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Ecological Studies of Wolves on Isle Royale

Wolves and Moose of Isle Royale

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Ecological Studies of the Wolf on Isle Royale, 1974-1975

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ECOLOGICAL STUDIES OF THE WOLF ON ISLE ROYALE*

Annual Report

(Covering the seventeenth year in the Isle Royale studies)

1974-75

by

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Durward L. Allen, Professor of Wildlife
Ecology

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30 April 1975

*Receiving principal support in the current year from the National Park Service, the National Audubon Society, the Boone and Crockett Club, and the National Rifle Association.

NOT FOR PUBLICATION

Fiscal year 1974-75, the seventeenth year of these studies, has particular significance, since it probably is the last year in which the work will be carried on in the usual manner, based at Purdue University and under the direction of Allen. Peterson finished his thesis, "Wolf ecology and prey relationships on Isle Royale," and received his doctorate in December. At that time he assumed the new status of post-doctoral research associate.

Beginning in fiscal year 1975-76 the continuation of the Isle Royale studies of wolves and associated wildlife will be under the direction of Rolf Peterson, who will be a staff member of the Department of Biology, Michigan Technological University, at Houghton, Michigan. This project will continue to be under the purview of Robert M. Linn, of the National Park Service, who has supervision of research projects in the upper lakes. Dr. Linn also is at Michigan Tech., with professorial status on the biology staff. At least for the next fiscal year, Allen (at Purdue) will remain a collaborator in the work-- he expects to go on emeritus status in July 1976. Perhaps we should mention that the mainland headquarters of Isle Royale National Park (Superintendent John M. Morehead) is at Houghton. Thus the new location will involve a minimum of travel.

In 1974 Rolf and Carolyn Peterson were in the field from April 29 to October 31 and were assisted by Joseph M. Sheldler and James D. Woolington, May 5 to August 14. Allen was in the field from April 29 to May 7 and from September 21-28. The pilot for Peterson's fall moose count was, again, Robert R. Mohr, of Crane Lake, Minnesota.

During the months of September and October Philip C. Shelton, now of Clinch Valley College, Wise, Virginia was in the field on Isle Royale updating (for the second year) his inventories of beaver colonies and marked beavers. He has contributed a section of this report on that work, which is a follow-up of his thesis research that terminated in 1966. Dale Chilson of Grand Marais, Minnesota was pilot for the fall count of occupied beaver sites.

The winter field program was opened on January 26, 1975-- after a five-day wait for the weather to clear for flying from Grand Marais, Minnesota to Isle Royale. Allen left the island on February 28, and Peterson closed the camp on March 8. Donald E. Murray of Mountain Iron, Minnesota, was our field pilot for the seventeenth winter. Connection flights from Grand Marais were provided by Wilderness Wings of Ely, Minnesota.

For the first five days of the winter period we were accompanied by Max C. Holden of the Regional Office, Omaha. During the second week (Jan. 30 - Feb. 7) Douglas B. Houston of Yellowstone National Park visited the camp as part of his preparation for aerial wolf counts in the Yellowstone region. From the 9th to the 14th of February we were joined by Assistant Secretary of the Interior Nathaniel P. Reed and Isle Royale Superintendent (at that time) Hugh P. Beattie.

Park personnel who were part of the field crew in various periods were: Ivan R. Tolley, 26-30 Jan. and 7-19 Feb; Carl M. Fleming, 30 Jan. - 7 Feb. and 28 Feb. - Mar. 8; W. Michael Quirk (Grand Portage National Monument), 19-28 Feb.

Our two most significant publications appearing during the year were:

R. O. Peterson and D. L. Allen

1974 Snow conditions as a parameter in moose-wolf relationships.
Le Naturaliste Canadien, 101:481-492.

D. L. Allen

1974 Of fire, moose, and wolves. Audubon, 76(6):38-49.

In March, 1975, Peterson delivered a paper entitled "Wolf response to increased moose vulnerability on Isle Royale" at the 11th North American Moose Conference and Workshop in Winnipeg, Manitoba. His thesis is now being edited for publication in the Research Monograph Series of the National Park Service.

Summer Field Work, 1974

The bulk of the summer field work was done by assistants Woolington and Scheldler, as Peterson was engaged principally in thesis-writing. Collections from moose carcasses and skeletal remains were given priority in May and June, while extensive coverage of the Island thereafter yielded many additional moose autopsy records and some information on wolf activity.

Spring temperatures were low and snow melt relatively late in 1974, resulting in late emergence of green vegetation. Moose were observed feeding on balsam fir in May, and nutritional stress was evident in the finding of seven moose that died of malnutrition during late winter and spring.

July and August were exceptionally dry months, and forest fires were frequent on the mainland. A lightning strike started a small fire on the north shore of Isle Royale west of Huggin Cove in July, and although it smoldered for several weeks, little more than an acre of ground cover was burned.

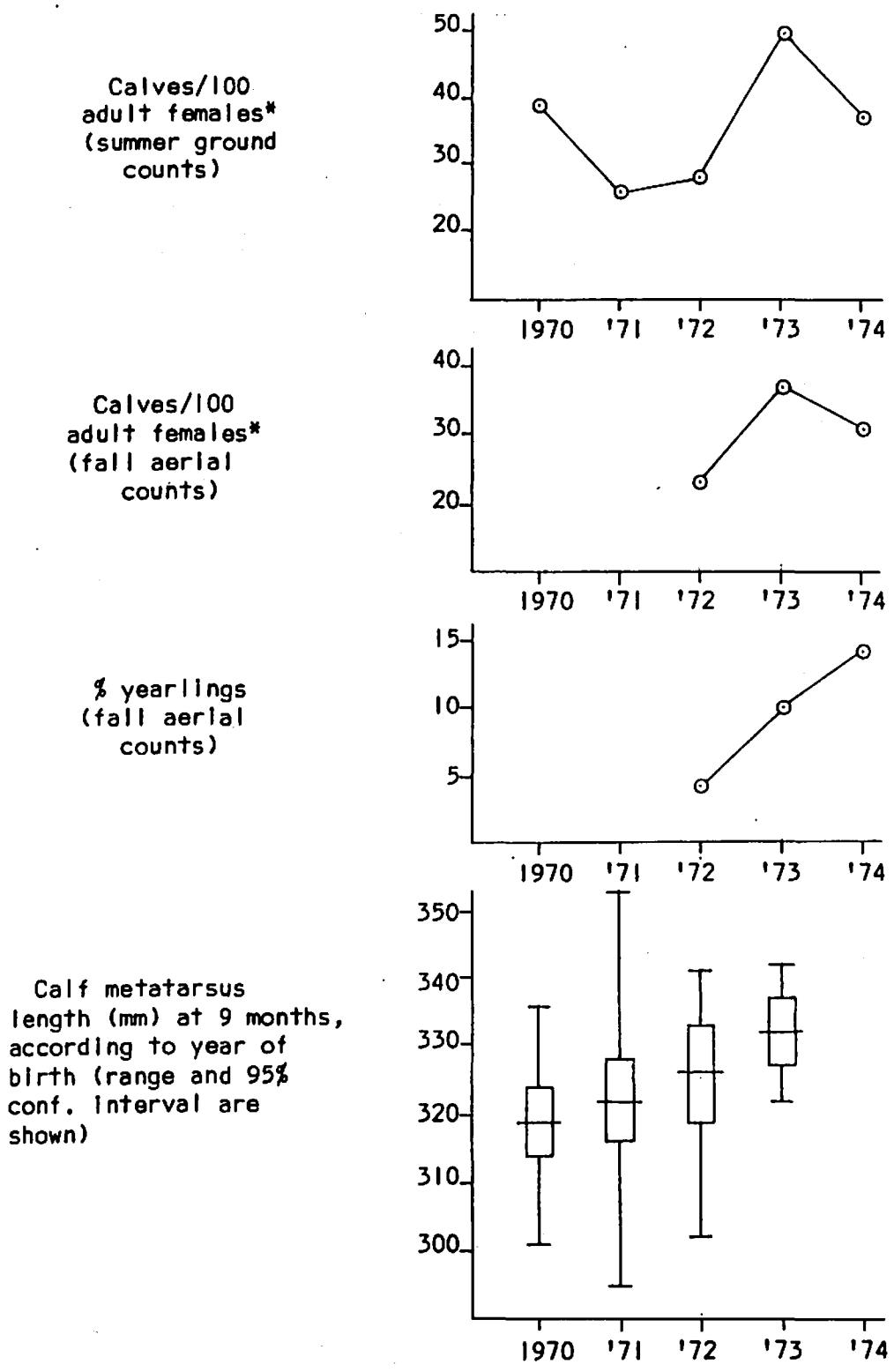
Moose observations

Summer ground observations and an aerial count after leaf-fall in October provided data on the incidence of calves in the population and recruitment of the 1973 calf cohort into the yearling age class. These data are summarized in Fig. 1 and Tables 1 and 2. Although ground observations are biased by a number of factors, such as the hiding of calves by the cows, summer ground counts show a trend similar to fall aerial counts, and can be used as a relative index to calf abundance.

The 1974 calf crop appeared to be lower than the 1973 generation, which was the largest observed since 1970. The 1973 calves, in addition to being the most abundant, were physically the largest calves since 1970, as indicated by metatarsus measurements (Fig. 1). This generation also showed high survival (15% of moose herd) compared to the previous two cohorts (Fig. 1). Comparative data on physical size of 1974 calves will be determined using bone collections from wolf-killed moose in 1975, and recruitment will be estimated from an aerial sampling of the population in October, 1975.

Moose mortality, 1974

During approximately 700 miles of hiking, project personnel examined 78 skeletal and carcass remains of moose, including 16 located initially during the 1974 winter study. This completed the collection of wolf-kills from the previous winter (Table 3). Although calves comprised about half of the 37 wolf-kills, aerial composition counts indicated high over-winter survival in the 1973 cohort: calves comprised 16% of the population in October, 1973, 15% in February, 1974, and the count was 14% in October, 1974.



* Includes yearling females, most of which are probably unproductive.

Fig. 1. Recent data on calf production, yearling recruitment, and physical size of calves by year.

Wolf-kills from 1974 also indicated that predation losses were generally heavier in the older age classes, although age determinations are not yet complete. This contrasts with recent years when young adult moose have been notably vulnerable to predation, and suggests that unusually vulnerable moose in this age group have been effectively removed from the population.

Table 1. Moose herd composition and productivity, 1970-74, based on ground observations in summer.

	<u>June 9- Sept. 4, 1970</u>	<u>May 18- Sept. 7, 1971</u>	<u>May 9- Sept. 25, 1972</u>	<u>May 4- Sept. 30, 1973</u>	<u>May 6- Aug. 13, 1974</u>
Total seen	192	142	231	244	118
Males	64	47	106	92	36
Females	91	64	92	102	57
Calves	35	19	23	38	21
Unknown	2	12	10	12	4
Calves per 100 adult females* (after June 1)	39	26	28	49	37
No. sets twins	5	1	2	4	4

* Includes yearling females, which at times can not be distinguished from older moose.

Summer wolf activity

At least three litters of wolf pups were born on Isle Royale in 1974. One sighting of five pups was made within the range of the East Pack in mid-August. Contrary to the pattern observed in 1973, the East Pack moved their pups frequently within a one-square-mile area from June through September, rather than occupying individual rendezvous sites for extended periods of time.

One rendezvous site of the West Pack was discovered in mid-August, 1974. Although the number of pups was not determined, five wolves were seen at this same site during an aerial moose composition count on October 24.

Tracks of pups and adults were seen in the middle of the island, although more conclusive evidence of the third litter was not gained until the presence of a third breeding pack was verified during the winter study in 1975.

Table 2. Fall aerial classification counts of Isle Royale moose, 1972-74.

<u>Date</u>	<u>Total observed</u>	<u>Bulls^{1/}</u>		<u>Cows</u>	<u>Calves</u>	<u>Males/100 females</u>	<u>Percent yearlings^{2/}</u>	<u>Calves/100 ad. females^{3/}</u>
		<u>Ad.</u>	<u>Yrl.</u>					
Oct. 17-19 1972	114	47	2	53	12	93	4	23
Oct. 23-25 1973	192	73	8	81	30	100	10	37
Oct. 22-25 1974	117	43	7	51	16	98	14	31

^{1/} Bulls with spikes or small forked antlers were considered yearlings.

^{2/} % yearlings = yearling bulls/(adult bulls + yearling bulls). This is analogous to "net productivity," as defined by Pimlott (1959).

^{3/} Yearling females probably are unproductive and are considered "adult" because they cannot be distinguished reliably from older cows.

Table 3. Preliminary age distribution of wolf-killed moose, winter 1973-74.^{1/}

<u>Age (years)</u>	<u>Calves</u>	<u>1+</u>	<u>2+</u>	<u>3+</u>	<u>4+</u>	<u>5+</u>	<u>6+</u>	<u>7+</u>	<u>8+</u>	<u>9+</u>	<u>10+</u>	<u>11+</u>	<u>12+</u>	<u>13+</u>	<u>14+</u>	<u>15+</u>	<u>16+</u>	<u>17+</u>
No.	19	1			1	1		1		2		1				1	1	

^{1/} Nine additional adults were collected but have not yet been aged. Wear class estimates indicate that these moose are all older than six years.

Winter Field Work, 1975

Of particular note during the 1975 winter study was the lack of shoreline ice, which greatly reduced the number of kills that could be examined and contributed to much fog and local snow. At no time was an ice bridge present to the mainland, and many usually frozen bays on Isle Royale were ice-free all winter. Average daily minimum and maximum temperatures were 9.8 and 26.7 degrees F, several degrees above average. Extreme temperatures were -12 degrees F. (Feb. 8 and 9) and 44 degrees F. (Feb. 21).

Snow depths usually ranged from 24 to 30 inches in open areas at Windigo. On February 10 and 11 a total of 15 inches of new snow fell, increasing snow depths temporarily to 36 inches, but within five days snow depths again fell below 30 inches. During the six-week study total snowfall amounted to 20.9 inches, with a water equivalent of 1.18 inches.

Flying conditions during the first 19 days of the study period were excellent, and almost half of our total flying time was logged during this period. Thereafter we experienced extremely poor flying conditions, and flight time for the entire period totaled only 74 hours.

Wolf population, 1975

The history of the Isle Royale wolf population has been one of amazing stability (Fig. 2), with the population averaging about 23 wolves from 1959 through 1974. During the past two years, however, wolf numbers have approximately doubled, and in 1975 Isle Royale supported one of the highest wolf densities ever documented (one per five mi^2).

This population increase has followed a generalized increase in food supply available to wolves. Since 1969 moose vulnerability in mid-winter has been generally high, and calculated food availability (on a basis of known kills) during the early 1970's was about twice the level of a decade earlier (Fig. 3). Shelton's studies (p. 17) indicate that the beaver population also doubled during the same interval. Beaver are now a principal source of food for wolves during the open-water season, and high beaver densities have been most important in ensuring an apparently high level of pup survival in the face of reduced moose calf production (especially twins).

In addition to changes in population size, there have been significant variations in the organization of the wolf population. From 1959 through 1971 only one large pack was consistently present, utilizing all or most of the island (Fig. 4). By 1971 the winter range of this pack (West Pack) had shrunk to less than half of the island, and the following year a new pack (East Pack) appeared on the other half of the island. For three years the East and West packs divided the island about in half, and the East Pack grew rapidly in size. In the summer of 1974 at least one litter of pups was present in both packs, with possibly a third litter in the middle of the island.

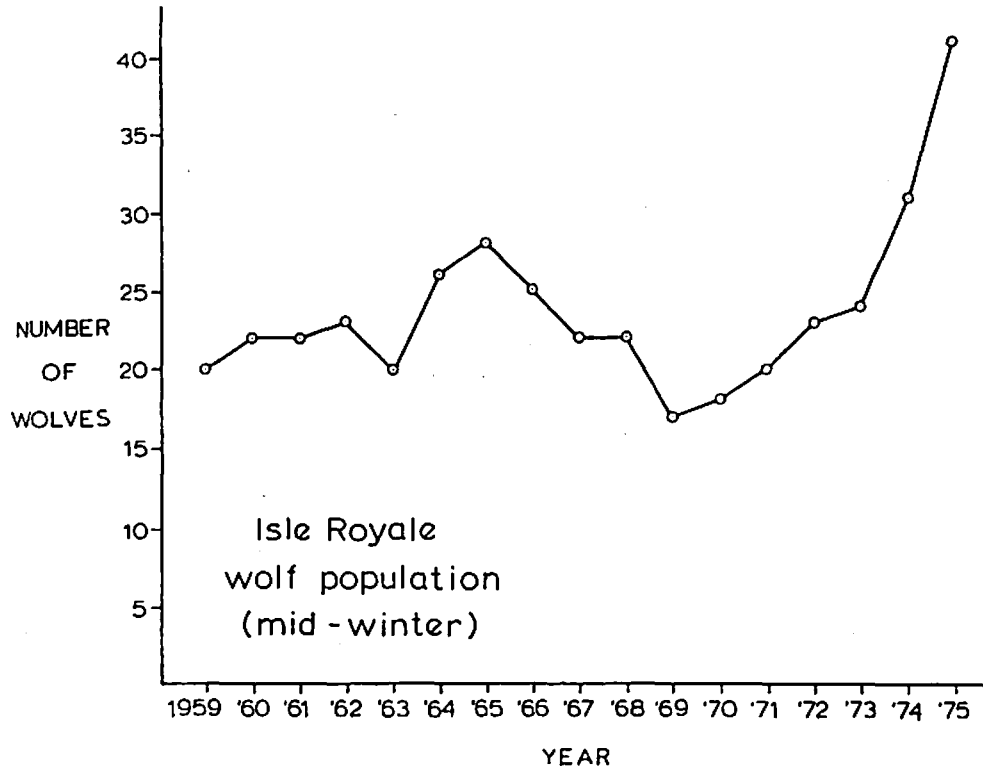


Fig. 2. Isle Royale wolf population, 1958 to 1975.

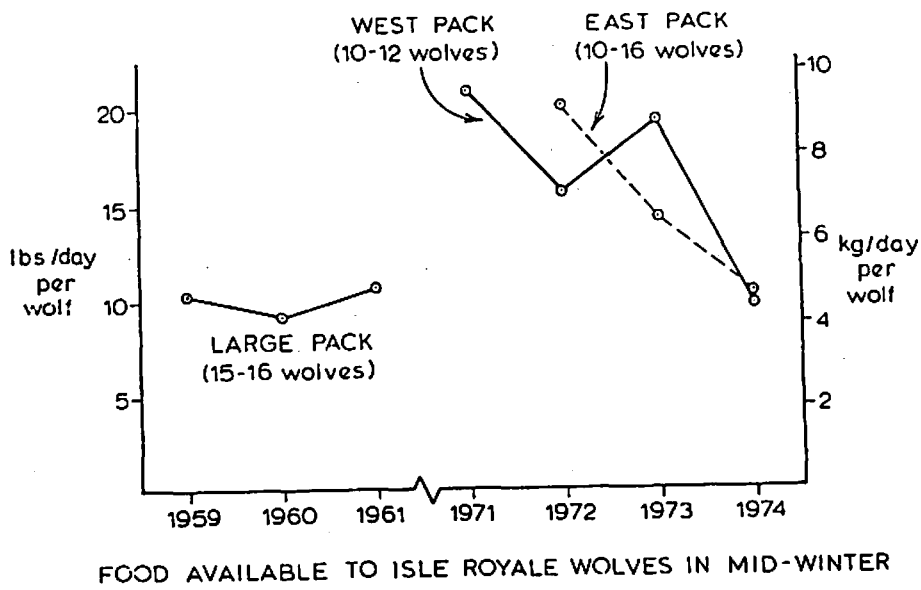


Fig. 3. Calculated feed availability for Isle Royale wolves in mid-winter, based on known kill rates. Adult bulls, adult cows, and calves were assumed to provide 725, 575, and 250 pounds of edible weight for wolves.

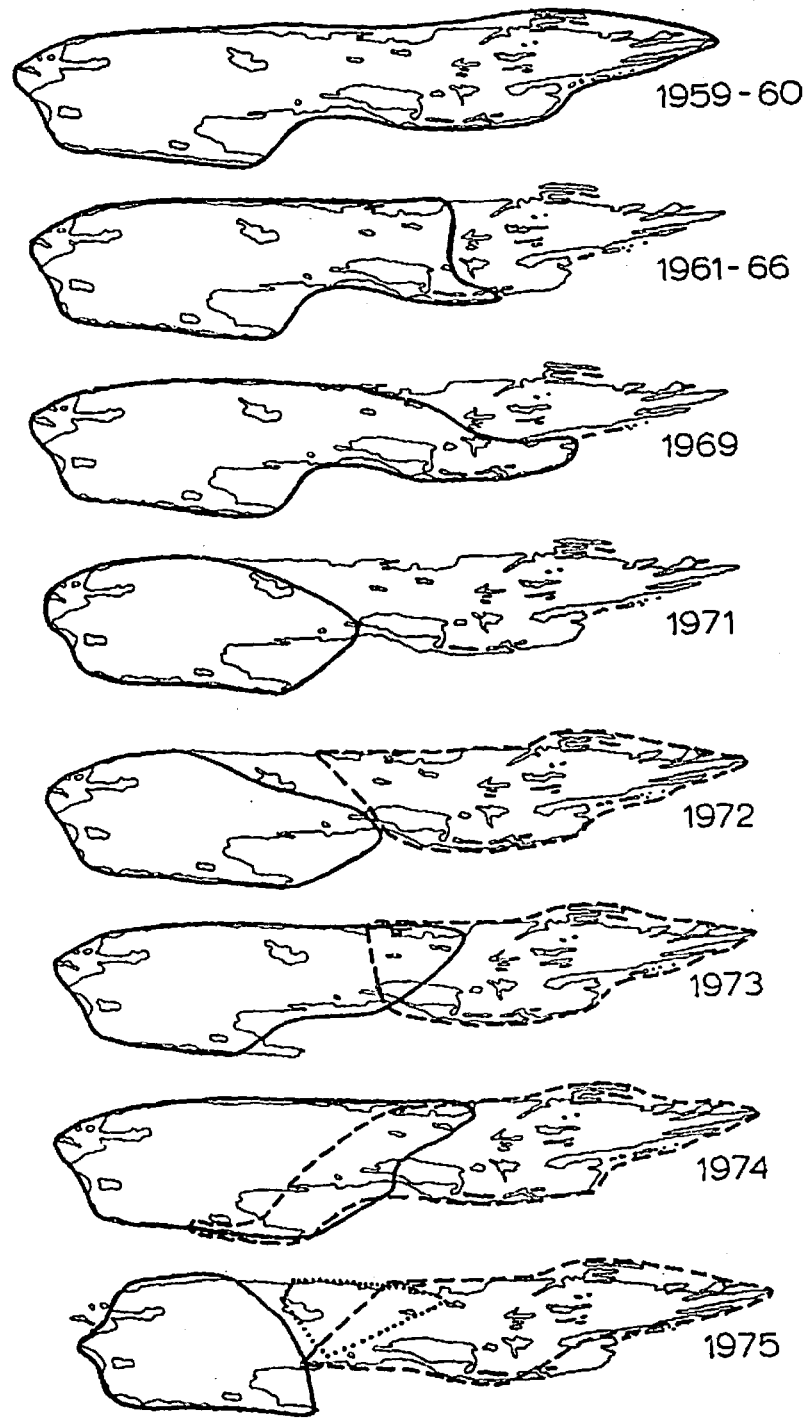


Fig. 4. Spatial relationships of Isle Royale wolf packs in mid-winter.

During the 1975 winter study we found that indeed a third litter had been born in 1974, and evidently most of the pups survived. This gave rise to a third large pack (Middle Pack), which in winter appeared to consist of an adult pair and five pups, ranging over the middle of the island between the two established packs. For the previous two winters a pair of wolves had occupied this general area (Todd Duo), and this is believed to be the pair that successfully raised a litter in 1974. Identification of this pair was not conclusive, but from 1973 to 1975 the smaller of the pair (probably the female) was noticeably reddish on its lower flanks and belly. The consistency in appearance and range suggests that the same pair was present each year from 1973 to 1975.

Although there were gaps in the travel records of the West and Middle packs in 1975, there was no evidence of direct conflict among any of the packs, in spite of some overlap in territories.

Censusing wolves in 1975 was difficult because of poor flying conditions and the increased population. Fortunately the three principal packs were usually at full complement and did not often split up. In addition to the large packs a trio of wolves and a loner were seen once in the Washington Harbor area. Two different pairs of wolves were subsequently seen in the middle of the island when the packs were all accounted for. One of these pairs could have been included in the above-mentioned trio, which Peterson was not able to observe. All of the lesser groups were seen only once when the three large packs were at maximum size and accounted for, and we could not be certain that a second duo was present and distinct from the Washington Harbor trio. We summarize on the basis that at least 41 wolves were present, and possibly as many as 43:

East Pack	18
West Pack	10
Middle Pack	7
Wash. H. trio	3
one duo	2
Wash. H. loner	1

41 wolves - minimum population and best estimate

In 1974 the alpha males in both the East and West packs and the alpha female in the East Pack were identifiable. Both of these alpha males disappeared by 1975. The alpha female in the East Pack has been distinguished each year since 1972, and is now at least 6½ years old (she had pups in 1971, and probably was at least 22 months old at that time). She has been alpha female for this entire period, and during our observations has been instrumental in leading the pack and making decisions regarding choice of travel route, etc. During this period three different alpha males have been present.

Since the population increased by 10 wolves from 1974 to 1975, and at least two adults were lost (the two identifiable alpha males), at least 12 pups were present in the total population of 41 wolves. Behavioral observations and physical appearance suggested that five pups were present in both the West and Middle packs, and a minimum of three pups had to be present in the East Pack to account for the growth of this pack from 16 to 18 and the loss of the alpha male. Thus a minimum of 13 pups appear to have been present in 1975. If these pups all resulted from a total of three litters (assuming an average of six per litter), a high survival rate among the young born in 1974 is indicated.

Two matings were observed in 1975, on February 20 and 27. One mating occurred between the alpha pair in the West Pack, and the other involved a subordinate pair in the East Pack. In the latter case the alpha pair were present, and they threatened and snapped at the tied pair, forcing them to the ground on their sides. A subordinate male and female in the West Pack exhibited courtship behavior toward each other in spite of threats and bites from the alphas, but it is not known if they mated. Courtship behavior was observed in the alpha pair of the East Pack, indicating a probable mating, and it is also probable that the adult pair in the Middle Pack mated. These behavioral observations and assumptions indicate a minimum of five adult females that possibly could bear pups in 1975 (two in the West and East packs, respectively, and one in the Middle Pack).

In spite of poor flying conditions, we were able to maintain a continuous travel record for the West Pack for 25 days and the East Pack for 36 days. During this period the West Pack averaged 7.3 miles per day and 20.3 miles between kills, and the East Pack traveled 7.2 miles per day and averaged 17.3 miles between kills. These figures are close to the 1971-74 average of 6.9 miles per day and 20.5 miles between kills, based on 234 "pack-days" (a pack followed for 24 hours). These data indicate relatively "normal" travel conditions and prey availability.

A record of kills made by the three main packs was maintained for as long a period as possible, despite gaps in the travel records. In 99 pack-days, the three packs killed a minimum of 28 moose, and dug out an additional seven old kills to feed on the remains. Also, the East Pack fed on a calf that had drowned last fall and was frozen in the ice, the Middle Pack scavenged carcasses of two moose that died from other causes and the West Pack fed on the remains of a moose collected and autopsied on Washington Harbor. Estimates of food availability for pack members will be made after sex and age data are gathered from all of the kills. The combined kill of the three packs indicated an average of one kill per pack every 3.5 days. With three packs operating, this implies a kill rate of almost one moose per day for the island as a whole in mid-winter.

Initial findings on Isle Royale between 1959 and 1961 indicated that the single large pack that traveled over most of the island killed a moose, on the average, every three days. This kill record was maintained also by the second and third packs as they became established on the island, resulting in a proportional increase in total predation.

Winter moose mortality

A record total of 42 moose carcasses were located during the 1975 winter study. Fresh wolf kills numbered 31, seven old kills were found, and four moose that died of other causes were located (one had drowned, one had fallen off 100-ft. Feldtman cliff, and two died of as yet undetermined causes). Because of poor landing conditions only 10 carcasses were examined on the ground; the rest will be checked early in spring, 1975.

The annual sample of wolf-killed moose has proved to be a valuable indicator of age-specific vulnerability and, indirectly, a reflection of general moose welfare. Of special interest in this regard is the incidence of moose between the ages of one and six among wolf kills. In early years of the study these young adults showed a strikingly low incidence of predation losses. But the proportion of kills in this group increased during the 1960s and jumped rapidly in the early '70s after a series of severe winters (Fig. 5). Moose born from 1969 to 1972 were especially vulnerable in their early years. Evidently this results from continuing adverse influences on growth and development following fetal (or calf?) malnutrition during winters of food deprivation. Calf metatarsus measurements (reflecting size at birth) show that many individuals in these generations also exhibited delayed closure of growth plates in their long bones. Undoubtedly the vigor of these moose was affected in other ways, but the bone measurements are the only indices available.

Vulnerable young adults appear to have been largely culled from the population by 1974, as shown by the age distribution of wolf-kills that year (Table 3). The record of the past five years has further demonstrated the extreme sensitivity of wolf predation to moose condition, and the importance of wolf predation in the maintenance of a healthy and vigorous moose population on Isle Royale.

Other moose research

Results from a 1974 census indicated a mid-winter population of about 1000 moose. An aerial moose census was not flown in winter, 1975. The accuracy of these counts is not sufficient to show inter-year variation in moose numbers, and at best they can only reflect general trends in the population. Lack of accurate estimates of the moose population remains a serious limitation in this work, as in similar moose research throughout North America.

An 850 lb. (386 kg) bull was necropsied in February, 1975. While most moose examined in mid-winter recently have shown little or no deposits of fat within the body cavity, this bull (#1068) possessed abundant heart, kidney and omentum fat. The articular cartilage in both hip joints had begun to degenerate, an early sign of arthritis (the age of this moose has not yet been determined). Arthritis in hip joints of Isle Royale bulls is not unusual after seven years of age, but it is rare in females.

Blood samples were collected from the necropsied bull plus an adult cow and bull that were immobilized with Rompun (Chemagro, Inc.) or Rompun plus Sucostrin (Squibb and Sons, Inc.). These blood samples are being analyzed by Dr. U. S. Seal of the Veterans Administration Hospital in Minneapolis. Hopefully blood studies can be expanded in the future and provide a more refined index of moose condition.

Bone marrow that was collected and frozen from 1972 to 1975 is now being analyzed for fat content. Following an upgrading of tooth grinding equipment to conform with federal safety codes, the ages of about 50 adult moose from which collections were made in the past year will be determined.

Secondary species of mammals

Fox observations were tallied to provide an index of their numbers and activities. Snow conditions markedly affect fox mobility and dependence on moose carrion as a source of food. From our arrival until the heavy snowfall on Feb. 10 and 11, foxes were easily supported by a crust (hardness ca. 600 g/cm²) eight inches (22 cm) below the surface of the snow, and their tracks were widely dispersed in the interior of the island. Of the 12 foxes observed at least half a mile (0.8 km) from a known kill, 10 were seen during this initial period of high mobility. After the rapid accumulation of 15 inches (38 cm) of new snow in mid-February, however, most of the foxes seen were associated with a moose carcass, and observations of tracks indicated reduced movement. Foxes in the Windigo area plowed through snow up to their chests, and chose to travel only on packed trails when possible. No mountain ash fruit was available in 1975, so foxes depended entirely on snowshoe hares and moose. When snow conditions interfered with fox mobility, they subsisted principally on moose carrion. Fig. 6 and Table 4 show that overall use of moose carcasses was relatively low in 1975, and the number of foxes seen away from carcasses was down slightly from the past three years. In view of the constant nature of this latter statistic from 1972 through 1974, the drop in 1975 may reflect a population decrease.

This year only three foxes (a male and two females) were seen regularly in the Windigo area in contrast to the six present in 1974 (two males and four females). The 1975 male was at least 4½ years old, and the females were 2½ and 3½ years, respectively. In previous years this male had been extremely submissive toward the local dominant male. Following disappearance of the dominant male, the subordinate male assumed an obviously elevated status. Correlated with his altered social role were major behavior changes. He began to scent-mark regularly throughout the range of his travels, and courted one of the local females. As the breeding season approached his testes grew visibly in size. Nothing like this had been observed in three previous winters when he had been in a subordinate role.

Otter tracks were again seen in many areas of the island. In spite of the warm weather and little ice, beaver sign was rarely seen.

Winter birds

No unusual bird species were recorded in winter, 1975, although blue jays were more frequent than normal in the Windigo area. Small fringillids (pine siskins, redpolls) were only infrequently seen. Diving ducks (old squaws and probably mergansers) were often seen from the plane in open water around the island.

Snow studies

A Rammsonde penetrometer was used to monitor snow depth and condition in three different canopy types at Windigo at weekly intervals. In addition, snow hardness, density, and texture were examined soon after our arrival to determine the importance of existing crusts.

On January 10, before our arrival, northeastern Minnesota and the Ontario mainland received a heavy rain which froze and created a strong surface crust. This crust appeared 14 inches (35 cm) from the ground in a snow profile measuring 29 inches (73 cm) at Windigo on January 29. Vertical hardness of this crust measured 6000 g/cm², but did not provide consistent support for moose. About 20 inches (50 cm) from the ground a lighter crust was found, with a hardness of about 600 g/cm². Wolves and foxes could travel easily on this crust. Thereafter snow depths usually ranged from 40 to 70 cm, depending on overhead canopy. Snow depths increased for about a five-day period during a snowfall of 15 inches (38 cm) in mid-February.

Snow conditions in mid-winter did not present an unusual problem for either moose or wolf on Isle Royale. However, heavy snowfall after our departure may have caused significant nutritional stress among the moose; during the period March 25-27 over 20 inches (5 cm) of snow fell in northeastern Minnesota and winds up to 100 mph were reported in some areas of Lake Superior. The effects of this storm on moose may be indicated after we have checked for malnutrition deaths in spring, 1974, and determined calf numbers next summer and fall.

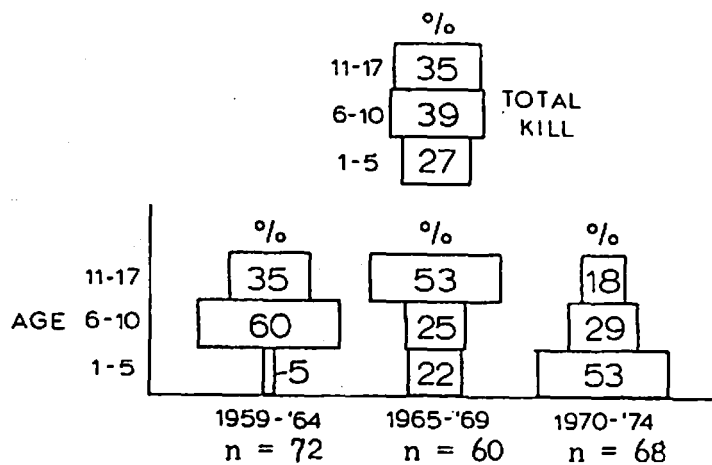


Fig. 5. Age distribution of wolf-killed adult moose on Isle Royale, by five-year intervals.

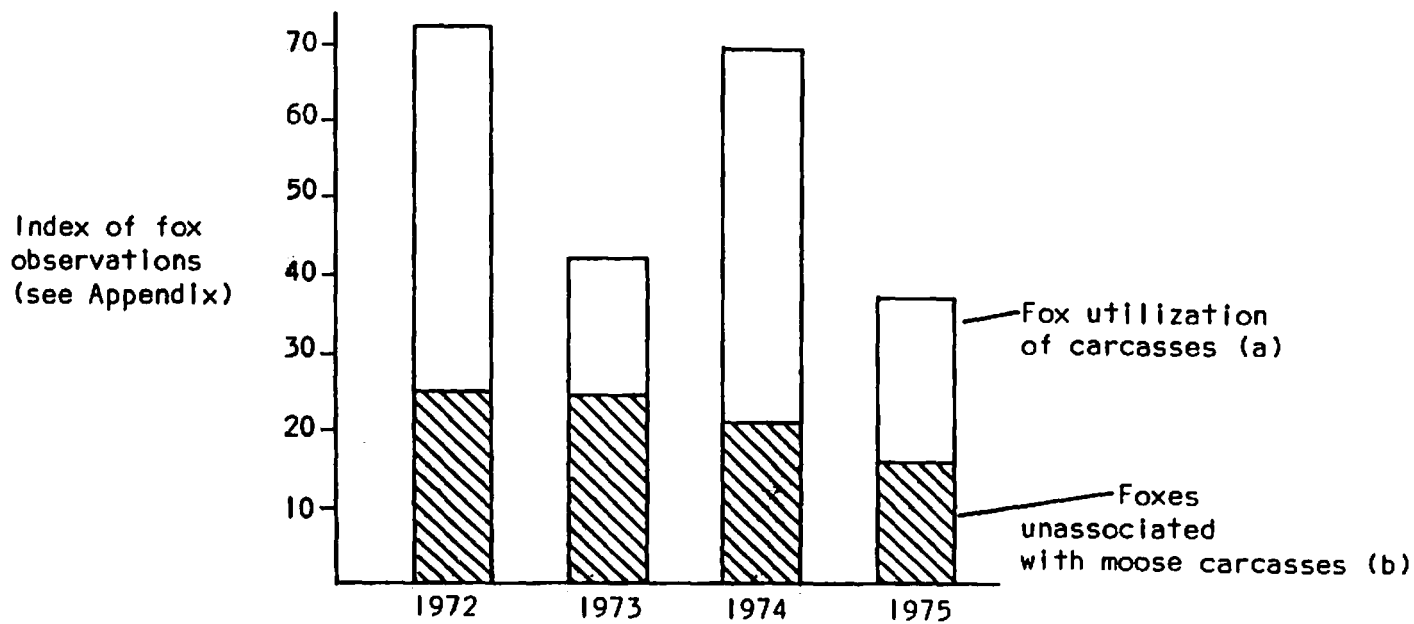


Fig. 6. Indices of fox observations in mid-winter on Isle Royale.

Table 4. Summary and Index of fox numbers in winter.

	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
Moose carcasses located	38	30	40	42
No. where foxes were observed	23(61%)	14(47%)	26(65%)	16(38%)
Foxes on utilized carcasses				
Ave. maximum number	2.4	1.3	1.9	1.3
Sum of max. numbers (a)	55	18	48	21
Other fox observations				
per 100 hours flying (b)	25	24	21	16
Index of fox numbers				
(a) + (b)	72	42	69	37

Beaver Studies, 1973 and 1974
by Phillip C. Shelton

During the periods 14-20 October 1973 and 10 September - 24 October 1974, information on Isle Royale beavers was up-dated through aerial surveys, live trapping, and studies of food utilization and availability.

Aerial surveys

Aerial counts of active beaver colonies were made during 12.5 hours flying time 15, 17, and 18 October 1973 and 12.5 hours flying time 16, 17, and 18 October 1974 from a float-equipped Piper J-3 "Cub" piloted by Dale Chilson of Grand Marais, Minnesota.

During the 1973 count 213 active sites were mapped, and estimates of probable error were made by intensively recounting selected areas after initial coverage of the entire island. The final estimate for number of active colonies present was 300, plus or minus 10 percent.

The 1974 count was made almost entirely (12 hours) on 17 and 18 October. These were days with high, thin overcast and light to moderate winds and therefore nearly ideal for observing freshly felled trees, food piles, and fresh mud on houses and dams. These conditions, plus the experience gained by the same pilot and observer working together two consecutive years gave us confidence that we had approached the practical limits of accuracy for such a count.

This survey revealed 286 sites with visible food piles or sufficient recent cutting and other sign to indicate the presence of one. About 30 additional sites had fresh mud on the house or dam or a small amount of fresh cutting, but no food piles were visible. Most of these probably represented sites occupied by lone beavers or pairs rather than colonies with reproducing adults and their offspring. The total number of active sites recorded for 1974 was thus a minimum of about 315. That this figure is slightly higher than that derived from the 1973 survey probably reflects the excellent conditions under which the 1974 survey was flown, and the additional experience by both pilot and observer, rather than any real increase in number of colonies.

These results verify the conclusions reached on the basis of 1969 data that the beaver population has increased substantially since the early 1960s. In 1969 it was conservatively estimated that the population had increased by at least 25 percent from 1962, when 140 active colonies were known to exist. The 1973-74 figures indicate an increase of 125 percent since 1962. In other words, it appears that Isle Royale now supports a fall beaver population of about 2000 animals.

These figures should not be interpreted to indicate that most of the increase occurred between 1969 and 1973-74, because the 1969 figure was a conservative estimate, based on only 3.5 hours flying time and three weeks of ground work. There is some evidence to indicate that most of the increase

occurred before 1969. On Tobin Creek, for example, there were two active colonies in 1962, five colonies in 1969 and 1973, and six in 1974.

The increase in colonies was confined almost entirely to stream habitats. For comparison, on Tobin and Rock Harbors and the scattered islands northeast of Tobin Harbor where there were six colonies in the early 1960s, there were only seven in 1969 and 1973 and eight in 1974. Sargent Lake had six colonies in 1961, but only three in 1974. Other large inland lakes appeared to have about the same number in the 1970s as they had in the 1960s.

Live-trapping

In 1973 seven beavers were trapped from two colonies in 12 trap-nights, 14-19 October. In 1974, 61 beavers were trapped from 14 colonies in 146 trap-nights, 11 September - 23 October.

One of the beavers caught in 1973 was an adult female that had been tagged originally during the period 1961-1965, but had lost her tags. She was also caught in 1969. In the 1974 sample, two were animals tagged originally in 1963, two in 1969, and two in 1965. All recaptured beavers were at or near the sites of original capture.

The raw figure for number of beavers per colony in 1974 (4.4) was corrected upward by using the number of adults caught at colonies with kits and presumed to have two adults. The corrected figure, 6.5 beavers per colony, agrees closely with the figure (6.4) similarly derived from 1961-1962 trapping data. Further consideration has revealed that this correction factor may not be wholly realistic, since, at least in the 1974 trapping, those colonies without kits were trapped more intensively (in attempting to determine if kits were present) than those with kits present, and therefore the same correction factor would not apply to both classes. A more realistic correction factor for colonies without kits needs to be derived.

Weights of adult beavers trapped in 1973 and 1974 show little change from earlier records:

Table 5

<u>Sample</u>	<u>Mean Weights (Range; number)</u>		
	<u>Aspen fed</u>	<u>Birch fed</u>	<u>Total</u>
1961-1963	42.0 (17)	36.4 (15)	39.8 (37)
1969	44.5 (42-47.5; 3)	36.5 (35-37; 4)	39.9 (7)
1973-1974	42.9 (39.6-46.2; 4)	40.4 (37.4-44.0; 14)	40.9 (18)

The means for the total samples varied only about a pound, but the difference between the means for animals feeding primarily on aspen and those feeding on birch became obscured by an apparent increase in weight of birch feeding beavers. Part of the explanation for this may be that many of the harbor beavers which formerly ate only birch are now ranging farther from their houses and are using remote aspen stands. For example, the Lorelei Lane colony, having nearly exhausted birch on islands near their house, were cutting aspen on the northwest side of Rock Harbor, 0.6 miles from their lodge on Inner Hill Island. In the 1973-74 sample all the beavers from colonies in Rock Harbor, which in the 1960s were almost exclusively dependent upon birch, were above the mean for birch feeding beavers. Only the Lorelei Lane colony was using aspen extensively, but others may have had access to a few trees.

Weights of the 19 kits caught in 1974 averaged 0.9 pounds heavier than kits at corresponding ages caught in 1961-63, and there was no readily discernable difference between food groups. This could have resulted from an earlier breeding season in 1974 than in the 1960s, or from better nutritional status of parents. Further analysis of these data may reveal other possible explanations.

During the investigations carried on in the early 1960s, no parasites were found on beavers handled, either alive or autopsied. In 1974 several insect ectoparasites were found on live beavers. These have not yet been identified, but probably are the beetle, Leptinillus. No attempt was made to determine rate of infestation, but after the first insects were observed, several animals were examined during handling, and parasites were found on less than half the animals searched. Systematic search should be made of all animals handled in the future.

Two beavers were drowned during the 1973-74 studies, an adult female in 1973 and a two-year-old female in 1974. No parasites were found on or in the adult female, but the two-year-old drowned in 1974 had several dozen thread-like red worms, about 12 mm long confined to the stomach.

These observations represent the first known incidence of parasites on Isle Royale beavers, and it probably is related to the increased beaver population.

Food relationships

In 1974 food availability information was obtained from a large sample of active and abandoned colonies in all major habitat types. Hopefully when these data have been analyzed and compared with similar records from the early 1960s they will reveal trends in species used, foraging distances, numbers of trees cut, and intensity of use. A few general comments can be made on the basis of preliminary consideration of the 1974 observations.

It is generally true that aspen has been worked out within 50 to 100 feet of most colony sites, but a surprising number of aspens are still being

found and cut close to ponds. At least three sites were found in 1974 where old growth aspen had been cut close enough so that the trees fell into ponds, and several more had aspens cut less than 50 feet from water.

The trend toward more complete utilization of aspen and birch continues. In 1974 the number of aspens cut per colony was usually less than half a dozen, and these often were completely trimmed and peeled except for the largest rough-barked portions of the trunks. Birch was also thoroughly utilized. Thus the wholesale waste of food trees that characterized the earlier stages of beaver occupancy of the island is no longer seen. Many of the old trees now being cut, however, produce less food than would younger trees.

Distances traveled overland to obtain aspen probably have increased since the earlier studies, although not strikingly so. In no case was cutting found farther from water than the 300 feet recorded at Newt Lake in 1963. Two colonies on Rock Harbor swam over half a mile to cut aspen in 1974.

Birch supplies within 50 to 100 feet of water are almost exhausted near some of the long-established harbor sites, but otherwise this species is still abundant close to water throughout most of the island.

Summary and discussion

In summary, the Isle Royale beaver population appears to have at least doubled in the last 15 years, mainly on streams and by reoccupation of previously abandoned sites rather than establishment of new ones. The physical characteristics of the animals do not appear to have changed, although the presence of both ecto- and endoparasites has now been established. Old growth aspen and birch continue to be the major food resources for Isle Royale beavers, at least during the fall. Moose browsing and the natural trend of plant succession from aspen-birch to spruce-fir continue to prevent significant regeneration of these beaver foods, although other species, particularly of shrubs and aquatic vegetation may have replaced them and contribute significantly to beaver food resources. The growth in numbers of beavers to about 2000 and their increased vulnerability to predation while foraging farther from water probably have contributed to the increased utilization of beavers by wolves. The interaction of these trends can be expected to slow the rate of growth of the beaver population and possibly reverse it. It is hardly possible at this point to estimate a time scale for this course of events or to predict its details with any certainty.