Roads, Trails, and Grey Wolf Habitat Selection

in

Michigan’s Upper Peninsula

by

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Abstract

Road density (km/km^2) and prey abundance have often been used by land managers use to predict habitat suitability for grey wolves in the northern Midwest. This study adds the density of the second and third type of roads, which are DNR managed roads and recreational trails, as a further predictor for habitat suitability. Using 15 years of grey wolf (*Canis lupus*) radiotelemetry location data gathered by the Michigan Department of Natural Resources from 2000-2015, the study examines whether any recreational trail surfaces impact habitat selection by grey wolves in Michigan's Upper Peninsula predicts habitat suitability similar to that predicted by road densities. While no surfaces improved the predictive power of the model developed by Mladenoff et.al. 1995, this study affirms the model's continued application in this field of predicting habitat suitability for grey wolves.

INTRODUCTION

Grey wolves (*Canis lupus*) once occupied every county in Michigan's Upper (UP) and Lower (LP) Peninsulas from approximately 10,000 years ago when the last glaciation period ended until shortly after European settlement(Stebler 1951, Beyer et al. 2009). From 1817-1959, public policy that sought to eliminate wolves forced them to recede into areas that were most difficult for humans to develop. This relegation to pristine habitat that was remote and inaccessible to humans created the stereotype for laypersons and professionals that wolves were a "wilderness" species that could only thrive in areas far from human activity (Mech 2014). With increased development opportunities, roads were built that allowed greater access to regions once thought as too difficult for vehicles to traverse. Once the roads were built, it became easier for hunters and trappers to claim the bounties that placed on wolves due to livestock depredation, and it increased the potential for wolf-vehicle collisions.

Road density (km/km^2) is a metric that land managers use to predict habitat suitability for grey wolves, target efforts to prevent depredations by wolves against cattle and dogs, and to establish population objectives for recovery plans for wolves under the Endangered Species Act. Our study aims to examine whether including in various other landscape fragmenting features such as Michigan Department of Natural Resources (MDNR) roads, snowmobile trails, and railways improves the predictability of suitable habitat. Roads present the largest threat to wolf mortality in the Upper Great Lakes Region through vehicle-wolf collisions (Wydeven et al. 2001), but this does not mean wolves simply avoid roads at all costs. Shoulders and medians of rural unpaved roads often provide grazing opportunities for white-tailed deer (*Odocoileus virginianus*), the primary food supply for wolves. Deer-vehicle collisions provide an easy meal without the expenditure of energy. Snowmobile and groomed cross-country ski trails afford the opportunity to travel long distances through difficult terrain with relative ease, and wolves have demonstrated willingness to take advantage of the snow compaction at these sites in order to cross highways (Kohn et al. 2009). Our study examines whether the densities of these features will improve the predictive model using road density (Mladenoff et al. 1995) for grey wolf habitat in the UP of Michigan.

Estimates are that nearly 20% of the United States land area is altered due to the public road network and the associated traffic (Forman et al. 2003). There are two primary variables that determine habitat suitability for grey wolves: (1) abundance of prey, and (2) tolerance of humans that also inhabit or utilize the area (Kohn et al. 2009, Mech 1995, Fuller 1995, Fritts et al. 2003). A graduate student of Aldo Leopold, Thompson (1952) cautioned that developing logging roads in Northern Wisconsin would open much more land to the public could result in extirpation of wolves from Wisconsin, which occurred in 1960 (Thiel 1985, Wydeven et al. 2001). This coincided with the repeal of the bounty for wolves in Michigan in 1960, after only one wolf carcass had been submitted in 1959 (Beyer et al. 2009). Wolves became a federally endangered species in 1966, and in 1976 Michigan's Endangered Species Protection law afforded similar protections for non-federal lands as well (MDNR 1976, Beyer et al. 2009).

There are disagreements as to whether grey wolves were ever completely extirpated from the UP. Eight dead yearling wolves recovered in the UP from 1970-1986. Due to the proximity to the borders, it is suspected that these wolves immigrated from Wisconsin and Ontario would be in that time. Six of the eight deaths were attributed to humans, further supporting that human attitudes were the primary factory in preventing the establishment of successful wolf populations in Michigan (Beyer et al. 2009, Thiel and Hammil 1998, Robinson and Smith 1997). In 1974, an experimental reintroduction of four wolves from Minnesota failed, again due to human causes. Two of the wolves were shot, one was trapped before being shot, and the final wolf was killed by a vehicle collision (Weise et al. 1975 Beyer et al. 2009). While roads did not directly cause the deaths of these individuals, a mechanism has shown that high road densities temper the rate of range expansion for recovering wolf populations (Kohn et al. 2009, Thiel 1985, Jensen et al. 1986, Mech et al. 1988, Mladenoff et al. 1995, 2006). It is important to note that a hierarchy of multiple factors influence wolf population recovery and habitat selection in respect to roads. Kohn (2009) refers to ‘road’ as a “broad and generic term used to describe a human-created structure to convey vehicles,” however, this can be broken down into three distinct categories: (1) paved, hard surfaces with higher speeds and volumes, (2) secondary access roads such as National Forest or DNR-managed roads, typically gravel and lesser maintained, and (3) public-use unimproved roads such as forestry and recreational trails. There also exists hierarchies within wolf packs selecting territories such as equality of traffic frequency, selection of den and rendezvous sites vital to reproductive success, distance from roads (Gehring 1995), and the availability of ballooned strips along highway where the median in enlarged to provide substantial amount of natural habitat allows wolves to only encounter traffic from one direction at a time (Frair 1999, Kohn et al. 2009). Some 75-90% of total mortalities come from wolf-vehicle collisions (Fritts et al. 2003), including an annual 4% of the wolves radiocollared in Wisconsin (Kohn et al 2009).

Biologists of the upper Great Lakes region were the first to use the density of roads in an area as an estimate of suitability of the landscape to support wolves. (Kohn et al. 2009, Thiel 1985 ; Jensen et al. 1986 ; Mech et al. 1988 ; Mladenoff et al. 1995, 2006 ; Mladenoff and Sickley 1998). In Wisconsin, Thiel (1985, 1993) compared historic road densities from 1920-

1950 in areas that were occupied and not occupied by wolves, and concluded that lands above a threshold of 0.58 km of road length per km^2 did not support wolves. Soon after, supporting evidence from Minnesota (Mech et al. 1988) and along the Michigan/Ontario border (Jensen et al 1986) agreed this density of roads acted as a cutoff for habitat suitability for wolves. There exist exceptions to this rule in the Superior National Forest with 0.73 km/km^2 (Mech 1989) and 1.42 km/km^2 on Camp Ripley, a National Guard base also in Minnesota (Merrill 2000). Later, the terms "sink" and "source" were used to help add nuance to these areas that support wolves despite higher road densities. Both landscapes controlled access by the public, and both areas have natural resource managers on-site with the express purpose of conservation. Therefore, it can be assumed these exceptions acted as "reservoirs" for the less suitable neighboring areas of higher road density (Kohn et al. 2009).

In 1995, Mladenoff et al. developed a model for estimating habitat selection probability for a growing, dispersing wolf population in the Great Lakes Region. Using radio-telemetry data from 17 of the 21 packs that existed in Wisconsin from 1979 until mid-1993 and historical tracking and trapping data, Mladenoff et al. (1995) developed a model that used road densities to reliably identify areas where wolves might persist. The authors predicted from their study that areas with road densities of less than 0.45 km/km^2 had probabilities > 0.50 of being selected by wolves as favorable habitat. The model highlighted the sink-source relationship of the Superior National Forest and Camp Ripley to the region around them, which had road densities above the threshold first put for by Theil (Mladenoff 1995, 1999, Thiel 1985). Natural Resource managers used this model extensively to predict the carrying capacity of the Great Lakes Region for wolves. In 1999, Mladenoff et al. reinforced the strength of their model using additional data collected after the first model's creation. Areas of Wisconsin with higher road density had increased anthropogenic caused mortality, and landscapes with lower density had more frequent wolf activity (Wydeven et al. 2001). Using pellet count transects, Potvin et al. (2005) improved upon this model for the UP by effectively eliminating northern, higher elevation areas that did not support adequate white-tailed deer in large enough numbers to support a wolf population. A dispute with Mech (2006) resulted in agreement that the Mladenoff et al. (1995) model depended on location data from early colonizing individuals with no competition and time for adaptation to human interaction. Mladenoff et al. (2006) stated the habitat selection would first begin with the most optimal habitat with low road densities, and that hierarchical decisions on marginal habitat selection could not be predicted by their model. The Mladenoff et al. (1995) model, despite its limitations, serves as a useful tool in habitat selection prediction so long as users keep its limitations in mind and natural resource managers understand that while the roads are relatively spatially and temporally permanent, human tolerance to wolf-presence in an area is always evolving. Again, this highlighted the sink-source relationship, with areas with lower road densities and higher tolerance to wolves compensating for mortalities in high road density/low tolerance for carnivore presence (Kohn et al. 2009, Mladenoff et al. 1995, 1999, 2005, Wydeven et al. 2001).

The purpose of this study is to assess whether the model developed using road density (km/km^2) and prey abundance (Mladenoff et al. 1995, Potvin 2005) can be more predictive by examining the density of the second and third type of roads, which are DNR managed roads and recreational trails. We are interested in whether the readily available geographic information systems (GIS) data for Michigan’s roads and trails densities and radio-telemetry data collected by the Michigan Department of Natural Resources (MDNR) will better inform resource managers of the highest and marginal habitat that exists to support an established, recovered grey wolf population in the (UP). The basis for this study was first described in the culmination of the original model's creation by Wydeven et al (2001), which simultaneously demonstrated the usefulness of road density in determining wolf habitat while acknowledging more understanding of wolves' relationships with these man-made alterations to the landscape.

METHODS

Study Area

This study focuses on the UP of Michigan with an area of 41,984 km^2, and a human population of approximately 300,000 (POTVIN et al. 2005). Due to the Wisconsin glaciation, there is wide variability of landforms, soils, and hydrology in upper Michigan with the present-day vegetation reflecting this. Logging, agriculture, fire, and fire exclusion are the major disturbances. The Great Lakes have a major effect on the climate, and elevations range from 177 to 604 m (580-1,980 ft). A wide range of habitats exist including coniferous and deciduous forests, plains, wetlands, and bogs (Albert 1995). National forests, a national wildlife refuge, state forests, and state parks comprise 40% of the total area of the UP (POTVIN et al. 2005).

Wolves faced an uncertain extirpation in Michigan's UP until 1988 when three wolves migrated from Wisconsin (Beyer et al. 2009). The gray wolf population in upper Michigan has increased every year since with the exception of 1997 and is currently present in every county of the UP. Wolf density tends to be higher in the western portion of the region. Wolves will occasionally be absent from Keweenaw County, which is at the northernmost portion of the state (Beyer et al. 2006).

Wolf Location Data

This study uses data provided by the Michigan Department of Natural Resources for 360 individual wolves over the years 2000-2015. Radio-telemetry is the most accurate source of location data that is readily available for wolves in Michigan (Beyer et al. 2009). Aircraft track collared wolves and observers record the date, time, life status, geographic coordinates, qualitative observations such as color or activity, and the presence of any additional individuals. There were 360 individual wolves that were trapped with foothold traps and fitted with transmitters that were recorded for a total of 29,364 data points. The wolf location data was analyzed digitally using ArcGIS 10.4 (Environmental Systems Research Institute, Redlands, California, USA), using the harmonic mean of home range estimation (Dixon & Chapman 1980). This technique generated 20, 40, 60, 80, and 95% use isopleths for every telemetry location recorded. Following the procedure in Mladenoff et al. 1995, we chose the 80% use isopleth, which generally retains large concentrations of observation locations, while excluding outliers, terrain used during dispersion, and errors or datapoints used to denote lost radio-collars. (Spencer & Barret 1984; Harris et al. 1990).

Landscape Coverages and Preparation

The geographic data layers for all Michigan roads, Department of Natural Resource managed roads, hiking, cross-country ski, snowmobile, ATV, ORV, equestrian, bicycling, and motorcycle trails are available for download from the State of Michigan and the Michigan DNR's open-data portals (MiGDL 2016). This data was analyzed to determine potential probability areas for grey wolf habitat suitability. Outliers for this study fell more than 5km from 98% of the other observed point locations for the individual wolf. A main use area of less than XX km^2 was excluded because the area is smaller than the smallest that has been found to support a breeding pack in the Upper Great Lakes region. Finally, converting this raster to a polygon layer and clipping it to areas within the UP resulted in 20 distinct pack areas. We created a buffer of 10 km around these main-use areas before sampling the remaining area for experimental comparison sites (Mladenoff 1995). The area that Potvin (2005) deemed low-quality habitat due to lack of abundant prey was eliminated next so that only the habitat with probability of support wolves was considered.

After the determined wolf 80%-use areas, a 10 km buffer, and the low-quality habitat was removed, 200 random polygons with an area equal to the mean 20 wolf 80%-use areas (121 km^2). In sequential order, the first 20 randomly-generated polygons that did not overlap the primary-use range of the wolf layer or the boundaries of the map. This prevented sampling of area that would not contain roads or that would be accounted for in the wolf-isopleth measurements.

Statistical Analysis

We recorded the area in km^2 of each wolf pack and non-wolf pack polygon, and the length of any roads and trails in km contained within each polygon and used this the road or trail density for each polygon in km/km^2. Using a t-test, the road densities of the experimental polygons for comparison were ensured to be representative of the UP's overall road density. The wolf-presence polygons were then compared using a t-test to the randomly selected polygons to test whether road density was still significantly different amongst means. The various road surfaces were compared to one another to test for collinearity. Finally, all variables were analyzed using a logistic regression to discover whether the addition or exclusion of any variables along. One polygon representing a wolf-presence area displays outlier characteristics. The tests were run on datasets including and excluding this outlier 80%-use area to perceive any skewedness that may affect the outcome. The resulting models were assessed for residuals, goodness-of-fit, and classification accuracy of the response variable.

DISCUSSION

The results of our study align with the previous studies' assertions that the predictability of habitat selection for grey wolves using road density appears to be the strongest statistical method, at least in comparisons of measuring densities of road surfaces in the Upper Peninsula of Michigan. When Potvin (2005) conducted pellet counts to determine white-tailed deer population estimates for the UP of Michigan, he determined there were areas of low density that could not support breeding wolf populations. A comparison showed Mladenoff et al.'s original prediction of total area (1995) to be within 10% of Potvin's (Mladenoff et al. 2006). Our study also agrees with those findings. Using the most recent telemetry spatial data, we found road density to be the variable that most strongly predicts habitat avoidance by grey wolves. We also confirmed that there is no long-term utilization of habitat by wolves in the areas that Potvin (2005) deemed to have a low probability of containing adequate deer populations. With sixty-five (13/20) percent of the designated areas of having high wolf presence falling in areas with road densities of less than 0.45 km/km2, the model's power to predict suitable wolf habitat is greater than half. We combined wolf data locations from over a span of 15 years, as opposed to biannually, to generate the territory occupancy of grey wolves in the UP. This may account for the higher mean road density than in the original models based upon road density, and therefore the threshold should not be reconsidered based upon the findings of this study. We chose this method because the model intended for expanding populations at the spatial scale level of packs, while the grey wolf population in Michigan is currently stabilizing and considering a home range within a population range (Johnson 1980, Zimmerman 2014). Also, the volume of data available for analysis using historical records and improved technological methods allows the inclusion of more spatial data, which allows for broader understanding of core-use areas. Zimmerman's study did not fully support the prediction that road density affects wolf habitat selection at the patch level. Not delineating wolf populations into packs based upon seasons as opposed to core-use areas allows an improved understanding of which habitat is selected by wolves based upon fixed features such as roads and avoids shifting variables such as public perceptions or traffic volume in any given year. It is worth noting that historical pack area construction relied on questionnaires and interviews from trappers, biologists, and "other knowledgeable people" (Thiel 1985) which provides valuable historical data, but it is not as fixed to an exact location and time with the degree of accuracy that radio-telemetry and GPS capabilities afford. Also, the increase of historical road densities correlated with the extirpation of wolves in Wisconsin were county averages, and the road densities did not necessarily represent actual wolf habitat. Thiel made sure to note that the road development occurred at the same time when the Wisconsin public's perception of wolves was at its lowest and there was a bounty in place. This gives strength to the argument that regardless of methodology used to calculate primary-use areas for grey wolves or social influences aside, road density remains a strong predictive variable of suitable habitat.

Some of the surfaces considered for this study simply did not appear to have enough representation on the landscape to contribute significantly to responses by wolves in the long-term. While wolves may take advantage of the compressed snow of a cross-country ski path or snowmobile trail, the spatial data of the trails do not more strongly predict habitat suitability or unsuitability. These trails permeate areas with high wolf activity, but the access and activities of humans on the landscape is not enough to dissuade avoidance altogether. It would be of further interest to compare road densities in an area with known negative historical perceptions of wolves and another area with a more positive outlook on their presence. A comparison of an American and a European recreational trail density in areas of wolf activity may differ dramatically. As suggested by Thompson (1952), the attitude and acceptance of people in the region may help explain at least some presence or absence of wolf populations. To map perceptions and attitudes towards wolf presence is possible, but it requires intensive survey and analysis, and the results are on a smaller temporal scale than the complete alteration of habitat that road construction creates. Attitudes towards wolves by inhabitants can change quickly for various reasons such as media campaigns, wolf depredations, and outreach efforts by conservation organizations, but the effects of road construction are often semi-permanent.

As Kohn (2009) emphasized, public perception and acceptance of wolves' presence is not spatially fixed as roads are, and the survivability of wolves in any given locality is relies on the attitudes of the humans nearby. When Thompson first made this observation in 1952, rural roads in Wisconsin were very limited outside of town limits (Thiel 1985). Alternatively, the roads represent access, concentration, and volume of human alteration upon the landscape, and this plays only a percentage in the decision-making process that results in habitat selection. This process is complex and empirical in nature, and the original authors of the model warn it was developed using a dynamically expanding population (Mladenoff et al. 2006).

The outlier in our study is the wolf 80%-use isopleth, which had an exceedingly high road density. There may be numerous factors not included in this study that attribute this anomaly to the limits proposed in previous studies including: the low population in the nearby village, the presence of large tracts of state forest land in close proximity with little to no roads or trails, positive attitudes and perceptions of wolves by inhabitants of the area, lower speed limits resulting in few wolf vehicle mortalities, habitat that does not support enough prey species, or lower volume of traffic on the roads that are in the study area. These represent the presence of areas of high road density potentially acting as a sink, while nearby areas of extremely low road density provide the population source (Mladenoff 2006). While all of these may have large impacts on habitat selection by wolves, they cannot be obtained, measured, and analyzed as easily as road density (Mladenoff 1995). There was also a railway that passed just outside of the area. It is possible that this railway serves as a potential conduit for wolves to pass through the area with ease. Train tracks would only have traffic from one direction at any time, which can influence wolves' ability to cross safely, and trains produce more sound, which could afford the wolves more time to react, making the route preferable to that of the higher concentration of roads in the designated region.

The presence of the highest densities of roads, DNR-managed roads, and railroads in the outlier WUP could also contribute to the higher detections rates of collared wolves in this landscape. In addition to the proximity of nearby areas of lower road densities to act as sources, the various trail surfaces represent choices for wolves. The DNR-managed road use and traffic is likely less regular, fragmented, and dangerous, while railroads may offer a way to avoid the area of high road density altogether. In the instance of the outlier, the train tracks are located outside of the hub of densely clustered roads. Train tracks represent an anthropogenic disturbance that is unique among the trails or road surfaces. Trains tend to run on regular schedule, are loud, and can only come from one direction at a time. As Kohn (2009) noted, wolves tend to have more difficulty crossing roads with two-directional traffic.

Although the rate at which wolves travel along, utilize, or are killed along train tracks is beyond this analysis, but exploration of how wolves utilize railroads to avoid metropolitan areas during dispersion could potentially enlighten research to how wolves bypass areas of high human populations. The smaller relative, *Canis lupus*, have been studied extensively and observed to use railways for permeating cities; however, coyotes do not have the aversion to humans that wolves possess. The same switching locations that allow some trains with goods to bypass cities while passenger trains switch tracks in order to enter the cities may serve as points where canids make similar decisions.

The implication of this study for land managers is that road densities are a crucial starting point for suitable habitat delineation for grey wolves. While Mech (2006) contends this represents little better than a coin toss, with technology and spatial data becoming more widely available, studies such as ours will continue to be more readily and easily completed (Mladenoff et al. 2006). The model has been shown to reliably predict grey wolf habitat decades after its original development with dynamically expanding populations, changes in public perception of wolves, and even hunting seasons (Mladenoff et al. 1999, Potvin 2005). During an initial assessment, management planners can take spatial and historical data and analyze it quickly to narrow down and target conservation and management efforts. For example, areas with high road densities and wolf presence could be targeted with information campaigns to raise awareness to vehicle mortalities, conservation efforts to reduce depredations can be shifted to areas with lower densities and higher probabilities of wolves, and further road construction into areas with low existing road densities can be limited. It also cannot be stressed enough that these studies still rely on labor and resource intensive efforts for the collection of the grey wolf data to develop and test these hypotheses. These activities range from the trapping and collaring of individuals to volunteer tracking teams that go through training and increase the area surveyed annually to maintaining and operating aircraft fitted with receivers to collect the signals used to locate individuals.

NOTES

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Maps developed as part of this study are not included in order to protect the data.

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