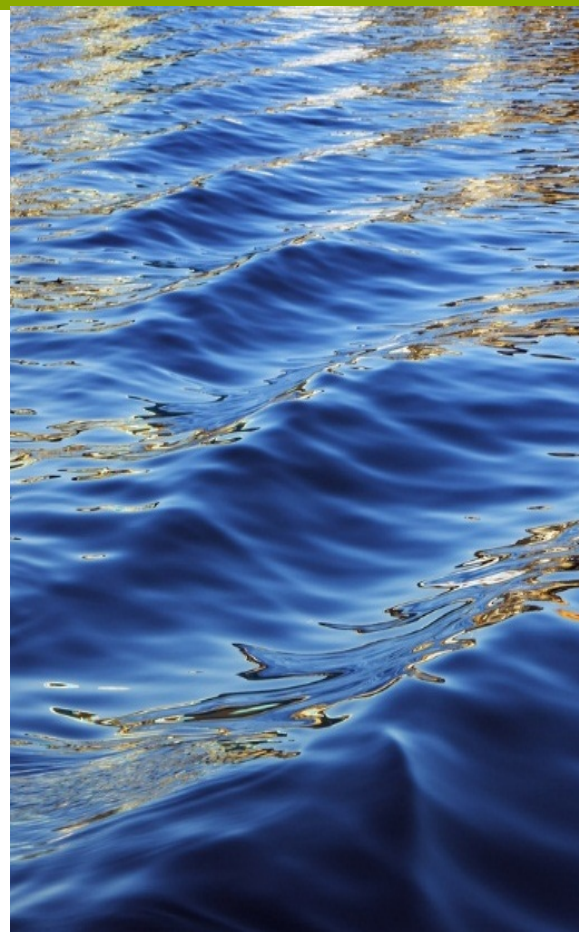
CLIMATE CHANGE CONSORTIUM FOR SPECIALTY CROPS

Impacts and Strategies for Resilience

December 2013



INTRODUCTION AND PRESENTATION LAYOUT

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FINAL REPORT

http://www.cdfa.ca.gov/environmentalstewardship/pdfs/ccc-report.pdf

BACKGROUND - AGRICULTURE IN CALIFORNIA

- Mediterranean climate.
- California is the nation's top agricultural state and has been for more than 50 years.
- A large percentage of farms in the state are smaller compared to the national average; indicative of crop diversity.
- California remained the No. 1 state in cash farm receipts in 2012, with $44.7 billion in revenue.
- The state accounted for 16 percent of national receipts for crops, and 7 percent of the U.S. revenue for livestock and livestock products.
- California's unique combination of fertile soils, various microclimates and irrigation have made it an agricultural wonder.
- More than half the nation's fruits, vegetables, nuts.

BACKGROUND - AGRICULTURE IN CALIFORNIA

- Year-round production in some regions; lemons, artichokes, avocados, broccoli, cabbage, carrots, cauliflower, celery, lettuce, mushrooms, potatoes, spinach, squash

- The most Specialty Crops in the nation; almonds, citrus artichokes, figs, table grapes, wine grapes raisins, kiwi fruit, olives, peaches, pistachios, walnuts, plums, pomegranates

Specialty Crops are defined as;

"fruits and vegetables, tree nuts, dried fruits, horticulture and nursery crops (including floriculture)"

(USDA Agricultural Marketing Service Definition)

BACKGROUND - AGRICULTURE IN CALIFORNIA

Examples of Specialty Crops:

Fruits and Tree Nuts

Almond	Grape (including raisin)
Apple	Guava
Apricot	Kiwi
Avocado	Litchi
Banana	Macadamia
Blackberry	Mango
Blueberry	Nectarine
Breadfruit	Olive
Cacao	Papaya
Cashew	Passion fruit
Citrus	Peach
Cherimoya	Pear
Cherry	Pecan
Chestnut (for nuts)	Persimmon
Coconut	Pineapple
Coffee	Pistachio
Cranberry	Plum (including prune)
Currant	Pomegranate
Date	Quince
Feijou	Raspberry
Fig	Strawberry
Filbert (hazelnut)	Suriname cherry
Gooseberry	Walnut

BACKGROUND - AGRICULTURE IN CALIFORNIA

Examples of Specialty Crops:

Vegetables

Artichoke	Mustard and other greens
Asparagus	Okra
Bean Snap or green Lima Dry, edible	Pea Garden, English or edible pod
Beet, table	Onion
Broccoli (including broccoli raab)	Opuntia
Brussels sprouts	Parsley
Cabbage (including Chinese)	Parsnip
Carrot	Pepper
Cauliflower	Potato
Celeriac	Pumpkin
Celery	Radish (all types)
Chive	Rhubarb
Collards (including kale)	Rutabaga
Cucumber	Salsify
Edamame	Spinach
Eggplant	Squash (summer and winter)
Endive	Sweet corn
Garlic	Sweet potato
Horseradish	Swiss chard
Kohlrabi	Taro
Leek	Tomato (including tomatillo)
Lettuce	Turnip
Melon (all types)	Watermelon

BACKGROUND - AGRICULTURE IN CALIFORNIA

- Agriculture needs to continue to be sustainable;
  - it is an important part of the economic engine of California.
  - produces a diversity of highly nutritious and safe food crops.

California should prepare for Climate Change and associated extreme events.

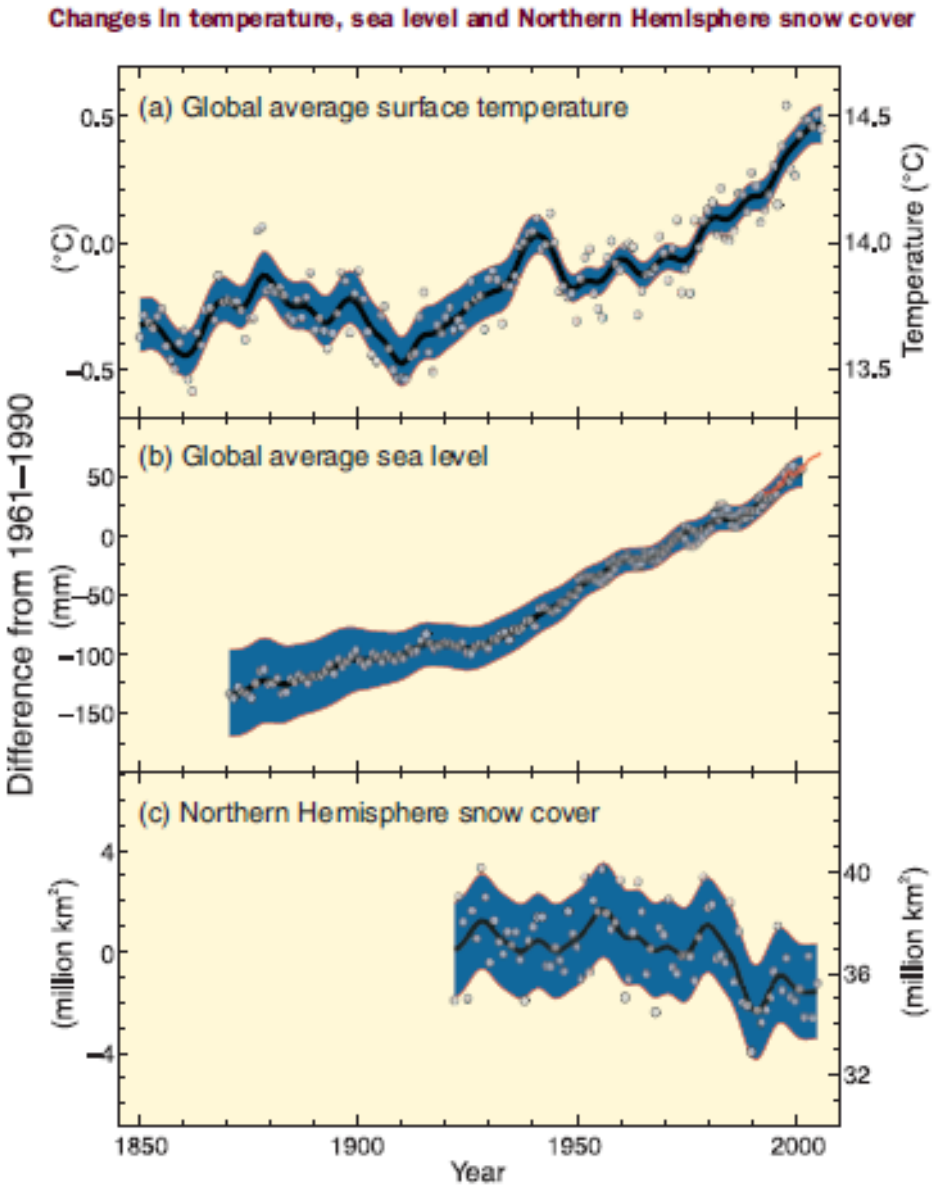
California's Top 10 Agricultural Export Markets, 2011

Rank	Country	Export Value *Millions*	Leading Exports
1	Canada	3,049	Wine, Lettuce, Strawberries
2	European Union	2,214	Almonds, Wine, Pistachios
3	China/Hong Kong	1,382	Almonds, Pistachios, Walnuts
4	Japan	1,415	Rice, Almonds, Beef and Products
5	Mexico	661	Dairy and Products, Processed Tomatoes, Table Grapes
6	South Korea	577	Oranges and Products, Rice, Beef and Products
7	India	360	Almonds, Cotton, Oranges and Products
8	United Arab Emirates	341	Almonds, Walnuts, Hay
9	Turkey	321	Walnuts, Almonds, Processed Tomatoes
10	Taiwan	249	Beef and Products, Almonds, Rice

Table from California Agricultural Statistics Review 2012-2013

BACKGROUND - AGRICULTURE IN CALIFORNIA

OBSERVATIONS - GLOBAL CLIMATE CHANGE



"warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"

IPCC. 2007. Climate Change - Synthesis Report.

OBSERVATIONS - GLOBAL CLIMATE CHANGE

Concentrations of Greenhouse Gases Continue to Increase in the Atmosphere

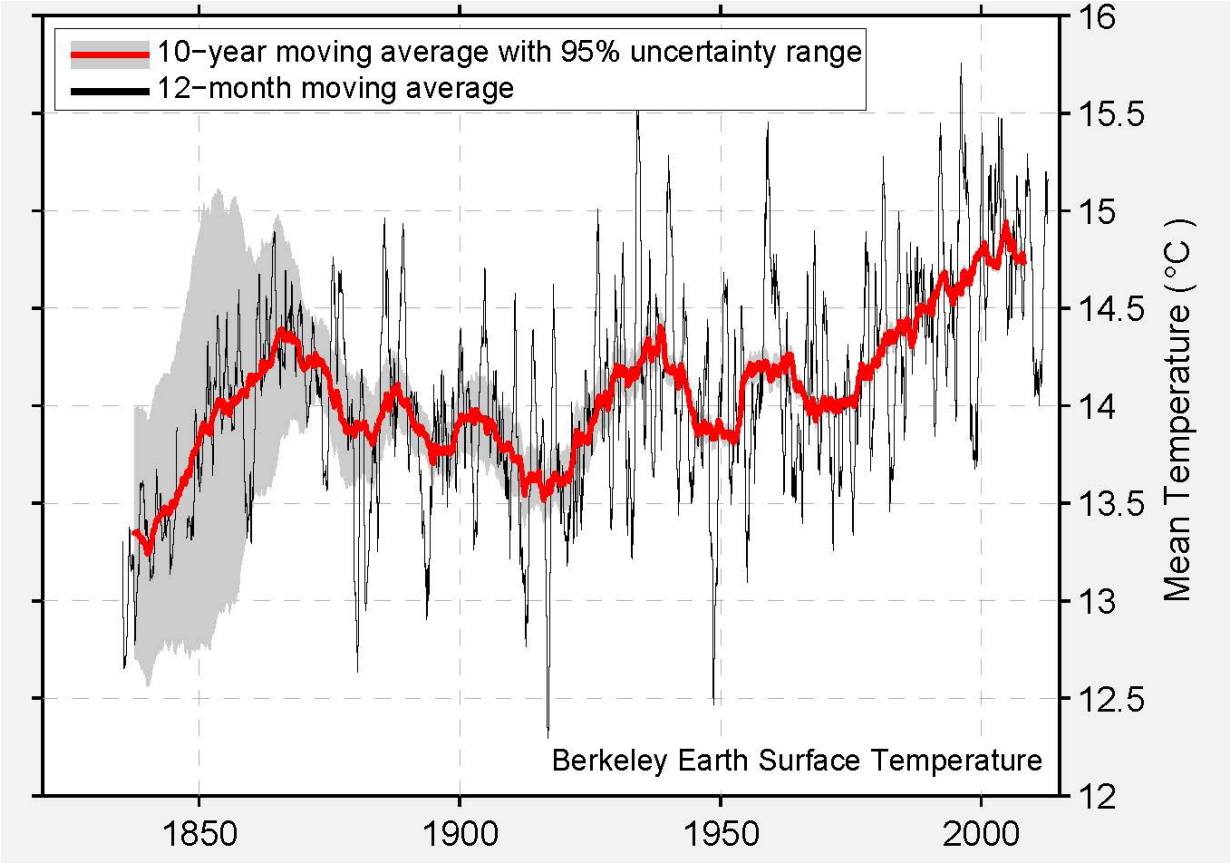
May 2013 - Scientists measure the *average* daily level of atmospheric carbon dioxide at 400 ppm; “scientists know that going back 800,000 years, the carbon dioxide level oscillated in a tight band, from about 180 parts per million in the depths of ice ages to about 280 during the warm periods between. The evidence shows that global temperatures and CO_2 levels are tightly linked.”

Gillis, J. May 10, 2013. Heat-Trapping Gas Passes Milestone, Raising Fears. New York Times

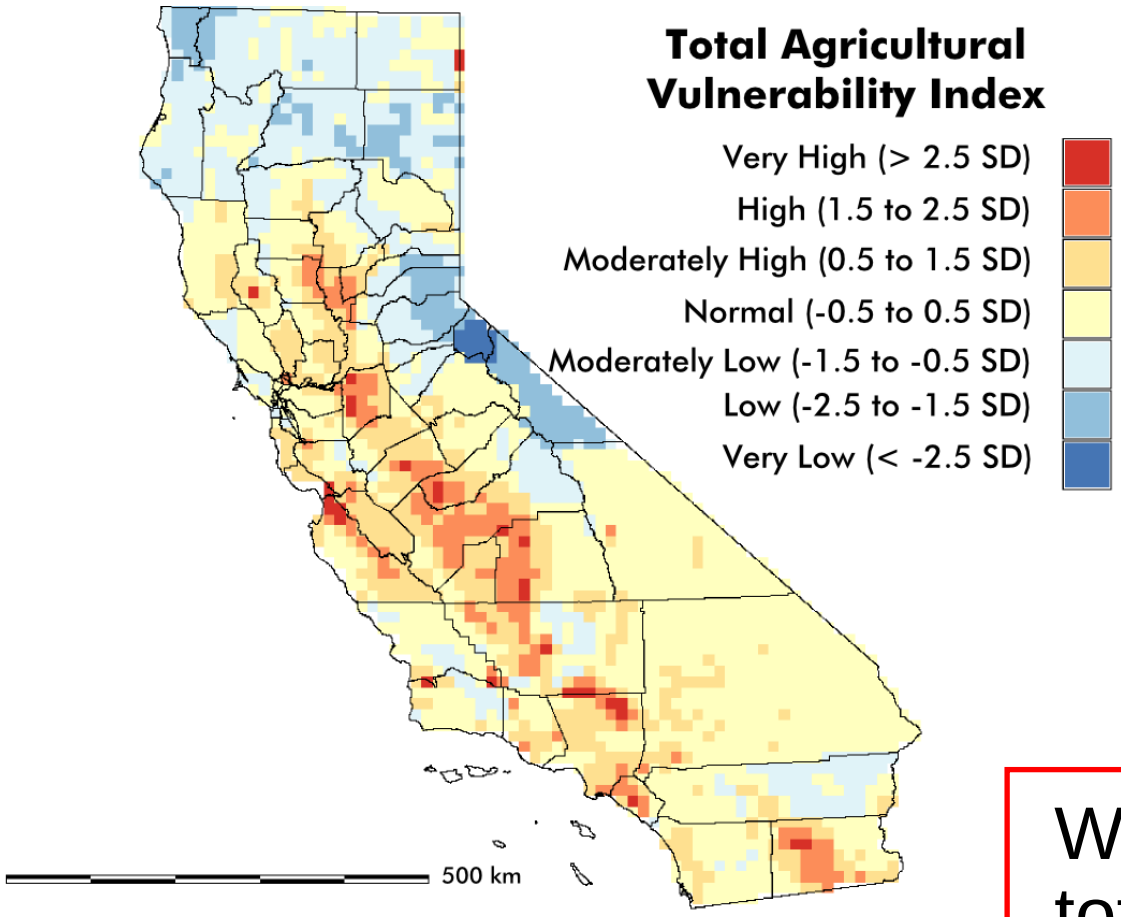
OBSERVATIONS - CALIFORNIA CLIMATE CHANGE

Temperature increase is one variable that is used to measure climate change.

This figure shows the average warming observed in the San Joaquin Valley near Modesto, Merced, and Turlock, California.



PREDICTIONS – CALIFORNIA CLIMATE CHANGE



Vulnerability Index uses 4 sub indices:

1. Climate
2. Crop
3. Land use
4. Socioeconomic

When indices are combined, total agricultural vulnerability in some areas of the state is very high

Jackson, Louise, Van R. Haden, Stephen M. Wheeler, Allan D. Hollander, Josh Perlman, Toby O'Geen, Vishal K. Mehta, Victoria Clark, John Williams, and Ann Thrupp (University of California, Davis). 2012. **Vulnerability and Adaptation to Climate Change in California Agriculture.** ***California Energy Commission. Publication number: CEC-500-***2012-031.

PREDICTIONS - CALIFORNIA CLIMATE CHANGE

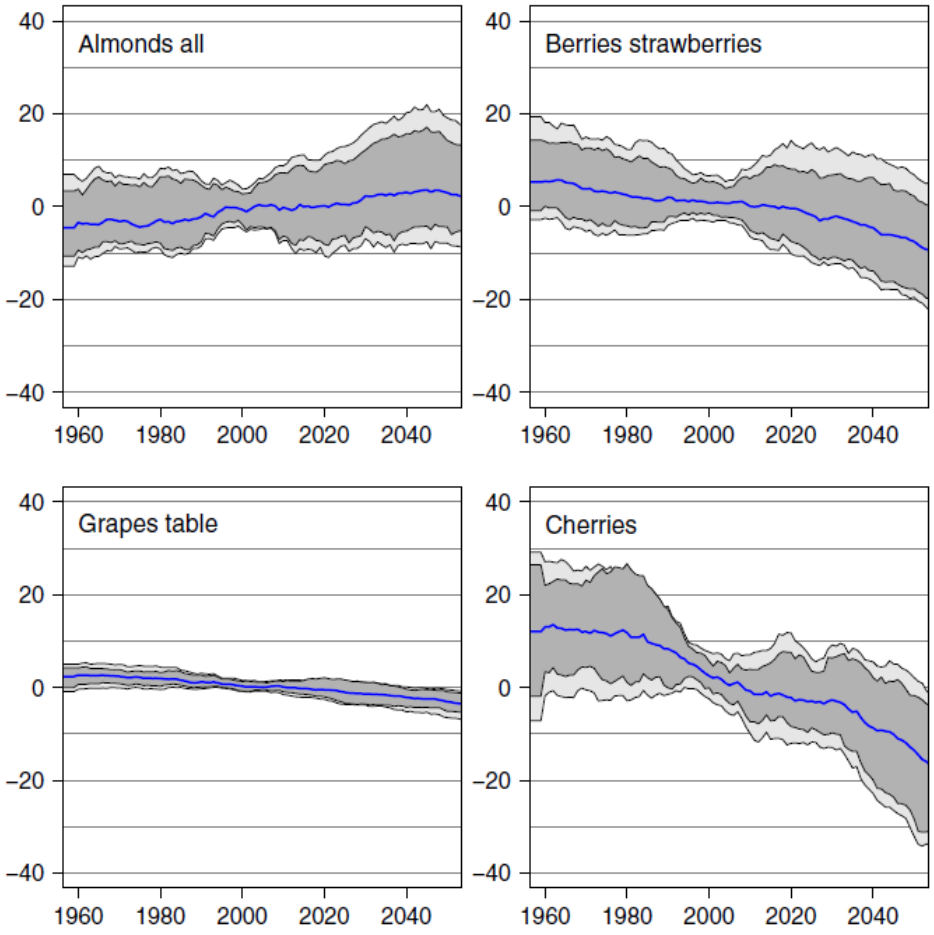


Fig. 9 Simulated change in crop yields for four crops with most reliable crop models. The thick blue line shows the average of all projections, the dark shaded area shows 5%–95% range of projections when using multiple climate models, and the light shaded area shows 5%–95% range when using multiple climate models and multiple crop models (based on bootstrap resampling). The results are presented as percent changes from the 1995–2005 average yields, and as 21-year moving averages in order to emphasize the trend rather than year-to-year variability

Climatic Change (2011) 109 (Suppl 1):S317–S333
DOI 10.1007/s10584-011-0303-6

California perennial crops in a changing climate

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Impacts on Specialty Crops will vary by the specific crop and location.

CONSIDERATIONS FOR AGRICULTURAL SUSTAINABILITY IN CALIFORNIA

1. The importance of California agriculture to food security and the economy.

2. Climate change has been occurring and impacts from extreme events will continue into the future.

3. The agriculture sector is vulnerable to climate change.

Steps should be taken for climate change adaptation.

CDFA CLIMATE CHANGE CONSORTIUM

As a proactive measure to help California agriculture prepare for climate change, CDFA Secretary, Karen Ross, established the Climate Change Consortium for Specialty Crops in August 2011.

The Climate Change Consortium is a group of growers, researchers and representatives from the specialty crop agricultural sector who were asked to evaluate climate change impacts and to propose potential strategies for adaptation under the assumption that climate change is taking place now.

CDFA CLIMATE CHANGE CONSORTIUM

Climate Change Consortium webpage:

http://www.cdfa.ca.gov/environmentalstewardship/ClimateChangeSupplement.html

News Release for membership:

http://www.cdfa.ca.gov/egov/press_releases/Press_Release.asp?PRnum=12-029

News Release of final report:

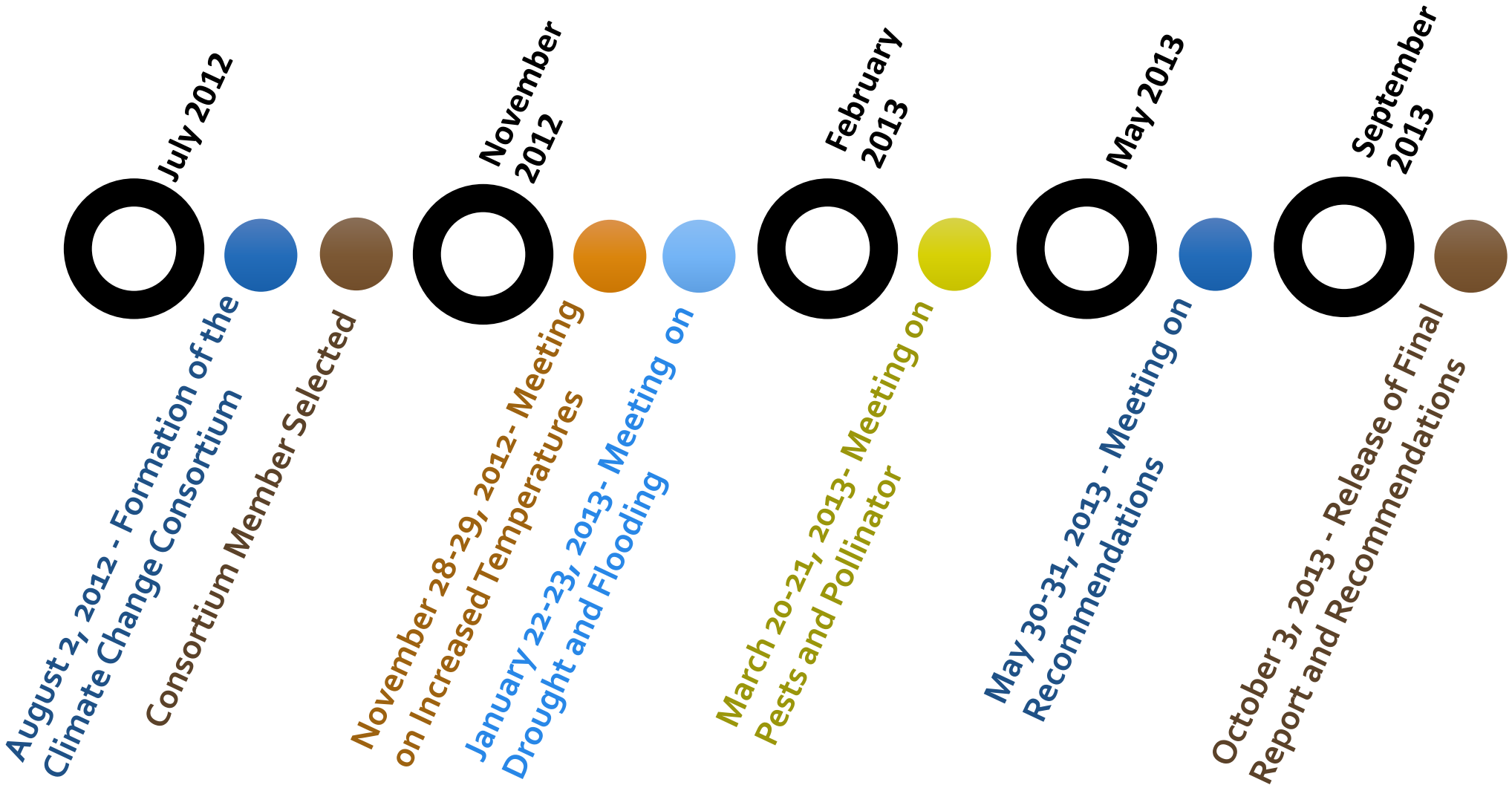
http://www.cdfa.ca.gov/egov/Press_Releases/Press_Release.asp?PRnum=13-032

The Climate Change Consortium is consistent with several other initiatives

CLIMATE CHANGE CONSORTIUM MEETING PROCESS

- Met four times from November 2012 - June 2013.
- At each meeting the Climate Change Consortium heard from scientific researchers and subject matter experts about climate change impacts and potential adaptation measures (if any).
- Discussed increased climate change impacts on temperatures, drought, flooding, pests, and pollinators.
- Break out groups and roundtable discussions were used to discuss climate change impacts and formulate recommendations.

CLIMATE CHANGE CONSORTIUM MEETING PROCESS



CONSISTENCY WITH OTHER INITIATIVES

Strategy 9

Assure Agricultural Adaptation to Climate Change

"Assure that all sectors of California agriculture can adapt to the most likely climate related changes in seasonal weather, water supply, pests and diseases, and other factors affecting agricultural production."

CHALLENGES - INCREASED TEMPERATURES

- Increased average, minimum, and maximum temperatures in all seasons;
- Increased temperature variability;
- More frequent and longer-lasting heat waves in the summer;
- Reduced number of winter chill hours and fog;
- Uncertainty in temperature change projections and forecasts;
- High spatial variability of climate change and impacts of climate change;
- Can effect crop fertility, quality and yields.

Los Angeles Times | LOCAL

Climate change could put the heat on California crops

Fruit and nut orchards in the Central Valley rely on winter chilling hours, but those are in decline, according to a UC Davis study.

Winter chill is the number of hours of cold temperatures below 7°C / 45°F. Many of California's fruit and nut crops are dependent on a certain number of winter chill hours every year.

Only 4% of the Central Valley is now suitable for apples, cherries and pears, all high-chill fruits that could once be grown in half the valley, according to the UC Davis study.

By the end of the century, UC Davis study says, "areas where safe winter chill exists for growing walnuts, pistachios, peaches, apricots, plums and cherries are likely to almost completely disappear."

San Joaquin Valley walnut farmer Chris Locke has noticed a change in the weather, with less frigid fog and more sunny days. Winter chilling hours have declined as much as 30% since 1950 in large swaths of the Central Valley, according to a UC Davis study. (Robert Durell / July 20, 2009)

Climatic Changes Lead to Declining Winter Chill for Fruit and Nut Trees in California during 1950–2099

Eike Luedeling[1,2]*, Minghua Zhang[1]*, Evan H. Girvetz[3]

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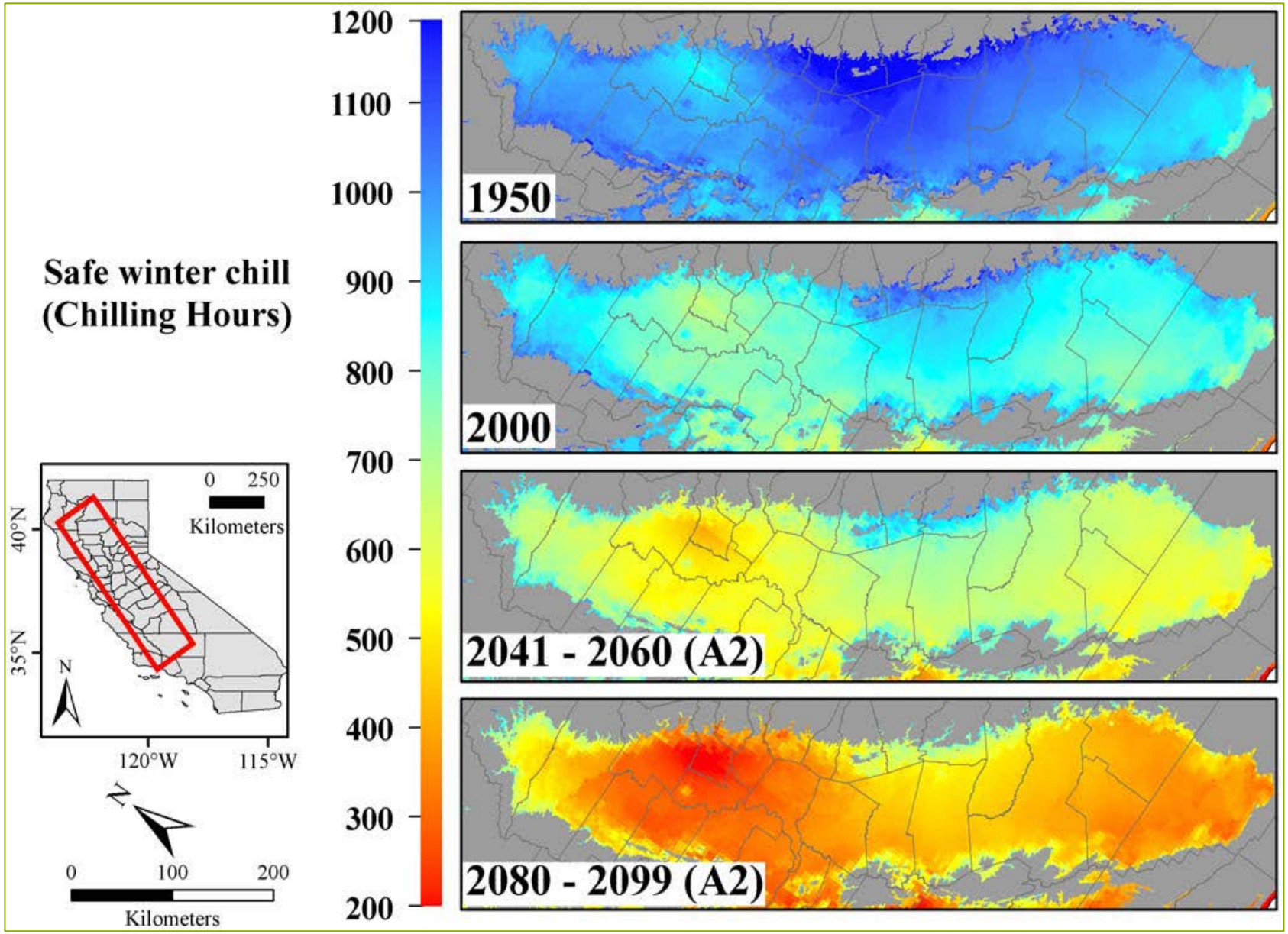


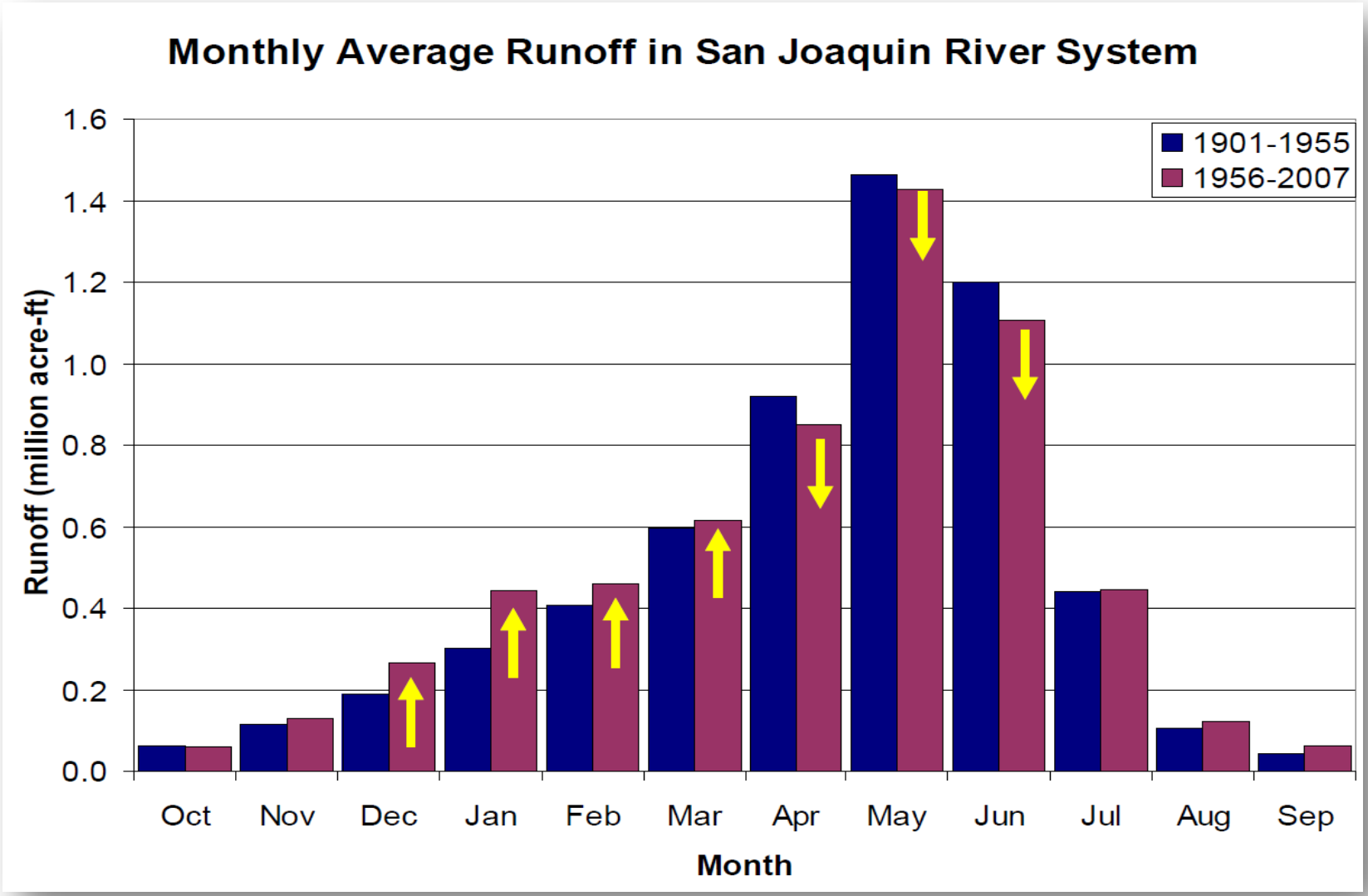
SOLUTIONS AND RECOMMENDATIONS INCREASED TEMPERATURES

- Crop breeding for increased heat tolerance of perennial and annual crops;
- Research plots for management practices that reduce impacts of increased temperatures;
- Literature review and additional research on the impact of high temperatures on crop fertility;
- Maintain the traditional use of rest breaking materials in crops that are impacted by reduced chill hours;
- Develop low-chill tolerant varieties of certain crops.

CHALLENGES - WATER RESOURCES

- Reduced precipitation (drought) or increased precipitation (floods);
- Decreased winter snowpack, altered (earlier) timing of snowmelt and spring river runoff, and reduced spring runoff;
- Variable precipitation and snowpack accumulation from more variable temperatures;
- Altered reservoir storage regimes;
- Reduced natural groundwater recharge;
- Reduced water quality due to reduced fresh water supplies;
- Uncertainty in existing predictions.

Historical monthly river runoff in the San Joaquin River showing an increase in winter flow since 1956 and a decrease in spring flow.



Anderson, Michael. 2013. “Climate Change, Floods and Adaptation” presented at the California Department of Food and Agriculture Climate Change Adaptation Consortium, January 23, Monterey, CA.

Due to shifting patterns in precipitation, water management will also shift; changing the current balance between flood control and water storage.

Flooded homes and farmland at Sutter Buttes, California.
California Department of Water Resources

Image from: American Society of Civil Engineers (2009), *So, You Live Behind a Levee!*, http://content.asce.org/ASCELeveeGuide.html

SOLUTIONS AND RECOMMENDATIONS WATER RESOURCES

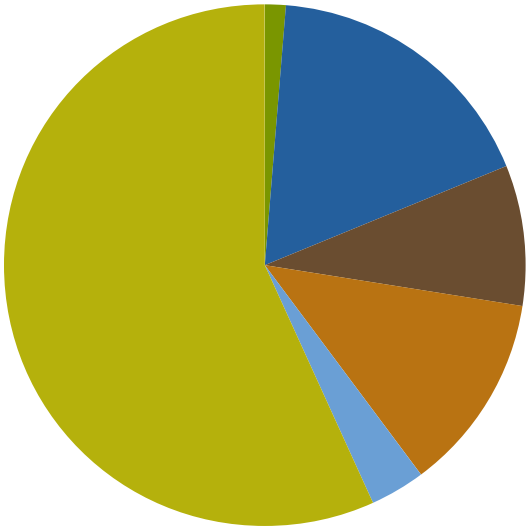
- Participate in a regional approach to water management;
- Groundwater recharge projects;
- Water recycling;
- Consider changes to water distribution systems;
- Forest management to maximize available water resources;
- Water conservation outreach and education;
- Flood plain outreach and education;
- Pilot projects and crop breeding.

CHALLENGES - PESTS AND POLLINATORS

- Altered temperatures and water availability will have direct impacts on individual plant, pest, and pollinator species;
- Climate change will alter inter-species dynamics and the larger ecosystems upon which agriculture depends;
- Conventionally grown, monoculture agriculture will likely be more vulnerable to pest and pollinator changes;
- Climate change impacts to plant, pest, and pollinator species are complex and unpredictable;
- Over-reliance on managed pollinators (e.g., honeybees) poses a potential risk to agriculture in light of climate change.

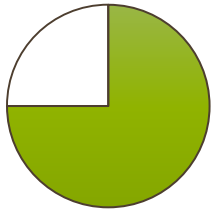
California Specialty Crops Rely Heavily on Pollination

California vegetable crops



- Essential
- Great
- Modest
- Little
- Unspecified
- No increase

40% by value



Globally, 75% of crop species

N L M G E

0 estimated reliance on pollination (%) 100

Klein et al. 2007; Chaplin-Kramer and Kremen 2011

A warmer climate will create more degree-days for pests. Some pests will have more generations each year.

Codling moth lifecycles will increase from 2-4 generations per year to 3-5 per year. Navel orange worm, and mites will also increase in generations (Luedeling et al 2011).

Images from UC IPM; http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7412.html

SOLUTIONS AND RECOMMENDATIONS PESTS AND POLLINATORS

- Fund and maintain strong pest detection and exclusion programs;
- Public outreach regarding invasive species;
- Pest forecasting and biological control;
- Provide habitat for and pollinators and other beneficial species;
- Crop breeding for pest resistance;
- Diversify pollinators by using native and managed pollinators;
- Establish pollinator habitats;
- Support research studies into honeybee health in relation to nutrition, genetics, disease, and pesticides.

Pollinator habitats

Photo courtesy of Mary Fahey, Wise Acre Farm, Arbuckle

Hedgerow alongside an almond orchard

Photo courtesy of John Anderson, Hedgerow Farms

Pollinator strip planted beside crops

TEN HIGHEST PRIORITIES ESTABLISHED BY THE CLIMATE CHANGE CONSORTIUM

1. Support economic and environmental studies of the costs, benefits, and risks of adaptation strategies;
2. Facilitate a reinvestment in grower technical assistance and trainings specific to climate change adaptation;
3. Include grower interests in the Integrated Regional Water Management discussions;
4. Perform or fund a review of regulatory barriers to adaptation mechanisms, such as food safety and other regulations;
5. Facilitate interagency coordination on the recommendations of the Climate Change Consortium;

TEN HIGHEST PRIORITIES ESTABLISHED BY THE CLIMATE CHANGE CONSORTIUM

6. Compile a list of grower needs for weather data and forecast products;
7. Develop research plots to study adaptation strategies and new technologies and products;
8. Promote farmland conservation;
9. Recognize growers who develop or adopt novel strategies to adapt to climate change;
10. Support USDA NRCS in a review and/or creation of policies to improve growers' ability to adapt to climate change.

CLIMATE CHANGE CONSORTIUM RECOMMENDATIONS

FINAL REPORT

http://www.cdfa.ca.gov/environmentalstewardship/pdfs/ccc-report.pdf

- **OUTREACH AND EDUCATION**

Pages 50 through 54 of final report

- **PLANNING AND RESOURCE OPTIMIZATION**

Pages 55 through 57 of final report

- **RESEARCH NEEDS**

Pages 58 through 60 of final report

- **TECHNOLOGY AND INNOVATION**

Page 61 of final report

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

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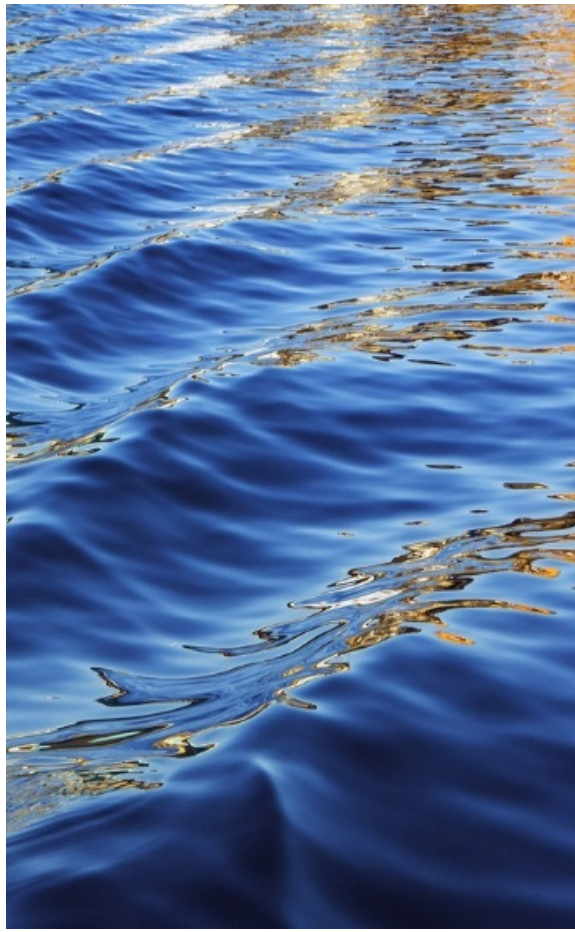

CDFA is grateful to the Consortium members, scientific researchers and subject mater experts who volunteered their time to this proactive work.