A Review of the Methods Used by Minnesota's Department of Natural Resources to Calculate the State's Gray Wolf Population

Introduction

The state of Minnesota contains the only indigenous population of gray wolves remaining in the continental United States. Wolves in all other states were exterminated throughout the 1800's and early 1900's due to human prejudice and misunderstandings about their true nature. In the early seventies, wolves were placed on the Endangered Species list, where they remained for nearly four decades. After the gray wolf was congressionally removed from the list in western states, and subsequently in the rest of the country by the U.S. Fish and Wildlife Service, humans resumed the relentless extermination used in centuries prior. Unless human interaction with wolves is tempered with rationality and a true understanding of the role of wolves in the ecosystem, the threats to their existence - human and otherwise - they will face extinction again. The majority of US citizens want to see the wolf protected for future generations, and our forests ecosystems depends upon their survival.

For these reasons it is important to assess the accuracy and effectiveness of the Minnesota Department of Natural resources (MNDNR) management methods, all of which are based upon the *presumption of a known wolf population*. To evaluate this presumption, Howling For Wolves (HFW) retained the services of Elite Research, LLC, in Irving Texas and they conducted an exhaustive analysis of MNDNR's techniques for the 2012 - 2013 population estimate. This document is a summary of that analysis and report which took almost 12 months to complete, and included the advice of known wolf experts.

Executive Summary

The wolf population numbers published by MNDR each year are not based upon an actual count of wolves. Instead, DNR relies on a simple three term equation to theoretically derive a population estimate. This method is susceptible to error and dramatic changes in the outcome with different assumptions or small changes is some variables ("blowing up"). The analysis described in the report and this summary shows that better techniques are available based upon a search of current scientific literature. Applying these methods results in a smaller population estimate in every case examined and suggests that the confidence implied by MNDNR's use of these estimates for management purposes is likely overstated.

MNDNR's Method

Contrary to the aforementioned presumption, the DNR does not "know" the wolf population because they do not count wolves. Instead, the DNR computes an estimate of the wolf population using an "ad hoc" (not published or scientifically reviewed) approach that combines attributes of territory mapping with measurements of selected pack size and range. It relies on the following simple calculation to extrapolate the state's wolf population:

Population estimate = (occupied range/ average pack territory) x (average pack size)/.85, or

(Minnesota area occupied by wolves) divided by (the estimated pack size) times (the number of wolves in each pack) then divided by .85. Dividing by .85 is intended to account for the presence of lone wolves not identified by pack observations. This is the same as inflating the population by 17.6%.

Minnesota Area Occupied by Wolves

MNDNR has conducted territory surveys at 10-year intervals from 1978 to 1998 and at approximately 5-year intervals since. This occupied range method depends on data collected from DNR employee observations during their normal work activities from November 2012 until snowmelt the following spring (around mid-May 2013).

Other signs of wolf presence from various participants were combined with DNR information to complete the survey. Survey results were then combined with wolf observations recorded on the MNDNR 2012 carnivore scent station survey and the MNDNR 2012–2013 furbearer winter track survey. Using this information, DNR defined three categories for inclusion in the occupied range calculation:

- Model. Townships within wolf range were presumed to be occupied by wolves if road density was < .7 km per km^2 and human density was < 4 per km^2, or if road density was < 0.5 km per km^2 and human density was < 8 per km^2.
- Pack. Townships in which a wolf pack (defined as > 1 wolf) was observed during the survey period were presumed to be occupied.
- Telemetry. Townships in which telemetry data was collected during the survey period were presumed to be occupied.

Note that all computations were based upon units of township. MNDNR chose township as the minimum resolution for the convenience of mapping purposes. Townships have no ecological relevance or significance. The contribution of various categories to the total "occupied range" are shown in the table below:

Inclusion Condition	Townships		Area	
	n	%	km^2	%
Model	266	31.2	20029.59	28.4
Model + Pack	273	32.0	24012.94	34.0
Model + Pack + Telemetry	72	8.4	6404.369	9.1
Model + Telemetry	47	5.5	3758.315	5.3
Pack	136	15.9	11715.23	16.6
Pack + Telemetry	15	1.8	1355.218	1.9
Telemetry	23	2.7	1903.707	2.7
NA	21	2.5	1399.174	2.0
Grand Total	853	100.0	70578.55	100.0

Model means that the township met the human/road density criteria; Pack means that one or more wolf packs were observed in the survey; Telemetry means collected telemetry data; NA – other reasons. The "+" rows indicate that more than one of the categories for inclusion applied.

It is important to note that over 31% of the townships and 28% of the area included in the occupied range calculation had no reported evidence of the presence of wolf packs.

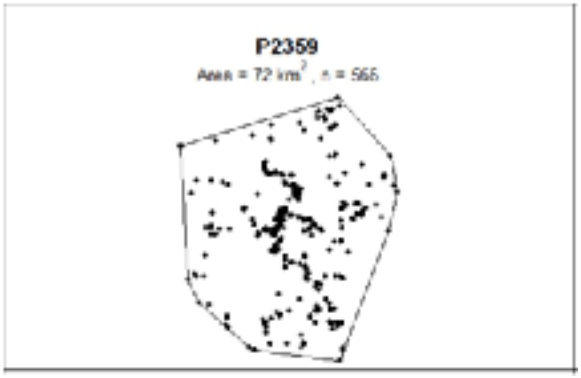
Average Wolf Pack Territory

Pack territory data was obtained from 36 radio-collared wolf packs by MNDNR. Territories of these packs were determined using minimum convex polygons (MCP) drawn around the locations of radio signals. One pack included a large area within the MCP that GPS data clearly indicated was not used. Prior to generating the MCP, "outlier" radiolocations were identified and removed based on two conditions:

- For wolves with weekly (approximately) VHF radiolocations, locations that were 5 km apart from other locations were excluded as extraterritorial;
- For GPS collared wolves with temporally fine-scale movement information, MNDNR removed paths if the animal obviously did not travel to that area on multiple occasions and if use of the path would have resulted in inclusion of obviously unused areas on the MCP.

These conditions require some subjective judgement. After the MCP's were determined, the total area bounded by the MCP was calculated for each pack. MNDNR's estimate for pack size was also obtained from radio-collared packs. Out of the 36 packs, a count could not be obtained for two. For the other 34 packs, multiple counts from different sources (e.g. snow track, sight) were recorded. Details from these counts are not clear from the data provided.

Some wolves were counted in the pack size even though they were dead by the end of the survey. For each pack, the maximum count obtained during the whole winter was used as the mid-winter pack size. The estimate of average mid-winter pack size was calculated by adding the 34 mid-winter pack sizes and dividing by 34 (simple average). The same method was used to compute average pack territory. MNDNR estimated that the average territory size for radio-collared packs was 161.13 km^2, and the average mid-winter pack size was 4.29 wolves. The following figures show the locations of pack territories and a more or less typical MCP.



Problems with Assumptions, Data Sources and Analysis Methods

In addition to analyzing and successfully reproducing MNDNR's methods, Elite Research reviewed current scientific literature and determined that some of the techniques used in DNR's method were outdated. They also identified missing components of a proper observational study, better techniques for computing pack territories and the use of assumptions which generally tended to increases the wolf population.

Observational Bias

The presence of wolves is the key to determining occupied range. All of the survey data are based upon self reported observations, but MNDNR has not examined the possibility of observer bias and its impact on the population estimate. Self reported observations can suffer from bias and misidentification and numerous studied have shown that using public observation can lead to flawed reporting, including both over and under reporting. Since the wolf population is a direct product of the assumed occupied range, a few mistakes involving area can lead to projecting wolves that do not exist. As mentioned previously, over 31 percent of townships assumed to contain wolves did not have supporting observations.

Township Criteria

In the 1980's, a single study suggested that 88% of wolf packs and 81% of lone wolves lived in townships that met certain criteria for road and human density. For this study, most of the observers made their observations from the road, possibly skewing the data, and there were many other factors which could have biased the data.

MNDNR's township model is based upon this study. Recent studies show that a different threshold should be used to assign "occupied" status to townships. If that criteria had been used, 92 of the townships in MNDNR's analysis would not have been included, reducing the wolf occupied range by 10.7%.

Pack Territory

Published studies of winter wolf densities in north-central Minnesota using radiotelemetry data indicate that 30–35 individual radio locations obtained at least 2 days apart described about 87–90% of a pack's territory in winter. The DNR's 2012-2013 data actually confirm this. Statistical tests were performed and indicate that MCPs derived from less than 100 radiolocations were significantly smaller than MCPs using more than 100 points. Additional research indicates that while the MCP method is simple, it is inaccurate in many situations, sensitive to sample size and to outliers. Other methods of determining pack territory (e.g. kernel density, objective restricted edge polygon) are more accurate and all tend to determine pack territories that are *larger* than simple MCP.

The most recent method for determining pack territory, the "asymptotic" method, tests for convergence with the MCP result as a function of the number of points contained within the MCP. These tests show that at least 303 points were needed to demonstrate convergence and less than 30 points were completely inadequate. When corrected using 30 packs with sufficient samples, the average MCP area increases from 144.4 km^2 to 165.4 km^2, and the average adjusted MCP increases from 161.1 km^2 to 182.6 km^2. Since the average territory is larger, the number of packs "contained" in the occupied range as defined by MNDNR falls proportionally.

Conclusions and Results

To estimate the effect of applying updated methods on MNDNR's population estimate, the data for the 2012 through 2016 seasons were re-analyzed using techniques identified in the report. The results are shown in the following table.

Winter season		Occupied range	Ave. pack territory	# of packs	Ave. Pack	Population Point Estimate
	MNDNR Results	70578.55	161.1	438	4.29	2211
2012-13	**Reproduced Results**	70578.55	161.1	438	4.29	2213
	Adjusted Results	63048.15	184.6	342	4.29	1729
2013-14	**Adjusted Results**	63048.15	180.98	348	4.4	1797
2014-15	**Adjusted Results**	63048.15	199.29	316	5.1	1988
2015-16	**Adjusted Results**	63048.15	165	382	4.4	1988

For 2012-13, the DNR's published results are shown, along with replication of their numbers to confirm the method and updated population estimates. The results show that current methods of estimating Minnesota's wolf population over predict. Reproducing the DNR's method and/or correcting the *procedure* with updated information should not be considered an endorsement of the underlying assumption that "packing" the modeled occupied range with multiple copies of the average pack territory is valid. This method has never been proven by comparison to an actual count of wolves.

Please consult the original report for a complete list of references, a more detailed explanation of the methods used and how they relate to the citations and additional analysis of MNDNR's methodology. A copy of the report is available from Howling For Wolves, a registered C3 non-profit.