Vineyard Plasticity in Changing Conditions

Can we adapt?

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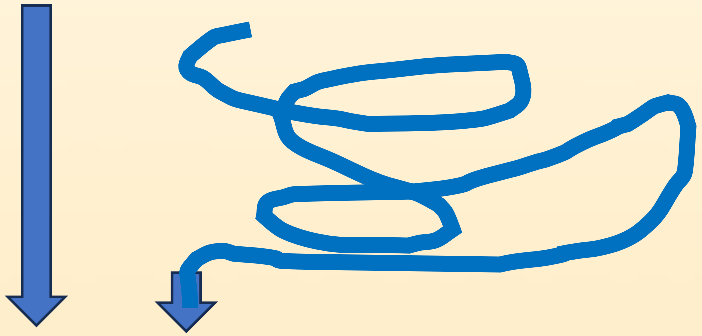
Climate Impacts

- Must consider both **direct** and **indirect** impacts of changing climates

  1. Change in growing season length
  2. Earlier or later budbreak and ripening
  3. Resource scarcity (i.e., water/fertilizer)
  4. Increased soil salinity
  5. More extreme weather events

Climate Change



Impacts


66.6
°F/°C

Extreme Heat

Extreme temperatures

⇩

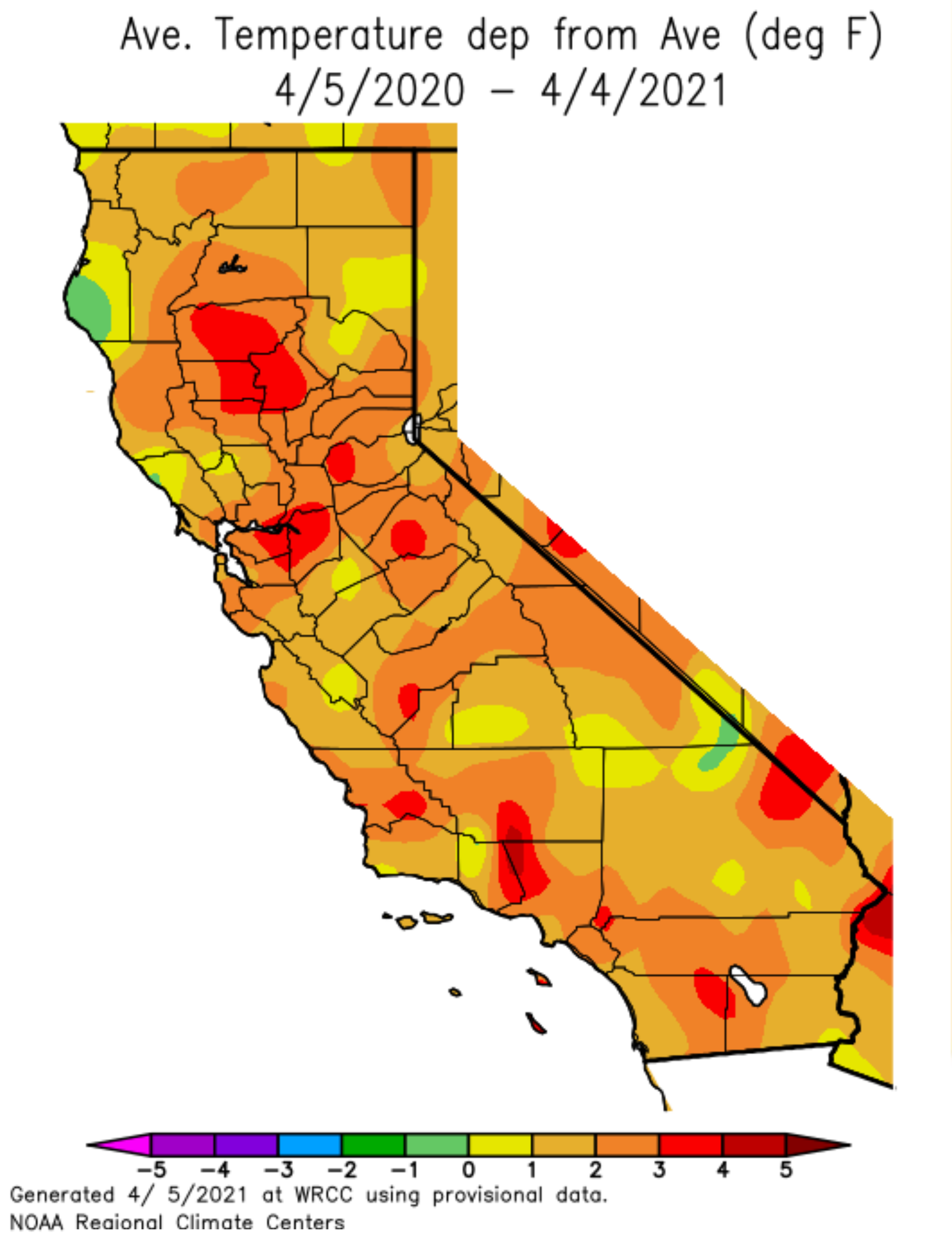
High evapotranspiration

⇩

Greater water demand

⇩

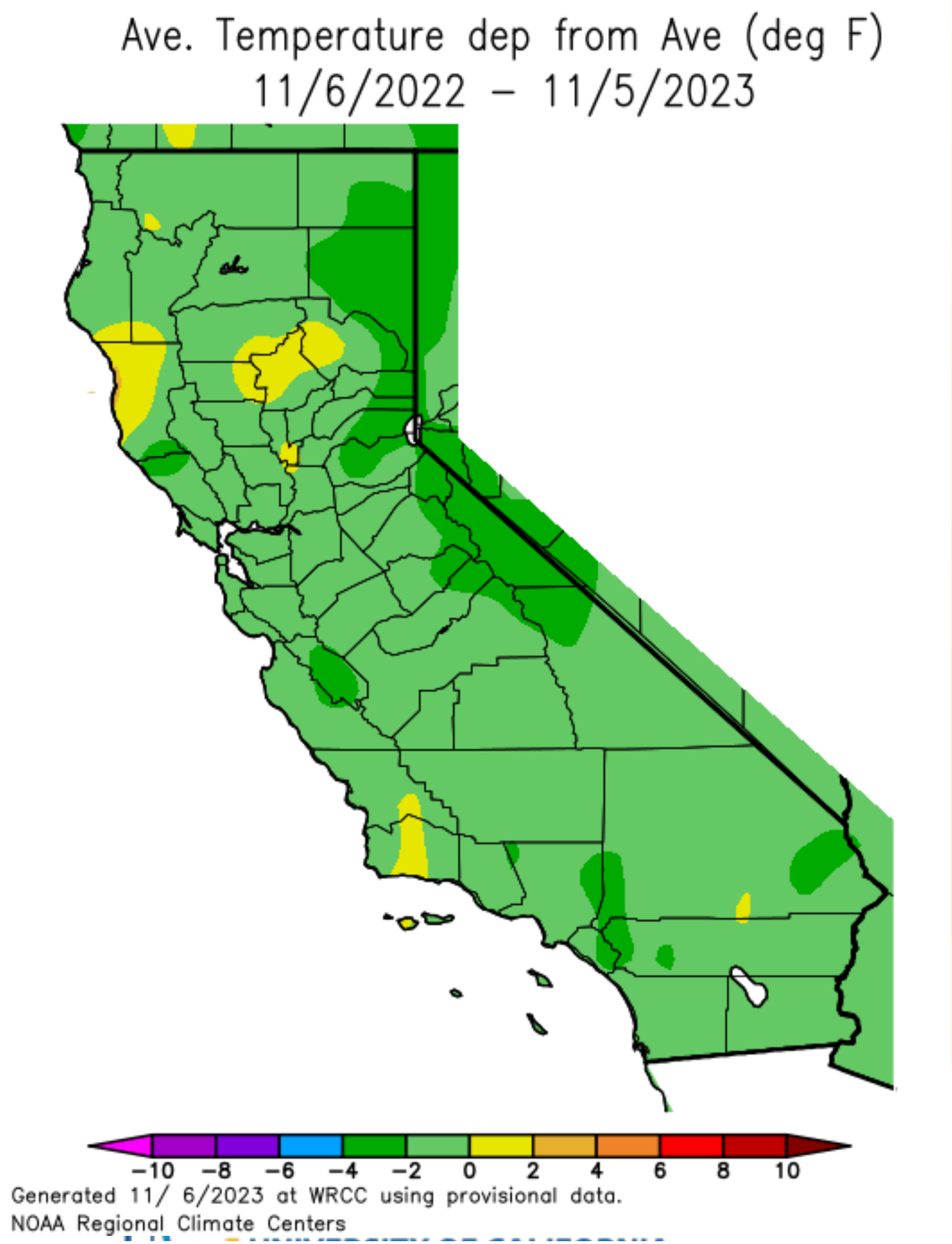
Damaged fruit



Credit: California Climate Data Archive (2021)

Extreme Heat?

Average temperatures in the 2023 growing season were notably lower across the state compared to average



Credit: California Climate Data Archive (2021)

Station	Year	Final GDDs	Winkler Zone
Ukiah	2023	3301.5	III
Ukiah	2022	3475.5	III
Ukiah	2021	3679.1	IV
Ukiah	2020	3604.9	IV
Ukiah	2019	3470.4	III
Ukiah	2018	3602.5	IV
Ukiah	2017	3640.7	IV
Ukiah	2016	3344.6	III
Ukiah	2015	3656.8	IV
Ukiah	2014	3635.5	IV
Ukiah	2013	3326.1	III
Ukiah	2012	3285.4	III
Ukiah	2011	2965.9	II
Ukiah	2010	3136.9	III
Ukiah	2009	3572.9	IV
Ukiah	2008	3516.6	IV
Ukiah	2007	3392.1	III
Ukiah	2006	3666.2	IV
Ukiah	2005	3335.1	III
Ukiah	2004	3575.9	IV
Ukiah	2003	3509.8	IV

Hottest

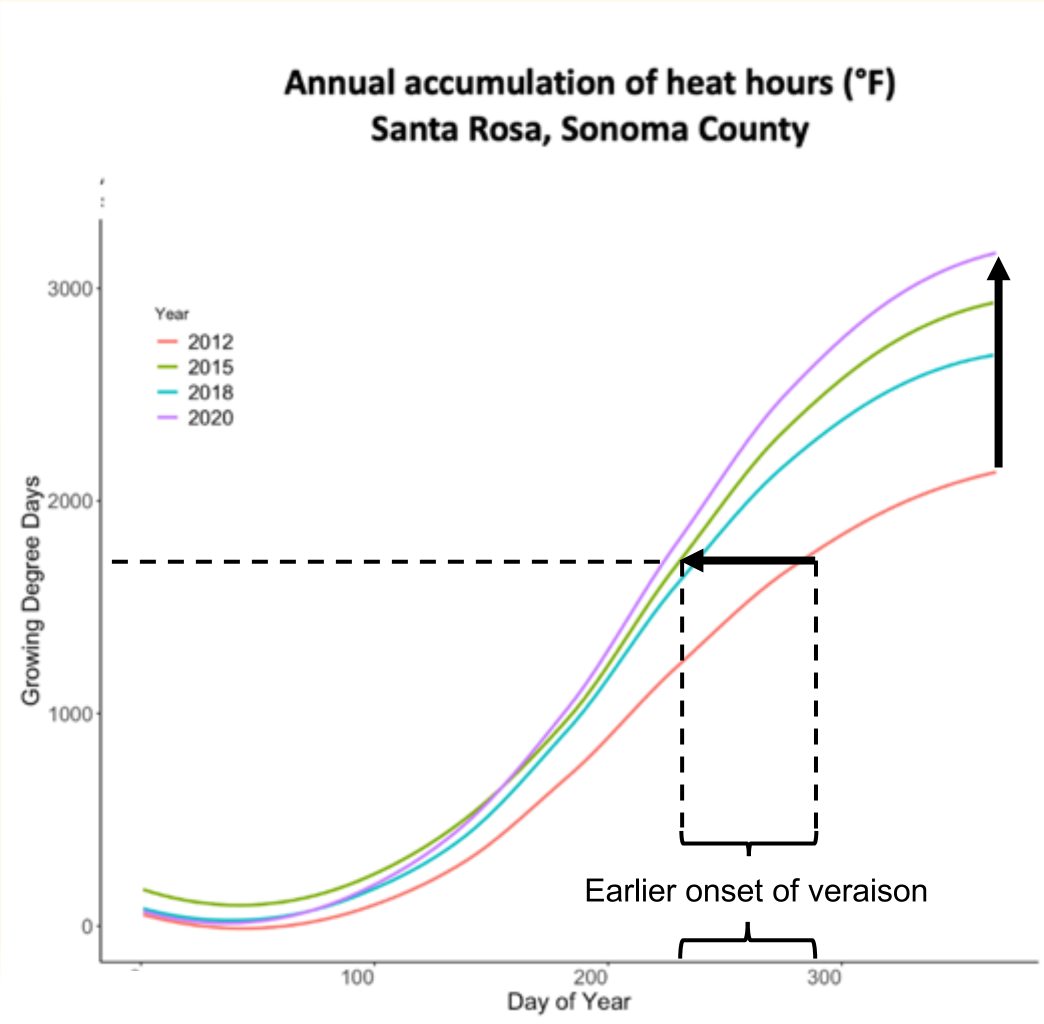
Coolest

Increasing Temperatures

In Central Europe the impact of warming climates has been documented in Bernáth et al. 2021

Between 1985 and 2018

- Budbreak: 5-7 days earlier
- Flowering: 7-10 days earlier
- Berry maturity: 18 days earlier
- Harvest: 8-10 days earlier



Cumulative heat accumulation in Santa Rosa, California in 2012, 2015, 2018, and 2020. (Data from https://cimis.water.ca.gov)

What can we do?

- Vineyards need tools to address extreme weather conditions and other impacts of climate change

- Concerns of note:
  1. Shorter time between budbreak and harvest
  2. Increased risks of heat damage
  3. Increased risks of cold damage
  4. Limited water availability
  5. Pest acclimation to climate and beneficials
  6. Soil salinization

Shade nets to mitigate heat and solar radiation damage

Artificial shading nets
- **Decreases direct solar radiation on fruit**
- **Decreases fruit zone temperatures**
- **Reduces number of sun-damaged clusters**
- **Improves or retains final quality of berries**

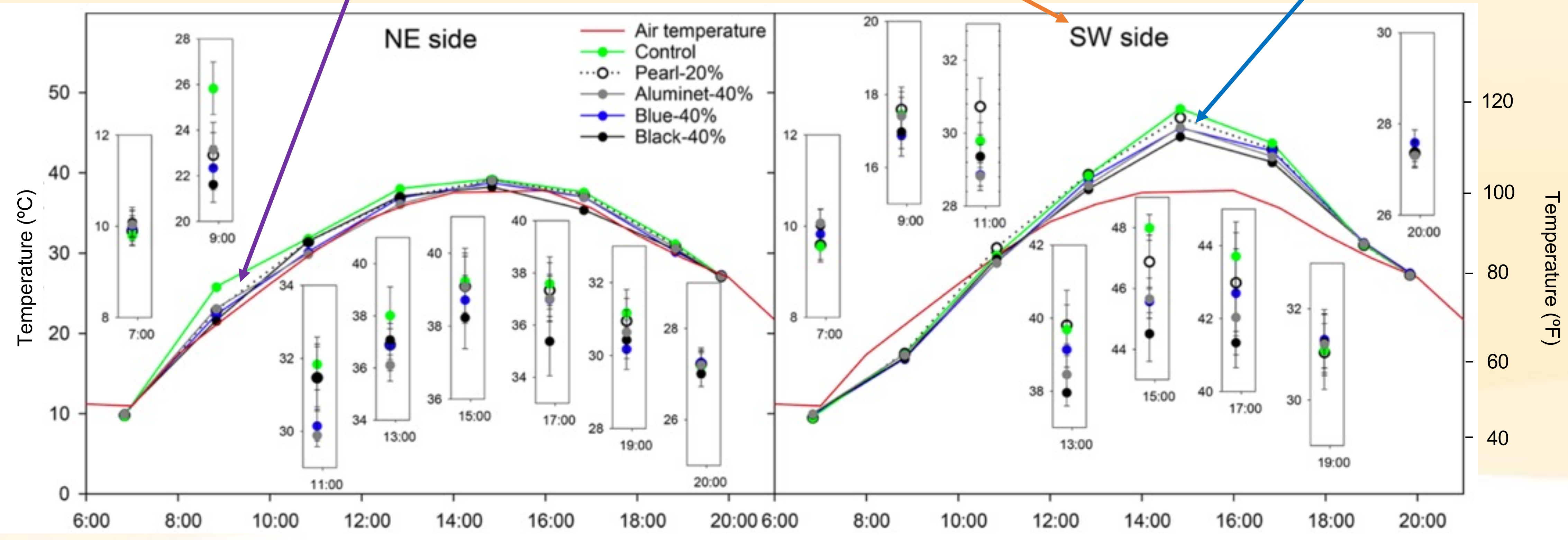
Different colored shade nets applied to Cabernet Sauvignon in Oakville, CA in 2017.

Effects of Shade Netting on Berry Temperatures

Very effective when either side is in direct sunlight

Impact last longer on the more exposed side of the canopy

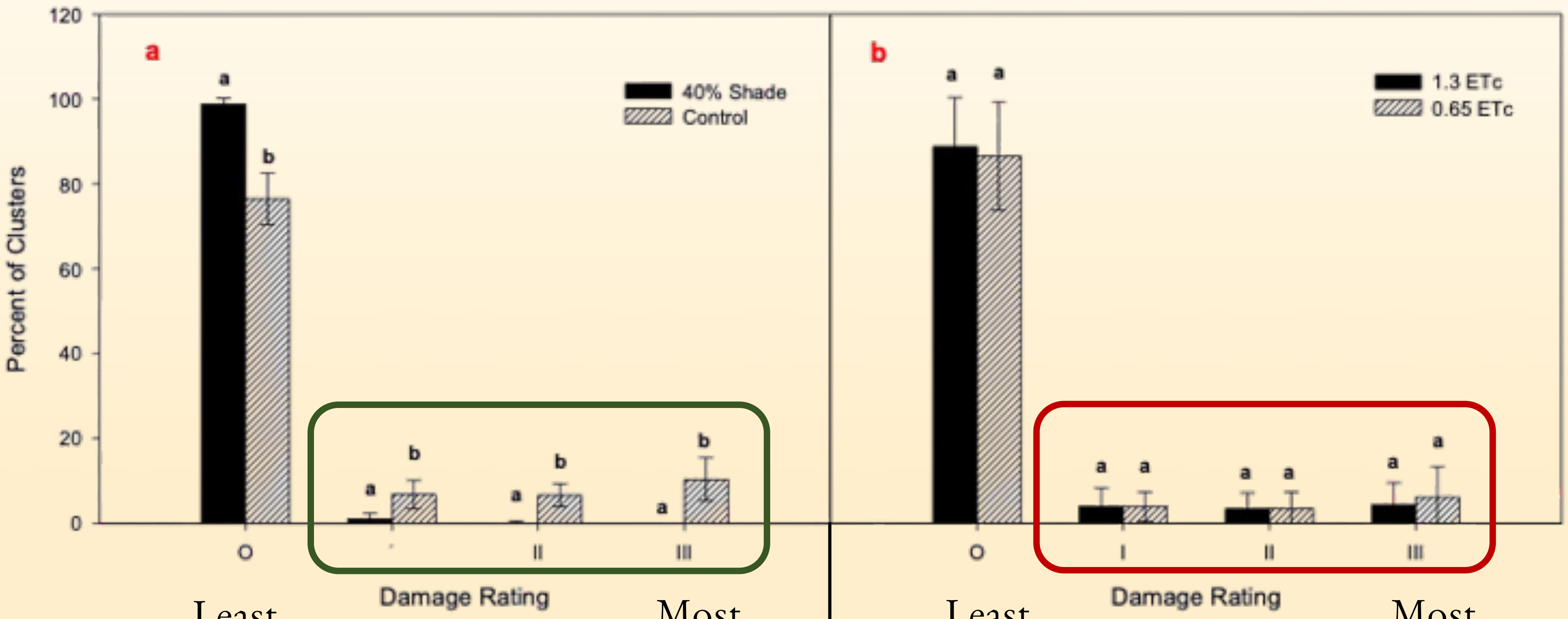
Can be up to **5 ºF cooler** under the canopy [2]



Cabernet Sauvignon fruit zone air temperatures measured under different colored shade nets in Oakville, CA in July 2016 (figure from Martínez-Lüscher et al. 2017)

Black shade net applied

Modified Irrigation



Least Damage → Most Damage

Least Damage → Most Damage

Increasing Temperatures

No shade netting

a

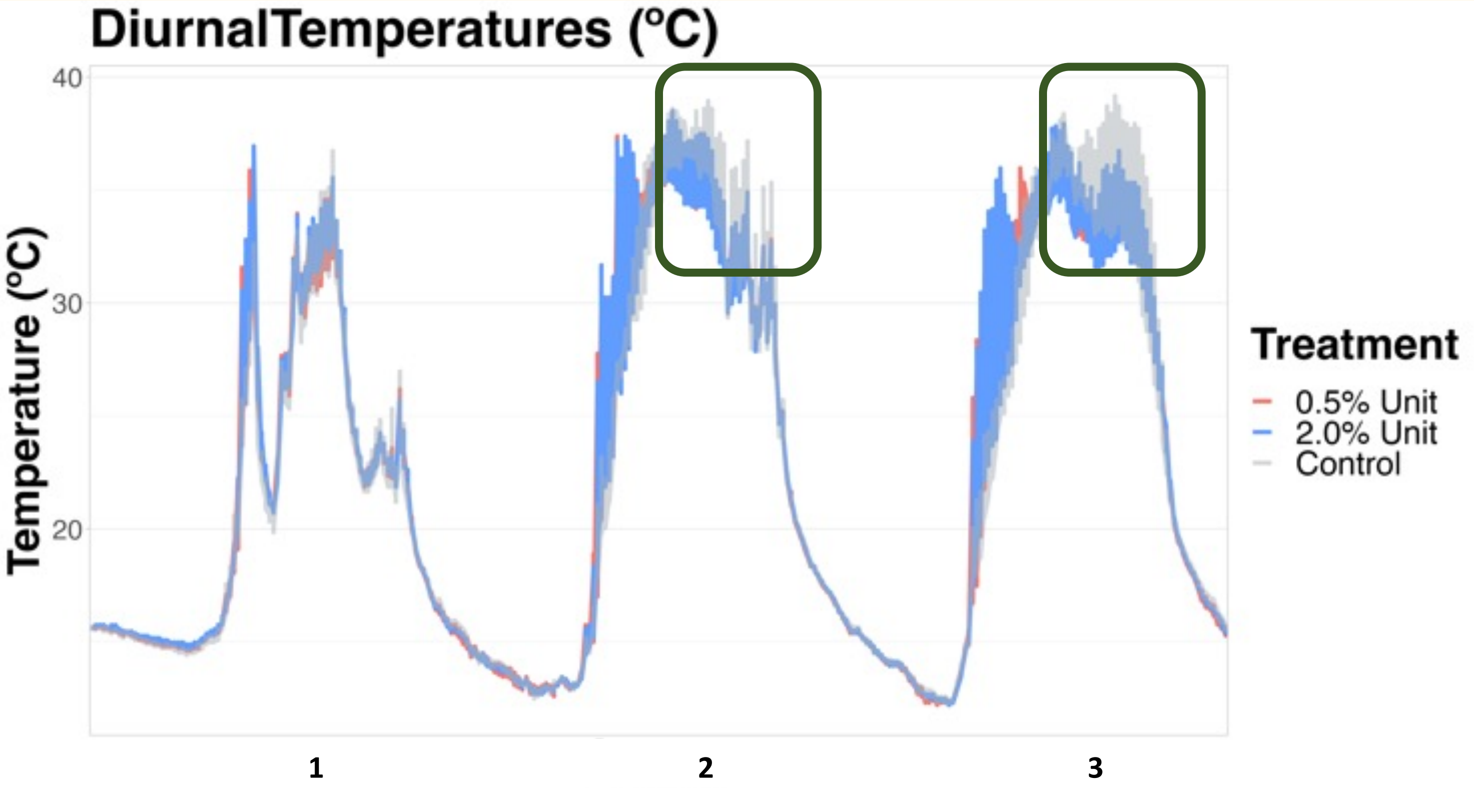
Shade netting

b

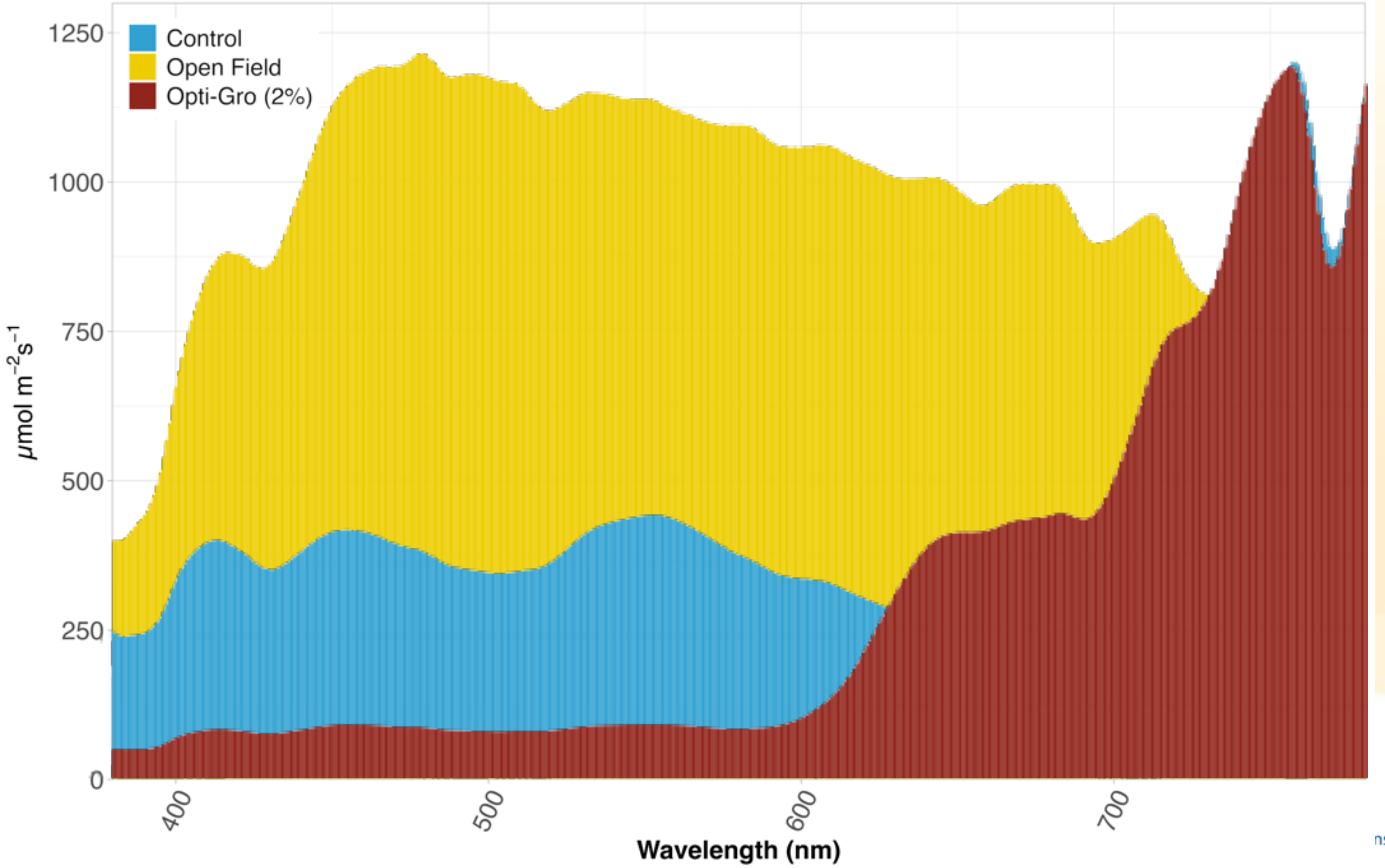
c

Left to Right: (a) no shade net applied; (b) example of black shade net applied following fruit set; (c) resulting cluster protected by shade net; all images were taken on the same day in Oakville, CA in August 2017.

Light Modification in Other Forms



Light Spectrum Intensity



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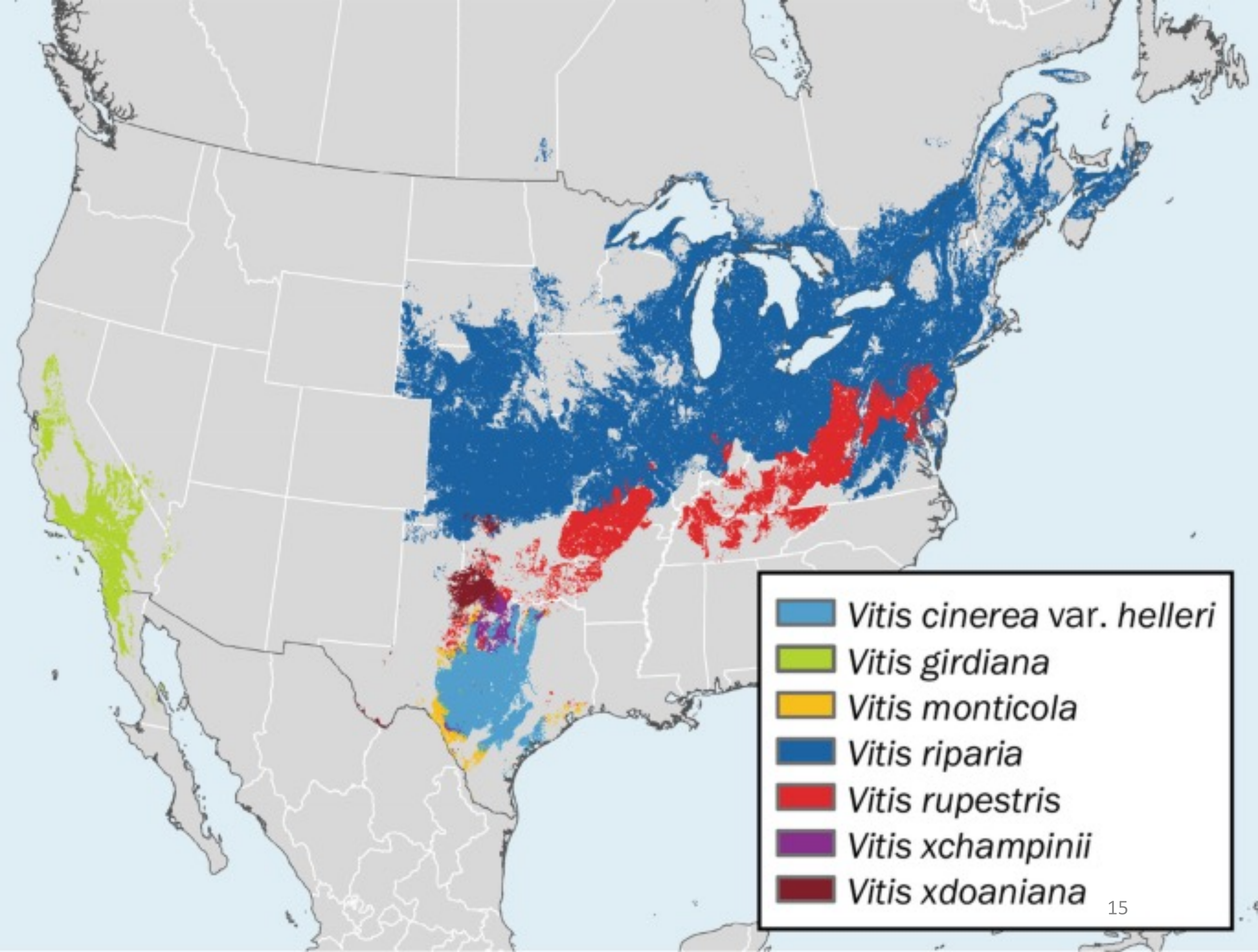
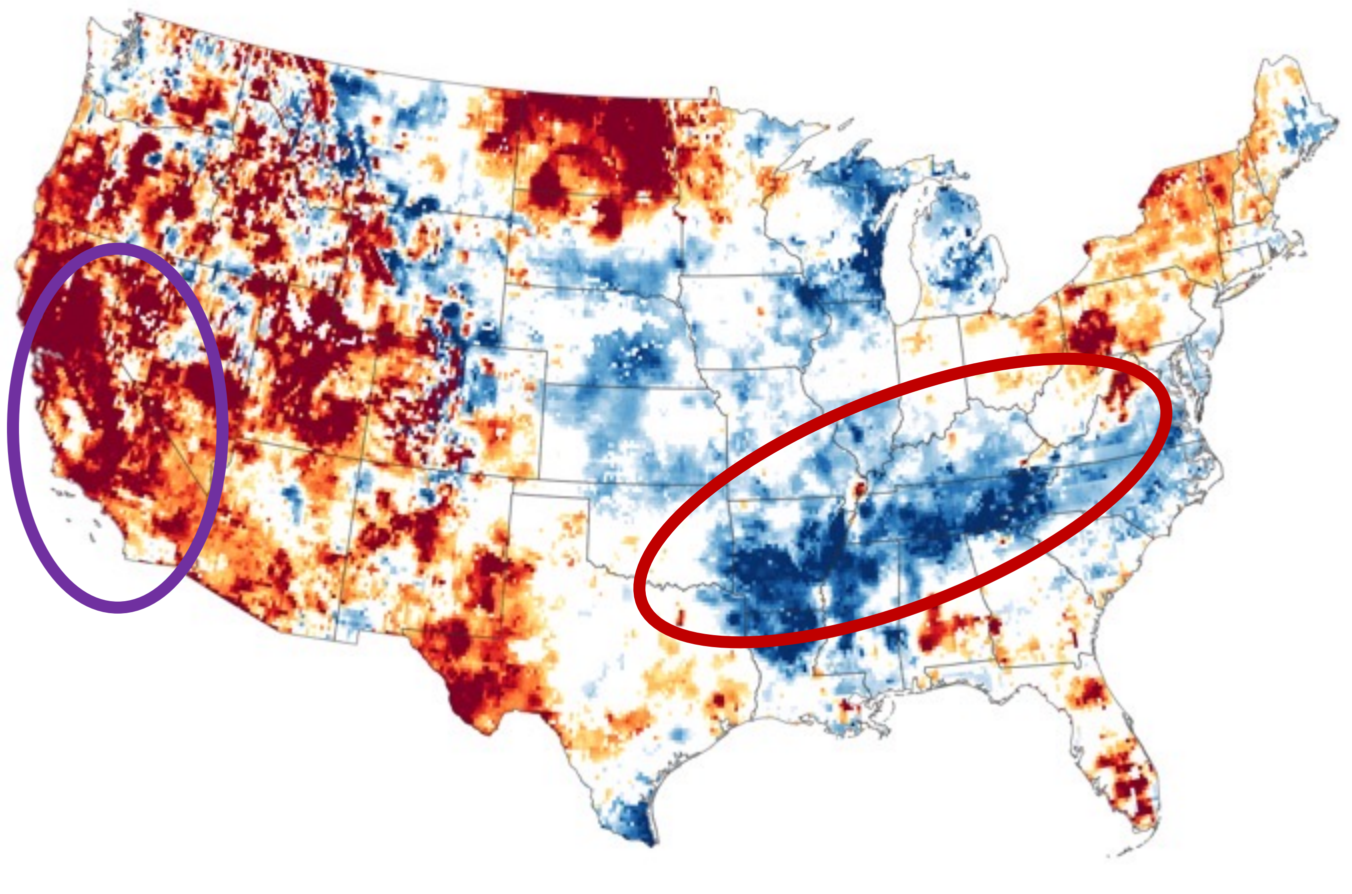
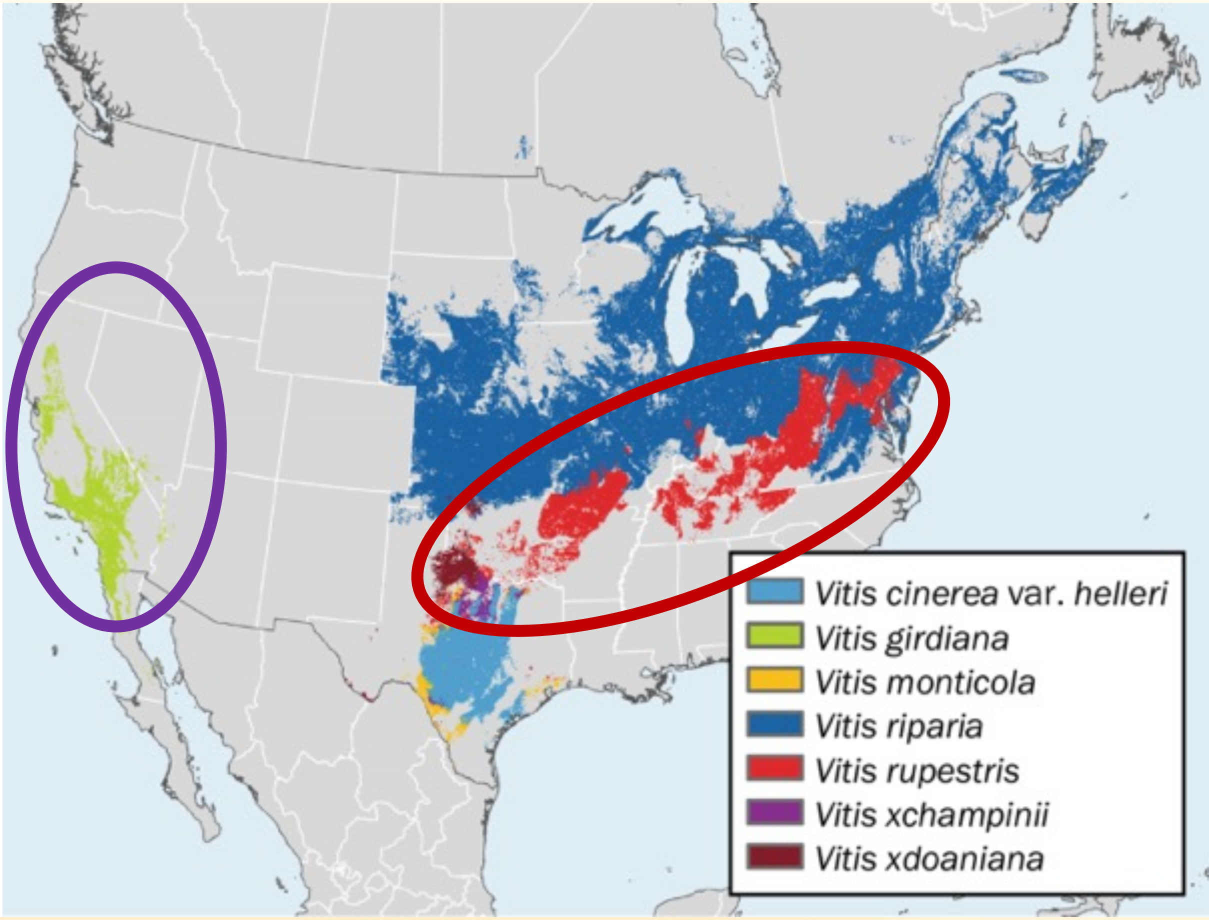
Trait sourcing

Wild vines





Drought conditions – 2021 (NASA)



Heinitz et al. 2019

Salinity Tolerance

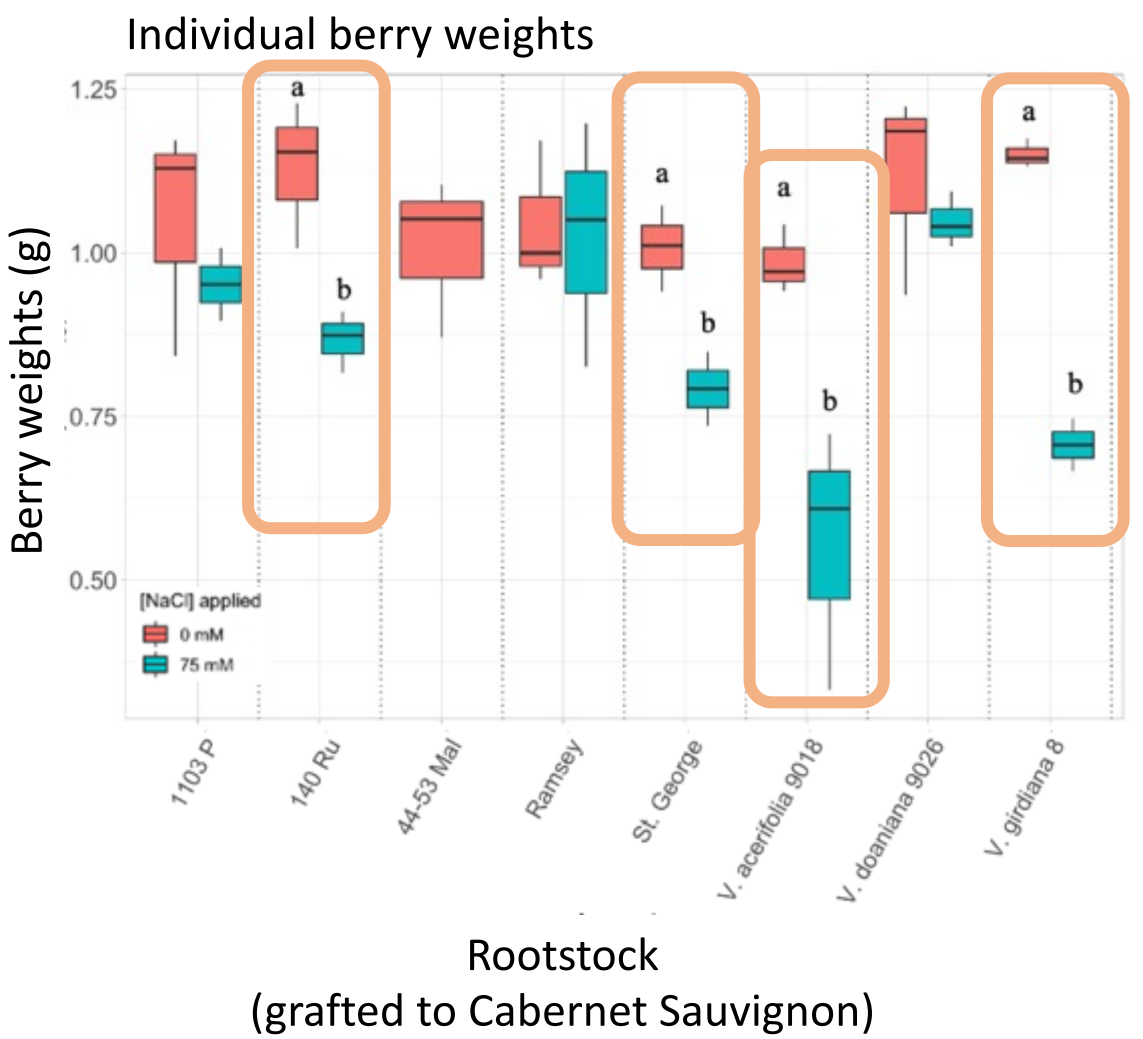
- Salinity tolerance is one of the traits we might seek in new phenotypes or species
- From 2018-2021 we tested wild grapevines to find a candidate
- Required to tolerate up to 12.5% the average NaCl concentration in seawater

New Agronomic Traits

Unexpected problems

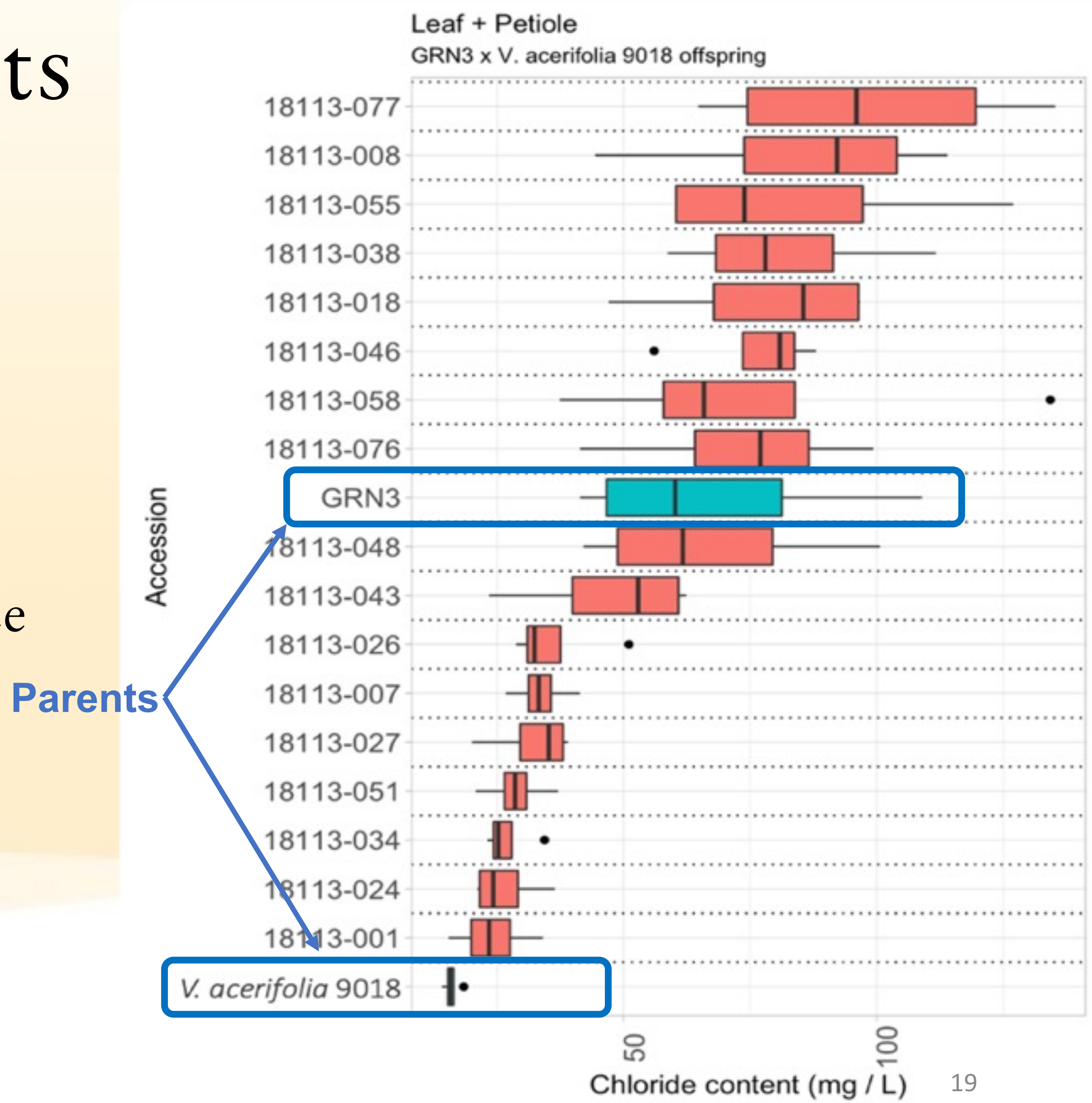
In some of the promising candidates we found that some agronomic traits were missing

- Up to 40% Smaller berries
- Poor vigor
- Low graft success rates



New Agronomic Traits
Breeding new cultivars

- Long term solution
  - Can take decades
- Utilize wild grapevines
  - Huge gene pool
  - Potential for high salinity tolerance
  - Largely unexplored
- Incorporate existing traits
  - Preserve other traits of existing rootstocks
  - Rootability, drought tolerance, vigor

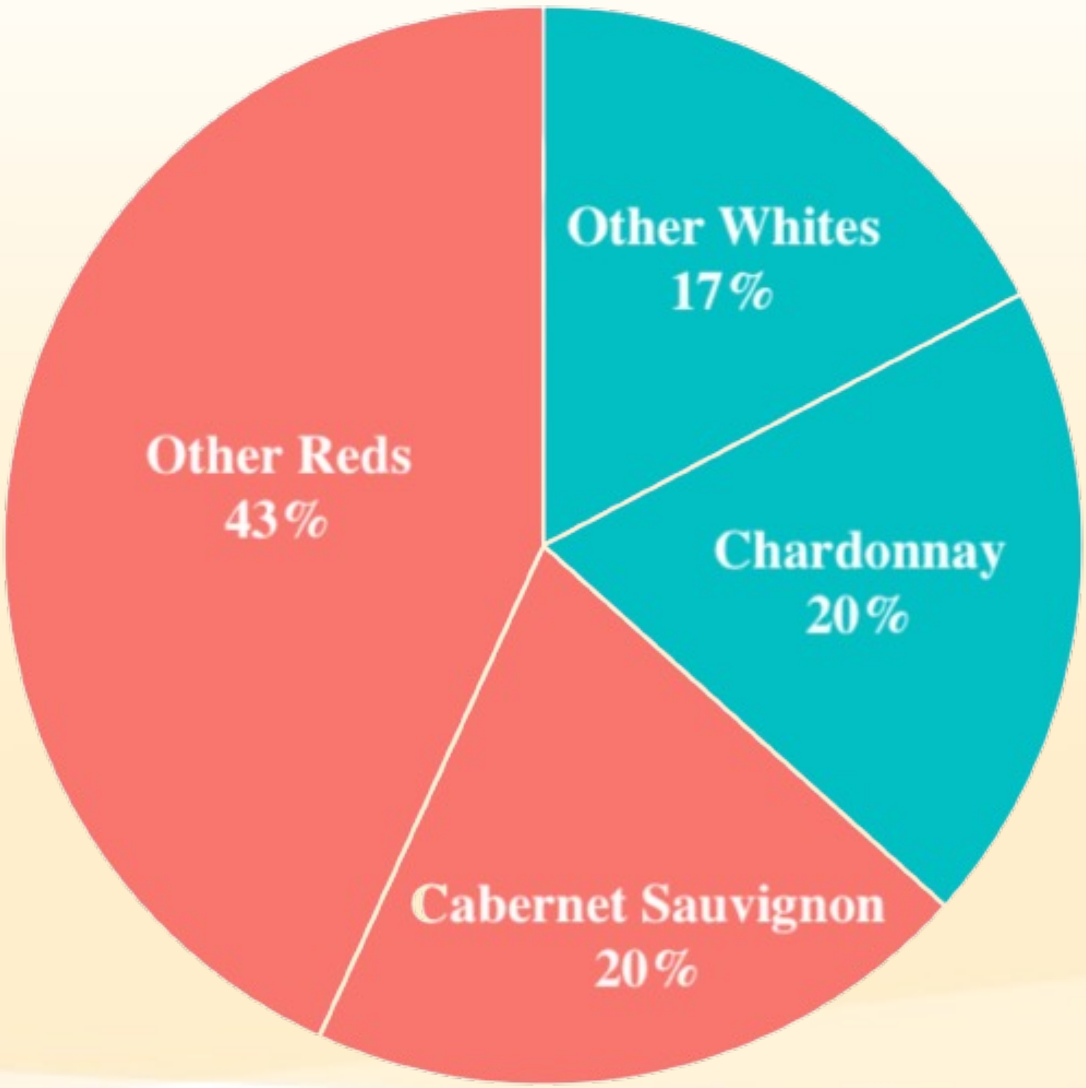


Scion Variety Bottleneck

- Market limitations on profitable cultivars
- Bottleneck down to two scions
- Wide range of climate adaptation in scions

Examples of desirable characteristics:

i. Late budbreak (avoid frost)
ii. Moderate vigor (less water demand)
iii. Early fruit maturity (maybe)
e.g., Sémillon; Tempranillo



CA Grape Acreage Report (2020)

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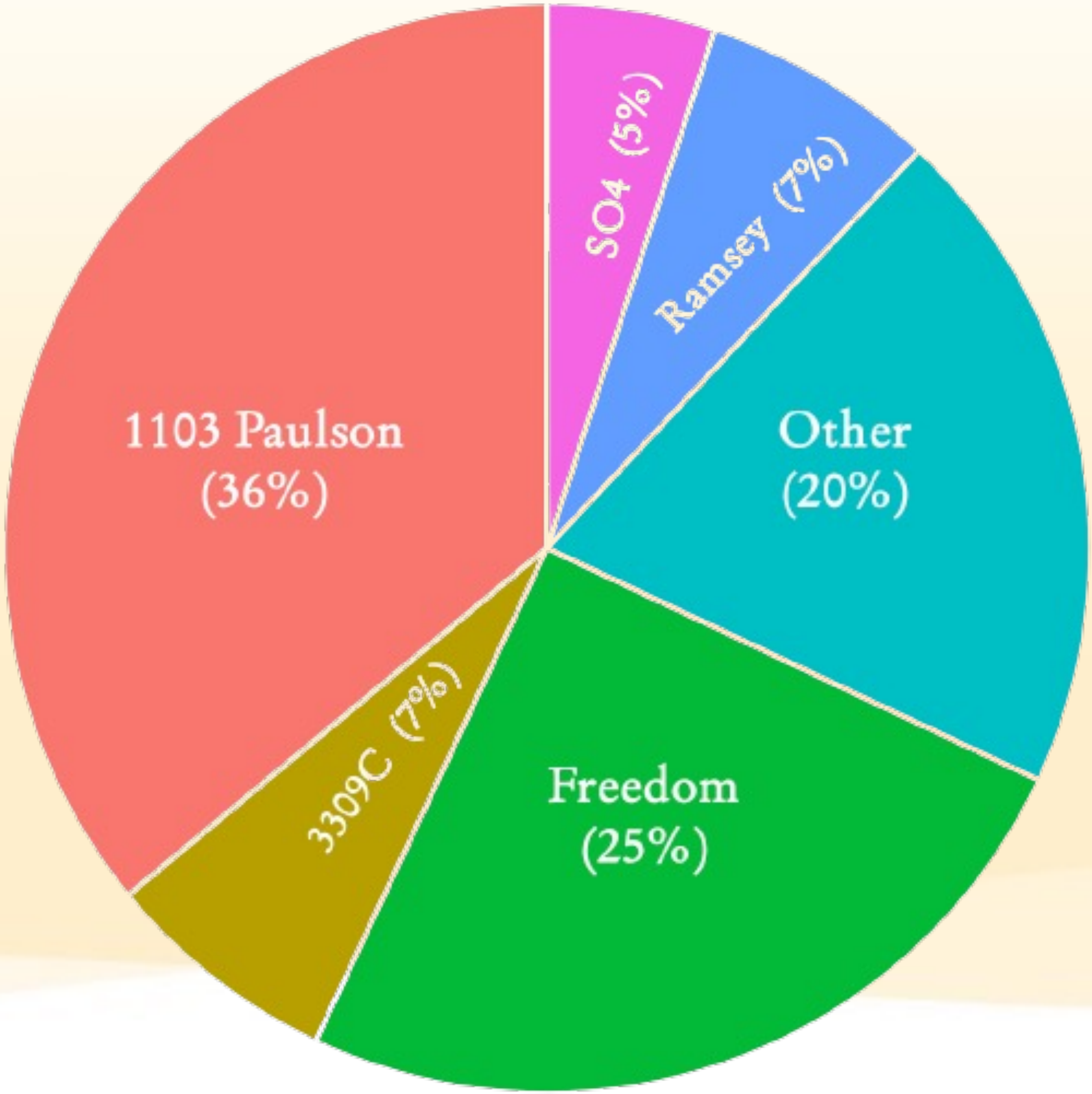
Limited Rootstocks

- The trend observed in scions appears to hold true for rootstock varieties as well
- Data is sparse for rootstocks
- In 2022, we identified the most planted rootstocks across California



Other Challenges

There are many more challenges when considering adapting vineyard systems to climate change that must be addressed:

Adaptable Infrastructure

Labor Supplies

Site Suitability

Smoke-taint in Fruit

Wildfires

'New' Pests

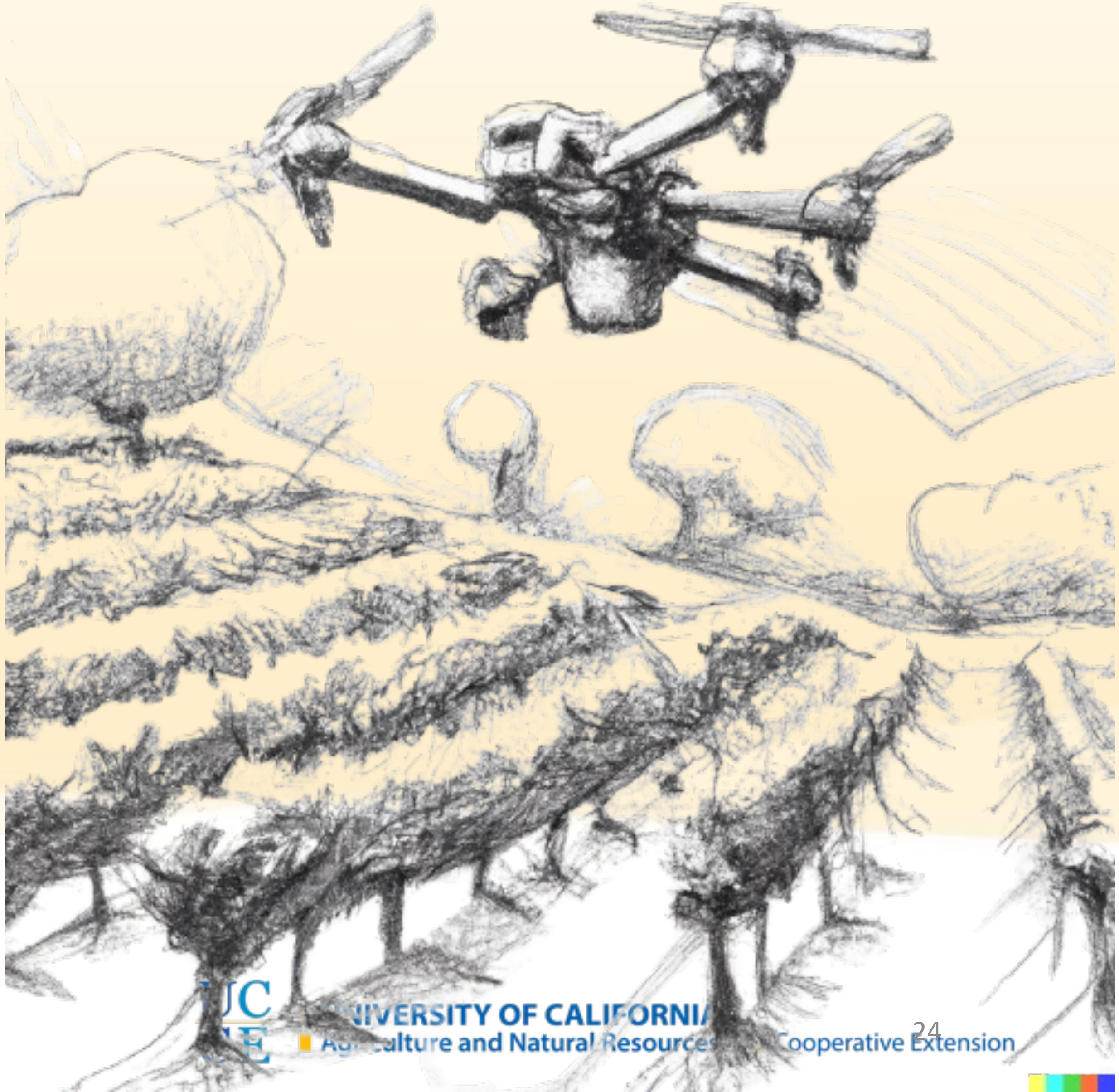
Changes in Beneficials

Alternative Chemical Controls

The Climate-Adaptive Vineyard

The Climate-Adaptive Vineyard

1. Water Use Efficiency
   - Drought tolerant cultivars
   - Precision irrigation methods
   - Water-efficient cultural practices
   - Better soil-water dynamics
2. Heat/Drought tolerant varieties
   - Research and testing
   - Available and adopted
3. Pest-tolerant rootstocks
   - Identify future pest risks
   - Select for current pests
   - Available and adopted



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The Climate-Adaptive Vineyard

4. Efficient management practices
   - Precision irrigation
   - Optimize canopy design
5. Improving soil health
   - Increasing water infiltration
   - Improve water retention
   - Improve nutrient retention
   - Promote mycorrhizae health
6. Desirable employment
   - Make jobs desirable
   - Improve employee retention and well-being
   - Keep skilled labor

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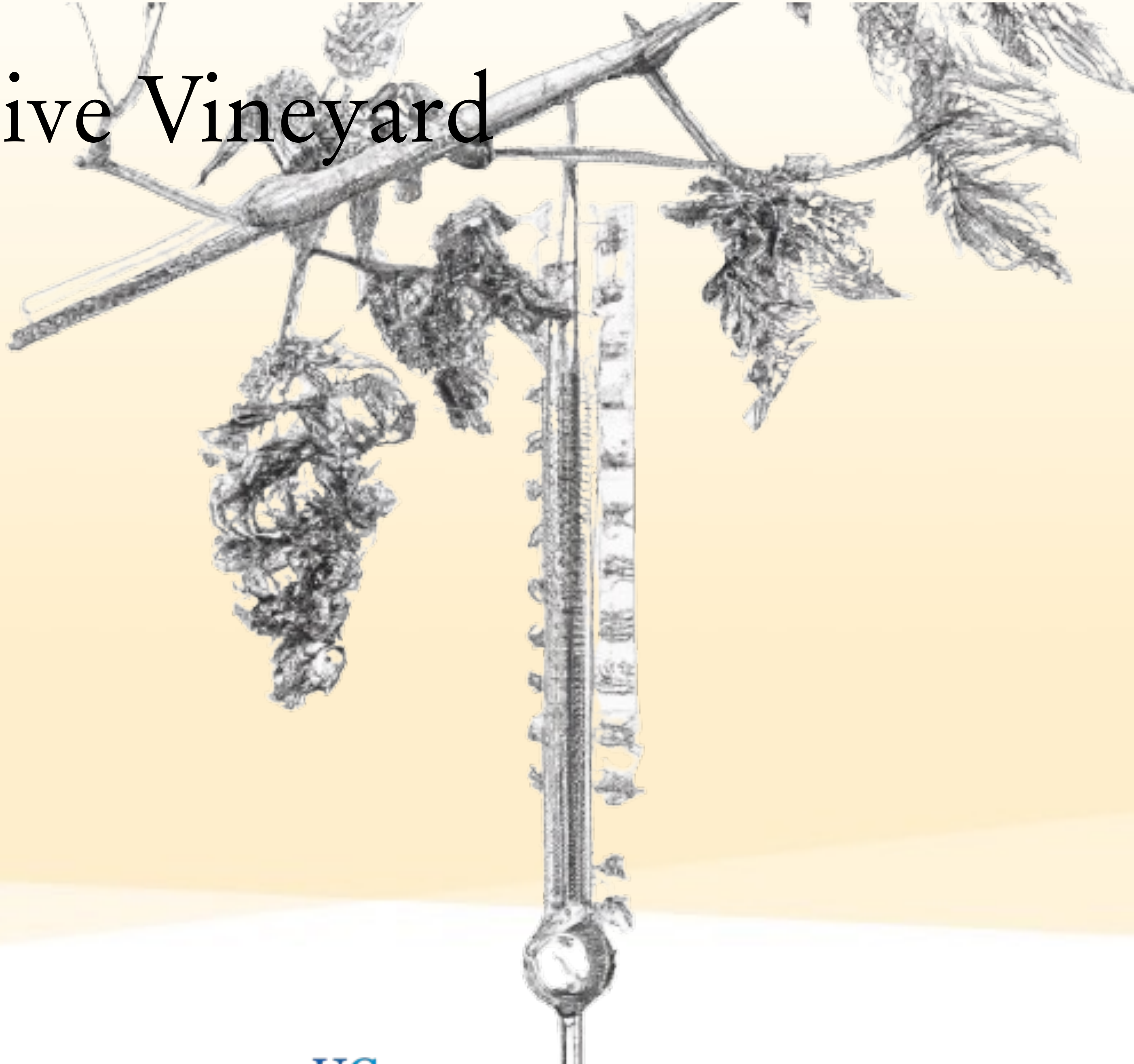
The Climate-Adaptive Vineyard

7. Adaptable Infrastructure
    - Dynamic trellises
    - As-needed devices
8. Consistent monitoring
    - Observe and record patterns and trends
    - Get ahead of challenges before they become costly
9. Ready adoption of new practices
    - Growers willing to try out new concepts and practices
    - Increase our climate-resilience greatly



Thank you

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