MONITORING THE IMPACT OF CLIMATE CHANGE ON VERMONT'S SUGAR MAPLES

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Background

The sugar maple (Acer saccharum) is an important staple of the state of Vermont ecologically and economically. This tree serves as a food source for various animals and insects such as white-tailed deer, squirrels, and earthworms. They are also commonly used as a habitat for many migrating and native birds (Gaudon, 2010). In addition, the sugar maple is designated the state tree because of Vermont's famous maple syrup industry. Sugar maple sap can be used to make many products such as maple syrup, maple candy, and maple sugar. Sugar maples are also sought after economically because they have "hard maple" wood and are an important timber species (Brown, 2015). But the future of this tree has become uncertain over the last few decades. Due to global climate change and the many impacts of warmer annual temperatures, it is likely that sugar maple populations will decrease or migrate north to colder weather.

Figure 1: Image shows a man checking a sugar maple that has been recently tapped for sap. (Image courtesy of Umaine Forestry)

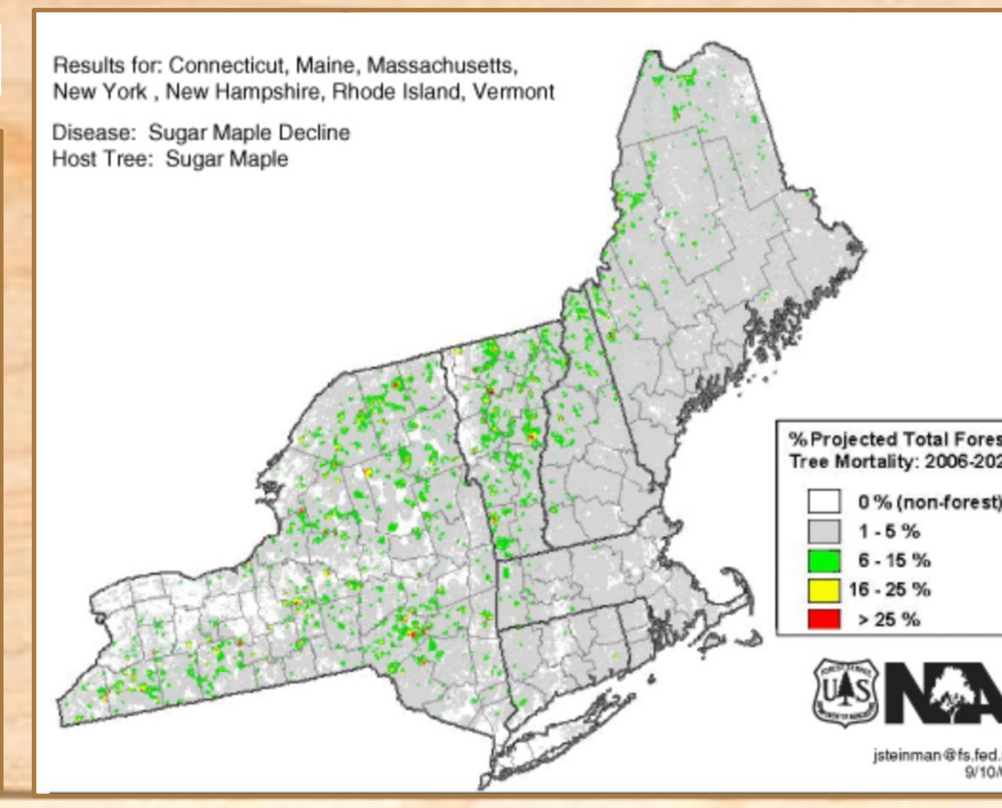

Figure 2: Map depicting % projected total sugar maple death in the states of CT, ME, MA, NY, NH, RI, and particularly VT. (Map courtesy of US Forest Service)

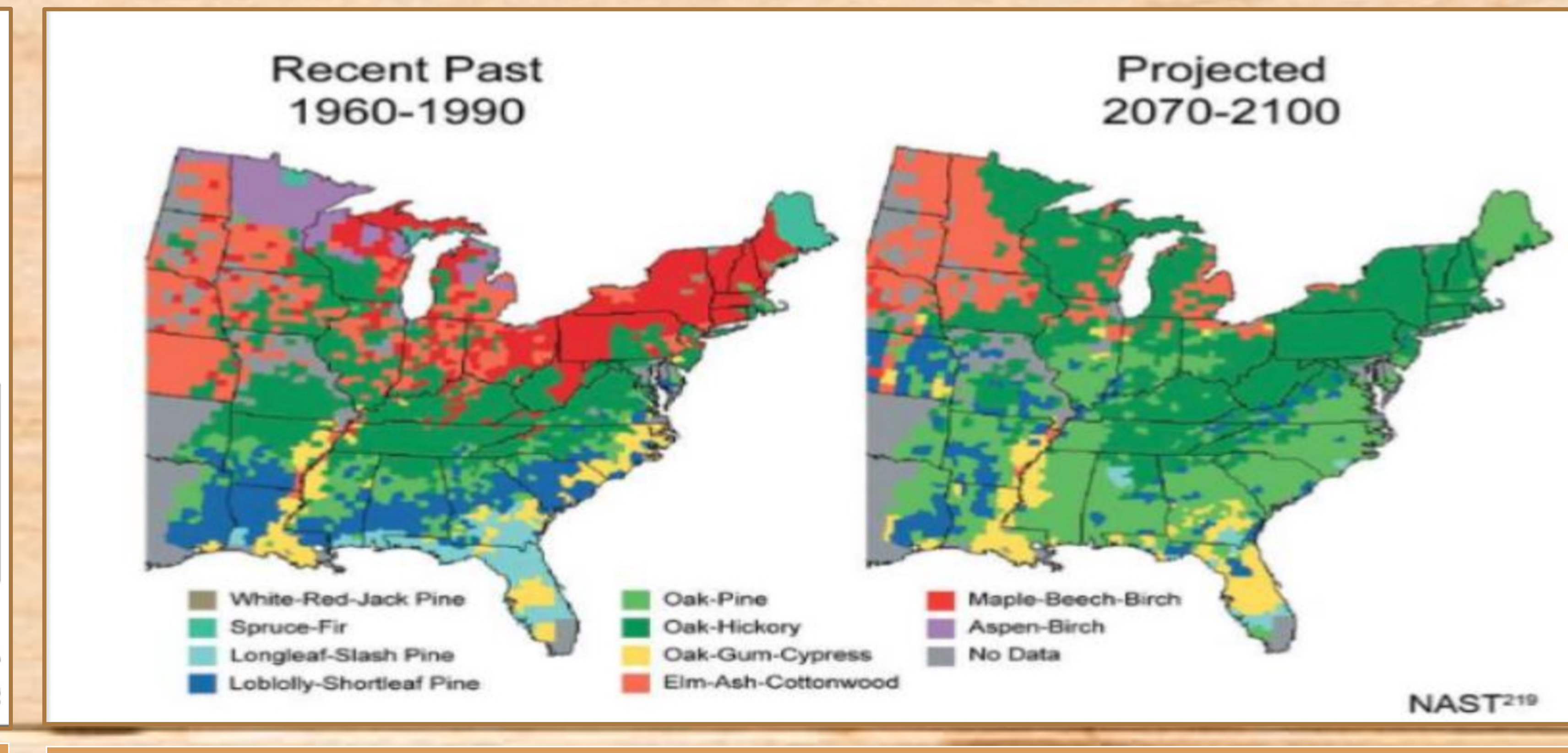

Figure 3: The past and predicted forest types of the eastern United States. Shows a major shift in the Northeast region forest type from maple-beech-birch to oak-hickory. (Image courtesy of Carelton.edu).

Objectives

1. Determine how an increase in average annual temperature impacts the number of existing sugar maples in Vermont.
2. Determine how an increase in average annual temperature impacts the health and growth rates of existing sugar maples in Vermont.
3. Determine if there is a significant trend of sugar maples shifting north into Canada.
4. Analyze what this data means for the state of Vermont from both an ecological and economic standpoint.

Intended Analysis

It is important to note that the results from this experiment will not be immediate. It will take roughly 25-50 years to even begin to see trends. Significant trends and comparisons may take up to 100 years to be seen. That being said, taking these annual measurements will help to see how increasing annual temperatures impact sugar maples. If the data shows that sugar maples are moving north into Canada, it will be important for Vermont to take necessary actions to slow the migration. Keeping sugar maple populations in Vermont is not only important for the environment, but also important for the economy, culture, and history of the state.

Motivation

As seen in Figure 2, most of the state's projected sugar maple mortality is 6-15%, but there are some locations that reach greater than 25% mortality. The causes of this mortality are impacts of increasing annual temperatures. Sugar maples thrive in cool, moist climates and are not as adaptable as other tree species are to the warming temperatures. The warming of annual temperatures has begun to cause sugar maples to shift their growing range north into Canada to meet necessary growing conditions. In addition to having less sugar maples to tap due to increased death, the increase in annual temperatures is creating major issues in the maple syrup industry. Warmer weather impacts the beginning and duration of the sugaring season as well as the quality of the sap produced by the trees (Brown, 2015). Sugar maple mortality and migration will drastically change the ecosystems of Vermont as well as negatively impact a major economic market of the state.

Study Design

In order to measure the impact of increasing annual temperatures on the number, health, and growth rates of existing sugar maples in Vermont, the experiment will need to be designed as long-term monitoring on pre-determined, set plots. These plots will be placed in areas with high populations of sugar maple stands. These stands will be marked, and measurements will be taken annually. For counting the number of existing sugar maples in the stands, field crews or LiDAR with GIS applications can be used and recorded. The best way to measure the health and growth rates of the sugar maples on the stand would be to use field crews. These crews would pick out the sugar maples present and take specific measurements such as tree height, diameter at breast height, canopy cover, crown spread, volume, and age. Crews will also take note of any unusual growth forms, cankers, or visible diseases present on trees. In order to compare these conditions with average annual temperature, monitoring of temperature changes will take place using national databases. The comparisons of the observations taken in the field will be compared to these temperatures annually. It will also be important to take note of sugar maple conditions on years that have a higher average temperature. To examine if sugar maple populations in Vermont are migrating north into Canada, it will be very important to run similar understory experiments in areas just north of the Vermont border. This will help to see if sugar maple populations in Canada increase as sugar maple populations in Vermont decrease.

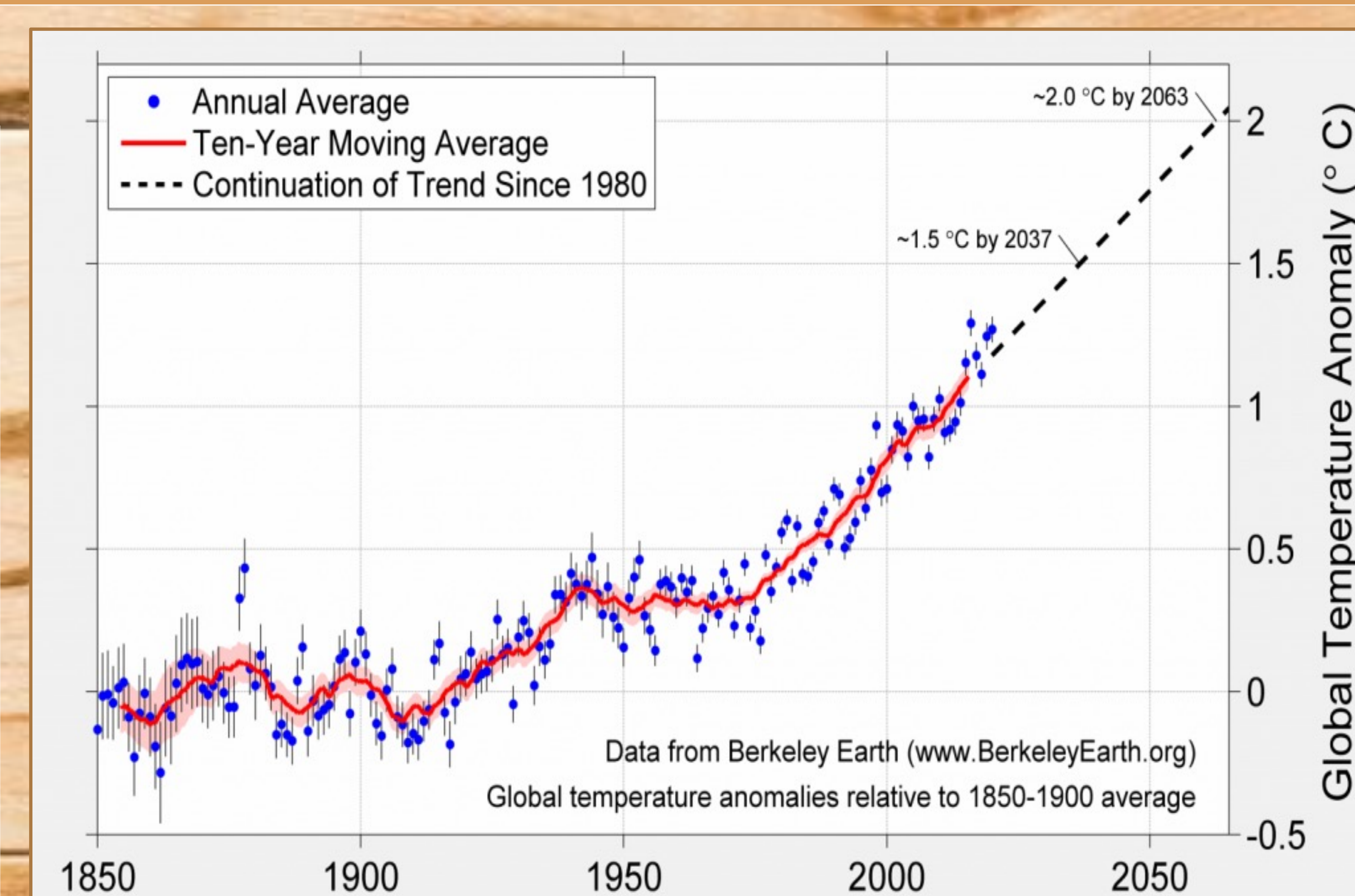

Figure 4: Graph depicting the estimated increase of global annual average temperature. Shows a steady average increase in annual temperature from around 1970-2075.

Hypothesis

If average annual temperatures continue to rise as a result of global climate change, then sugar maples will no longer be able to grow in Vermont and will shift their growing range north into Canada

Independent/Predictor Variable: Average annual temperature (°C)

Dependent/Response Variables: Number of existing sugar maples in Vermont and the health/growth rates of existing sugar maples in Vermont

Literature Cited

Augspurger, C. (2013). Reconstructing patterns of temperature, phenology, and frost damage over 124 years: Spring damage risk is increasing. *Ecology, 94*(1), 41-50. Retrieved May 1, 2021, from http://www.jstor.org/stable/23435667

Brown, L. J., Lamhonwah, D., & Murphy, B. L. (2015). Projecting a spatial shift of Ontario's sugar maple habitat in response to climate change: A GIS approach La projection d'un décalage spatial de l'habitat de l'érable à sucre en Ontario suite aux changements climatiques : une approche fondée sur les SIG. *Canadian Geographer*, *59*(3), 369–381. https://doi.org/10.1111/cag.12197

Caughron, A., Legault, S., Haut, C. *et al.* A Changing Climate in the Maple Syrup Industry: Variation in Canadian and U.S.A. Producers' Climate Risk Perceptions and Willingness to Adapt Across Scales of Production. *Small-scale Forestry* 20, 73–95 (2021). https://doi.org/10.1007/s11842-020-09457-2

Justin M. Gaudon, Michael J. McTavish, Sivajanani Sivarajah, Emmett H.U. Snyder, Samara M.M. Andrade, & Stephen D. Murphy. (2020) Effects of earthworms and warming on tree seedling growth: a small-scale microcosm experiment. *Canadian Journal of Forest Research.* 50(11): 1253-1257. https://doi.org/10.1139/cjfr-2020-0097

Maguire, T. J., Templer, P. H., Battles, J. J., and Fulweiler, R. W. (2017), Winter climate change and fine root biogenic silica in sugar maple trees (Acer saccharum): Implications for silica in the Anthropocene, J. Geophys. Res. Biogeosci., 122, 708– 715, doi:10.1002/2016JG003755.