



California Agriculture and Climate Change: Impacts, Policy and Solutions

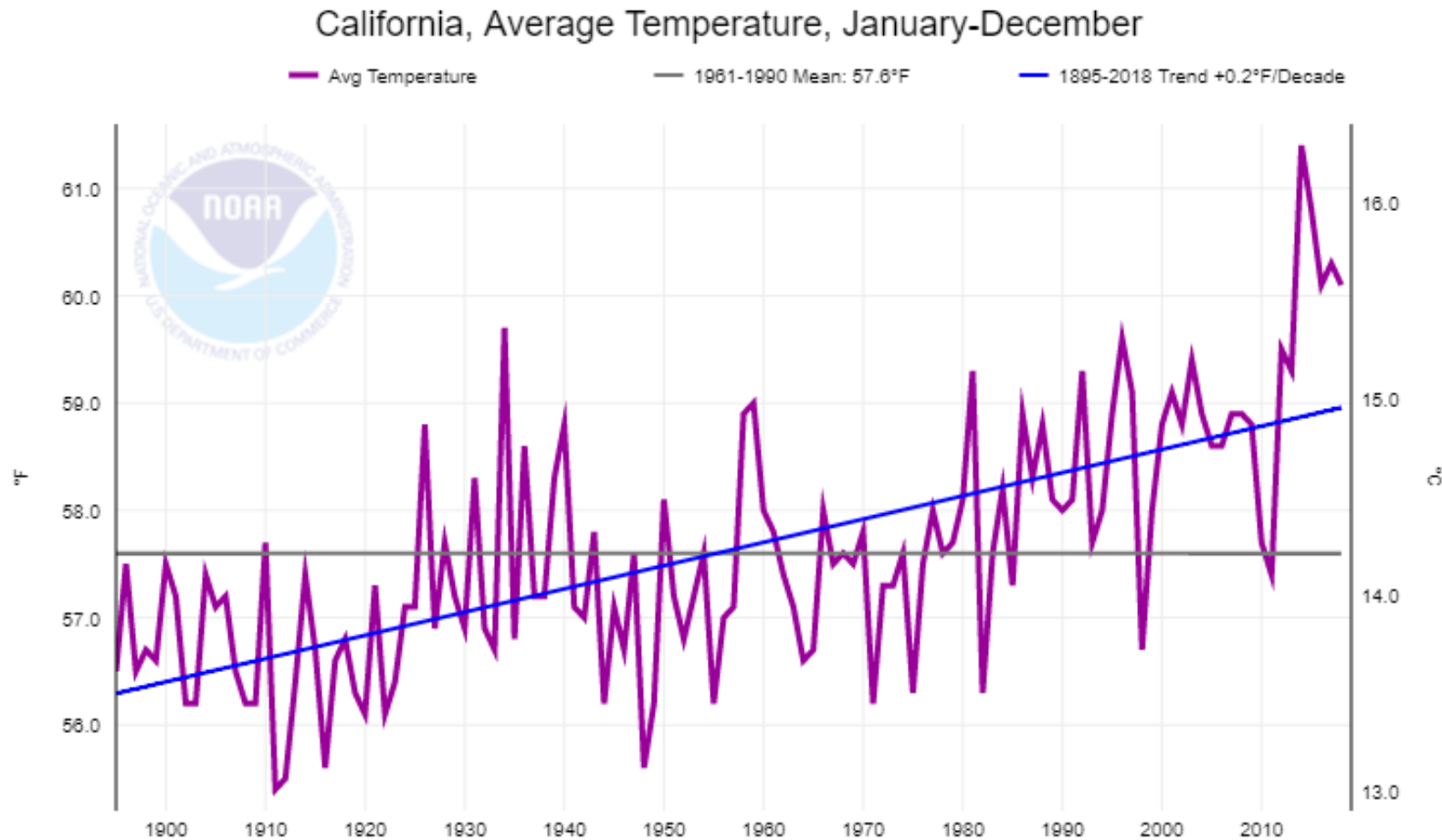


UC DAVIS
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Climate change has entered our living room

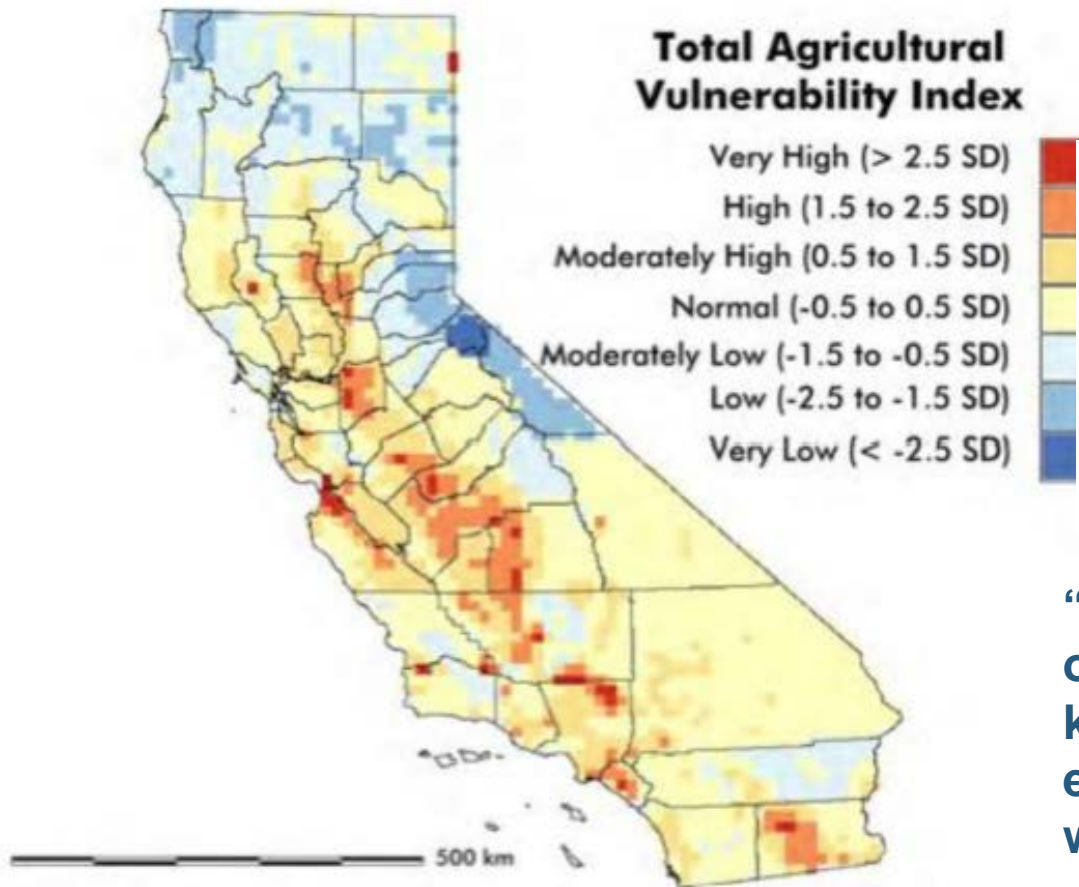


NOAA National Centers for Environmental information, Climate at a Glance: Statewide Time Series, published May 2019, retrieved on May 28, 2019 from <https://www.ncdc.noaa.gov/cag/>

Examples of recent climate change impacts on California forests and agriculture

- CA agriculture >\$50 billion dollar industry, largest producer of nuts, fruits and vegetables and dairy in the US
- 2014 - 2016 record drought resulted in ~\$6 billion (USD) in total economic losses in California (Howitt and Lund, 2015; Medellín-Azuara et al., 2016)
- In 2017, ~3000 – 6000 dairy cow fatalities due to a summer extreme heatwave, resulting in “state of emergency” declaration in much of the Central Valley
- The fires of 2018 resulted in >\$15 – \$19 billion (USD) of economic losses, with 97 fatalities reported

Climate impacts will increase in the future – need to consider local climate resilience




agronomy



Review

Climate Change Trends and Impacts on California Agriculture: A Detailed Review

Tapan B. Pathak ^{1,*} , Mahesh L. Maskey ², Jeffery A. Dahlberg ³, Faith Kearns ⁴, Khaled M. Bali ³ and Daniele Zaccaria ²

“Warming temperatures will make it difficult for most of the Central Valley to grow crops such as apricots, kiwis, peaches, nectarines, plums and walnuts. By the end of the century, only 23-46 percent of the Valley will be suitable for those crops.”

CA Climate Law and Policy**

- AB 32: GHG emissions to 1990 levels by 2020;
- SB 32: 40% of 1990 levels by 2030
- SB 100: Carbon neutral energy by 2045

**Policies include Cap and Trade, plus various regulations and incentives

Figure 1

GHG Emissions Come From a Wide Variety of Sources

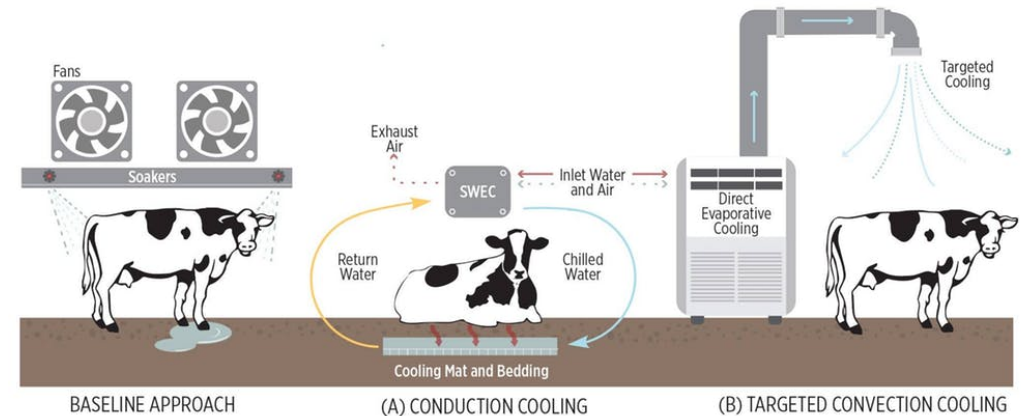
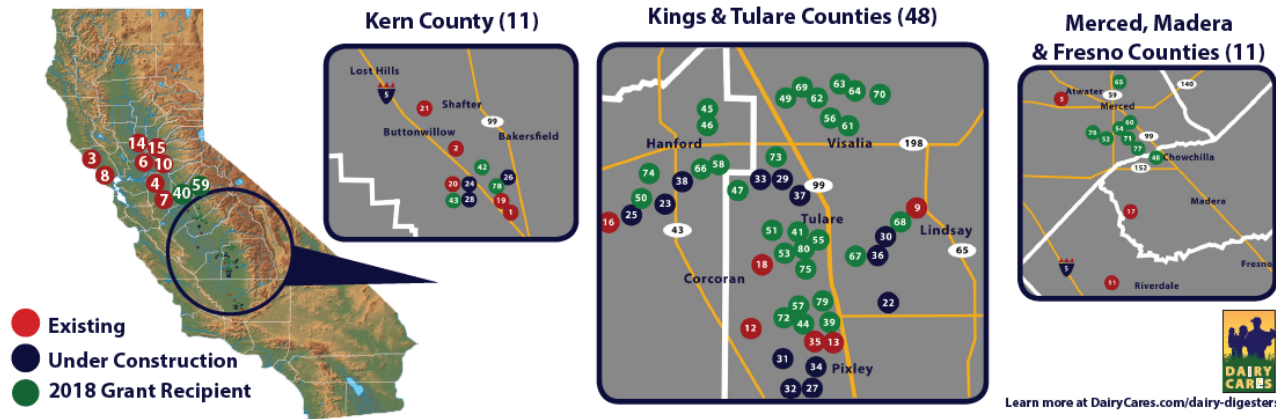


GHG = greenhouse gas; GWP = global warming potential; and ODS = ozone depleting substance.

1. Climate-smart dairies

- CDFA's Dairy Digester Program, targeting a 40% methane reduction from manure ~ \$9/ton of CO₂eq reduced
- Using this electricity and new research on cooling facilities can result in climate mitigation and adaptation

California Dairy Digester Development



2. Healthy soils - croplands

Surface vs. Deep Soil Inventories of Carbon Sequestration



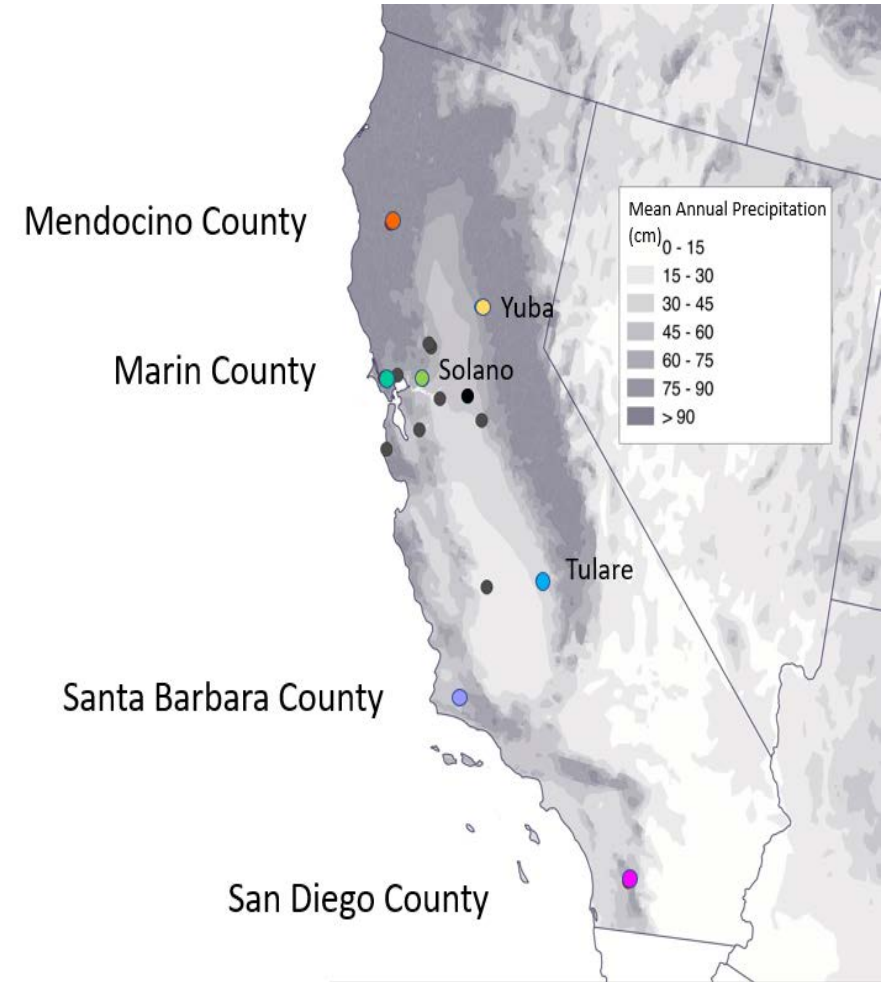
2. Healthy soils - rangelands

Relative change in soil C stocks (Mg C ha^{-1})

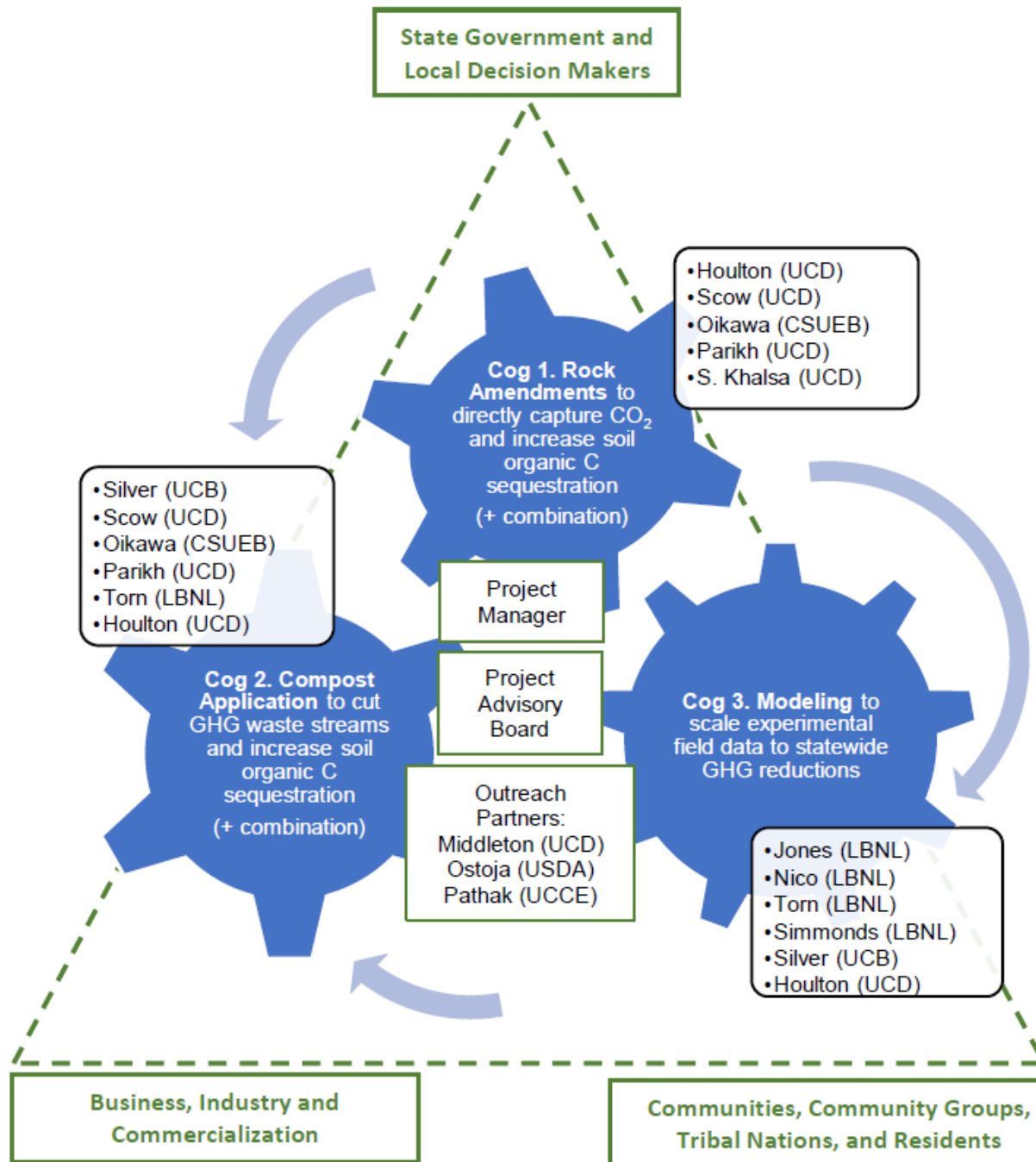
3.5
3
2.5
2
1.5
1
0.5
0

All sites

New Sites



Silver et al. 2018



Working Lands Innovation Center (\$4.7 million over three years, beginning July 2019, PI Houlton)

- UC Davis, UC Berkeley, UC Merced, UC-ANR/Cooperative Extension, LBNL, CSU-East Bay, USDA
- 27 demonstration sites -- corn, wheat, tomato, almond, alfalfa, vegetables, rangelands
- Additions of basalt, wollastonite, gypsum, compost, biochar to soil, singly and factorial
- Private and commercial growers and ranchers, tribes, small business development
- Analysis of carbon capture, GHG reductions, crop yields and quality, cap and trade offsets, economics

3. Water-efficiency and renewable energy

State Water Efficiency and Enhancement Program (SWEEP)

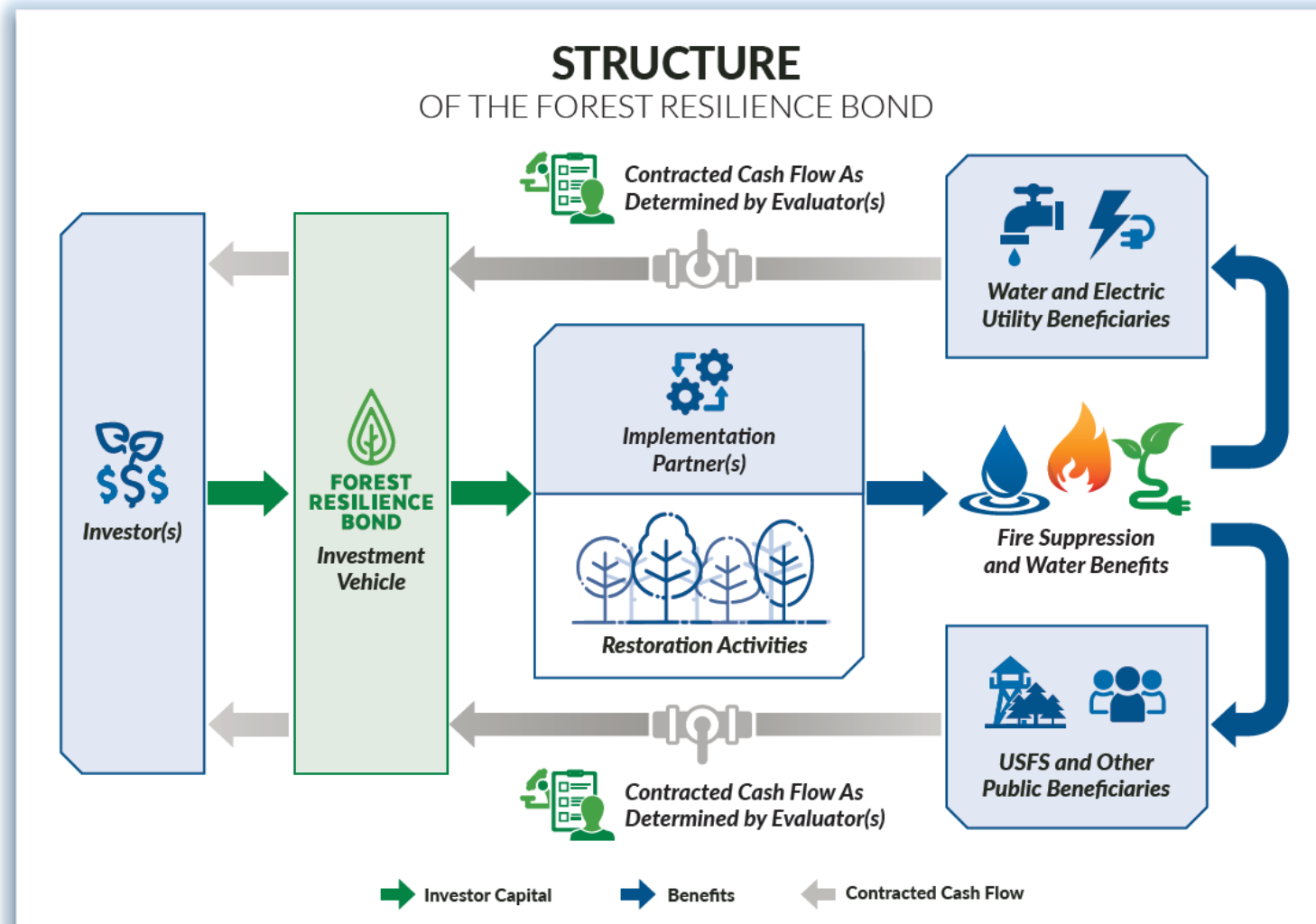
In 2014, Governor Brown authorized a new program called the State Water Efficiency and Enhancement Program (SWEEP). The program's funding comes from the state's cap-and-trade and bond revenue and is used to make grants to farmers and ranchers for practices that reduce both water and energy use. Coordinated by CDFA, SWEEP funded over 600 projects in 33 counties between 2014-2017.

Cobenefits

- Reduces energy costs
- Reduces energy CO₂ emissions
- Increases water use efficiency
- Reduces N₂O through precision deliver



4. Forest resilience bonds



Grasslands may be more reliable carbon sinks than forests in California

Pawlok Dass^{1,5} , Benjamin Z Houlton^{1,2} , Yingping Wang³  and David Warland⁴

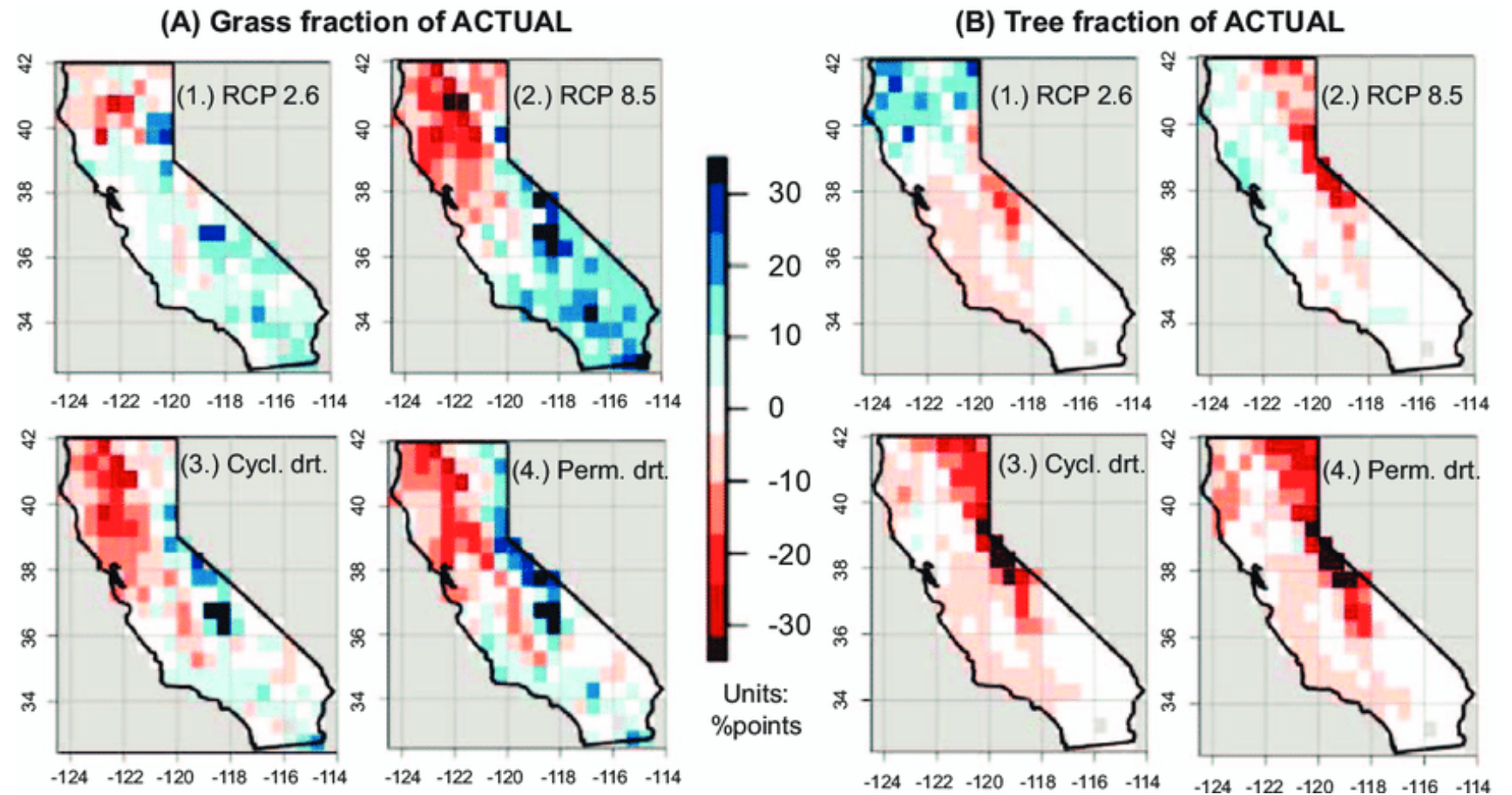
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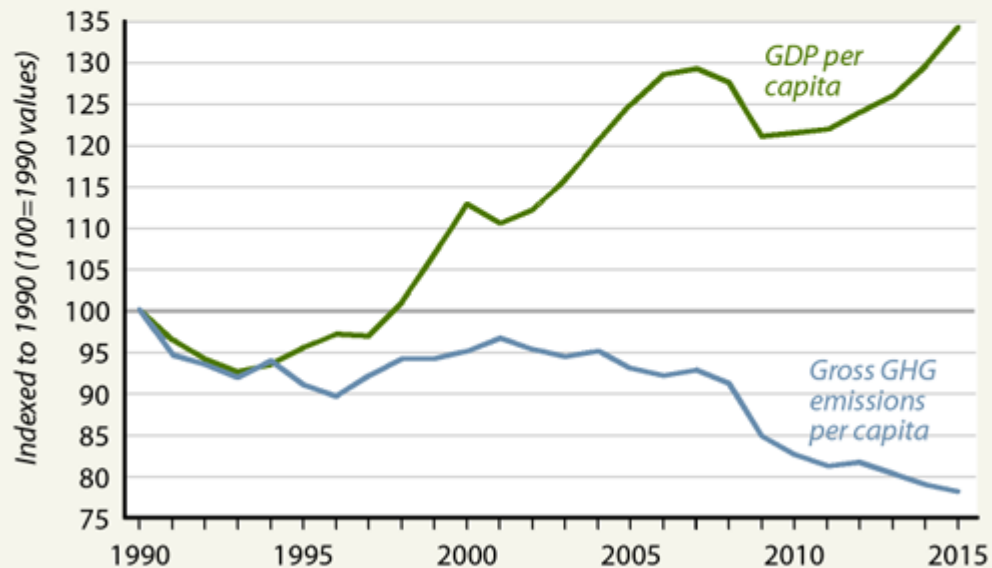
Where is California headed?

Decoupling: California's Economy Grows as Emissions Fall

Since the state passed climate legislation establishing a cap-and-trade system in 2006, California's gross domestic product per capita has grown more quickly than that of the nation as a whole, even as greenhouse gas emissions have fallen.

GREENHOUSE GAS EMISSIONS AND GDP

California relative trends, 1990-2015

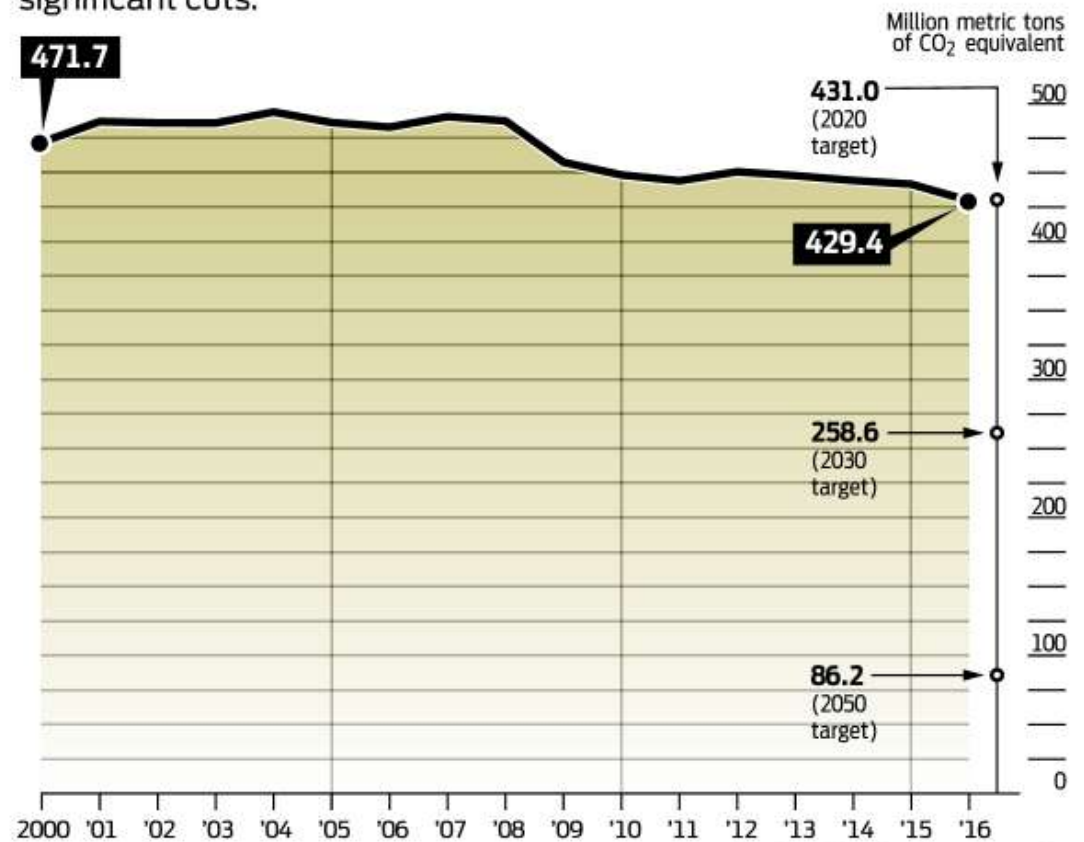


SOURCE: NEXT 10 (via data from Calif. Air Resources Board; Calif. Greenhouse Gas Inventory; Bureau of Economic Analysis, U.S. Dept. of Commerce; U.S. Census Bureau)

PAUL HORN / InsideClimate News

Stepping off the gas

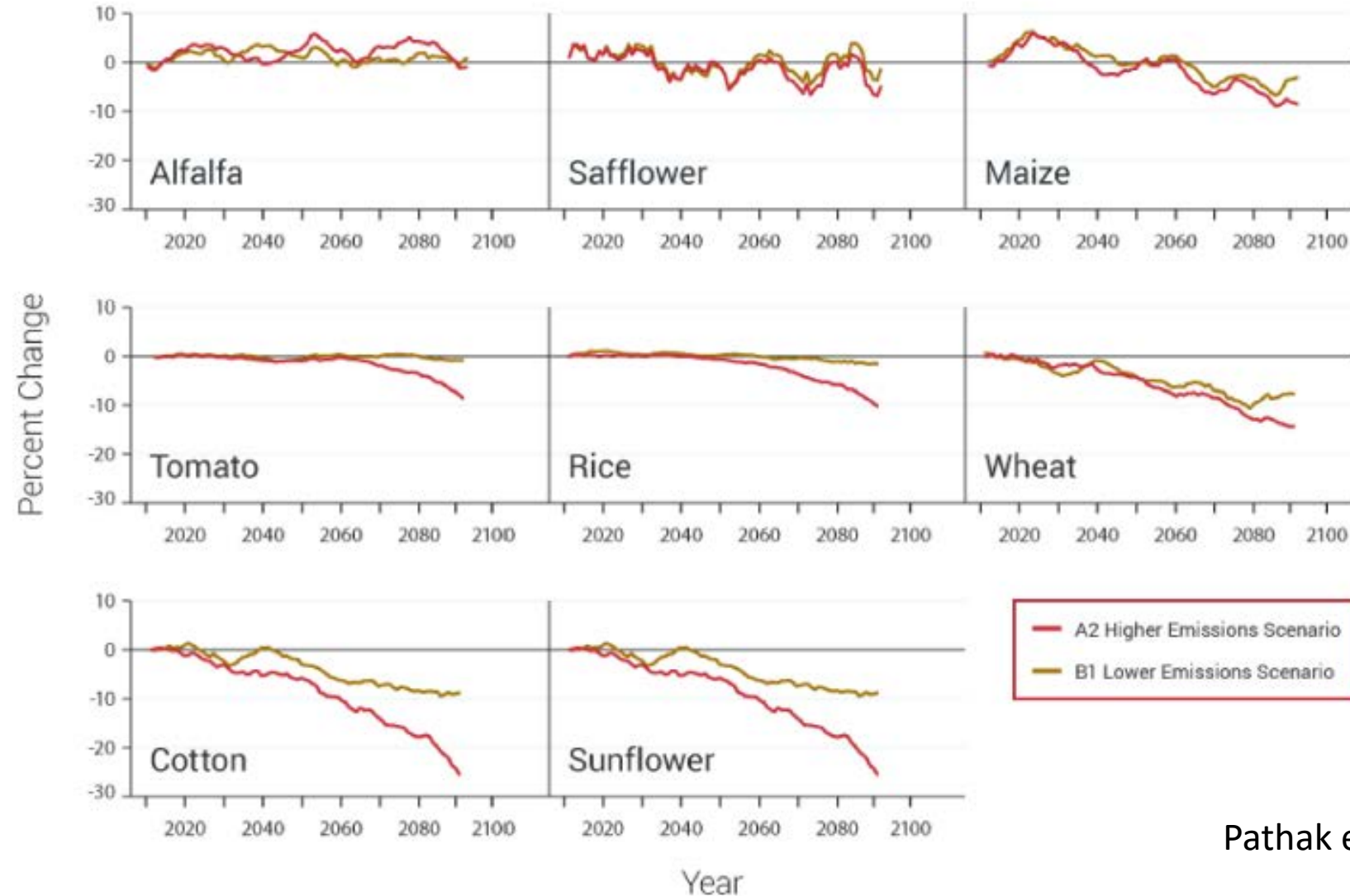
California has achieved its 2020 goal for reducing greenhouse gas emissions, but targets in 2030 and 2050 will require far more significant cuts.



Source: California Air Resources Board

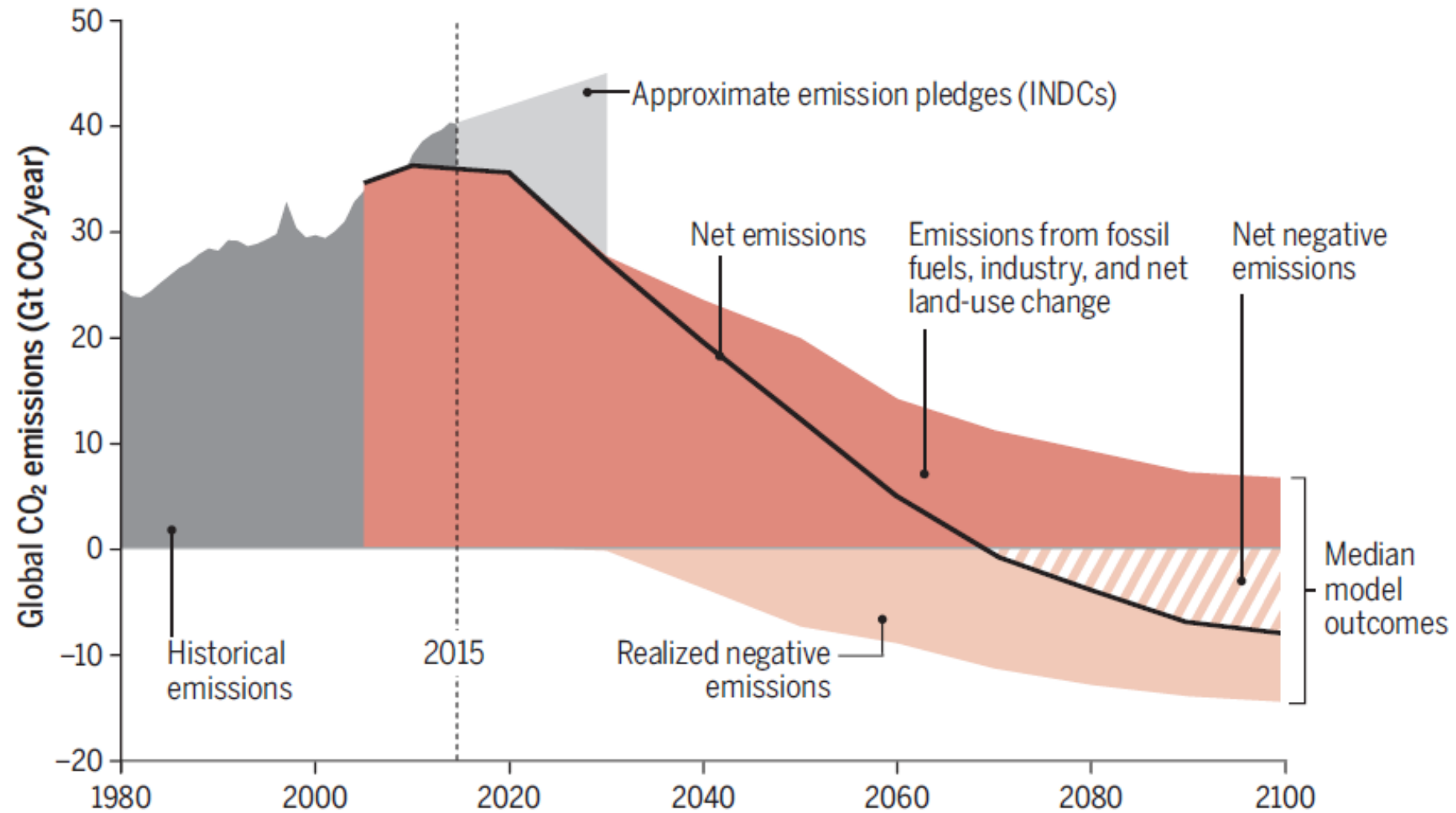
John Blanchard / The Chronicle

However...global GHG reductions affect CA agriculture



Pathak et al., Agronomy, 2018

Paris Agreement





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Key challenge of the 21st century:
Negative carbon emissions while
feeding people, and protecting
agriculture, economy, planet