Apple cultivars and climate change in the Eastern Mountain region of the United States

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Introduction

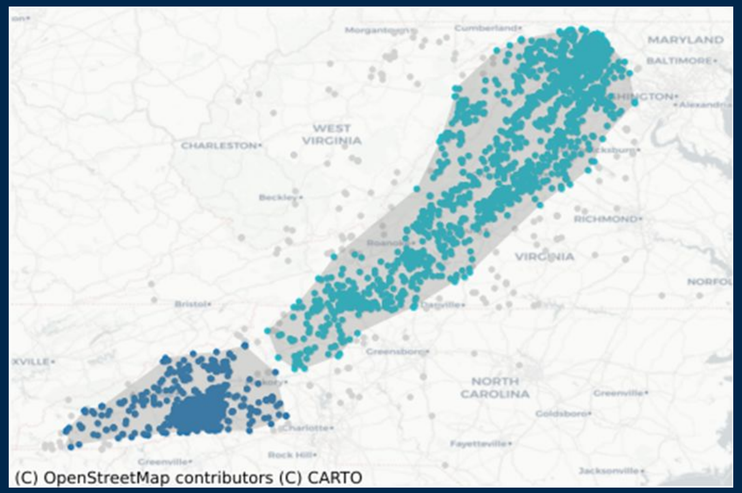
Extensive research exists regarding the effects of climate change on agriculture. However, there is often a gap between researchers and decision makers, particularly in industries with limited resources. The apple industry is one such example. Though apples are the most consumed fruit in the United States, apple orchards occupy less than 1% of the 880 million acres of United States farmland (Industry at a Glance, n.d.; National Agricultural Statistics Service, 2024). To bridge this gap, we have developed a proof of concept for an apple manufacturer, providing insight into the resilience of cultivars in the Eastern Mountain region of the United States.

Data

Our proof-of-concept is based on data from four sources: the United States Department of Agriculture (USDA), the National Aeronautics and Space Administration (NASA), Oikolab, and the Stark Bro's website. FixCarbon provided access to data from NASA and Oikolab.

NEX-GDDP-CMIP6 from NASA and ERA5 from Oikolab are the two most important data sources. CMIP6 includes daily downscaled climate predictions under different climate scenarios, providing the features for our elastic net regression. ERA5 includes hourly weather data, providing the ground truth for our regression.

Figure 1. Orchards and orchard clusters in the Eastern Mountain region.



Approach

To obtain a manageable dataset, we identified existing apple orchards using USDA data and created clustered the orchards with HDBSCAN (Figure 1). We adjusted the spatial resolution of the CMIP6 dataset to match ERA5. To reduce volatility, we applied, a 30-day rolling minimum to both CMIP6 and ERA5 data. We then used elastic net regression to weight the CMIP6 climate projections, yielding an R^2 score of 0.89 and an RMSE of 5.67.

Being able to predict minimum annual temperature allowed us to update USDA Plant Hardiness Zones in the Eastern Mountain region. Hardiness zones are frequently used for crop selection in the United States.

Results

While minimum temperatures increase up to 12 degrees Fahrenheit by 2050, the change in USDA Plant Hardiness Zones is more gradual (Figure 2). Most apple cultivars will continue to be available, with the exception of Cortland and Franklin Cider. Ben Davis, Empire, Enterprise, and Liberty are also in jeopardy, though on a longer timescale.

With this procedure, it is possible to predict temperature and USDA Plant Hardiness Zones, not only for apples, but for other permanent crops as well, allowing growers and manufacturers to make more informed decisions, even as climate conditions change.

Figure 2. USDA Plant Hardiness Zones in the Eastern Mountain region from 2014 to 2050.