Climate Change & Extremes:

Impacts, Mitigation & Cultivar Suitability

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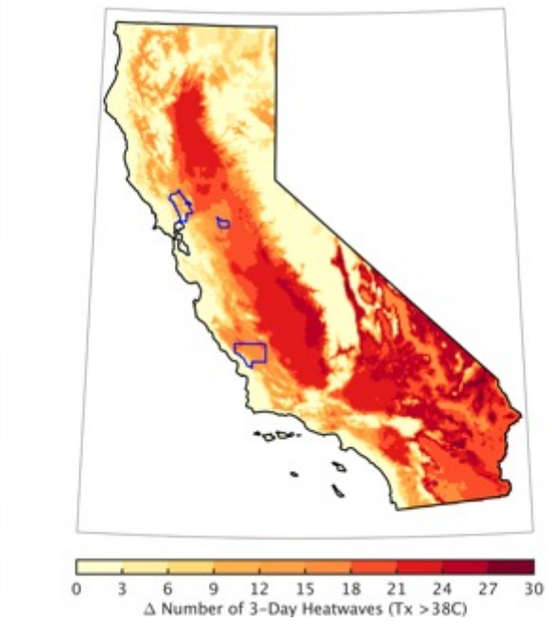
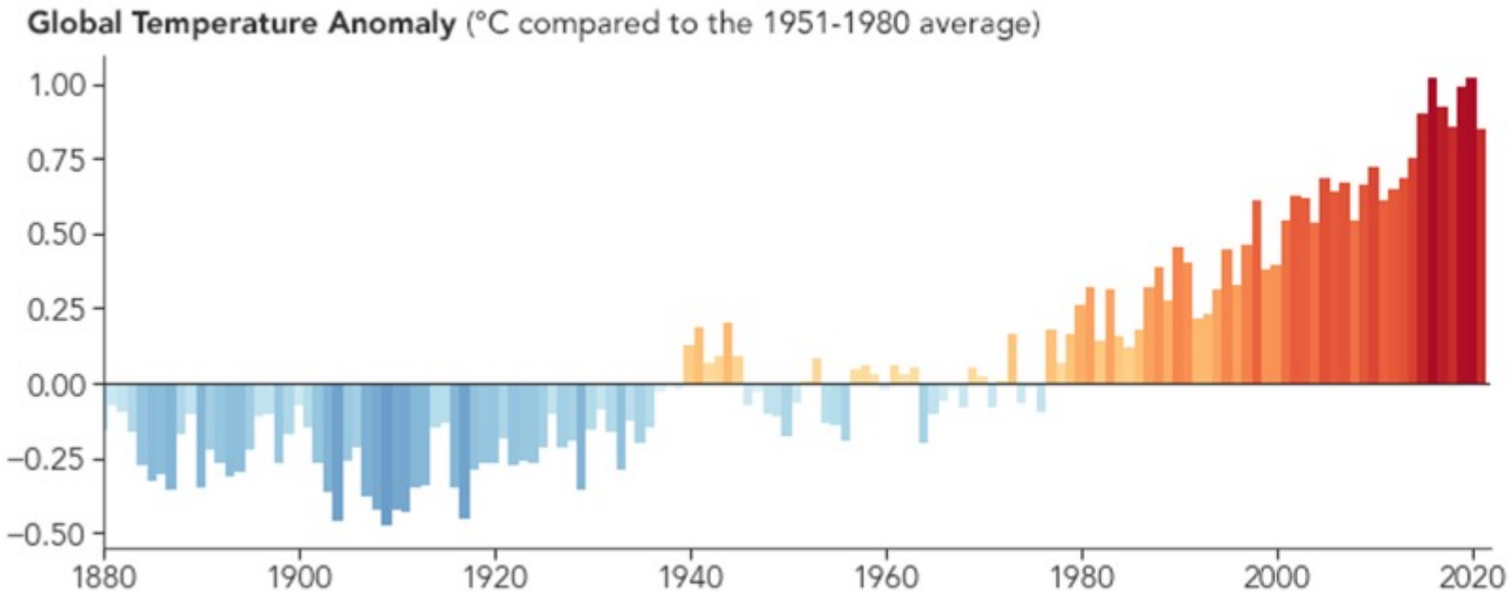
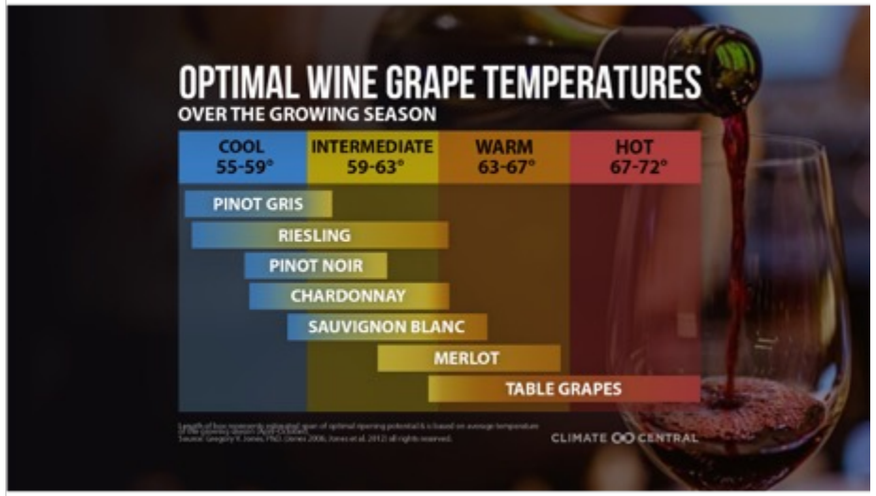
Dep't of Viticulture & Enology
University of California at Davis

Grape Day, Oakville Station,
June 5, 2024



Impacts of Climate Change on Grapes & Wine





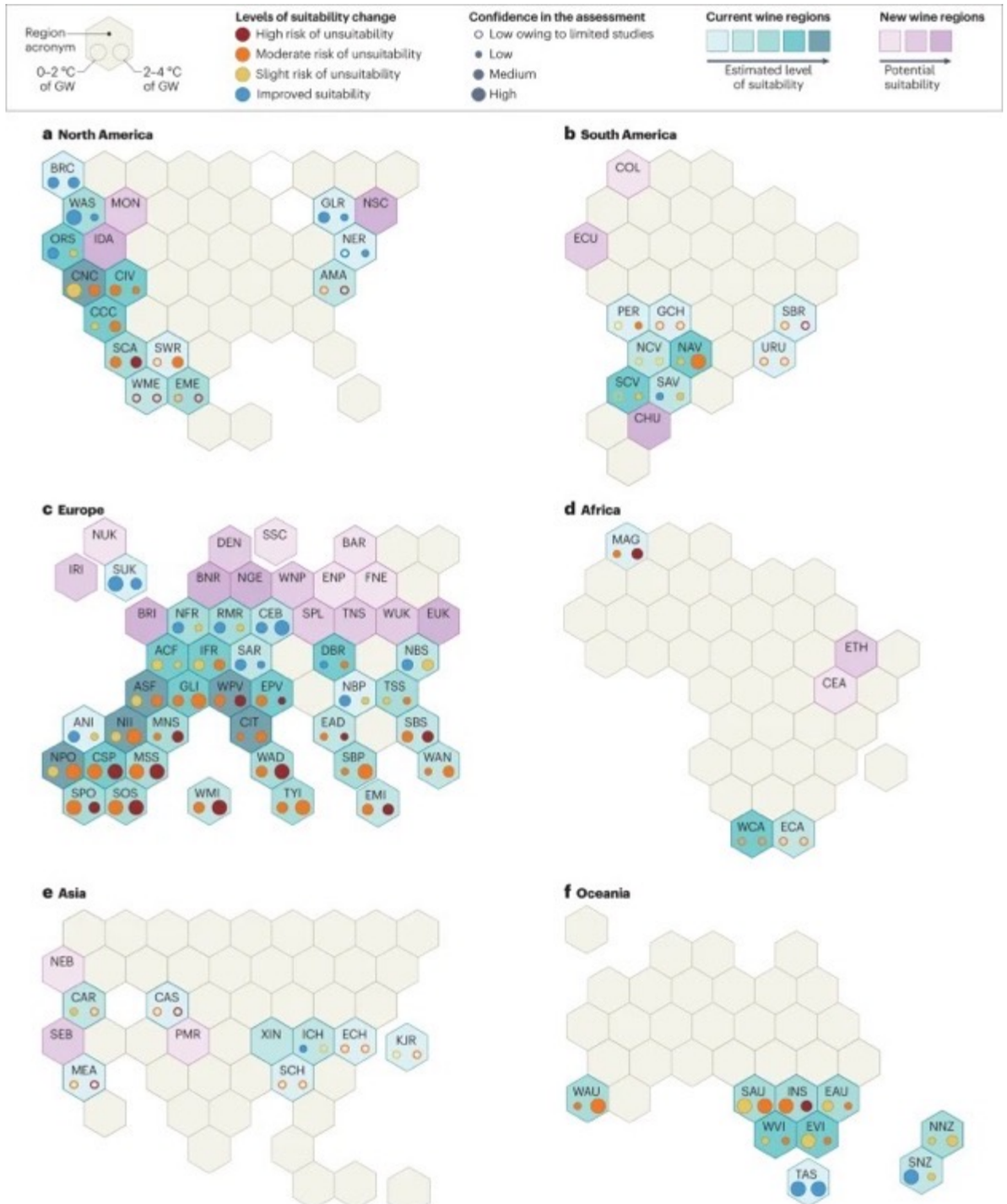
Cold Snaps/Spring Frost

Drought/Floods

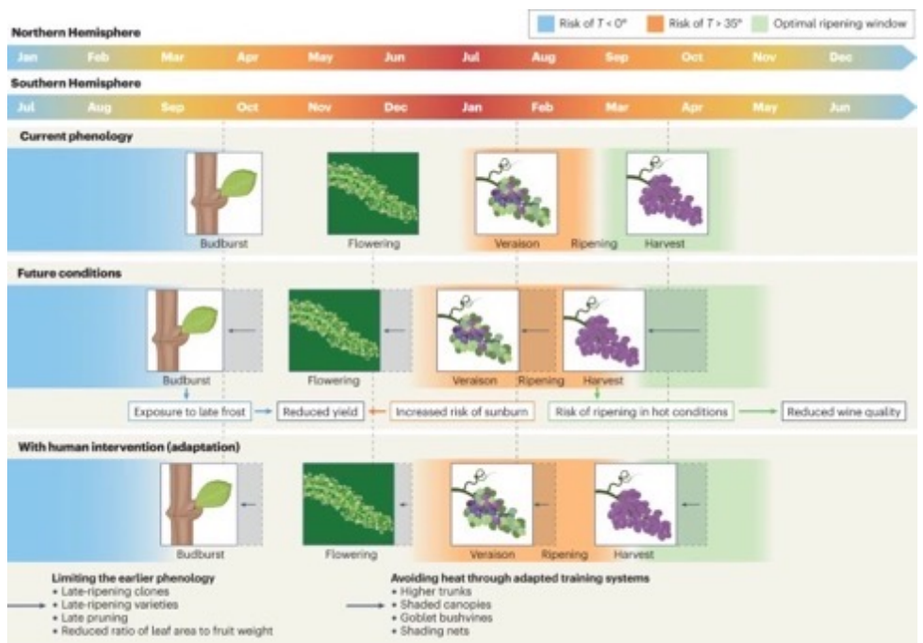
Wildfires

Heatwaves

Impacts of Climate Change on Grapes & Wine

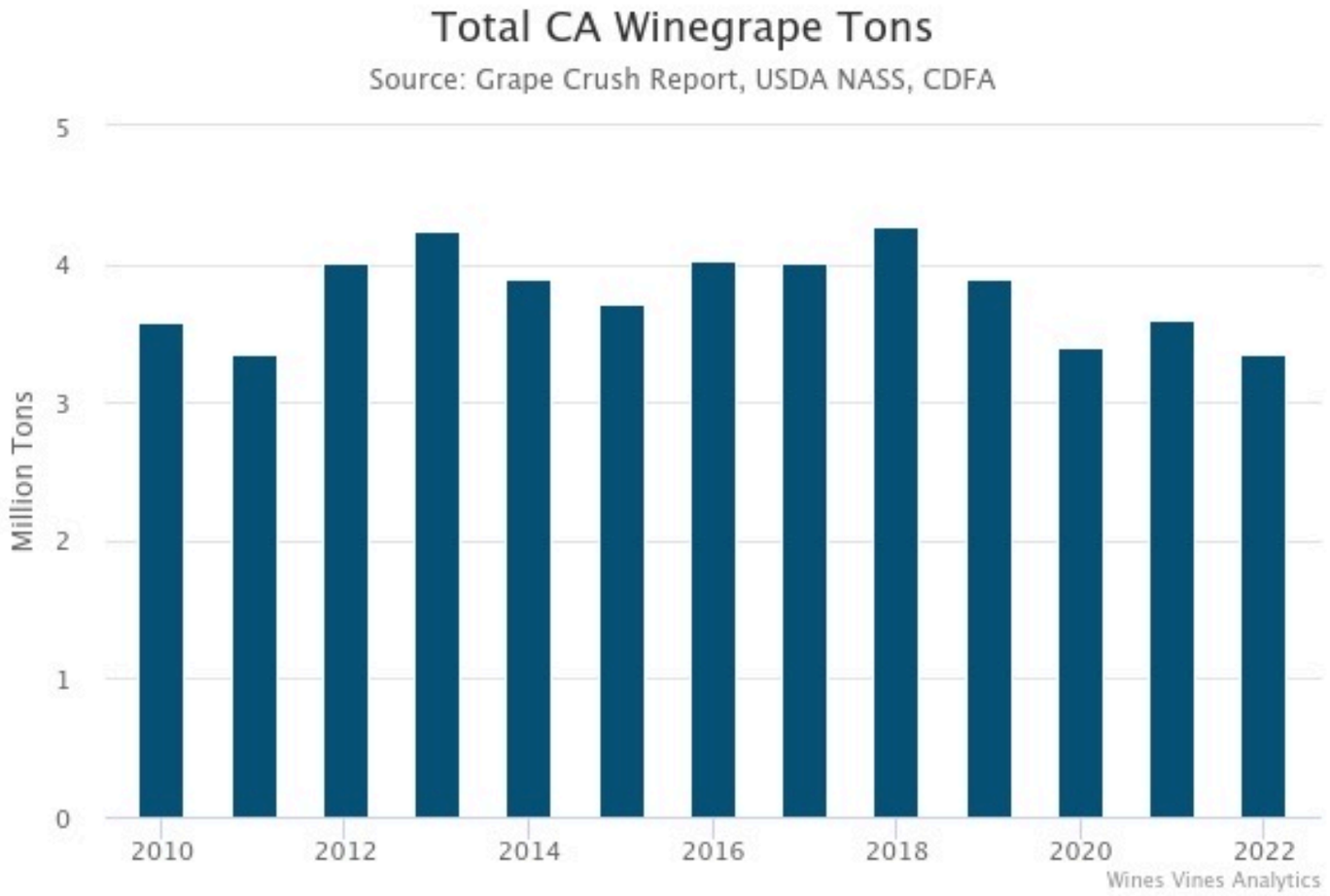


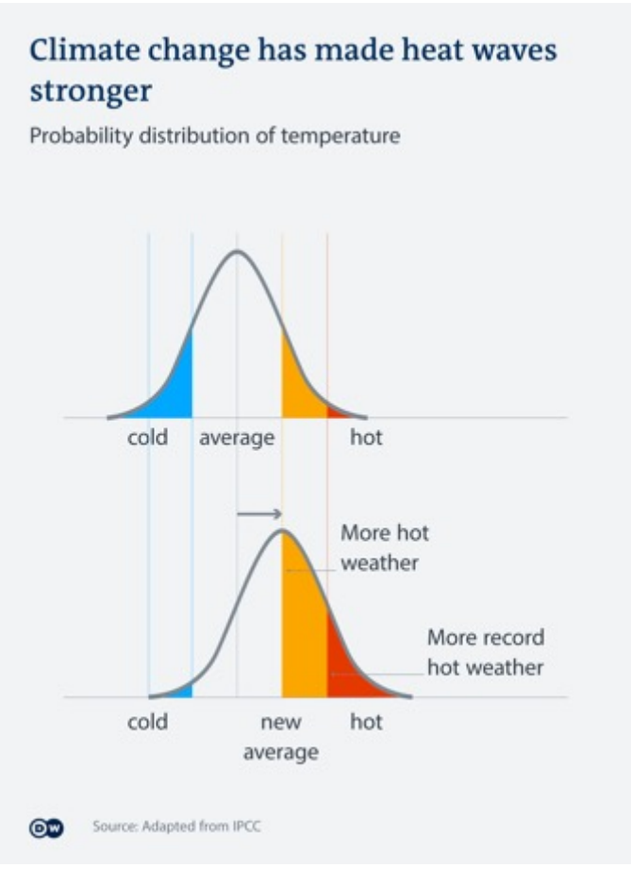
Majority of cultivar suitability Studies to date under future climate change look at mean temperature shifts & impacts on phenology/timing of ripening



Van Leeuwen et al. 2024

Attribution of Impacts Driven by Extreme Events





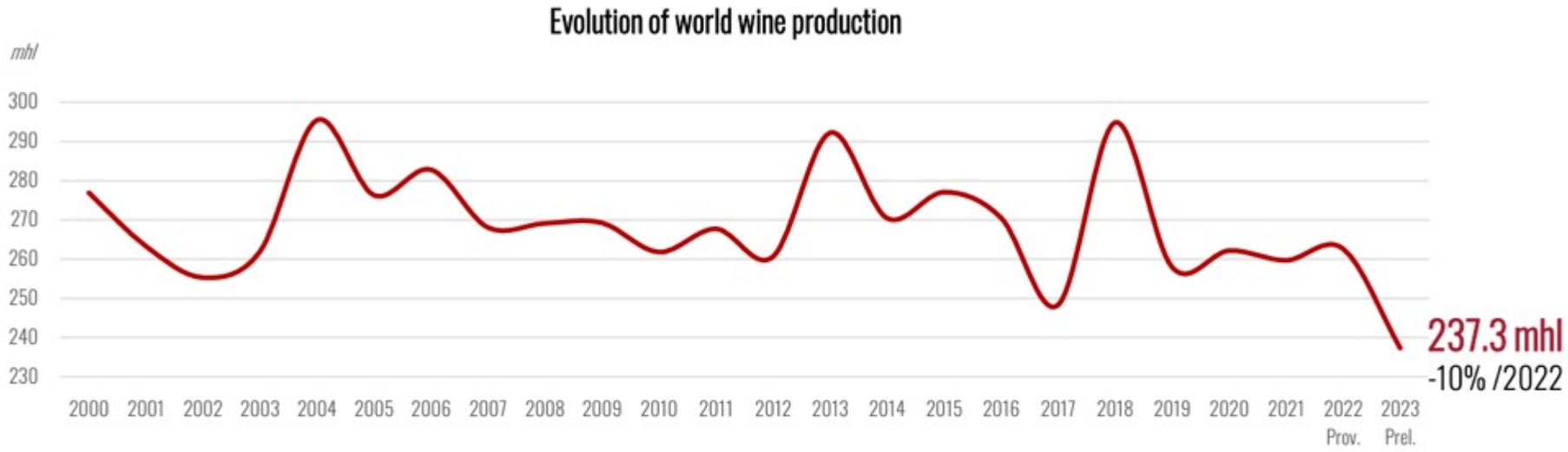
Cold Snaps/Spring Frost

Drought/Floods

Wildfires

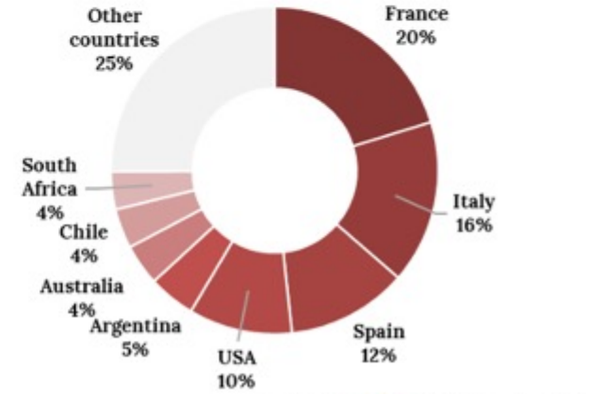
Heatwaves

Wine Production



Extreme climatic conditions and widespread fungal diseases severely impacted many vineyards worldwide, culminating in a **historically low global wine production of 237 million hectolitres.** This marked a **10% drop from 2022** and represented the **lowest output since 1961.**

Very low production volumes were recorded in both the **EU (145 mhl, -11%/2022)** and the **Southern Hemisphere (47 mhl, -15%/2022)**.



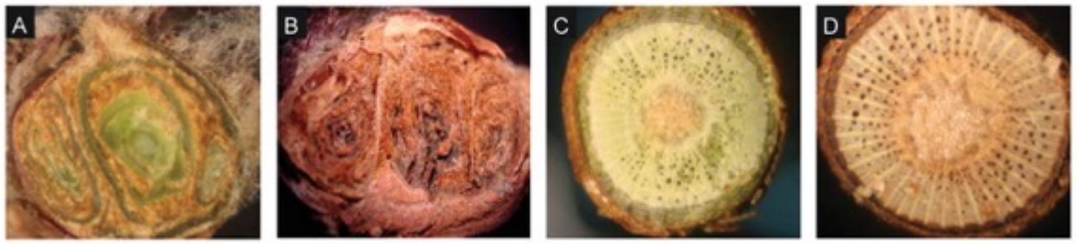
Cold Snaps/Spring Frost

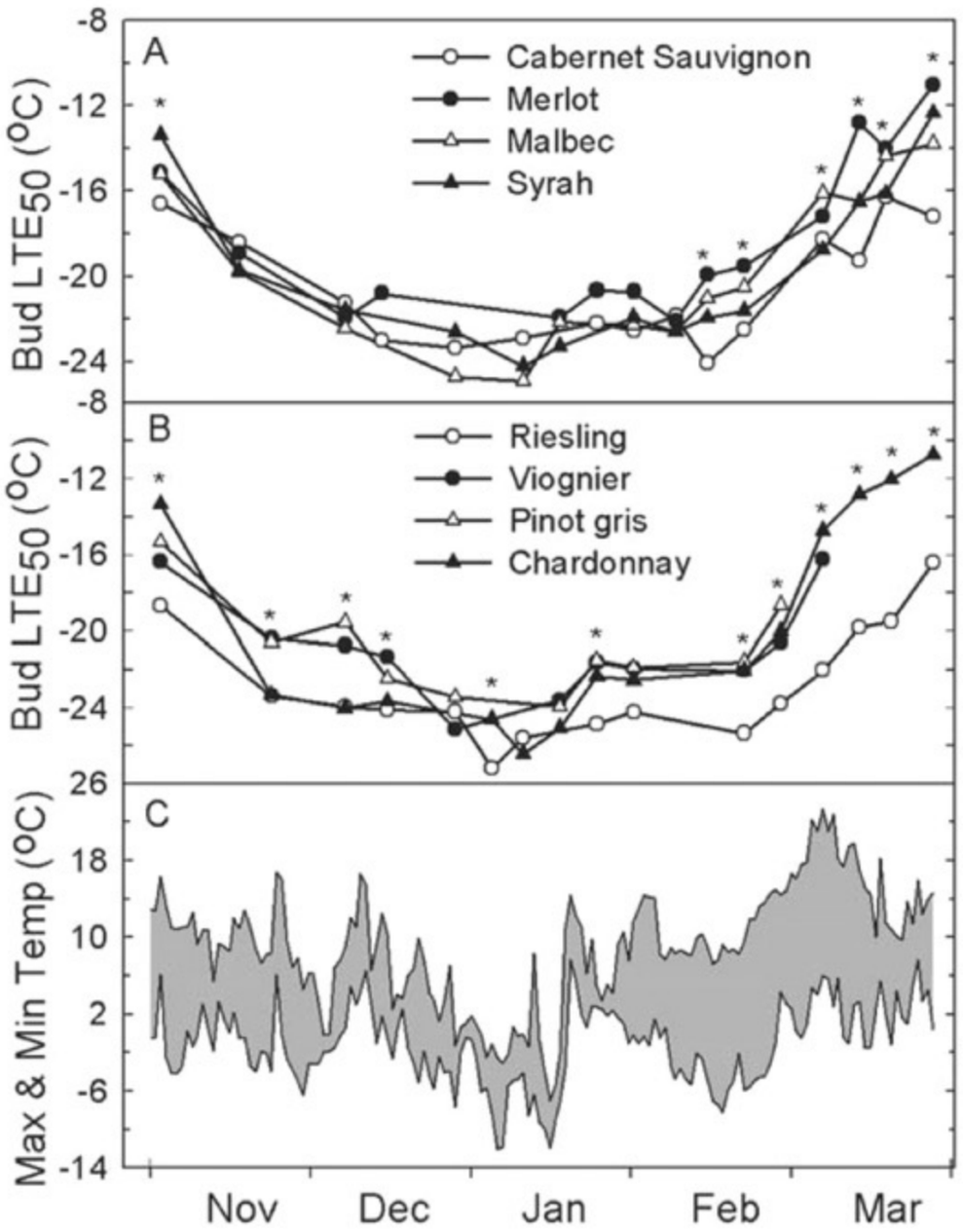
Drought/Floods

Wildfires

Heatwaves

Cold Snap & Frost Damage





Mills et al. 2005

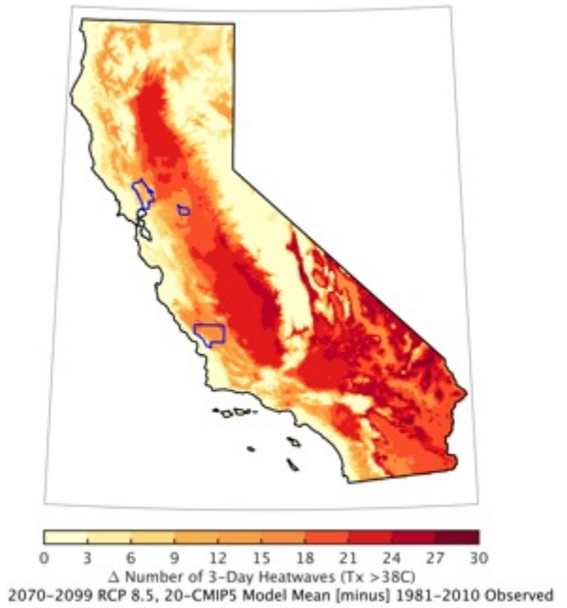
Vitis amurensis (-40 LTE50)

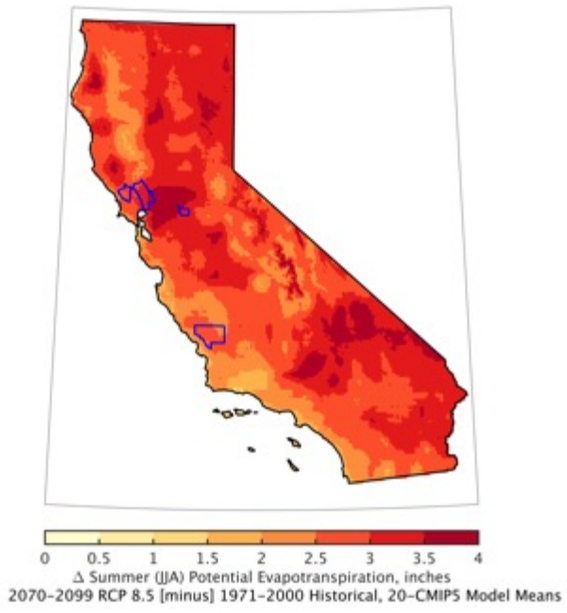
Decanter China

- Cold hardy hybrids
- Breeding - leveraging wild species
- Better phenological modeling of dormancy dynamics

Drought/Flooding Impacts

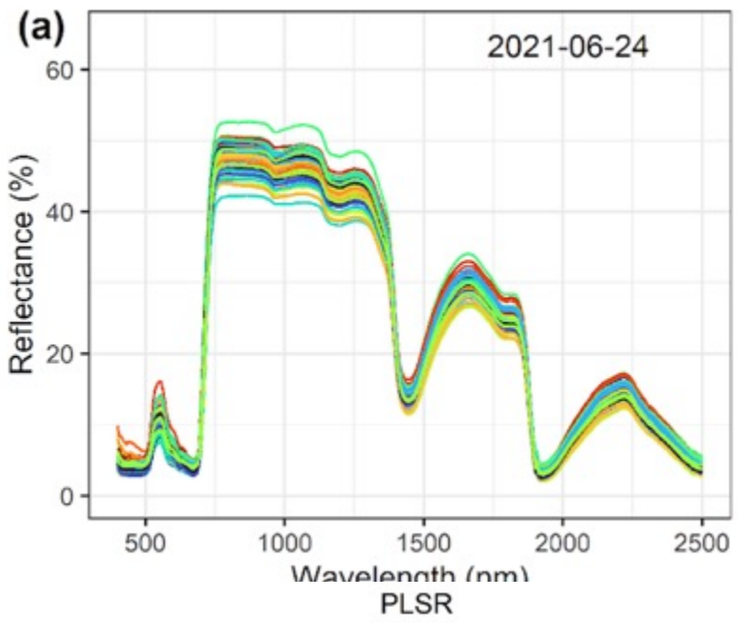
- Warmer temperatures, higher evaporative demand, drier soils
- More inconsistent and intense precipitation events

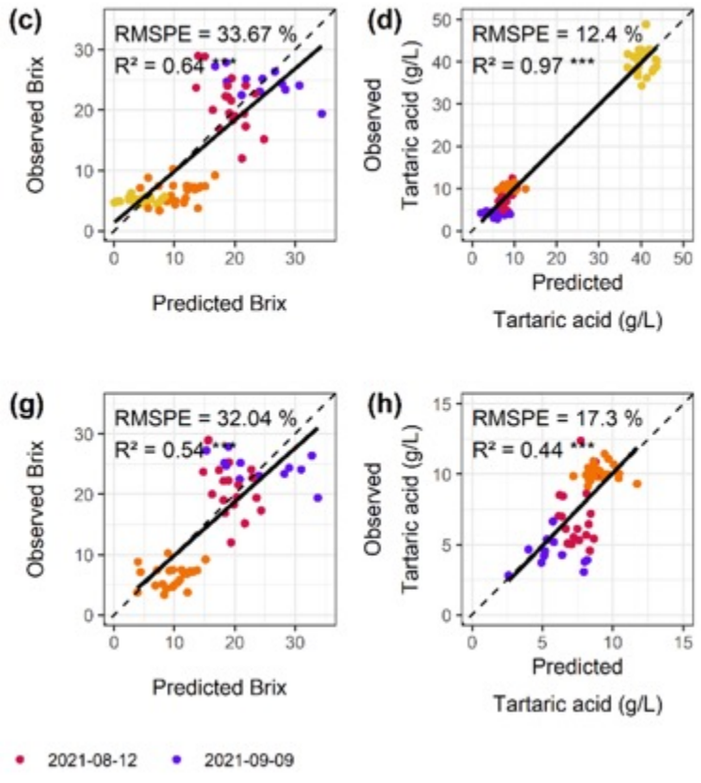




- Rootstock selection, breeding
- Canopy manipulation
- Regenerative practices: cover crops, improved infiltration, soil aggregate stability, and soil health — all can save water

Wildfire Smoke Impacts



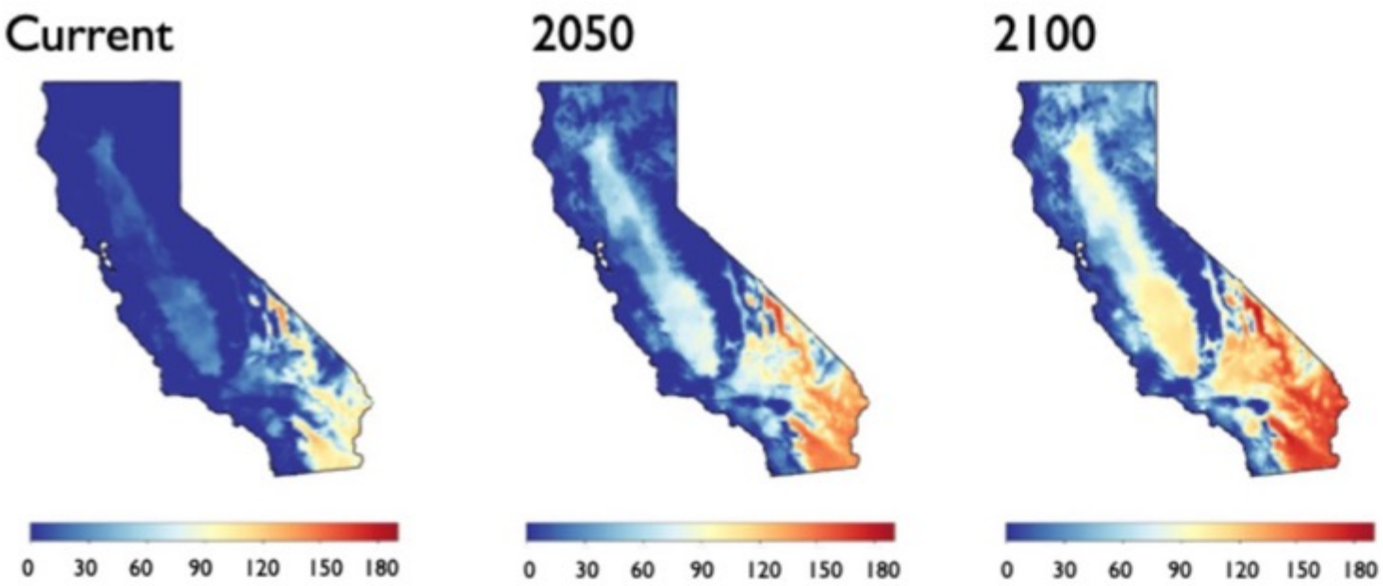


Wong, Magney & Forrestel in prep

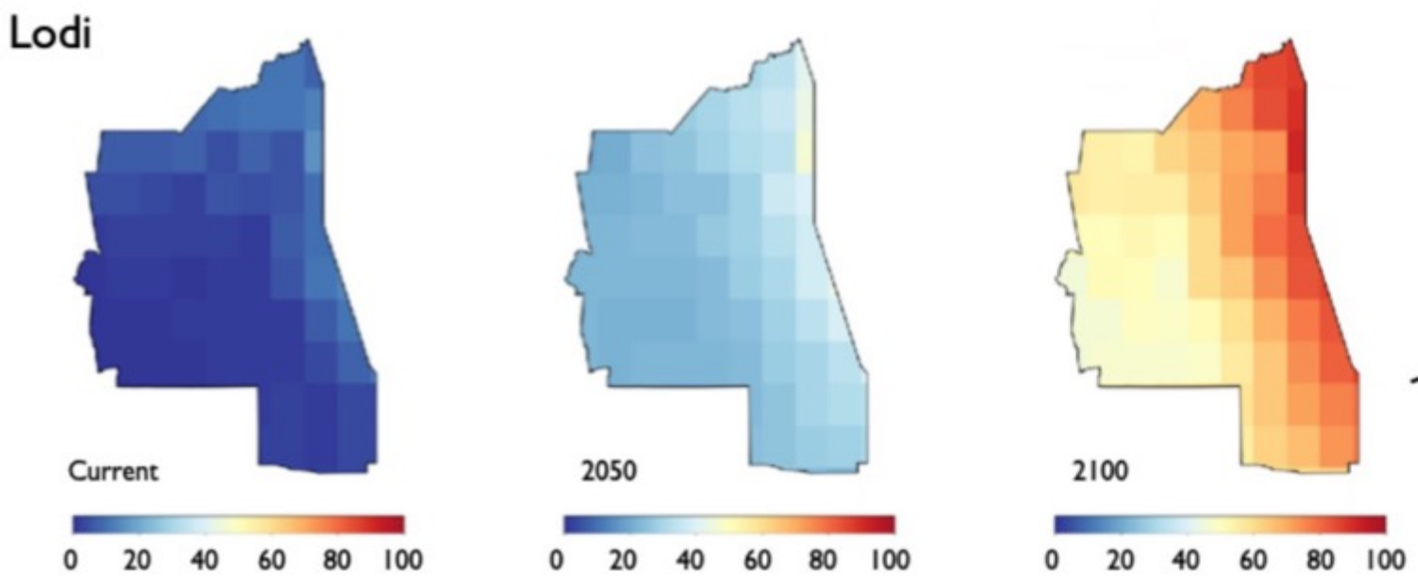
- Considering phenology & timing of harvest
- Sprays for smoke barriers
- Mitigation in winery
- Better predictions of smoke taint: how far from fires, wind movement
- Better assay for compounds associated with smoke taint
- When is it necessary to test fruit?

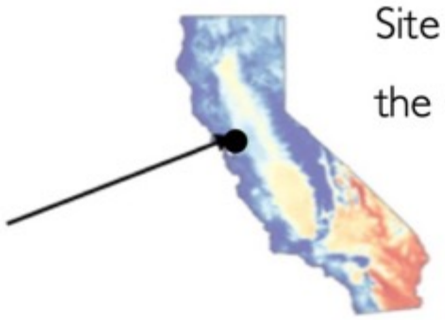
Specialty Crop Research Initiative, USDA: UC Davis, Oregon SU, Washington State U

Heatwave Impacts



- Three consecutive days > 38 Degree C
- Lots of unknows
  - How often?
- Impacts…
  - Vine physiology?
  - Berry and Wine Chemistry?
  - Sensory?



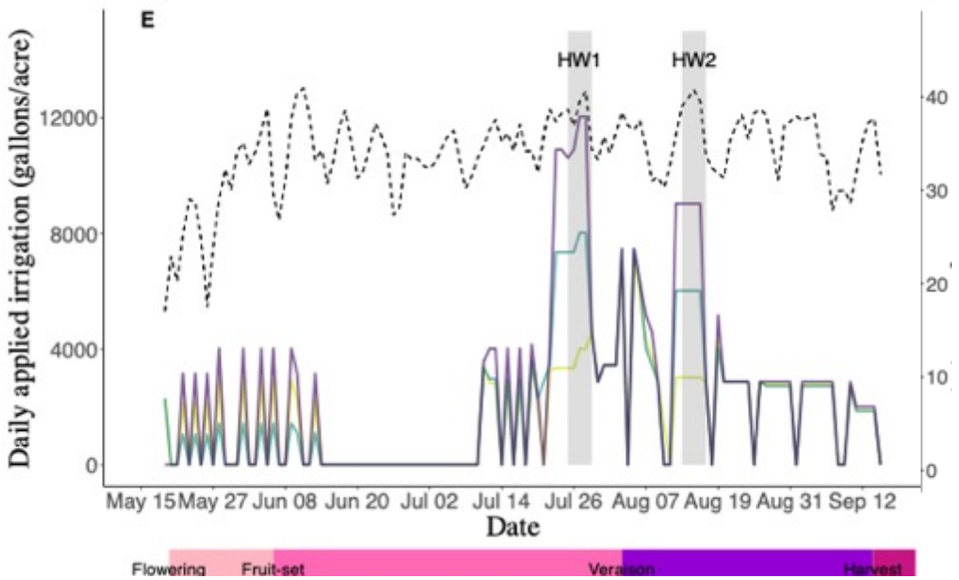


Site in **Lodi** in the San Joaquin County in the Central Valley of California

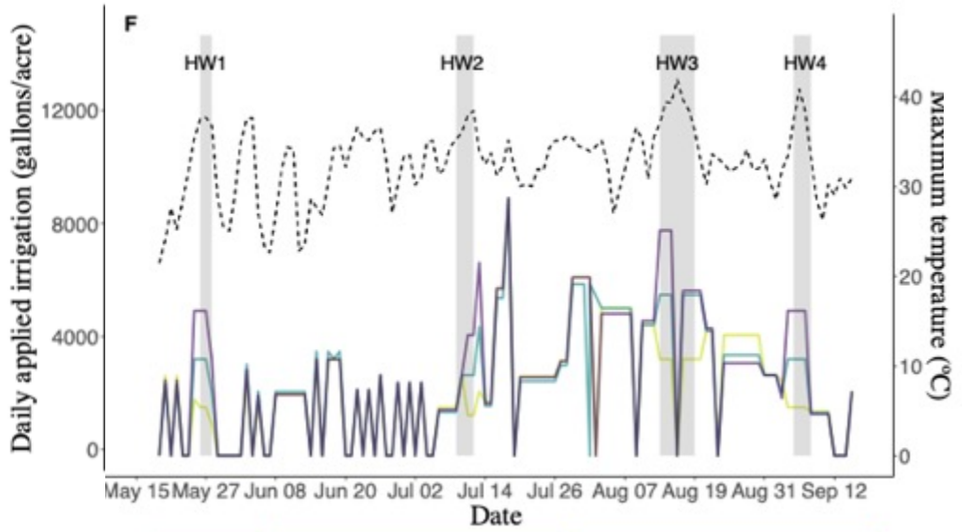
RCP 8.5, 6 square-km resolution

What is the impact of varying irrigation amounts prior to and during heatwaves on vines, berries & wine?

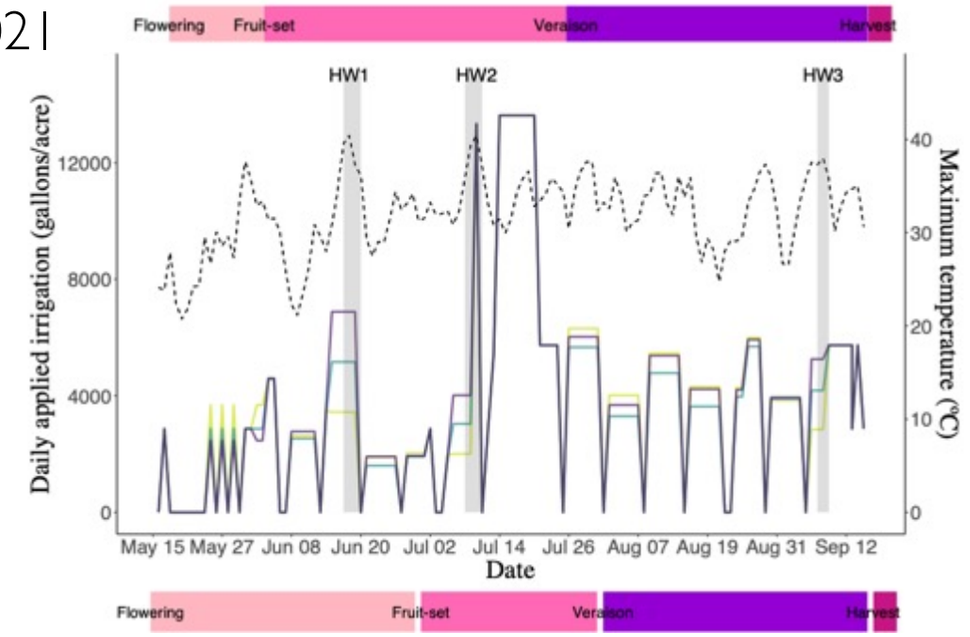
2019

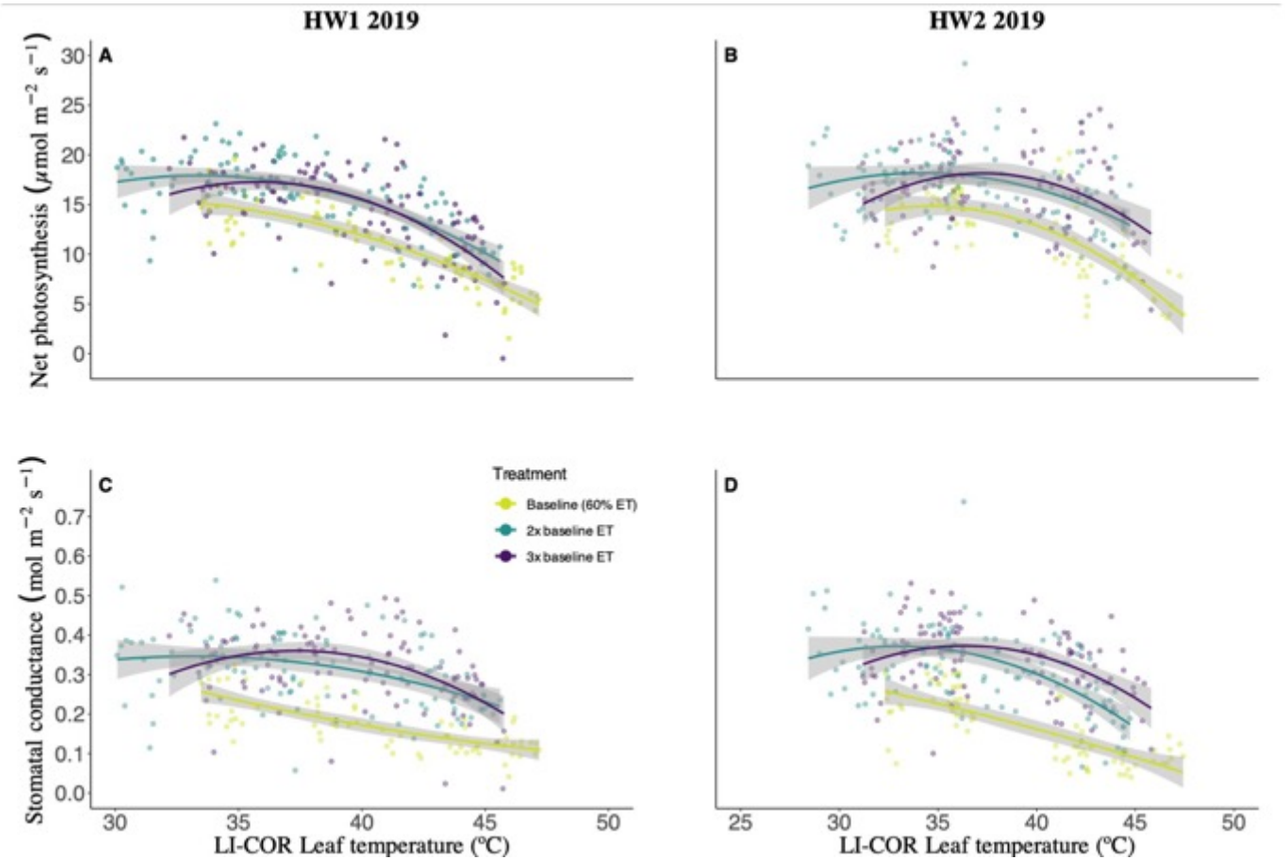


2020



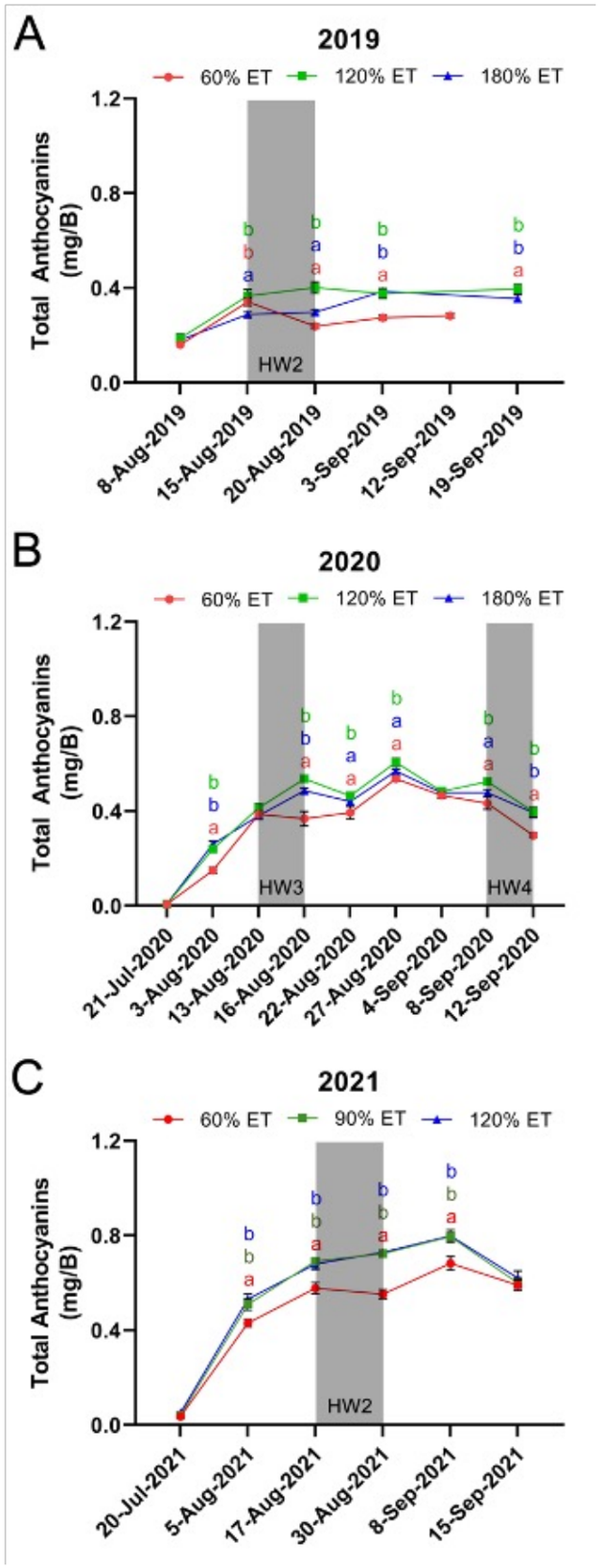
2021



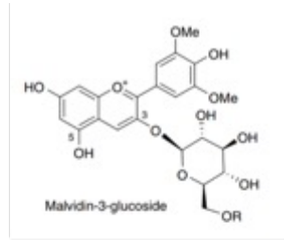


Galeano et al. in prep

Berry Phenolics: Total Anthocyanins



- Consistent and persistent differences between treatments in anthocyanin content (lowest in baseline).

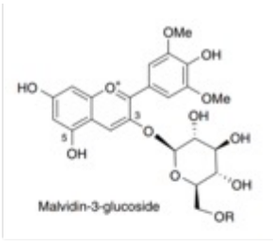


- Inconsistent differences in flavonols (impact of exposure?)
- Transient reductions in tannin

Campbell et al.; Galeano et al. in prep

Irrigation Practices to Mitigate Heatwave Impacts

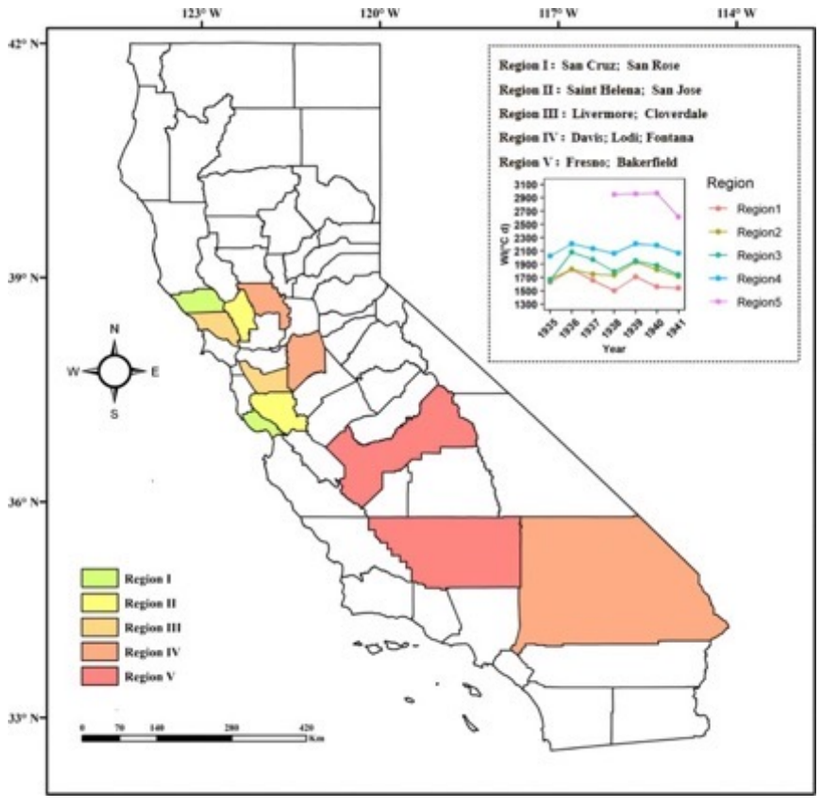
- **Supplemental irrigation (with restraint) prior to and during heatwaves helps mitigate heatwave impacts via:**
  - Cooler canopies and berry temperatures
  - Reduced vine water stress
  - Increased synthesis/reduced degradation of anthocyanin above certain temperatures (35/38 C)
  - Higher astringency and more desirable aroma profiles in wine



Heatwave Mitigation Techniques

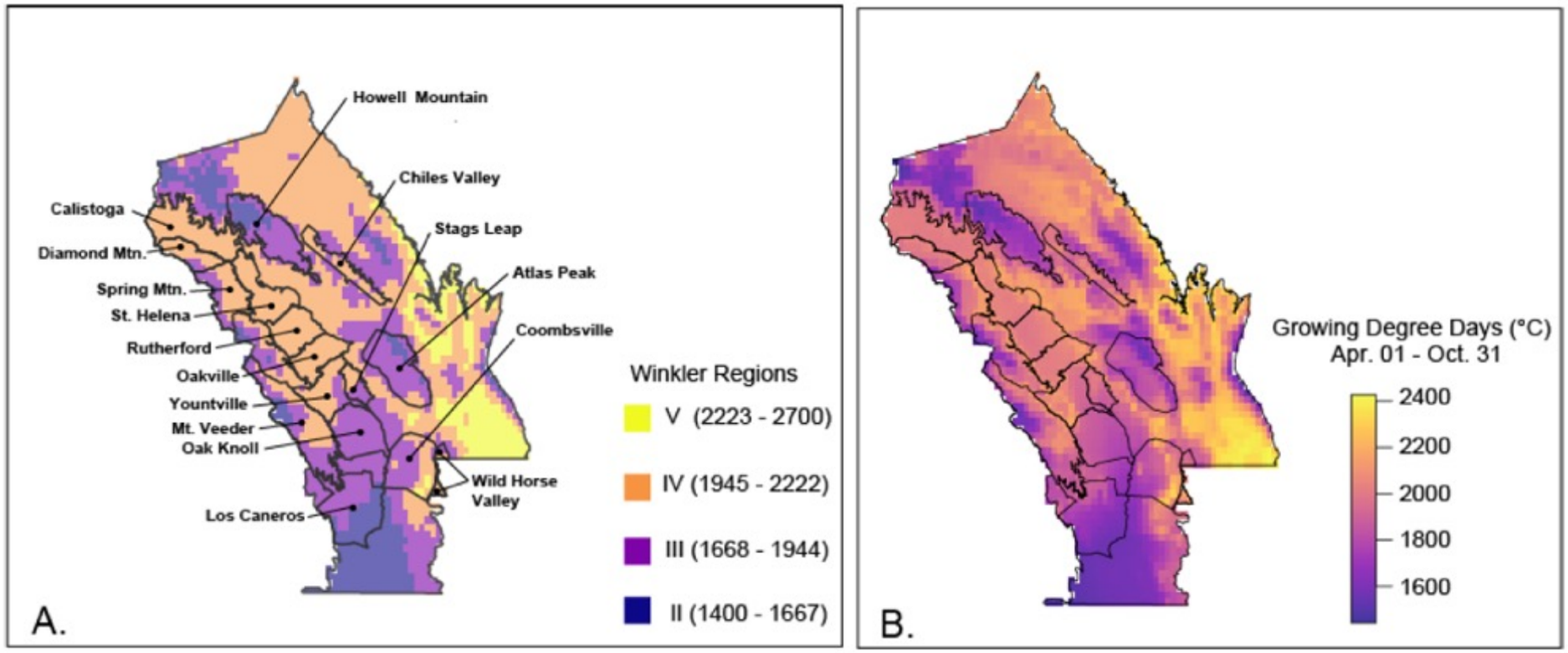
- Irrigation Management
- Misters & sprinklers
- Shade cloth
- Shifting row orientation, vine height & training (providing shade)
- Vineyard floor management — cover crop choice & management, maintaining cover throughout season, short & longterm impacts
- Considering phenology & timing of harvest
- Cultivar choice

Winkler Study: Developing New Indices for Cultivar Suitability



Napa was initially classified as Winkler Region II and ideal for Cabernet Sauvignon (1936-1960); current climate normals have Napa spanning regions II - V

Bai et al. 2022



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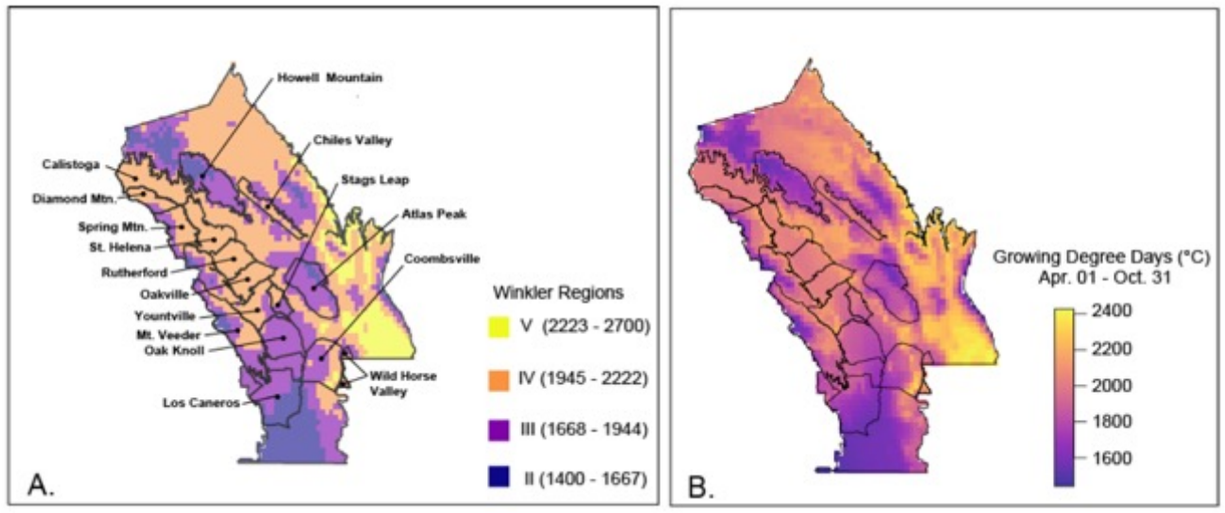
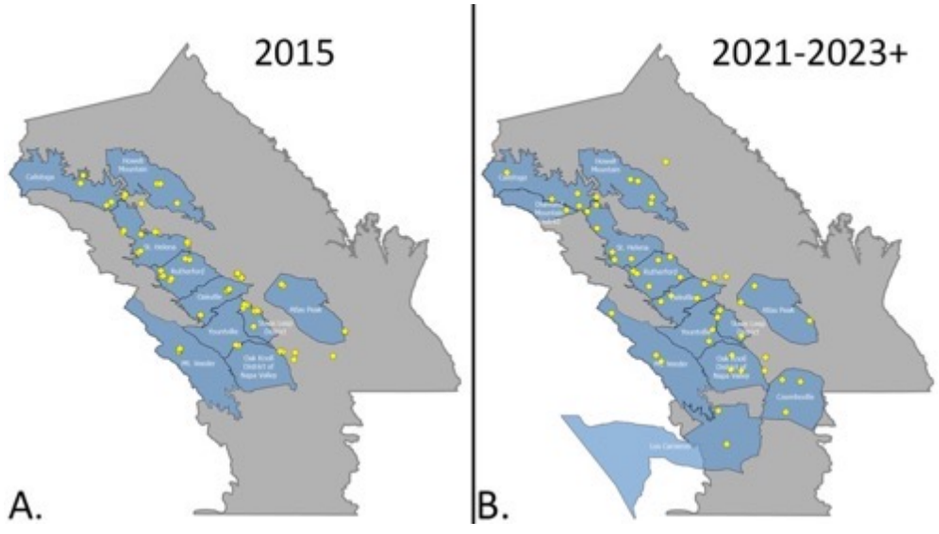
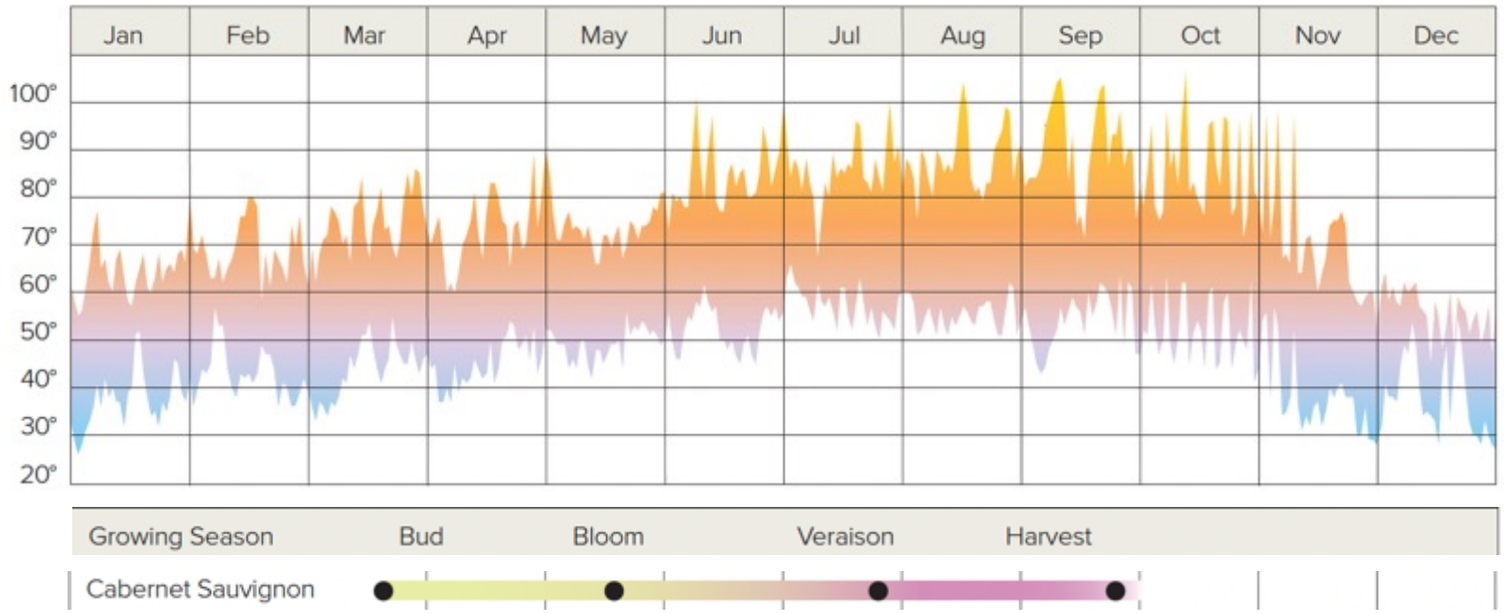
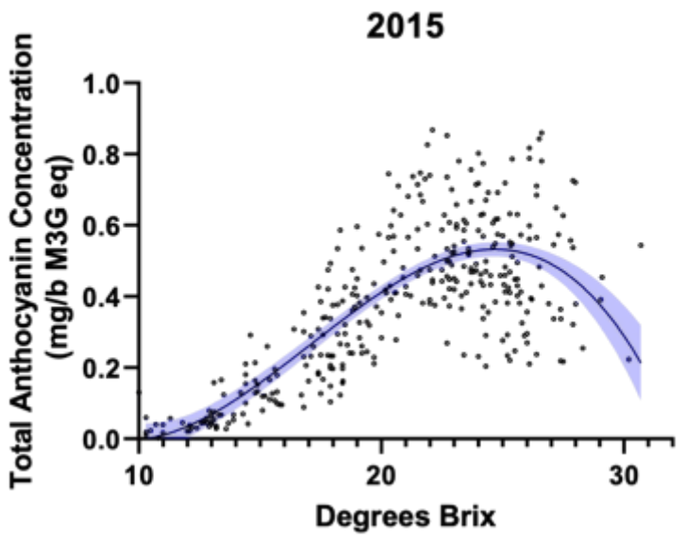




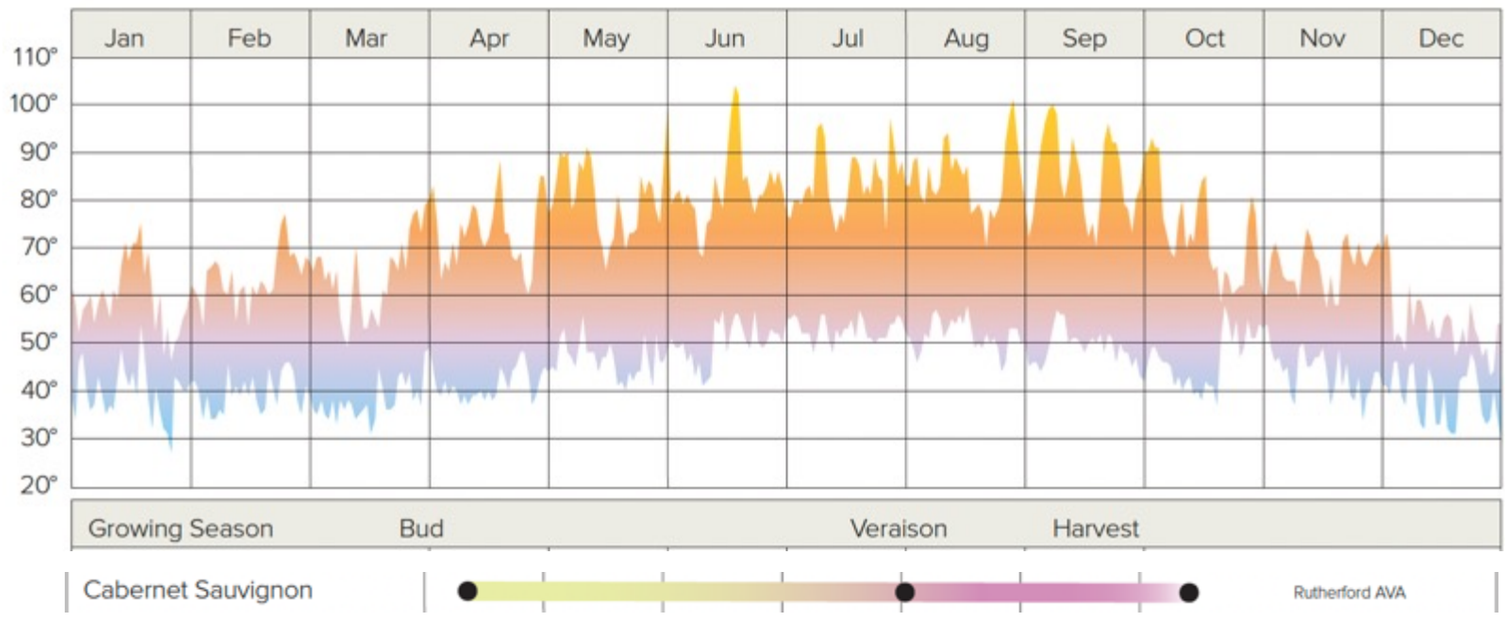
- 60 blocks across Napa covering all AVAs; 24 participating wineries/growers
- Historical on-site phenological, irrigation and weather data
- Longitudinal study of climate and environmental impacts on berry chemistry; primary chemistry
- In conjunction with 2015 dataset, sampled in 2021 - 2023, initially Cabernet Sauvignon, adding other cultivars this year

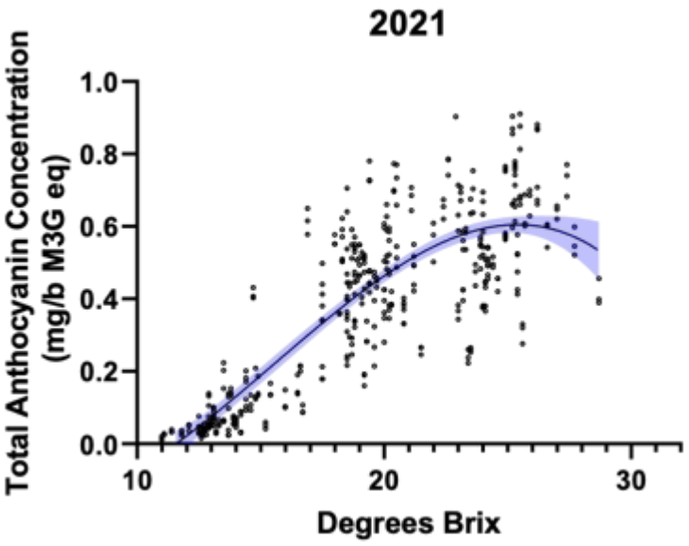
2015



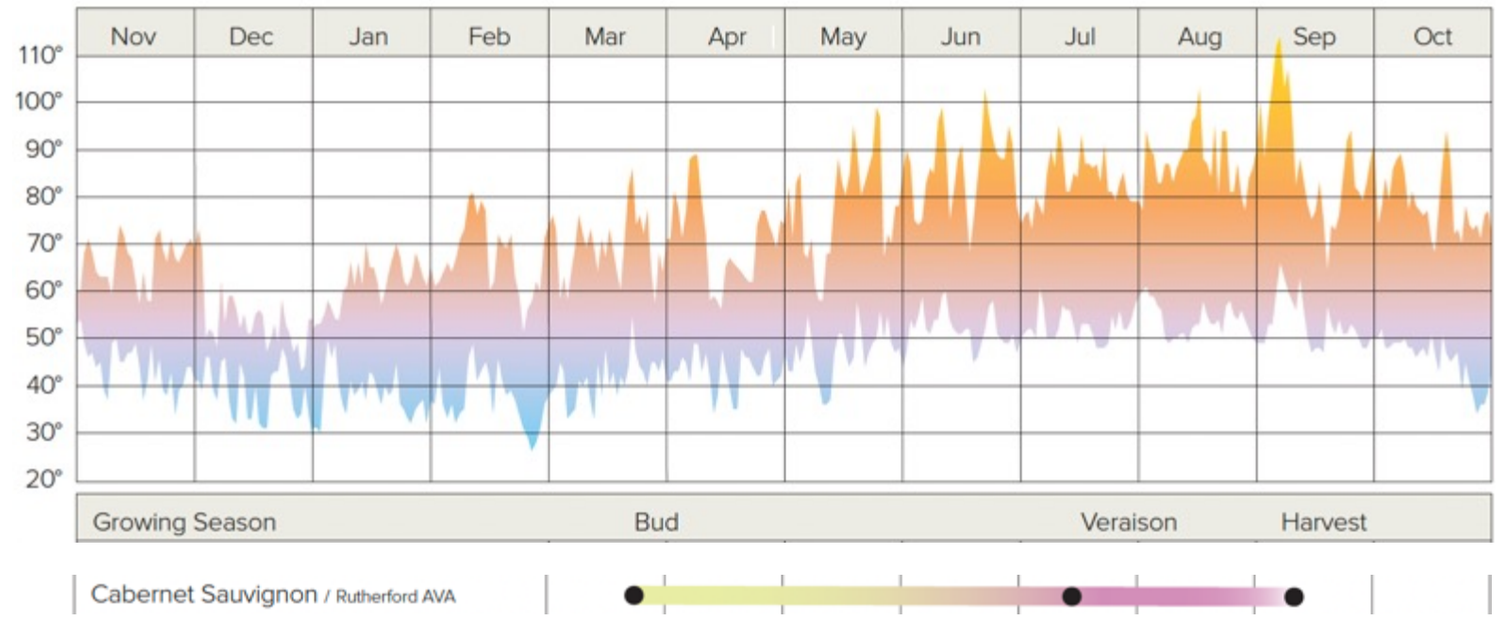


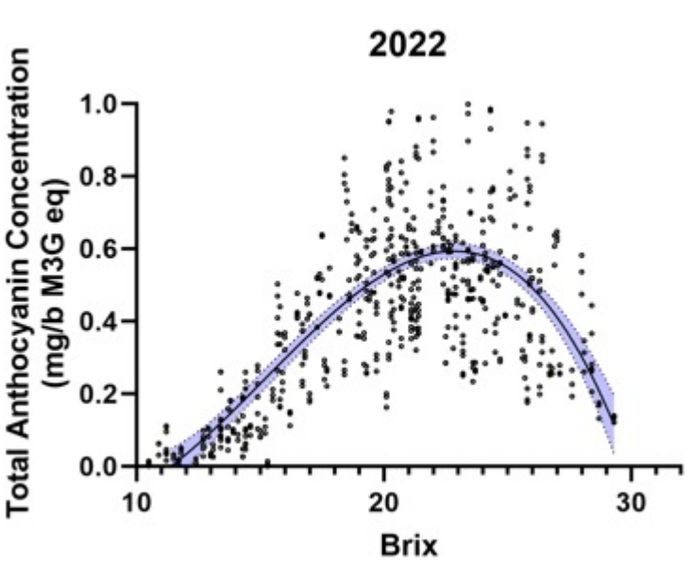
2021





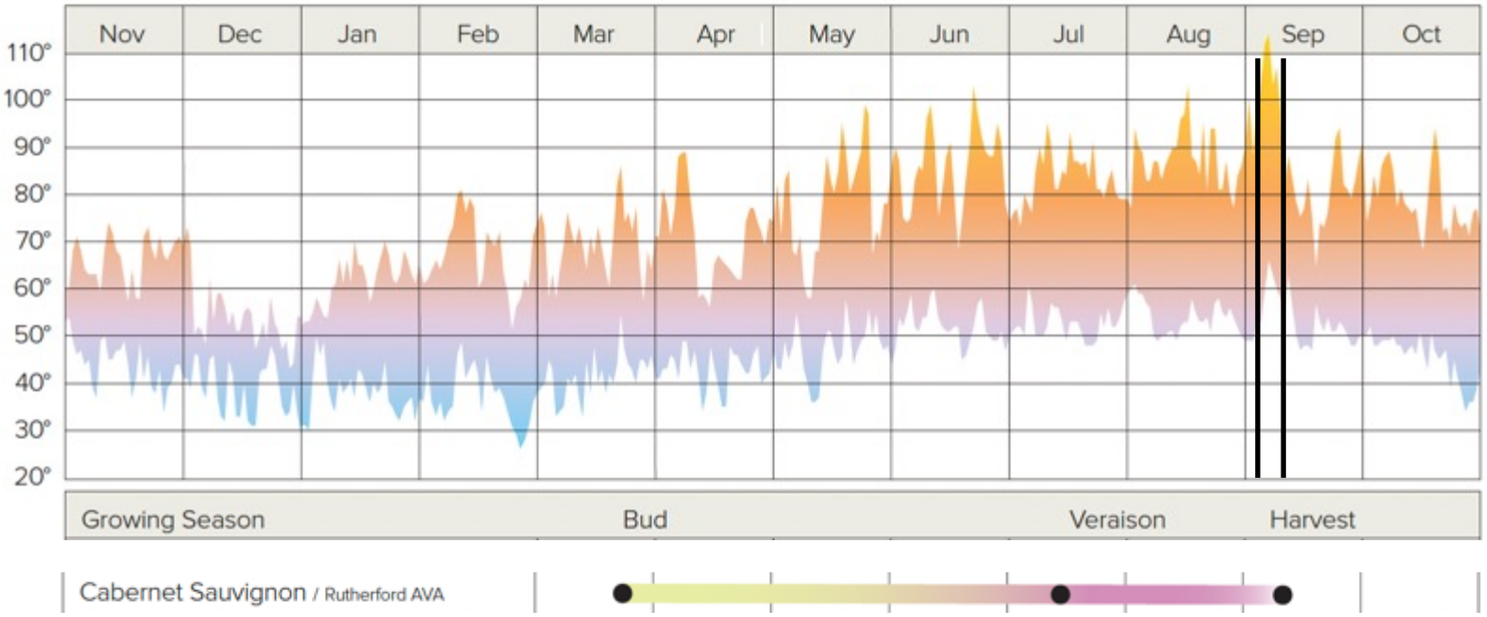
2022

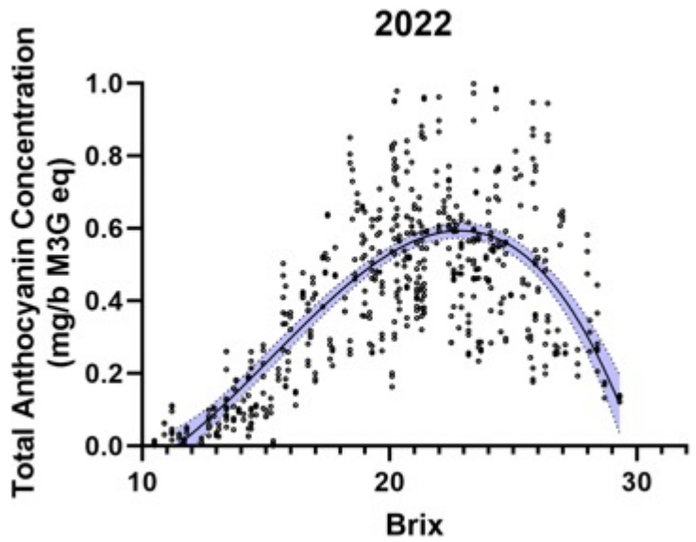




napa valley vintners

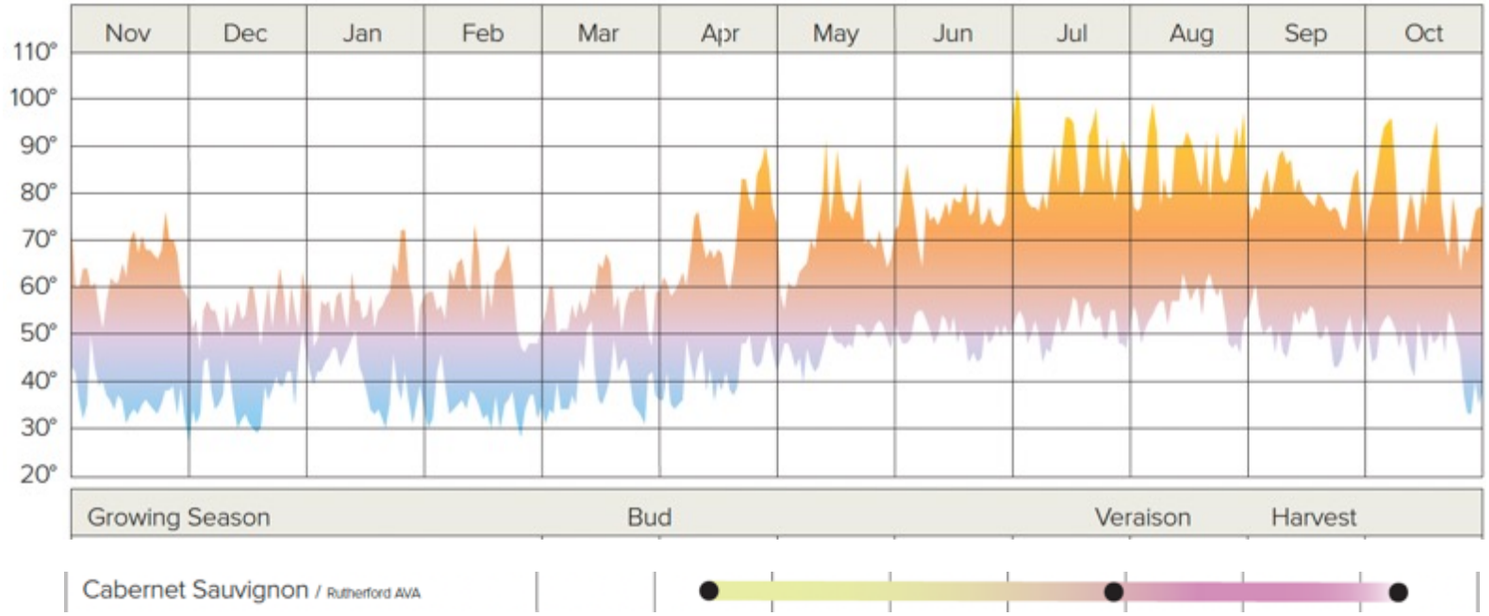
2022





Seasonal Tmax = 115°
F

2023

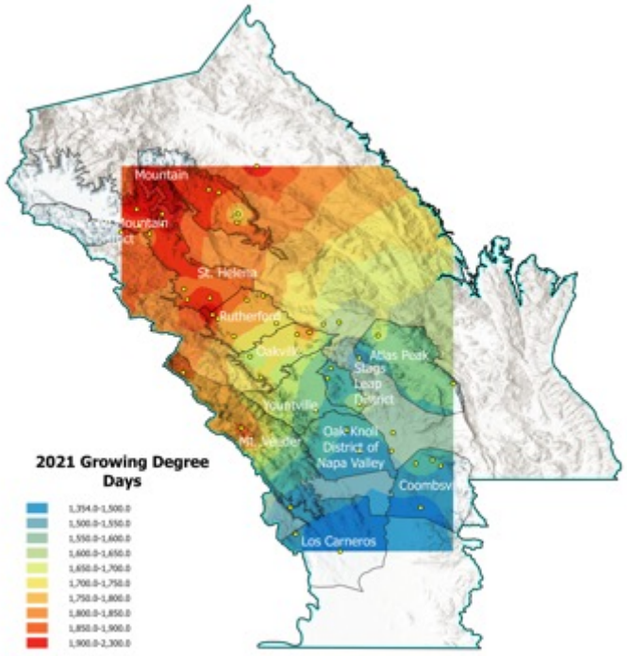


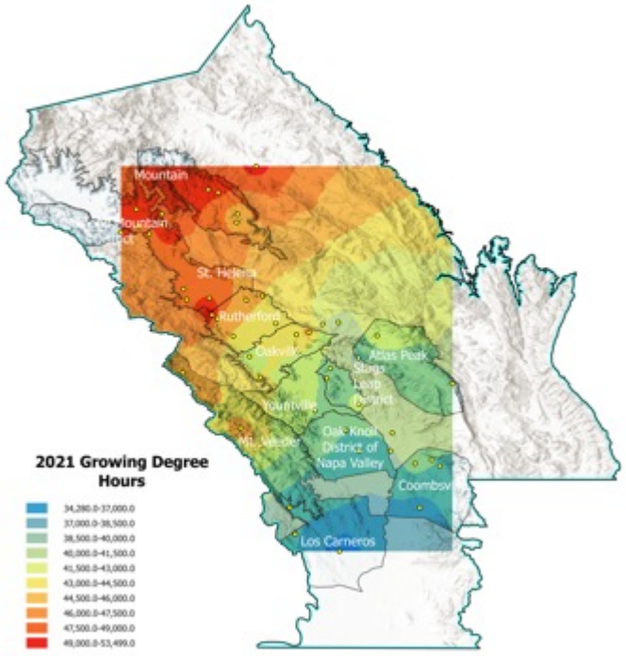
Seasonal Tmax = 96° F

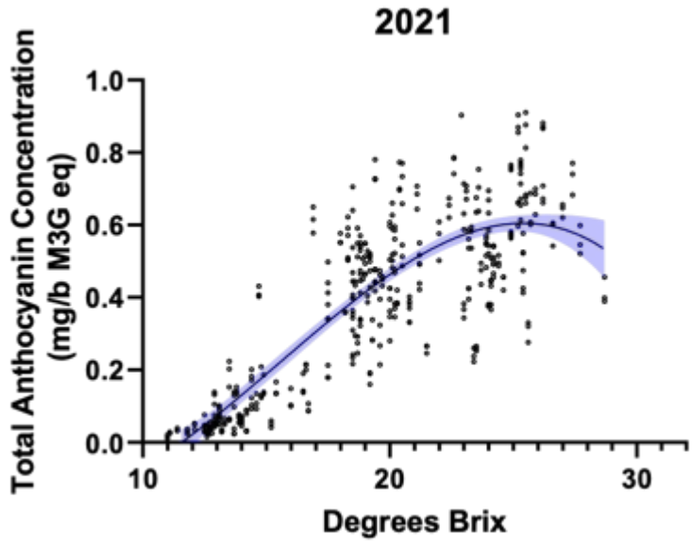
napa valley vintners

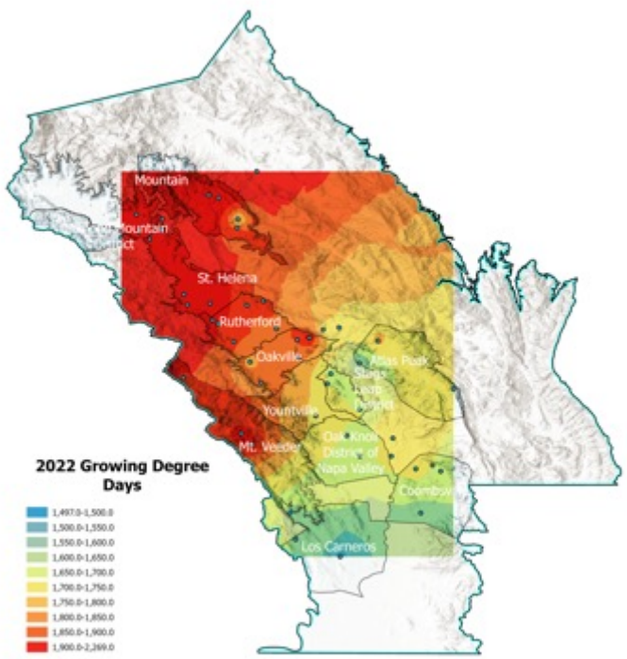
Winemaking in Changing Climates: How do we manage to extremes?

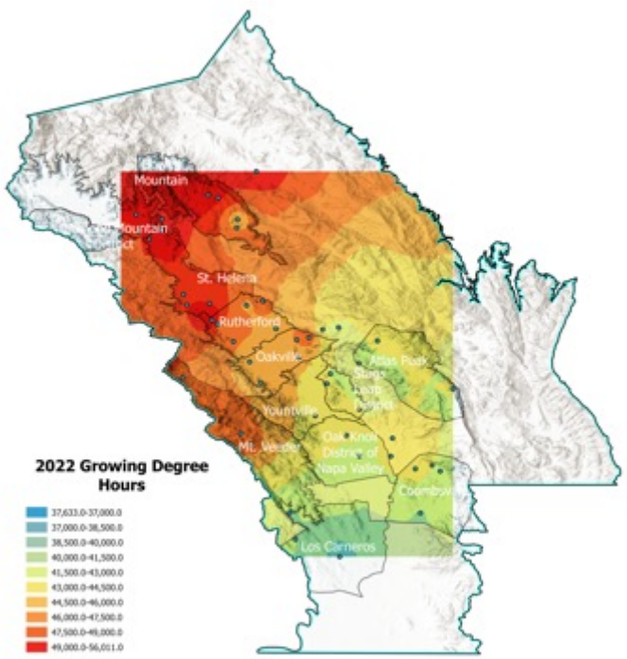
Heat Accumulation Indices: Growing Degree Days & Hours

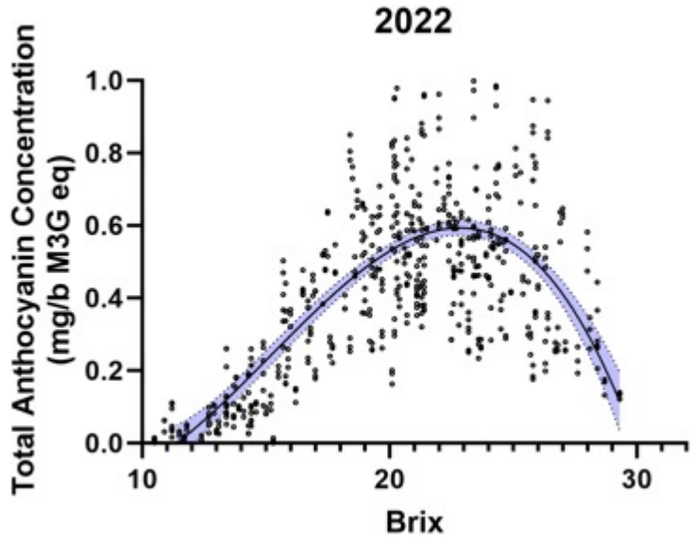






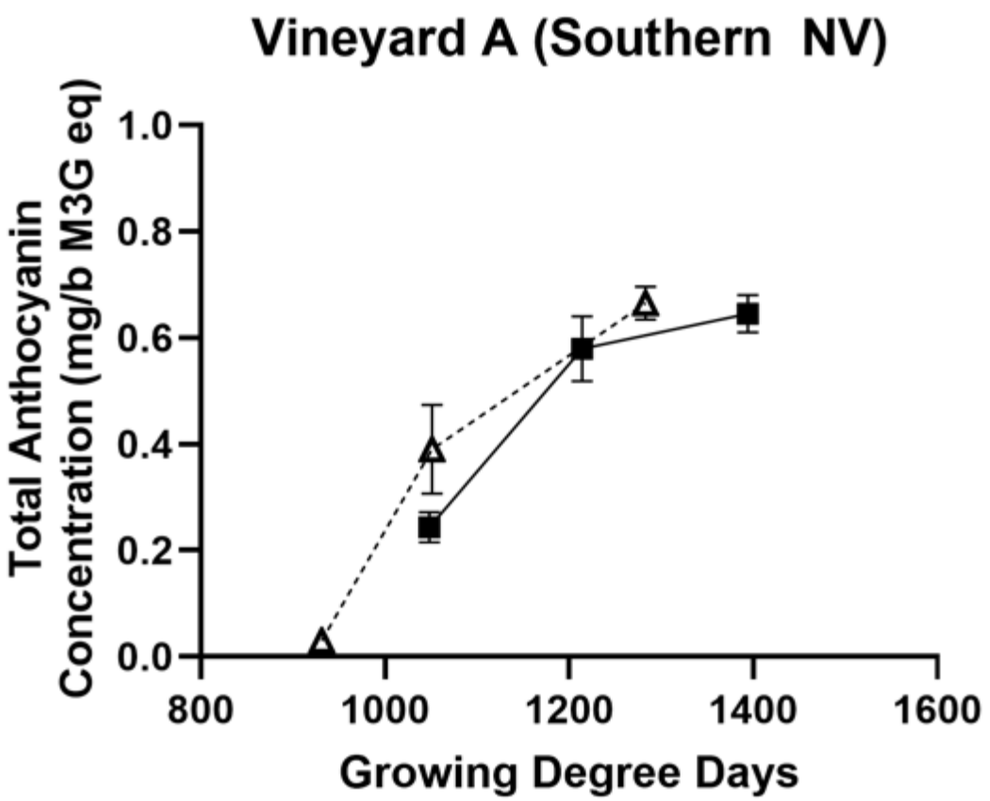


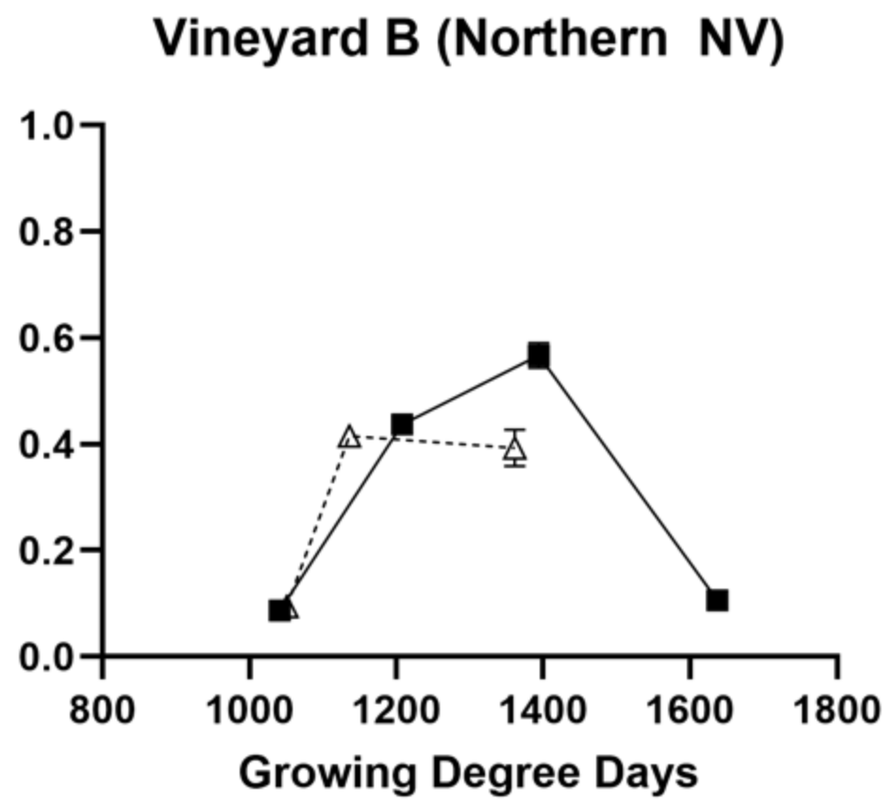


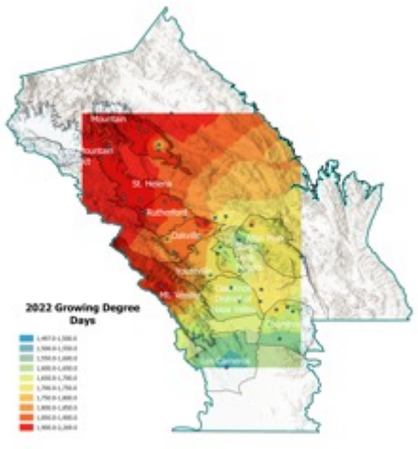


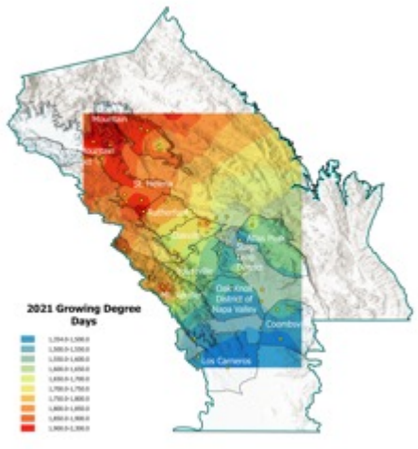
Campbell, Libbey, Forrestel

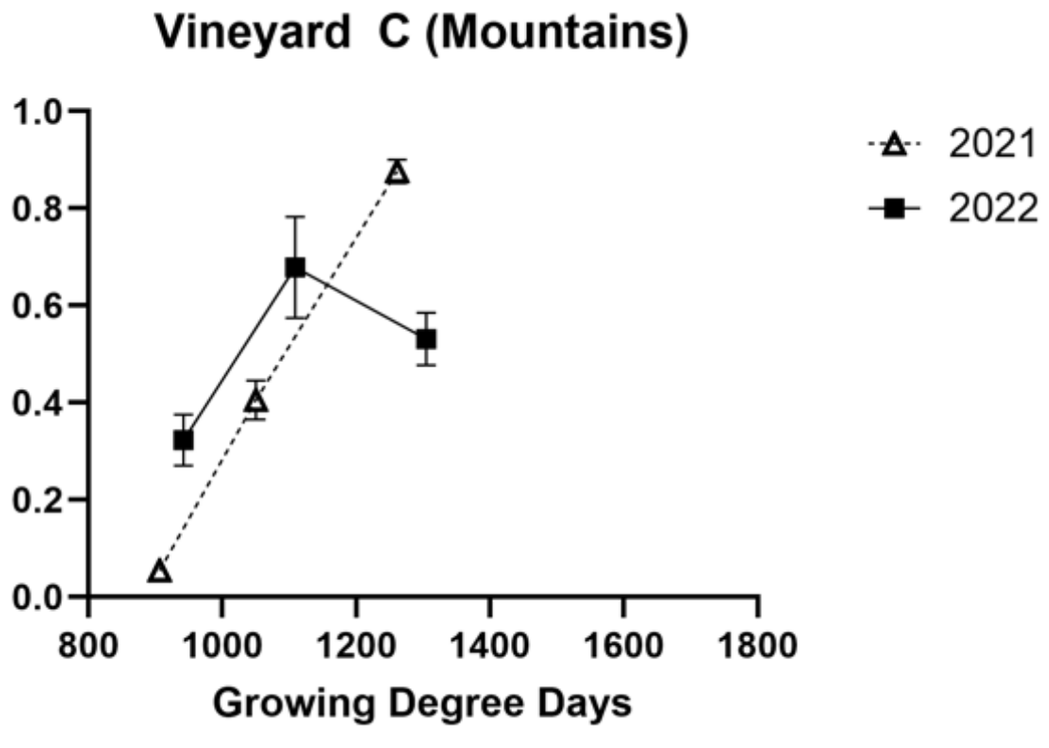
Heat Accumulation Indices: Growing Degree Days & Hours





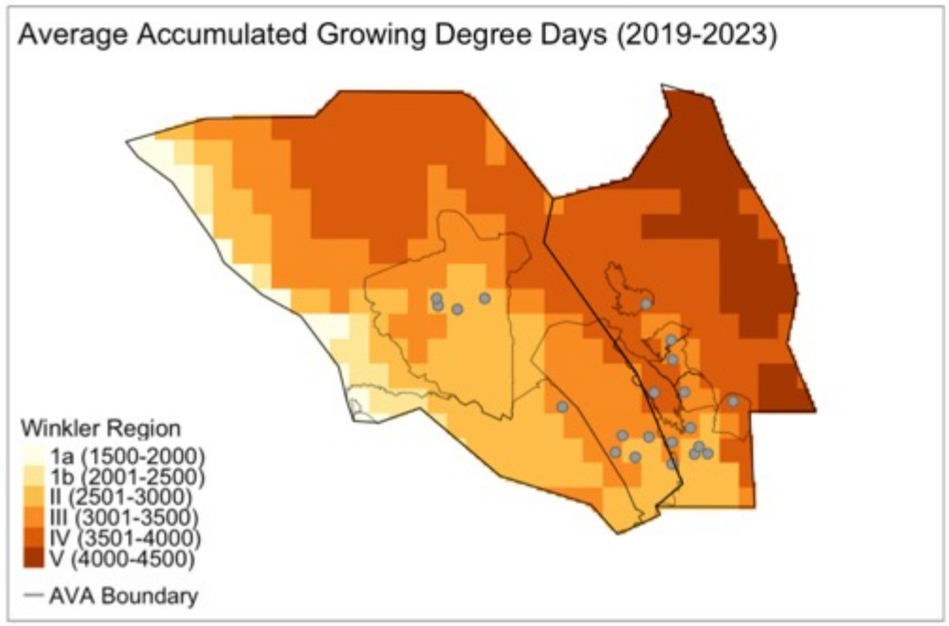


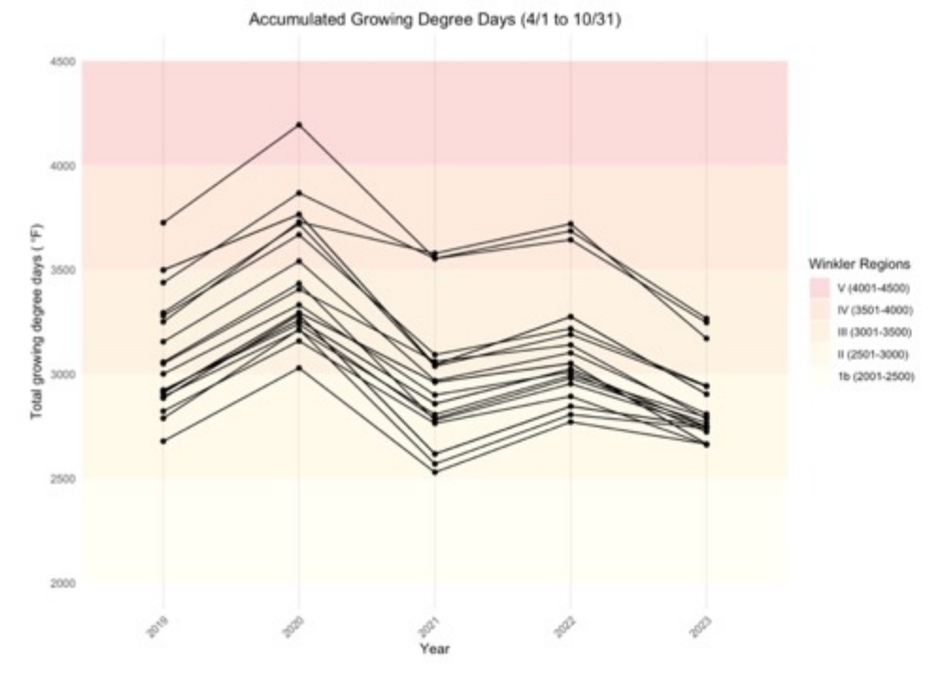




Campbell, Libbey, Forrestel

White Cultivar Suitability & Berry Composition





Understanding the Climatic Drivers of Chardonnay Berry Composition

A survey of the variation in ripening and berry chemistry of Chardonnay grown in Napa and Sonoma across a climatic gradient.

White Cultivar Quality Variables

- Brix / TA / pH
- Malic Acid
- Aromatic precursors (glycosides)
- $\delta^{13}C$ (water status proxy)

Kait Libbey, Horticulture and Agronomy Master's student

Acknowledgments

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Lauren Parker (U.C. Davis)
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Amanda Rodriguez
Fallon Ely
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Cultivar Choice: Potential Traits to Select For Resilience

- Phenology
- Water use efficiency; drought tolerance
- Berry chemistry and/or extractability under future climate
- Responses to extreme heat; heat tolerance
- Susceptibility & sensitivity to smoke exposure
- Consider shifts in stylistic choices & impacts of vineyard pra

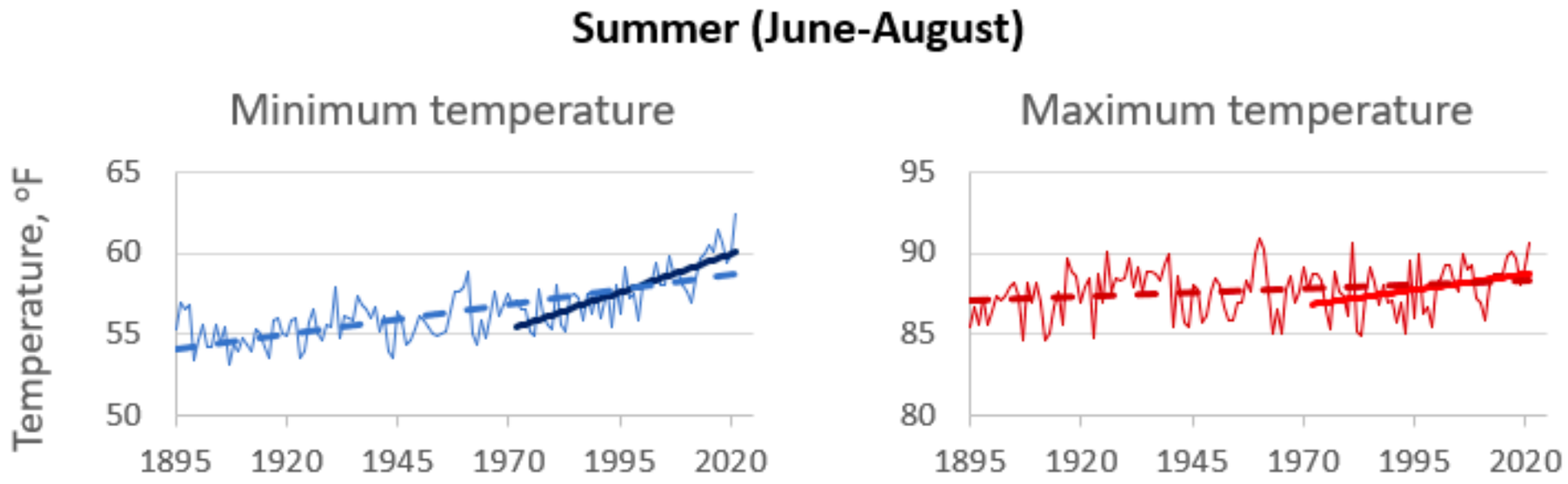
Spring Frost

Drought

Wildfires

Heatwaves

Trends in Extreme Temperatures in California



Report 2022: Indicators of Climate Change in California

Summary of Irrigation & Heatwave Impacts 20192020

- Consistent impacts on vine physiology (water potentials, lower conductance, decreased assimilation), but with recovery post-heatwave
- Lower yield impacts at baseline irrigation in 2019 & 2020
- Decrease in anthocyanin content in baseline irrigation in 2019 & 2020
- Decreased in tannin content in 2019 through to harvest for under and over-watering; reduced in 2020, but transient
- Decrease in flavonols in 2019 in baseline, but transient decrease in 2020
- Changes in wine chemistry and sensory perception

Watering prior to heatwaves has a positive impact on vine physiology, berry chemistry and resulting wine; BUT adding excessive water prior to and during heatwave events can have a lasting negative impact on berry chemistry and wine.