Mitigating climate risks on the farm: tree nut perspective

David Doll
Tree Nut Pomology Advisor
UCCE Merced
Let’s Talk About the Weather...

“It impacts everything we do.”

“Something we can’t control, but....

“something in which we have to manage.”
Let’s Talk About the Climate...

“They can’t even get the weather right, how can they predict climate?”

Various forecasting models are adding to the confusion;

No ability to determine long range forecasts;

Lack of concern for the long term due to day-to-day operation management.

In many cases, not much can be done on a day-to-day basis to manage.
Concerns: Weather v/s Climate

Weather Concerns
• Rain during bloom/harvest
• Spring frost events
• Late season rains

Managed on a day-to-day basis

Climate Concerns
• Flooding/drought
• Warmer winters and springs
• Hotter summers
• Shifting rainfall patterns

Managed on a farm development level
Mitigating Risks: Almond Case Study

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Mitigating Weather: Almond Case Study

Rain during bloom:
- Placement of 2-2.5 strong, 8 frame hives/acre;
- Utilization of fungicides;
- Varieties resistant to disease;
- Diversification of bloom timings.
Mitigating Weather: Almond Case Study

**Spring Frost**

- Almond flowers and nuts are sensitive to freezing temperatures
- Utilize strategies to increase orchard heat (e.g. mow cover crop, use of sprinkler systems)
- Plant later blooming varieties
Mitigating Weather: Almond Case Study

Late season rains
- All agricultural crops are susceptible to diseases, which thrive in warm, wet conditions;
- Use of properly timed pesticides;
- Resistant varieties.
Mitigating Weather: Almond Case Study

Rain During Harvest

- Almonds have to be brought to the processor at a specified moisture level
- Utilization of extra passes to reduce orchard debris, quicker drying time
- Select earlier harvesting varieties.
Mitigating Weather: On-farm Options

Methods of Management:

• Orchard layout and design (e.g. varieties, irrigation systems);
• Increased investment;
• Increased operational costs;
• Increased environmental impact.

Mid-term (10-20 years)

Short-term (1-5 years)

Long-term (20-50 years)
Mitigating Risks: Almond Case Study

**Weather Concerns**
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**Climate Concerns**
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Managed on a day-to-day basis

Managed on a development basis
Mitigating Climate: Almond Case Study

Managing Drought/Floods

- Land selection and purchase;
- Diversification of parcel locations;
- Diversifying water resources on the ranch;
- Installing drainage systems
Mitigating Climate: Almond Case Study

Reduced Winter Chill

Figure 4. Safe winter chill in California's Central Valley in 1950, 2000, 2041–2060 and 2080–2099, calculated with the Dynamic Model.

http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006166
Mitigating Climate: Almond Case Study

**Warmer winters, springs**
- Earlier bloom, increased frost risk;
- Development of low chill varieties/higher spring heat unit accumulation;
- Utilization of heat reflecting products to delay bloom;
- Different disease and insect pressures.
Mitigating Climate: Almond Case Study

**Hotter Summers**
- Impacts on nut quality and rate of development;
- Increased insecticide applications;
- Increased water costs.

![Insect Population Development](image)

More insects, more damage, more sprays, less money!
Mitigating Climate: Almond Case Study

Shifting Rainfall Patterns

- Increases in fungicide and herbicide usage;
- Impacts crop quality and productivity.
Mitigating Climate: On-farm Options

Methods of Management:

- Breeding of varieties; Long (20-50 years)
- Increased capital outlay; Medium (10-20 years)
- Increased farming costs (sprays, chilling options); Short/Medium (5-20 years)
- Choice of crop. Medium/Long (10-50 years)
## Mitigating Climate and Weather

<table>
<thead>
<tr>
<th>Managing Weather</th>
<th>Managing Climate</th>
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<tbody>
<tr>
<td>Orchard layout; Variety selection; Irrigation systems.</td>
<td>New varieties; Better crop modelling; Farm Diversification—crops and location; Infrastructure improvements.</td>
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<tr>
<td>Site selection; New modes of action for pesticides; Techniques to increase chill, decrease sunburn; More efficient farm equipment.</td>
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### Expenses/Research Timeline

<table>
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<th>Low/Short</th>
<th>High/Long</th>
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<tr>
<td>Economics will play a part in adoption of practices.</td>
<td>Farm size will influence the ability to adapt!</td>
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Mitigating Climate and Weather

What we know:
It is going to be expensive
• Crop loss;
• Increased operational expenses;
• Farmers will go out of business.
Changes in cropping patterns will occur.
It will require multiple strategies to manage.

What we need:
Better forecasting to help influence weather based decisions.
More tools to control unknown issues (emerging diseases, pests).
More investment in long term public research (breeding programs, more accurate crop modelling).
Policy that provides support to the industry;
Infrastructure or policy improvements that help manage climate influenced inputs.
Climate Impacts on California Agriculture and Tools for Managing Risks

Tapan Pathak, Ph.D.
Cooperative Extension Specialist - Climate Adaptation in Agriculture
University of California Merced

Email: tpathak@ucanr.edu
Facts about California Agriculture

- 76,400 farms producing more than 400 commodities with a farm-gate value of $54 billion
- Leading producer of almonds and pistachios in the world
- Leading fresh market vegetable producing state
- Leading the nation in milk production, producing 41.2 billion pounds of milk

California's top—ten valued commodities
- Milk — $9.4 billion
- Almonds — $5.9 billion
- Grapes — $5.2 billion
- Cattle, Calves — $3.7 billion
- Strawberries — $2.5 billion
- Lettuce — $2 billion
- Walnuts — $1.8 billion
- Tomatoes — $1.6 billion
- Pistachios — $1.6 billion
- Hay — $1.3 billion
Climate Variability is a measure of shorter term climate fluctuations above or below long term average.

Climate Change is a measure of longer term statistically significant continuous change (increase or decrease) in the measures of climate, such as temperature, rainfall, frequency of extreme events.
- Average temperature across the US has increased at an average rate of 0.13°F per decade.
- Southwest has experienced significant warming.
- Seven of the top 10 warmest years on record have occurred since 1998.
Changes in California Temperatures

Fig. 4 Annual temperature trends (°C dec⁻¹) for the 11 climate regions labeled A-K computed between 1918-2006 for Tmax (left) and Tmin (right), where the trends that are statistically significant at the 95% confidence level are indicated with an asterisk.
Changes in Average US temperatures

Higher Emissions (A2)

2041–2070

Lower Emissions (B1)

MERCE COUNTY

The information in the chart below corresponds to the selected area on the map (outlined in orange).

Historical Average: 62.0 °F
Low-Emissions Scenario: 65.6 °F (+3.6 °F)
High-Emissions Scenario: 68.2 °F (+6.2 °F)

Observed and Projected Temperatures
How can a change of one or two degrees in global average temperatures have an impact on our lives?

For about every 2°F of warming, we can expect to see:

- 5—15% reductions in the yields of crops as currently grown
- 3—10% increases in the amount of rain falling during the heaviest precipitation events, which can increase flooding risks
- 5—10% decreases in stream flow in some river basins
- 200%—400% increases in the area burned by wildfire in parts of the western United States

Source: http://www.epa.gov/climatechange/facts.html
How does temperature increases affect plants?

**Temperature and Plants**

- Crops respond to temperature
  - Photosynthetic rates respond to temperatures
  - Respiration increases with temperatures

http://www.colorado.edu/eeb/courses/4140bowman/lectures/4140-06.html
Trends in Chill Hours

- Around the year 1950, growers in the Central Valley could rely on between 700 and 1200 Chilling Hours.
- By 2000, this number had already declined by up to 30% in some regions.
- Chill Hours are projected to decrease significantly under future climate change scenario.

*Decreasing Chill Hours, 2070–2099*

- Minimum chill hours for almonds, apples, and walnuts.
- Lower Warming Range.
- Medium Warming Range.
- Increasing Emissions.
Length of Growing Season

![Graph showing the deviation from average days in growing season over time, with lines indicating West and East regions. The graph shows a generally increasing trend.]
Since 1901, global precipitation has increased at an average rate of 0.2 percent per decade, while precipitation in the contiguous 48 states has increased at a rate of 0.5 percent per decade.
Extreme Precipitation Indicators

- Graph shows the trend of percent of land area over years (1910-2020).
- The orange line indicates a rising trend in recent decades.
California state wide snowpack is projected to shrink drastically


25% of Sierra snowpack will be lost by 2050

Department of Water Resources, State of California
Climate Information for Managing Risks

- Climate has direct influence on agricultural production

- Integrating climate information into agricultural decisions can enhance agricultural resiliency to climate risks

- However, this information is not always available in a format that is desirable to agricultural producers/decision makers

- Translating climate information into actionable knowledge can greatly enhance growers’ capacity to manage risks and increase productivity
Climate Information Needs

- United States Government Accountability Office – “**USDA faces the challenge of turning the large amount of often technical climate research into readily understandable information.**”

- Decision support processes need to take account of the values and goals of stakeholders, evolving scientific information, and perceptions of risk. *(National Climate Assessment)*

- Climate Change Consortium for Specialty Crops report- “**CDFA should compile a list of grower needs for weather data and forecast products**”
Examples of Agro-Climate Decision Support Systems
Adaptation to Climate Variability - Southeast US
ENSO Adaptations – Example 1
ENSO Adaptations – Example 2

Planting Date Planner

Yield Probability | Phenology Table / Freeze probability

Tomato Spring - Irrigated - Collier County (FL), Soil: Boca Fine Sand - Compare ENSO Phases

Select a planting date:
- Dec 22
- Dec 29
- Jan 6
- Jan 13
- Jan 21
- Jan 28

Select crop:
- Corn
- Cotton
- Peanut
- Potato
- Tomato Pak
- Tomato Spring
- Tomato Winter

Select variety
Select location
Select soil
Irrigation management
Select nitrogen
Select ENSO phase
About crop yield risk

Yield

Probability (%)

Low yield Median yield High yield

Neutral
El Niño
La Niña
ENSO Adaptations – Example 3
Example from the Midwest

Decision Dashboard

U2U_{DST} Suite | Other Decision Resources | Agro-Climate Reports | Weather/Climate Maps | Drought Info | Climate Outlooks | Helpful Links

U2U_{DST} SUITE

Featured Tools and Resources

**Irrigation Investment**_{DST}

The U2U Irrigation Investment DST lets you explore the potential profitability of installing irrigation equipment at user-selected locations across the Corn Belt. Discover how many years from 1980-2010...
Tapan Pathak, Ph.D.
Cooperative Extension Specialist-
Climate Adaptation in Agriculture
University of California Merced

Email: tpathak@ucanr.edu
Using climate information for long-term adaptation planning:

Information needs, modeling capabilities & tools

Kripa Jagannathan - PhD candidate, UC Berkeley

Background

Why to use climate information in long-term planning?
### Climate & Weather Info Are Important

<table>
<thead>
<tr>
<th>Type of information</th>
<th>Farm decisions affected</th>
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</table>
| Weather (days to weeks)                      | • Timing of planting or harvest, fertilizer or pesticide application  
  • Irrigation scheduling                      |
| ![Weather Icon](image)                       |                                                              |
| Weather/Climate (months to years)            | • Crop varieties to plant  
  • Intensity of fertilizer or pesticide or water  
  • Intensify or diversify crops                |
| ![2014 Weather Icon](image)                  |                                                              |
| Climate (10 yrs or longer)                   | • Major capital investment land purchase, irrigation system etc.  
  • Deciding whether or not to farm  
  • Changing farming systems                    |
| ![Climate Icon](image)                       |                                                              |

Source: CGIAR CCAFS
Utility of long-term projections overlooked...

- Information not immediately actionable but go into 5-10 year or longer plans i.e. ‘farm development plans’
- Climate one among many factors influencing decisions
- Uncertainty

Some factors affecting long-term decisions
....BUT UN-PREPAREDNESS CAN BE VERY COSTLY!

Cost of inaction & unpreparedness can be very high!


Informed decisions about uncertain future may be better than uninformed decisions.

Despite uncertainty, long-term projections can provide information on broad trends that help in better planning or preparation.
Farmers’ Information Needs

Interviews with almond growers in the Central Valley
INTERVIEWS

- Semi-structured interviews (Central Valley)
  - Farmers, Farm advisors, industry board members

- Non-random, purposeful, and snowball sampling

INTERVIEW THEMES

- Role of climate info in decision-making
- Relevant climatic variables/metrics
- How to make info on future climate ‘usable’

Preliminary findings (not to be cited or distributed)
CURRENT USE OF WEATHER/CLIMATE DATA

Diversity of growers

Data lovers
“spreadsheet junkie”
“love crunching data”

Farm observers
“crops/soil will speak to us”
“data alone is not that important”

Data indifferent
“can’t do anything about it”
KEY CLIMATIC VARIABLES FOR THE ALMOND CROP

Dormancy (Nov-Feb)
- Chill hours

Bloom & Pollination (Feb-Mar)
- Frost patterns
- Wind, temp, rain

Maturing Nuts (Apr-Jun)
- Temp
- Extremely hot days

Hull-split & Harvest (Jul-Oct)
- Rain or high humidity
- Extremely hot days

Snow pack and water availability.

Long-term projections for such crop-specific climatic variables are not readily available.

GROWERS ARE EXPERIENCING CHANGES IN CLIMATE

- Most said they experienced warmer winters and lesser fog.
- Other key impacts mentioned were:

  - **Hotter springs**
    - Earlier and quicker bloom
    - Pesticide spray timings changed
  - **Hotter summers**
    - Earlier harvest
  - **Snowpack change**
    - Anecdotal
  - **Change in pests/disease paradigms**
Usefulness of information depends on its specificity to context

Not useful
- Broad average temp projections:
  - “Statewide avg temp will increase by 3-5 deg F by 2050”
  - “Winter min temp will increase by 2-4 deg F by 2050”
- Climate info provided without decision-making context

Useful
- Contextualized projections: “Chill hours will reduce by 10 hrs/yr in the next 10-20 yrs”
- Clarify that info is for longer term decision-making scales not day-to-day decisions
**What about uncertainty?**

**Accuracy**
- Need accurate weather not climate.
- Tolerant of uncertainties at climatic time scales

**Risk expression**
- Confidence, likelihood, or scenarios.
- > 60% likelihood ok, 70-80% very good

*“Every predication comes with uncertainty and we work with that all the time”*

*“Yes – I know you do not have a crystal ball”*
Can this information lead to adaptive decisions?

What can you do with the data??

Solutions after prompts

Adjustments
- Crop varieties, rootstocks
- Frost protection
- Efficient irrigation
- Different crops
- Lesser crops
- Abandon farming

Transformation
SUMMARY OF INTERVIEW FINDINGS

There is interest in long-term information if it is context & crop-specific

Projections must transparently include uncertainties/likelihoods/confidence

Farmers may be open to thinking about adaptive actions based on projections

Great value in having open discussions and dialogues with growers!!
CLIMATE MODELING CAPABILITIES

Can models provide “usable” info?: A deeper delve into analysis of chill hour projections
Observed Chill Hours in and Around Fresno

Chill hours per year

Declining trend ~ 10 ch/yr
Future projections for chill hours in Fresno

- **What the models can say:**
  - Broader trends: By 2040 ~ 600 ch/yr, By 2060 ~ 500 ch/yr

- **What the models cannot say:**
  - Year to year variability
  - Chill in a particular year, 5-year or very near-term trends
  - Specific micro-climatic projections

Climate projections will remain somewhat uncertain. However, there are broader trends or patterns that models can predict reasonably well. But is this enough?
CAL-ADAPT TOOL

Platform for climate data and other resources for CA adaptation
CAL-ADAPT

Climate Tools

The tools featured here are built using LDCA downscaled CMIP5 climate change projections. If you are looking for our other Climate Tools (local snapshots, snowpack, wildfire, extreme heat) built with CMIP3 downscaled climate change projections visit cal-adapt.org.

ANNUAL AVERAGES

Explore charts of projected annual averages of maximum temperature, minimum temperature and precipitation for your location.
Sources: Pierce et al., 2014; Lmeh et al., 2015

EXTREME HEAT

Explore charts of projected frequency and duration of extreme heat events for your location.
Sources: Pierce et al., 2014; Lmeh et al., 2015

SEA LEVEL RISE - CalFioD-3D

Explore maps of inundation location and depths for San Francisco Bay Area, Sacramento - San Joaquin Delta and the California coast during near 100 year storm events coupled with projected Sea Level Rise scenarios.
Source: Rockie et al., 2016

SNOWPACK

View a map displaying the projected snowwater equivalent for each year from 2006-2099 for each month of the year using a variety of climate models and scenarios.
Source: Pierce et al., 2014

Fresno extreme heat projections, Temperature degrees of change
Questions for audience:

- Is the tool useful for you to understand extreme heat projections?
  - What information did you find useful, what is not useful?

- What other metrics would you like information on?

- Does such data help you in planning for the future i.e. consider adaptive decisions?
  - {e.g. switching to heat tolerant crops/varieties, temperature management strategies, pest control, irrigation planning, changing cropping patterns, Alter planting and harvesting schedules, etc.}

- Any other comments on useful tools/information that can assist in taking adaptation action?
THANK YOU!

kripajagan@berkeley.edu
Future climate tool, for GDD for tart cherries in Great Lakes Region.

http://pileus.msu.edu/tools/t_future.htm
OTHERS

- Climate-smart farming tools (Cornell University)
  - http://climatesmartfarming.org/tools/

- Useful to Usable Project (U2U)
  - https://mygeohub.org/groups/u2u/tools#U2Utools

- UC Davis Fruit & Nut Research and Information Center
  - http://fruitsandnuts.ucdavis.edu/Weather_Services/chilling_accumulation_models/Chill_Calculators/

Note: Some of these tools only have historical records, or near-time forecasts (not long-term climate projections)
EXTRA SLIDES
Cal-Adapt
For most areas around the state, the climate models project a significant rise in the number of days exceeding what is now considered extremely hot for the given area. Explore how the frequency and timing of extreme heat days and warm nights is expected to change under different emission scenarios for your location.
Past trend and projections for 2030-40

Number of Extreme Heat Days
Area near CALWA, CA, USA
Emissions continue to rise strongly through 2050 and plateau around 2100 (RCP 8.5)

Observed Data (1950-2013), Model Projections (2006-2100)

Extreme Heat Threshold
106.6°F

Average number of days with high above 106.6°F in 1961-1990
4.3

Average number of days with high above 106.6°F in 2030-2040
19

RCP 4.5
Emissions peak around 2040, then decline

RCP 8.5
Emissions continue to rise strongly through 2050 and plateau around 2100
SHORTER TIME SERIES GRAPH

Observed Data (1950-2013), Model Projections (2006-2100)

Extreme Heat Threshold
106.6°F

Average number of days with high above 106.6°F in 1961-1990
4.3

Average number of days with high above 106.6°F in 2040-2050
23

RCP 4.5
Emissions peak around 2040, then decline

RCP 8.5
Emissions continue to rise strongly through 2050 and plateau around 2100
PROJECTIONS FROM DIFFERENT MODELS TO ASSESS UNCERTAINTY
This chart displays a point for each day that exceeds the extreme heat threshold. Time of year between April through October is plotted along the y axis and each year 1950-2100 along the x axis. For most areas around the state, the models project not only an increase in the number of days expected to exceed the extreme heat threshold, but also their occurrence both earlier and later in the season.
The tool shows extreme heat days (EHD) in Fresno. In the past EHD were ~ 4 days/yr, but it is projected to increase to:

- ~18-23 days in 2040-50
- ~ 20-30 days in 2050-60, and so on
TEMPERATURE DEGREES OF CHANGE MAP

TEMPERATURE: DEGREES OF CHANGE MAP

Merced Area
Elevation: 191 ft

MONTH
November

HIGH / LOW

Lock to one location
Metric
Emissions Scenario
LOW
HIGH

Degrees Changed
6.9°F
5.6°F
5.4°F
4.9°F
4.3°F

Low Emissions and GCM Range
High Emissions and GCM Range

Add Chart
THANK YOU!

kripajagan@berkeley.edu