Mapping Drought Impacts on Agricultural Production in California's Central Valley

James Verdin, USGS

Project Team

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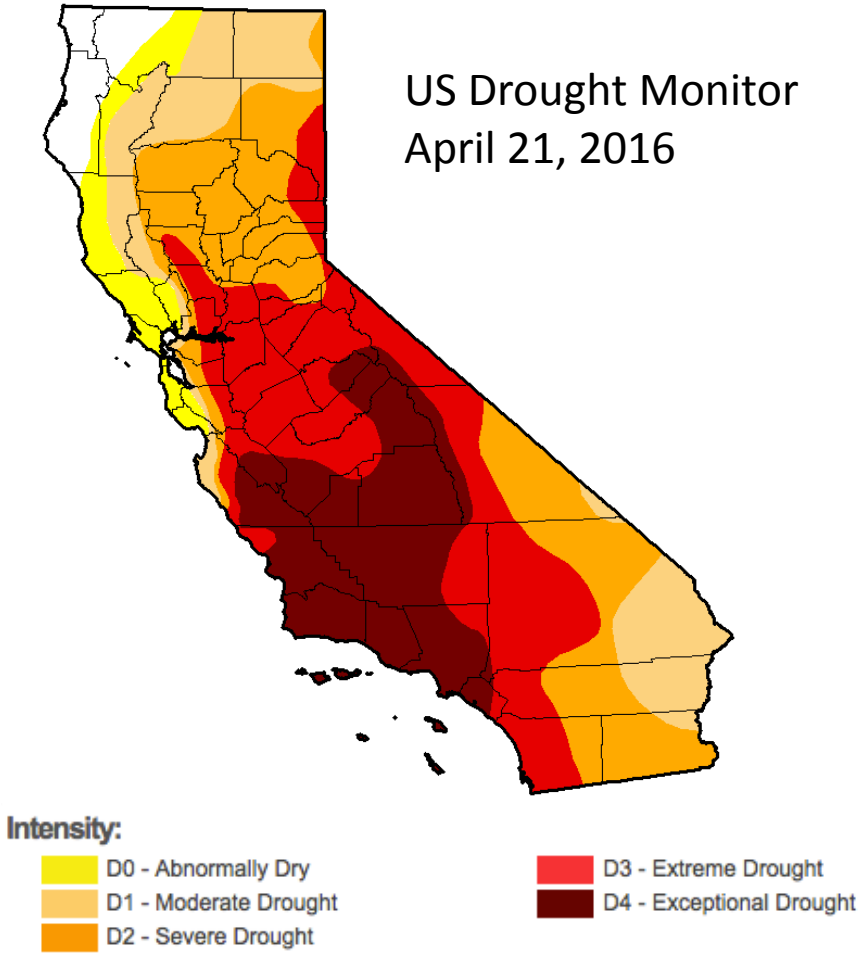
Support from the NASA Applied Sciences Program and NIDIS Program Office

Motivation: California Drought

- 2011 – 2015 has been the most severe drought on record for California
- ~44% of CA farms received surface water allocations of 0% in 2015
- ~75% of CA farms received <20% of full surface water allocation in 2015
- Reductions in surface water supplies offset through increased reliance on groundwater resources
- Estimated economic losses of $2.7 billion for agricultural sector (UC Davis, 8/17/2015)
- Drought continuing in San Joaquin Valley: 2016 allocation for growers south of the Bay Delta is 5% of full allocation



US Drought Monitor
April 21, 2016

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Drought Impacts and Land Fallowing

- **Background:** Mapping of fallowed areas during drought identified as a priority by CA Department of Water Resources (CDWR)

- **Information needed:** Monthly estimates of idle and cropped acreage, with <2 week delay, field-scale resolution, accuracy of +/- 25% acceptable (similar to USDA Cropland Data Layer 'Idle' class)

- **Objective:** Apply satellite data to provide information that will allow CDWR and other stakeholders to identify extent of fallowed acreage during droughts

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Drought Impacts on Land Fallowing

Actions supported:

- Assessment of extent and severity of drought impacts
- State proclamations of emergency pursuant to the California Emergency Services Act and allocation of drought relief funding
- State priorities for providing assistance to impacted counties
- Quantification of economic impacts

Limitations of previously available information:

- USDA NASS Cropland Data Layer (CDL) considered confidential and market sensitive during the growing season
- Fallowed acreage reports from other sources do not follow standard definitions or data collection methods → often generate conflicting estimates

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Project Partners and Stakeholders

Project Partners

CA Department of Water Resources
USDA National Agricultural Statistics Service
USGS
NASA / CSU Monterey Bay
UC Davis
NOAA NIDIS

Project Stakeholders

CA Governor's Drought Task Force
CA Department of Water Resources
CA Department of Food and Agriculture
CA Social Services Agencies and Food Banks
CA State Water Resources Control Board (water rights admin.)
California Farm Bureau
Nature Conservancy (solar development planning)

New / Future Stakeholders

Project Partners

Desert Research Institute
Washington State Department of Ecology
University of Montana

Project Stakeholders

Nevada State Engineer's Office
Nevada Governor's Office
Washington State Department of Ecology
Sustainable Conservation

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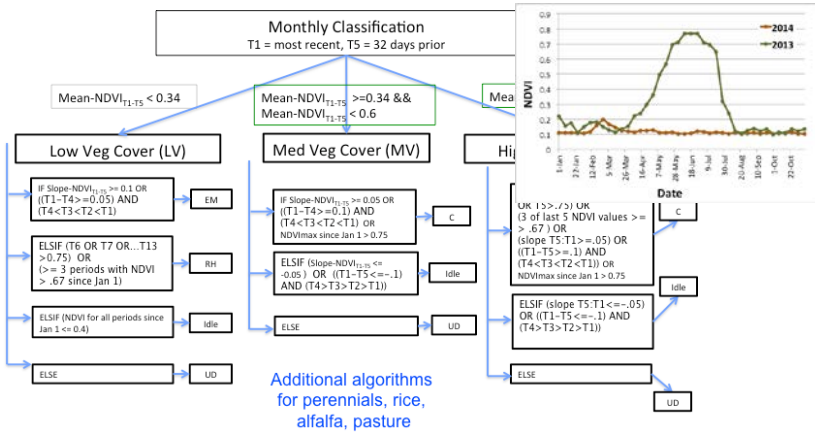
Approach

Satellite Data

Landsat (TM / ETM+ / OLI)
+SPOT, DMC, Sentinel-2(?)

Terra / Aqua (MODIS)
250m / 15.5 acre
Daily overpass

Decision Tree Algorithms



Outputs: Maps and Summary Tables

Central Valley, Total Fallow Acreage During the Drought (Sept. 30, 2015)		
Year	Summer Fallow (idle since June 1)	Annual Fallow (idle since January 1)
2015	1,917,100	1,032,500
2014	1,893,700	1,310,100
2013	1,446,800	680,600
2011	1,394,900	406,000
2015 - 2011	522,200	626,500

- Annual idle mapping from USDA NASS
- Early season + summer mapping from NASA
- Comparisons against baseline period

Validation

Via USDA FSA Data and Field Surveys

2015 Accuracy Assessment

Season	Overall, % correct	Cropped, % correct	Fallow, % correct		Cropped, producer's accuracy	Cropped, user's accuracy		Fallow, producer's accuracy	Fallow, user's accuracy
Winter	95%	97%	88%		97%	97%		88%	88%
Summer	96%	96%	95%		99%	96%		95%	88%

- Accuracy statistics derived from comparisons against field survey data collected in 2014 and 2015 at ~670 field sites
- Statistics focus on crop/non-crop classification
- Majority of discrepancies explained by issues with young perennials (vineyards, orchards) and transitional fields

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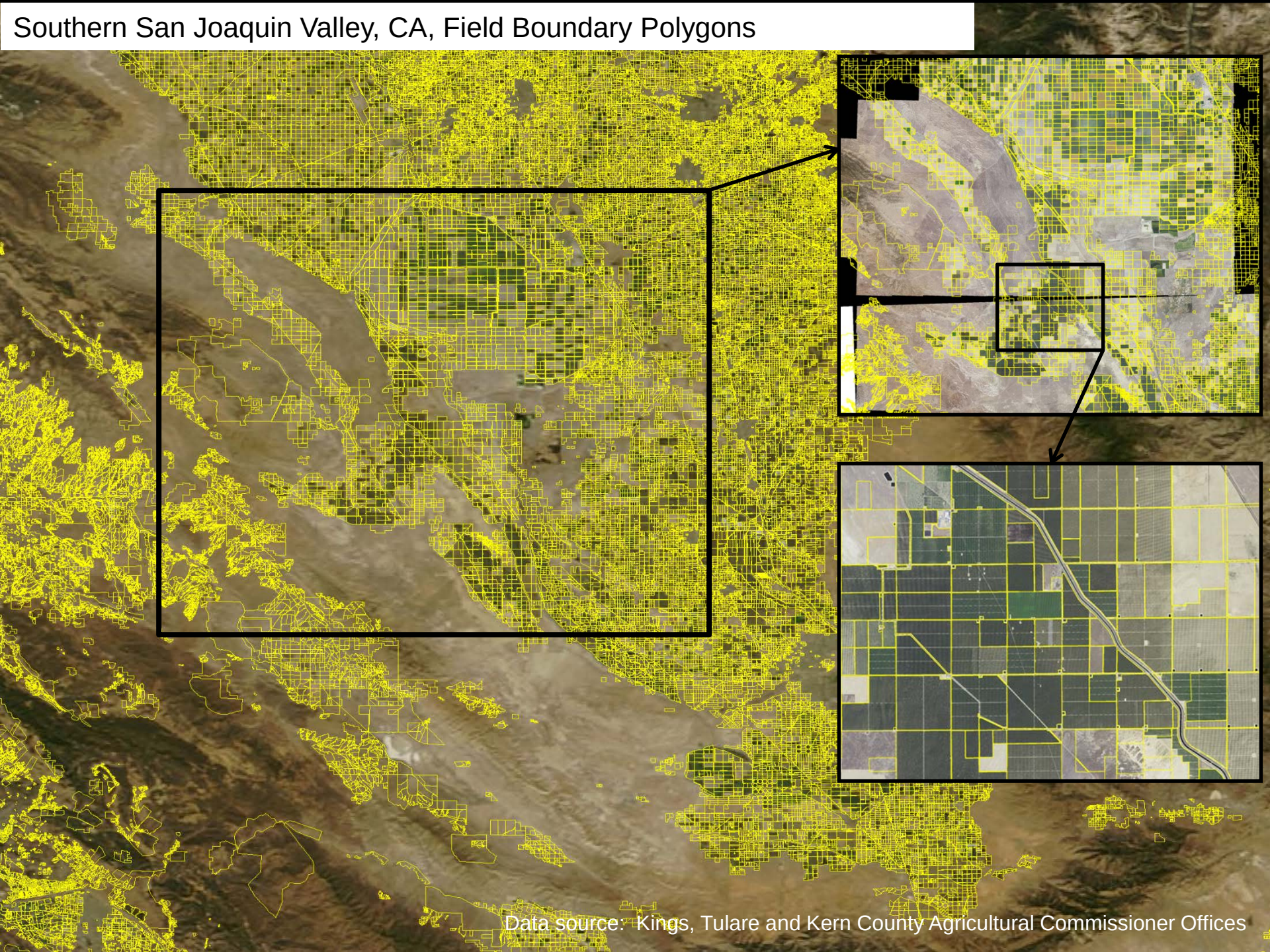
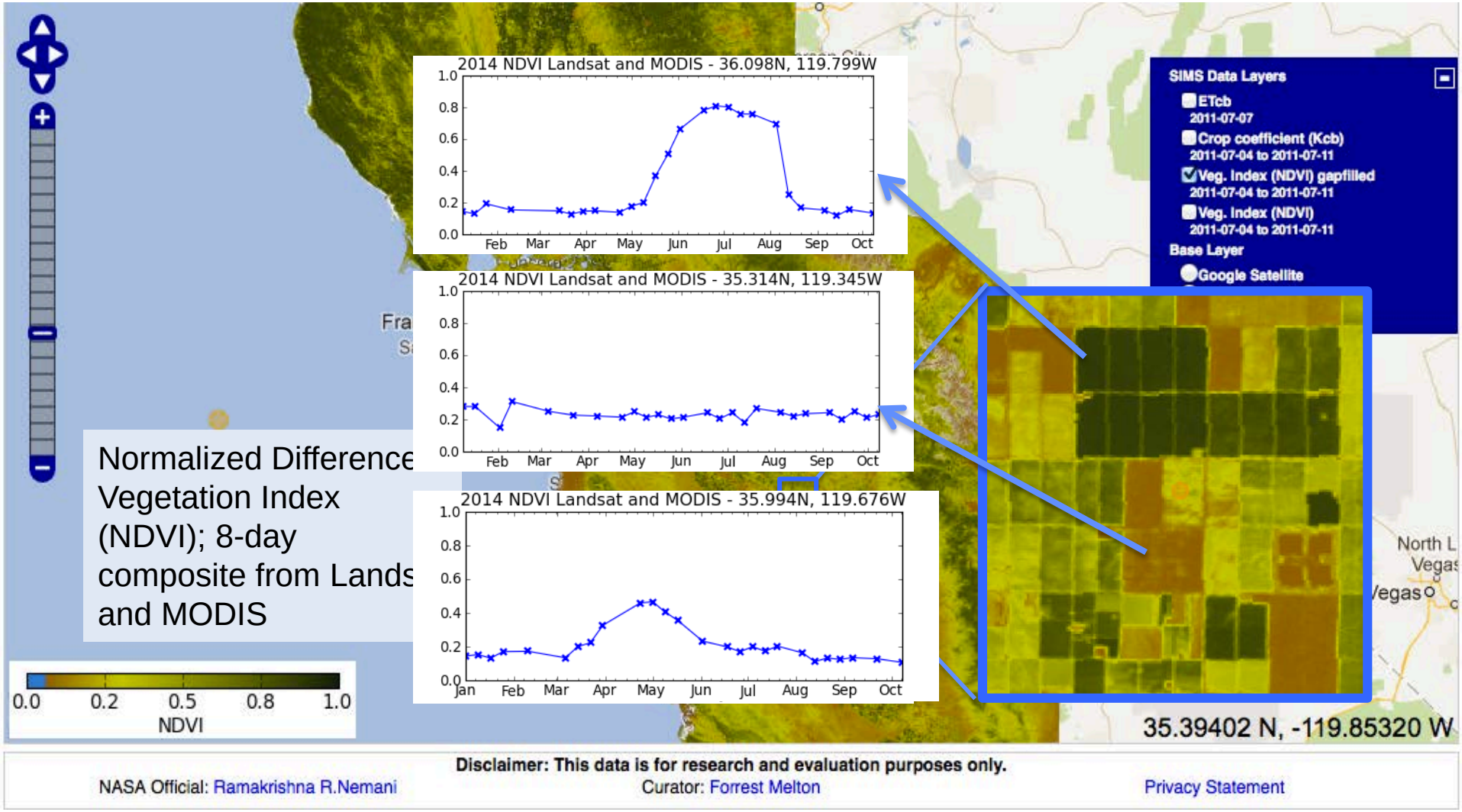
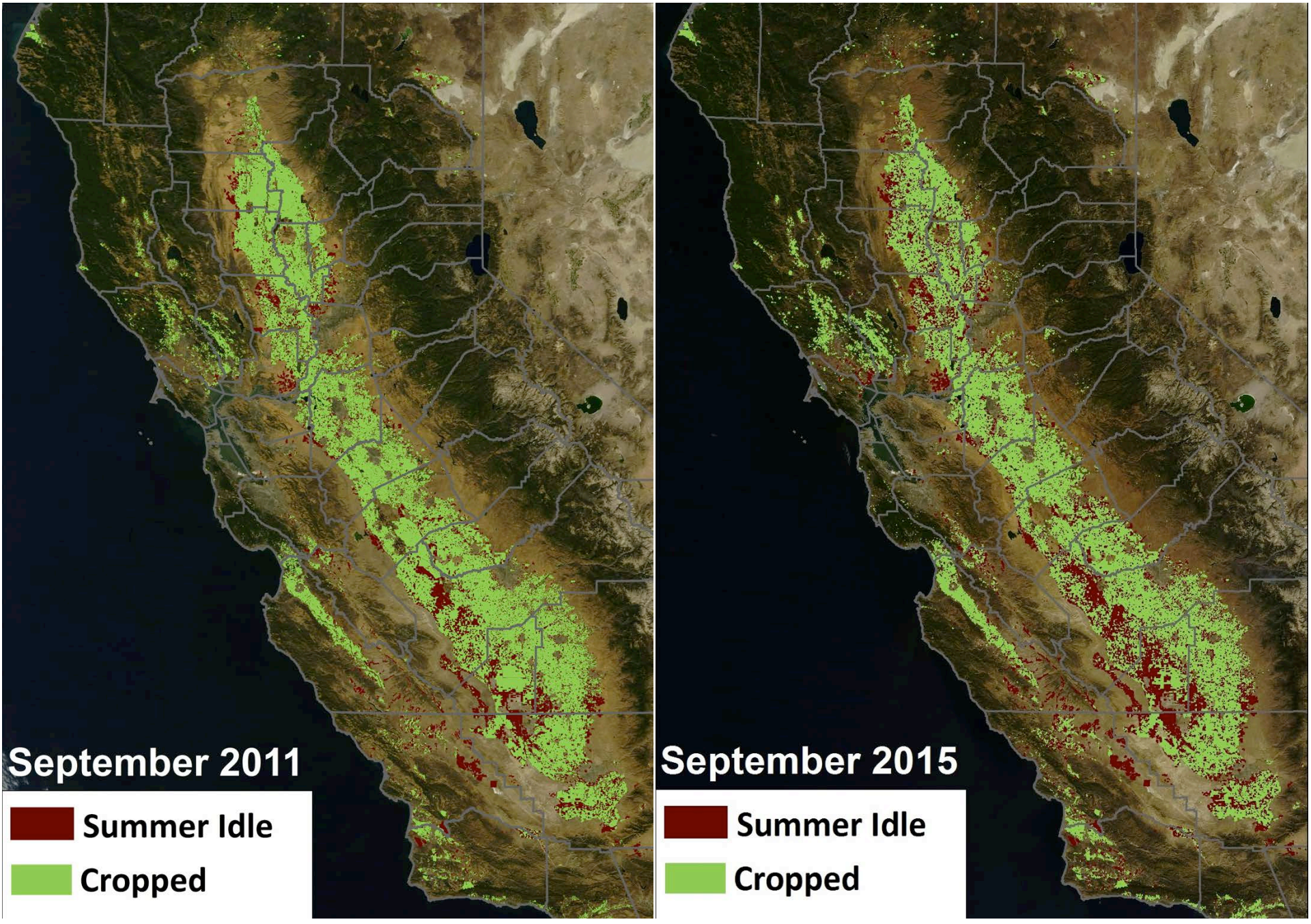
Southern San Joaquin Valley, CA, Field Boundary Polygons



Data source: Kings, Tulare and Kern County Agricultural Commissioner Offices

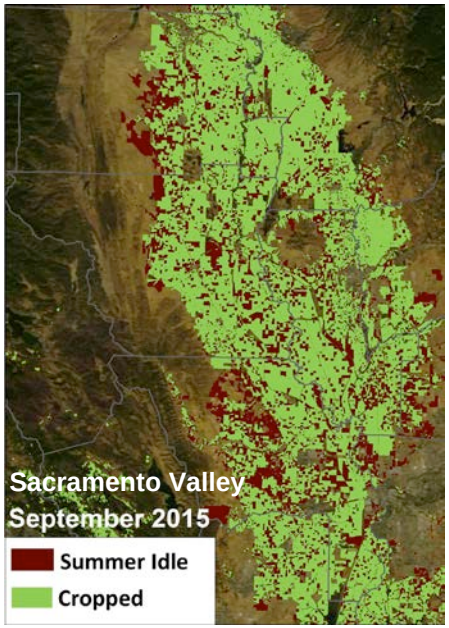
Monitoring Crop Development

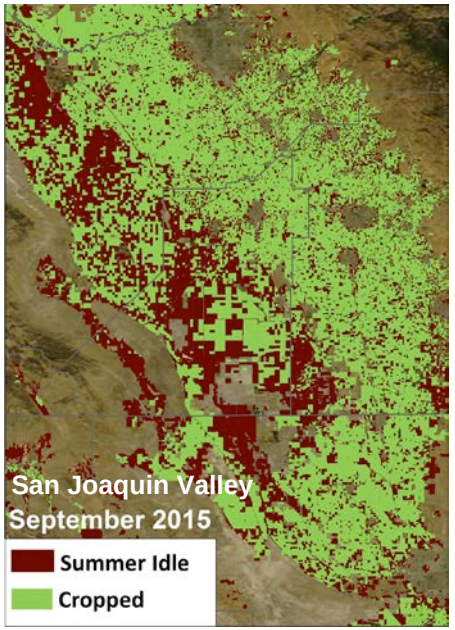


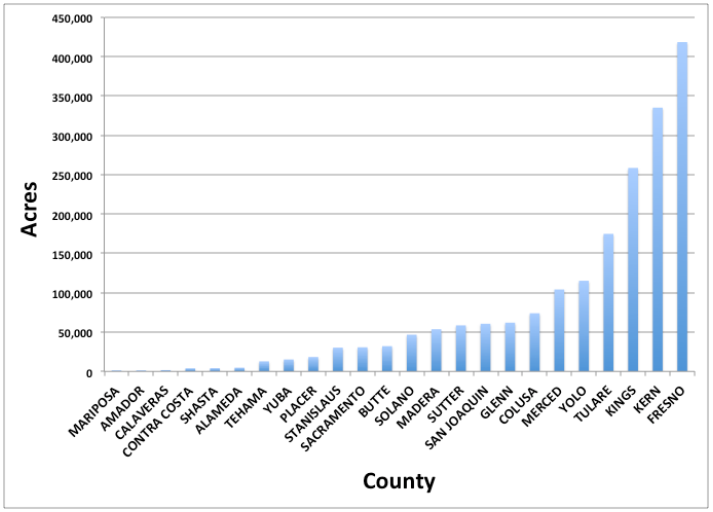

September 2011
Summer Idle
Cropped
September 2015
Summer Idle
Cropped

Highlights

- Collaborative, interagency effort between USGS, NASA, USDA, and CA DWR → responds to request from CA Dept. of Water Resources
- Successfully demonstrated capability for within season mapping of idle acreage (advanced delivery of information >10 months).
- Monthly estimates generated by the project team for March – September, 2014/2015 and delivered to DWR within two weeks of end of month.
- Overall accuracy has been approx. +/- 15% or better in all months.
- Good agreement between USDA/NASA year-to-date idle estimates



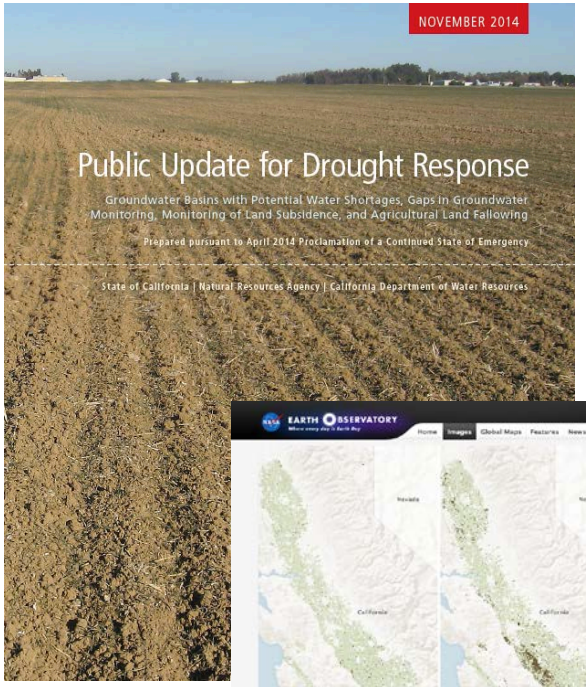


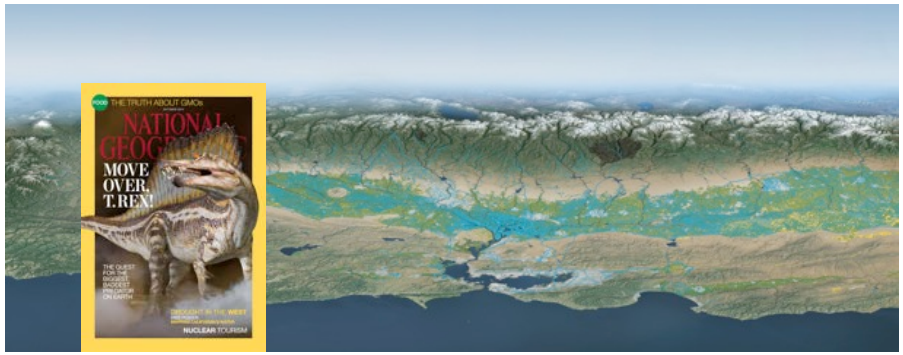


Examples of information products delivered to CDWR in 2015, including maps of land fallowing and graphs summarizing total land fallowing by county.

Impacts

- Data presented to Governor's Drought Task Force by CA DWR in 2014/2015
- Data used by CDFA in modeling of economic impacts of drought on agriculture in 2014/2015
- Data used in allocation of emergency drought relief funds to food banks in impacted counties
- Data highlighted in CDWR 2014 Public Update for Drought Response (Nov 2014)
- Data featured in 5-page poster in National Geographic issue on Drought in the West (Oct 2014)
- NASA Earth Observatory Image of the Day (1/30/2015)





Transition Strategy

- USDA NASS mapping will be supported by NASS as part of the Cropland Data Layer program

- CDWR forming working group to advise on final implementation
  - Option 1: Algorithms / processing workflows to be implemented on Google Earth Engine
  - Option 2: Algorithms and workflows transferred to CDWR IT infrastructure

- Challenge: Cloud-based solution is lowest cost, scalable to other regions, and most flexible, but may not be compatible with partner IT policies

- Nevada and Washington have requested capability via NIDIS

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Lessons Learned

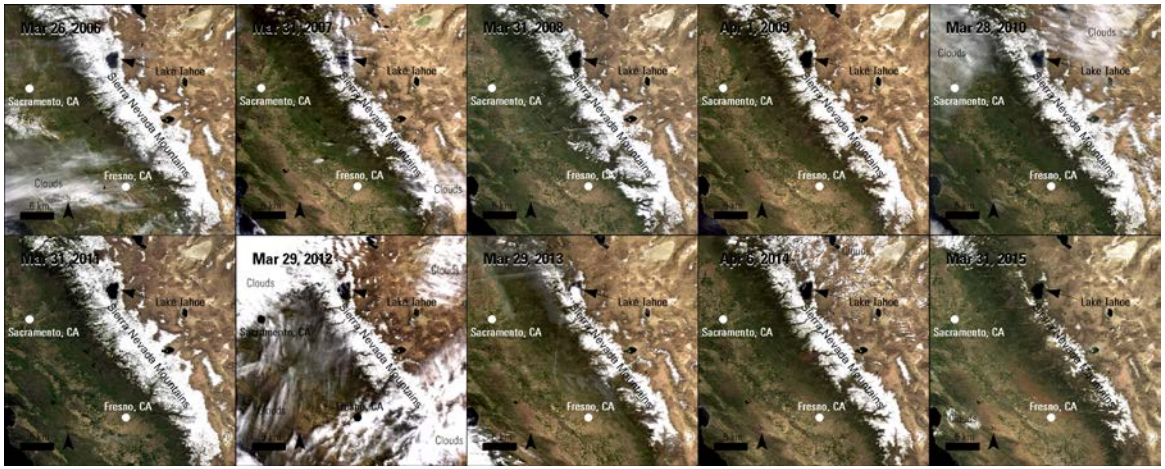
1) Frequent communication is essential

2) Quantifying accuracy increases utility for decision makers

3) Simple summary graphics / maps are key tools for policy-makers and public communication and outreach

4) There are many definitions of “fallow” → buy-in to technical definitions used is key

5) Completing the transition process takes a very, very long time



April 1st Sierra Nevada Snowpack, 2006-2015

MODIS / USGS

Publications

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Melton, F., Rosevelt, C., Guzman, R., Johnson, L., Zaragoza, I., Thenkabail, P., Wallace, W., Mueller, R., Willis, P., Jones, J., & Verdin, J. (2015). Fallowed area mapping for drought impact reporting: 2015 assessment of conditions in the California Central Valley. NASA Ames Research Center report published online October 14, 2015. https://nex.nasa.gov/nex/resources/371/ on February 5, 2016.

Melton, F., Rosevelt, C., Guzman, R., Johnson, L., Zaragoza, I., Thenkabail, P., Wallace, W., Mueller, R., Willis, P., Jones, J., & Verdin, J. *in prep.* Satellite mapping of land fallowing in California during drought of 2011-2015.

Questions?

https://c3.nasa.gov/water/projects/5/

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