Monitoring Wolf Recovery in Michigan's Northern Lower Peninsula: Can human densities predict wolf presence?

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Abstract: Gray wolves are staging a comeback throughout many parts of the Great Lakes Region. Models have identified current available wolf habitat in these areas, with likelihood estimates of wolf occurrence. These models fill a vital role in supplying scientifically-sound information to managers so proactive measures can be taken to ensure survival, reduce conflict, and preserve species. These models however have yet to address future available habitat under the driving forces of human-related activities. Studies (Woodroffe 2000, Woodroffe & Ginsberg, Thiel 1985) have shown that humans and their activities are often the cause of large carnivore declines. The GIS model presented in this paper addresses the future of wolf habitat in Montmorency County, Michigan, based on localized human densities in and around suitable wolf habitat. Based on analysis, Montmorency County may lose up to 23% of suitable wolf habitat by the year 2050.

Introduction

After decades of persecution, gray wolves (*Canis lupus*) have made a remarkable recovery in the northern Great Lakes region. Following extirpation from the state of Michigan in the 1950s, the Endangered Species Act of 1973 gave needed protection to remaining disjunct wolf populations, allowing for expansion. Since this time, residual wolf populations in Minnesota have expanded and recolonized areas of Northern Wisconsin and Michigan's Upper Peninsula (UP) (Michigan Department of Natural Resources 1997). Wolves have yet to reclaim much of their historical range throughout the Great Lakes region and much of the lower 48 states, likely due to human inhabitance, development and fragmentation. Human population growth often creates new environments that are hostile to many wild species and ultimately often lead to species decline (Woodroffe 2000). This is especially true of large carnivores because tolerance by humans is often quite low and conflict is typically "resolved" by carnivore eradication (Woodroffe 2000, Woodroffe & Ginsberg 1998).

Relative to this, research (*see* Theil, R.P. 1985; Mladenoff et al. 1995; Mladenoff et al. 1999) has found that road density (linear km/km^2) of a given area is the best predictor of wolf occurrence. While roads do not present any physical barrier to traveling wolves, roads provide an index of human contact and indicate likelihood of deliberate or accidental human-caused mortality (Mladenoff et al. 1997). Mladenoff et al. (1995) used a 10-km moving-window analysis and neighborhood statistics in a Geographic Information System (GIS) based on logistic regression of road density. Gehring and Potter (2005) were able to apply this model to Michigan's Northern Lower Peninsula, where current wolf status is unknown. This model identified areas of suitable habitat (>50% probability of wolf occurrence) in Michigan's NLP and determined that this area has enough suitable habitat for approximately 100 wolves.

Increases in recent sightings and reports in the NLP indicate that wolves may soon return in viable numbers. This calls for the need to create proactive management plans, which may help prevent conflict and ensure the long-term viability of wolves in this area. It may be beneficial to managers and researchers to have a model that not only predicts where wolves may occur in present landscapes (as previously mentioned authors have done), but also into the future. A predictive model that forecasts available wolf habitat for decades will allow managers to make sound long-term conservation decisions that have ecological reasoning and scientific support.

The most logical approach to modeling wolf habitat change would be to predict changes in road density. Few models of forecasted land-use change exist, and none are able to predict both changes in road density and exact spatial distribution of future roads. Given the fragmentation of wolf habitat in the NLP, it is imperative to know changes to habitat (i.e. through road building) on a fine scale, and neither models nor transportation agencies can provide this information. Another caveat to this approach is that even though new roads may not be built, human densities along existing roads may increase, thereby increasing contact rates with wolves without a direct increase in roads. For this reason, and with the knowledge that roads serve as an index to human contact, it was hypothesized that human densities and their respective growths could provide information on wolf occurrence in the future.

Census data is readily available and documented on a census-block scale. While even finer scales would be preferable, this information may provide an idea of not only the intensity of human growth, but also the location. Since road densities are still considered the best predictor, changes to human densities *within* already defined suitable habitat will be analyzed.

A GIS-based approach was used for this model for many reasons. Statistical approaches require the use of non-correlated variables to define accuracy. It is already known that road density and human densities are often correlated so a statistical approach using both variables would not be warranted here. In GIS models, however, redundancy in variables does not affect accuracy and the model may in fact improve as variables are added (Beier et al. 2007). The main impact is instead on ecological interpretation, and not the accuracy of numerical predictions (Beier et. al 2007). In other words, this GIS model will be used for identifying trends in wolf occurrence in relation to trends in human populations, and not applicable to determining exact numbers of wolves in a given area. In addition to this, a GIS-based approach provides a visual representation that is easily interpreted without a technical or statistical background.

There are therefore two objectives of this study: 1) Determine if trends in human densities coincide with suitable wolf habitat determined by road density; and 2) Use projected census data to predict the future of wolf habitat in Michigan's NLP.

Methods

Study Area: Michigan's Northern Lower Peninsula is generally referred to as all areas north of M-55. In this paper, only Montmorency County was chosen for analysis (Figure 1). While identified suitable habitat lies in many counties throughout the NLP, Montmorency was chosen for its fairly central location (in suitable wolf habitat) and identified suitable habitat is spread out over much of the county rather than confined to one or few areas.

Data and Analyses: Maps and analyses were performed in ArcGIS 9.0 (ESRI, Redlands, CA.). Data pertaining to Michigan counties and census block tracts were downloaded from Michigan's CGI Website and census numbers were obtained from the U.S. Census Factfinder website (http://factfinder.census.gov). The Gehring and Potter (2005) output of suitable habitat was obtained from the authors.

Figure 1. Montmorency Co., MI. Pink shading represents >50% probability of wolf occurrence as defined by roads (from Gehring and Potter 2005).

Objective 1: To determine if trends in human densities are found in suitable wolf habitat from Gehring and Potter (2005), census data first had to be integrated into spatial census block data. All population data for census blocks were downloaded in text file form and added to ArcMap as a table. It was then possible to join the census data file to census block shapefiles. This gave an idea of approximate numbers of humans living in that census block.

As census blocks are irregular and non-uniform in shape and size, it was necessary to determine human populations in terms of density. To determine current density, spatial statistics tools in ArcToolbox were executed to calculate the area (in km^2) per census block. The number of people was then divided by the area of the census block to obtain human densities. Census blocks were mapped and displayed as graduated colors based on human density. This gave a visual representation of where human populations were concentrated throughout the county. Human densities within already identified suitable habitats (Gehring and Potter 2005) were examined until 90% of suitable areas could be defined as falling under a given human density. This defined suitable habitat on a census basis.

Objective 2: To predict future availability of wolf habitat, future census data for Montmorency County was projected. Previous rates of growth were determined based on census data from 1970-2005, obtained from the Michigan Office of the State Demographer. Rates of growth (in 5-year increments) were analyzed and showed no indication of substantial increase or decrease over time, so growth rates per 5-year segments were averaged for an average population growth of Montmorency County. This rate of growth was then applied to census blocks that lie in suitable habitat and projected to the year 2050. If human densities grew above 90% human density cutoff defined from objective 1, they would be excluded and considered unsuitable habitat.

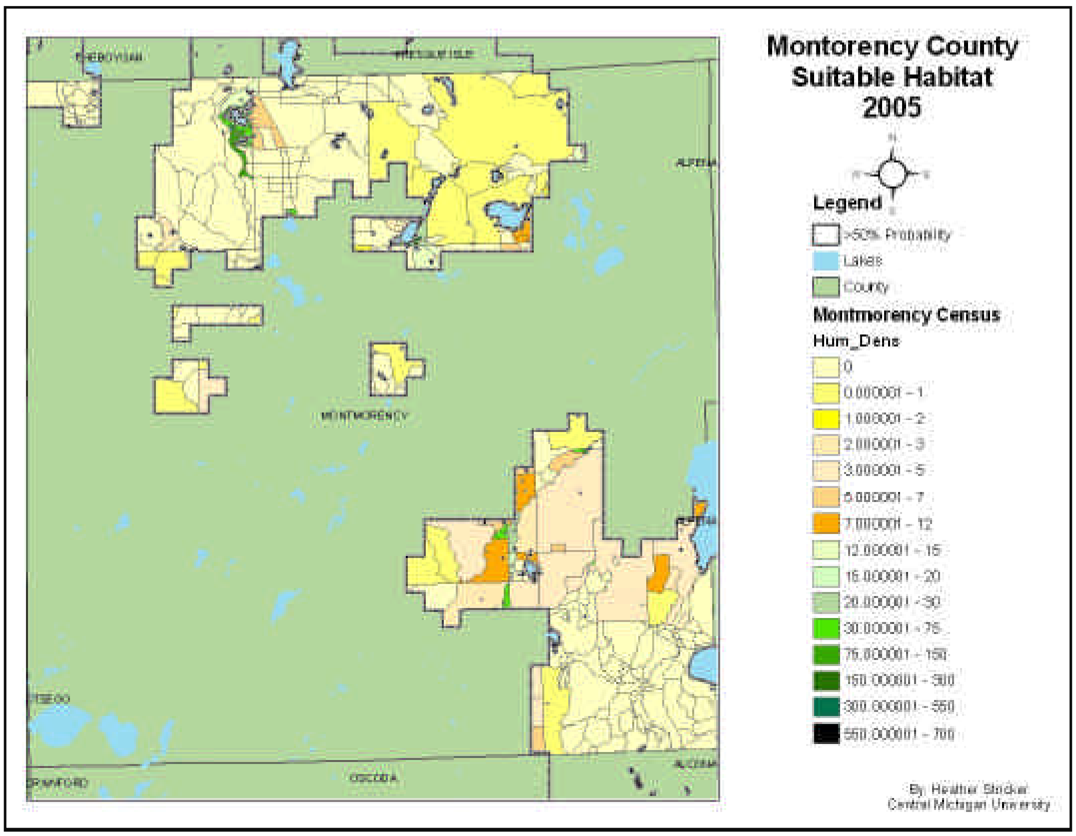

Figure 2. Census blocks and respective human densities within suitable wolf habitat in Montmorency County.

Results

Objective 1:

On a county-wide basis, the average human density of Montmorency County was approximately 7 people/ km^2. Average human density in suitable wolf habitat was approximately 2.4 people/km^2 (see Figure 2). Most census blocks in suitable habitat had no human inhabitance (Figure 3). Of the total 685 km^2 of suitable habitat in Montmorency County, 90% of that land area was found to have a human density of <5 people/km^2 (Figure 4).

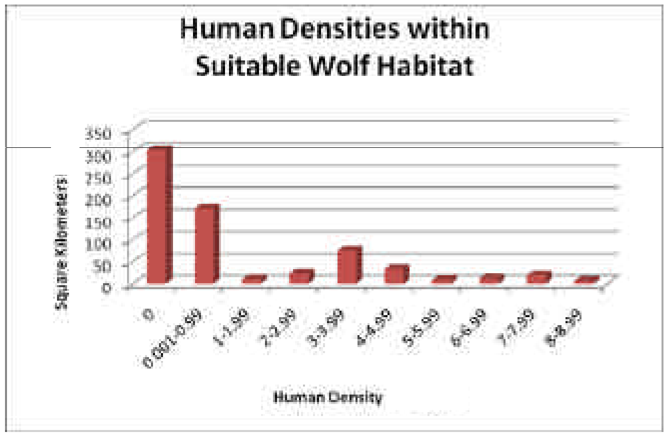

Figure 3. Area (km^2) occupied by respective human densities.

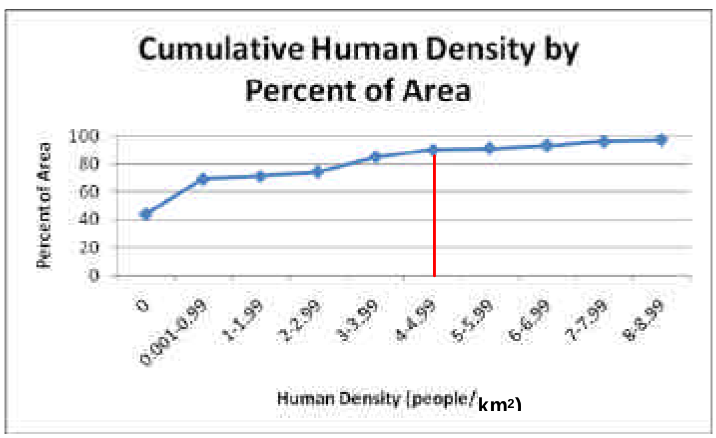

Figure 4. Percent of suitable habitat area that falls below a given human density. Red line indicates 90% cutoff.

Objective 2:

Human population growth in Montmorency County has continually increased since the 1970s. Data does not suggest that rates will change substantially in the next four decades if growth continues to follow similar patterns as the past three decades (Figure 5), so 5-year growth rates were averaged. Average growth of Montmorency County per five years was approximately 1.152.

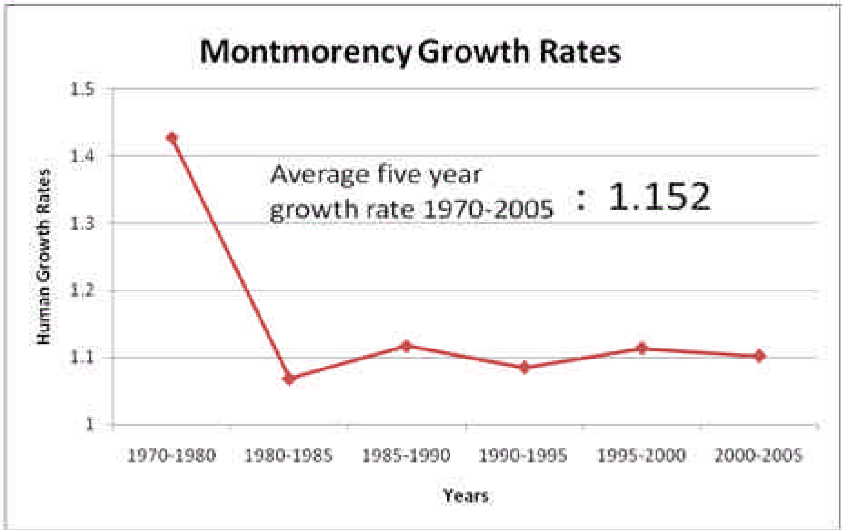

Figure 5. Montmorency Co. human growth rates 1970-2005.

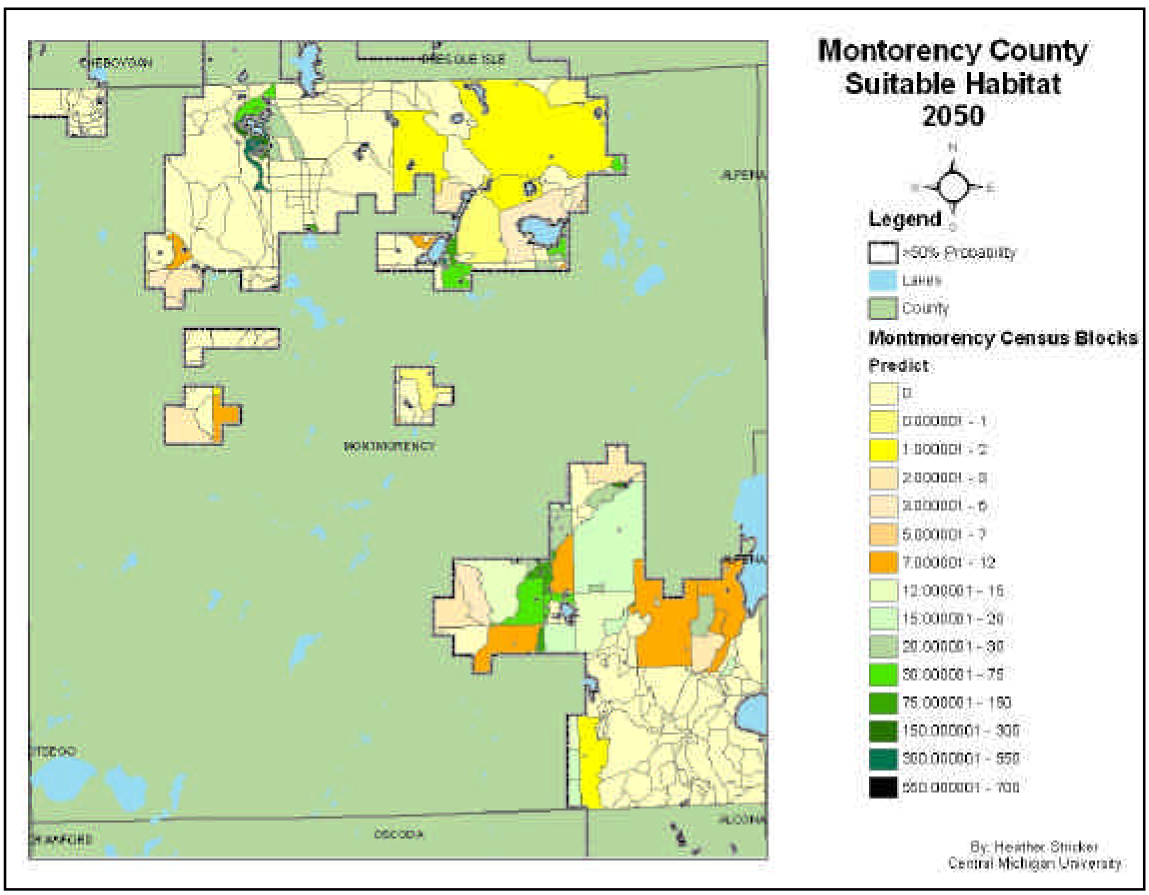

Figure 6. Census blocks and respective projected human densities within suitable wolf habitat in Montmorency County, projected to the year 2050.

When this rate was applied to census blocks in suitable habitat areas, some blocks experienced high levels of change while other blocks experienced no change (i.e. blocks with no initial human inhabitance) (see Figure 6). Predictions indicate that overall, 2050 average human density of suitable habitat may increase to 8.4 people/km^2, as compared to 2.4 people/km^2 in 2005.

Table 1. Comparison of human densities and percent of suitable land area 2005 and 2050. Red number indicates 90% cutoff. Shaded columns pertain to 2050 projected data.

Human Density (people/km^2)	Percent of Area 2005	Cumulative % of Area 2005	Percent of Area 2050	Cumulative % of Area 2050
0	44	44	44	44
>0-1	25	69	4.4	48.4
>1-2	1.5	70.5	11	59.4
>2-3	3.5	74	7	66.4
>3-4	11	85	2.6	69
>4-5	5	90	1	70
>5-6	1	91	0	70
>6-7	1.5	92.5	.5	70.5
>7-8	3	95.5	1.5	72
>8-9	.5	96	.2	72.2
>9	4	100	27.8	100

Of the suitable area, 44% remained without human inhabitance, but changes in areas of different initial human densities changed dramatically in some cases. Areas of less than 5 people/km^2 only accounted for 70% of the total identified suitable land, and the 90% cut-off was not achieved until > 11 people/km^2 (Table 1, Figure 7).

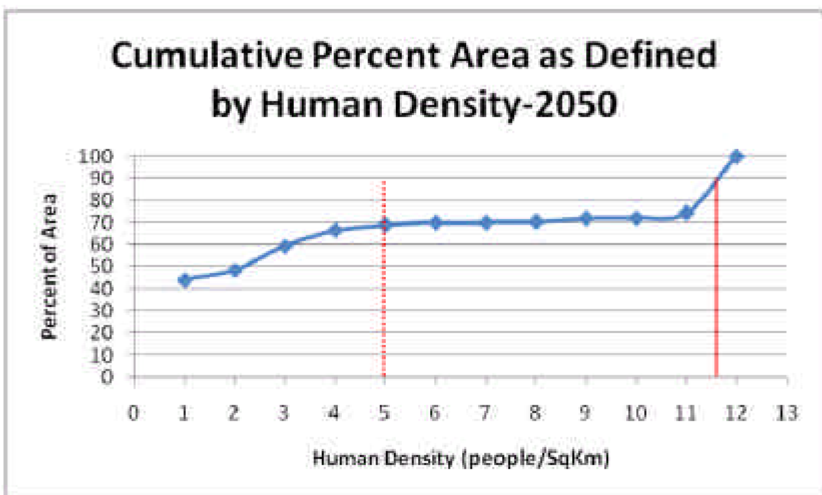

Figure 7. Cumulative percent land area occupied by a given density or below. Red line indicates 2050 90% cut-off, dashed red line indicates 2005 90% cut-off for comparison.

Discussion

Within defined suitable habitat (from Gehring and Potter 2005), 90% of this area has a human density of <5 people/km^2. This is comparable to other studies, where Fuller et al. (1992) found that 88% of wolves in Minnesota were found in townships that had <4 people/km^2. Wydeven et al. (2007) found mean human density in known wolf pack habitat in Northern Wisconsin to be approximately 4 people /km^2, and the 90% pack cut-off (i.e. wolves do not occur in human densities above this level) was 10 people/km^2. These studies used known wolf pack areas for census analysis, thereby validating this model.

With census data appearing to be a valid indicator of wolf occurrence, census data was used to project the availability of suitable wolf habitat into the year 2050. Current (2005) estimates showed the average human density in all identified wolf habitat to be 2.4 people/km^2. 90% of this area had a human density of under 5, and 97% under a human density of 10 people/km^2, which is under the Wydeven et al. (2007) cutoff for suitable wolf habitat. Projections for 2050, however, resulted in an average of 8.4 people/km^2, of which only 70% was under 5 people/km^2, and only 74% falling under the cutoff level of 10. This may mean that based on census data, Montmorency County may stand to lose between 20-23% of suitable wolf habitat by the year 2050.

This approach has identified areas of human growth and has shown the ability to predict trends, and to some extent give a spatial indication of potential changes to fragile wildlife habitat. As previously mentioned, this approach may be very beneficial and useful for identifying ecological trends, but numerical results must be interpreted with caution and limitations of the model should be known. This approach necessarily ignored processes such as local urbanization and human migration between census blocks. Blocks that began with zero human inhabitation remained at zero because growth rates only pertained only to existing 2005 populations. Also, localized human populations such as small towns may be concentrated in one area of the census blocks, but numbers were required to be extrapolated across entire census blocks because spatial distribution of humans within those blocks were unknown. Another limitation of this model is that human growth rates applied to each census block were based on growth rates of the county as a whole.

Studies have indicated strong associations between local human density and carnivore extinctions (Woodroffe 2000, Woodroffe and Ginsberg 1998). This study presents a predictive model that has the ability to provide managers with information on localized change in critical wolf habitat. Future work should expand this model to all areas of wolf habitat (both known and potential) so that managers may take appropriate steps to reduce the impacts of human inhabitation.

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