"The effects of climate temperature on the autumn foliage of different birch species"

Introduction:

For the past few weeks, our Global Environmental Studies class has been recording data for our Green Down study at a research site behind Brooke-Boulet Field at Kents Hill School and entering our observations into the GLOBE database. Ultimately the purpose of our research was to compare our data to other Green Down research sites around the world. At the conclusion of our data collection, I wanted to find possible answers to a particular question: what effects do temperature have on the autumn foliage of different species of birch trees? I hypothesized that lower temperatures stagnate the production of chlorophyll, therefore birch trees in colder climates will have a more rapid rate of color change than those in warmer climates.

Materials and Methods:

In establishing our research site, our group followed the GLOBE protocol, marking four leaves to measure on a branch of a paper birch tree, a species native to North America and is commonly known by its Latin name, *Betula papyrifera*. Our group unimaginatively named our site Paper Birch #1. Members of our group would return to the site twice a week to record the color of each leaf based on the GLOBE Plant Color Guide. After only three weeks, our study came to an abrupt conclusion when harsh winds blew the leaves away.

In an extension of the green down study, I researched the green down data of different birch trees in various climates around the world using the GLOBE database to see how our data measured up to others' and what it would determine about the effects of climate temperature on birch trees. For this research, I chose to compare our group's data with Birch 1:GRN-03, another

paper birch green down research site at Palmer High School in Palmer, Alaska, which was the only one in the entire database with sufficient data on the species and represented a vastly different climate zone from central Maine.

In addition to the data study in North America, I had also selected three research sites in Europe that would represent various climates zones, only this time these research sites would study the slightly different native European counterpart to the paper birch: the silver birch, or *Betula pendula*. For each of these, I collected data from sites with varying climates in accordance with daily average temperatures I had found from weather.com. I collected data from a relatively warmer climate from School Backyard, a research site at the Dame Gruev Primary School in Bitola, North Macedonia. Nearly identical to Kents Hill's climate, I collected data from береза, a site at the Ivano-Frankivsk City Environmental Station in Ivano-Frankivsk, Ukraine. Finally, I collected data from Budburst_Suveaiast_N, a site at the Kilingi-Nomme Gymnasium in Kilingi-Nomme, Estonia, where the climate is colder than Kents Hill and is closer in average temperature to Palmer, Alaska.

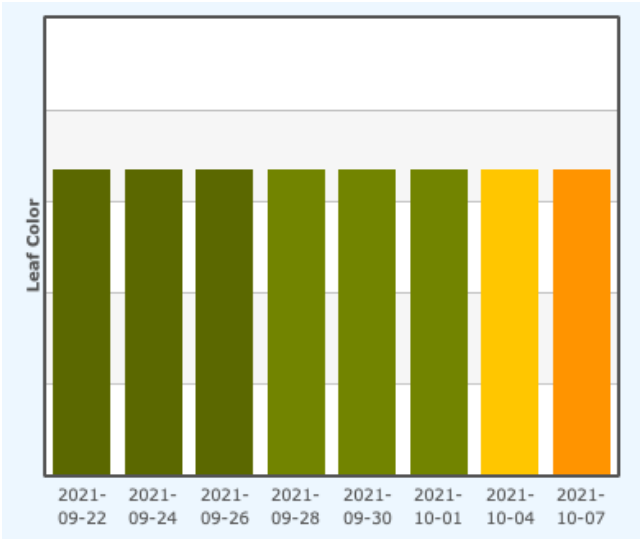
Results:

It is important to note that some of the data that I had collected from each of these sites come from past years such as 2016, 2017, and 2019. For example, in nearly every green down study done by Palmer High School, the leaves of all their paper birches are reported as fallen right at the beginning of their study. This is most likely due to their study beginning in early September, where in Alaska, temperatures begin to rapidly decrease and harsh winds begin to pick up while transitioning from summer to autumn. The only exception I could find to this recurring problem was the data collection of Birch 1:GRN-03 in 2016. While the years may be

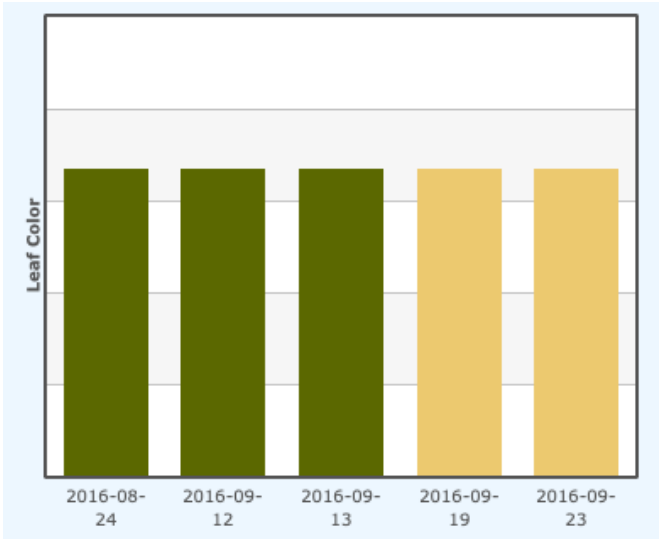
inconsistent with each other, the data still accurately reflects the same species of trees in different temperatures.

Paper Birch/*Betula papyrifera* (North America)

Paper Birch #1: Kents Hill, ME, (44.4045°, -70.002°)

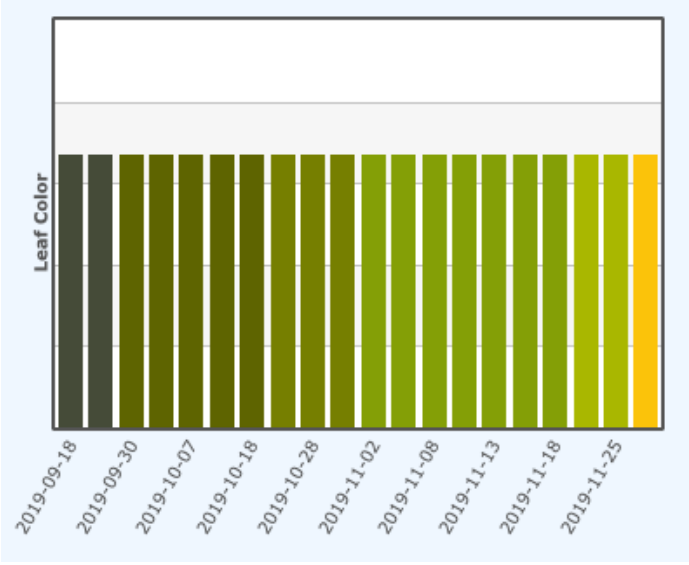


Birch 1:GRN-03: Palmer, Alaska (61.607°, -149.164°)

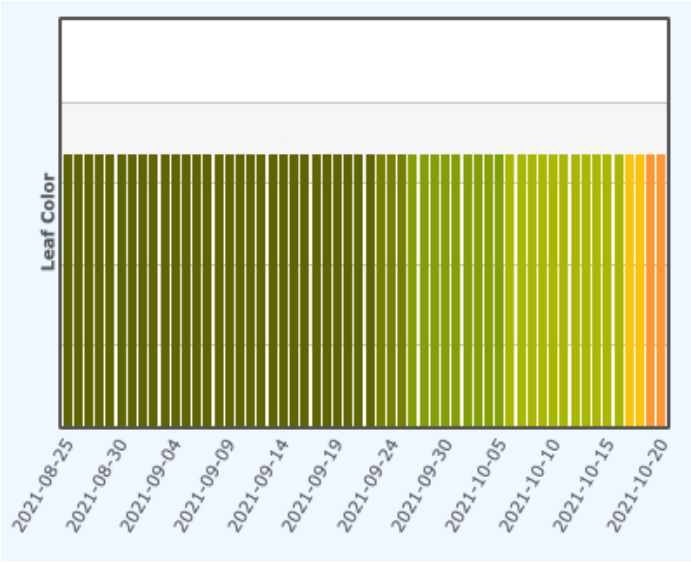


Silver Birch/*Betula pendula* (Europe)

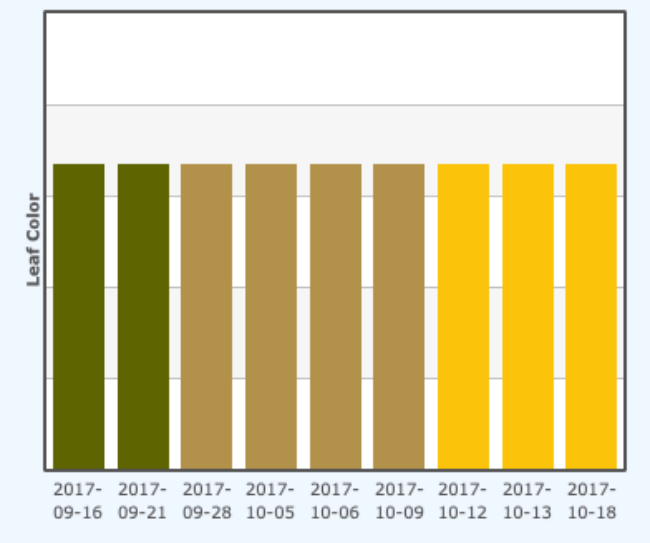
School Backyard: Bitola, North Macedonia (41.0336°, 21.3458°)



березa: Ivano-Frankivsk, Ukraine (48.92°, 24.6911°)



Budburst_Suveaiast_N: Kilingi-Nomme, Estonia (58.1506°, 24.9526°)



Upon observation of the two North American paper birch sites, it is clear that the green down of Birch 1:GRN-03's predominant leaf color in Alaska occurs much earlier in the fall than Paper Birch #1's in Kents Hill, Maine. In addition, the colors of both sites' leaves start at the same shade of green of 5GY:4/8, Birch 1: GRN-03's leaves suddenly transitions to a light beige shade of 2.5Y:8/6 then falls a couple days later whil Paper Birch #1 gradually changes to a slightly lighter shade of green of 5GY:5/10, to a golden yellow shade of 2.5Y: 8/12, to a bright orange shade of 5YR:7/12.

In the European silver birch sites, we see a similar pattern in the green down of their predominant leaf colors. At the School Backyard site in North Macedonia, the leaves start out as a very dark shade of green of 5GY:3/2, then slowly over the course of over two months they transition to lighter shades of green, 5GY:4/8 to 5GY:5/10 to 5GY:6/10 to 5GY:7/10, then finally changing to the bright shade of yellow of 2.5Y:8/12 at the end of November. At the береза site in Ukraine, however, the colder climate conditions seemingly accelerate the predominant leaf color's change. The same predominant leaf colors of the School Backyard site's birch are present

on береза's birch, but the color change occurs much earlier in the fall, changes in less time, and ends its leaf cycle with an orange hue of 5YR:7/12 on the береза's birch, which makes it very similar to Paper Birch #1 at Kents Hill. At the site with the coldest climate of all European green down sites, the predominant leaf color of Budburst_Suveaiast_N in Estonia changes rapidly from the green color of 5GY:4/8 directly to the golden yellow 2.5Y:8/12, then finally turning to a light brown 2.5Y:6/6 at the end of October before the loss of all its leaves.

Discussion:

Looking over the data, there are many presumptions that can be drawn from the patterns in both the North American paper birches and European silver birches. To begin with, there is an obvious pattern across both of the observed species of how the colder the environment is, the earlier and the faster the green down of the leaves are. Drawing upon what I mentioned earlier, the chlorophyll production within a leaf slows down as temperature decreases. The appearance of a green leaf indicates a steady production of chlorophyll. When a leaf begins to lose its color, it indicates that chlorophyll production is slowing down.

In the warmest climate of the School Backyard site, the leaves of the silver birch are able to sustain its green color longer, almost all the way into the end of November. Meanwhile at the coldest sites, Budburst_Suveaiast_N and Birch 1:GRN-03, their leaves immediately lose their color early in the season in September and fall prematurely relative to the other sites. In the neutral temperature climates of the research sites of Ivano-Frankivsk and Kents Hill, they both share a wider range of predominant leaf color patterns throughout the season, which shows that while the leaves are gradually producing less and less chlorophyll, the leaves will display a more varying pattern in leaf color over the course of time than the birches in a warmer climate that

sustain its green color through autumn and the trees in a colder climate that immediately lose its color and falls once autumn begins. Overall, given the results of the study, my hypothesis correctly predicted the patterns of the data and provided a reasonable explanation for the difference in color changes at each of these sites.

Conclusion:

What started as a simple collection of data and observations of one particular paper birch in the woods behind our school turned into a complex study of the species as a whole and its survival in different temperature climates. Using knowledge that we had obtained from class and advanced research, we were able to find answers to a lingering thought we had throughout the study as to what the leaves of our birch tree would look like at this time of year if it were in a place like Alaska where temperatures drop significantly earlier in the fall. The answer is not as simple as I thought it would be, however, because it went deeper into an advanced level of chemistry that centers on the correlation between temperature fluctuation and the production of chlorophyll. The results of my study also gave me answers to questions I didn't even consider about the similarities and differences between a paper birch and a silver birch.

I entered this study having very little knowledge about birch trees and how they can survive in different climates. Growing up in New England, I've been surrounded by birches for almost my entire life, but the only fact I knew about them is that their bark is the ideal kindling for a campfire. Over the course of this study, however, I was given the opportunity to connect with the Earth and learn about the birches that inhabit it, which gave me knowledge that can be applied to arborology and environmental science as a whole.

References:

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