last year seemed to be operating on a definite nutritional deficiency, and it is possible that this increased their vulnerability this winter. Kills examined during summer, 1972, should shed light on this question, as well as the apparent lack of older moose in the winter kill.

Two moose were shot for necropsy purposes this winter. One, a 7-year-old female weighing 880 pounds, had excellent body and marrow fat reserves, and carried a 4 1/4-pound fetus. The other, a 6-year-old male weighing 990 pounds had good body and marrow fat reserves. The female had a total of 15 small to medium-sized hydatid cysts in its lungs, while the male had four. Tick infestation on both was light.

An 8-year-old female moose, mortally wounded by the wolves and then abandoned, was examined shortly after it died. The anal region had been the primary area of attack, with additional light wounds on the left shoulder and upper abdomen. The moose had undepleted body and marrow fat and carried a 3 1/2-pound fetus. A total of 38 small to medium-sized hydatid cysts were found in its lungs. There was no evidence of peridontitis or degenerative joint disease.

This winter it was established that the incisiform canine tooth of a moose can be easily and quickly removed using equine incisor elevators and forceps. No moose have been live-captured to date, so this technique has not yet been rigorously tested. Since an age determination can be made from the canine tooth, this would make it possible to age a live-tagged animal accurately.

The Wolf Population

This year, for the first time since the Isle Royale studies began, the wolf population was dominated by two packs, both numbering 8 in late January and changing to 7 and 10, respectively, by mid-February. These packs became known as the West and East packs, with Siskiwit Lake appearing to be the approximate boundary between their observed ranges. In addition, a trio of wolves operated in the Malone Bay - Siskiwit Bay area, perhaps ranging as far east as Chippewa Harbor. A minimum count was made on February 24, after a fresh snow left us with ideal tracking conditions. Twenty wolves were observed that day (packs numbering 7 and 10 plus the trio), and it was obvious from tracks that at least two lone wolves were also present. The West Pack had 8 members until approximately February 15, after which the number dropped to seven. A single wolf, possibly the eighth pack member, was seen following and apparently trying to remain hidden from the West Pack on March 3. Adding this wolf to the above census figure yields 23 wolves, summarized as follows:

West Pack	7 + 1
East Pack	10 (numbering 7, 8, and 9 on occasion)
Malone Bay Trio	3
loners	2
	23 probable total population

There was no observed interaction between the two main packs, though both were observed on Siskiwit Lake at different times during the same day. The only overlap in the observed ranges of the two packs was on Siskiwit Lake and, possibly, parts of Malone Bay.

The West Pack is the same group as the "Big Pack" of 1971. There was no evidence of pups in the pack this winter. A large black wolf has been lead, or alpha, wolf since 1971. In 1970 this wolf closely accompanied the lead pair and was considered to be the beta male. The lead female and mate of the alpha male in the last two years has been an extremely small wolf, who also was present in the pack and mated with the large, grey alpha male in 1970. The black alpha male came from Canada with several other wolves in 1967, perhaps as a pup. This would place his age at a minimum of 6 years. It is possible that the alpha female is an older wolf. She was often limping, favoring her left front foot, when closely observed this winter. In spite of this handicap she generally led the pack, falling behind only on February 24, when her limping was obviously slowing her rate of travel.

The East Pack had its origins within the wolf population present last winter, since there was no ice bridge either after winter study, 1971, or before winter study this year. On the basis of behavioral observations and physical appearance, there seem to be from three to six pups in the pack, with a best estimate of five. The only sexual activity observed outside the main pack last winter took place when a female, evidently from the pack, joined two males near Houghton Point. It is possible that this group served as a nucleus for the East Pack. The lead male in this pack could be identified by its relatively large size, dark back, and distinctive tail markings, though he usually could not be distinguished when the pack was traveling inland. The lead female also had distinctive tail markings, but conditions had to be nearly ideal in order for her to be readily distinguishable.

It is probable that three females were bred on Isle Royale this winter. The black male in the West Pack consistently traveled at the shoulder of the small lead female, and was observed mounting her several times during the course of the winter study. They were not observed copulating, but there is little doubt that breeding took place. On February 26 a female in estrous was chased out of the West Pack after being punished repeatedly by the lead female. She was apparently accepted back into the pack, since by March 3 their numbers were back to normal, and a mating was observed between a subordinate male and a female (probably the female that had been evicted earlier). This mating pair was punished by the lead male and female during their six-minute tie, but not severely. When the pack was last seen on March 9, the subordinate mating pair were still in the pack, with the male closely following the female.

In the East Pack the only breeding pair seemed to be the lead male and female. The lead male in this pack did not follow his female as closely as the black male did in the West Pack, but he was seen mounting her and showing other courtship behavior. On February 7, at a time when the West Pack numbered eight, the lead pair was seen frolicking on Siskiwit Lake, several miles behind the other six members of the pack. They may have mated during this time.

As in the past, the main travel routes of the wolves were the shorelines of the island and the frozen lakes of the interior. Twenty-three out of 39 "kills" located were 100 yards or less from a lakeshore, and all but seven were less than 1/8 mile from shore.

During the 42-day period in which observations of the wolves were made, a relatively complete record was made of the kills and travels of the two primary packs. Since this requires extensive and difficult backtracking, a few kills may have been missed. Also, the mileages obtained in this fashion are minimum figures, generally including only major movements of the entire pack. This information is summarized in Table 5.

Table 5. Travels and kills of two wolf packs in 42 days, 1972.

	West Pack	East Pack
Miles traveled, Jan. 27 to Feb. 22	153 (5.9 per day)	130 (5.0 per day)
Miles traveled, Feb. 22 to March 9	118 (7.4 per day)	117 (7.4 per day)
Known kills, Jan. 26 to March 9	8	16

In addition to fresh kills, the East Pack visited six old kills within its range, while the West Pack visited one (plus an autopsy carcass in Washington Harbor). The two packs showed similar travel rates, and both showed longer movements in late February and March. In contrast to last year, this increase in travel was not correlated with decreasing snow depth, since the snowfall increased significantly during the same period. The lead pair in the West Pack showed less courtship behavior later in the winter study, suggesting that a decrease in sexual activity may explain the increase in travel.

Sixteen moose-wolf encounters involving 22 moose were observed this winter. Only one moose was killed, a calf whose mother ran off when the wolves attacked. Another calf was wounded in the rump area before its mother managed to chase the wolves off. In two other calf encounters observed, the mother provided adequate defense. Eighteen adults were "checked" by the wolves and abandoned.

Snow studies

Snow is an extremely important factor in the winter ecology of Isle Royale wildlife, affecting moose distribution and certain facets of the wolf-moose relationship, such as calf vulnerability and kill distribution.

This winter snow cover characteristics were examined using two primary methods. The first involves digging a pit in the snow and measuring the following variables in each distinct layer in the profile: density, hardness (the amount of force necessary to collapse the snow structure), temperature, and grain size and form. This is a time-consuming operation, and it was done at intervals of about two weeks to obtain basic information on an exposed site at Windigo. The other method involves the use of a "penetrometer," a hollow aluminum tube that can be loaded with lead weights. The device simulates the pressure exerted on the snow by a walking animal with a corresponding weight-load. The tube is held at the snow surface and dropped, and the depth to which it falls is recorded. By adding weights, any weight-load from 100 g/cm^2 to 700 g/cm^2 (in 50 g/cm^2 steps) can be tested. In sampling an area, total depth was measured, then the average depth to which each weight-load sank in the snow was recorded. This was done every 7 to 10 days in ten different habitats in the Windigo area.

When we arrived on Isle Royale, over 12 inches of new snow lay on top of a base of about 21 inches, with an icy crust separating the two layers. During the next three weeks no new snow fell, and the fluffy top layer compacted to about two-thirds of its original depth, the bottom layer settling only an inch or two. The crust between them was quite firm, often showing a vertical hardness of up to 3000 g/cm^2. This easily supported a man on snowshoes and appeared to support wolves, based on few observations. Moose probably received some support from this hard layer, but in no observed cases were the moose entirely supported by it. During this time, an interesting wolf-moose encounter was observed, illustrating how deep snow can be advantageous to wolves under specialized crusting conditions. The East Pack attempted to attack a calf when protected by its mother. Cows generally break trail for their calves, but with the wolves present, this cow took a position at the rear of her calf, protecting the area most vulnerable to attack. The calf made little headway in the snow, while the wolves easily trotted alongside, supported by the crust in the snowpack. They did not attack the calf, however, and soon left the pair. The cow then took up her customary position in front of her calf, leading it out of the area. Wolves did not always have the advantage over moose during the winter, since there is great variation in snow conditions and other factors. Other hunts were observed where wolves were seriously hampered by the deep snow.

During the remaining weeks of the study period, several layers of snow were added, complicating the crust picture. When we left on March 10, a total of 40 inches of snow had accumulated, and the original hard crust had settled to a depth of 27 inches.

Analysis of penetrometer data continues, but a sample of the records compiled appears in Table 6.

Table 6. Penetrometer data for three sites on February 17, 1972*

		"Open" station, with no canopy	Ridge top, with low density birch canopy	Balsam fir and cedar grove, with dense canopy
Total depth (cm)		73.9 ± 2.0	60.1 ± 1.6	53.5 ± 4.1
Sinking depth (in cm) of penetrometer at specified weight-load	100g/cm^2	26.1 ± 0.8	22.8 ± 1.3	32.6 ± 4.3
	150g/cm^2	32.0 ± 2.4	45.9 ± 7.3	52.3 ± 3.9
	200g/cm^2	44.6 ± 5.0	56.2 ± 6.1	bottom (53.5)
	250g/cm^2	63.6 ± 8.6	bottom (60.1)	bottom (53.5)
	300g/cm^2	72.5 ± 3.4	bottom (60.1)	bottom (53.5)
	350g/cm^2	bottom (73.9)	bottom (60.1)	bottom (53.5)

*Mean depths plus 95 percent confidence intervals are shown.

In general, exposed sites accumulated more snow than sites with canopy cover, and of the ten stations, the dense conifer grove in Table 6 accumulated the least amount of snow. Wind and sun crusts probably do not form as often in such sheltered sites, explaining the apparent high penetrability of the fir grove. In spite of this, such a site would probably still be favored by moose because of lower snow depth and protection from wind.

More data must be gathered to determine where the moose fits into the weight-load picture, but limited data indicate that most moose-track depths are duplicated approximately by the penetrometer when loaded to 200 g/cm^2.

OUTLINE OF PROPOSED RESEARCH, 1972-73

Research during the coming year will follow the same general lines as that of 1971-72. Peterson has completed course work at Purdue and will spend as much time as possible in the field. Allen will be on a half-year sabbatical beginning in July and anticipates summer and fall trips to the island.

Summer study, 1972

Peterson and his wife plan to begin the summer's activities in early May, as soon as suitable transportation is available. Ronald L. Bell, a wildlife graduate student at Ohio State and summer assistant in 1969 and 1970, will again assist in 1972 along with an undergrad in wildlife from Purdue. By traveling in pairs, coverage of the island will be increased greatly.

Of the 39 kills located from the air this past winter, 28 remain to be examined. This will be done as early as possible, in order to appraise the condition of marrow in the long bones. By following known winter travel routes of the wolves, as in 1971, it is hoped that a large number of previously undiscovered winter kills can be examined. A large sample of moose-kills is especially helpful in making inferences about age distribution, the percentage of calves in the winter kill, and other facets of the moose-wolf relationship. For example, several kills examined this winter belonged to age classes which have not been extensively preyed upon by wolves in past years. By finding additional carcasses in the summer, it should be possible to reach a more reliable conclusion regarding this apparent departure from the normal pattern.

With more extensive coverage of the island we will have increased opportunities for finding fresh wolf signs and, hopefully, a den. The howling technique will be used as much as possible in attempting to locate wolves.

Moose observations will be recorded as before, to obtain information on herd composition and reproduction. Such figures become more accurate when the data are gathered during extensive travels over the entire island, as has been done in the past two summers.

For the first time since 1969, fall flying will be conducted to determine moose herd composition in October, which serves as a valuable comparison with summer observations.

Winter study, 1973

Peterson looks forward to his second 7-week study period, with Allen present for five weeks, as in 1972. Since neither Allen nor Peterson will have course obligations on campus in early January, it may be possible to open the winter study earlier in January than normal. When planning the winter schedule, consideration must be given to the flying conditions; an earlier start would mean shorter days and probably more early morning fog due to open water.

As in previous years, Donald E. Murray will pilot the research craft. Emphasis will be on a study of the two main packs on the island. Since, at present, each pack occupies about half of the island, interesting comparisons between the two can be made, and perhaps we can gain some insight into the spacing mechanisms of wolf packs. Recognizing individual wolves from day to day (as well as from year to year) is essential if we are to learn more about such questions as the role of the lead wolves in a pack, how social restrictions on breeding operate in the wild, and how the social position of a wolf affects its daily activities. It was evident this year that certain wolves can be recognized on the basis of their physical appearance and behavior, though this is initially a time-consuming process and is limited by the degree of variation in the wolves. For example, most of the animals of the East Pack (believed to be pups) were virtually indistinguishable from the air, and photographs revealed no helpful features. The wolves of the West Pack were much more varied in their physical appearance and offer more hope in identifying individuals if sufficient observation time is available.

Snow investigations will be continued in 1973 using the same technique as this year. Additional measurements will be made in other locations on the island to provide a measure of the variability of the snow cover on an island-wide basis, though intensive measurements through the course of the winter study are practical only at Windigo. Moose and wolf track depths will be measured and penetrometer data taken to determine what weight-loads simulate moose and wolf track depth most accurately.

We will continue to examine moose killed by wolves whenever possible, collecting appropriate specimens. In addition, at least one moose will be collected for autopsy purposes. A dart gun will again be available for the immobilization of moose for tagging and aging experiments, though opportunities for its use have been limited to date.

In the course of the winter study, observations of the fox populations will yield data on numbers and behavior. Status reports on other wildlife species will be made as in past years.

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