

The usage of GIS to track the movement of black bears in Minnesota due to climate change

Introduction

In northeastern Minnesota, black bears migrate from 1971-1991. I chose to focus on the black bears that have been tested in 1971 and 1991. The 1971 data is the home range of eleven black bears (*Ursus americanus*) in Isabella and Kawishiwi Ranger Districts in the Superior National Forest (Fig. 1). The 1991 data consists of three black bears in the same area as the 1971 data. This movement may be due to the climate change in the twenty year span. The black bear is the only species of bear found in Minnesota. They are generally restricted to forested areas (Minnesota DNR, 2012).

Climate change is a change in the statistical properties of the climate system over long periods of time, regardless of cause (IPCC, 2001). Climate change is known to have an effect on the environment and animals in that environment. Climate change can cause draughts making any wildlife in the area to migrate out and find a new place to live. Other ways that climate effects the environment is if it the area becomes too cold or too hot for a species and are unable to adapt to the new conditions which make them migrate. To test this hypothesis, I used ArcMap to create maps of the migration of the black bear in 1971 and in 1991.



Figure 1

Black bear test area (USGS).

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Data Collecting

The data that I used to track the black bear movements comes from the USGS Fort Collins Science Center (http://www.fort.usgs.gov/Products/GIS/GIS_abstract.asp?GISID=2) as a polygon shapefile. I decided to use the 1971 and 1991 data so I could have the first and last areas that the black bears lived. I downloaded the climate raster data from <http://www.worldclim.org/> for 1991, and the raster data for 1971 was gathered from <http://www.ccafs-climate.org/>. I used the United States shapefile from lab 2 in our GIS lab class folder. I also downloaded a polygon shapefile of the Minnesota water areas from MapCruzin.com (<http://www.mapcruzin.com/free-united-states-shapefiles/free-minnesota-arcgis-maps-shapefiles.htm>).

I also decided to mess around with MaxEnt, a program for modeling species distributions from presence-only species records (Elith et al., 2011). I downloaded the MaxEnt program from the Princeton website, <http://www.cs.princeton.edu/%7Eeschapire/maxent/>. In order to use this program, I had to convert my black bear data into a .CSV form using Excel. The climate data I used is the same 1971 data and the 1991 data was downloaded from <http://www.ccafs-climate.org/>. MaxEnt is used predict species habitat modeling by using maximum-entropy approaches (Phillips et al., 2004).

Data processing

My first step was to create a map showing the climate in the United States during 1971 and 1991. I started with a blank map in ArcMap and first uploaded my 1971 black bear data. I then added the United States shapefile making the color hollow so I could see my black bear data. After adding the United States shapefile, I added the shapefile containing the Minnesota water areas (Fig. 2) making it blue without an outline so only the major lakes and rivers are shown. The coordinate system for my map is WGS 1984. From here I added raster data for the mean temperature for 1971. This raster covers the entire globe, so I clipped it to just the United States because this is my area of study. The steps for that are below:

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- First I converted my raster to a polygon using the Raster to Polygon tool (Fig. 3)
- Now that my raster is a polygon, I can clip it to the United States shapefile (Fig.4)

The end result of the clipping and adding all layers are shown in Figure 5.

Next I created a new map in ArcMap for my 1991 data. I added the mean annual temperature raster for 1991 first. Then I added the states shapefile and also made it hollow so I could see my other data. The last two layers that I added was the black bear 1991 data I downloaded from the USGS website and added the Minnesota waters shapefile. The map created showing the location of the black bears in Minnesota during 1991 is shown in Figure 6.

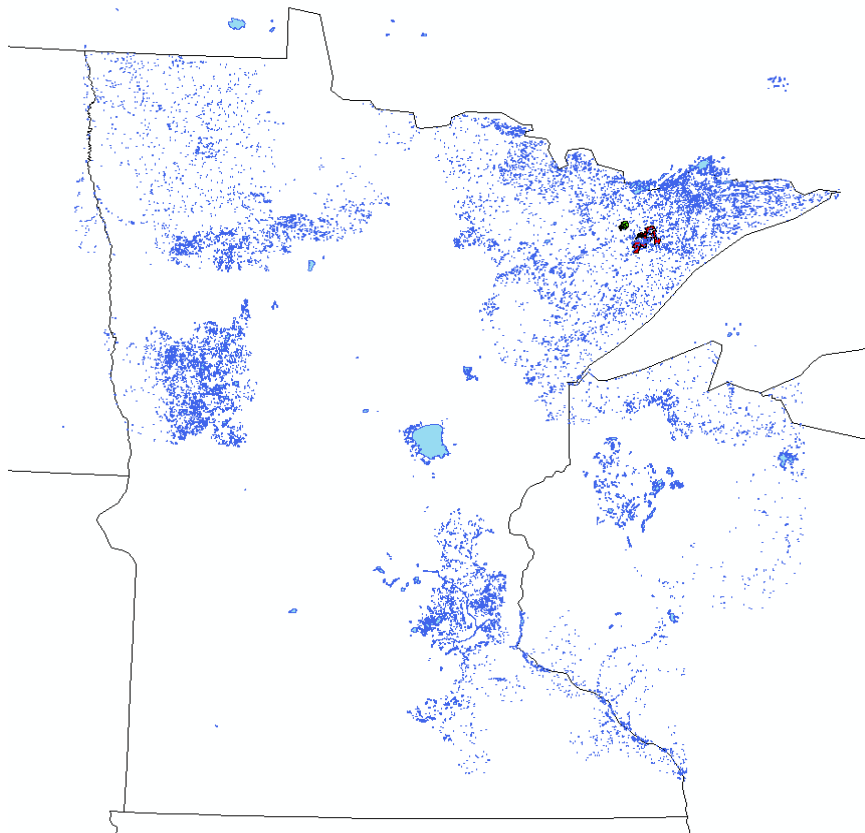


Figure 2

Snap shot of ArcMap. Blue areas are water, the red area is 1991 black bear data and the green is the 1971 black bear area.

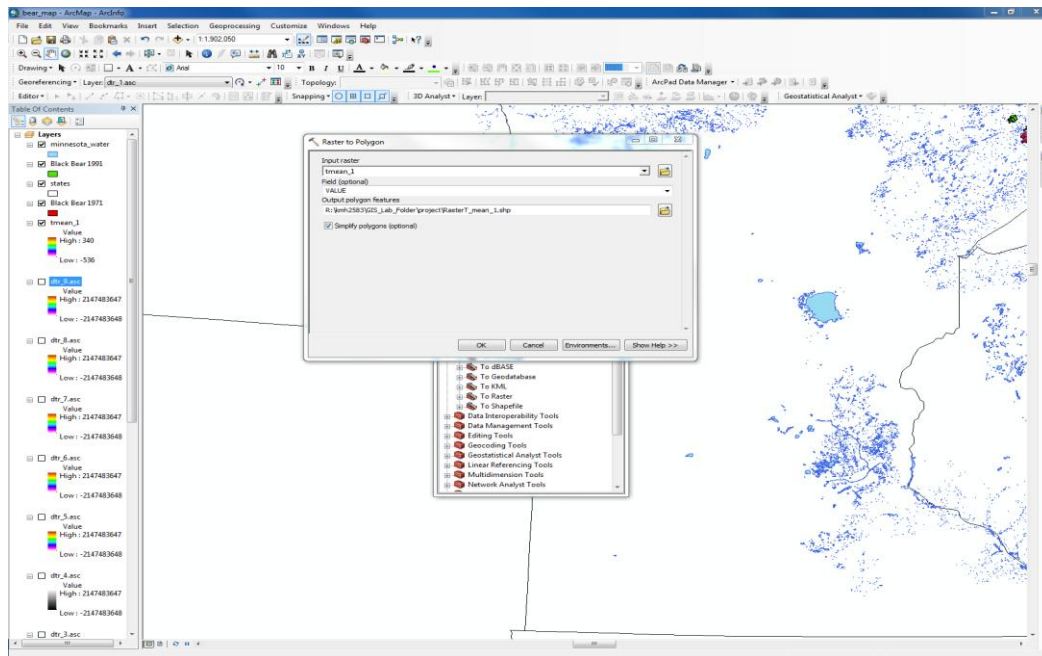


Figure 4

Snap shot of converting raster data for 1991 mean temperature to a polygon.

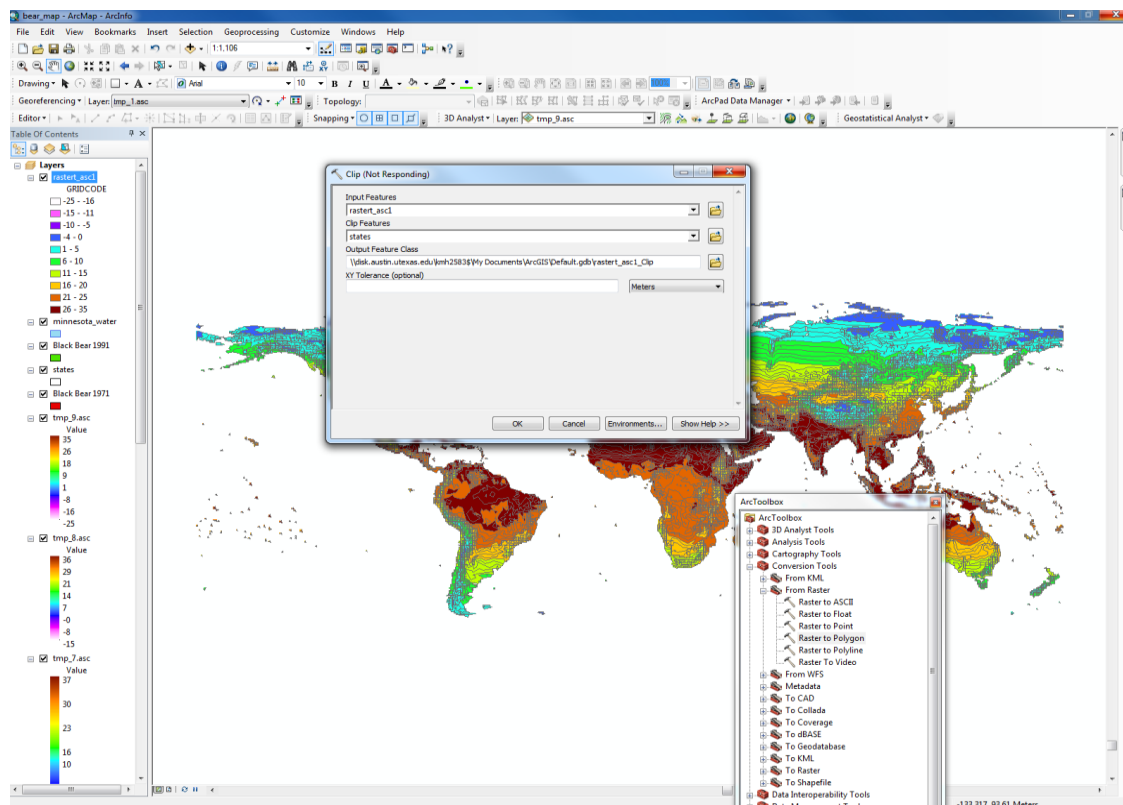


Figure 4

Snap shot of clipping polygon raster mean temperature data for 1991 to the United States shapefile.

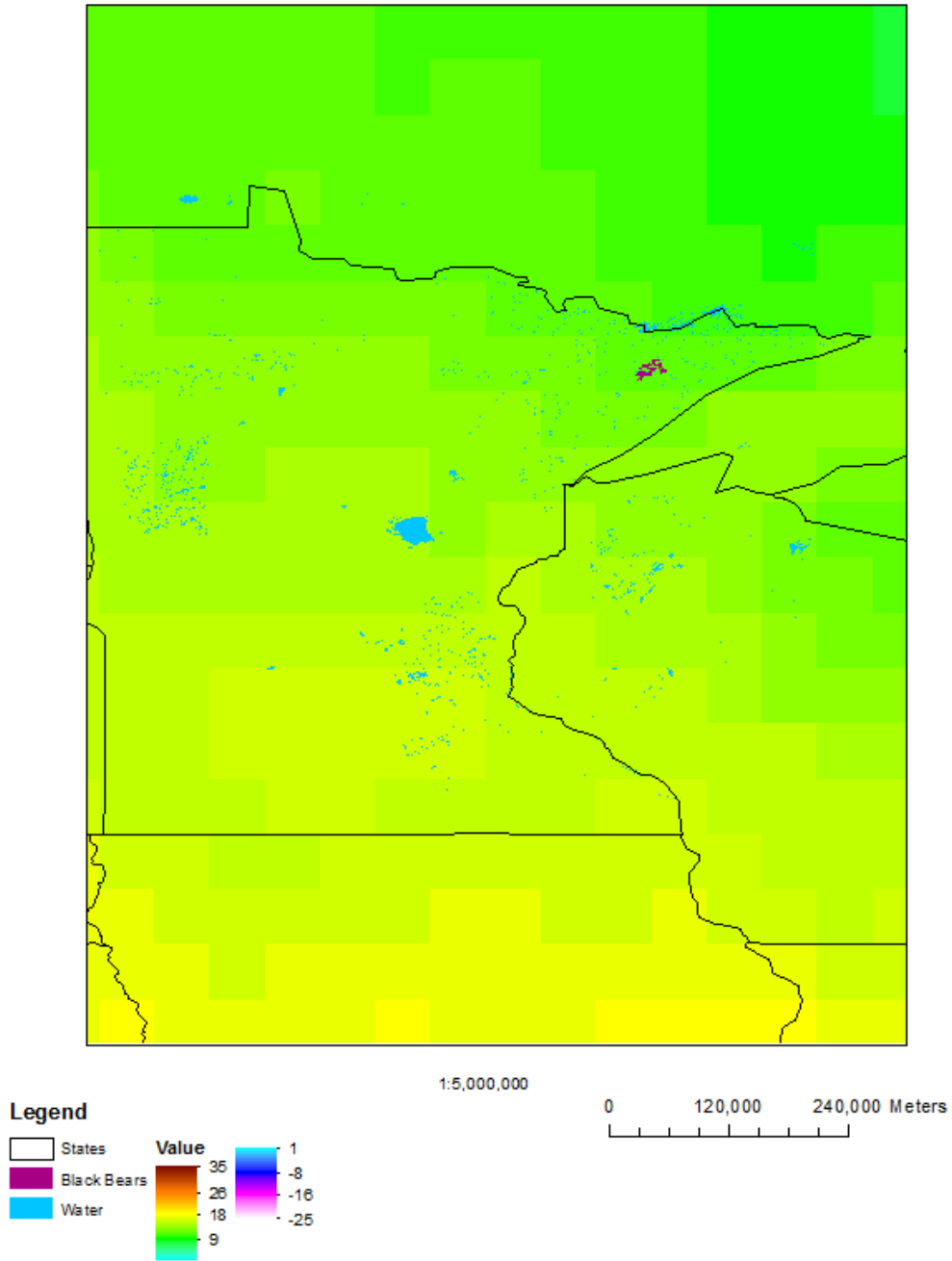


Figure 5
Climate map of the black bears in Minnesota during 1971.

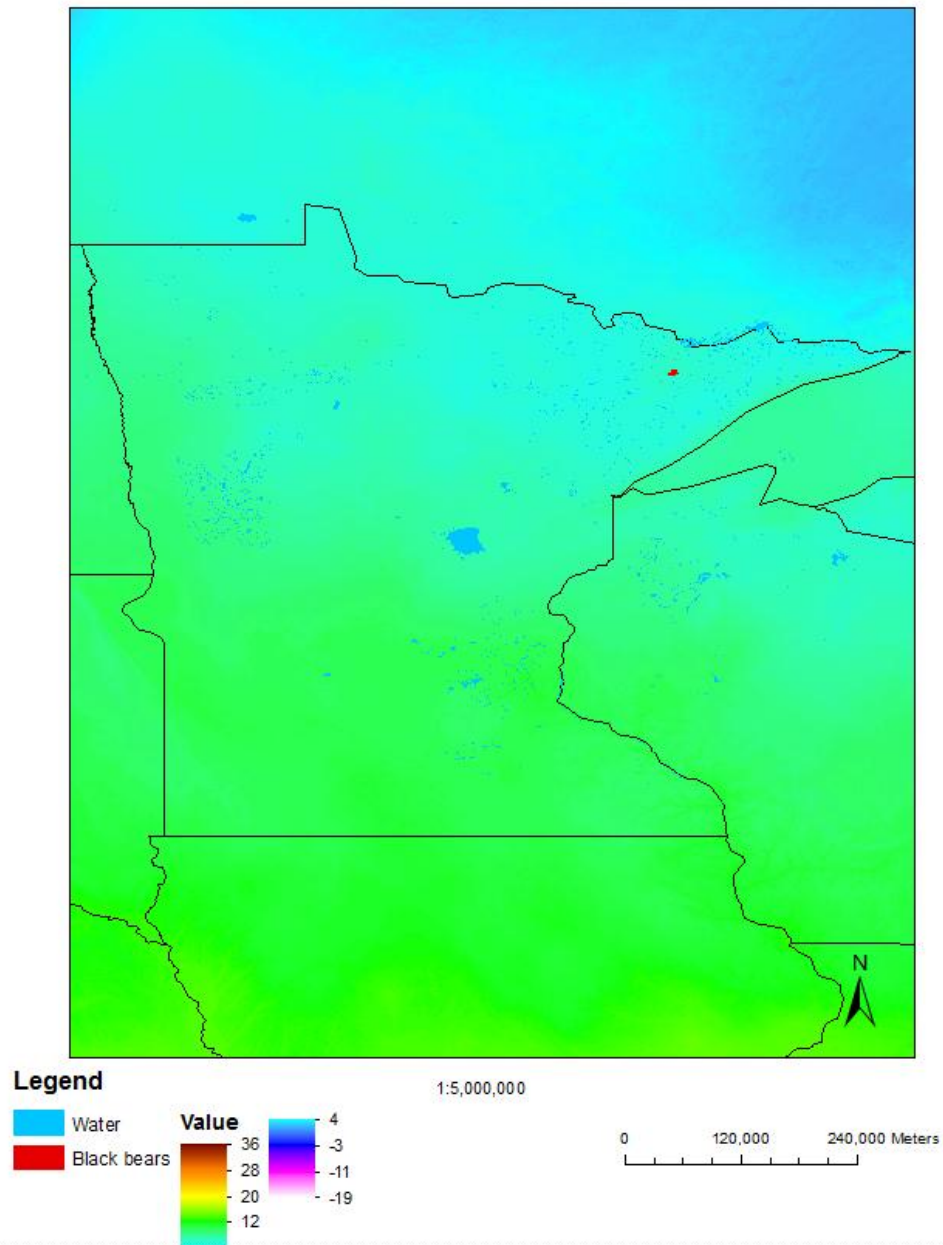


Figure 6
Climate map of the black bears in Minnesota in 1991.

After creating my two maps in ArcMap for a visual comparison, I decided to run my climate and bear data in MaxEnt. The GPS coordinates used for both the 1971 and 1991 data were put into an Excel spreadsheet and saved as a .CSV file (Fig. 7). MaxEnt uses a set of environmental variables, in this case mean annual temperature, as well as a set of georeferenced locations, and produce a model of the range of the given species (Phillips et al., 2004). The results produced for the black bear data are found below in the Results section.

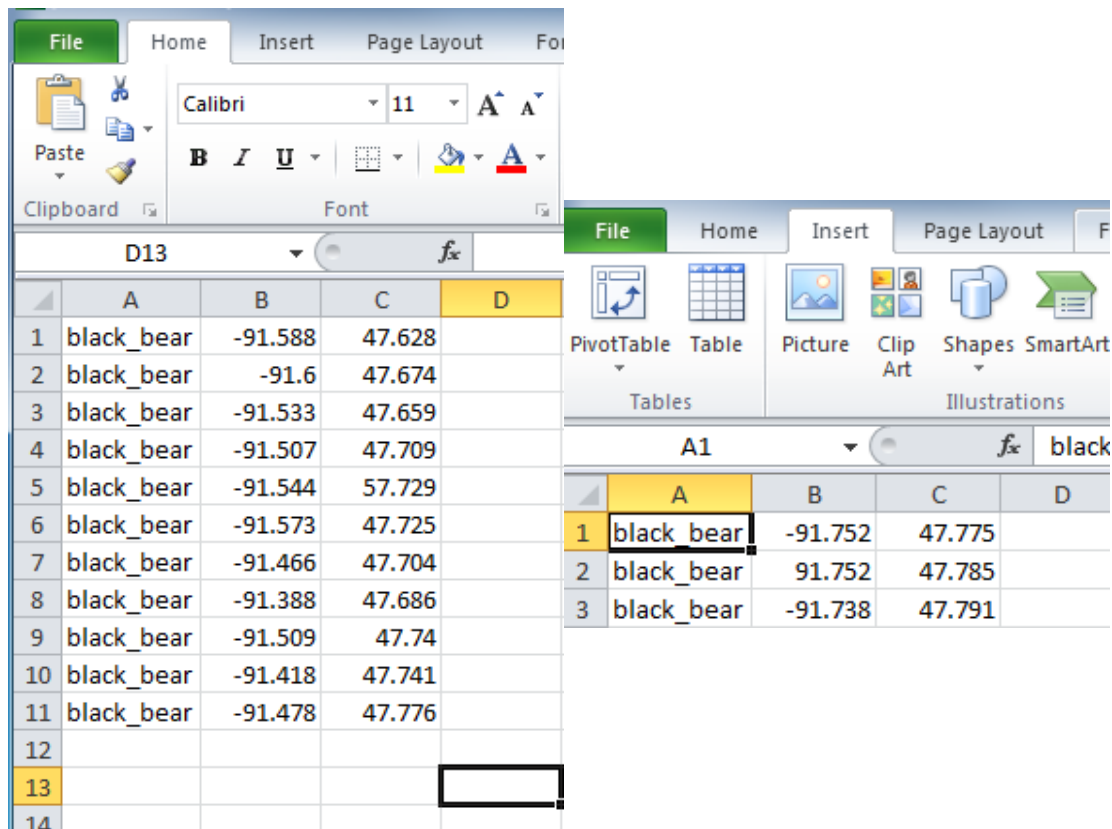


Figure 7

(Left) GPS locations of 1971 black bears.

(Right) GPS locations of 1991 black bears.

Results

From comparing the two maps generated from using ArcMap (Figs. 5 and 6), the temperature in northeastern Minnesota has become cooler in the twenty years. The temperature has dropped about five degrees Celsius. The black bears in this area have not migrated much, but the population of black bears has decreased significantly. In 1971, there was a count of eleven black bears. This number has been reduced to only three black bears in 1991. This may be a cause of the temperature drop or some other factor.

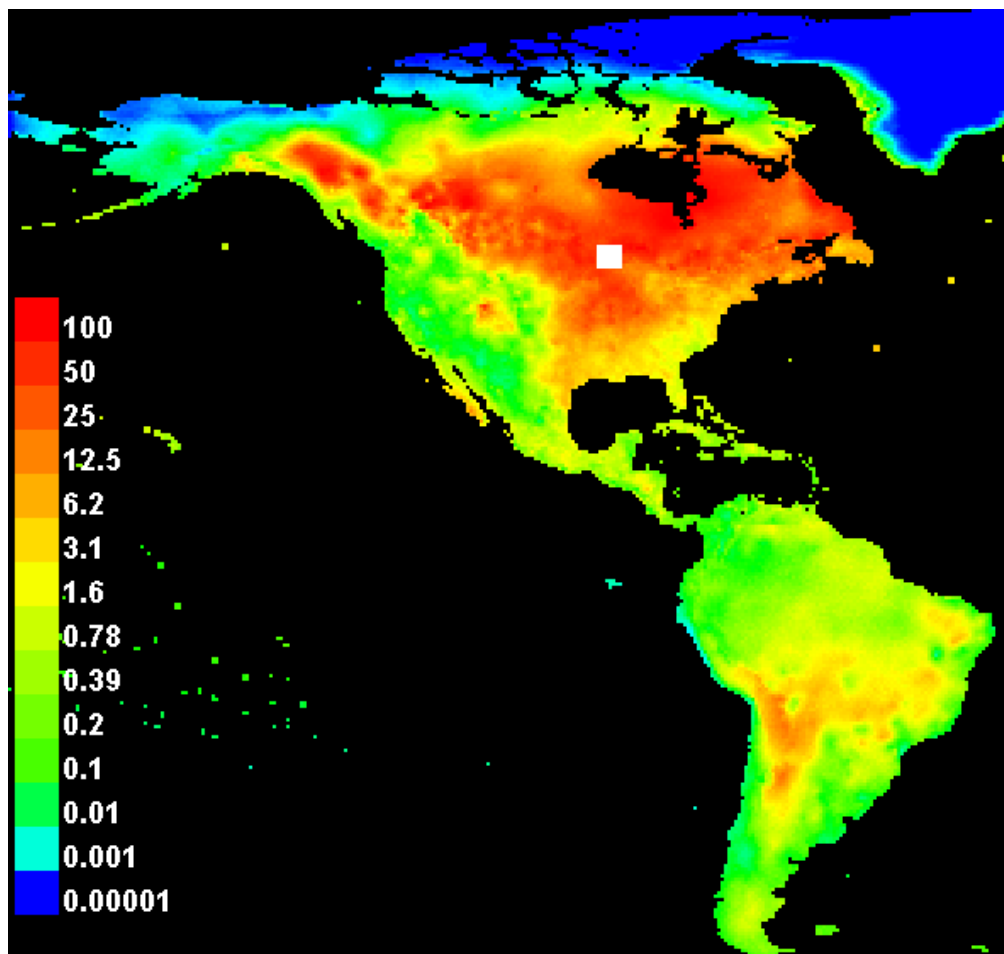


Figure 8

MaxEnt map of 1971 black bears. The white dot is the location of black bears. Temperature is in Fahrenheit.

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The maps created using MaxEnt is very similar to the maps that I created using ArcMap. The map for the 1971 black bears (Fig. 8) shows the bears to be in a moderate temperature. During 1971 the temperature in Minnesota is about 50°F (10°C). The map created using MaxEnt for the 1991 data was corrupted during the process. This is probably because I did not have the correct file type for my weather. I tried different ways to convert my climate data so it would work in MaxEnt, but nothing came out right. The map that was created from my first run is found in Figure 9.

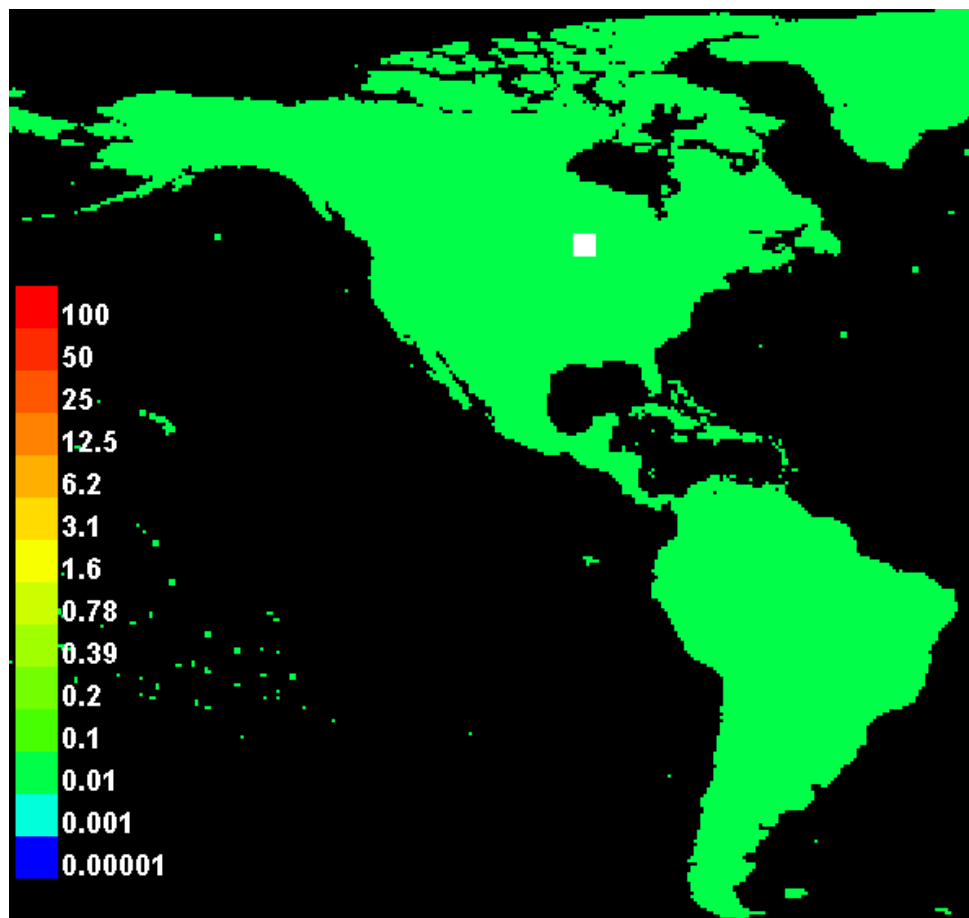


Figure 9

Climate map created by MaxEnt. White dot is the black bear location. Temperature is in Fahrenheit.

Conclusions

The climate change happening in northeastern Minnesota seems to not have as much of an impact on the migration of the black bears in the Superior National Forest as I thought it would. It does seem however that it might have an influence on the population of the black bears. The results of my two maps in ArcMap show that the weather did decrease in twenty years. The black bear population in this area decreased in twenty years. This might be caused by something other than climate, but I did not go in to see what these factors might be. The results from MaxEnt that were produced also show that the temperature did change a little, but the black bears did not migrate.

Another possibility is that the black bears have adapted to the cool weather in the Superior National Forest and this is why they do not migrate to warmer weather. To go further into this hypothesis, I would have to do more research about the black bears in this area in the past and present. In my maps, I added a water shapefile for Minnesota to see if the black bears were moving to areas with more water. This hypothesis also seems to be false. The black bears stay in a similar area with little lake sand ponds all around them. The black bears did not move to the area with the giant lake in the east central area of the state.

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References

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