Climate Change Effects on Bird Migration

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Introduction

As climate change continues to devastate the environment, many species have dwindled in numbers or gone extinct. Birds across the world are especially affected, since they rely on migration to survive winters, but their migration habits are extremely sensitive to environmental factors.

Habitat loss, changing day and night cycles, temperature shifts, rising sea levels, intense storms, all of these problems, caused or exacerbated by climate change, can interfere with their migration. The reproductive success of birds often depends on their migratory success, as does their health, feeding behaviors, and stress [3][7].

This project will allow the general public to tangibly understand and visualize the effects of climate change on bird species, including their reproductive success and migration patterns. By raising public awareness and sympathy, the website could be a valuable tool in conservation efforts. Furthermore, it could drive further research into this area.

Implementation

For statistics about bird populations, I used four different datasets:

- CBC = Christmas Bird Count, 512 species, yearly North American bird abundance data
- BF = Migratory Birds Database, 112 species, migration locations with date & other data
- SMB = Status of Mountain Birds- 2024 review and 2010-2021 comprehensive dataset

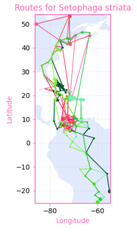
For temperature data, I used timeseries temperature anomaly data from BerkeleyEarth.

I picked the blackpoll warbler to do more detailed analysis on since it's classified as "Near Threatened" by IUCN, undertakes long distance intercontinental migrations, and is "Moderately Vulnerable" to climate change warming effects, according to the Audobon Institute. Using SMB data I modeled its population and whether its migration movements are changing with temperature. I also graphed a few of its routes. I found that westward changes in longitude were happening as the years went by, so I correlated these with the simulated temperature time series prediction data to make a Gillespie simulation to model the warbler's possible routes.
I also made an interactive map with bird species information and migratory routes.

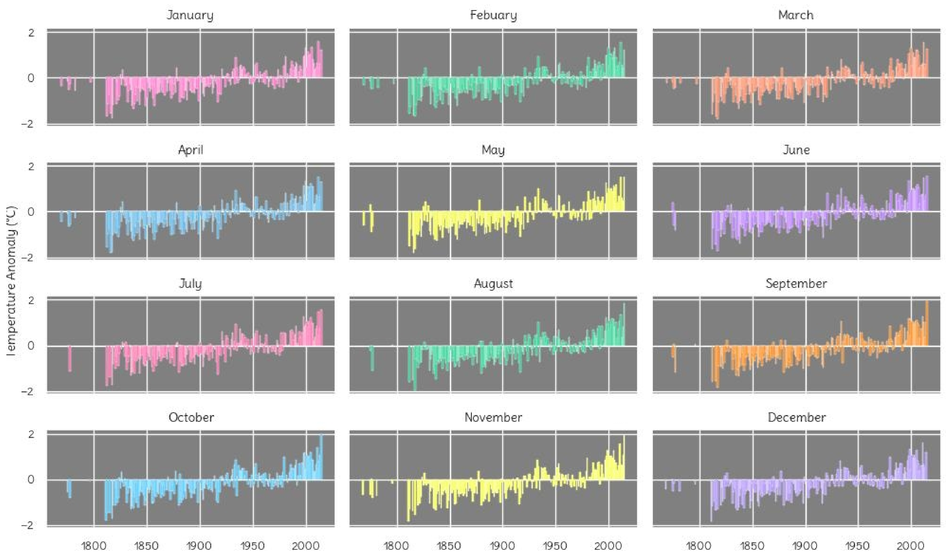
Next Steps

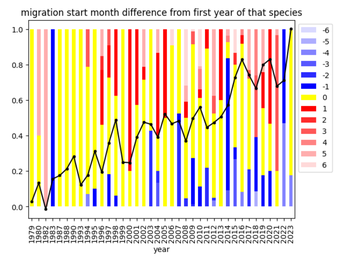
I'm going to add these figures to my interactive map, along with population abundance metrics for 35 species which BF and CBC have in common, correlated with temperature anomalies in North America.

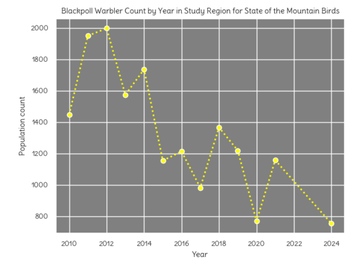
As an extension of the project, bird breeding and reproductive data could be incorporated, as climate change is a major potential disruptor to bird reproduction.
Storm frequency and wind patterns, which are also influenced by climate change, could be another type of data to explore and correlate with migration
beyond just temperature anomalies.

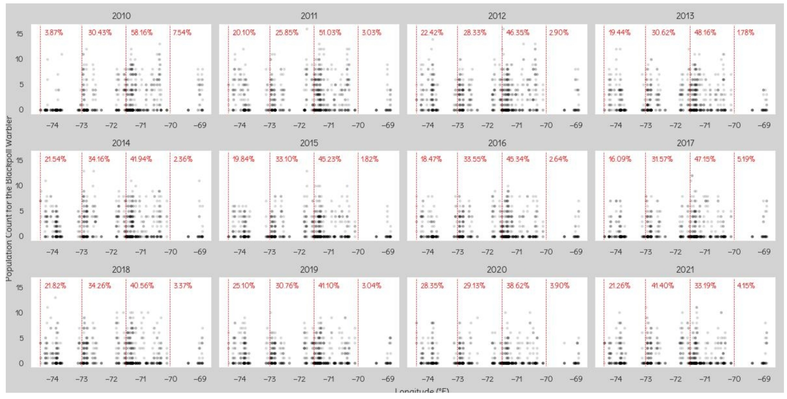


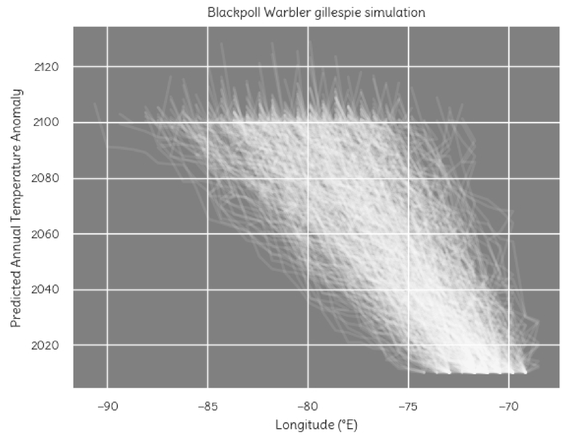
Figures











Discussion

The yearly frequency plot shows evidence that the warbler is moving west. Paritcularly, this plot shows that they are moving west of the 71° W longitude line each year. For each year, I graphed the annual temperature anomaly and the percentage of the population that month which was west of the 71° line. But, it was not easy to see any correlation, except that for the extreme high end of the temperature anomaly, we saw the highest percentage of the bird population being west of the 71° line. So, I simulated bird migratory routes, using a Gillespie simulation. For probabilities I used the existing probabilities I had found with the frequency plot, correlated with the step westward that they represented. I also picked random starting locations between the range of longitudes in the data. For each year, I used a regression correlation between temperature anomalies and time. This predicted the degrees of warming that would be seen in that year, which was plotted against the trajectories. It showed that warbler trajectories could shift as many as 20° W as temperatures increase due to climate change.
The migration start month plot shows the shift in migration start months for bird species in BF which had more than one unique route. It has global time series data layered over it, showing more shifts in start months with increased warming.