LEICESTERSHIRE & RUTLAND ENTOMOLOGICAL SOCIETY

60 Years of climate change in Leicestershire

- affecting our wildlife?

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Introduction

A while ago I was asked if it was possible to statistically link changes in Leicestershire flora and fauna to changes in climate. This is a very difficult question to answer as there are so many potential sources of influence to unpick, including factors unrelated to climate, such as pollution in all its many forms. However, we must first ask if there is evidence of changing climate in Leicestershire and, to answer this question, it is necessary to find suitable data. We are fortunate in Leicestershire that there is a long term weather station at Sutton Bonington (just north of the VC55 boundary in Nottinghamshire; Figure 1) which provides free access to 60 years of monthly weather observations as a text file (UK Met Office, 2022).

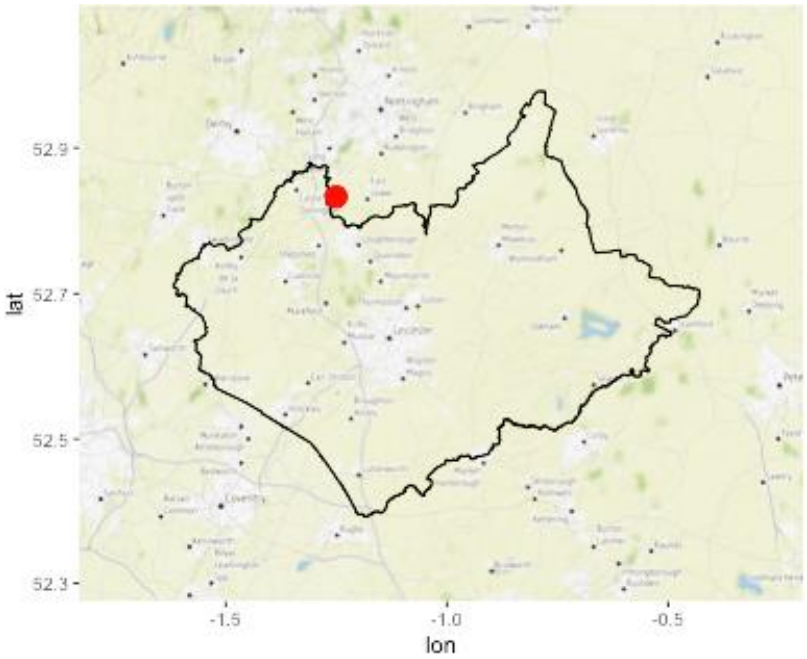

Figure 1: Position of Sutton Bonington in relation to VC55

This data has allowed me to produce a series of graphics to represent variations in the local climate using carefully chosen colours. The eye is very good at picking up patterns using colour allowing me to avoid the use of statistics until the final summary where perhaps the reader will be ready for a few numbers to quantify the observations made about climate change.

Temperature

The ribbon plot in Figure 2 is very effective in conveying the warming trend in annual average temperature over the past sixty years. Notice that the progression is not smooth and continuous, but instead cold years can follow warm years. It is important to realise that the average (or mean, which is the same thing) temperature is really just a mathematical device to make a summary as a single number. If you were to dress for "average" annual temperature you would nearly always be too hot or too cold as no day is ever a constant average day. The same is true for the flora and fauna of Leicestershire, so it is reasonable to wonder if the maximum and minimum temperatures are actually more important than the average in when trying to understand the impacts of weather.

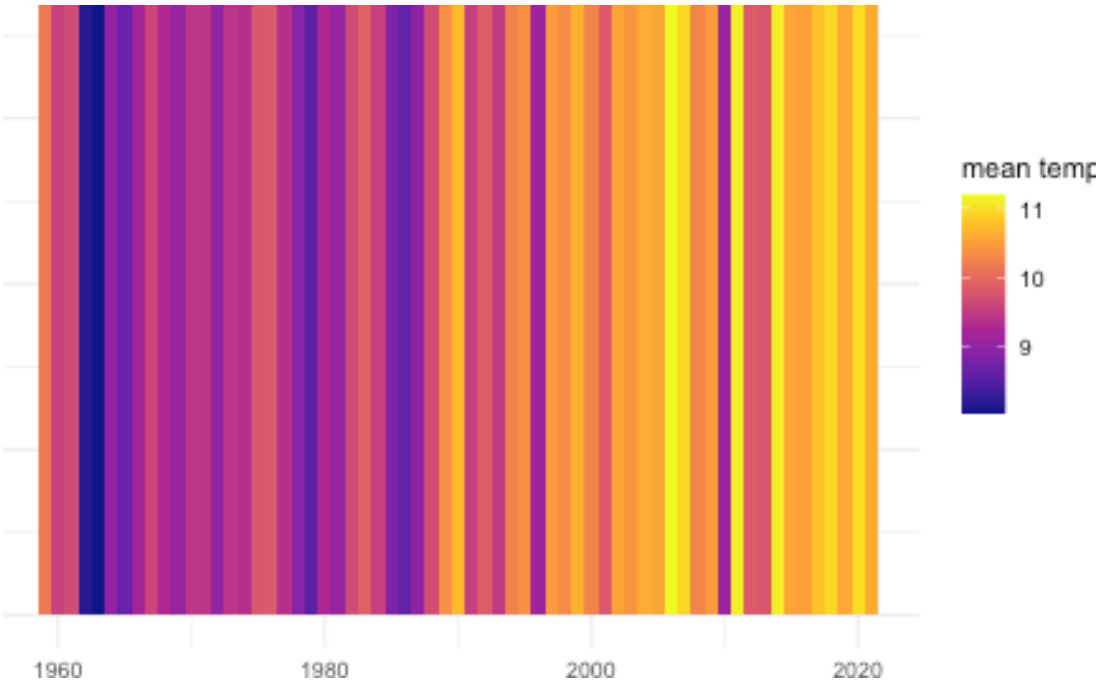

Figure 2: Average annual temperature °C

So in Figure 3 why does the warming trend not look so obvious? The answer is because the range of our measurement scale is almost double that of Figure 2 which halves the apparent change. The warming trend is actually small, so our choice of scale has an impact on our perception of its magnitude. There is a technique we can use to overcome this problem, but I shall save that for the end of this article. If we plot the two components of Figure 3 using separate scales as in Figures 4 and 5 we can see the warming trend clearly again.

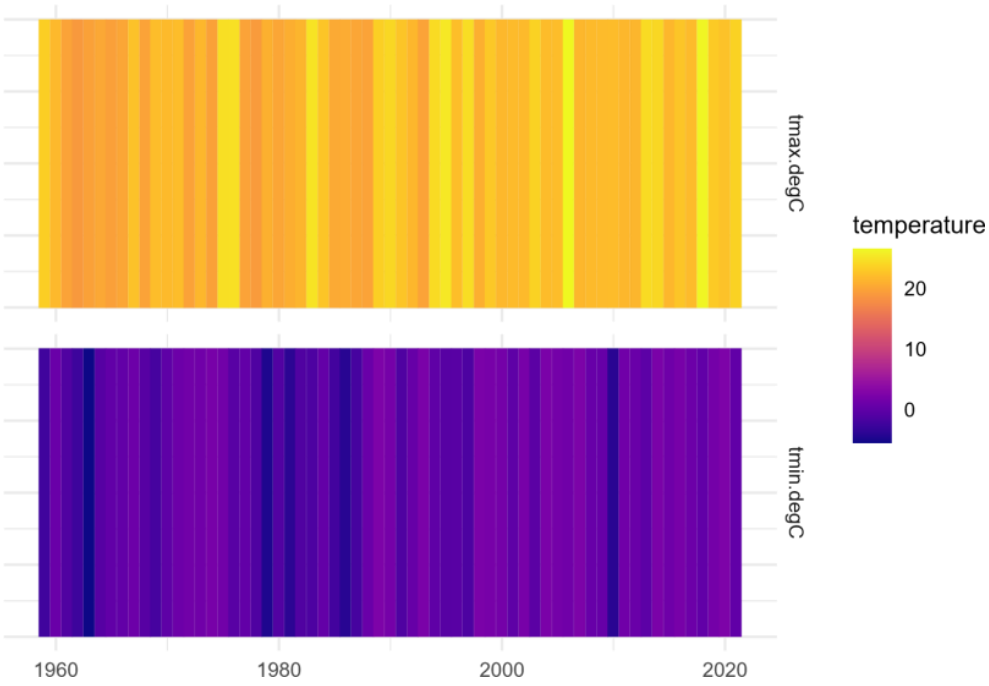

Figure 3: Maximum and minimum temperatures °C

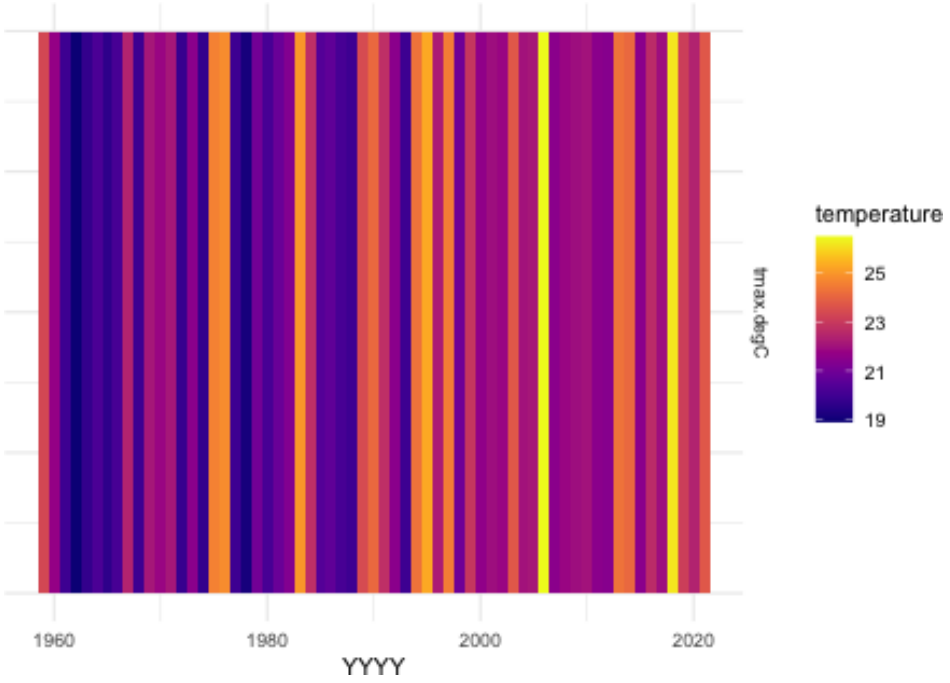

Figure 4: Maximum temperature °C

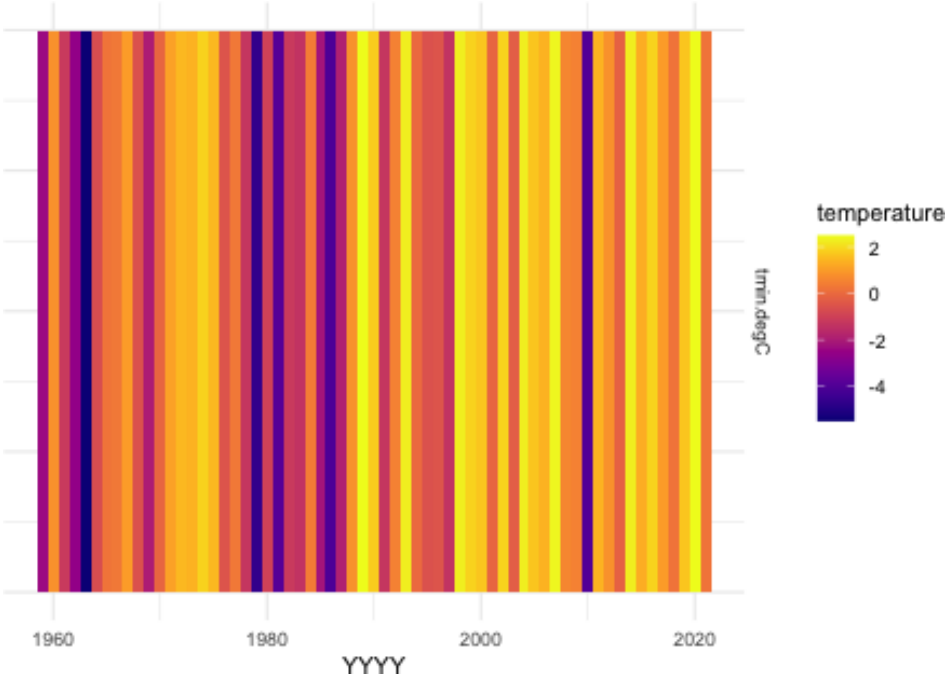

Figure 5: Minimum temperature ^{0}C

While maximum and minimum temperatures are important factors of our climate we are starting show that overall the magnitude of the trends are small in relation to natural variation in temperature. Another factor that can have great impact on wildlife is the number of days of air frost. It is well known amongst breeders of lepidoptera that some species need exposure to low temperatures to develop correctly and in a timely fashion - gardeners know all too well the impact of untimely frosts and their impact on germination. In Figure 6 we can

see a trend that suggests the number of air frost days in Leicestershire has halved over the past sixty years from 80 to 40.

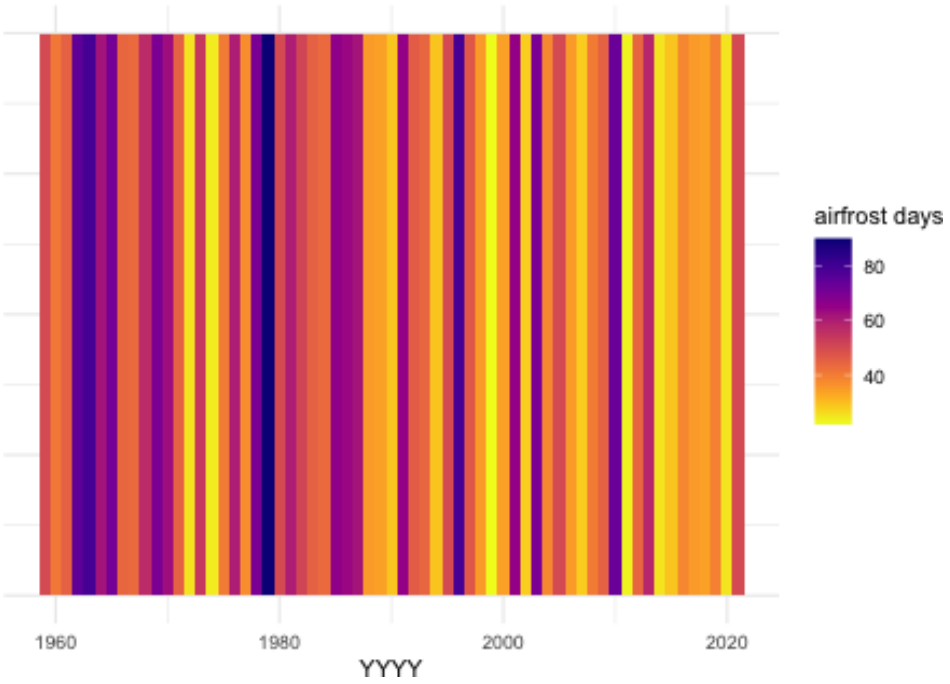

Figure 6: Number of air frost days

Rainfall

Enough about temperature, what about rainfall? Overall, total annual rainfall is increasing too, but, again there is great variability between years as can be seen in Figure 7. The wettest years have both occurred in the past decade, but with only 401.9 mm in 2011, this was the driest year since 1960. This was followed by the second wettest year with 831.8 mm in 2012. (The wettest year was 2019 with 846.4 mm).

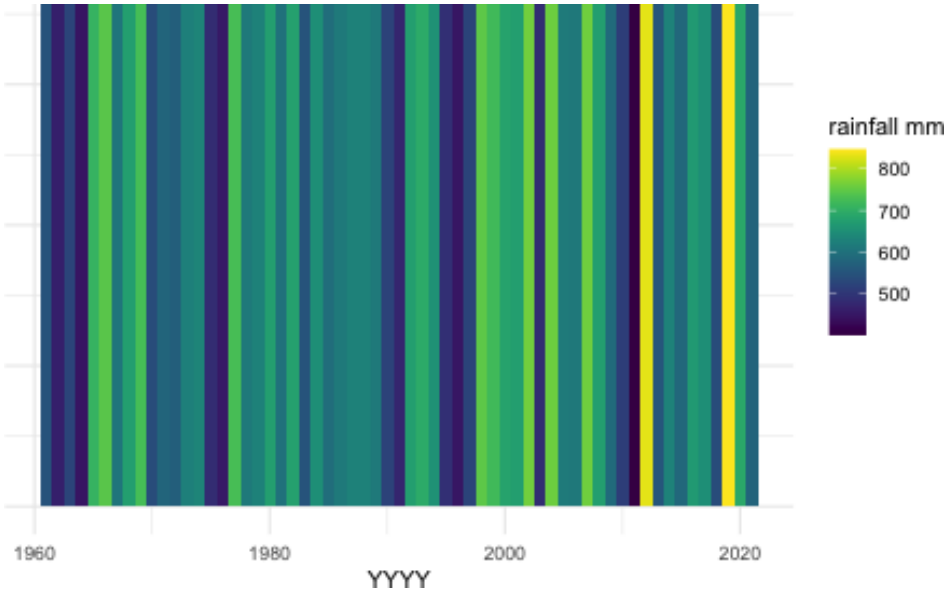

Figure 7: Average annual rainfall

As I have started quoting some numbers, now is the time to dive a little deeper and quantify some of the trends that we have been looking at. Figure 8 shows the average annual temperature for each year along with a "best fit" straight line.

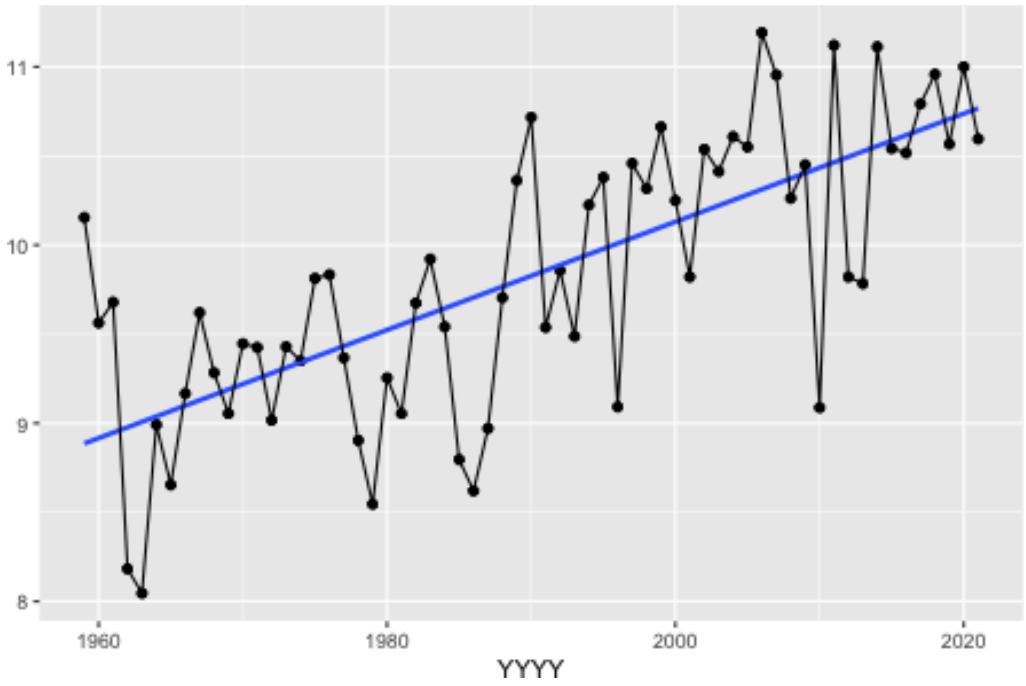

Figure 8: Average annual temperature trend °C

The slope of the line indicates that average temperature has been increasing by 0.03°C per year indicating that the average annual temperature in Leicestershire has increased by 1.82°C since 1960.

Earlier, I mentioned that there was a technique that we could use to get around the problem of choice of units affecting our perception of scale when looking at trends. This is known as the "Z Score" and is calculated by subtracting the average from each value and dividing by the standard deviation. Don't worry about why this works, instead look at the result in Figure 9. It is now possible to plot all the measurements on a single scale where zero represents the average value. Rather than show all the points, a series of curves represent the trend of each measurement. [Note that recording of sun hours was discontinued in 2020].

This was the first exploratory graphic I produced and the clarity of the trends was a real shock as I had never expected to see such a dramatic evidence of change. The ribbon plots were made later as a form of visual verification that Figure 9 was correct. To interpret this figure in words and describe the changes in Leicestershire climate over the past sixty years: we do not have to look far -

- **The number of air frost days per year are declining;**
- **Annual rainfall is increasing;**
- **Annual maximum temperature is rising, and;**
- **Annual minimum temperature is increasing at a faster rate than maximum temperature.**

Does this affect our wildlife?

If I now return to the question that I was originally asked: "*Is it possible to statistically link changes in Leicestershire flora and fauna to changes in climate?*"

The answer has to be qualified in the light of the observations made here. While they are real, all the trends are much smaller than the year-to-year natural variability in Leicestershire weather. However, just because they are small does not mean that they have no impact. So first we have to find changes in flora and fauna that might be linked to weather.

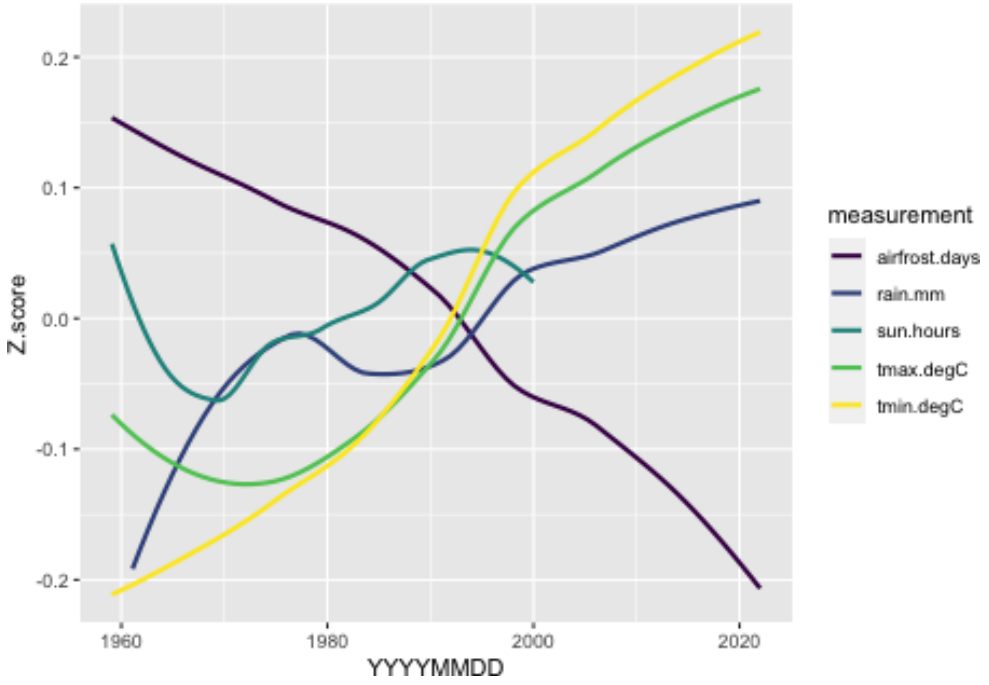

Figure 9: Plotting trends with Z scores

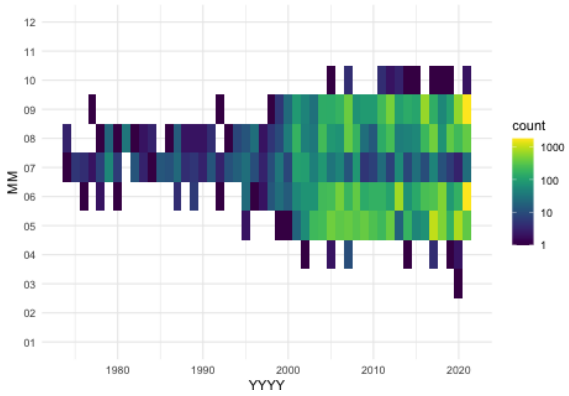

Figure 10: The changing phenology of the Green Carpet (Xanthorhoe fluctuata) in Leicestershire
(data from the late Adrian Russell)

The records from moth trapping show that many species are changing their flight times. As an example, Figure 10 shows that the Green Carpet *Colostygia pectinataria* has gone from a single generation to a much wider flight time with two peaks in abundance. There are similar changes in many species of Lepidoptera. Proving that these changes are linked to changing climate is not easy, but the correlation can be seen by anyone who plots the numbers.

So, the answer to the question has to be: "**Probably yes**."

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