

The Future of Vermont's Sugaring Industry in the Face of Climate Change

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How will climate change affect sugar maple "*Acer saccharum*" regeneration success?

Our Hypothesis- We hypothesize that there is a relationship between conditions created by climate change and the regeneration success of sugar maples.

Predictions- We predict that atmospheric conditions created by climate change will decrease regeneration success in sugar maples. The species has evolved over time to suit a cooler and more predictable environment, so the increased temperatures and increased variability of weather caused by climate change is expected to have a negative impact on regeneration success. Unseasonal weather conditions will become more common as climate change continues which will lead to an increased mortality for sugar maple saplings. Warm spells near the end of winter will cause seeds to sprout, and when a return to cold weather comes these seeds will die.

Motivation- In Vermont, the sugar maple is a commercially and culturally significant tree species. Conducting this research will provide land managers with further information to guide management strategies for the Sugar Maple.

Study Design- Sugar maple seeds will be planted in a controlled environment that will simulate expected atmospheric conditions in the future, present conditions, and past conditions. There will be 20 seeds per condition, for a total of 60. The growth of saplings under each condition will be measured

Intended Analysis- We intend to analyze the effects that climate change has on the growth of *Acer saccharum*. To do this, we will analyze the growth data that we collect using ANOVA. For this study, the independent variable (climate conditions) is categorical. There are three categories; past, current, and future climate conditions. The dependent variable, seed growth, is dependent, measured in centimeters.

Scope of Inference-

- Spatial extent: Climate conditions will be specific to Vermont, so the findings of this study can be applied to Vermont.
- Temporal extent: This study will take place during the early life stage of the sugar maple tree. It is meant to study the regeneration success of the species under different climate conditions, so the growth that occurs after the early stage of life won't be measured.
- Ecological extent: The results of this study will only apply to sugar maples, as no other tree species will be measured. This study will only examine the effect of climate on sugar maple regeneration success, other variables will not be implemented or measured.

Site Selection- This study will be conducted in the controlled environment of the University of Vermont Greenhouse. Use of the greenhouse will allow for the regulation of atmospheric conditions to match projected conditions in the future, current conditions, and historical conditions from the past.

Experimental Variables- Temperature and precipitation will be the variables that are controlled. Growth (in centimeters) of the seeds into saplings will be the variable that is measured.

Expected Benefits- Completion of this study will help to guide management strategies for sugar maple in Vermont and elsewhere in the American Northeast. *Acer saccharum* is an economically and culturally important species to this region, so it is important to guide decision making with the best available information. If it is found that climate change is indeed negatively impacting sugar maple regeneration, management efforts can be shifted to focus on improving future tree regeneration.



Figure 1.1: A picture of a sugar maple "*Acer saccharum*" exhibiting its vivid fall foliage. Being the state tree, the sugar maple has a very important role in Vermont's economy and culture, with the syrup and tourism industries owing much of their success to this specific tree species. (Image credit: Cannon nurseries, 2020)



Figure 1.5: A close-up view of an adult leaf from an *Acer saccharum*. In the fall, these leaves turn a bright orangey-red. (Chesapeake Bay Program, 2020)



Figure 1.2: Tapping maples for sap happens in late winter and early spring, when the nightly freezing and thawing process forces sap to flow intensely. This process is heavily dependent on predictable, unchanging warming annual weather patterns, which are under threat from climate change. Maple syrup is an extremely important cultural resource for Vermont.



Figure 1.6: A visual of our study design, growing trees in a controlled greenhouse environment that can simulate precipitation and temperature conditions of the past, present, and future.



Sources-

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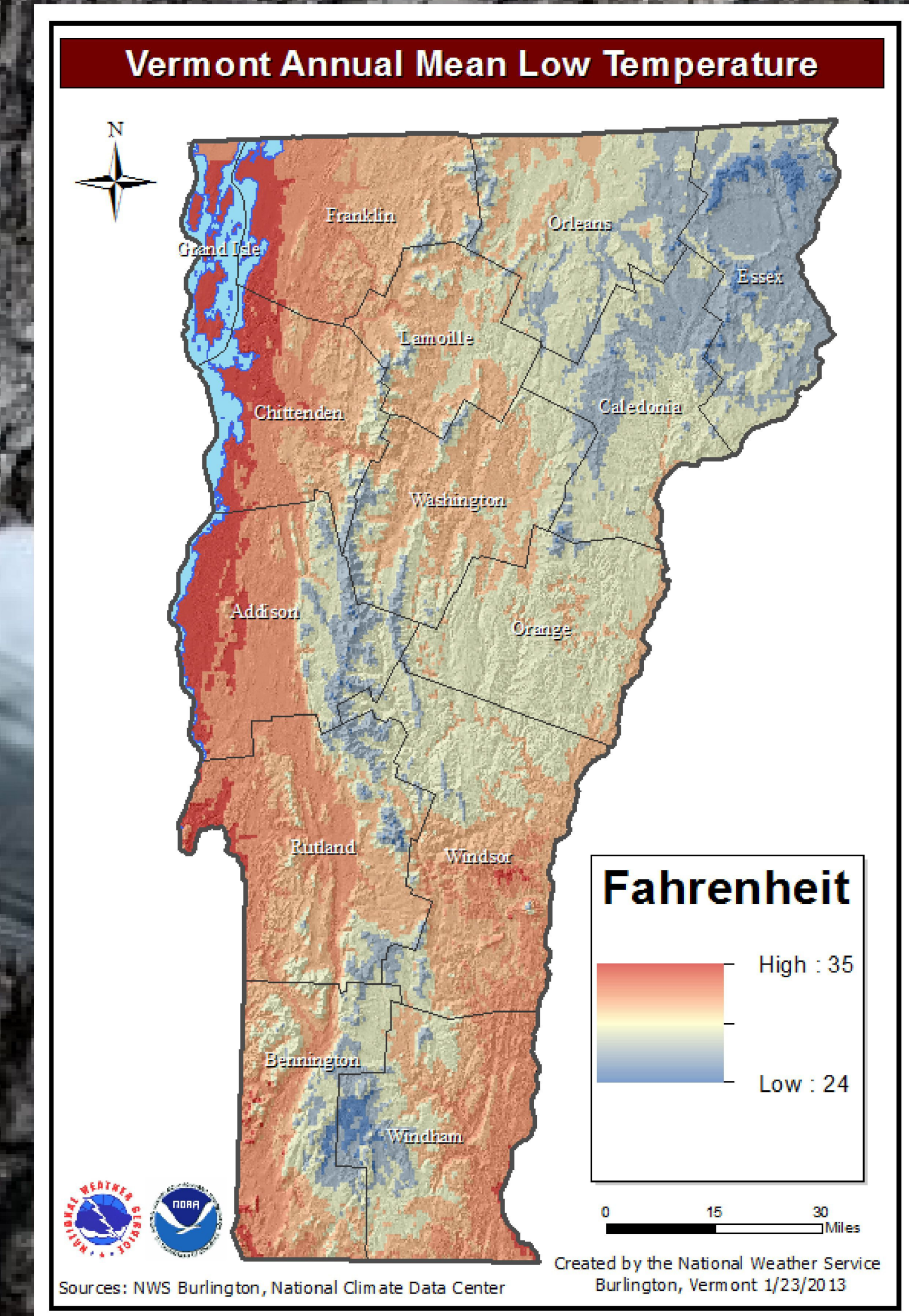


Figure 1.3: A choropleth map representation of all Vermont locations by mean low temperature in winter (National Weather Service, 2013) Besides being our home state, Vermont is perennially America's largest producer of maple syrup, and sap flow rates depend heavily on winter temperatures, which are rising.

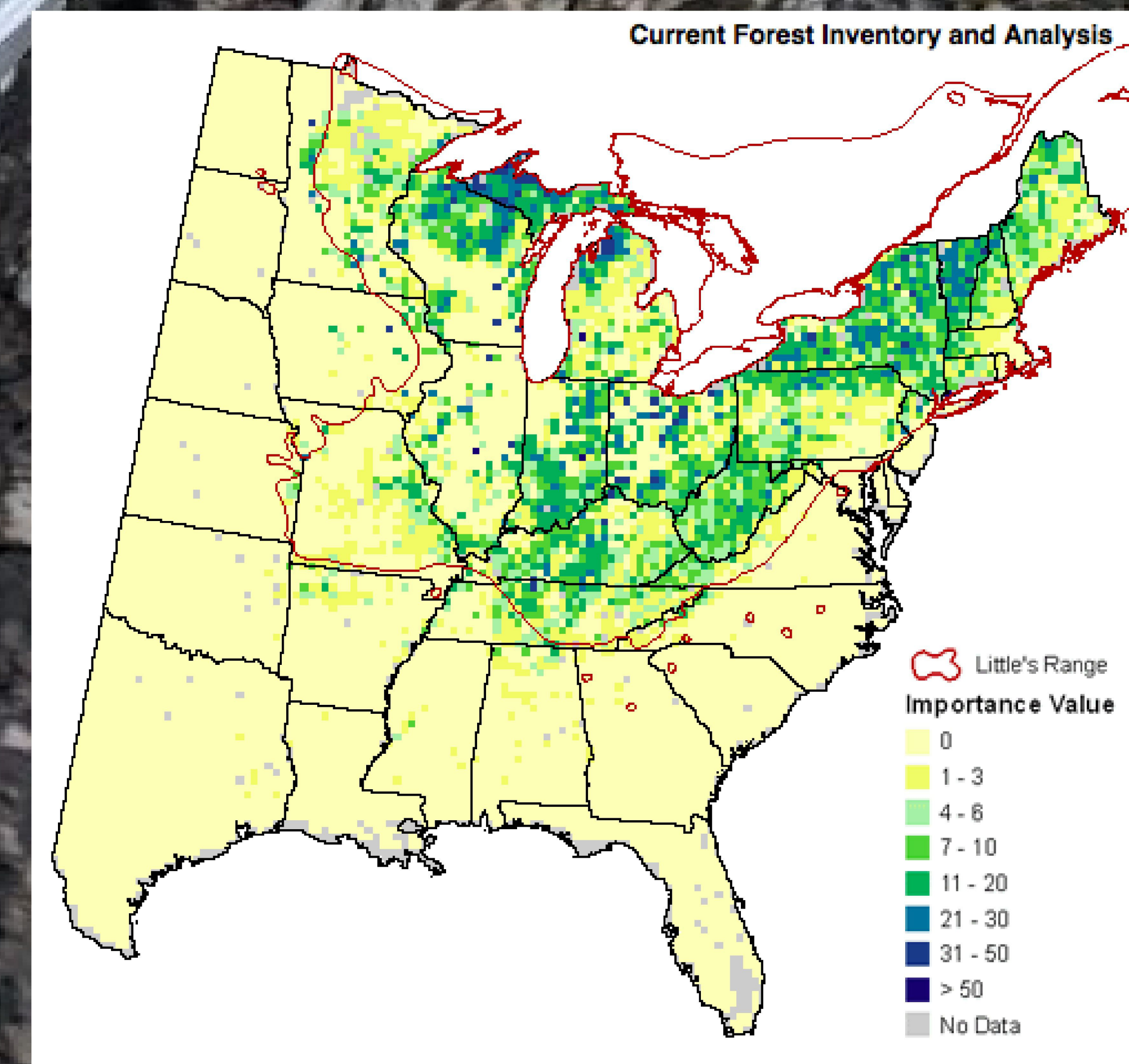


Figure 1.4: A map characterizing the range of *Acer saccharum* across Eastern North America. The sugar maple can be found as far south as Tennessee and as far west as Kansas, but the majority of trees are in the Northeastern United States and the Canadian provinces of Quebec and Ontario. This range is shifting northward due to warming temperatures associated with global climate change, a point of concern for Vermont (USDA Forest Service, 2020)