Agricultural Impacts and Adaptation Options

Draft CEC PIER-EA Discussion Paper

Louise Jackson
UC Davis

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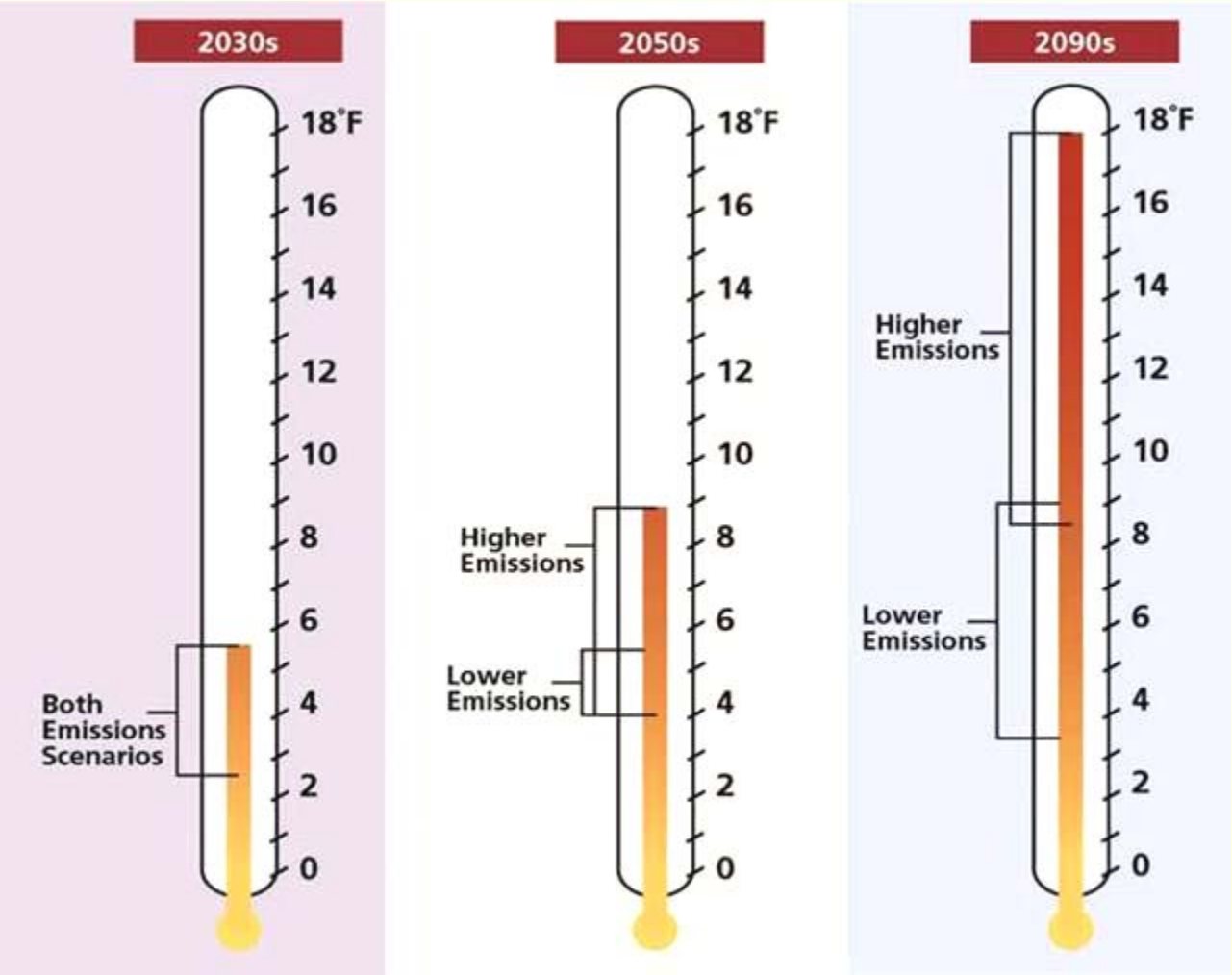
California's unique agroecosystems in a changing climate

- Can California's agricultural production respond successfully to climate change?

- Can California achieve agricultural sustainability as the climate changes?

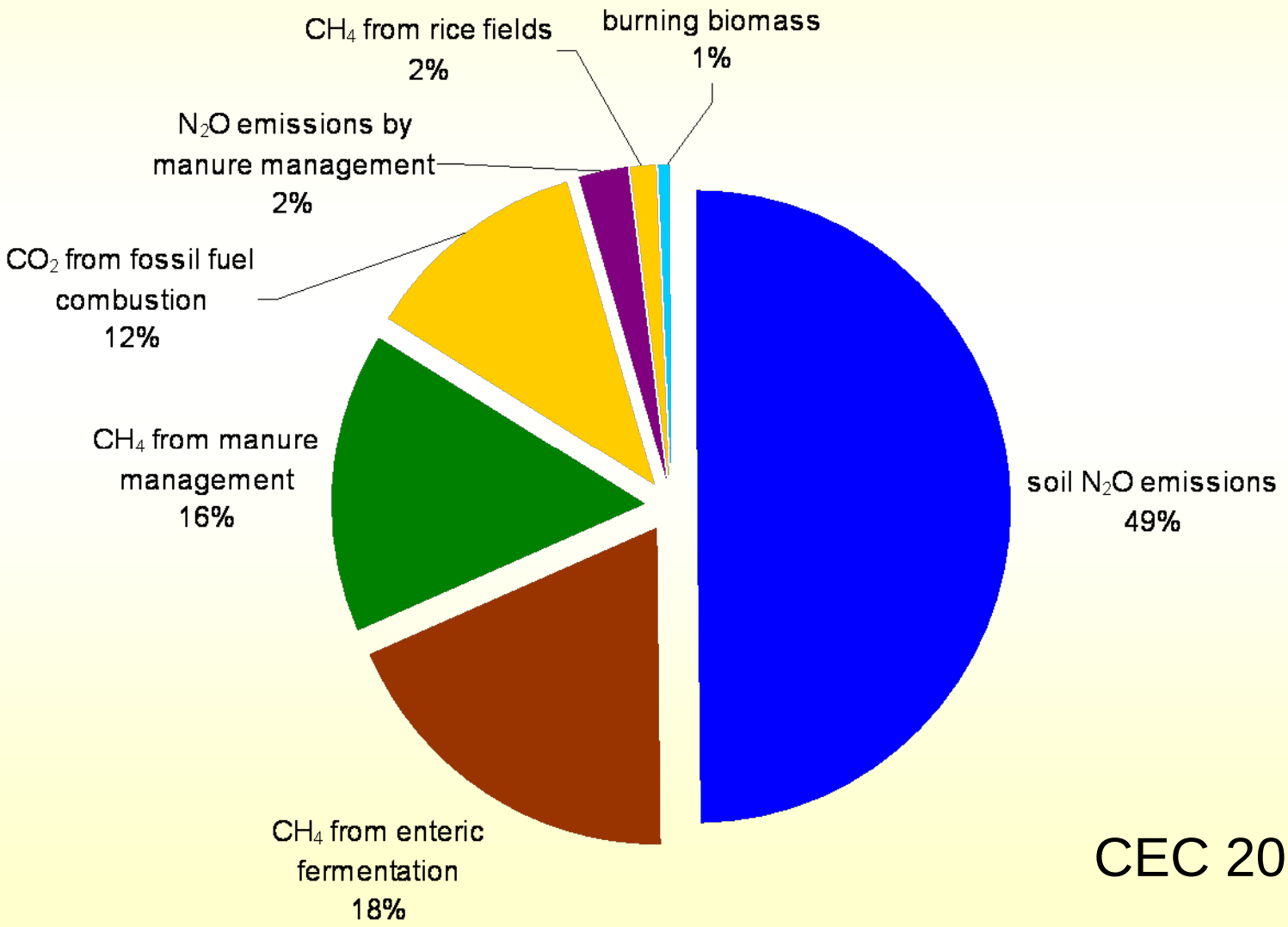
Rising temperatures

Projected average summer temperature changes; California statewide

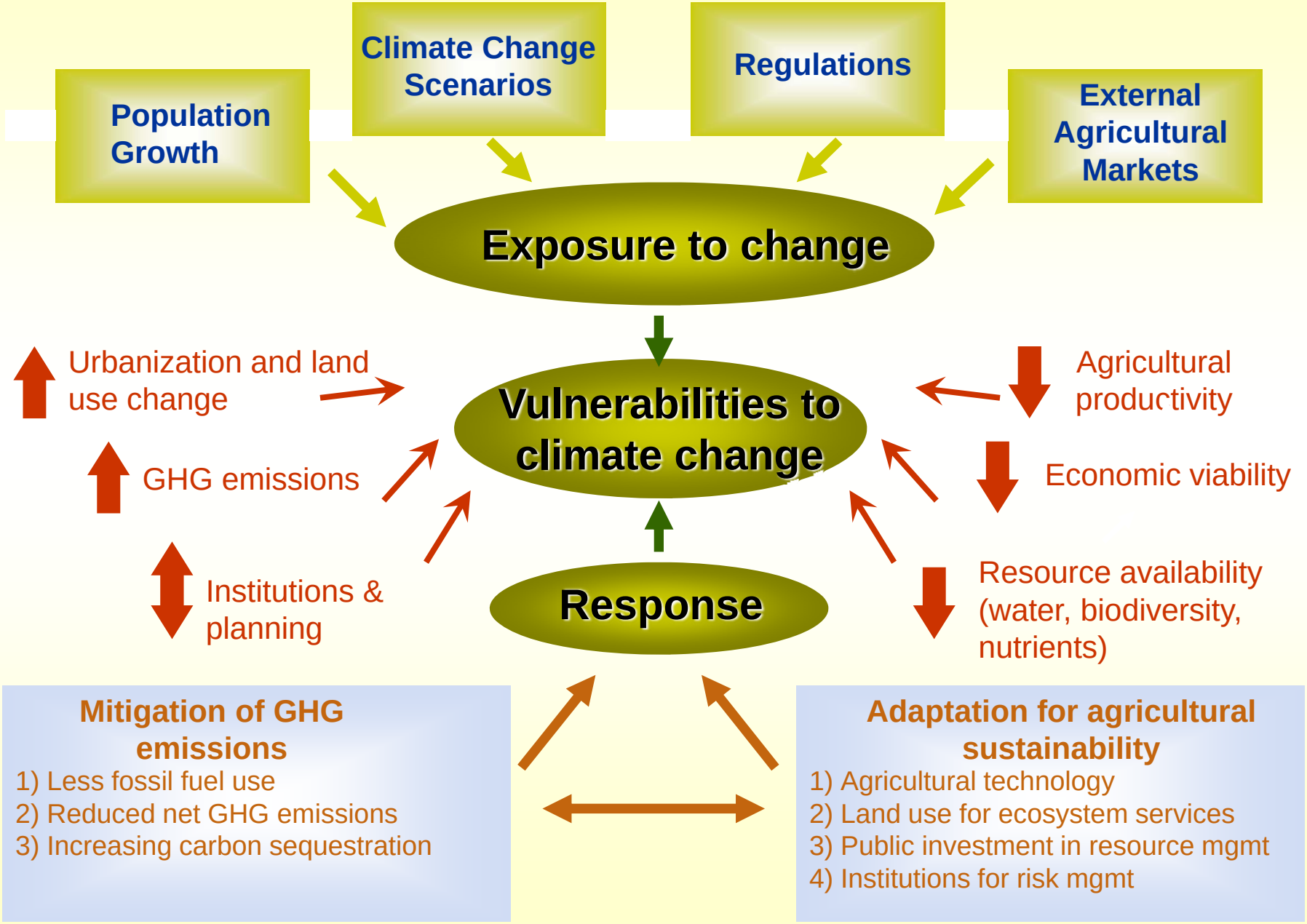


Hayhoe et al. 2004; UCS 2005

Agricultural GHG emissions



CEC 2006a


Population Growth
Climate Change Scenarios
Regulations
External Agricultural Markets
Exposure to change
Urbanization and land use change
GHG emissions
Institutions & planning
Vulnerabilities to climate change
Agricultural productivity
Economic viability
Resource availability (water, biodiversity, nutrients)
Response
Mitigation of GHG emissions
1) Less fossil fuel use
2) Reduced net GHG emissions
3) Increasing carbon sequestration
Adaptation for agricultural sustainability
1) Agricultural technology
2) Land use for ecosystem services
3) Public investment in resource mgmt
4) Institutions for risk mgmt

PIER research to date

- Greenhouse gas (GHG) mitigation strategies
  - Soil carbon sequestration
  - Modeling of soil CO_2 and N_2O emissions
  - Manure management for CH_4 emissions
- Water supply for agriculture and economic impacts
  - CALVIN model, WEAP model
- Crop responses to elevated CO_2 and temperature
  - A few crops and cropping systems, a few traits
  - A few examples of disease and insect pest risks
- Cross-sector adaptation strategies for agricultural landscapes (starting point)
  - Linking biophysical and social science
  - Decision support tools

Key topics for agriculture and climate change in California

- Crop and livestock responses to rising temperatures and CO_2 concentrations
- GHG emissions and carbon storage in California agriculture
- Regional-scale impacts of global climate change on irrigated agriculture
- Regional land use and food systems

Crop and livestock responses to rising temperatures and CO_2 concentrations

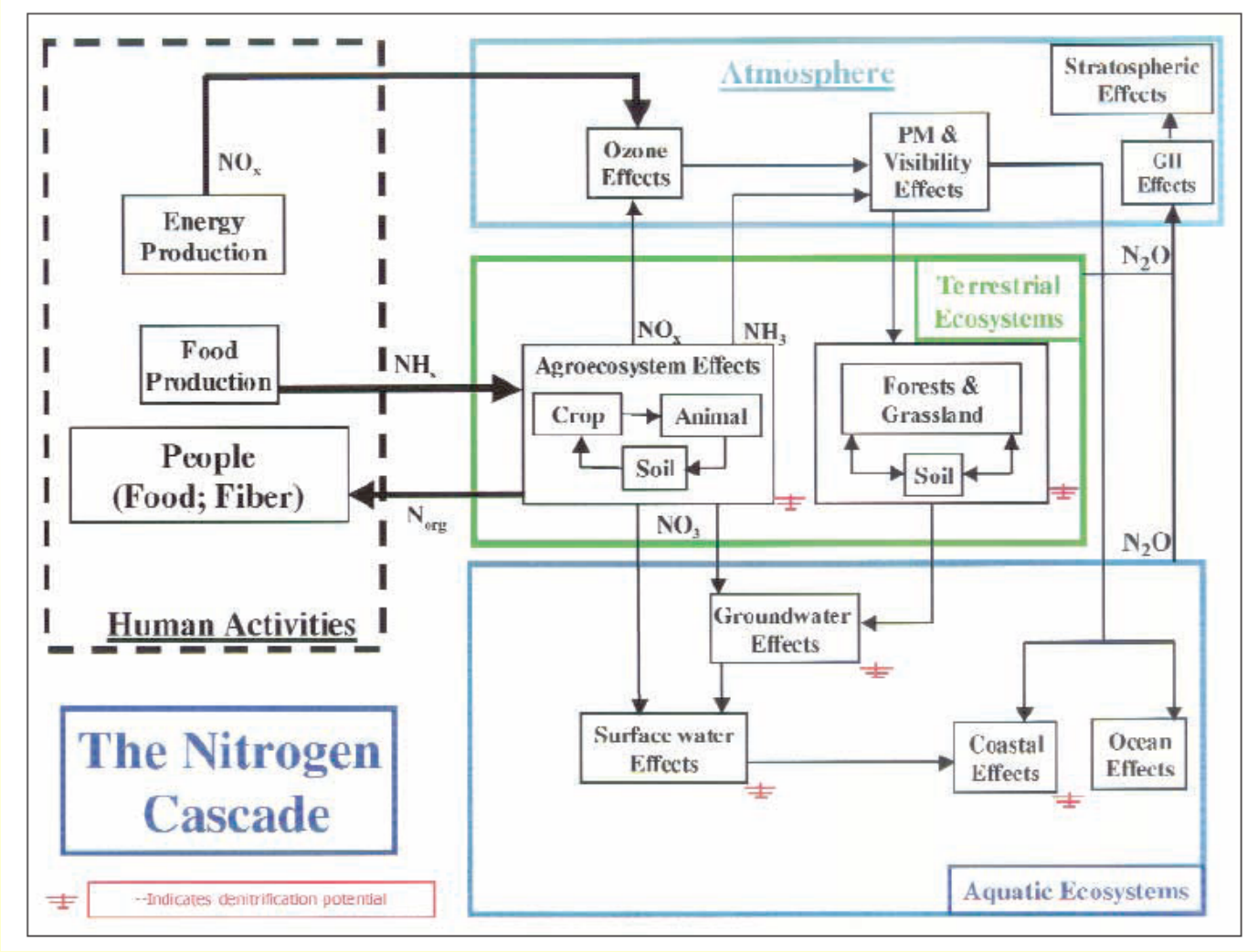
- Productivity of California's diverse crops
  - Growth responses to elevated CO_2,
  - Effects of higher temperatures and water stress
  - Carbohydrate "sink limitation"
  - Soil nitrogen limitation (changes in soil/microbe/root biology, and capacity for nitrate assimilation)
  - Ozone and salt sensitivity
- Physiological response of livestock to warmer temperatures and drought, forage quality of rangeland, and abundance of feed crops
- Networks and databases to monitor and model phenology of crops, quality, diseases and pests

GHG emissions and carbon storage in California agriculture

- GHG (especially N_2O) emissions and carbon storage under irrigation and fertilization practices used on actual farms
- Database of fertilizer, manure and fossil fuel inputs for California's many types of commodities
- Full impact of the agriculturally-driven "nitrogen cascade"
- Life cycle analysis for biofuel crops and tradeoffs e.g., economic profits and other ecosystem services
- Accounting mechanisms for agricultural participation in the statewide cap and trade system for reduction of GHG emissions

“Nitrogen Cascade”

Nitrogen cascade showing nitrogen processes as a nitrogen atom is converted from a nonreactive to a reactive form (Galloway et al. 2003).



Regional-scale impacts of global climate change on irrigated agriculture

- Water supply under different adaptive management scenarios (e.g., groundwater pumping and land fallowing)
  - Downscaling of GCM climate projections for watersheds at risk
  - Modeling of crop water demand along with regional hydrological modeling
- Monitoring systems for changes in air quality and ocean currents that may be driving changes in weather patterns that influence the timing and availability of water resources
- Effects of water transfers and alternative soil and water management practices on energy use
- Economic tradeoffs of local vs. statewide impacts of climate change on hydrology and water availability

Regional land use and food systems

- County-level assessments of climate change impacts on agricultural landscapes
  - GIS analysis
  - Models and templates
- Monitoring and inventory systems for changes in commodities and agricultural practices
- Energy efficiency at the regional scale
  - Distribution centers, transportation
- Recycling of end products
- Vulnerable commodities and communities
  - Climate, demographic and land use projections

Conclusions

- Foresight, planning and investment may maintain the productivity and diversity of California's agricultural sector
- Horticultural crops require more emphasis than field crops
- Water resources and water quality are the most crucial factors requiring adaptation
- Greater research emphasis on adaptation strategies, energy efficiency than GHG emissions reduction
  - Integration of adaptation solutions across farm, regional, and statewide scales

Prioritized recommendations

- Develop information and databases to be used with GCMs to forecast vulnerabilities of agriculture to climate change for California crops and agroecosystems
  - Current information is not adequate for planning adaptation strategies
- Engage the agricultural community in how to combine mitigation and adaptation strategies
  - Monitoring networks for crops and livestock
- Conduct life cycle analysis and full impacts for energy use and GHG emissions
  - “Nitrogen Cascade”
  - Wide range of crops, facilities, and transportation
- Understand land use change and impacts on food systems, marketing, and ecosystem services that provide environmental, cultural and aesthetic value