Capstone Project Proposal For GEOG 596A

Penn State | College of Earth and Mineral Sciences Master of Geographic Information Systems
Author: Jason Biagio | jrb430@psu.edu
Advisor: Dr. Richard Marini | rpm12@psu.edu
December 2019

A bit about me

- I work as a geospatial developer/analyst for Setton Farms. My primary job function is to track,evaluate, and model orchard health of over 200,000 acres of citrus, hazelnuts, and pistachios in the western united states, primarily in California. My focus usually begins with remote sensing of high-resolution, multi-spectral satellite imagery, performing a series of standardized and proprietary analytic indices and resulting in a determination of health, or prescription of improvement. Due to the sensitivity of my work (regarding pistachios), I am performing a focused study on the specific crop of hazelnuts.

List of Terms

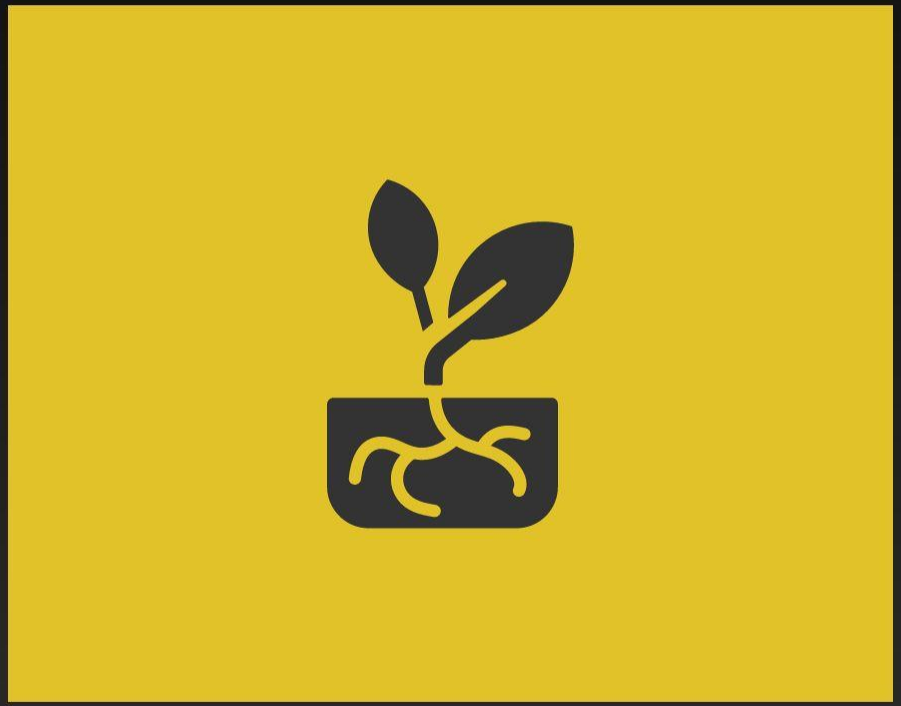
Phenology

Model

Principal Component Regression (PCR)

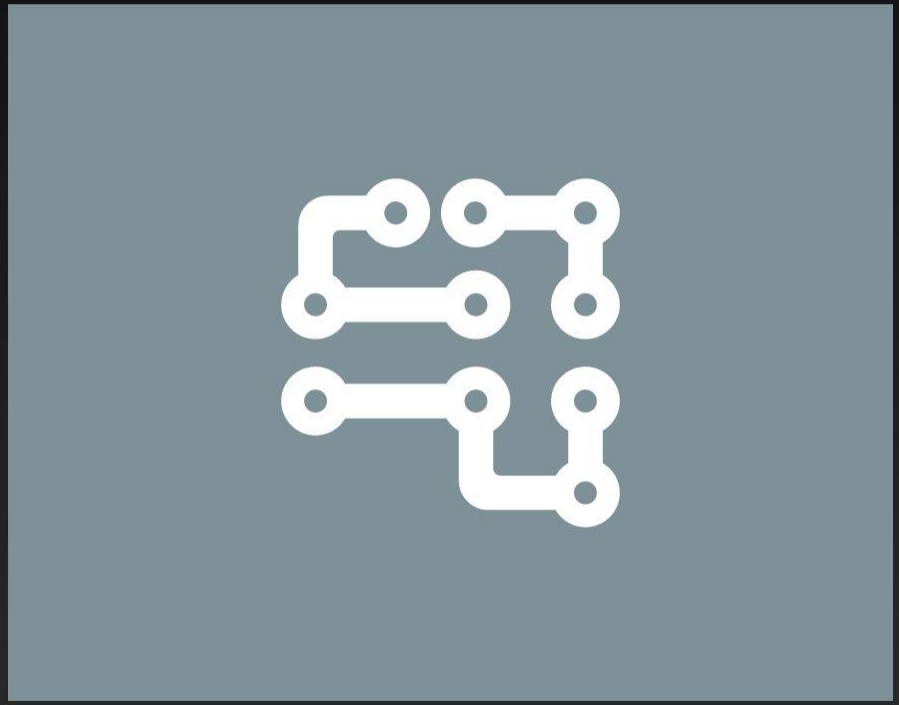
Jupyter Notebooks

Phenology



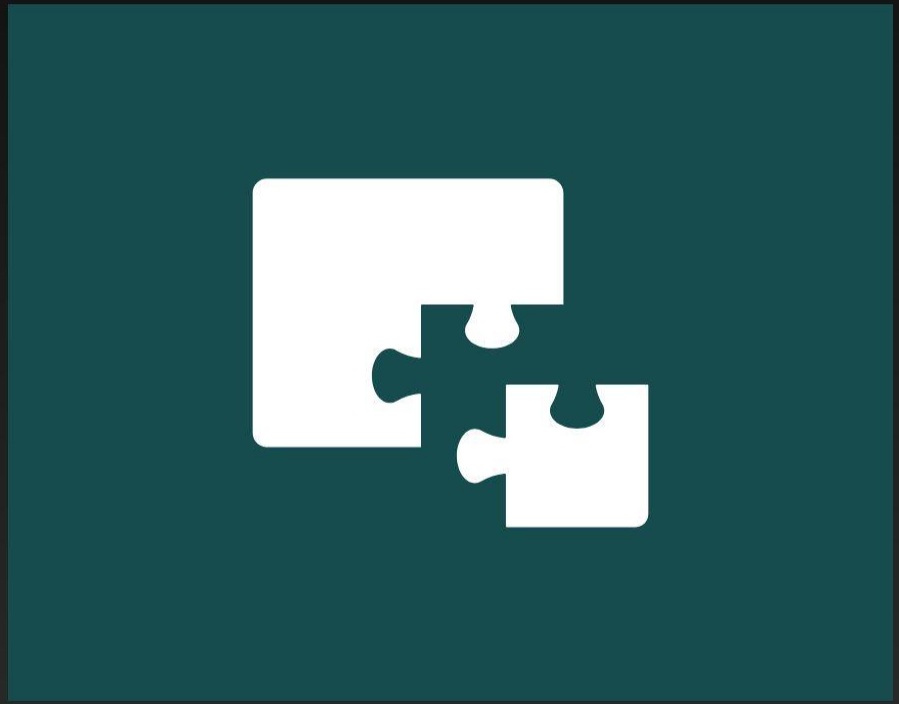
A branch of science dealing with the relations between climate and periodic biological phenomena (such as bird migration or plant flowering) -or- periodic biological phenomena that are correlated with climatic conditions (Phenology | Definition of Phenology by Merriam-Webster n.d.). In horticulture, phenology generally refers to a growth stage, such as bloom, the timing of which is influenced by temperature.

Model



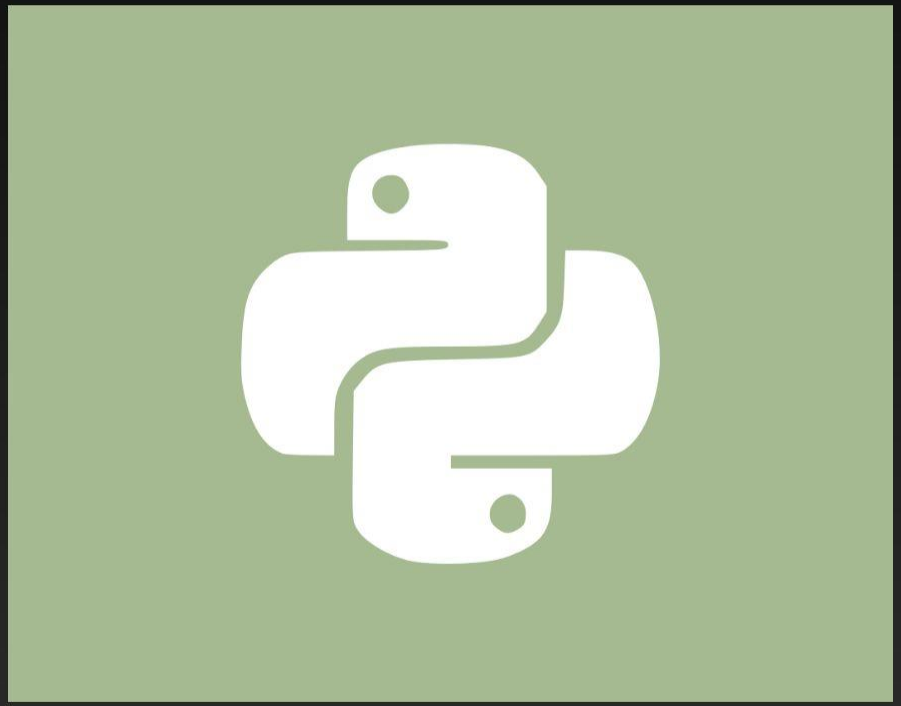
A system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs -also- a computer simulation (see ‘simulation’: the imitative representation of the functioning of one system or process by means of the functioning of another) based on such a system [“climate model”] (Model | Definition of Model by Merriam-Webster n.d.).

Principal Component Regression (PCR)



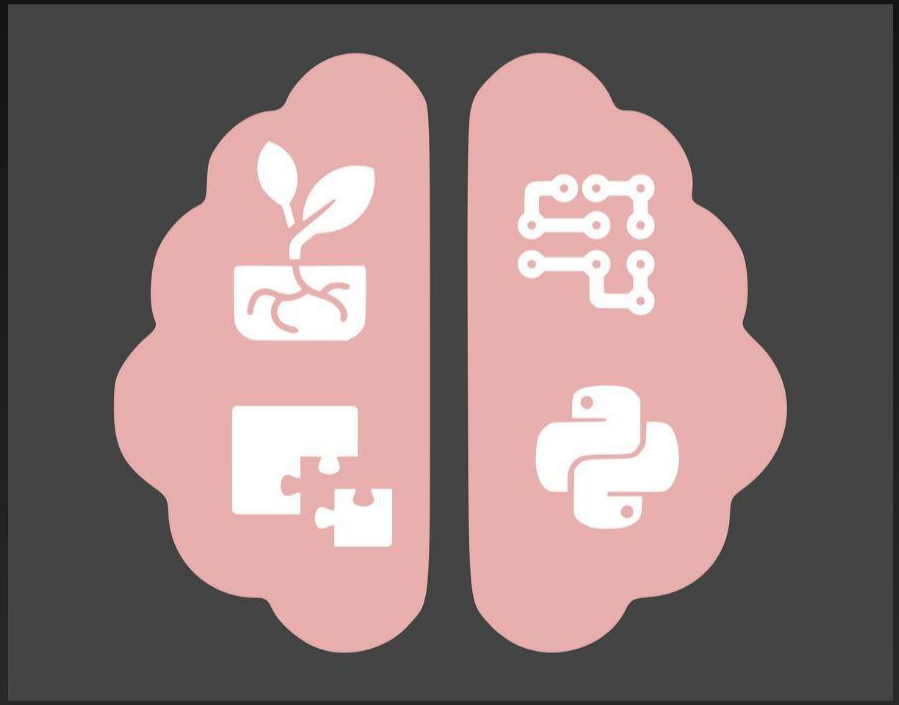
In principal components regression, we first perform principal components analysis (PCA) on the original data, then perform dimension reduction by selecting the number of principal components (m) using cross-validation or test set error, and finally conduct regression using the first m dimension reduced principal components (7.1 - Principal Components Regression (PCR) | STAT 508 n.d.).

Jupyter Notebooks

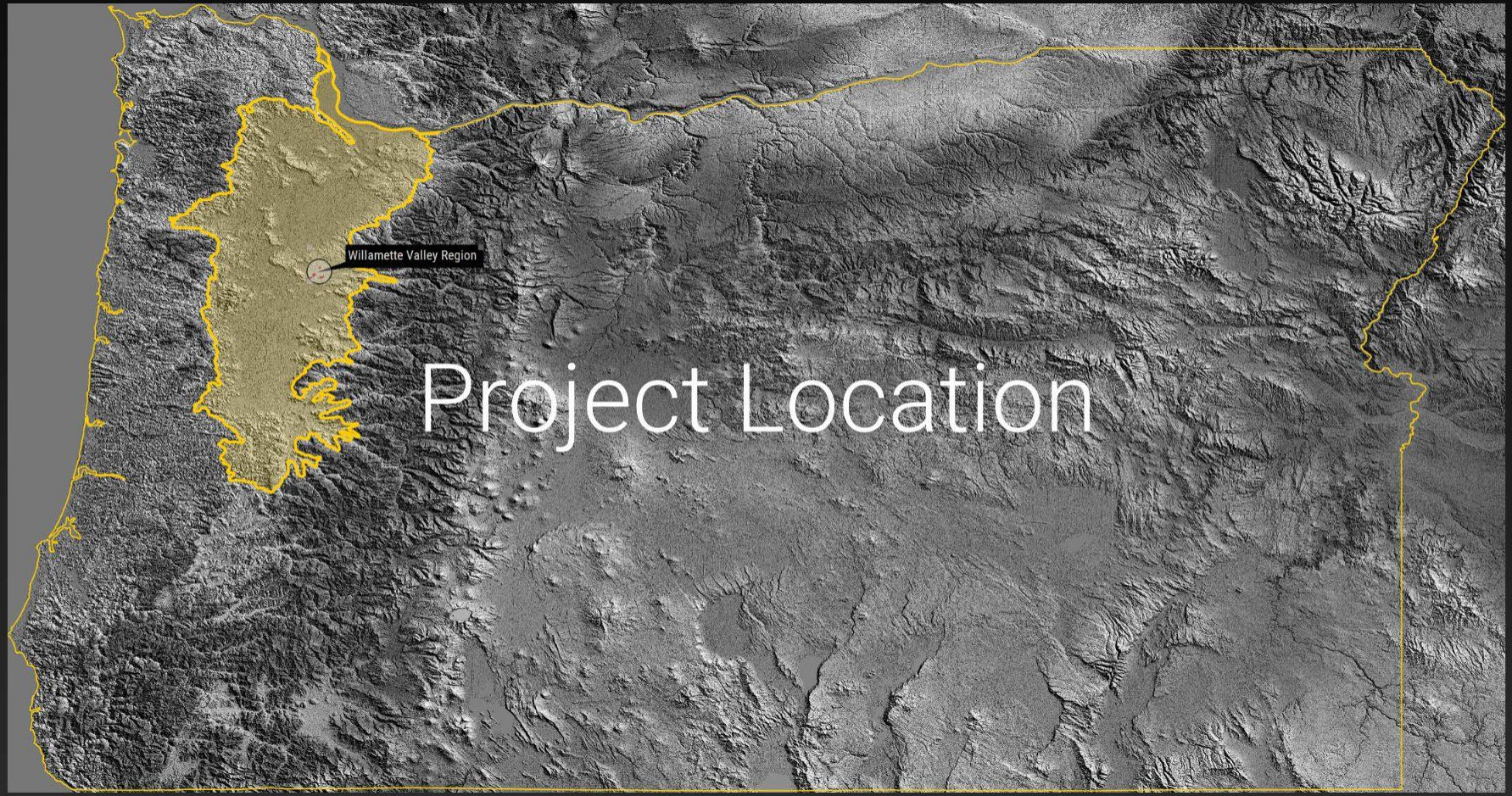


Is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations, and narrative text. Uses include data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more (Project Jupyter | Home n.d.).

Problem Statement



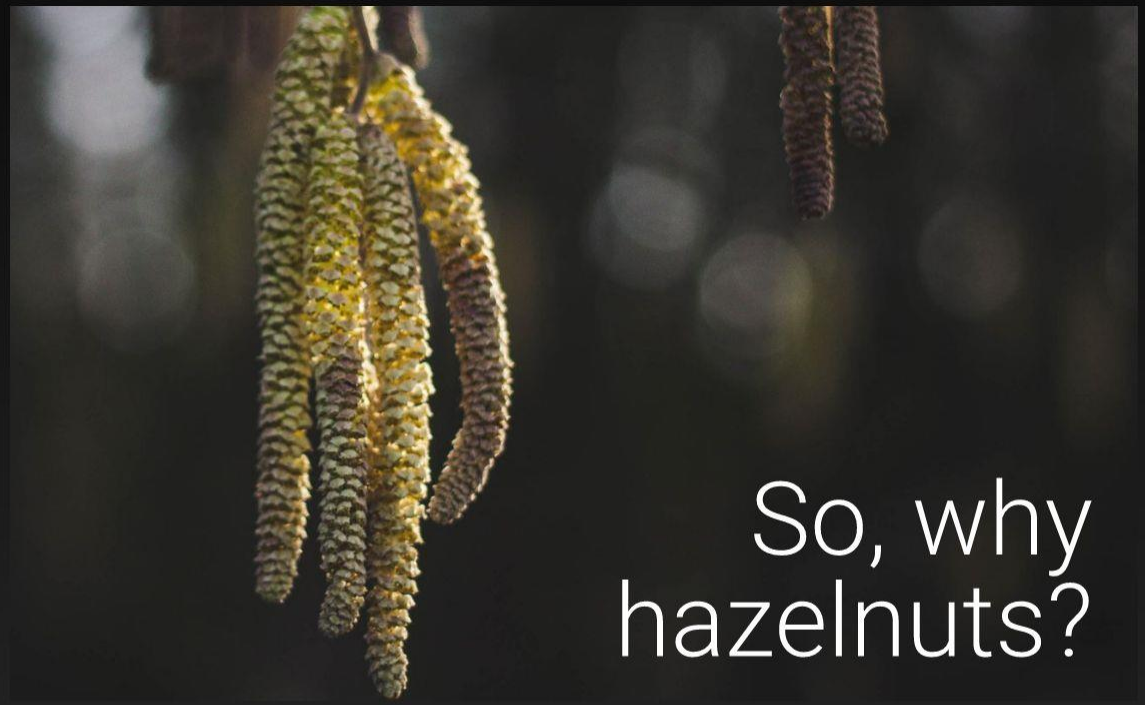
Forecasting harvest date and yield (phenological model) of selected hazelnut orchards within Oregon's Willamette Valley using Principal Component Regression (PCR) on highly multivariate data within a novel Python-based Jupyter Notebook.



Research Questions to be answered:

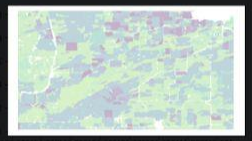
1. Can an accurate phenological model for hazelnuts (and a template for other deciduous species) be developed using highly multivariate (yet sparse) historical data?

2. Can a free and open-source Python-powered Jupyter Notebook be used in lieu of a more traditional statistical software package (such as SAS) for statistical analysis and visualization?



So, why hazelnuts?

https://nassgeodata.gmu.edu/axis2/services/CDLService/GetCDLFile?year=2018&bbox=-2104652.68239778 5,2705049.2359260 18,-2087416.7376986747,2724034.3809795515 5&format=json



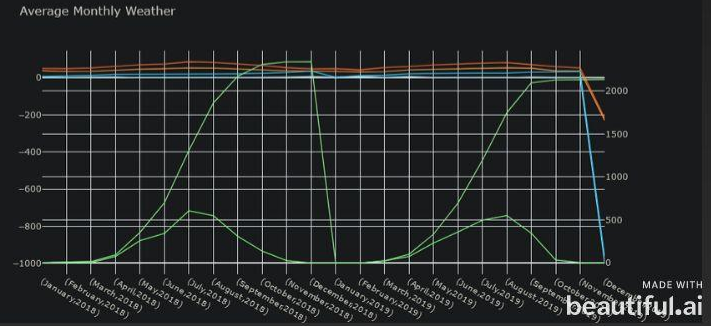
Get Weather Data from AOI and GUI inputs

This queries NOAA's Regional Climate Center's (RCCs) ACIS (Applied Climate Information System) weather data.

For large AOIs data may not be an accurate representation of all areas as query is based on centroid of AOI

[11] `# create GUI widgets`

[38] `# make JSON request based on inputs`



Background

- Man has always attempted to model the physical world in mathematical simulations/models (O'Connor and Robertson n.d.)
- Phenology is just another model – 'Agricultural Meteorology' (Helmut Lieth (auth.) 1974)
- Use of historical data – budburst, harvest, yield and climate (Fornaciari, Orlandi, and Romano 2005; Luedeling, Zhang, McGranahan, et al. 2009; Oteros et al. 2013)
- Never all at once

Methods/Approach

Methods/Approach - cont.

- Historical yields (from the Oregon Hazelnut Industry)
- Historical weather/climate data will be obtained from *Agrimet, *Hydromet (* = closest station) and NOAA's Regional Climate Center's (RCCs) ACIS (Applied Climate Information System). (Mehlenbacher 1991; Heide 1993; Pope et al. 2015; Rahemi and Pakkish 2009; Luedeling, Zhang, Luedeling, et al. 2009)
- Pollination Period
- Budburst/bloom dates for previous years
- Harvest dates for previous years
- Vegetative Indices (NDVI, GNDVI, OSAVI, etc.)

Methods/Approach - cont.

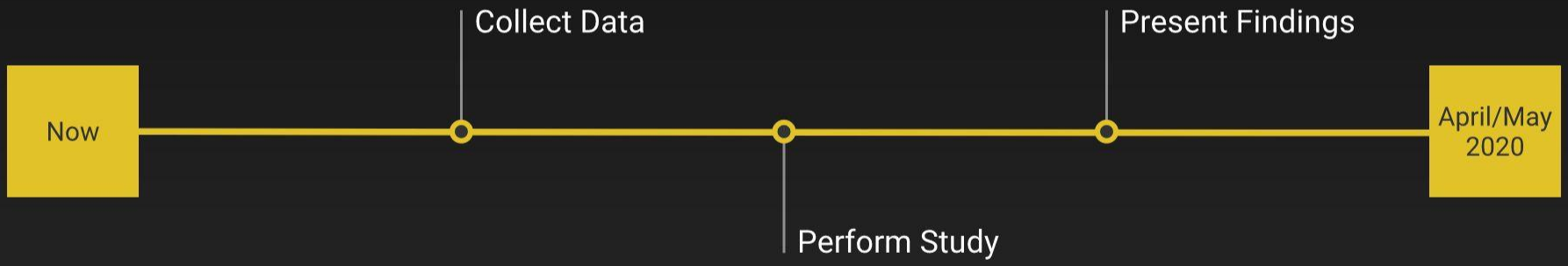
- MN = Minimum Daily Air Temperature (F)
- MX = Maximum Daily Air Temperature (F)
- MM = Mean Daily Air Temperature (F)
- Budburst/bloom dates for previous years
- Chilling hours
- Growing Degree Days (GDD) (calculated)
- ET = Evapotranspiration Kimberly-Penman (in)
- PC = Accumulated Precipitation Since Recharge/Reset (in)
- PP = Daily (24 hour) Precipitation (in)
- PU = Accumulated Water Year Precipitation (in)
- SR = Daily Global Solar Radiation (langleys)
- TA = Mean Daily Humidity (%)
- YM = Mean Daily Dewpoint Temperature (F)
- UA = Daily Average Wind Speed (mph)
- UD = Daily Average Wind Direction (deg az)
- WG = Daily Peak Wind Gust (mph)

Anticipated Results

1. Successfully develop a rough phenological model used to forecast potential harvest dates and yields for hazelnuts in the Willamette Valley, OR.

2. Successfully memorialize project process and methods within a Jupyter Notebook; to be used in future studies.

Proposed Timeline



Proposed Applications/Future Work

1. Basis for other studies of similar deciduous phenology
2. Modular notebook approach could allow data to be evaluated from several different techniques if proposed does not produce a usable model
3. Modular Notebook could serve as the basis for more exhaustive evaluations such as local or cloud-based machine learning efforts

Possible Venues

1. Potential presentation for the Hazelnut Industry of Oregon
2. Potential presentation for the International Nut & Dried Fruit Council
3. Potential presentation for the American Pistachio Growers (APG) Annual convention, February 2020
4. Potential presentation as published white paper
5. No definitive venue has been decided upon as of the writing of the draft and the date of this presentation


Questions?


beautiful.ai

References

- Fornaciari, Marco, Fabio Orlandi, and Bruno Romano. 2005. “Yield Forecasting for Olive Trees: A New Approach in a Historical Series (Umbria, Central Italy).” Agronomy Journal. https://doi.org/10.2134/agronj2005.0067.
- Helmut Lieth (auth.), Helmut Lieth Ph.D. (eds.). 1974. Phenology and Seasonality Modeling. 1st ed. Ecological Studies 8. Springer-Verlag Berlin Heidelberg. http://gen.lib.rus.ec/book/index.php?md5=eaa0d216d5692b3749911c4f3c61197d.
- Luedeling, Eike, Minghua Zhang, Volker Luedeling, and Evan H. Girvetz. 2009. “Sensitivity of Winter Chill Models for Fruit and Nut Trees to Climatic Changes Expected in California’s Central Valley.” Agriculture, Ecosystems and Environment. https://doi.org/10.1016/j.agee.2009.04.016.
- Mehlenbacher, Shawn A. 1991. “Chilling Requirements of Hazelnut Cultivars.” Scientia Horticulturae. https://doi.org/10.1016/0304-4238(91)90010-V.

References

- Oteros, J., H. García-Mozo, C. Hervás, and C. Galán. 2013. “Biometeorological and Autoregressive Indices for Predicting Olive Pollen Intensity.” International Journal of Biometeorology. https://doi.org/10.1007/s00484-012-0555-5.
- Pope, Katherine S., Volker Dose, David Da Silva, Patrick H. Brown, and Theodore M. DeJong. 2015. “Nut Crop Yield Records Show That Budbreak-Based Chilling Requirements May Not Reflect Yield Decline Chill Thresholds.” International Journal of Biometeorology. https://doi.org/10.1007/s00484-014-0881-x.
- Rahemi, Majid, and Zahra Pakkish. 2009. “Determination of Chilling and Heat Requirements of Pistachio (Pistacia Vera L.) Cultivars.” Agricultural Sciences in China. https://doi.org/10.1016/S1671-2927(08)60281-3.
- n.d. 7.1 - Principal Components Regression (PCR) | STAT 508. https://newonlinecourses.science.psu.edu/stat508/lesson/7/7.1.

References

- n.d. Model | Definition of Model by Merriam-Webster. https://www.merriam-webster.com/dictionary/model.
- n.d. O'Connor, J J, and E F Robertson. Physical World. http://mathshistory.st-andrews.ac.uk/HistTopics/World.html.
- n.d. Phenology | Definition of Phenology by Merriam-Webster. https://www.merriam-webster.com/dictionary/phenology.
- n.d. Project Jupyter | Home. https://jupyter.org/.

Thank you for listening