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# Ecological Studies of Wolves on Isle Royale, 1979-1980

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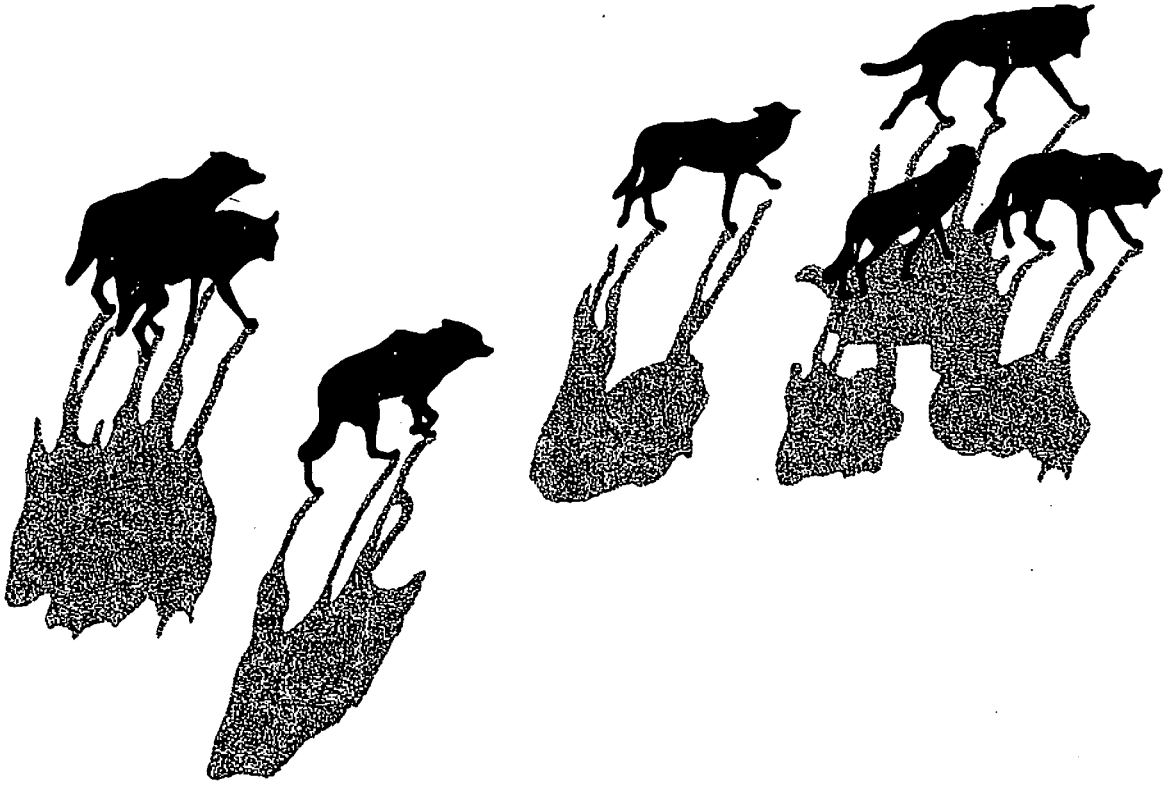
# ECOLOGICAL STUDIES OF WOLVES ON ISLE ROYALE

## ANNUAL REPORT

## 1979-80



# ECOLOGICAL STUDIES OF WOLVES ON ISLE ROYALE*

Annual Report - 1979-80

(Covering the twenty-second year of research)

by

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# INTRODUCTION

The wolves of Isle Royale have been the focus of continuous research since 1958, research which has contributed much to our understanding of the ecology of this species and especially its relationship to a naturally-regulated moose population. Over the past decade the wolf population has been steadily increasing, while the moose population has likewise declined. In 1980, the wolf population reached an all-time high of 50 individuals, while the moose population was estimated at 650-700.

Joseph M. Scheidler completed his master's thesis on moose mortality patterns in May, 1979, and Philip W. Stephens began graduate work in July, 1979. Peterson directed the summer field work in 1979, although primarily engaged in analyzing data from a wolf-moose research project at Kenai, Alaska. Field assistants were Mark S. Cramer (May 29-Aug. 29), John W. Brooks (May 29-Aug. 29), Douglas Smith (June 12-Aug.15), and Philip W. Stephens and Susan M. Stephens (July 17-Nov. 1). Donald E. Glaser (Wings North, Grand Rapids, MN) flew the autumn aerial survey, with Phil Stephens as observer, on October 25-26, 1979.

The 1980 winter study extended from January 21 to March 11. Present for the entire period were Peterson and pilot Don Glaser; Stephens was present from Jan. 21 to Feb. 14. National Park Service personnel from Isle Royale were: Roy A. Peterson, Jan. 21-Feb. 6; Robert A. Huggins and Carol A. Koepcke, Feb. 6-14; Charles L. Dale, Feb. 14-27; Larry T. Wiese, Feb. 27-Mar. 11. Also present were Robert A. Janke (Michigan Tech), Feb. 14-27, and J. Robert Stottlemyer (NPS), Jan. 31-Feb. 6 and Mar. 5-11. Supply flights were flown by Stephen Gheen and Carlo Palombe of the Ely Aviation Unit, Superior National Forest, USFS.

Peterson and Isle Royale Superintendent John M. Morehead co-authored a paper entitled "Isle Royale wolves and national park management", presented at the 2nd Conference on Research in the National Parks, San Francisco, November 27, 1979.

## SUMMER FIELD WORK, 1979

During summer field work, the field crew examined and collected specimens from 71 moose carcasses, both winter-spotted kills and randomly discovered carcasses. Wolf food habits and summer homesite locations were also studied. Phil Stephens began a study of moose behavior, especially as it relates to certain indices of population density that we have developed. Hiking mileage was 1330 mi (2141 km), including 371 mi (597 km) off-trail.

## Moose surveys - summer and fall, 1980

Moose population composition and productivity were estimated by summer ground surveys and an aerial survey after leaf-fall in October. The ground counts (Table 1) provide relative indications of density and calf production, while the aerial survey (Table 2) provides data on calf abundance, adult sex ratio, and overwinter survival of calves born the previous year (Fig. 1).

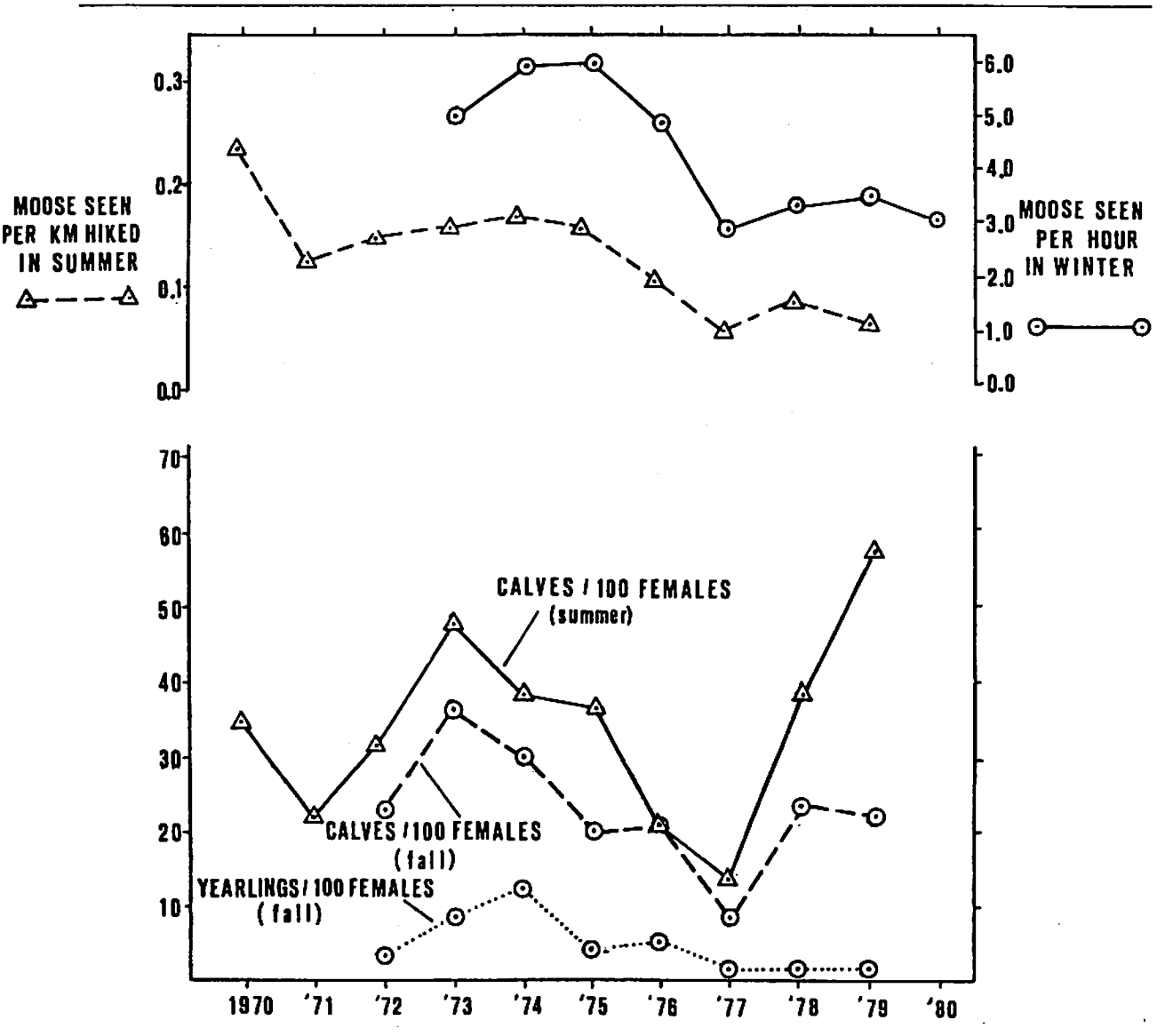


Figure 1. Indices of moose population parameters. (Ground-based observations have triangles; aerial observations have circles.)
Upper graph: Two indices of moose abundance on Isle Royale.
Lower graph: Trends in calf production and survival, 1970-79.

Table 1. Summer (June - August) ground observations of moose on Isle Royale, 1970-79. These include only standardized observations made by wolf-project personnel. Observations made by moose-study personnel are excluded to achieve year-to-year consistency.

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total observed | 160 | 97 | 157 | 176 | 114 | 163 | 123 | 42 | 68 | 88 |
| Males | 58 | 33 | 70 | 67 | 34 | 64 | 46 | 14 | 23 | 32 |
| Females | 74 | 45 | 65 | 71 | 55 | 70 | 60 | 24 | 31 | 33 |
| Calves | 26 | 10 | 20 | 34 | 21 | 26 | 14 | 3 | 12 | 19 |
| Unk. sex (non-calves) | 2 | 9 | 2 | 4 | 4 | 3 | 3 | 1 | 2 | 4 |
| Sex ratio (males/100 females) | 78 | 73 | 108 | 94 | 62 | 91 | 77 | 58 | 74 | 97 |
| Calves per 100 females[1/] | 35 | 22 | 31 | 48 | 38 | 37 | 23 | 13 | 39 | 58 |
| No. sets of twins | 4 | 1 | 2 | 4 | 4 | 1 | 0 | 0 | 2 | 2 |

1/ Includes yearling females, most of which are probably unproductive but which cannot be reliably distinguished from older cows.

Table 2. Autumn aerial composition surveys of Isle Royale moose, 1972-79.

| | Oct. 17-19, 1972 | Oct. 23-25, 1973 | Oct. 22-25, 1974 | Oct. 21-22, 1975 | Oct. 18-20, 1976 | Oct. 18-20, 1977 | Oct. 17-18, 1978 | Oct. 25-26, 1979 |
|---|---|---|---|---|---|---|---|---|
| Total observed | 114 | 192 | 117 | 157 | 120 | 75 | 118 | 250 |
| Adult bulls | 47 | 73 | 43 | 61 | 50 | 29 | 53 | 102 |
| Yearling bulls[1/] | 2 | 8 | 7 | 4 | 3 | 1 | 1 | 2 |
| Cows | 53 | 81 | 51 | 76 | 55 | 41 | 51 | 119 |
| Calves | 12 | 30 | 16 | 16 | 12 | 4 | 11 | 27 |
| Bulls/100 cows | 93 | 100 | 98 | 86 | 96 | 73 | 106 | 87 |
| % Yearlings[2/] | 4 | 10 | 14 | 6 | 6 | 3 | 2 | 2 |
| % Calves | 11 | 16 | 14 | 10 | 10 | 5 | 9 | 11 |
| Calves /100 cows[3/] | 23 | 37 | 31 | 21 | 22 | 10 | 25 | 23 |
| Yearlings/100 cows[3/] | 4 | 10 | 14 | 5 | 6 | 2 | 2 | 2 |

1/ Bulls with spikes or small forked antlers were considered yearlings.
2/ % Yearlings = yearling bulls/(adult bulls + yearling bulls).
3/ Yearling females are included in the total number of cows observed.

For the first time in at least 10 years, over half of the cow moose observed during summer field work were accompanied by calves. Analysis of wolf scats (p. 7 ) indicated that wolves shifted from beaver to a diet of predominantly moose, and by October the calf proportion had dropped to just over 20 calves/100 cows. Wolf predation on calves remains quite high, and it remains to be seen if increased calf production will reverse the downward trend in the moose population. While greater calf production may be the result of higher nutritional plane for pregnant cows, we did find carcasses of 7 moose (including 5 calves) that died of malnutrition in 1979, and bone marrow fat content of 3 calves killed by wolves averaged only 30%.

Since we are able to examine large numbers of moose skeletons each year, we have been interested in any skeletal measurements which provide a quantitative indicator of population performance, especially for the annual cohort of calves. Since 1970 we have collected metatarsi from 8-10-month-old calves,since the metatarsus is most-developed at birth and therefore more sensitive to in utero malnutrition than other leg bones (it is also one of the few bones generally left intact by wolves). Metatarsus length is compared to winter severity in Fig. 2; while these two variables are generally inversely related, there is also tremendous variation within cohorts. In addition, we are collecting data on braincase volume and tooth eruption in calves, in the hope of providing long-term skeletal indices to population condition.

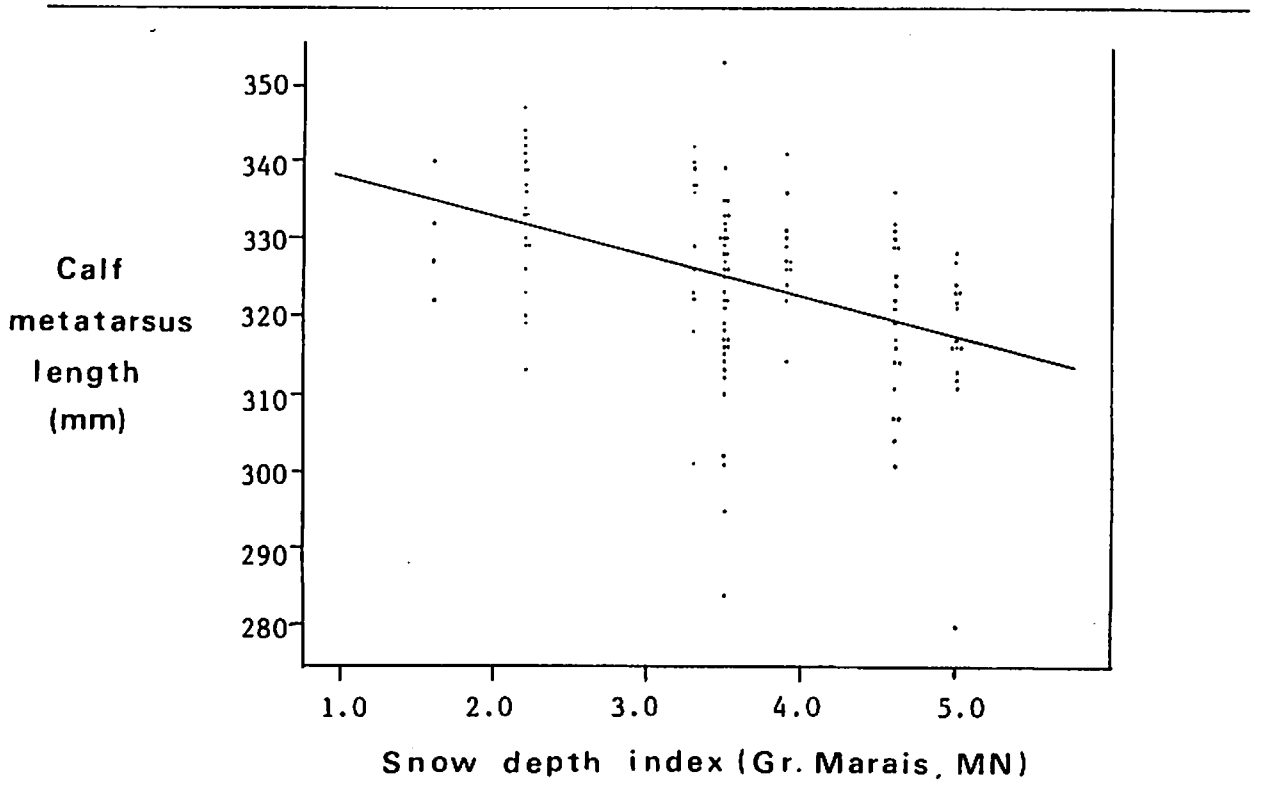


Figure 2. Relationship between Isle Royale calf size and severity of previous winter, determined from an annual snow depth index for Grand Marais, Minnesota. Line represents Y=342.8-5.18X, r=0.41, $P<0.01$. When only annual mean metatarsus length is considered, r=0.87 and $P<0.01$.

During the autumn aerial survey of moose herd composition, we were fortunate to have 95% of Isle Royale covered with up to 8 cm of fresh snow. This produced our largest sample size for an autumn survey in over a decade, with about one-third of the estimated population observed. High moose densities were recorded in traditional wintering areas, and the 1936 burn was sparsely populated, as usual.

Of the250 moose recorded in the fall survey, 69% were in groups. A quarter of the groups consisted of only cow-calf pairs. In groups of two or more adults, 54% were mixed bull-cow, 20% were all females, and the remaining 26% contained only males. Average group size was 2.8 moose (Figure 3).

By mid-September, rutting behavior was conspicuous: on September 14, a bull was seen with a velvetless rack; mounting marks on a cow were noticed on September 19, and courtship behavior noted in a pair of moose on September 23. During the aerial survey on October 25-26, sparring and related activities were still noted in seven groups of 2-3 bulls each.

General observations have suggested that cows with calves may choose small islands as a refuge from wolves, and this was further indicated by the fall survey. The proportion of calves to cows was considerably greater on small islands (63 calves/100 cows) than on the main island (23 calves/100 cows), although the small sample size precluded a statistical test. Cows with calves may remain on islands even in winter, when wolves often gain access over the ice. In February, 1980, 4 cows with single calves were among 14 moose on a 0.4 $mi^2$ plot on Washington Island, and 7 moose on Wright's Island (0.2 $mi^2$) included two cow-calf pairs. A pack of 4 wolves regularly visited Wright's Island in 1980 and eventually killed an adult bull there, but were unable to kill either calf. The cow-calf pairs remained on the island even with the wolves present.

Human settlement may also provide a refuge for cows with calves (at least where not hunted by humans), suggested by the preponderance of cows and proportionately more calves observed around settlements (Fig. 4). Differential habitat selection by various sex and age groups must be evaluated if we are to develop a meaningful moose density index from summer ground observations.

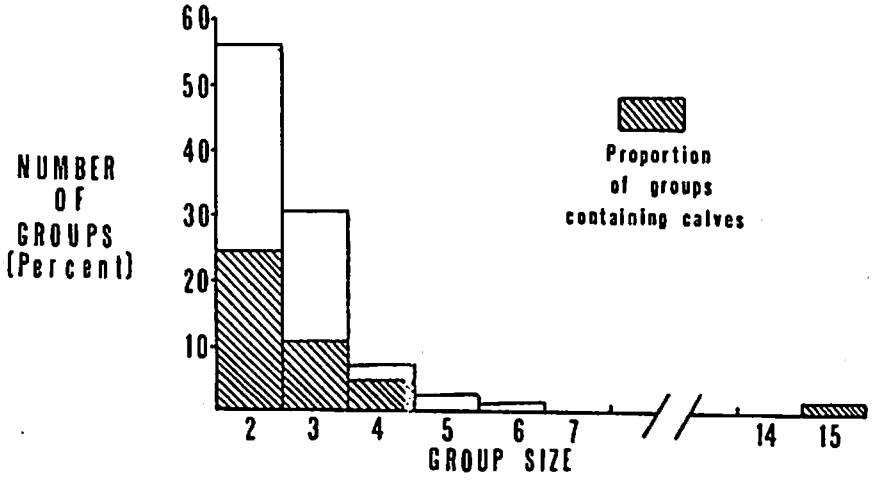


Figure 3. Comparison of the group sizes of moose seen during the fall aerial count, 1979.

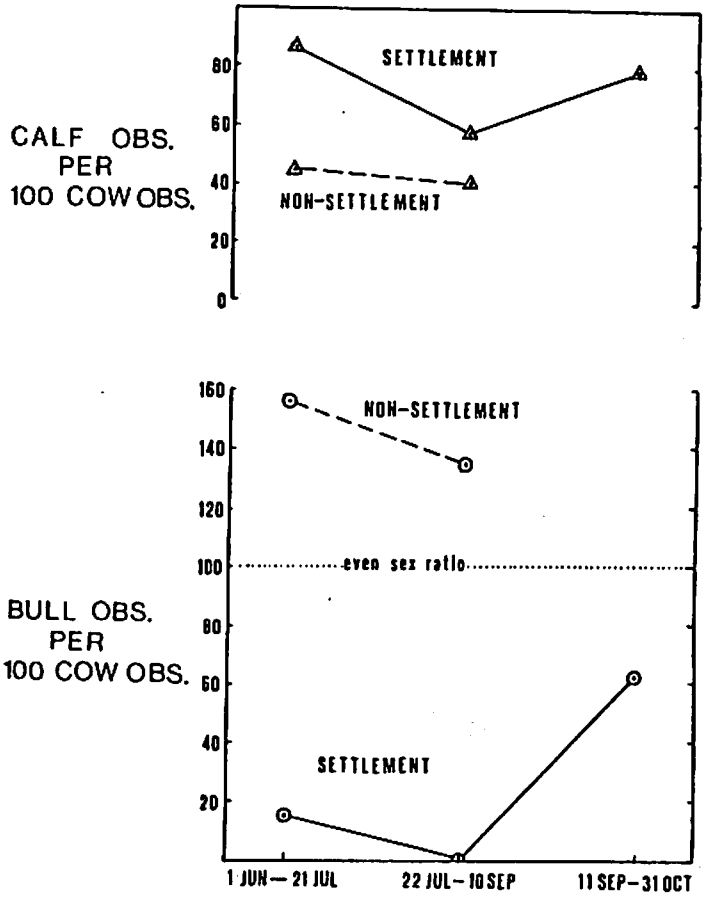


Figure 4. Seasonally changing sex and age ratios. Moose seen within 800 m of buildings occupied in summer are "settlement moose" (most of these were at Windigo). The smallest sample-size for the above ratios is 13.

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## Summer wolf activity, 1979

A minimum of one litter of pups was confirmed for SW, Middle, and East packs, and winter observations indicated at least one additional litter of pups born in 1979. All of the litters were judged to be rather small (maximum 3-4 wolves each) on the basis of howling responses. One den and six rendezvous sites were located in 1979 (two of these sites had been used in previous years).

Wolf food habits (determined from scat analysis) indicated that wolves switched to a predominantly moose diet in summer, 1979, after several years of heavy reliance on beaver (Fig. 5). P.C. Shelton's work, briefly summarized in last year's report, indicated that the number of established beaver colonies declined by 50% between 1974 and 1978.

If wolf pups are well-fed during their first six months of life, they resemble adults during aerial observations in winter. Growth retardation was evident among 1979 pups in at least two packs (SW and Harvey L.), since the pups could be readily distinguished from adults.

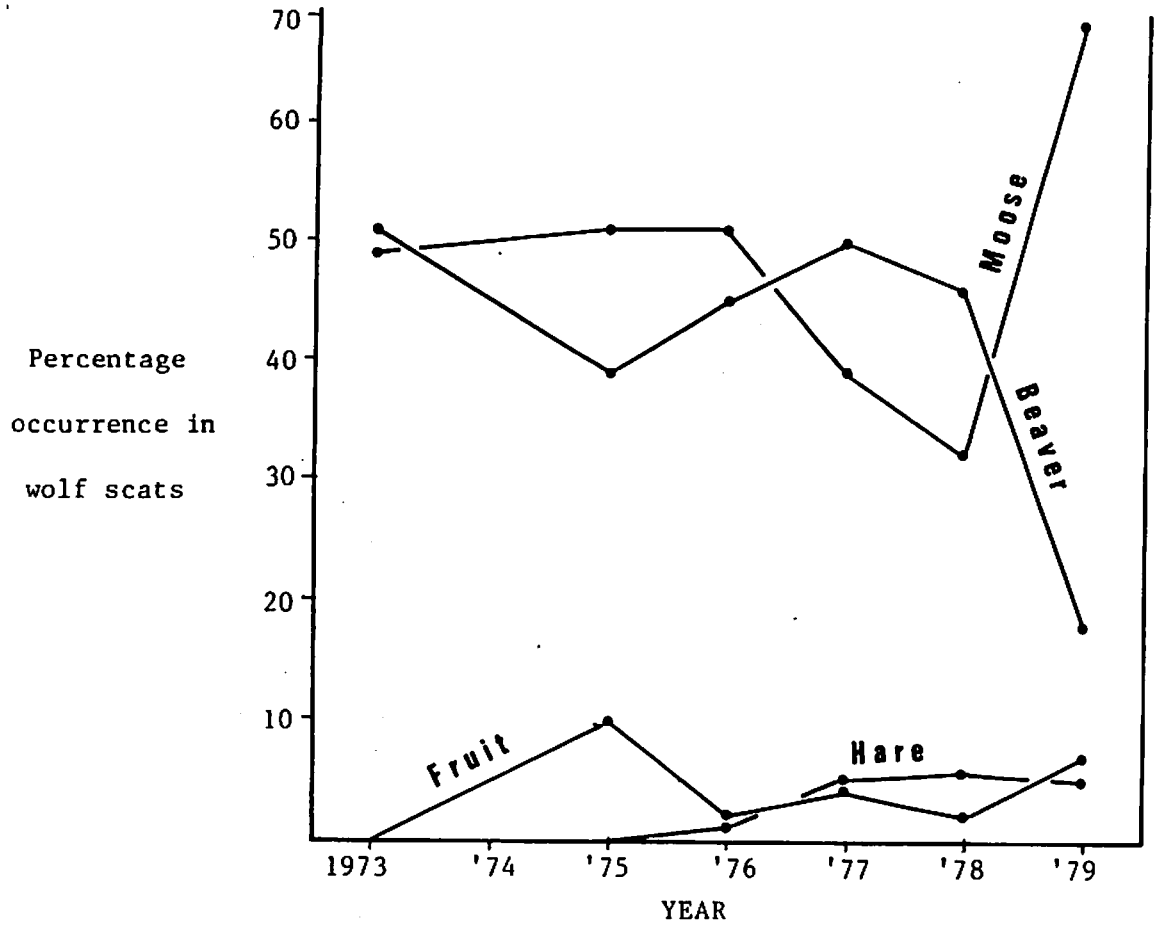


Figure 5. Trends in summer food supply of Isle Royale wolves.

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Although wolves have been totally protected during their entire 30-year history on Isle Royale, they continue to show marked avoidance of man, and are rarely seen by the thousands of back-country visitors to Isle Royale each summer. The National Park Service wants to maintain avoidance behavior in Isle Royale wolves and avoid the problems associated with carnivores that become habituated to humans. Wolves on Isle Royale usually choose to raise their young at least 0.5 miles from significant human activity. Avoidance behavior is well-developed in Isle Royale wolves by the age of 4-5 months, and we believe separation of pups from humans is critical to the development of fear toward humans. As shown in Fig. 6, less than half of Isle Royale's land area is more than 0.5 miles from established human activity in summer. Park management recognizes that expansion of park development (especially the trail system) cannot be accomplished without a reduction in the security level for wolves which now exists.

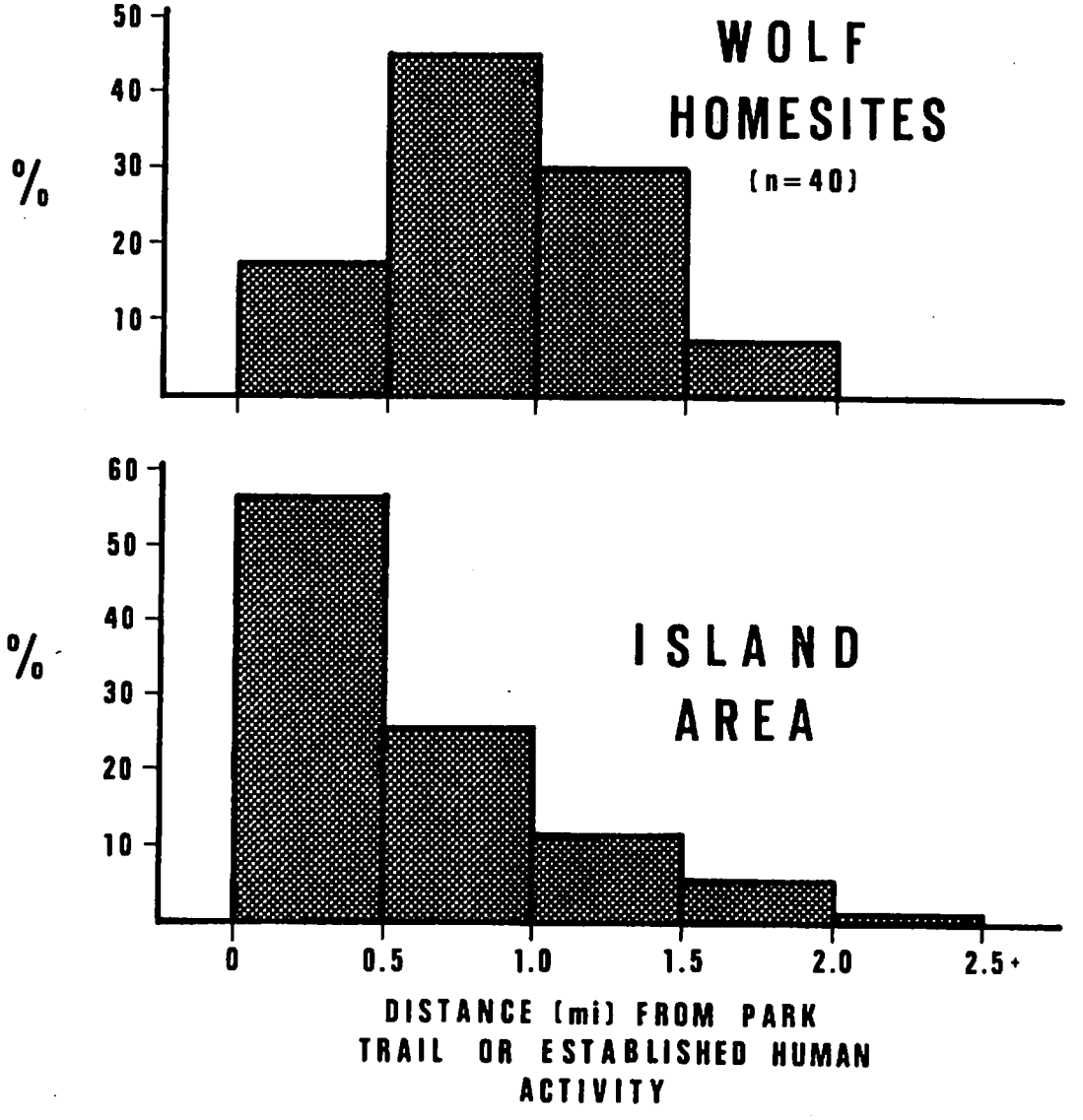



Figure 6. Distribution of Isle Royale wolf homesites (dens and rendezvous sites) in relation to human activity.

## WINTER FIELD WORK, 1980

Temperatures during the 1980 winter study period were near normal, with snow accumulation somewhat less than usual. The early part of the winter had been quite mild with little snow, and very little ice had formed around the periphery of Isle Royale. A solid ice bridge never formed to the mainland. Average daily minimum and maximum temperatures for the study period were 2.5 deg.F. and 20.8 deg.F., respectively. Flying was generally good, except for the first week of continual light snow off the open lake and a 9-day period of bad weather in February; we flew on 27 out of 46 days for a total of 106 hours.

### Wolf population, 1980

An all-time high population of 50 wolves was recorded on Isle Royale in 1980 (Fig. 7), or a density of 1 wolf/4.2 $mi^2$ (10.9 $km^2$). The Middle and Southwest packs spent most of their time in traditional pack territories. The East Pack utilized about 2/3 of their usual range, with the remainder occupied by two new groups of four wolves each, the Harvey L. pack and the NE4. The Harvey L. pack consisted of an adult pair and 2 rather small pups, and occupied an area which had been used extensively by the Middle Pack in 1979 but which was traditionally East Pack territory. The other pack of four (NE4) included one old-appearing wolf with a lame leg, but we could not determine if any in this group were pups.

It is very likely that the new groups arose from non-territorial groups of two and three wolves observed in 1979, groups which were thought to represent the splintered West Pack of former years. Both of the new packs exhibited territorial behavior (scent-marking), and there was relatively little spatial overlap between packs (Fig. 8).

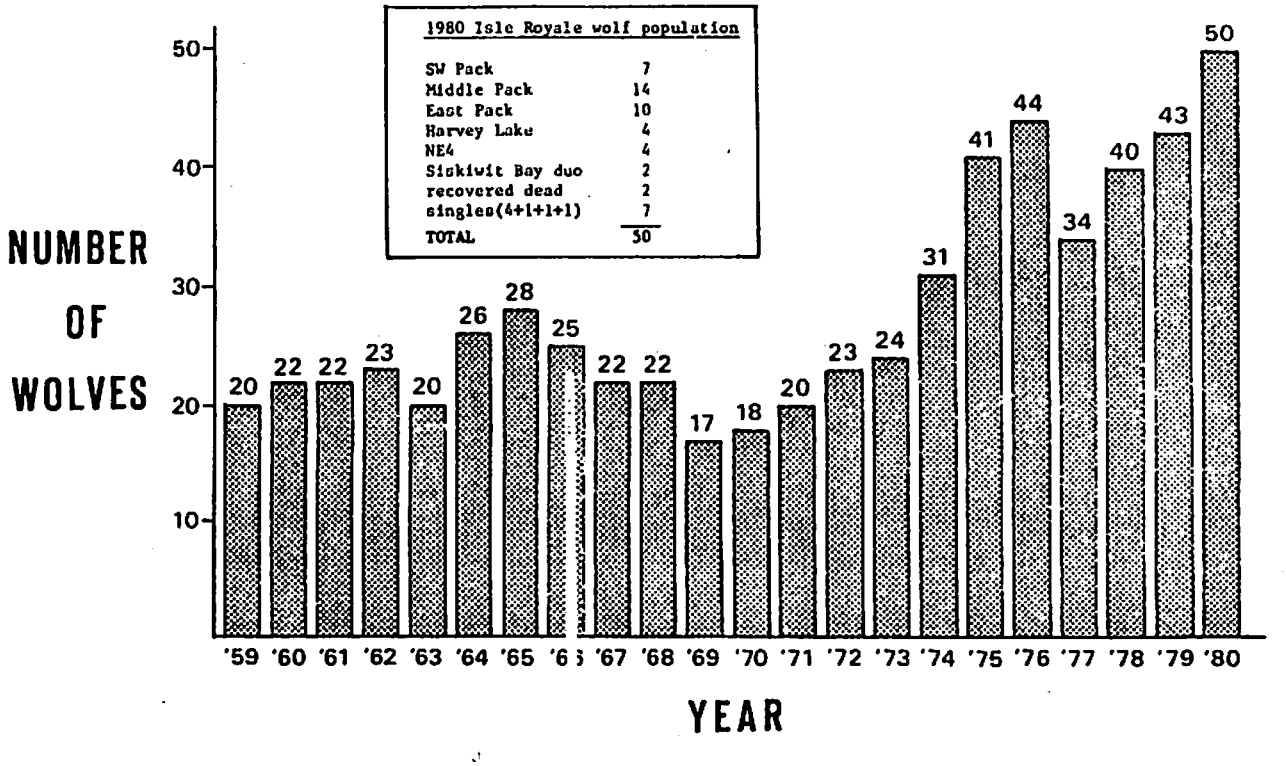



Figure 7. Midwinter wolf population level, Isle Royale National Park.

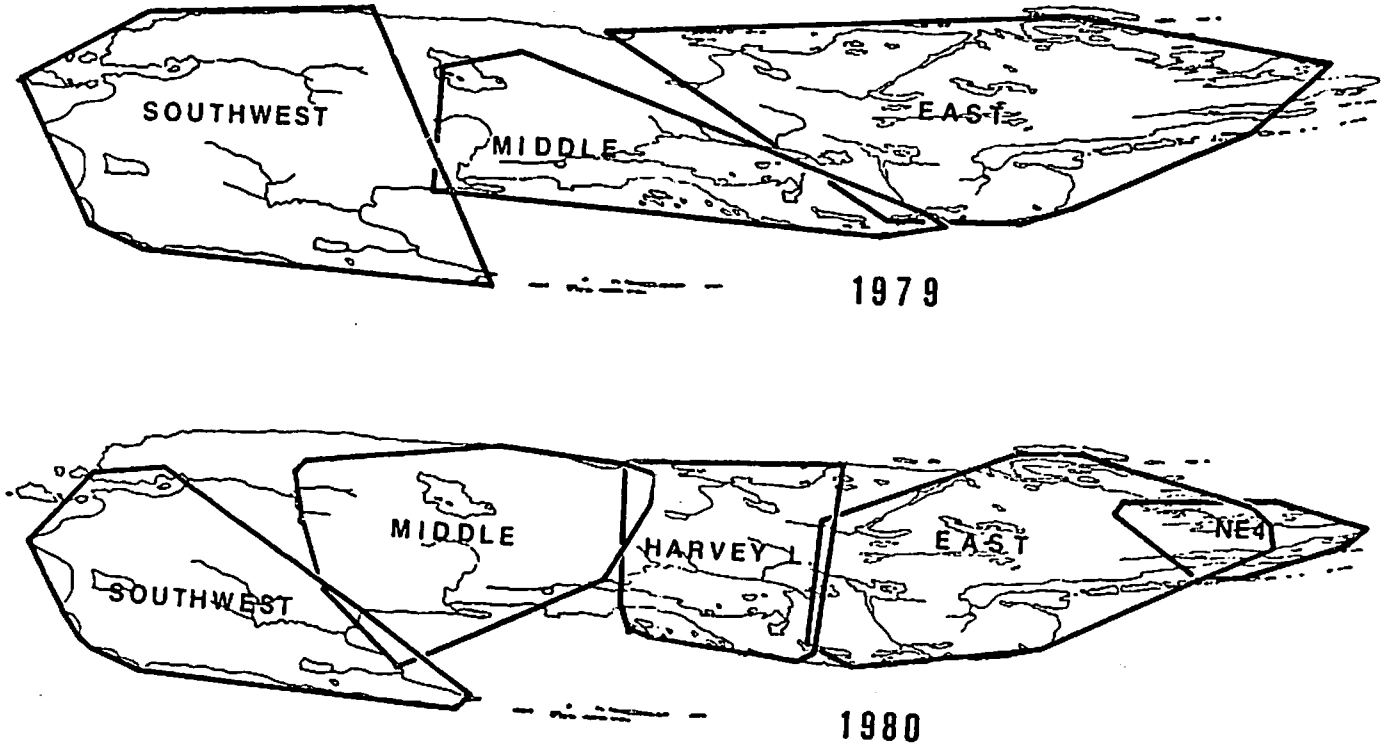



Figure 8. Extent of movements of Isle Royale wolf packs in winter, 1979-80.

Figure 9. Alpha female (upper left) in East Pack, February, 1980. This wolf has held a dominant position throughout the history of this pack, and is now at least 10 years old.

In addition to the 39 members of recognized packs, there were 11 wolves existing as loners, or in small, transient groups without a territory. Up to 3-4 of these wolves existed temporarily in a group, but they did not seem to occupy any territory nor did the group remain intact. Future trends in the wolf population will depend critically on how the newly-established packs fare, and also whether or not additional pairs form and are able to somehow carve out a territory of their own. During our last flight on Mar. 7, we observed two recently-formed pairs, each on a fresh kill in East Pack territory. Tracks of a pair were also regularly seen near Siskiwit Bay (SW Pack territory).

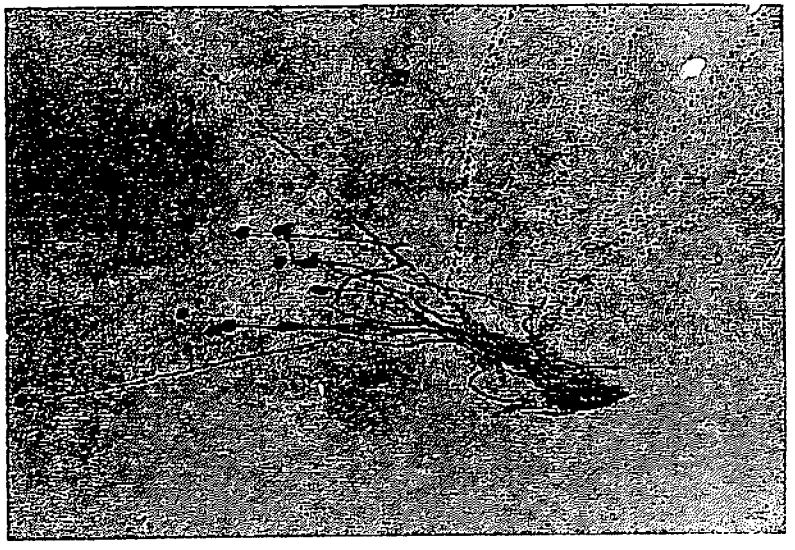
Actual copulation was not observed in 1980, although courtship behavior was noted in the three large packs. The old alpha female in the East Pack was actively courted by a new alpha male, the fourth in a succession of mates. This female has been recognized each year since 1972, has outlived three alpha males, and is now at least 10 years old (Figure 9).

We determined that at least three pups were present in the SW Pack of seven wolves and the Harvey L. Pack of four included two pups. These five pups were readily distinguished by their smaller size. The East Pack and Middle Pack probably also contained pups, but they could not be distinguished from adults.

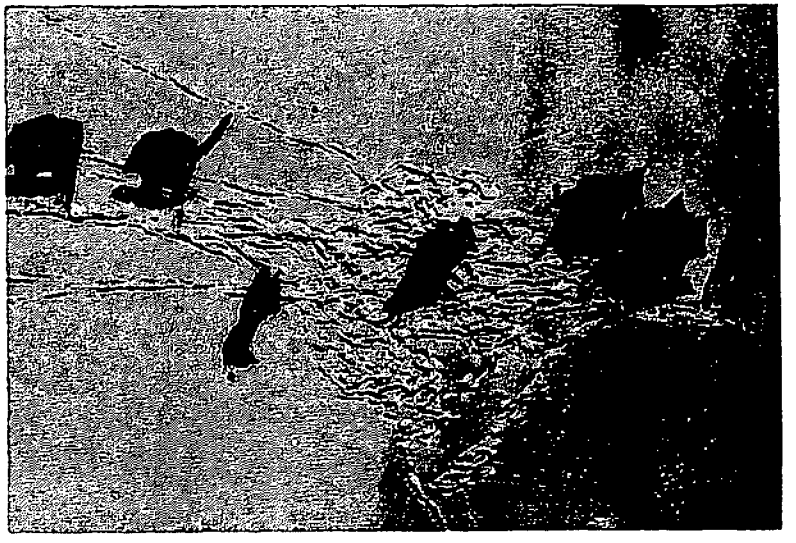
Carcasses of two wolves (included in the total of 50) were recovered in Feb. 1980. The first (aut.#1516) was an old male killed by other wolves near Siskiwit Bay. When found, the carcass was being guarded closely by another wolf from 4 foxes and a flock of ravens, and two additional wolves rested 100m away. While this occurred within SW Pack territory, we did not determine which wolves were responsible for the kill. The dead wolf was missing 5 of its 12 incisors and had one broken canine, but was in good condition (bone marrow fat content of 62% with considerable body fat).

The second dead wolf (aut.# 1521) was recovered a few days after we observed the East Pack attack a lone wolf on Angleworm Lake (Fig. 10). We first found the East Pack resting near the outstretched form of the loner, which we presumed to be dead. After several minutes, however, the loner suddenly arose and began running for shore; this brought the East Pack on a run, and they renewed their attack on the highly submissive wolf. The loner appeared to be bitten several times while lying on its back, but was allowed to arise again and take refuge in a thicket on the lakeshore, and shortly thereafter the pack left. The alpha female took little part in the attack, so we suspect that the loner was a male. After the East Pack departed, we landed and found the loner still hiding near shore. It walked off in a very submissive posture, but without obvious injuries.

Five days later we found a wolf that had just died near a moose-kill on Five-Finger Bay, 9 miles from the earlier attack. The dead wolf closely resembled the loner that had been attacked, but possessed no unique body markings to confirm identity. This was also an old male, suffering from malnutrition (bone marrow fat content of 10% and virtually no body fat) and a variety of ailments. The immediate cause of death seemed to be a chest injury caused by a freshly-broken rib; the adjacent lung tissue had a large clotted area, and the wolf had coughed up and swallowed



(a)



(b)

(c)

(d)

Figure 10. (a) East Pack resting next to loner after initial attack, Angleworm L., 2/2/80. (b) Pack members renew their attack on lone wolf; alpha female (raised tail, upper left) leaves scene. (c) Pack member biting lone wolf as it attempts to leave. (d) Pilot D. Glaser and dead wolf (aut. #1521) found five days after the observed attack.

considerable blood. The wolf had three broken and heavily worn canines, was missing 8 of its 12 incisors and both upper first molars, and suffered periodontal infections at three sites. Nine ribs had been broken 12 times and subsequently healed, and old fractures of the scapula and nose were evident, along with 3 arthritic vertebral joints. A rabies check was negative, and no attempts at viral isolation were successful. The only tissue abnormality described was chronic fibrotic hepatitis, diagnosed by Dr. J. Studt, Michigan DNR wildlife pathologist. Its intestinal track contained several meters of long tapeworms (Taenia sp.) as well as hundreds of Echinococcus granulosus.

## Moose population, 1980

In addition to an aerial census of moose in winter using stratified sampling and intensive circling over small plots to determine moose density, we are trying to refine other indices of moose abundance which may be accurate indicators of annual variation. Two indices which appear promising are presented in Fig. 11. Although it is not possible to completely validate these indices with precise censuses, the high degree of correlation between these indices over the past seven years is encouraging.

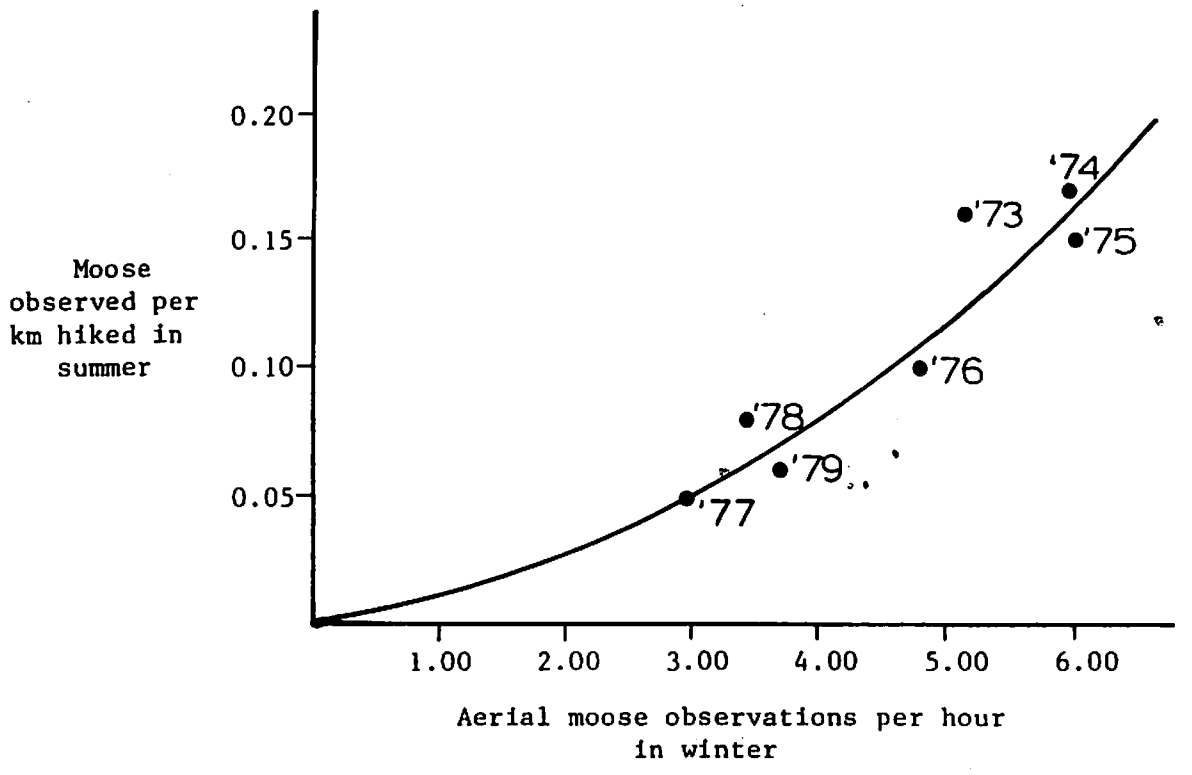



Figure 11. Relationship between two independent indices of moose density on Isle Royale, 1973-79. Line represents $Y=0.008X^{1.67}$, $r=0.95$, $P<0.01$.

The 1980 aerial census of moose is summarized in Table 3 and Figure 12, along with the 1979 results for comparison. While this year's island estimate of 664 moose is some 20% lower than last year's estimate of 826, confidence intervals for the estimate were so large that the two estimates are not significantly different. The 95% confidence interval for the 1979 estimate was ±24% (not 16%, as stated in last year's report), and in 1980 this interval was ±28%. Other indices suggest that the population declined, but not as much as 20%: the actual number of moose observed on the same plots in 1980 dropped only 3% from the 1979 figure (the differences between the census results arose largely from stratification changes), while the number of moose seen/hour in winter declined 16% from 1979 to 1980. Thus, the moose population currently seems to be slowly declining, with 650-700 moose present.

More effort was spent in 1980 in dividing the island into different strata of relative moose density, based on moose track abundance. While the high density areas in 1980 were largely unchanged from 1979, low density strata included a higher proportion of the island in 1980. It appears that we could lower sampling variance by increasing the intensity of coverage of the high-density stratum while reducing our coverage of low density strata, so future censuses will be re-designed accordingly.

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Table 3. Aerial censuses of Isle Royale moose in midwinter, 1979-80.

1979

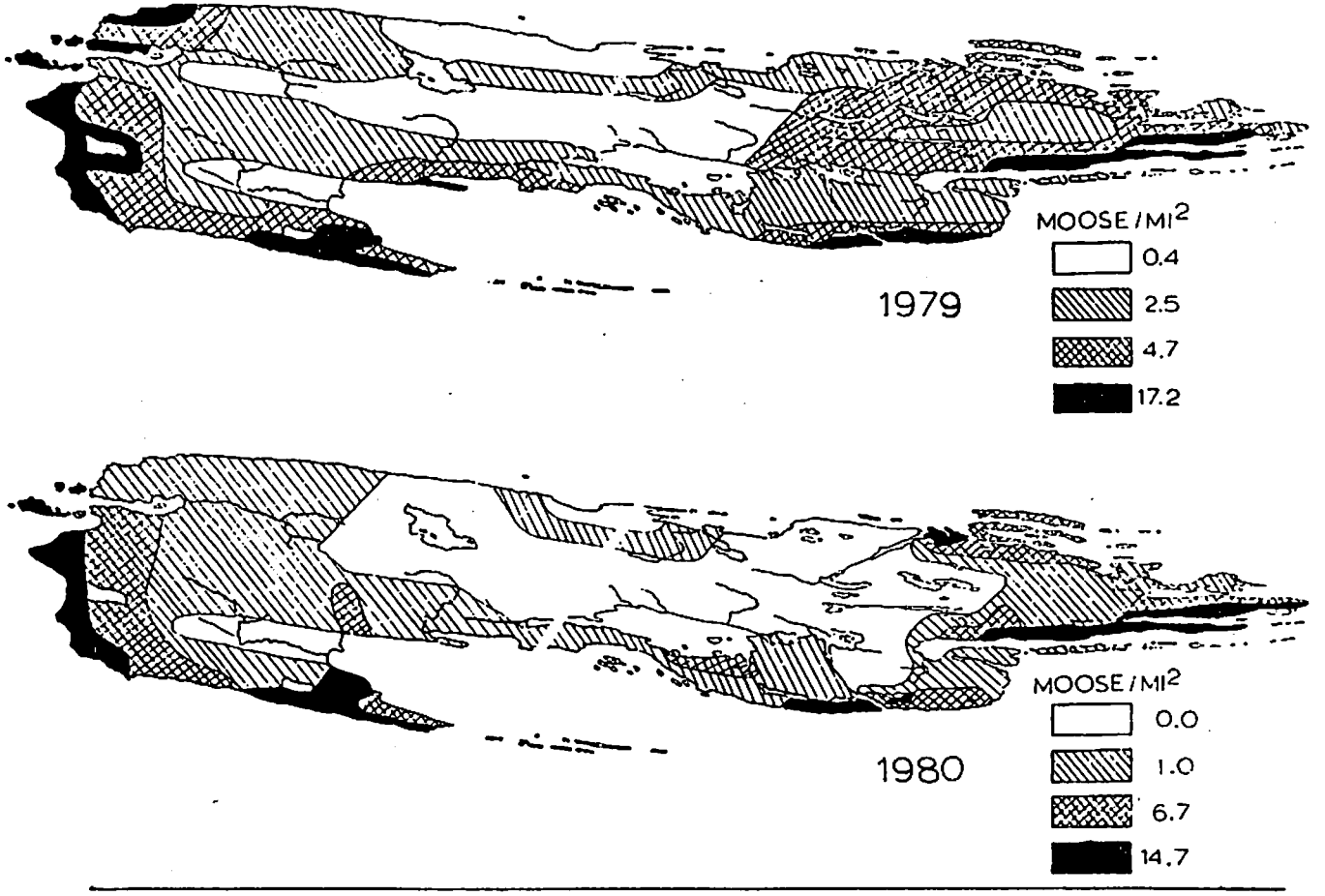
| Zone | Area($mi^2$) | No. of plots | Proportion of zone counted | Moose counted | Flying intensity ($min/mi^2$) | Moose per $mi^2$ | Estimated total from direct count | Assumed sightability | Adjusted total |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 47.5 | 12 | 11.6% | 2 | 29.3 | 0.36 | 17 | 95% | 18 |
| 1 | 88.1 | 26 | 12.7% | 26 | 33.2 | 2.33 | 205 | 95% | 216 |
| 2 | 56.7 | 19 | 13.4% | 32 | 40.8 | 4.22 | 239 | 90% | 266 |
| 3 | 18.9 | 13 | 25.9% | 69 | 50.5 | 14.65 | 277 | 85% | 326 |
| Whole island | 211.2 | 70 | 13.8% | 129 | 37.3 | 3.50 | 738 | 89% | 826 |

1980*

| Zone | Area($mi^2$) | No. of plots | Proportion of zone counted | Moose counted | Flying intensity ($min/mi^2$) | Moose per $mi^2$ | Estimated total from direct count | Assumed sightability | Adjusted total |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 79.2 | 13 | 7.5% | 0 | 23.1 | 0.00 | 0 | 85% | 0 |
| 1 | 87.6 | 28 | 13.2% | 12 | 30.8 | 1.03 | 90 | 85% | 106 |
| 2 | 25.6 | 18 | 26.9% | 46 | 37.4 | 6.68 | 171 | 85% | 201 |
| 3 | 18.3 | 12 | 25.0% | 67 | 44.6 | 14.66 | 268 | 75% | 357 |
| Whole island | 210.7 | 71 | 13.8% | 125 | 33.0 | 2.51 | 529 | 79% | 664 |

*Assumed sightability was lower in 1980 because of less favorable snow conditions and use of an observer with less experience. The same pilot and aircraft type were used in both years.

Figure 12. Midwinter distribution of moose on Isle Royale, 1979 and 1980.




## Wolf-moose relationships

During summer field work in 1979 we completed ground-examinations of all moose carcasses located during the previous winter study. The age distribution of moose killed by wolves in 1979 is presented in Table 4. While in 1978 predation on calves dropped to an all-time low because so few calves were present, in 1979 calves comprised 38% of winter wolf-kills, near the long-term average of 35%. In addition to calves, wolves relied once again on old adult moose. Food availability for wolves during the 1979 winter study was relatively low, with the East Pack doing somewhat better than other packs (Fig. 13).

During the past two winters, Isle Royale packs have traveled somewhat less each day than average, but considerably farther between kills. Long-term travel and kill records have been updated and are summarized in Table 5. The declining level of wolf predation in winter is also evident in Table 6, which shows the island-wide predation loss. While the wolf population has remained high, just reaching its highest point this year, the level of predation loss has now dropped to about 2/3 the peak level observed in 1976 and 1977.

Table 4. Age distribution of wolf-killed moose, winter 1979.

| Age | Calf | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | 10+ | 11+ | 12+ | 13+ | 14+ | 15+ | 16+ | 17+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | 19 | - | - | - | - | - | - | 1 | 1 | 2 | - | 3 | 8 | 5 | 4 | 2 | - | 2 | 51(including 3 adults of unknown age) |

Table 5. Composite Isle Royale wolf pack, summarized from data on 23 wolf packs studied during 1971-1980*.

| | All packs, 1971-80 | Sample size |
|---|---|---|
| Average pack size | 10.5 wolves | 23 packs over 10 years |
| Average travel in midwinter | 6.4 mi/day | 4526 mi in 702 pack-days |
| Average kill rates (moose) | 1 kill/4.3 days | 218 kills in 942 pack-days |
| Average amount of travel between kills | 21.8 mi | 183 kills/3995 mi |
| Average proportion of calves among wolf-killed moose | 35% | 199 kills |

*These data were compiled during January, February, and March, and can be safely applied only for the winter period. They are probably realistic data for the period November-April. Wolf-caused mortality rates for adult moose on Isle Royale are about 12 times higher in winter than in summer, based on antler development in all skeletons examined (Peterson 1977).

Table 6. Island-wide predation rate in midwinter, 1976-80.

| Year | No. kills | No. days coverage | No. kills per day |
|---|---|---|---|
| 1976 | 51 | 48 | 1.1 |
| 1977 | 39 | 40 | 1.0 |
| 1978 | 26 | 42 | 0.6 |
| 1979 | 30 | 44 | 0.7 |
| 1980 | 28* | 50 | 0.6 |

*Coverage of the SW Pack was incomplete during the 1980 study period. The kill rate for SW Pack, determined over 27 days, was projected to 50 days, resulting in the addition of 3 kills to the number actually found over the 50-day period.

The distribution of moose carcasses located in 1980 is shown in Fig. 14. Wolf-kills were generally further inland than usual, probably due to relatively low snow depths and favorable travel conditions for wolves.

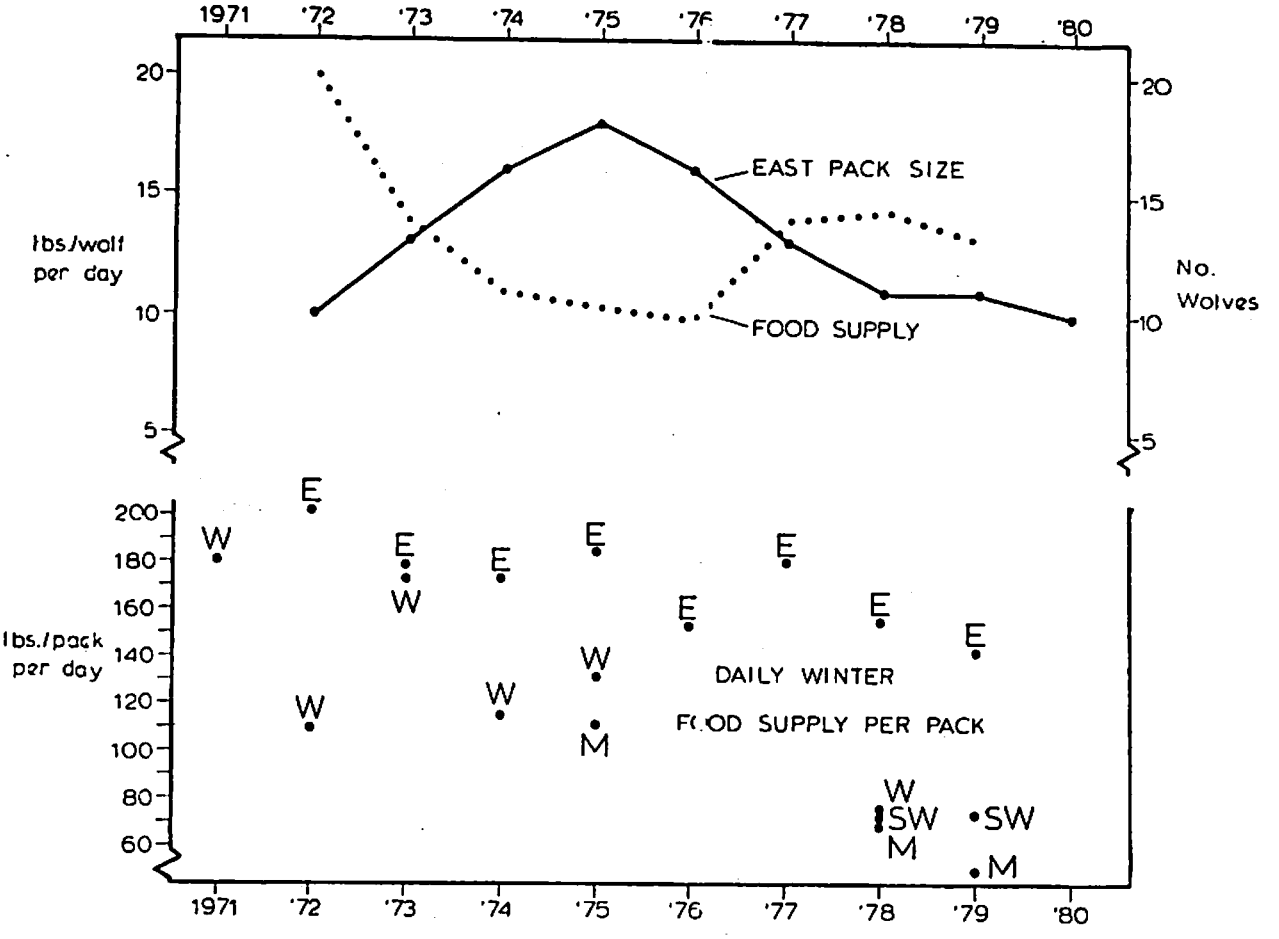



Figure 13. Upper graph: East Pack size and food availability per wolf, 1972-80. Lower graph: Predation rate as indicated by food availability per pack. E=East Pack, W=West Pack, M=Middle Pack, SW=Southwest Pack.

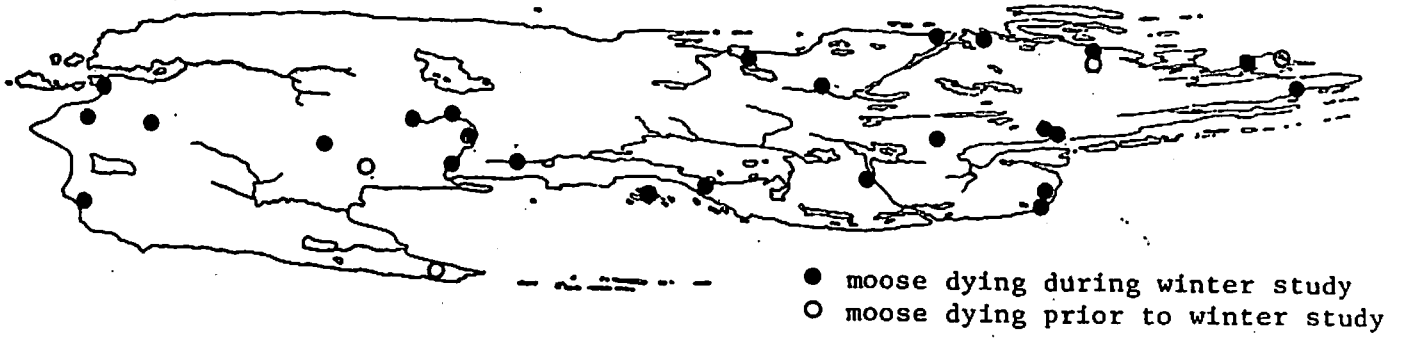



Figure 14. Distribution of moose carcasses located by aerial search in 1980.

## Snow conditions, 1980

Snow depths ranged from 20-45 cm when we arrived on Isle Royale, and varied with overhead canopy. There were no major thaws during the winter period, and a total of 44 cm (water content 1.7 cm) produced a slight increase in the snowpack during our stay. Snow depths ranged from 30 to 55 cm by early March. New-fallen snow had a density of 0.04, while the total snow profile averaged 0.23.

In mid-January the region experienced a thaw which produced an icy surface layer capable of supporting a human on snowshoes or skis, foxes, and smaller species. Vertical crust strenth varied between 100 and 600 $g/cm^2$. Wolves did not receive consistent support when walking on this crust, but had access to most parts of the island on well-used trails. Running wolves consistently broke through the crust and were thus hampered considerably, while moose could readily escape. The crust did not have any obvious effect on moose distribution, although blood seen in one set of fresh moose tracks indicated the abrasiveness of the crust.

## OTHER WILDLIFE SPECIES

Observations of foxes unassociated with moose carcasses were exceptionally frequent in 1980 (Fig. 15). The combination of unlimited mobility for foxes along with an abundant snowshoe hare population and mountain ash (Sorbus) fruit crop produced a widely dispersed pattern of fox distribution. Snowshoe hares seem to be more abundant now than at any time in the past decade, and it is quite possible that a real increase in the fox population has occurred.

Otter tracks were observed at five sites in 1980, and beaver sign noted at six colonies (winter). Lone wolves and small packs spent much time hunting beaver at a couple locations, especially Lake Whittlesey and the drainage SW of Duncan Bay. At least three beavers were killed at these sites during the winter.

One lynx was observed at close range by summer field assistant Mark Cramer in 1979 on Feldtman Ridge, just two days after a lynx had been reported at Tobin Harbor, at the opposite end of the island. It has been 10 years since project personnel last observed a lynx, although scattered reports have been made by others in the intervening period. The excellent ice bridge early in 1979 could have provided an excellent avenue for dispersing lynx to reach the island, and the relatively abundant snowshoe hare population may enable lynx to re-establish themselves.

In spite of constant open water around Isle Royale in 1980, no gulls or ducks were observed during the seven-week winter study. Common winter birds included ravens, black-capped chickadees, pine siskins, and gray jays, with occasional pileated woodpeckers, flocks of evening grosbeaks, and one American three-toed woodpecker. No eagles were observed during the winter study, and no eagle or osprey nests were observed during summer field work in 1979.

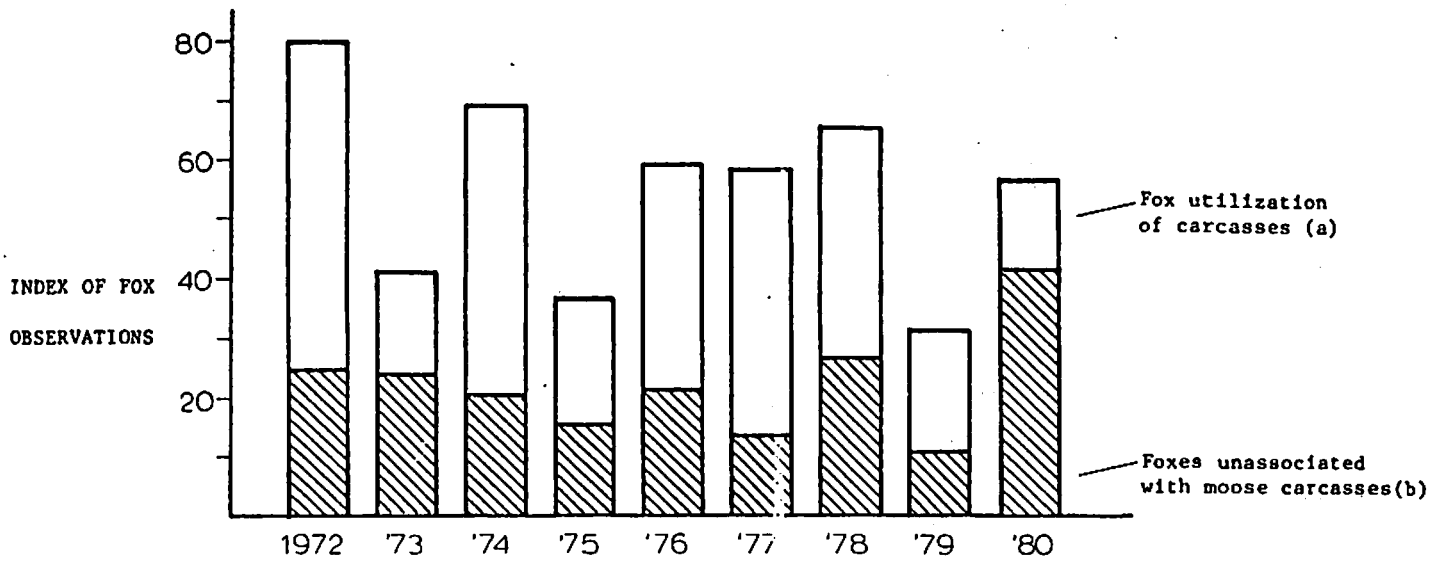



Figure 15. Midwinter fox observations, 1972-80. (a) is the sum of the maximum number of foxes seen on each moose carcass, (b) other fox observations per 100 hours of flying (more than 1 km from a moose carcass).