HORTICULTURE AND LANDSCAPE ARCHITECTURE
COLORADO STATE UNIVERSITY

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January 20, 2022

Orchard & Environmental Factors Affecting Peach Productivity & Harvest Quality

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Cold damage of floral tissues is the biggest single limitation to profitability of the Colorado tree-fruit industry

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April 14, 2020
T_{min}=-5.9°C

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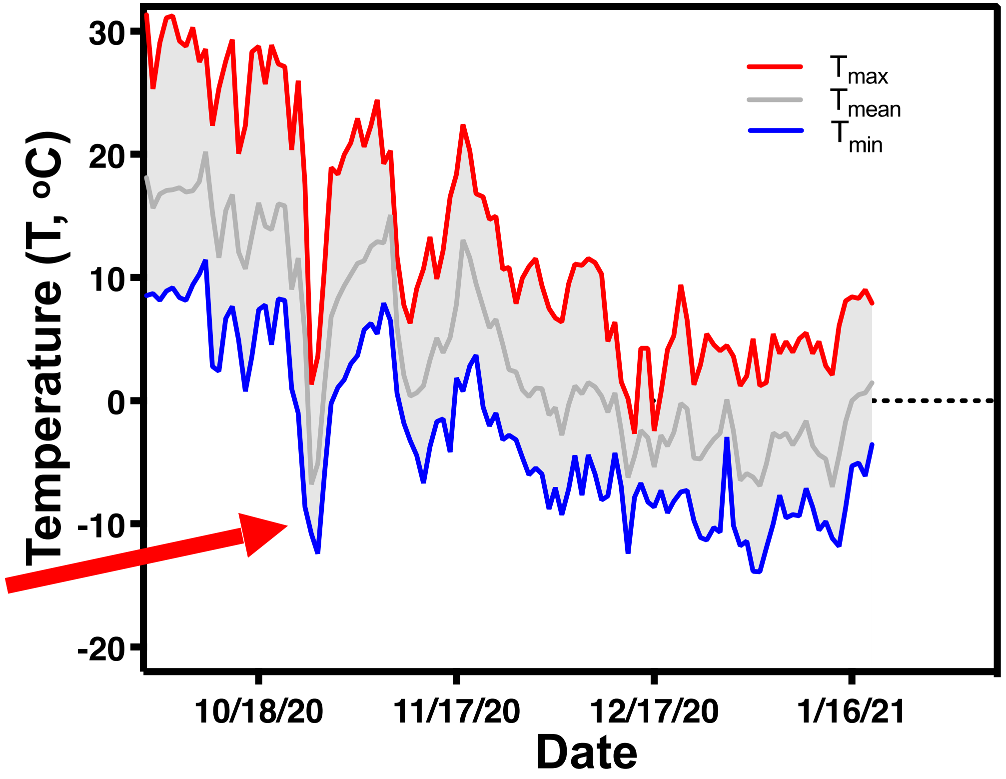
Cold damage during fall 2020



10/26/2020: -10.6°C (13°F)

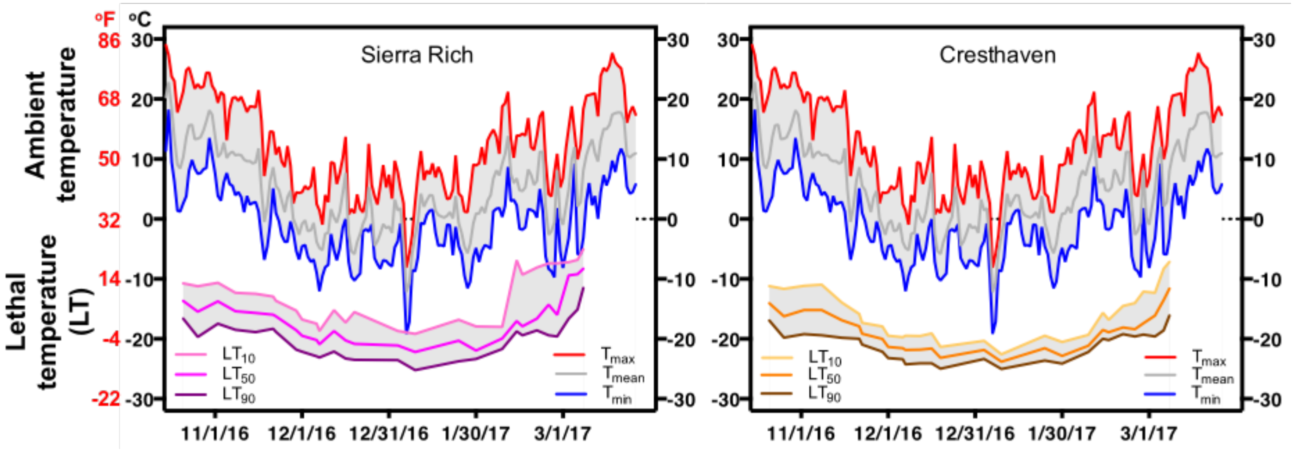
10/27/2020: -12.4°C (9.7°F)

*windy nights and no inversion

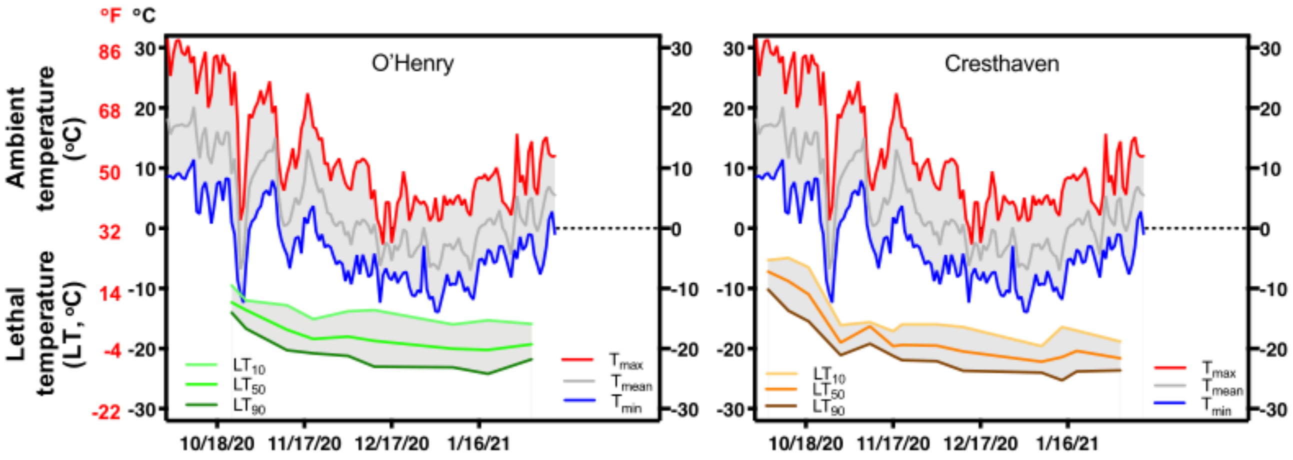
Cold damage during fall 2020 - Acclimation

- Acclimation a genotype x climate x management equation
- Peach acclimation mainly related to chilling and freezing events in fall
- Most cultivars coming from cold breeding programs are very good in acclimation in response to freeze
- Cultivars coming from warm breeding programs do not respond to freeze
- No freeze signal to the plants to acclimate in fall 2020
- Vegetative vs floral tissue acclimation?

2016-17



2020-21



Range of Tissue Damage

- Trees didn’t receive adequate chilling before the frost
- Cambial and xylem damage
- Potential disease (e.g. Cytospora or bacterial canker) vulnerability

*These shoots looked similar from the outside

Gummosis in Wood Damage

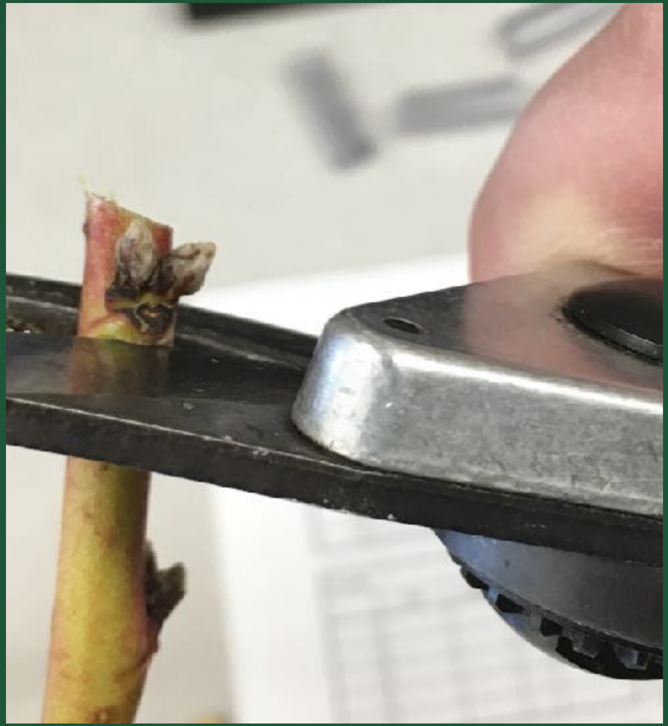
- Increased young shoot gummosis seen, especially in cultivars displaying woody tissue browning
- Bark cracking, often leading to gummosis

Whole Tree Damage

Shoots, scaffolds and trees with previous cankers collapsed often

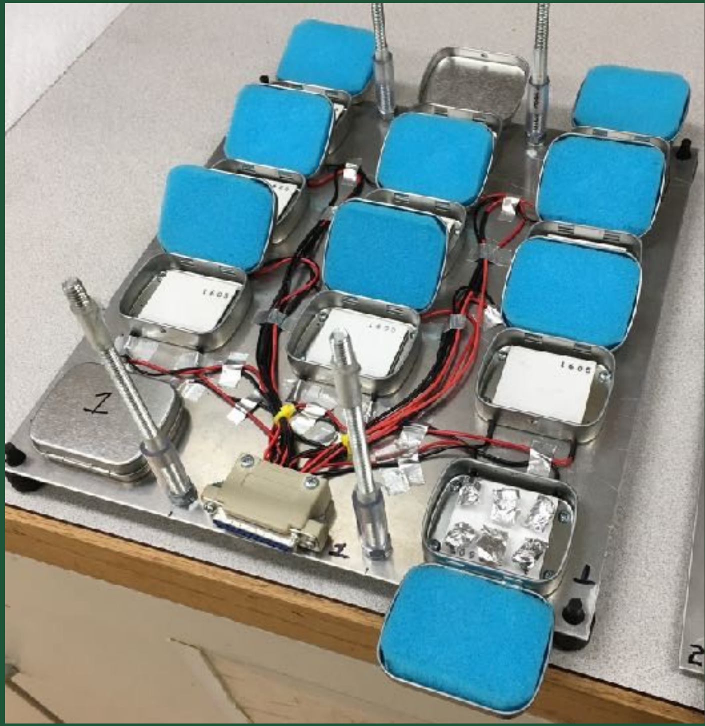
Can we develop reliable tools to determine lethal temperatures of peach floral buds precisely?

- Differential Thermal Analysis (DTA)
- Monitors difference in temperature between a sample and a reference thermocouple
- Thermoelectric modules (TEMs) detect temperature gradients (exotherms) generated by the freezing floral parts (method described by Mills et al., 2006)



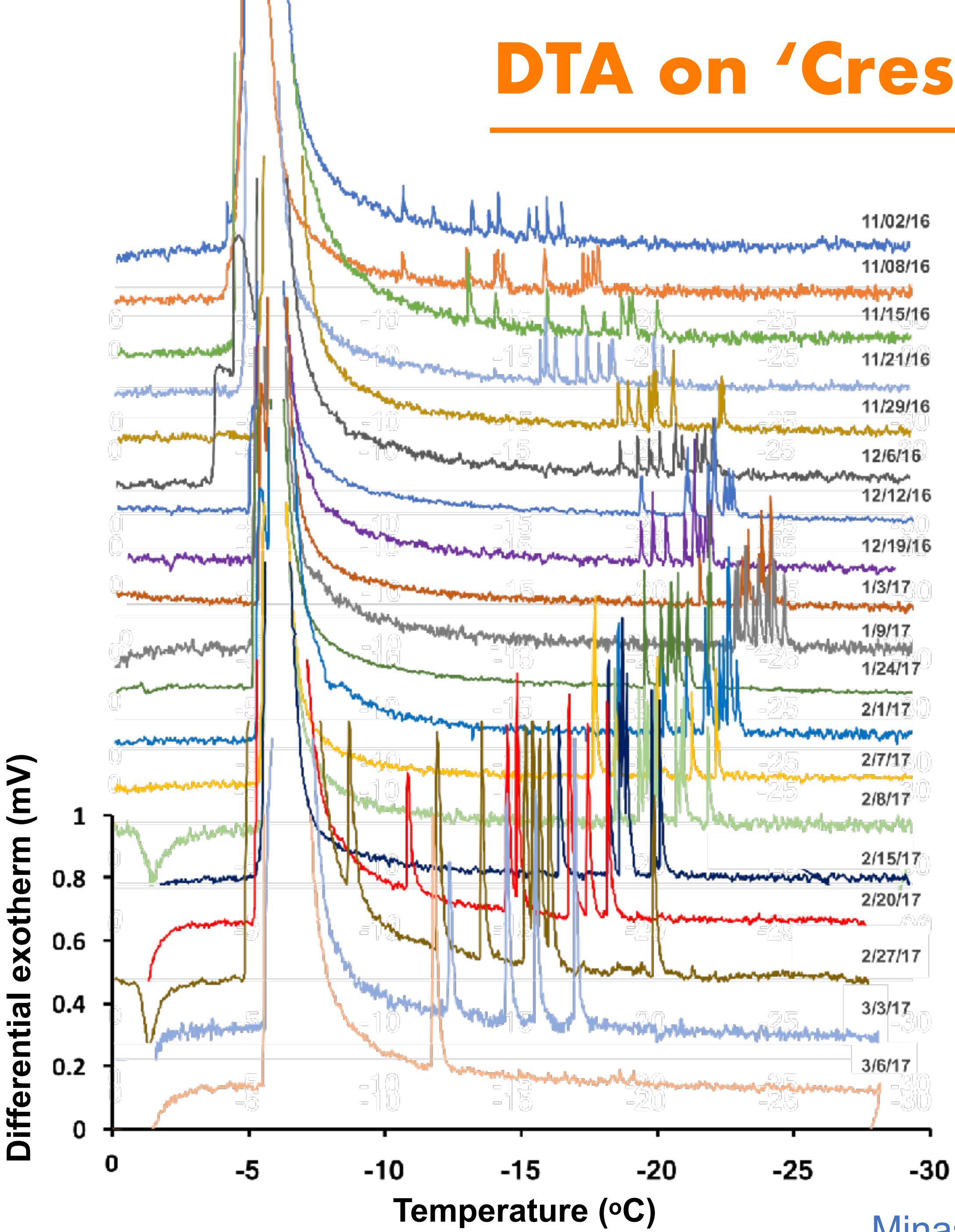
Minas & Sterle. 2020. Acta Hortic. 1281, 385-392

10-12 peach buds per TEM



10 replicated TEMs plus one reference

DTA on 'Cresthaven' floral buds



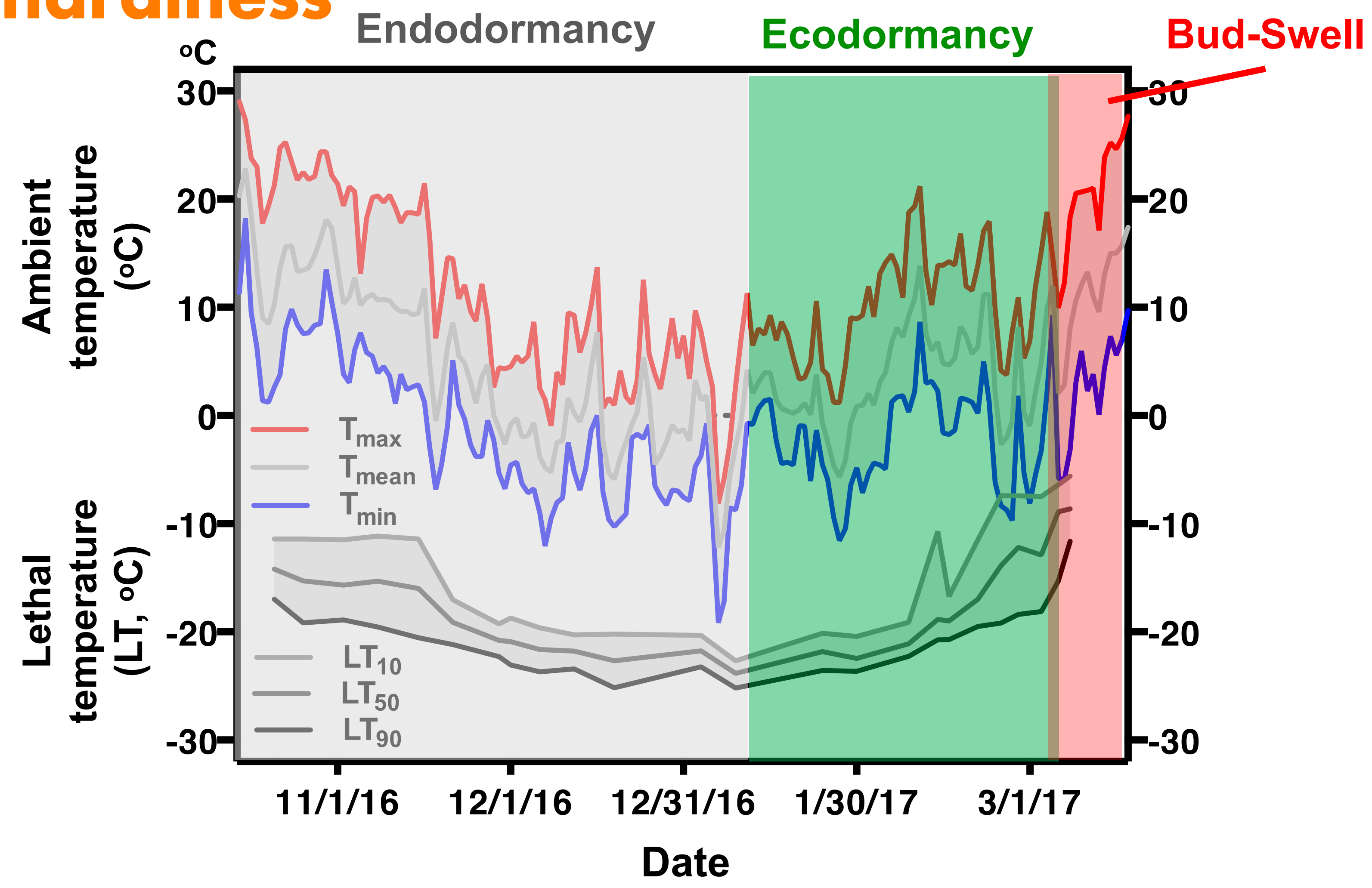
Acclimation: the gradual increase of cold hardiness **(Fall – Dec 6th, 2016)**

Maximum Hardiness
(Dec 12th - Feb 1st, 2017)

De-acclimation: the decrease of cold hardiness towards bud break **(Feb 7nd - March 6rd, 2017)**

Minas & Sterle. 2020. Acta Hortic. 1281, 385-392

'Redhaven' peach floral bud cold hardiness



Seasonal patterns of temperature and cold hardiness (expressed as lethal temperature, LT) for 'Redhaven' peach floral buds

Dormancy phases as described by Lang, 1987. HortScience 22, 817–820

Peach bud cold hardiness monitoring updates

http://minas.agsci.colostate.edu/tree-fruit-information/cold-hardiness/

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Cold Hardiness

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Peach Floral Bud Cold Hardiness Updates

Cold hardiness update 2020-21 | Chilling hours/portions | Cold hardiness updates 2019-20 | 2018-19 Updates | 2017-18 Updates | 2016-17 Updates | Critical Phenological Temperatures

Peach floral bud cold hardiness update #21 02_03_21

Data from the last dormant seasons (2016-2021) on peach cold hardiness, chilling accumulation & critical phenological temperatures

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Effect of Rootstock on 'Red Haven' peach floral buds acclimation, max hardiness & deacclimation (2017-18)

	Atlas	Bright's Hybrid-5	Guardian®	Krymsk®86	Lovell	Krymsk®1	Date
LT_{10}	-14.9	-14.9	-14.4	-13.8	-15.4	-15.4	11/6/17
	-16.6	-16.7	-17.8	-15.4	-14.9	-17.0	11/17/17
	-18.4	-16.7	-17.8	-18.6	-18.7	-17.9	11/28/17
	-18.3	-19.0	-16.9	-15.3	-19.2	-18.1	12/14/17
	-19.3	-18.2	-17.5	-21.0	-16.8	-18.3	1/4/18
	-13.8	-15.0	-12.7	-18.4	-15.3	-8.2	1/24/18
	-6.2	-7.0	-6.5	-6.5	-6.4	-6.4	2/14/18
LT_{50}	-18.1	-17.1	-18.2	-18.2	-17.2	-17.8	11/6/17
	-19.3	-19.0	-19.5	-19.4	-18.6	-19.0	11/17/17
	-19.8	-19.6	-19.6	-19.9	-20.0	-19.9	11/28/17
	-20.4	-21.1	-21.3	-21.5	-21.0	-20.2	12/14/17
	-22.6	-22.3	-22.5	-22.9	-21.5	-21.9	1/4/18
	-20.5	-22.2	-22.7	-22.6	-22.6	-21.0	1/24/18
	-17.8	-19.0	-18.2	-18.9	-19.4	-18.2	2/14/18
LT_{90}	-19.1	-18.8	-20.1	-19.8	-19.5	-19.4	11/6/17
	-20.1	-20.8	-20.2	-20.8	-20.4	-20.0	11/17/17
	-20.9	-21.2	-21.4	-20.6	-21.1	-20.9	11/28/17
	-22.1	-22.0	-22.5	-22.1	-22.4	-21.8	12/14/17
	-23.5	-23.7	-24.1	-23.9	-23.8	-21.9	1/4/18
	-23.0	-23.8	-23.7	-23.6	-23.6	-23.3	1/24/18
	-20.9	-21.4	-20.9	-21.3	-20.9	-21.0	2/14/18

NC-140

2009 NC-140 Red Haven Peach Rootstock Trial

Least hardy: Atlas and Krymsk®1
Most hardy: Guardian, Krymsk 86

Early acclimation: Guardian®, Lovell
Late acclimation: Krymsk®86, Atlas, BH-5

Late deacclimation: Krymsk®86

Cold Hardy Cultivars Evaluation Trial

More information:
Today @ 2:30 PM
CSU Showcase

David Sterle

We are using DTA to acquire large data sets in order to fully characterize the seasonal changes in hardiness across 13 peach cultivars that:

1. Cover different harvest times
2. Defend against hardiness using multiple hardiness strategies (ie. delayed bloom, earlier acclimation, or mid-winter hardiness)

California Bred Cultivars* | *Michigan Bred Cultivars

Notice variety of sizes and colors

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Dormant Season 2020-21 Cold Hardiness Data (LT_{50})

													Date
Floral bud	-13.0	-12.6	-13.8	-10.8	-12.8	-12.3	-12.1	-13.4	-15.3	-12.2	-13.7	-13.6	10/23/2020
	-16.6	-14.5	-14.9	[redacted]	-16.0	-16.3	-14.5	-18.6	-18.3	-16.4	-17.8	-16.5	10/28/2020
	[redacted]	-17.9	-18.6	-17.5	-18.5	-16.9	-16.6	-19.4	-18.4	-18.5	-19.0	-18.1	11/11/2020
	-18.2	-19.8	-20.5	-19.7	-20.1	-20.4	-20.5	-21.7	-21.3	-21.3	-21.4	-21.4	12/8/2020
	-19.0	-18.8	-19.9	-17.7	-18.6	-19.0	-20.6	-21.0	-21.5	-21.0	-20.4	-20.6	12/29/2020
	-19.9	-20.2	-21.0	-20.3	-20.7	-19.9	-21.2	-21.0	-22.5	-20.8	-20.9	-22.1	1/21/2021
	-19.3	-20.5	-21.4	-22.2	-19.9	-21.4	-22.6	-20.4	-20.1	-20.2	-21.8	-22.2	2/23/2021
	-17.9	-18.4	-19.3	-18.1	-18.4	-18.6	-19.4	-19.5	-20.1	-19.1	-19.6	-20.0	Average

Tender — **Hardy**

Bloom date	8-Apr	14-Apr	10-Apr	10-Apr	10-Apr	9-Apr	9-Apr	9-Apr	8-Apr	10-Apr	9-Apr	9-Apr	Bloom date
Mid shoot Damage	0%	20%	14%	45%	18%	52%	25%	38%	15%	48%	32%	27%	Mid shoot Damage

Fail in bud acclimation before extreme freeze was associated with shoot browning

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Forcing Early Fall Acclimation Using Abscisic Acid (ABA)

Yellowing after 5 days

ABA (PGR)

Control

Today @ 2:30 PM
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ABA Treatments Sprayed in October

- ABA stopped photosynthesis and caused leaf yellowing in 2 days and increased hardiness for the following 1 week to 2 weeks

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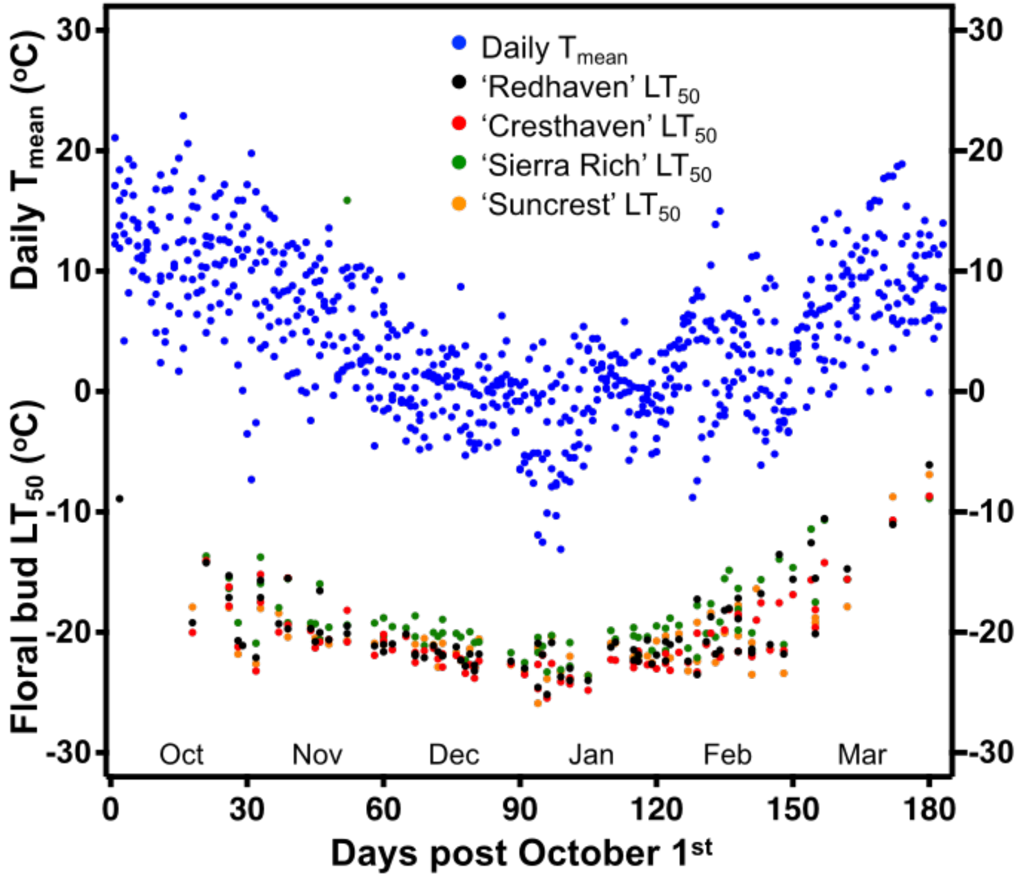
Can we develop accurate cold hardiness prediction models based on thermal and weather data?

- DTA (LT) and weather data collected over 4 dormant seasons (2016-20)
  - ~6000 lethal events per cultivar
  - 80 time points per cultivar (each comprised of 75 LTs)
- Models were validated by randomly selected data in a ratio of 2:1 for training data to validation data
- Standard least squares with an iterative approach to compared models with different variables
- Favored models which had low error in validation with the least number of variables
- Frost control methods can only raise temps to 1-2 ^{o}C (need low error in H_c prediction)



Sterle et al., 2021. *Submitted to Environmental & Experimental Botany.*

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Different models for the different phases of dormancy

Endo- and ecodormancy models were created using data from predictor variables that were separated by place-holder at a point of chill satisfaction

- $T_{min,1-4}$ (recent climate history)
- Photoperiod (seasonal progression)
- Interaction: ($T_{min,1-4}$ and photoperiod)

- $T_{max,1-4}$ (recent climate history)
- GDD >0 (GDD_0, seasonal progression)
- Date post October 1st (seasonal progr.)
- Interaction : (GDD>0 x $T_{max,1-4}$)

Endodormancy | **Ecodormancy** | **Full bloom**

DPO_{EDB}

October — **Chill Satisfaction** (700 chilling hours @ 0-7 °C) — April

DPO_{EDB}, days past October that EDB was reached
EBD, endodormancy barrier
Chill Satisfaction = EDB

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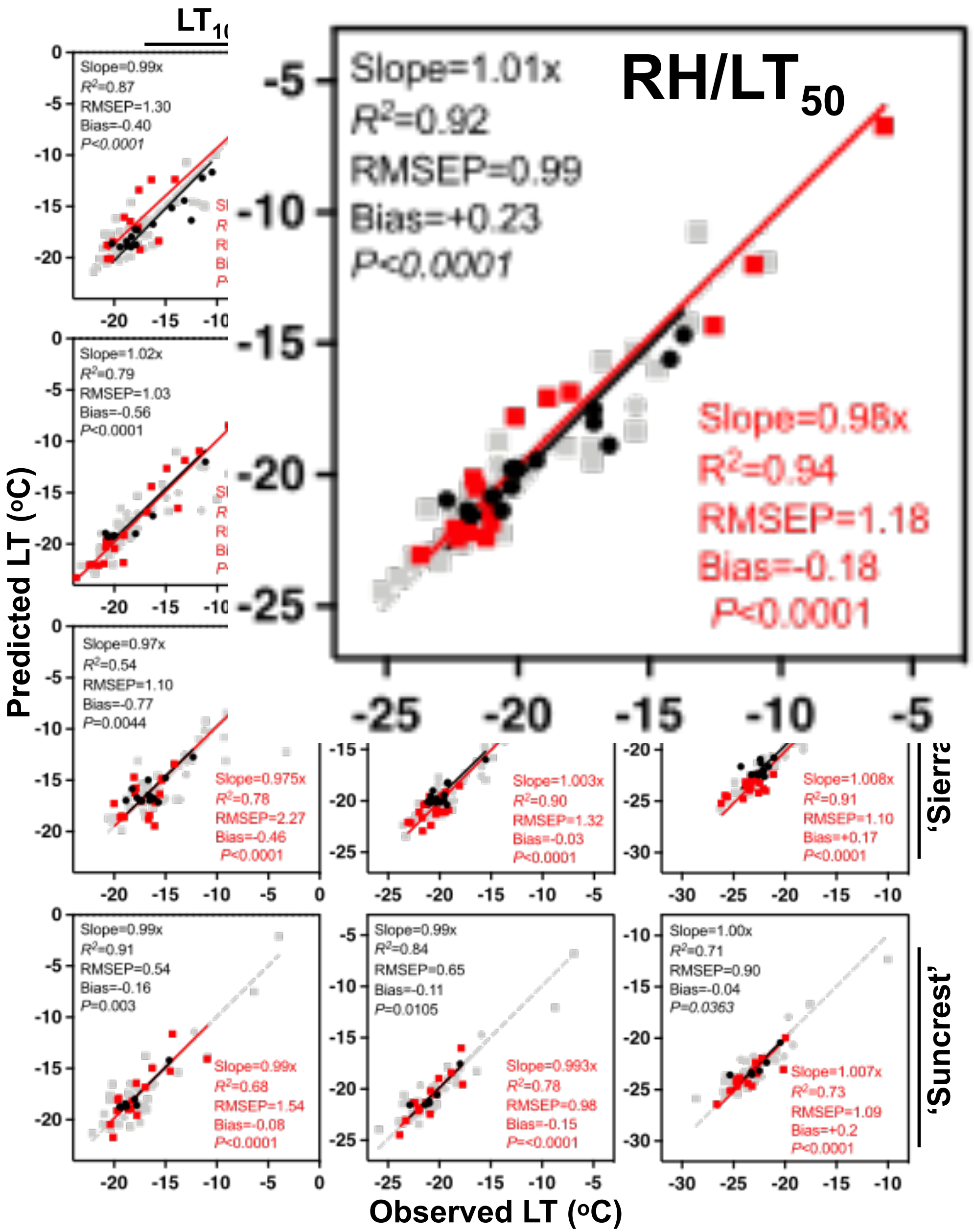
Model prediction performance



- LT_{50} + LT_{90} are predicted very accurately
- RMSEP= error (oC)
  - Low error
- Endodormancy black
- Ecodormancy red

Sterle et al., 2021. *Submitted to Environmental & Experimental Botany*

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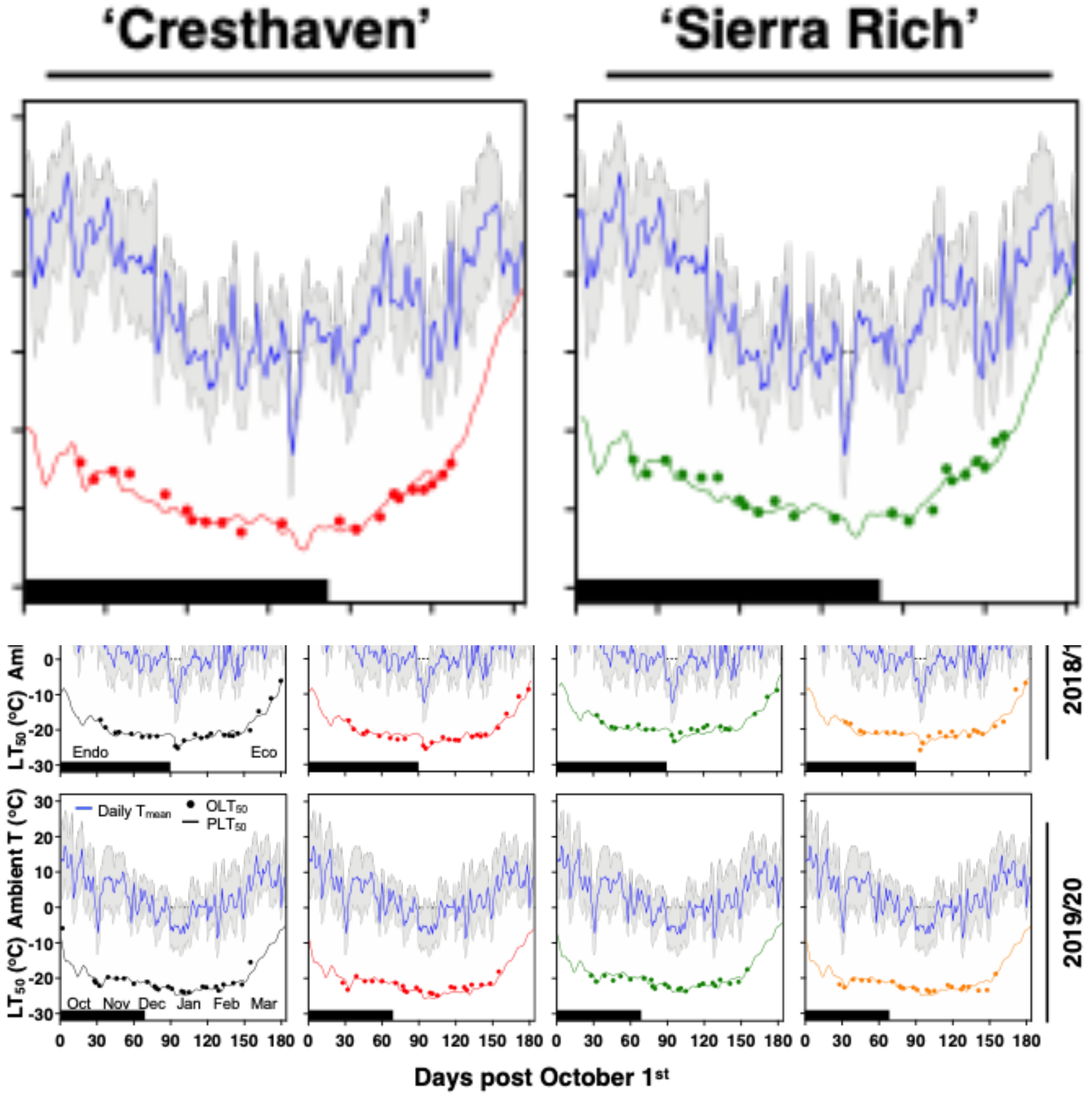
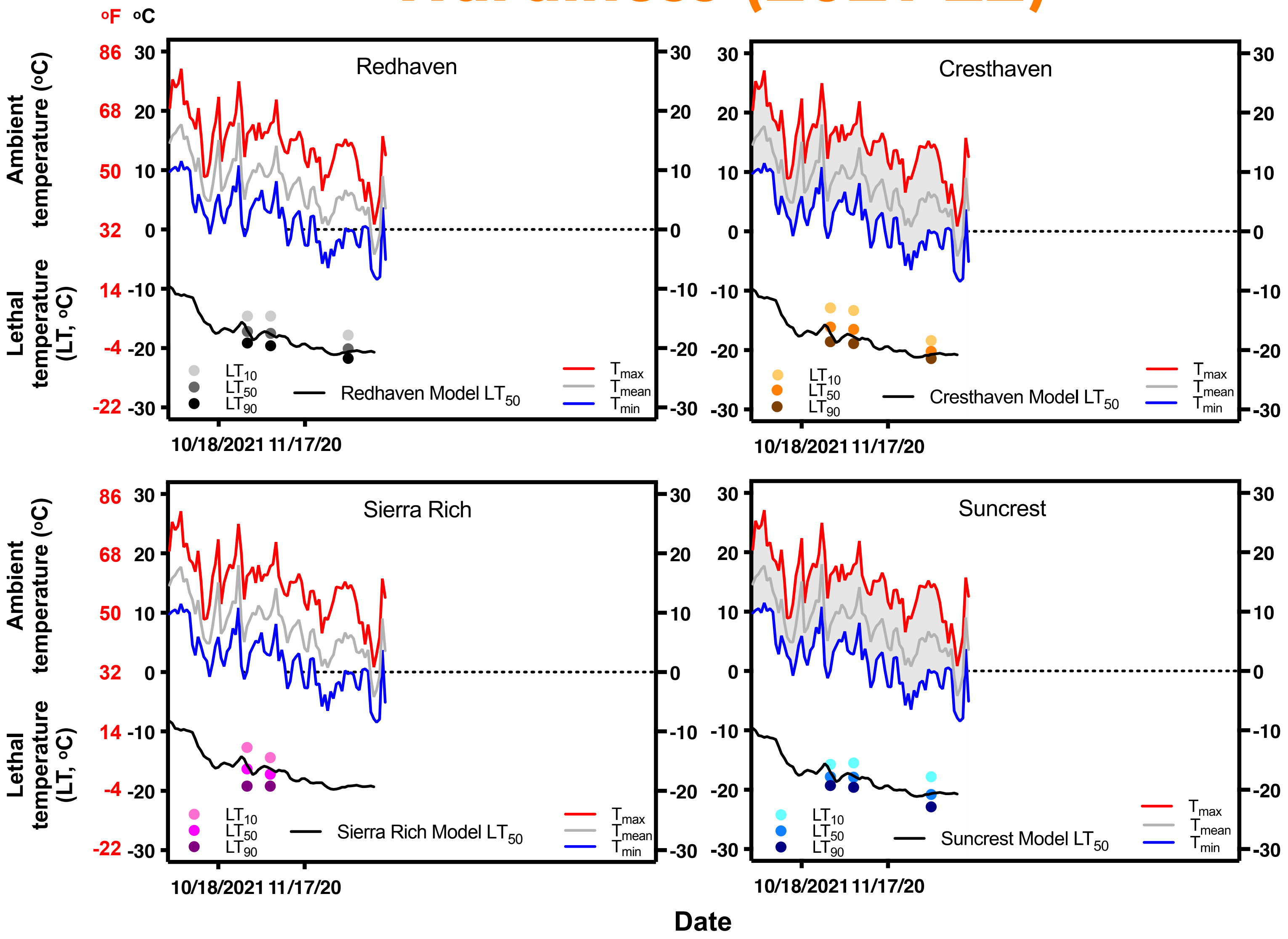
Seasonal Prediction Curves



Sterle et al., 2021. *Submitted to Environmental & Experimental Botany*

Using Developed Models to Predict Current Cold Hardiness (2021-22)



Sterle et al., 2021. *Submitted to Environmental & Experimental Botany*

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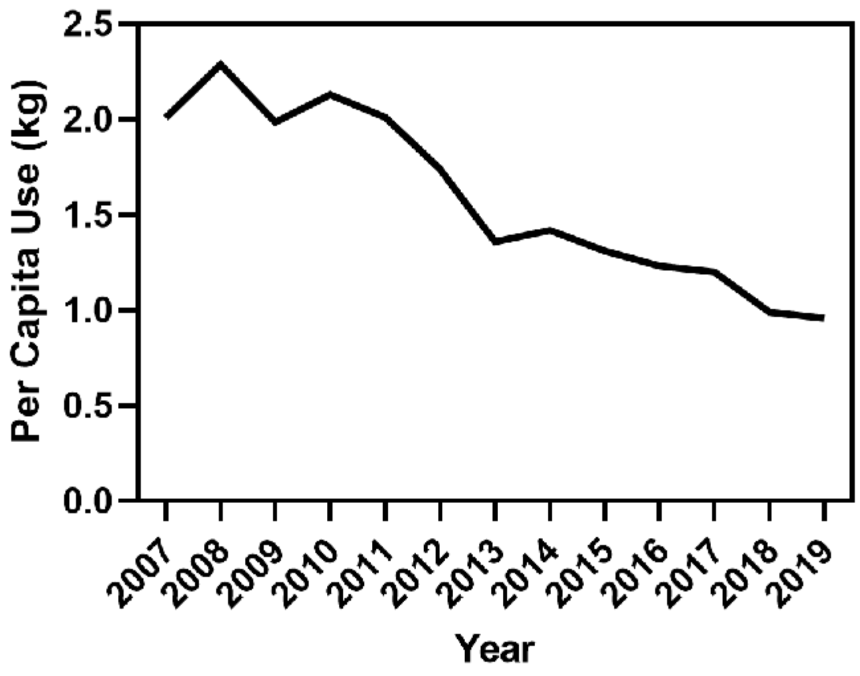
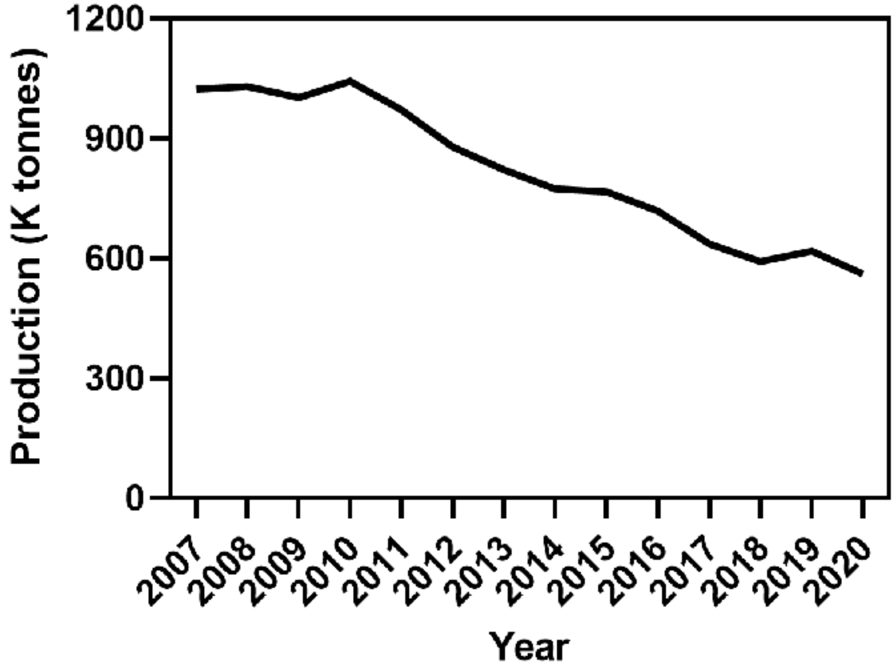
Peach per capita use in USA reduced between 2007 – 2020

- Consumption is falling
- 1.3 kg/capita in 2020



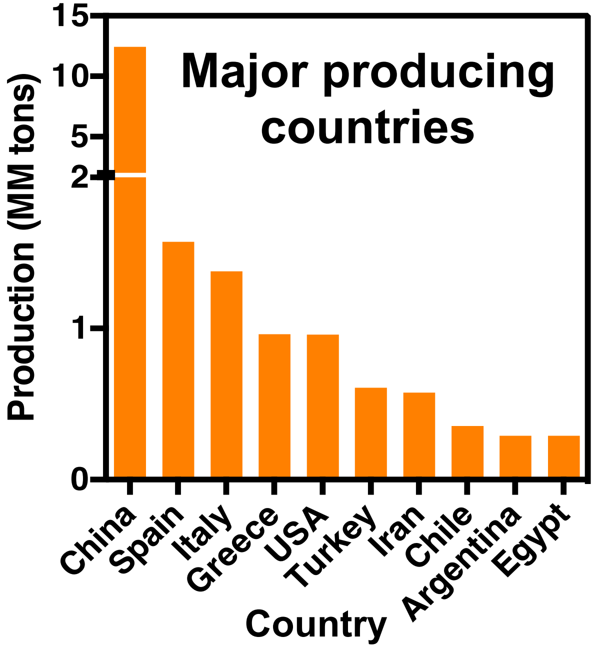
Peach and nectarine production distribution per utilization in US

- Production is falling
- Poor peach quality
- Labor costs increasing

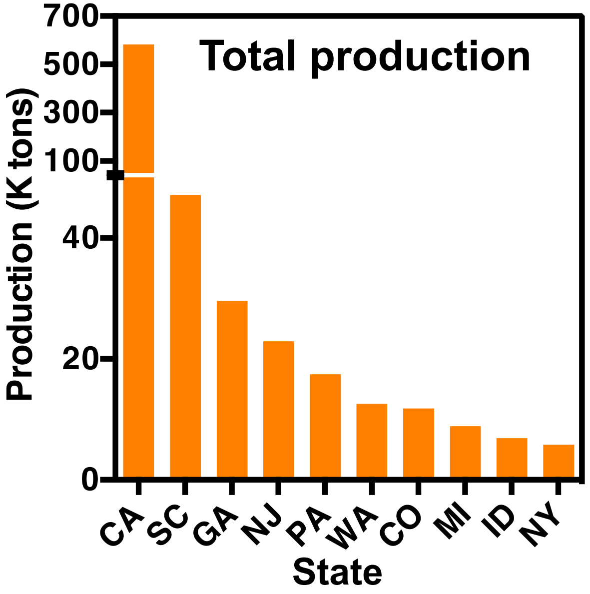


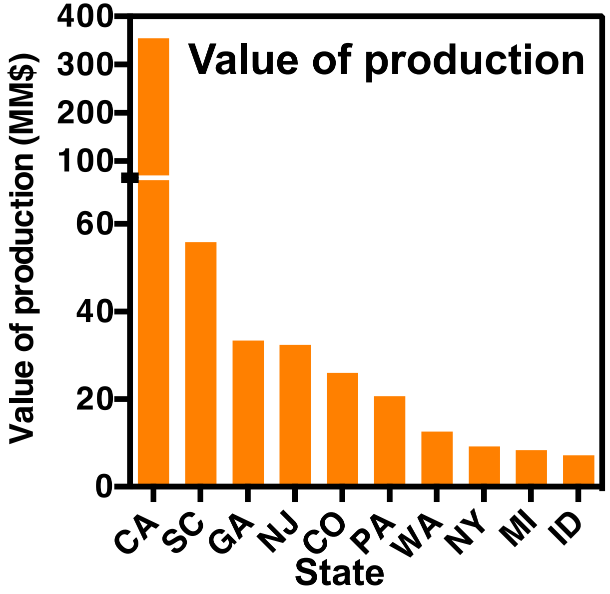
(USDA-NASS, 2017; 2019)

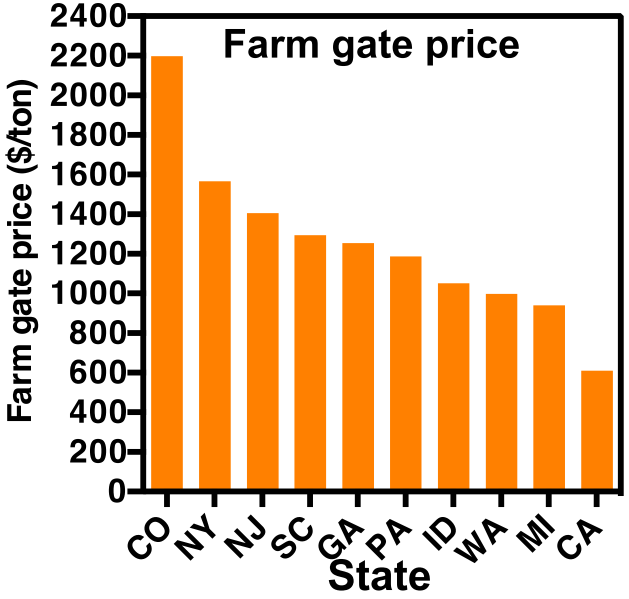
Peach & nectarine production in the world and US



Major producing states in USA*







- National 'farm gate' avg. price = $1.2/kg
- Colorado 'farm gate' avg. price = $2.2/kg
  - $1 difference = ~$15 million (*quality premium*)

***Average values of 2014-17**

Source: FAO, 2019; USDA-NASS, 2019

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