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PREFACE

This publication on wolf numbers is based on an intensive, continuing study of the spatial organization and population-regulating factors of wolves in the Superior National Forest. The details of spacing and population regulation will be the subject of an extensive report, now being prepared.

Meanwhile, it was deemed worthwhile to publish this shorter paper to provide the scientific community, wildlife and forest administrators, and the general public with one of the important fruits of this research, an estimate of the number of wolves in the Superior National Forest.

WOLF NUMBERS IN THE SUPERIOR NATIONAL FOREST OF MINNESOTA

L. David Mech

The purpose of this paper is to present an estimate of the number of eastern timber wolves (*Canis lupus lycaon*) inhabiting the Superior National Forest of northeastern Minnesota. Such an estimate is important because: (1) the main population of this subspecies of wolf in the United States occurs in Minnesota, with probably fewer than 50 other individuals remaining elsewhere in this country (Mech 1970), and therefore, the subspecies has been declared "endangered" by the U.S. Secretary of the Interior;[1/] (2) the ecologically sound management of the wolf depends at least partly on knowledge of wolf numbers, densities, and population trends; (3) the Superior National Forest harbors a significant part of the total wolf population of Minnesota; and (4) the 3,000 square miles of federally owned land contained within the Forest boundaries represents a large part of wolf range under public control.

Accurate estimates of wolf populations are difficult to make because the animals are elusive, they occur in relatively low densities, and they travel over large areas. Therefore, the few estimates of wolf numbers that have been made anywhere have varied greatly in precision and area covered.

Outside of the Superior National Forest, reasonably accurate censuses have been conducted on Isle Royale in Lake Superior, in certain regions of Alaska, and in Algonquin Park, Ontario. All of these censuses used small aircraft during winter and relied on visual tracking and observation of wolves and attempts at identifying individual packs.

On Isle Royale's 210 square miles, researchers estimated wolf populations at between 15 and 28 from 1959 through 1970, based on attempts at complete counts (Mech 1966, Jordan et al. 1967, Wolfe and Allen (in press)). On 20,000 square miles of south-central Alaska, wolf estimates varied from 12 to 450 during the period 1953 through 1967 based on transect sampling, with the variation thought to reflect actual population changes (Rausch 1969). In Algonquin Park, wolf numbers were estimated at about 290 in 2,900 square miles from 1958 to 1962 as projected from an intensive sampling of 500 to 1,000 square miles (Pimlott et al. 1969). In all three cases, hundreds of hours of flying were involved in obtaining the estimates.

The first attempt to estimate wolf numbers on the Superior National Forest was made by Olson in 1938. Based on his extensive travels throughout the Forest and interviews with trappers, game wardens, and rangers, he subjectively estimated a wolf density of one wolf per 10 square miles for some 2,500 square miles of wilderness on the Forest.

The next estimate was made by Stenlund (1955) for the period 1948 to 1953. Using subjective observations supplied by warden-pilots, private pilots, and trappers, he judged that the population was between 205 and 273 wolves, with the mean about 240, on 4,100 square miles of the Forest, or one wolf per 17 square miles.

From 1964 through mid-1969, Mech and Frenzel (1971) conducted a series of studies in the Forest that depended primarily upon aerial observations of wolves, tracks, and kills and included the aerial tracking of five radio-tagged wolves. Besides the 319 locations we obtained through studying the five radioed wolves and their associates, we also saw a total of 323 wolves (no doubt many of them duplicate sightings) during 77 separate observations. Some 490 hours of flying were involved in those studies.

Although at that time we were unable to estimate the wolf population on the Forest, we did compare our observations with the 112 observations of 318 wolves summarized by Stenlund (1955) and concluded that the wolf population of the Forest probably had increased between 1953 and 1967, but that it apparently had remained stable between 1967 and early 1969.

While these studies were being expanded, Van Ballenberghe (1972) also conducted a study of the wolves of the Forest from 1969 through early 1972. He too used radio-tracking as a primary technique. During his last 2 years he concentrated on a 1,006-square-mile area of the Forest adjacent to Lake Superior. As will be discussed in detail later, he defined 11 packs containing 79 members occupying an estimated 720 square miles, for an average density of one wolf per 9.1 square miles.

1/ This subspecies of wolf is still common throughout eastern Canada and is not considered endangered there. In addition, several other subspecies of wolves inhabit western and northern Canada and Alaska, where they are not considered threatened.

THE PRESENT STUDY

The present study is basically a continuation and expansion of the earlier investigations by Mech and Frenzel (1971) and includes data collected through June 30, 1973. The area studied is the entire Superior National Forest (exclusive of the separate Virginia District), with the most intensive work being conducted in the central region of the Forest. (See Stenlund (1955) and Mech and Frenzel (1971) for a description of the area.) The Forest, outside of the Virginia District, encompasses a total of 4,203 square miles, about 3,000 of which are federally owned.

The area studied intensively for the present population estimate is an irregular-shaped, 1,005-square-mile region that extends from Lake Vermilion on the west to Fourmile Lake on the east, with the town of Isabella on the south boundary, and the Canadian border on the north (fig. 1). About half this region is in the Boundary Waters Canoe Area (BWCA), with about 20 percent in the zone where no timber cutting is allowed. Densities of deer (*Odocoileus virginianus*), the wolf's primary prey, on this basic census area, range from the lowest to nearly the highest on the Forest. Moose (*Alces alces*), a secondary food source, occur throughout the area in various densities, including the highest density known for the Forest (Peek 1971).

METHODS

The methods used in this study include (1) live-trapping wolves, extracting blood samples from them, and examining, weighing, radio-tagging them (Kolenosky and Johnston 1967), and radio-tracking them from the air and ground as described by Mech and Frenzel (1971); (2) directly observing radio-tagged individuals and their associates from the air whenever possible; (3) determining the ranges, territories, movements, and interactions of packs and lone wolves; (4) determining the actual density of pack wolves in the intensive census area by direct counting of pack animals; (5) observing tracks and nonradioed wolves on the basic census area and on the rest of the Forest and compiling the observations of wolves and tracks reported systematically by other workers on the

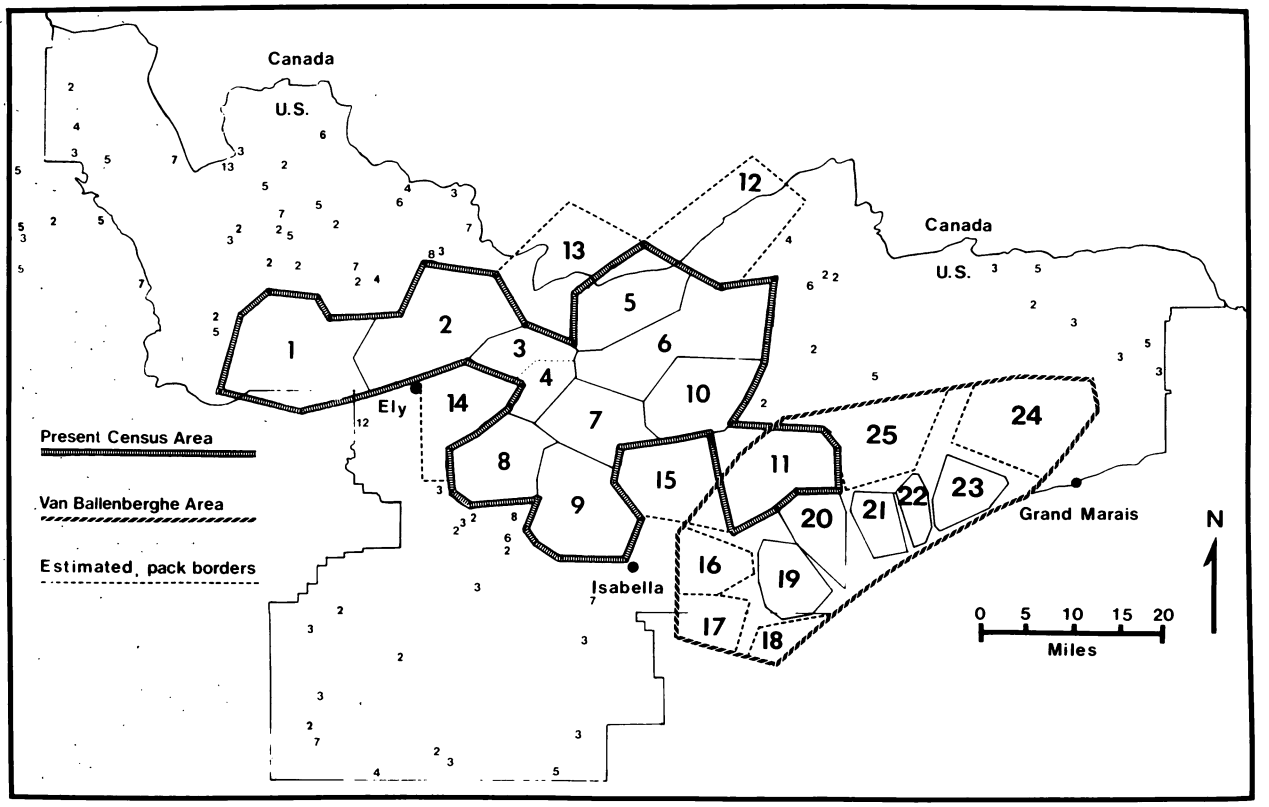

Figure 1.--The Superior National Forest study area. Large numerals identify wolf packs (table 3), and lines around them indicate approximate pack territory borders. Small numerals represent the sizes of packs or their tracks observed outside of the intensive census areas (lone wolves not plotted).

Forest; (6) applying an adjustment factor to account for lone wolves and pairs; (7) projecting the density figures for the basic census area to the entire Forest, with adjustment of the estimate in certain areas to account for unusual circumstances not significant in the basic census area.

RESULTS

Data used in the present investigations include those reported in the pilot study by Mech and Frenzel (1971) plus more substantial data collected since then. The author and his assistants flew for approximately 1,600 hours during the study, and radio-tagged a total of 77 wolves on the Forest, six of them twice. The transmitter-collars (Mech and Frenzel 1971) have functioned as long as 20 months on wolves, including one operating since November 4, 1971 and still going. More than half (43) of the radioed wolves were located over periods of at least 4 months each, and 38 percent (28) for at least 6 months each. Radioed wolves followed for shorter periods were those that dispersed out of range, died, were killed, or on which transmitter-collars failed. I located wolves by radio over 3,000 times and actually observed them on 1,337 occasions, or 41 percent of the time (table 1).

Table 1.--*Seasonal distribution of radio locations and observations of wolves, 1968-1973 (as of June 30, 1973)*

Wolves		Radio locations:	Radioed wolves actually observed	
	Number	Number	Number	Percent
January	44	389	231	59
February	41	641	439	68
March	34	367	236	64
April	31	221	79	36
May	31	262	32	12
June	31	263	13	5
July	22	112	6	5
August	17	68	5	7
September	19	100	11	11
October	49	223	11	5
November	59	274	92	34
December	47	307	182	59
Total		3,227	1,337	41 (Average)

Members of 12 contiguous packs were radio-tagged during this study, and were radio-located intermittently (usually at least once per week) for periods ranging from 3 months to 5 years (table 2). Sufficient data were obtained from 10 of those packs to allow an accurate determination of their ranges and total members. Observational data from one additional pack that was not radio-tagged were also adequate for this purpose because the pack contained the only black wolves in the general region and therefore was identifiable, and because its range was bordered on six sides by ranges of radio-marked packs. Thus the basic census area of 1,005 square miles upon which the population estimate for the Forest is based, is the region inhabited by these 11 packs (fig. 1, packs 1 to 11).

Because we were not always able to radio-tag members of each study pack during each year of the investigation, information on pack sizes during some years had to be determined from strictly observational data of tracks and unmarked packs. Data from packs that were radio-tagged for more than 1 year indicated that pack home ranges were consistent from year to year. Therefore, once a range was delineated by radio-tracking data, all the observations that were made in that range before or after the delineation were considered to apply to the pack occupying that range. A total of 76 such observations was made (table 2).

Nevertheless, for some of the study packs, yearly or seasonal pack size data are incomplete. The period for which the most data are available from the basic census area is winter 1971-72, so those data will be used to project an estimate for the Forest. Estimates of population trends before and after this period will be based on comparisons with those data.

To understand wolf population dynamics, one must be aware of the annual sociological cycle of the wolf pack, a description and documentation of which will be published in more detail elsewhere. Briefly, however, a pair of adults in Minnesota mates in February, and an average-sized litter of five or six pups is produced in late April. Under good conditions, the survivors become adult-sized by autumn and accompany the adults during winter. As early as February of their first year, and possibly before, some of the pups may disperse from the pack, although usually they remain with the adults at least until a second litter of pups is produced. During the next winter, the pack is composed of the adult pair, the surviving new pups, and whichever yearlings have not dispersed or died during summer. As winter progresses, however, some pack members, presumably some of the yearlings and/or some of the pups, disperse and/or perish. Each year, this history is repeated, with new pups being produced, yet the pack usually remains approximately the same size from year to year.

Therefore, it is of particular interest to assess the size of each pack in early winter, when the surviving pups accompany the rest of the pack, and again in the spring, after the winter's loss. Such an assessment is best made on radioed packs because at any given time a pack may temporarily split, or any number of members may wander away from the group for a

Table 2.--*Radio-tracking and observational data on which pack size estimates are based (as of June 30, 1973)*
(In numbers)

Pack	Radioed wolves	Months of data	Biological years[1] represented by radio-tracking data	Radio locations	Observations based on radio-tracking	Observations of pack or tracks when not radioed
Glenmore L.	5	11	2	83	55	2
Newton L.	3	17	3	178	74	7
Pagami L.	2	6	2	69	32	9
Greenstone L.	1	5	1	41	29	10
Ensign L.	3	13	2	158	63	8
Thomas L.[2]	--	--	5	--	--	14
Quadga L.	5	7	2	101	52	3
Harris L.	7	34	5	426	185	4
Jackpine	12	25	4	558	218	4
Maniwaki L.	3	18	3	155	77	14
Timber L.	1	3	1[3]	19	9	1
Total	41	--	--	1,479	675	76

1/ A biological year begins in late April when the pups are born.
2/ This pack was not radioed but was identifiable because of its black members.
3/ See also Van Ballenberghe (1972).

day or two, rendering incidental single counts of the pack open to inaccuracies. Only after a number of counts are made over a period of weeks can one be certain of the full complement of a pack. This means that single observations of unmarked groups may tend to be lower than the actual number in the pack and should only be used when radio-tracking data are unavailable.

During late November 1971 through February 1972, referred to hereafter as "winter 1971-72," the maximum sizes of the 11 packs occupying the basic census area (fig. 1, packs 1 to 11) totaled 82 wolves (table 3). The packs in the Superior National Forest are basically territorial, with each occupying a discrete area (Mech 1972). Therefore, the number of wolves in the 11 packs represented the total number of pack wolves in the census area, and this amounts to a pack-wolf density of 1 wolf per 12.3 square miles in early winter.

In addition to the pack wolves, an unknown number of lone wolves and pairs also circulate within the census area, having dispersed from the 11 packs and their neighbors. Their numbers can be estimated, however, from figures given by Mech and Frenzel (1971, table 10):

1. Assume that the proportion of lone wolves, pairs, and packs observed incidentally are reasonably representative of the proportion in the population at large.

2. 34 of 77 observations (or 44 percent) involved loners and pairs, and 56 percent involved packs (Mech and Frenzel 1971, table 10).

3. Let X = the total number of population units (packs, pairs, and loners) in the census area.

4. 0.56X = 11 packs.

5. X = 11/.56 = 19.6 population units.

6. 32 percent of the population units observed were loners (Mech and Frenzel 1971, table 10).

7. 0.32(19.6) = 6.3 loners.

8. 11.0 packs + 6.3 loners = 17.3 packs and loners.

9. 19.6 population units - 17.3 packs and loners = 2.3 pairs.

10. Therefore, there were 11 packs, an estimated 6 loners, and an estimated 2 pairs (4 wolves) on the 1,005-square-mile census area; or 82 pack members, 4 members of pairs, and 6 lone wolves, totaling 92 wolves, an estimated density of 1 wolf per 10.9 square miles in early winter 1971-72.

11. Because there may be less chance of observing lone wolves and pairs than of packs, one might arbitrarily double the number of these individuals. When added to the 82 pack members the new figure would yield an estimate of 102 wolves on the census area, or an estimated density of 1 wolf per 9.9 square miles.

12. Thus, the estimated number of wolves on the census area in winter 1971-72 was 92 to 102, or a density of 1 wolf per 9.9 to 10.9 square miles.

In spring 1972, it was known that the 11 packs totaled not more than 61 animals (table 3), a decrease of at least 26 percent over winter.

Table 3.--*Sizes of known wolf packs on the Superior National Forest (Underlined figures indicate pack was radioed. Packs 16 to 25 from Van Ballenberghe (1972). Winter figures are the maximum pack sizes observed from December through February; spring figure represents maximum pack size observed during March and April.)*

(In numbers)

Pack No.[1]	Name	1966-67 Winter	1966-67 Spring	1967-68 Winter	1967-68 Spring	1968-69 Winter	1968-69 Spring	1969-70 Winter	1969-70 Spring	1970-71 Winter	1970-71 Spring	1971-72 Winter	1971-72 Spring	1972-73 Winter	1972-73 Spring
1.	Glenmore L.	6	--	--	--	8	--	--	--	--	--	12/7	8/7	12/2/6	4
2.	Newton L.	6	--	6	--	8	--	11	11	--	7	7	7		--
3	Pagami L.	6	--	--	--	--	--	--	--	6	6	5	3/3	} 6	3
4.	Greenstone L.	--	--	--	--	4	--	--	--	5	5	4	3/3		
5.	Ensign L.	4/7	--	--	--	--	--	--	--	--	11	15	3/9	10	5
6.	Thomas L.	--	5	5	--	6	--	--	--	--	6	5	5	7	0
7.	Quadga L.	--	--	--	--	--	--	--	--	6	6	5	3/4	2	--
8.	Harris L.	--	--	--	--	5	5	--	4	9	6	3	2	4	4
9.	Jackpine	--	--	--	--	--	--	6	5	7	6	9	6	7	6
10.	Maniwaki L.	8	8	6	--	10	7	14	--	7	--	5/9/8	3/7	9	3
11.	Timber L.	--	--	--	--	--	--	8	--	--	--			7	--
12.	Knife L.	--	--	--	--	13	9	--	--	--	--	--	8	--	--
13.	Canadian Pt.	7	6	--	--	4/6	--	--	9	8	4	4	--	--	--
14.	Birch L.	--	6	--	--	--	--	--	--	--	--	--	--	2/6	--
15.	Sawbill	--	--	--	--	6	--	--	--	3	2	5	3	2/4	--
16.	Houghtaling Creek	--	--	--	--	--	--	--	--	--	--	5	--	--	--
17.	Manitou R.	--	--	--	--	--	--	--	--	--	--	6	--	--	--
18.	Dyers L.	--	--	--	--	--	--	--	--	--	--	8	--	--	--
19.	Cross R.	--	--	--	--	--	--	--	--	--	--	9	--	--	--
20.	Temperance R.	--	--	--	--	--	--	--	--	--	--	8	--	--	--
21.	Onion R.	--	--	--	--	--	--	--	--	--	--	8	--	--	--
22.	Lutsen	--	--	--	--	--	--	--	--	--	--	5	--	6/5	6/5
23.	Ward L.	--	--	--	--	--	--	--	--	--	--	10	--	--	--
24.	Devils Track	--	--	--	--	--	--	--	--	--	--	7	--	--	--
25.	Clara L.	--	--	--	--	--	--	--	--	--	--	5	--	--	--

1/ See figure 1.
2/ Based on a single observation from the ground.
3/ May be less.
4/ May be more.
5/ Van Ballenberghe (1972).
6/ Lloyd Scherer (personal communication).

No doubt the decline of pack members was caused not only by mortality but also by dispersal of members into the ranks of the lone wolves. However, in the Superior National Forest the lone wolf is an insecure and temporary member of the population, having a much lower survival rate than permanent pack members (Mech 1972).

To convert the population estimates for the basic census area to meaningful figures for the Forest, it would not suffice merely to project the density figures to the total Forest acreage and then compute the standard error. This is because the 11 packs from which data are available were not chosen at random from the total population of packs within the Forest. Therefore, a nonstatistical approach will be used to derive a subjectively modified projection of the data from the census area.

Three types of data are available to aid in this projection. The first type includes data from two packs adjacent to the basic census area that were radio-tagged but from which relatively few location data were obtained (fig. 1, packs 12 and 15). Observational data (sightings and tracks recorded by the author and his assistants, and reports of sightings and tracks by other personnel) were also obtained for both these packs and for two other packs adjacent to the basic study area (table 3; fig. 1, packs 13 and 14). Although such data are not considered sufficient to fully delineate the ranges of these four packs, they do tend to support the data from the basic census area, and bolster confidence that the figures from the census area are generally applicable beyond it.

The second type of data for the Forest outside of the basic census area are those presented by Van Ballenberghe (1972). These data are based on trapping and recapture in 1970 and on radio-tracking during 5 months in summer 1971 and from 1 to 3 months per pack in winter 1971-72. Van Ballenberghe estimated the sizes and ranges of five packs (fig. 1, packs 19 to 23), and the sizes and approximate ranges of six other adjacent packs (fig. 1, packs 11, 16, 17, 18, 24, and 25), one of which was included in the present study.

Van Ballenberghe's 720-square-mile census area can be divided into two general zones. A

213-square-mile "core" region extends from the southeast boundary of the Forest, along the Lake Superior shore and to about 10 miles inland, and northeastward to within about 7 miles south of Grand Marais. This area includes a number of deeryards (Krefting 1938, Erickson et al. 1961), where winter deer densities are the highest in the State, having reached an estimated 166 deer per square mile in 1959 (Krefting and Shiue 1960). Five packs inhabited this area on a year-round basis and contained a total of 40 members during winter 1971-72, a density of one pack wolf per 5.3 square miles (fig. 1, packs 19 to 23; table 3).

The second zone in Van Ballenberghe's census area comprised 507 square miles extending in a 5- to 10-mile-wide semicircle inland and adjacent to the core region. Prey populations in most of this peripheral area were typical of those of the Forest in general. Six packs, including 39 members in total during winter 1971-72, occupied this area, for a density of one pack wolf per 13.0 square miles (fig. 1, packs 11, 16 to 18, 24, and 25; table 3). This compares favorably with the density of pack wolves in the 1,005-square-mile census area of the present study, one wolf per 12.3 square miles. (Van Ballenberghe made no estimate of the number of lone wolves and recently formed pairs in his study, so only pack-wolf densities can be compared.)

Van Ballenberghe's data are of interest here for two reasons. First, those from the peripheral zone confirm the density figures from the present study and demonstrate that they can be applied to a much larger area of the Forest. Secondly, the density data from the core area containing the deeryards indicate that this area is unique in the Forest. Although there are a number of smaller deer concentration areas throughout the Forest (Erickson et al. 1961), none approaches those of the Lake Superior shore in extent or numbers of deer. Furthermore, several of these smaller yards occur within the 1,005-square-mile census area of the present study, and in general do not seem to support unusually high wolf densities, probably because they are too small and dispersed.

The third type of data available for the remainder of the Forest consists of sightings and tracks recorded by project personnel and reports of sightings and tracks from other field workers, primarily Forest Service and Minnesota Department of Natural Resources employees (fig. 1). A total of 73 such observations was recorded, including some of those already reported (Mech and Frenzel 1971).

When a population estimate is based on such data alone, the estimate is subject to a high degree of error and must always be viewed with utmost caution. However, in the present study these data are useful in helping to decide subjectively the degree to which the density figures from the census area are applicable to the rest of the Forest.

In this respect, two judgments have been made from the observations. In general, packs of wolves or their sign have been observed throughout most of the Forest outside both intensive census areas (fig. 1). These observations establish that wolf packs do occur throughout most of the Forest. Because the remainder of the Forest is similar in topography, vegetation, and land use, the assumption is reasonable that the wolf density figures from the census area can be projected to much of the remainder of the Forest.

The second judgment from the observational data is that in areas of high accessibility, i.e., with a high density of roads, most observations other than those of lone wolves are those of pairs or other small groups of wolves or their tracks. I attribute this to the fact that in accessible areas, wolves are killed by humans year-round, so full-sized packs rarely get the chance to develop and persist. There are always enough wolves left to keep the population "smoldering" in accessible areas, because of the dispersing animals from the reservoir of packs in wilderness areas (Mech 1972). Nevertheless, there is a constant cropping of accessible populations, and thus presumably a lower density.

Therefore, I have arbitrarily assumed for a total of 540 square miles of the Forest--13 townships and halves of four other townships containing a high density of roads--the wolf density is approximately half that of the census area, or about one wolf per 19.8 to 21.8 square miles.

However, such an unusually low density in the accessible areas would be nearly compensated for by the abnormally high density of wolves in the deeryard area along the shore of Lake Superior. In that 213-square-mile area, the density of pack wolves was one per 5.3 square miles (Van Ballenberghe 1972), close to 2-1/2 times the density of the intensive census area of the present study.

Thus, it would be reasonable to project the density figures from the 1,005-square-mile census area to the total Forest exclusive of the Virginia District. A density of one wolf per 9.9 to 10.9 square miles applied to these 4,203 square miles amounts to an estimated 386 to 425 wolves or 405 $\pm$ 20, on the Superior National Forest in winter 1971-72.

The above estimate applies to the wolf population during the part of the biological year when the maximum number of surviving pups is circulating about with the adult members, and thus can be considered a measure of the maximum free-roving population of wolves on the Forest. As shown earlier, by spring 1972 the study packs had diminished in size by an average of about 26 percent, which, when projected, would yield a population estimate for that period of 286 to 315 wolves, or 300 ± 15.

Although lone wolves may have decreased at an even greater rate over the winter (Mech 1972), some of the decrease in pack members resulted from dispersing members becoming lone wolves, so these two factors would tend to compensate for each other.

From winter 1971-72 to winter 1972-73, a decrease in wolf numbers was observed in seven of the 11 study packs (table 3) in the central region of the Forest, where deer populations are lowest.

There was no evidence that the decrease occurred elsewhere, so it may be unsound to project the census-area density figures to the rest of the Forest for winter 1972-73. The best estimate for that winter is that the Forest wolf population generally remained about the same as that of the winter before in an estimated 80 percent of the Forest, but that in the remaining 20 percent it dropped by about 15 percent (based on packs 1 to 11, table 3), yielding an estimate of 374 to 412 wolves or 388 ± 14, for winter 1972-73.

An overwinter reduction in number of pack wolves seems to be a general phenomenon, probably taking place during most years under normal conditions. If the 26 percent overwinter decline for 1971-72 were applied to the winter 1972-73 figures, an estimate for wolf numbers in spring 1973 could be made. However, on an estimated 20 percent of the Forest where the decline took place from 1971-72 to 1972-73, the 1972-73 overwinter reduction, based on pack numbers 1, 3 to 6, and 8 to 10, was 55 percent, so this estimate would be too high. An estimate of 257 to 285 wolves or 271 ± 14 appears more accurate, based on an assumed 26 percent overwinter decline for 80 percent of the Forest, and a 55 percent overwinter decline for the remaining 20 percent.

DISCUSSION AND CONCLUSIONS

Early estimates of wolf numbers on the Superior National Forest were largely subjective, so there is little to be gained by comparing them with the present estimates. However, it does appear from comparisons of recent data with past observations of pack sizes that from about 1950 to 1967 the wolf population increased (Mech and Frenzel 1971). This increase may be attributable to a prohibition against aerial hunting of wolves in the BWCA in 1951 (Stenlund 1955), the curtailment of wolf control as a program by the Minnesota Conservation Department in 1955, and the repeal of the bounty in 1965.

From 1967 to 1969 it appears that the wolf population on the Forest remained relatively stable (Mech and Frenzel 1971).

From winter 1970-71 to 1972-73 the best indication of population trends can be obtained by comparing the relative sizes of nine packs from which the most radio-tracking data are available. The mean size of these packs for winter 1970-71 was 6.7; for 1971-72, 6.8; and for 1972-73, 5.9 (table 4).

Table 4.--*Average annual winter pack sizes for the nine radioed packs for which there are sufficient data*

(In numbers)

Pack	Winter 1970-71	Winter 1971-72	Winter 1972-73
Harris L.	9	3	4
Jackpine	7	9	7
Quadga L.	6	5	2
Maniwaki L.	7	9	9
Pagami L.	6	5	1/ 6
Greenstone L.	2/ 5	4	
Newton L.	7	7	6
Glenmore L.	--	12	12
Timber L.	--	3/ 8	7
Average size	6.7	6.8	5.9

1/ By winter 1972-73, the Pagami L. and Greenstone L. packs, after an attack by one upon the other, apparently merged. To compare the average pack sizes for this year with previous years, this combined pack is treated as two in computing the average size.

2/ Could have been larger.

3/ Van Ballenberghe (1972).

The mean sizes of wolf population units of three or more animals observed during the winters of 1966-67, 1967-68, and 1968-69 (not necessarily all of the same packs studied in 1970-73) was 6.5 wolves per pack (Mech and Frenzel 1971, table 1, excluding 25 observations of lone wolves and nine observations of pairs).

The above mean pack sizes strongly suggest that the wolf population of the Superior National Forest has remained comparatively stable during the six winters from 1966-67 (and possibly earlier) through 1971-72, and that in part of the area it decreased in 1972-73.

The decrease may be linked closely to a general decline in numbers of deer that is ocurring throughout not only northeastern Minnesota (Erickson et al. 1961, Mooty 1971), but also throughout midnorthern and northeastern United States and south-central and southeastern Canada (Anon. 1972, Byelich et al. 1972), apparently caused by maturing forests and an increasing predominance of conifers.

Although a gradual decrease in the deer population of northeastern Minnesota has been underway for two or more decades (Karns 1967), the most drastic decline in recent years took place in the winter of 1968-69, when the area experienced the deepest snowfall on record (Mech and Frenzel 1971). The drop in wolf numbers from 1971-72 to 1972-73 was most apparent in the area of the Forest that was historically the poorest deer range, primarily the eastern half of the BWCA (Olson 1938). This will be discussed and documented in a later paper. Suffice it to say for now that during winter 1971-72, there were virtually no deer present in some 300 to 500 square miles of the east-central portion of the Superior National Forest and in an even larger area in 1972-73. Some deer still inhabit that region during summer and migrate to wintering areas beyond. However, many deer overwintered in that region through 1968-69 (Mech and Frenzel 1971), and thus supported wolf packs there, whereas they do not now.

Two main conclusions should be apparent from the above. First, it appears that even with relatively high deer populations on the Forest, wolves will not increase beyond a certain average density, approximately one wolf per 9.9 to 10.9 square miles in early winter except in local areas with extremely high prey densities (Kuyt 1972, Van Ballenberghe 1972, Parker 1973). This agrees closely with studies of wolves on Isle Royale (Mech 1966) and Algonquin Park, Ontario (Pimlott et al. 1969), as summarized by Pimlott (1967) and by Mech (1970).

Secondly, maintenance of peak wolf numbers on the Forest depends primarily on restoration of higher densities of deer, which in turn depends on the rejuvenation of maturing forest (Erickson et al. 1961, Mooty 1971, Byelich et al. 1972).

A final word of caution is necessary: the results herein apply only to the Superior National Forest, so far as is now known. This area comprises only one-third of the primary wolf range in Minnesota and only about one-sixth of the total wolf range in the State (fig. 2). It is not sound to project wolf densities or population trends from the Forest to the remainder of the wolf's range in the State unless substantial evidence from several other areas demonstrates that such a projection is warranted.

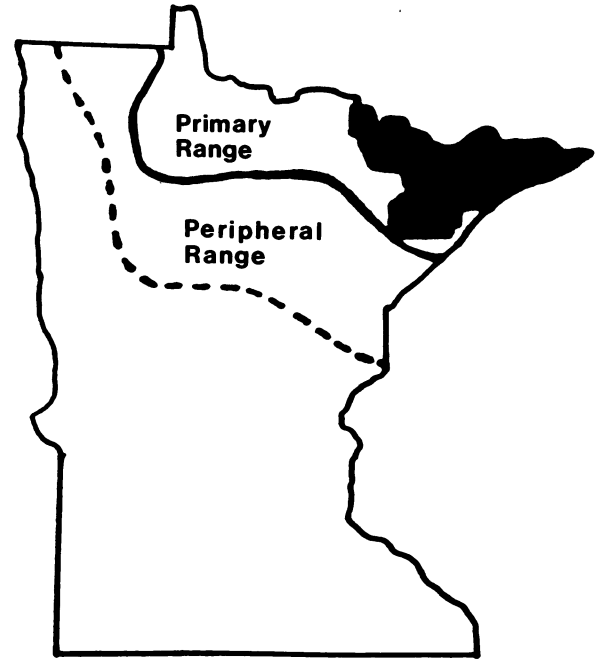

Figure 2.--The primary and peripheral ranges of the wolf in Minnesota. (The Superior National Forest is shown in black.)

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2/ Mention of trade names does not constitute endorsement by the USDA Forest Service.

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