
Effect of climate change on the distribution of Caribou and Canis Lupus in North America

Maximilian Alverson

malverson@wesleyan.edu

Biology Major, Wesleyan University, Middletown, 06459, CT, USA

Maksim Trifunovski

mtrifunovski@wesleyan.edu

Computer Science, Wesleyan University, Middletown, 06459, CT, USA

Abstract

Background

Caribou refers to the North American subspecies of *Rangifer tarandus*, also known as the Reindeer in Europe and Asia. North American populations of caribou primarily inhabit the tundra and boreal forest ecosystems, presently ranging from Alaska across most of northern Canada. The gray wolf (*Canis Lupus*) is the primary predator of caribou, and is found in much of the same habitat as the caribou. On the other hand, caribou's main food, especially during winter when other food sources are not available, is fruticose deer lichen (*Cladonia rangiferina*), and it is also found in much of the same habitat. Because arctic environments and the species inhabiting them are particularly vulnerable to the effects of climate change, the natural distributions of the caribou, the gray wolf and the reindeer lichen are expected to change in the near future due to the adverse effects of climate change. To analyze the effect of climate change, climate data variables such as temperature and precipitation, are measured at present time and by using climate models to predict the conditions in 2070.

Results

Using maximum entropy (Maxent) species distribution modeling, we examine the current distribution of *Rangifer tarandus*, *Canis Lupus* and *Cladonia rangiferina*

on the continent of North America, predict the possible distribution in 2070, and attempt to explain the various factors that influence the distribution of caribou, gray wolves and reindeer lichen. The results show us that the suitable habitat area of the Caribou shrinks by quite a lot, while the habitat of the gray wolves and the lichen remain almost the same.

Conclusions

The main conclusion that we can make is that the distribution of caribou will shrink due to the effects of climate change, even though food sources such as *Cladonia Rangiferina* will still be available. While the results of the habitat change of gray wolf are inconclusive, we have to consider what the lesser numbers of Caribou, the gray wolf's main food, will mean for the distribution of gray wolves in North America. However, it is important to note that the analysis of these species' distributions only took into account the effects of climate change based on climatic variables. Other anthropogenic factors such as increased human activity in the arctic and tundra regions are also likely to have an impact on many arctic species, including caribou and grey wolves.

Keywords

Caribou, Raindeer, *Canis Lupus*, Gray Wolf, Reindeer lichen, *Cladonia rangiferina*, Maxent, Climate change.

1 Introduction

Our research involved three species: Reindeer lichen (*Cladonia rangiferina*), caribou (*Rangifer tarandus*), and gray wolves (*Canis lupus*), which can all be found in similar ecosystems, including boreal forests and tundra. We chose to focus on these species' distributions in North America specifically, as they all also exist on other continents, most notably in the northern latitudes of Europe and Asia, where similar ecological conditions are found. These three species are also integrally connected as part of a food web: lichen makes up a substantial part of the caribou's diet, especially in the winter months when other vegetation is not available as a food source. Wolves are one of the main predators of caribou, especially at northern latitudes where other prey is not as

common.

We chose to investigate the potential effect of climate change on these species because they inhabit an ecosystem that is very vulnerable to climate change. Air temperatures in the Arctic have been warming on average at twice the global rate, with the strongest warming in the winter and spring. Precipitation in the arctic has also been slowly increasing, but the overall trend is less clear than for temperature (IPCC 4th Assessment Report). Arctic climate change is expected to have a direct impact on species such as caribou, which have evolved specifically to thrive in cold climates. In addition, climate change could have significant effects on the food web, which is why we decided to investigate the caribou's primary food source and predator as well.

Our investigation used Maxent to establish distributions for all three species, based on location data found online. By comparing these distributions to current climate data, Maxent can predict a distribution of these species in 2070, using future climate data obtained from climate models. Since arctic climate change will mainly be affecting temperature and precipitation, we chose similar climate variables that we thought would be most likely to affect our three species. Although we only considered climate related variables, Maxent showed that the distribution of caribou was likely to decrease in the near future, which in turn might have significant effects on other species, including grey wolves.

2 Methods

We gathered the caribou and gray wolf current data from vertnet.com, and the *Cladonia rangiferina* data from gbif.org. From the downloaded datasets, only the latitude and longitude coordinates were used to create the current distributions of all three species. These distributions were also filtered to only consider location data for North America, as all three species can also be found elsewhere with similar ecosystems, such as Eurasia.

In order to predict the distribution of each of our three species of interest in the year 2070, we used Maxent. We used current global climate data as well as future predictions from worldclim.org. We decided on using the following four variables: Annual Mean Temperature, Precipitation Seasonality, Precipitation of Driest Quarter and Pre-

cipitation of Warmest Quarter. These variables should account for the main differences in climate between now and 2070. *Cladonia Rangiferina* is a very hardy lichen, which can grow in varied conditions of temperature and precipitation. Unlike many vascular plants, it is also well-suited to very cold climates, which enables it to grow at high latitudes.

3 Results

We started by predicting what is going to happen to the Caribou distribution, by first making a Maxent run of the current habitat of the Caribou (Figure 1).

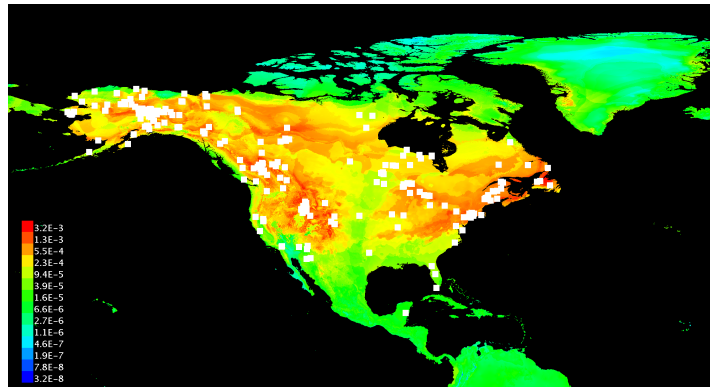


Figure 1: Distribution of Caribou in North America

We then made another Maxent run with the worldclim predicted 2070 climate conditions (Figure 2).

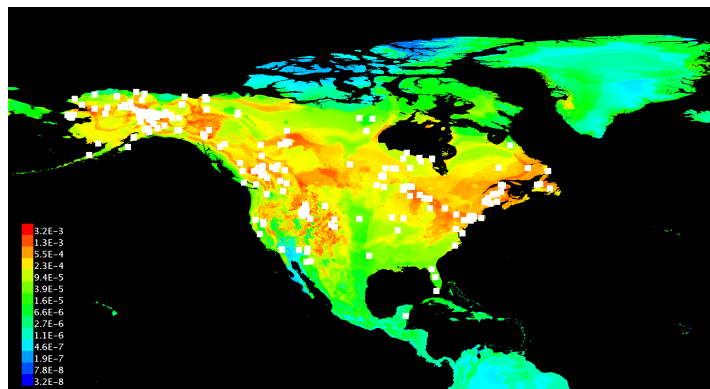


Figure 2: Predicted Caribou habitat for year 2070

As we can see the habitable area of the Caribou will noticeably shrink in the year 2070 according to our predictions. One factor we could not include in our Maxent runs (we could not add it as a variable), is the distribution of the Caribou's primary food, the *Cladonia rangiferina*. Instead we are going to try to use Maxent with the current distribution of the reindeer lichen and predict its future habitat and then try to explain if that would effect (shrink even more) the habitat of the Caribou in 2070. We still consider the same four variables that we used in our Maxent runs for the present and future habitat of the Caribou (Figure 3).

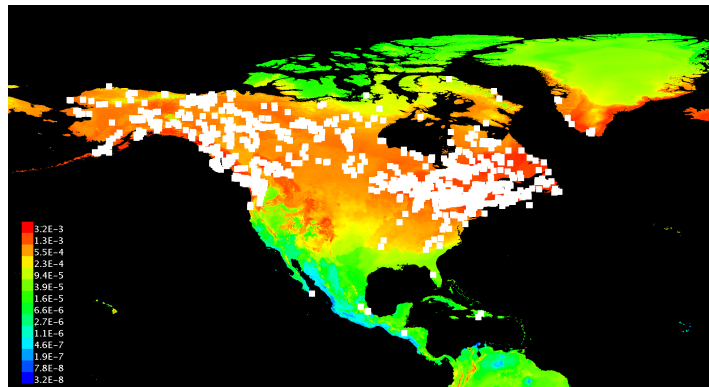


Figure 3: Distribution of *Cladonia Rangiferina* in North America

As we can see, the habitat of the *Cladonia Rangiferina* overlaps with the habitat of the Caribou. In fact, Caribou's habitat is a subset of the habitat of the reindeer lichen, giving us even more proof that the Caribou will only survive in the boundaries of the reindeer lichen's habitat. Then we run a simulation of the future conditions to see if they restrict Caribou's habitat even more (Figure 4).

4 Discussion

References

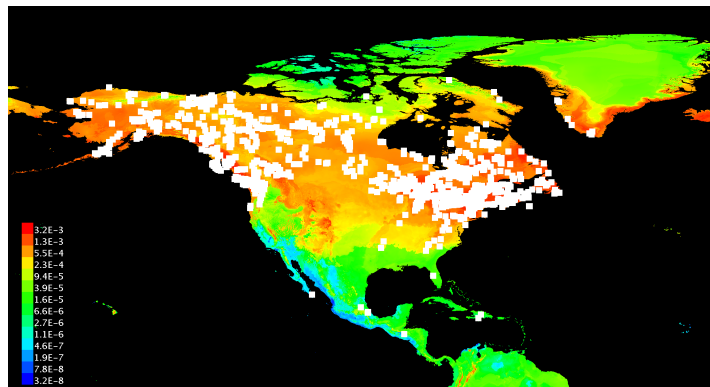


Figure 4: Distribution of *Cladonia Rangiferina* in North America