The California Agricultural Vulnerability Index

A tool for climate change adaptation and land use planning

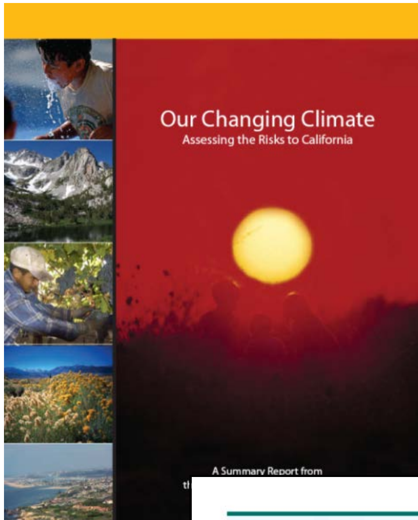
Ryan Haden & Joshua Perlman
University of California, Davis

Collaborators:
L. Jackson, A. Hollander, T. O'Geen, D. Sumner, H. Lee, M. Lubell, M. Niles, W. Salas, M. Dempsey, M. Tomuta, & S. Wheeler

Climate Change Adaptation and Mitigation

- Global Warming Solutions Act - Assembly Bill 32 (2006): Reduce GHG emissions to 1990 levels by 2020
- New emphasis in CA state agencies
- California agriculture is important locally and nationwide
- Since agriculture relies on natural resources it is vulnerable to climate change and urban development
- Without adaptation, urban conversion is more likely
  - Less land for food provisioning, C sequestration and other ecosystem services provided by agriculture
  - Higher greenhouse gas emissions from urbanized land
    - Agriculture: only 6% of statewide greenhouse gas emissions

California Energy Commission
Public Interest Energy Research Program (PIER)



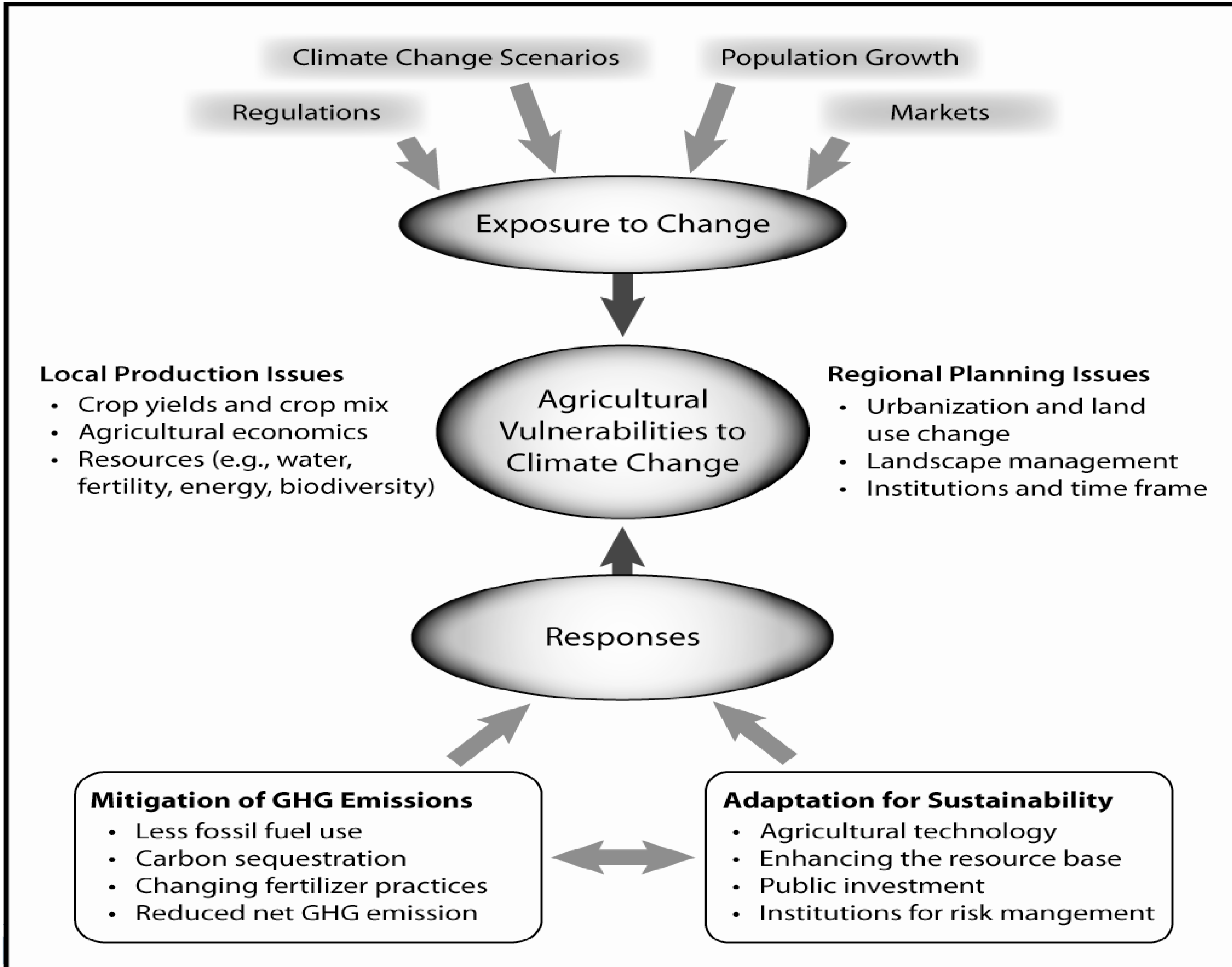
AB32: Global Warming Solutions Act

PIER's goals:

Conduct, publish and communicate relevant climate science info to decision makers and stakeholders throughout California.

- cross-cutting research that is relevant to multiple sectors
- energy and water nexus
- climate change vulnerability and impacts
- adaptation strategies
- opportunities for GHG mitigation

CAS: California Adaptation Strategy



Climate Change Scenarios
Population Growth
Regulations
Markets
Exposure to Change
Local Production Issues
• Crop yields and crop mix
• Agricultural economics
• Resources (e.g., water, fertility, energy, biodiversity)
Agricultural Vulnerabilities to Climate Change
Regional Planning Issues
• Urbanization and land use change
• Landscape management
• Institutions and time frame
Responses
Mitigation of GHG Emissions
• Less fossil fuel use
• Carbon sequestration
• Changing fertilizer practices
• Reduced net GHG emission
Adaptation for Sustainability
• Agricultural technology
• Enhancing the resource base
• Public investment
• Institutions for risk mangement

How are we using soil survey tools to support adaptation and mitigation efforts in California agriculture?

Outline

- A geospatial index of agricultural vulnerability to changes in climate, land use, and socio-economic factors

  How do different aspects of vulnerability vary across the landscape?

  What agricultural regions in California merit special attention and planning?

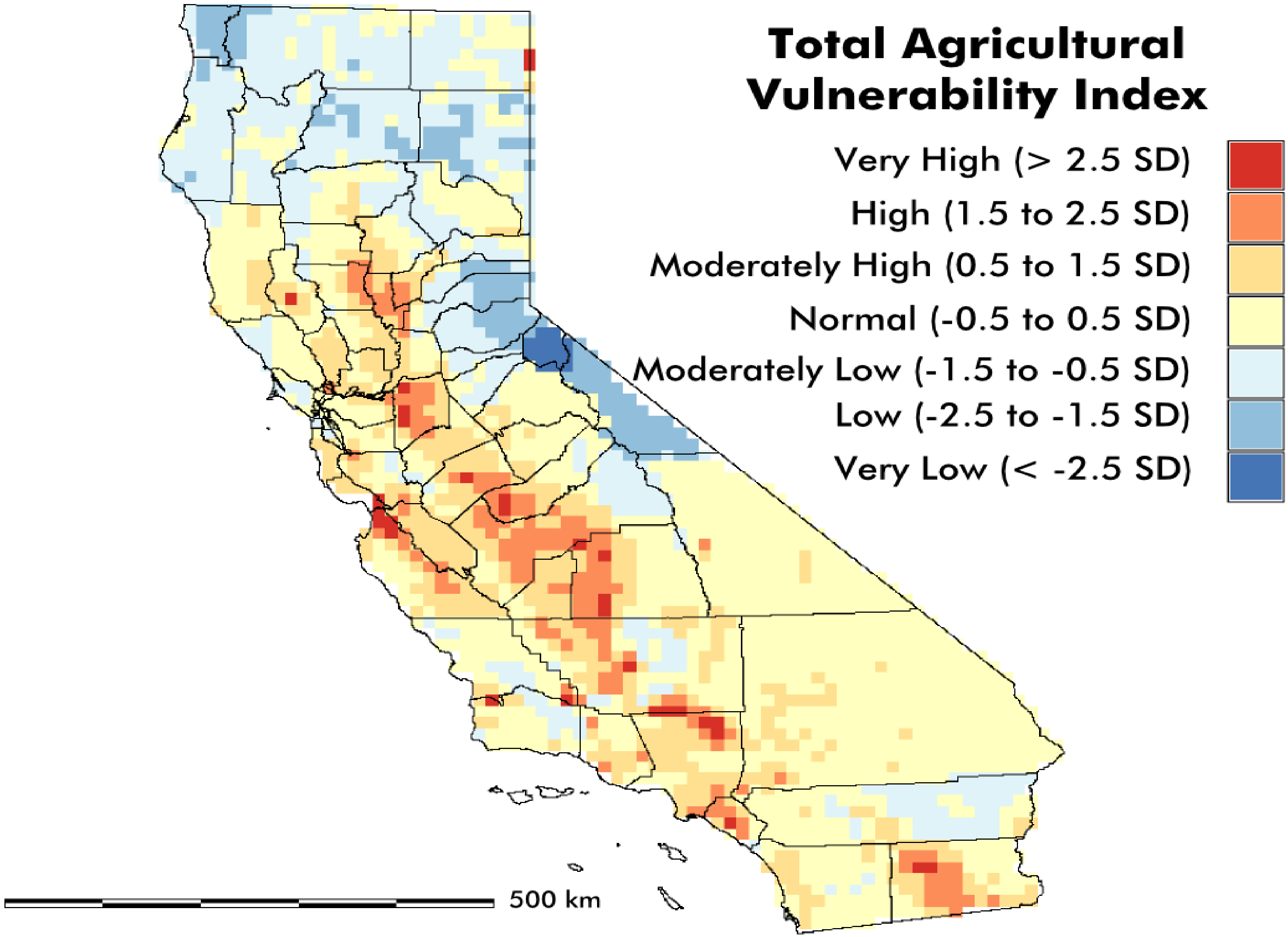
- Example of "placed-based" climate action planning from a case study of Yolo County

Vulnerability Indicators: Biophysical & Social

Sub-index	Variable	Unit mapped
Climate Vulnerability[1]	Potential ET	Average annual mm ,1971-1999
	Precipitation CV	Inter-annual variance, 1981-2009
	Days in July > 35ºC	Average annual days , 1981-2009
	Days > 30ºC	Average annual days, 1981-2009
	Precipitation	Average annual mm , 1981-2009
	Lowest annual temp.	Average lowest temp. ºC, 1981-2009
	Days in growing season	Average annual days, 1981-2009
	Chill hours	Average annual hours, 1981-2009
Crop Vulnerability	Crop dominance index	Area weighted ave. Simpson index value
	Crop climate sensitivity index	Area weighted ave. index value
	Pesticide application rate	kg of pesticide per km^2 cropland
Land Use Vulnerability	% Land area in cropland	Percent of area in each grid cell
	Storie index	Area weighted ave. index value (SSURGO[2])
	% Area converted to urban	Percent of area in each grid cell, 1991-2000 (NLCD)
	Soil salinity (EC)	Area and depth weighted ave. $dS\ m^{-1}$ (SSURGO[2])
	% Area in 100y flood plain	Percent of area in each grid cell
Socioeconomic Vulnerability	Farm workers	Workers per km^2 of cropland in county, 2000
	% Loss of farms	County percent loss from 2002-2007
	Farm disaster payments	\$ per km^2 of cropland in county 1995-2010
	Social vulnerability index	County index value, 2000
	% Loss of farm jobs	County percent loss from 1999-2009
	Commodity concentration	County Herfindahl index value for 2002

- [1]Climate data derived from NOAA Geophysical Fluid Dynamics Laboratory (GFDL) general circulation model (CM 2.1)
[2]Rasterized version of SSURGO soil data (Beaudette and O'Geen, unpublished)

Total Agricultural Vulnerability Index



Haden et al. In Prep.

Geospatial Indexing Method

Time frame

- Statewide geospatial data for each variable were obtained for the approx. 2000-2010 time frame and represent "present" vulnerability.

Standardization for principal component analysis

- 22 indicator variables calculated to represent percentages, index values densities or area weighted averages for12.5km^2 raster cells covering CA (2,628 cells)

Principal component analysis (PCA)

- Carried out on the variables in each sub-index to reduce the dimensionality

Calculation of sub-index values

- For each sub-index, principal components with eigenvalues > 1 are retained
- Variables assigned to component where they have the highest loading
- For each grid cell, the retained component scores are extracted and summed

  to give a sub-index value
- Sub-index values mapped based on standard deviation around the statewide mean value.

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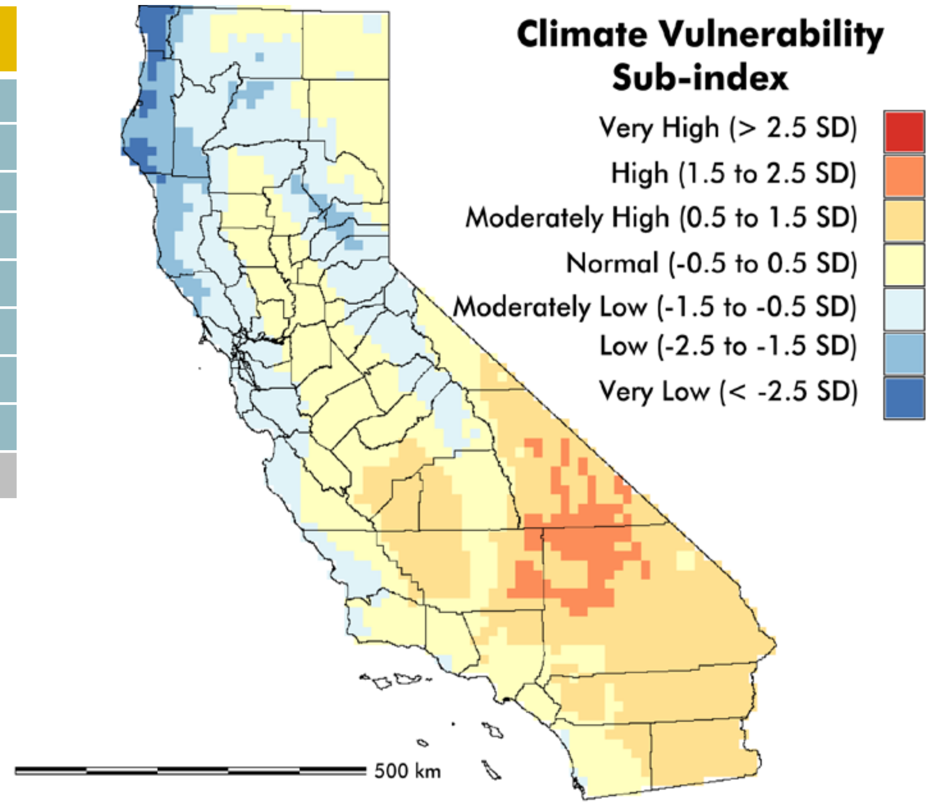
Climate Vulnerability Sub-Index

Sub-index	Variable	Retained PC axis
Climate Vulnerability[1]	Potential ET	I
	Precipitation CV	I
	Days in July > 35°C	I
	Days > 30°C	I
	Precipitation	I
	Lowest annual temp.	--
	Days in growing season	--
	Chill hours	--
	Cumulative Variance %	69.3



Component Scores for each grid cell

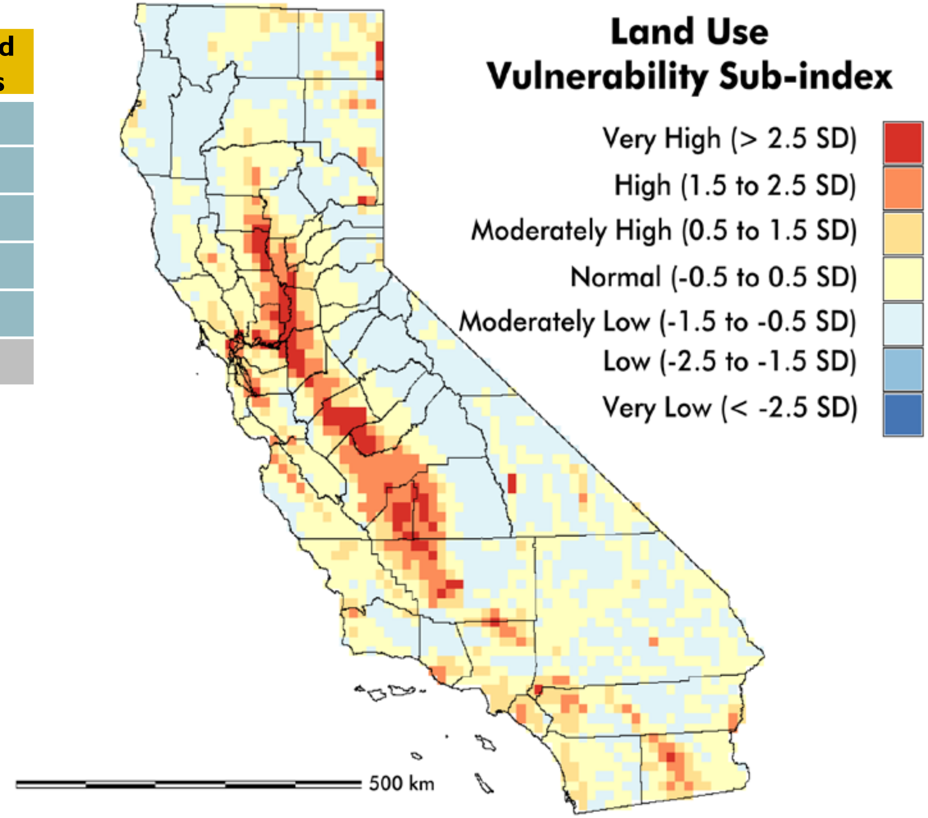
PC1 = Sub-Index Value

- Low and variable precipitation & higher maximum temp and PET indicate higher climate vulnerability in southeastern California.
- Imperial Valley and Southern San Joaquin Valley are the main ag. regions impacted.

Haden et al. In Prep.

Land Use Vulnerability Sub-Index

Sub-index	Variable	Retained PC axis
Land Use Vulnerability	Land area in cropland	1
	Storie index	1
	Land area converted to urban	1
	Soil salinity	2
	Land in 100y floodplain	2
	Cumulative Variance %	67

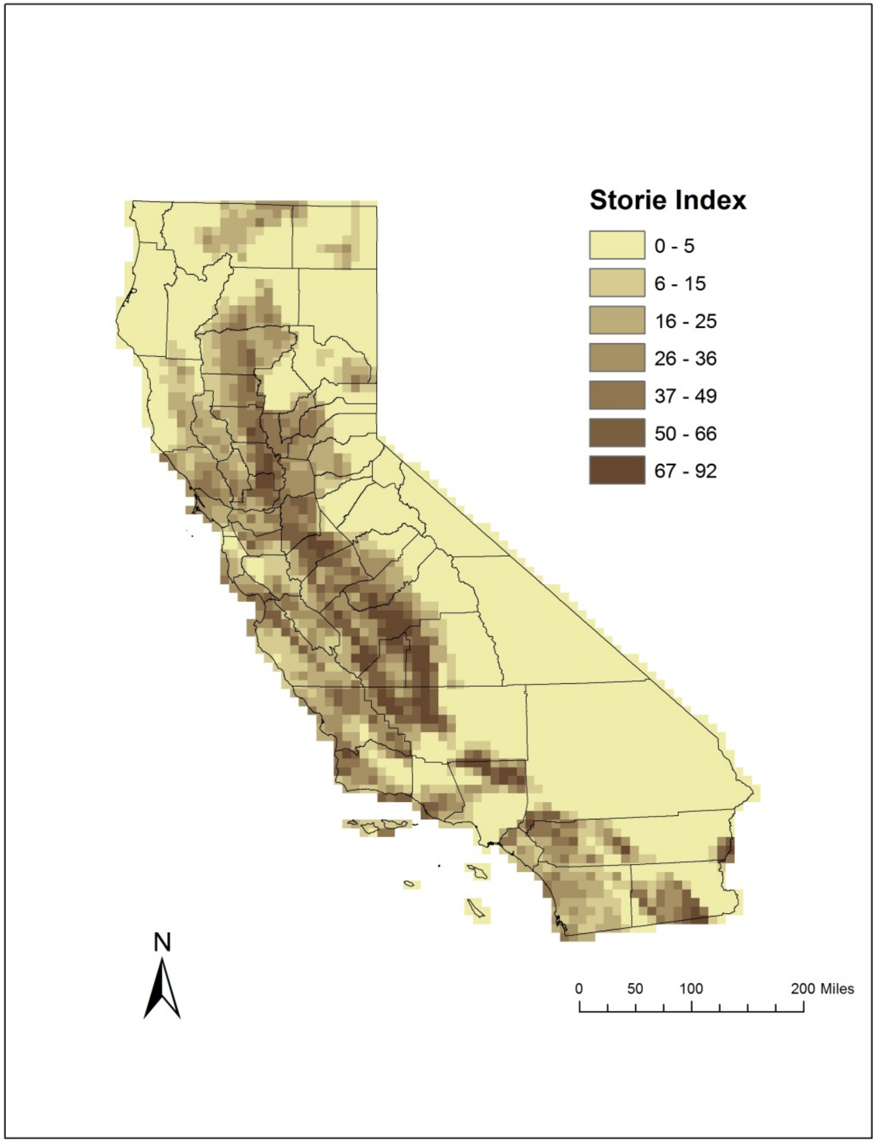


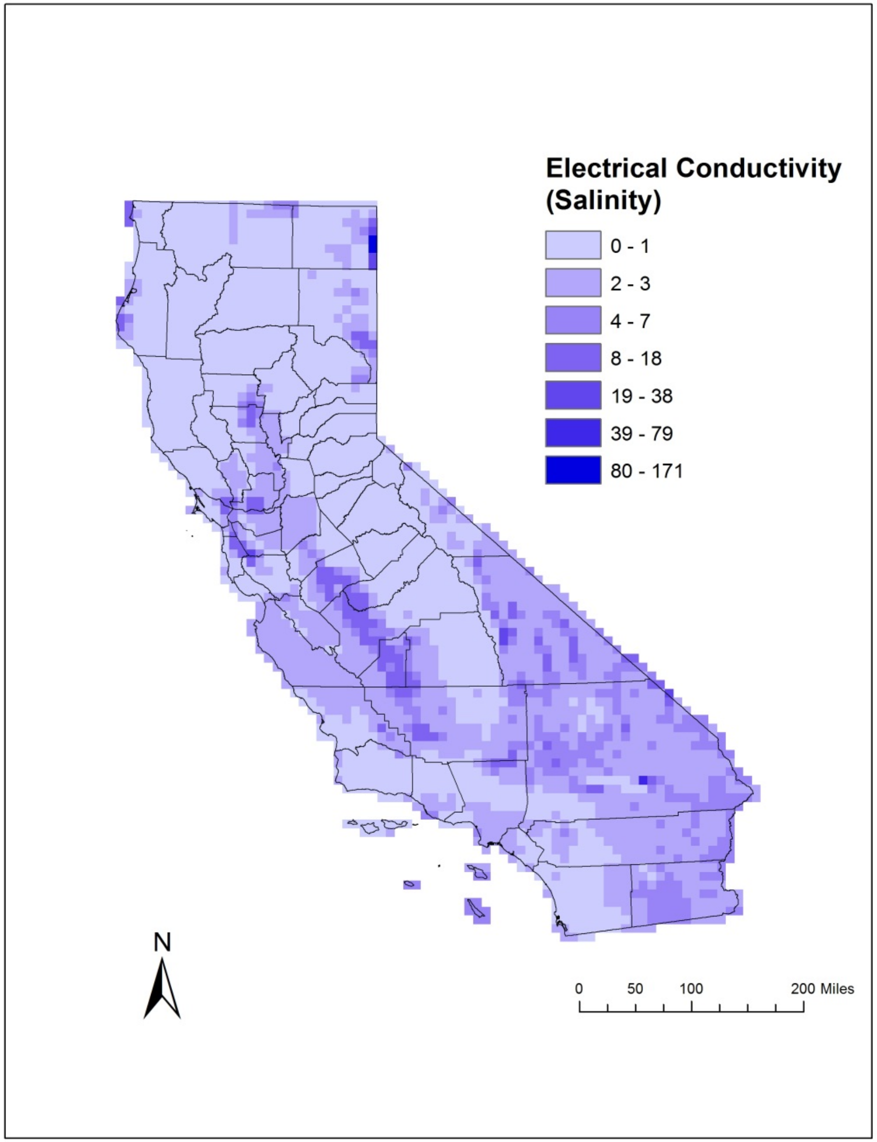
<u>Component Scores for each grid cell</u>

PC1 + PC2 = Sub-Index Value

- Urbanization and salinity risks on high quality agricultural land (Storie index) led to high vulnerability in the Merced / Fresno / Bakersfield corridor and parts of the Sacramento-San Joaquin Delta.

Haden et al. In Prep.


Storie Index
0 - 5
6 - 15
16 - 25
26 - 36
37 - 49
50 - 66
67 - 92
N
0 50 100 200 Miles


Electrical Conductivity (Salinity)
0 - 1
2 - 3
4 - 7
8 - 18
19 - 38
39 - 79
80 - 171
N
0 50 100 200 Miles

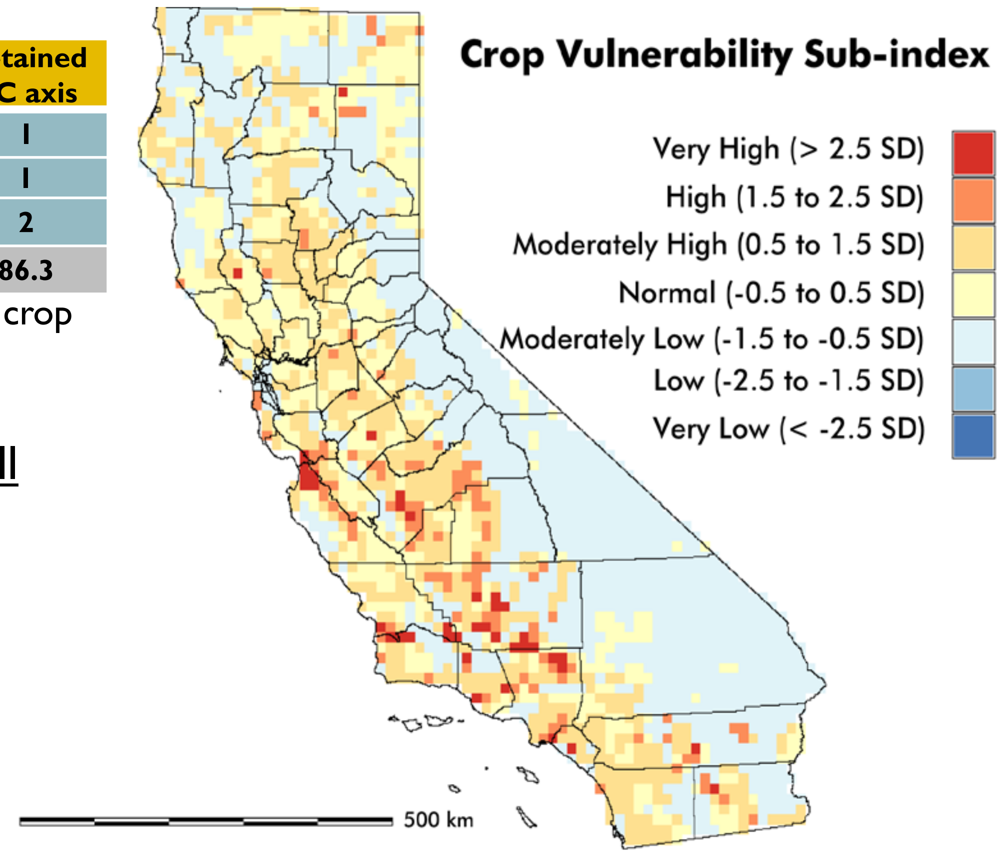
Crop Vulnerability Sub-Index

Sub-index	Variable	Retained PC axis
Crop Vulnerability	Crop dominance index	1
	Crop Sensitivity index	1
	Pesticide rate	2
	Cumulative Variance %	86.3

*looking for more variables to include in the crop vulnerability index.

<u>Component Scores for each grid cell</u>

PC1 + PC2 = Sub-Index Value



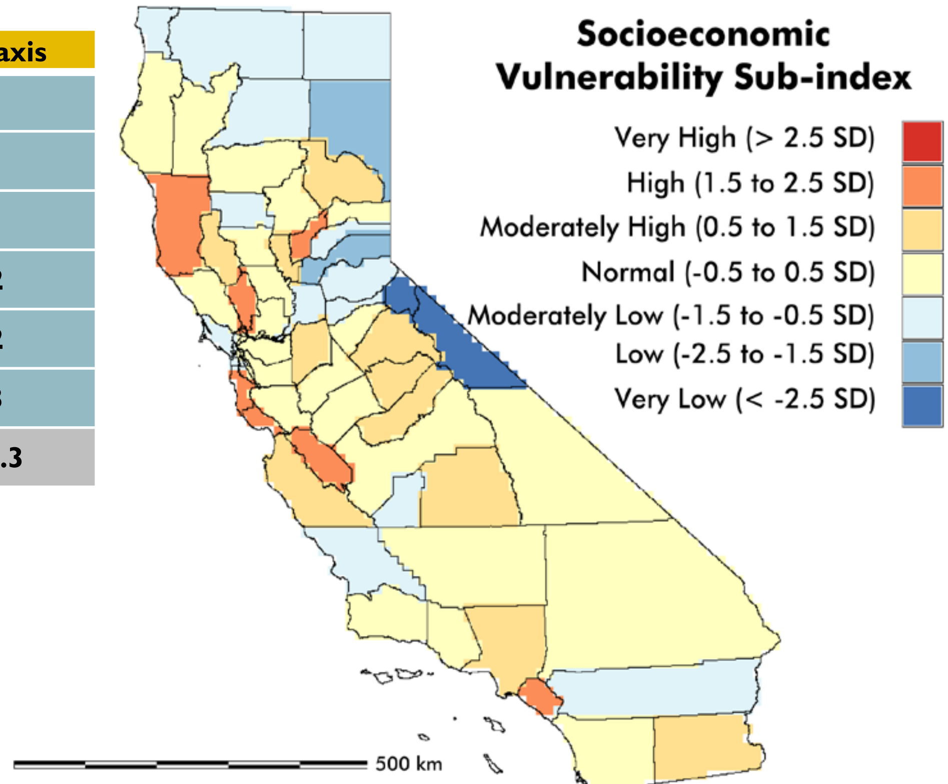
•High crop sensitivity and pesticide use indicates greater crop vulnerability in the Fresno/Bakersfield area and the Salinas, Santa Maria, and Imperial Valleys.

Haden et al. In Prep.

Socioeconomic Vulnerability Sub-Index

Sub-index	Variable	PC axis
Socioeconomic Vulnerability	Seasonal/migrant workers	1
	Loss of farms	1
	Disaster payments	1
	Social vulnerability index	2
	Loss of farm jobs	2
	Commodity concentration	3
	Cumulative Variance %	70.3

* data available at county level only



Component Scores for each grid cell

PC1 + PC2 + PC3 = Sub-Index Value

- High numbers of migrant workers and disaster payments per ha of cropland let to high socioeconomic vulnerability in the central coast (indicative of high value and labor intensive vegetable and berry crops)
- High commodity concentration (i.e. low diversity) in Mendocino and Napa increased vulnerability in these counties (wine grapes).

Haden et al. In Prep.

Need for "Placed-Based" Responses

Work in Progress

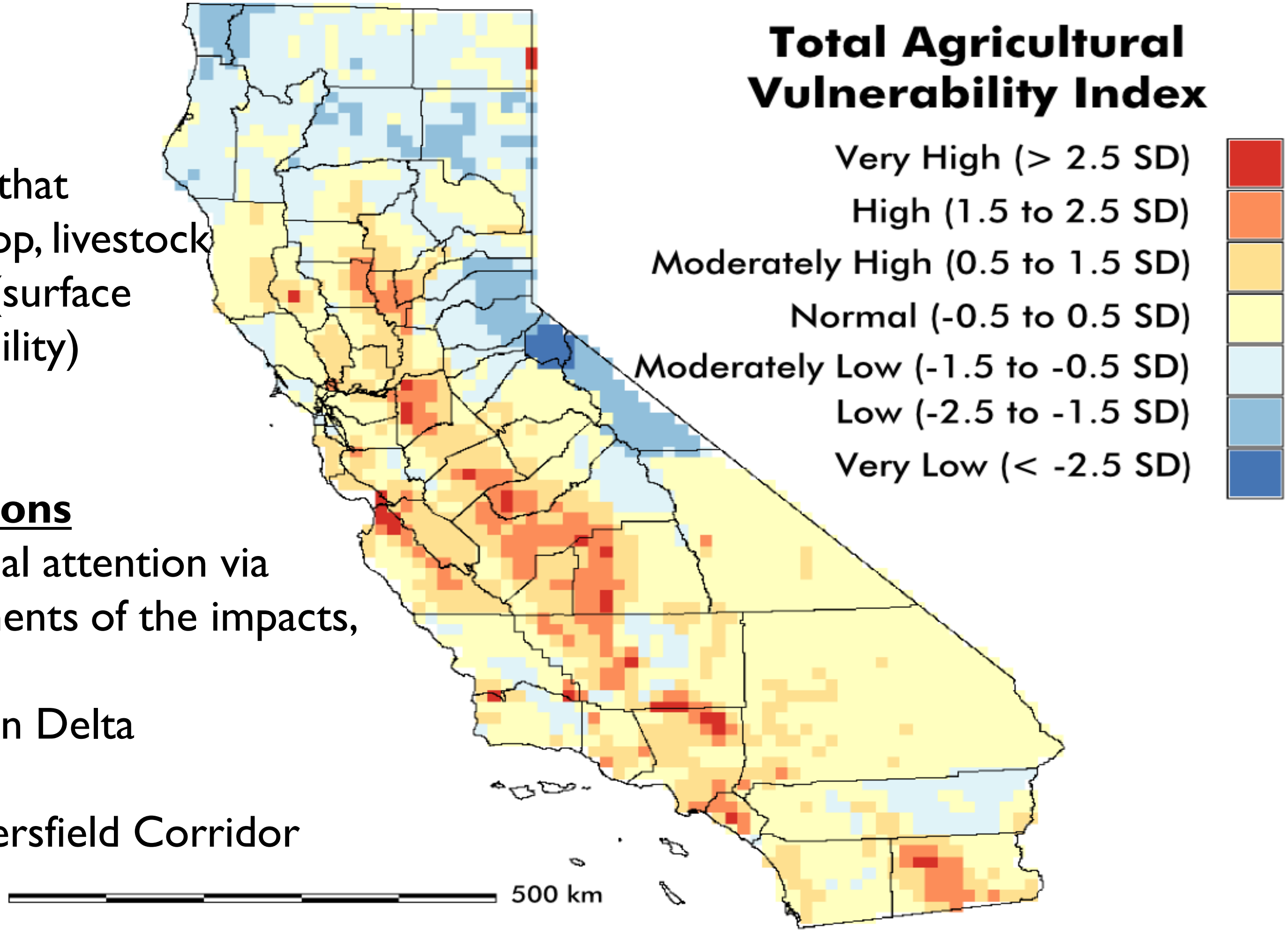
Looking for spatial data that captures elements of crop, livestock and water vulnerability (surface and groundwater availability)

Any ideas?

Preliminary Conclusions

Regions that merit special attention via context specific assessments of the impacts, risks and responses:

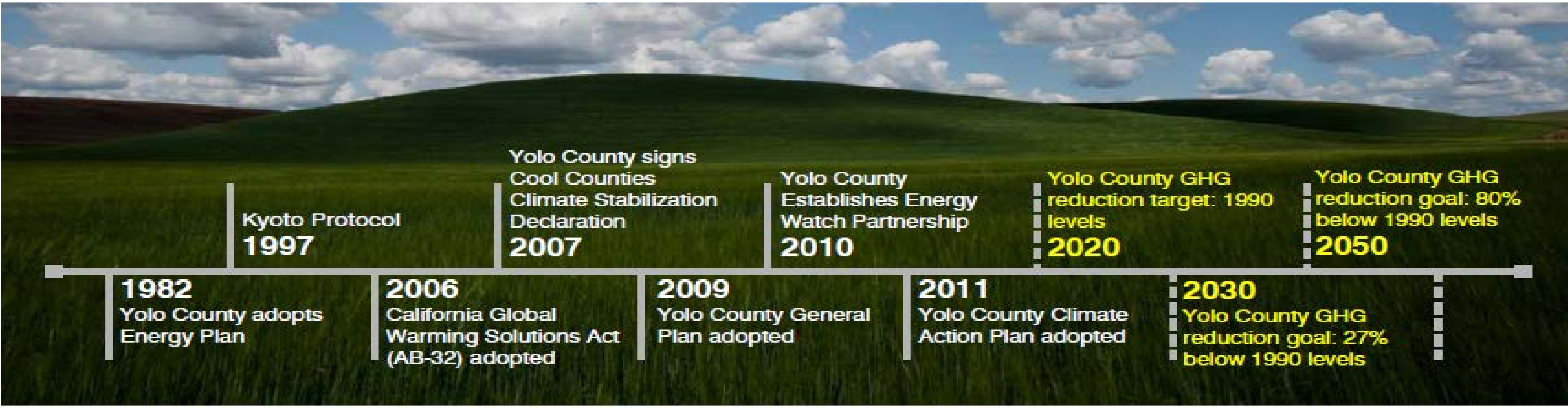
- Sacramento-San Joaquin Delta
- Salinas Valley
- Merced / Fresno / Bakersfield Corridor
- Imperial Valley



Haden et al. In Prep.

Yolo County Climate Action Plan

- Under AB 32 all CA counties and cities will have to carry out a "climate action plan" (CAP) when they update their General Plan.
- CAP typically include: 1) Inventory of 1990 and current emissions, 2) set of local policies to mitigate future emissions, 3) strategies to adapt to climate impacts.
- Local government sought input on the CAP through rural stakeholder workshops.
- Our research team participated in the CAP process by providing technical input on data sources, GHG inventory methods, and agricultural response strategies.



Source: Yolo County CAP, 2011

GHG Mitigation via Farmland Preservation

Land-Use Category	Land Area		Average Emissions Rate	
	1990	2008	1990	2008
	----- acres -----		--- MT CO_2e $acre^{-1}$ yr^{-1} ---	
Rangeland	131,945	135,717	**0.28**	0.32
Cropland	344,335	324,654	**0.87**	0.80
Urban*	22,471	29,881	**61.50**	--

*Countywide urban emissions for 2008 are not yet available

Importance of Farmland Preservation as a Mitigation Strategy

- In Yolo, 1/3 of lost cropland was due to urban development (1/3 to wetland habitat)
- Emissions rate from cropland has declined in Yolo due to larger fraction of land in grapes & alfalfa which require less N. (market driven changes)
- Urban land use generates > 70 times more emissions per acre than cropland.
- Keeping land in agriculture can help to stabilize and reduce emissions in the future.
- Important justification for maintaining agriculture's unique "voluntary" mitigation status among other industries in the state.

Source: Haden et al., in press

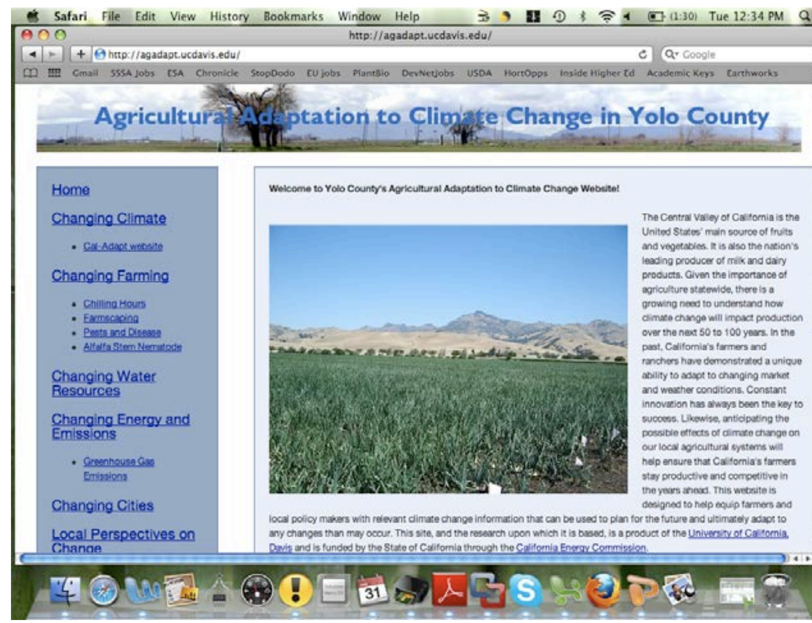
Acknowledgments

Collaborators in Yolo County

- Ag. Stakeholder Steering Committee
- UCCE farm advisors in Yolo County
- Yolo County Agricultural Commissioner (John Young)
- Yolo County Farm Bureau
- Yolo Climate Coordinator (John Mott-Smith)
- Yolo Flood Control and Water Conservation District (Tim O'Halloran & Max Stevenson)
- Yolo County Planning Dept.
- Ascent Environmental & AECOM
- Landowners and farmers in Yolo County
- Many other Yolo County agencies

Funding Sources

- California Energy Commission
- Kearney Foundation of Soil Science
- USDA Organic Research and Education Initiative



Learn more about the Yolo County Climate Adaptation Project at: http://agadapt.ucdavis.edu/