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"COMMENTS . . ."

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Distribution of the wolf (*Canis lupus*) in parts of Wisconsin (Thiel 1985) and Michigan and Ontario (Jensen et al. 1986) has been related to the density of roads passable by 2-wheel-drive vehicles. Wolves in those regions generally do not occur where road densities exceed 0.58 km/km^2, whereas similar areas nearby with fewer roads do contain wolves.

In a small segment of the wolf range in Minnesota, wolves did not have territories where roads exceeded a density of 0.73 km/km^2 (T. K. Fuller, Minn. Dep. Nat. Resour., unpubl. data). In another small area of Minnesota with 0.73 km of roads/km^2, >50% of known wolf mortality was caused by humans despite prohibitions of the Endangered Species Act, but wolves survived there probably because the area was surrounded by an extensive wilderness reservoir (L. D. Mech, unpubl. data).

The areas of Wisconsin, Michigan, and Ontario studied previously were either relatively small or were studied after wolves had disappeared. We investigated recent wolf distribution relative to road density over an area of 100,576 km^2, constituting the entire occupied or potentially occupied range of the wolf in Minnesota. The purpose of this paper is to present an evaluation of Thiel's (1985) finding that road densities of 0.58 km/km^2 represent a threshold level for the occurrence of wolves.

METHODS

About 46% of Minnesota was considered in this study (Fig. 1). The region is primarily coniferous and deciduous forest, but the southern and western portions also contain brushlands, scattered old fields, and pastures.

The current, primary distribution of wolves in Minnesota was mapped by the 3 coauthors who had knowledge of wolf distribution based on 40 years of combined experience with wolves in the region. Portions of the primary range devoid of wolves were determined by surveying local Minnesota Department of Natural Resources personnel. To determine distribution of breeding pairs or packs along the frontier of the known range, the authors surveyed 112 local canid trappers by mail and telephone in 1982 and 1983. There was considerable agreement among trappers who had knowledge of the same areas.

Three peripheral and 3 disjunct areas of current wolf distribution were identified adjacent to the primary range (Fig. 1). In addition, 2 regions

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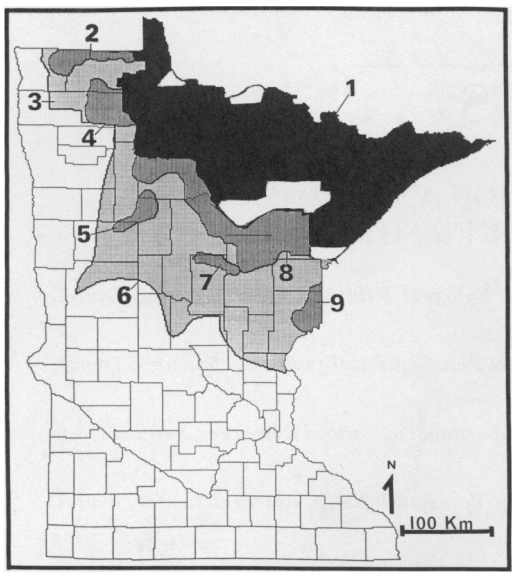

Fig. 1. Occupied and potential wolf range in Minnesota. 1 = primary, 2 = Roseau peripheral, 3 = northeast not occupied, 4 = Marshall peripheral, 5 = Hubbard disjunct, 6 = central not occupied, 7 = Crow Wing disjunct, 8 = main peripheral, 9 = Nemadji disjunct. Blank areas indicate intensively farmed or developed areas devoid of wolves.

of similar habitat contiguous with these areas, but known to contain only single wolves, were also delineated based on boundaries of habitat similar to that containing wolves. Each area was then digitized, and the computerized Minnesota Land Management Information System data base was used to obtain data on road density for each area. That data base was derived from 8 mm/km highway maps updated for roads through 1982. Roads were defined as those open to public use and passable by 2-wheel-drive vehicles. Cell size used in the data base was 92 km^2. The mean road density was then calculated for each area of wolf range.

RESULTS

The area currently inhabited by wolves totaled 59,900 km^2, which differs from an earlier estimate (Berg and Kuehn 1982), and the mean density of roads was 0.36 km/km^2 (Table 1). The peripheral and disjunct parts of the wolf range

Table 1. Density of roads in various areas of the occupied and potential wolf range in Minnesota, 1982–1983.

Range	Area (km^2)	Mean road density (km/km^2)
Occupied	59,900	0.36
Primary	42,945	0.29
Peripheral	13,827	0.55
Main	9,915	0.55
Marshall	2,217	0.61
Roseau	1,695	0.44
Disjunct	3,128	0.50
Hubbard	1,134	0.61
Nemadji	1,308	0.44
Crow Wing	686	0.43
Peripheral and disjunct		0.54
Not occupied[a]		
Northwest	4,168	0.88
Central	32,453	0.81
Primary	4,055	>0.83

[a] No wolves or only lone wolves.

varied in size from 686 to 9,915 km^2 and density of roads averaged 0.54 km/km^2. The 2 contiguous regions uninhabited by wolves had mean road densities of 0.88 and 0.81 km/km^2, and the part of the primary range devoid of wolves, >0.83 km/km^2.

Densities of roads for the entire range of the wolf in Minnesota, the primary range, the peripheral range, and the disjunct range fell below the threshold found by Thiel (1985) and Jensen et al. (1986). Likewise, means for 5 of 7 individual regions inhabited by wolves fell below the threshold, and means for the remaining 2 regions were 0.61 km/km^2, just above the threshold. Considering the effect of nearby reservoirs with low densities of roads on areas of higher road densities (L. D. Mech, unpubl. data), all these data support the road density threshold that Thiel (1985) reported. Densities of roads in areas without wolves (Table 1) also fit the Thiel model, but these values were so much higher than the threshold of 0.58 km/km^2 that little can be inferred.

Our findings should not be taken to imply that roads themselves prevent wolves from inhabiting an area. Except for the direct danger to wolves from vehicles (De Vos 1949), the primary threat of high road densities to wolves comes from the

accessibility they allow to humans who deliberately, accidentally, or incidentally kill wolves by shooting, snaring, or trapping (Van Ballenberghe et al. 1975, Mech 1977, Berg and Kuehn 1982). Furthermore, road densities may be associated with different types of land use, which may also affect wolf security. Our data base did not allow us to investigate other variables.

Our only conclusion is that the data presented here are consistent with, and supportive of, findings by Thiel (1985). These results, however, probably would not apply to areas with different human populations or road use than in our study area, or to roads on which public access is restricted.

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