Migratory shifts in bird abundance along Atlantic Flyway

https://github.com/jofrear/JaffeWellbaumFrear_ENV872_EDA_FinalProject

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Contents

List of Tables

List of Figures

1 Rationale and Research Questions

Bird presence and abundance shifts seasonally for many species in the US. We wanted to investigate these shifts, both within a year, and across years, and compare it with temperature data. To do this, we analyzed citizen-science observations from Ebird of three key bird species: Pandion haliaetus (Osprey), Aix sponsa (Wood Duck), and Agelaius phoeniceus (Red-Winged Blackbird). These species from different orders were selected based on news reports and published papers that suggested recent shifts in abundance and range.

2 Dataset Information

Bird observation data was downloaded from the Cornell Lab of Orinthology eBird Database (https://ebird.org/). Data was obtained for the three target species in three states along the Atlantic migratory Flyway: Maine, Massachusetts, and North Carolina. All observations uploaded to ebird and marked with an observation date between January 2010 and March 2021 were used. Citizen science observers using ebird enter the bird species seen and numbers observed for each species, and can optionally track their effort in birding by including distance traveled during a trip (which can be manually entered or derived from smartphone gps data) and time spent observing.

3 Exploratory Analysis

It became clear that observations dataset had generally increasing observations year-over-year, regardless of species (Figure 1). This is possibly attributable to increasing ebird use in the US, especially as smartphone adoption increased over the last decade, providing an electronic alternative to pen-and-paper notations of field observations.

To adjust for this trend, we used the reported time spent observing birds on each checklist to create a value of observed birds per minute (Figure 2). The distribution of birds observed per minute was non-normal, but log-transforming the data revealed a roughly normal distribution.

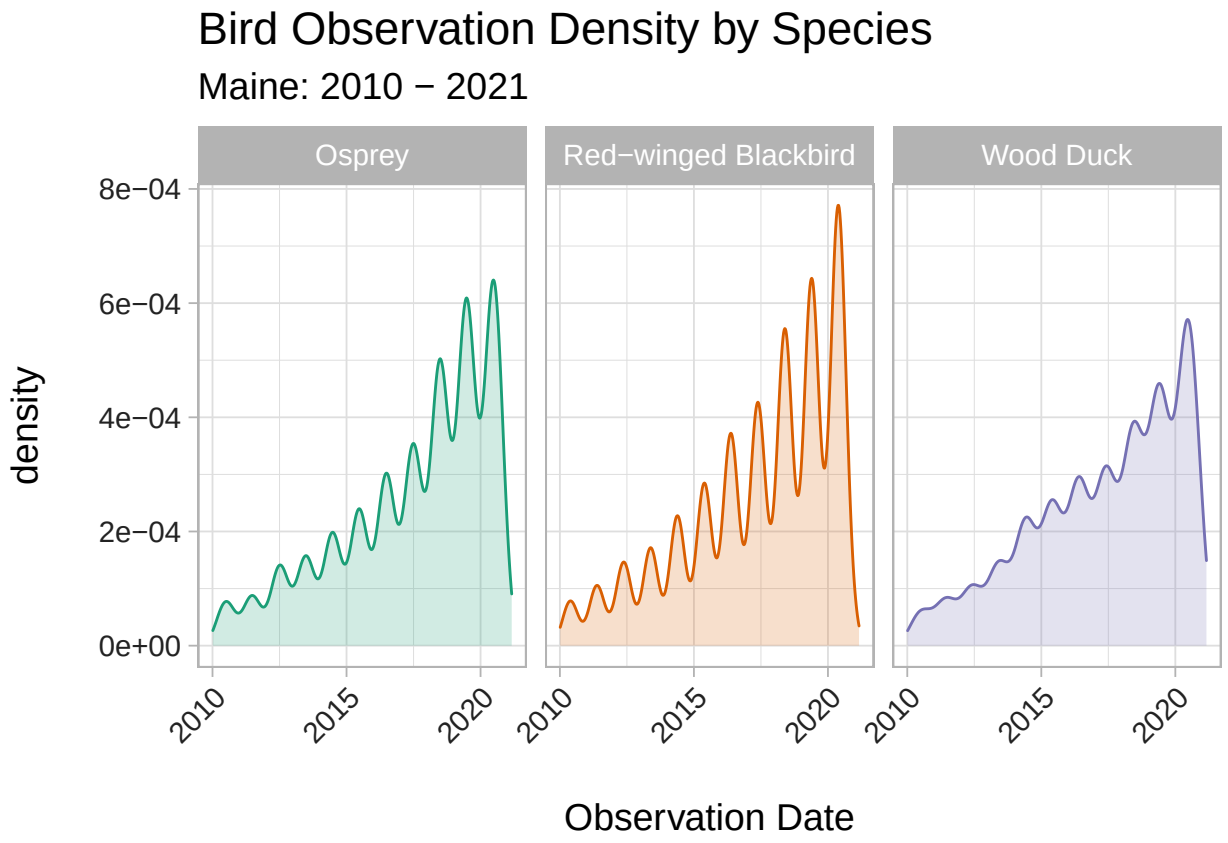

Figure 1: Density of ebird observations in Maine from 2010 - 2021.

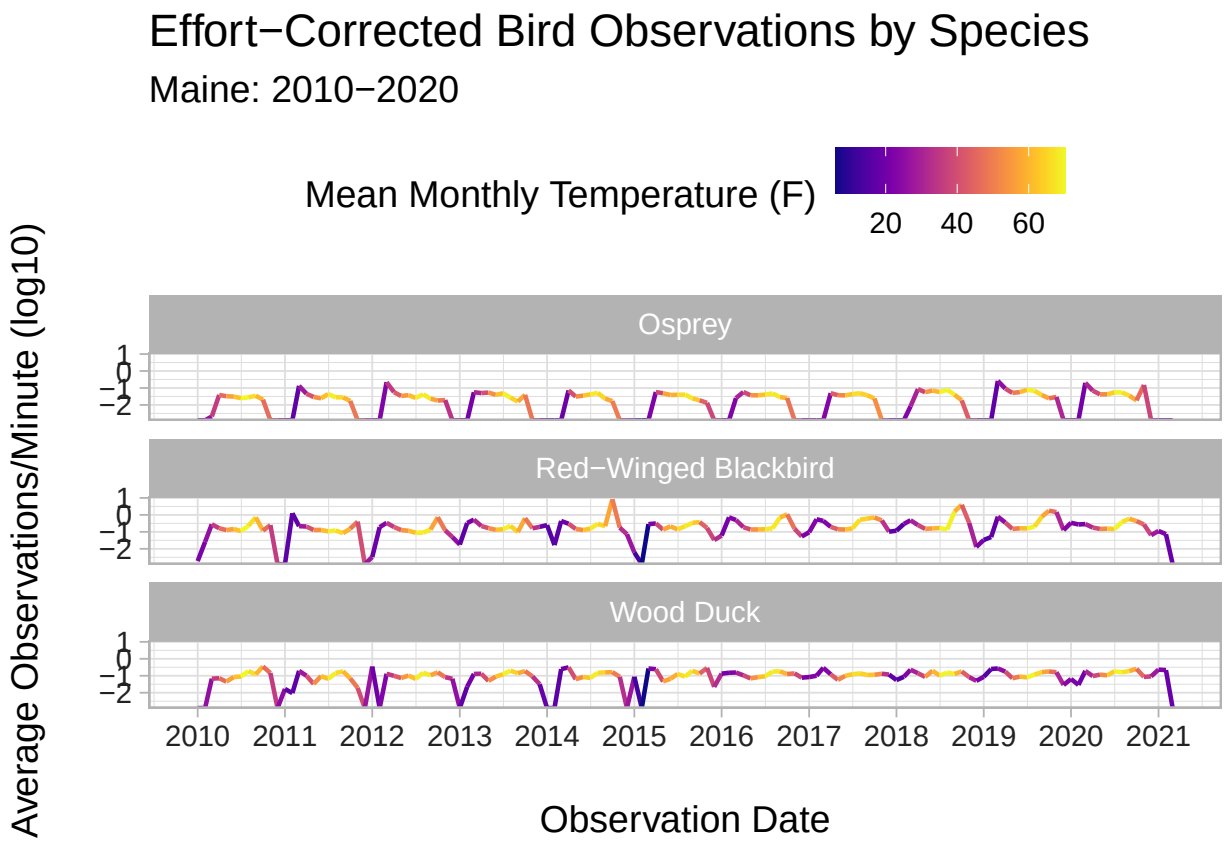

Figure 2: Bird observations in Maine, grouped by month, adjusted per minute of observation and log-transformed.

4 Analysis

Two approaches were taken towards analyzing whether there has a been a shift in abundance over the study period. The simpler but cruder approach is to use a linear model with the month of observation as a continuous variable. When examined this way, Of the three species, only Wood Ducks showed a statistically significant change in observations per minute across the study period (slope = 1.289e-05, R^2 = 0.04, $p < 0.05$). This small shift in abundance for Wood Ducks may indicate increasing abundance, but it does not explain the variance in the data, likely because seasonal migration patterns are dominant.

The second approach is to construct a time series analysis for the observations. According to the time series analysis, each of the species showed both a strong seasonal component in observations, and a rising monotonic trend across the study period in Maine, according to the seasonal Mann-Kendall test (Osprey: tau = 0.389, $p < 0.001$, Wood Duck: tau = 0.269, $p < 0.001$, Red-Winged Blackbird: tau = 0.335, $p < 0.001$) (Figures 3 - 5). This rising trend may be due to increasing abundance of these species, but it may also be due to several confounding factors, including variability in observations by birders (e.g. location, time of day, or increasing expertise).

Each of the species had an influx of observations associated with spring migration (Febuary-April). Wood Ducks and Red-Winged Blackbird seasonal trends revealed two spikes, suggesting that most spring and fall observations are not from summer residents, but from migrating individuals from out-of-state. Osprey observations, on the other hand, had a relatively constant seasonal component for summer and fall.

4.1 Question 1:

Are non-migratory populations of a species establishing themselves in regions that formerly only had migratory populations of that species?

The first step towards answering this question would be the identification of overwintering individuals - that is, observations of individuals during the time that migratory populations should be absent from the region, typically December and January. In Maine, we see observations of Red-Winged Blackbirds during all months, indicating that there is a resident population, despite the migratory behavior and strong seasonal trend. Ospreys are completely absent from Maine for the winter months, with the latest observations in the 2nd week of November, and the earliest observations at the end of March.

Wood Ducks, however, present a possible trend. The first 5 winters had gaps between 33 and 86 days during which no Wood Ducks were observed in Maine. Beginning in the 2015-2016 winter, the observations gaps disappeared, with individuals seen on both in the last week of Decemeber, and first week of January. A small gap did reappear in the last two winters, with periods of 27 and 13 days in which no individuals were observed.

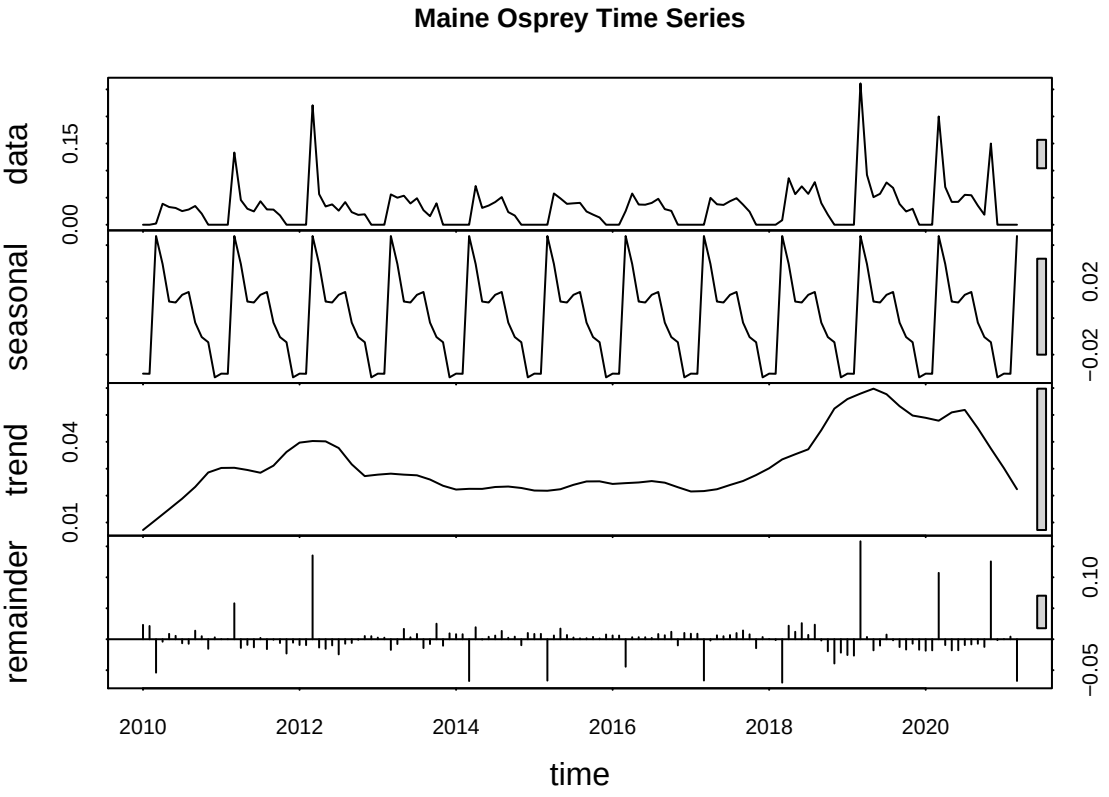

Figure 3: Time Series of Maine Osprey Observations per Minute, 2010-2021.

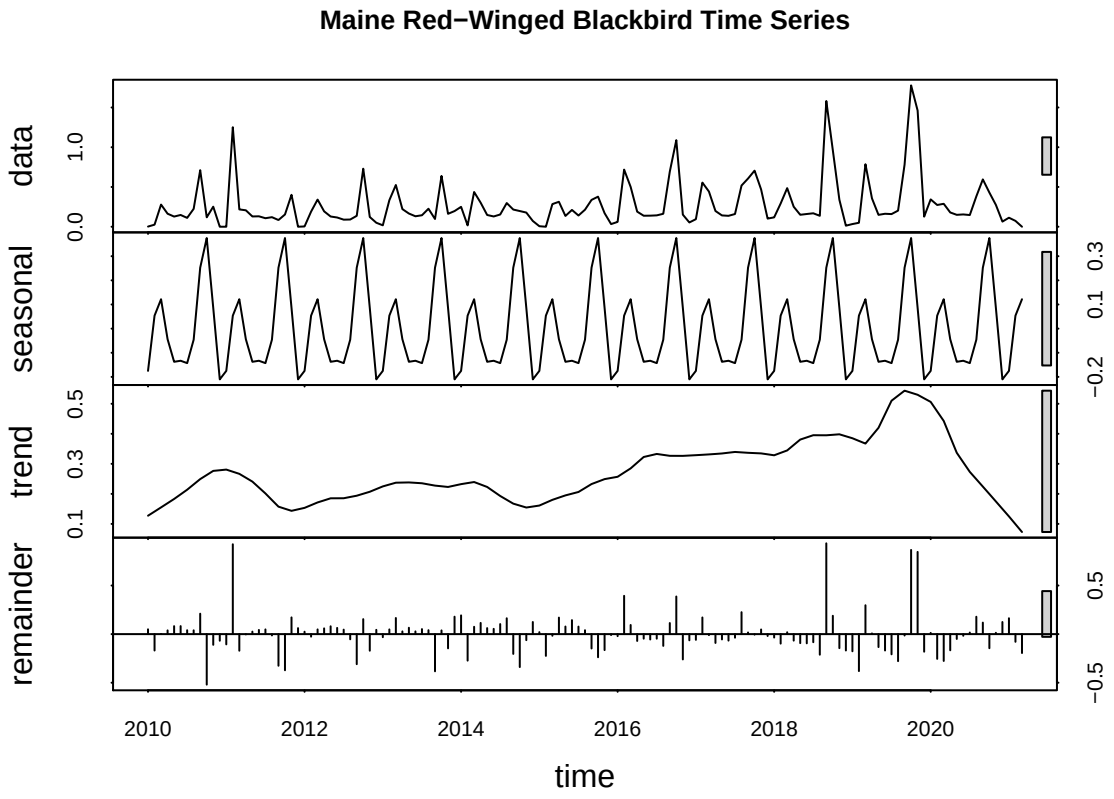

Figure 4: Time Series of Maine Red-Winged Blackbird Observations per Minute, 2010-2021.

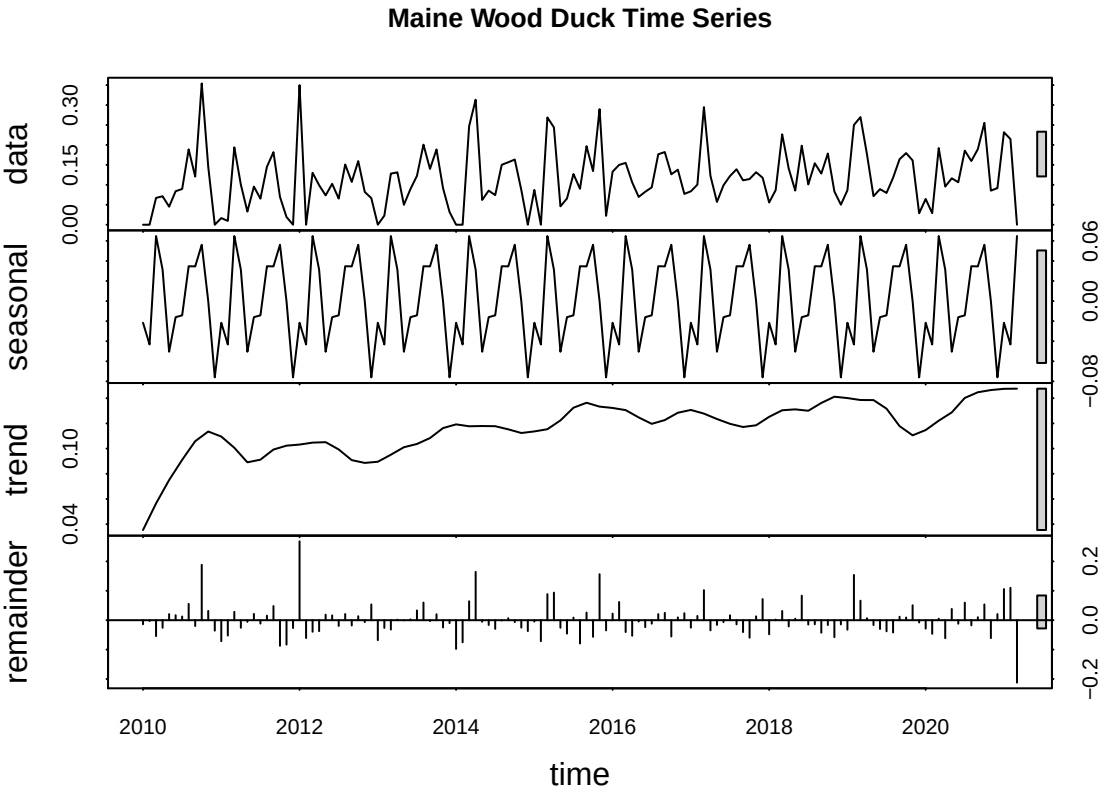

Figure 5: Time Series of Wood Duck Observations per Minute, 2010-2021.

5 Summary and Conclusions

The Wood Duck data suggests that either birders in Maine are discovering wintering Wood Ducks that they previously overlooked, or that Wood Ducks are responding to climate shifts that make certain locations in Maine suitable wintering habitat. More observations are needed to explore this trend.

We expect to see significant shifts in bird distribution and abundance as temperatures rise over this century, particularly in species like Osprey (Pandion haliaetus) that have both migratory and resident populations. Populations in regions that are currently migratory (like those in Massachusetts and Maine) may become year-round residential populations if the climate facilitates this. The study period of ten years does not reveal any shifts in seasonality. The first indicators of a shift like this will likely come in changes to "first-of-year" sightings, which are worth monitoring. Migratory species that are unable to adapt to climate shifts will likely face strong inter-specific competition from non-migratory species.