



# Remote Sensing of Drought Impacts on California Agriculture

**Forrest Melton, NASA ARC-CREST**  
**forrest.s.melton@nasa.gov**

*Forrest Melton, Lee Johnson, Carolyn Rosevelt, NASA ARC-CREST / CSU Monterey Bay*

*James Verdin (Project PI), Prasad Thenkabail, John Dwyer, Cynthia Wallace, USGS*

*Rick Mueller and Audra Zakzeski, USDA NASS*

*Rama Nemani, NASA Ames Research Center*

*Jeanine Jones, California Department of Water Resources*

*Support from NASA Applied Sciences Program and NIDIS*

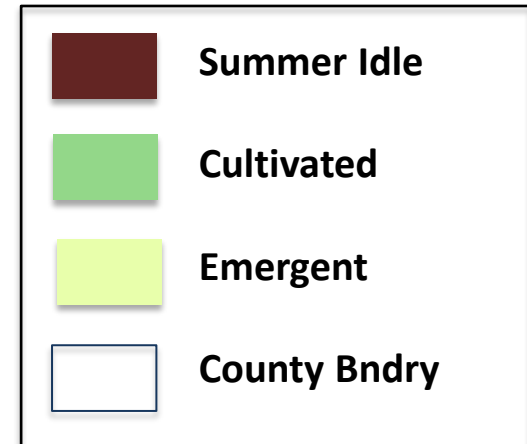
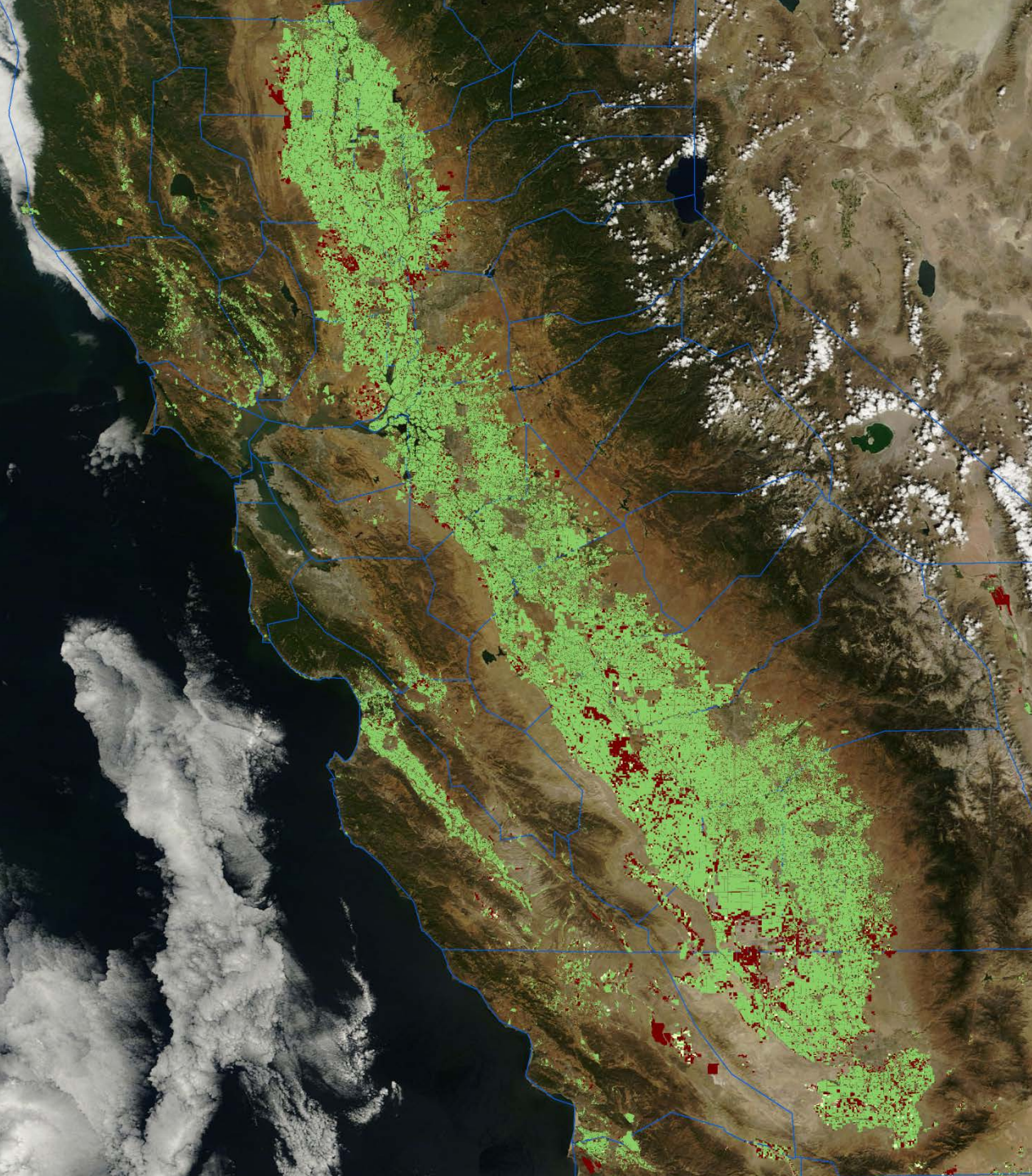
# Drought Impacts on Land Following

- **Background:** Mapping of fallowed areas during drought identified as a research priority for NIDIS by CA Department of Water Resources (CDWR)
- **Information needed:** Product similar to 'idle lands' class in USDA cropland data layer for California, but on a monthly basis during growing season(s)
- **Project objective:** Apply satellite data to provide information that will allow CDWR, CDFA and other stakeholders to identify extent of fallowed acreage due to water shortages relative to previous years

# Drought Impacts on Land Following

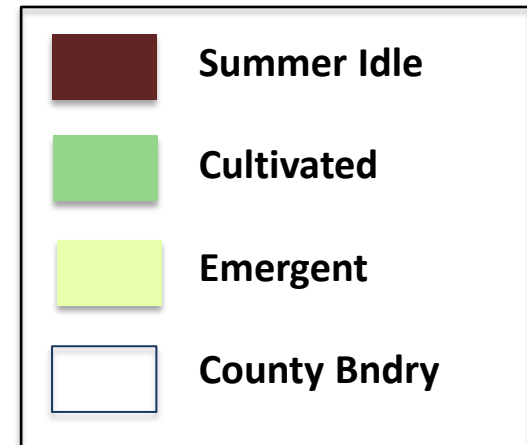
- **Decisions supported:**
  - State proclamations of emergency pursuant to the California Emergency Services Act and allocation of drought relief funding
  - State priorities for providing assistance with and processing of local water transfer requests
- **Limitations of previously available information:**
  - 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

Sept 22, 2011  
Central Valley  
Summer Conditions  
(June 1 – Sept 22)

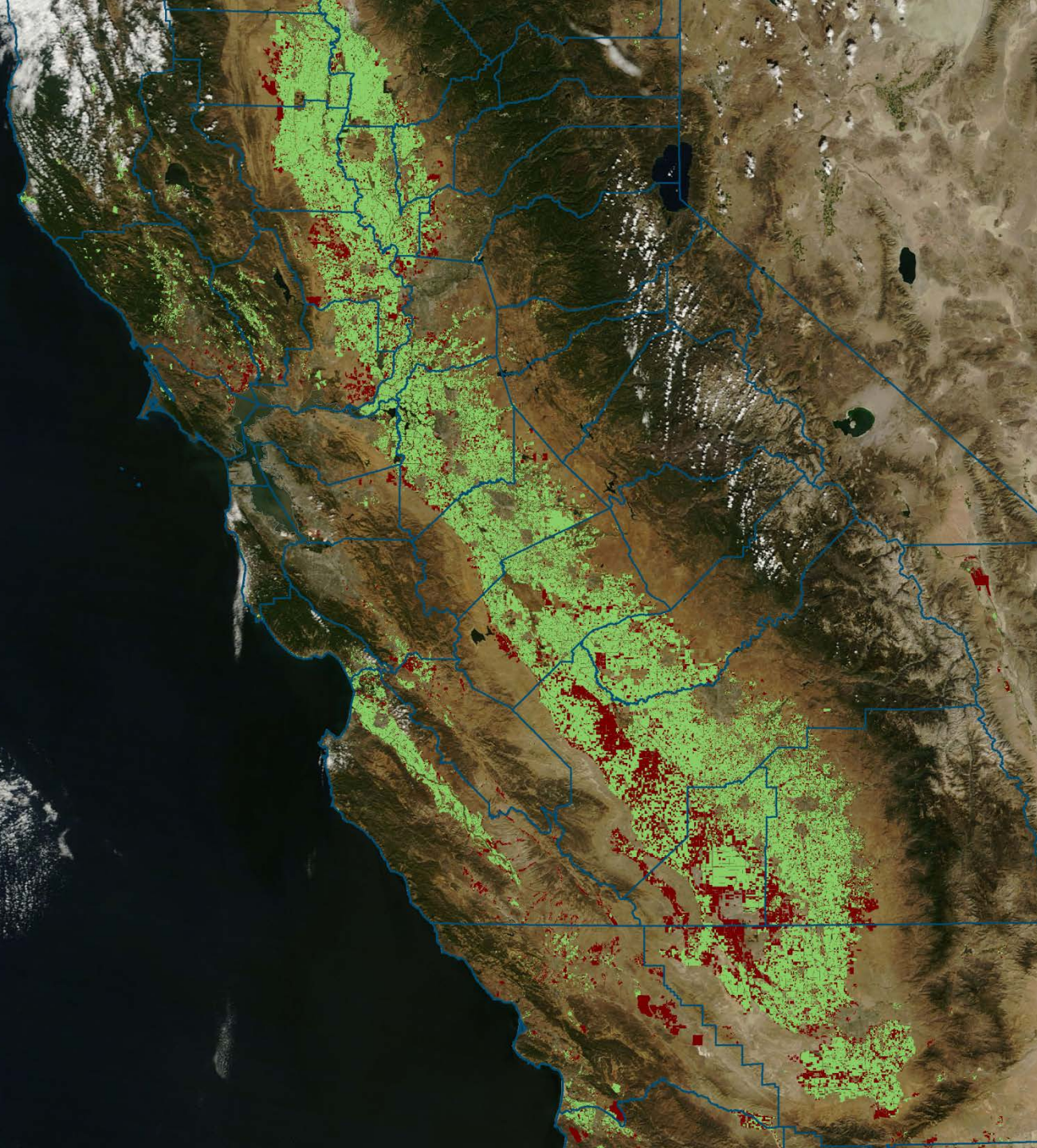


Data source: NASA /  
CSU Monterey Bay.  
Map derived from  
data from Landsat 7,  
Landsat 8, Terra and  
Aqua satellites.  
Satellite observations  
for ~200,000 fields  
obtained every 8  
days.

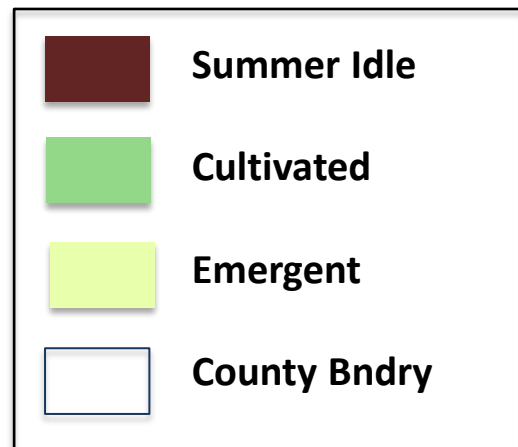
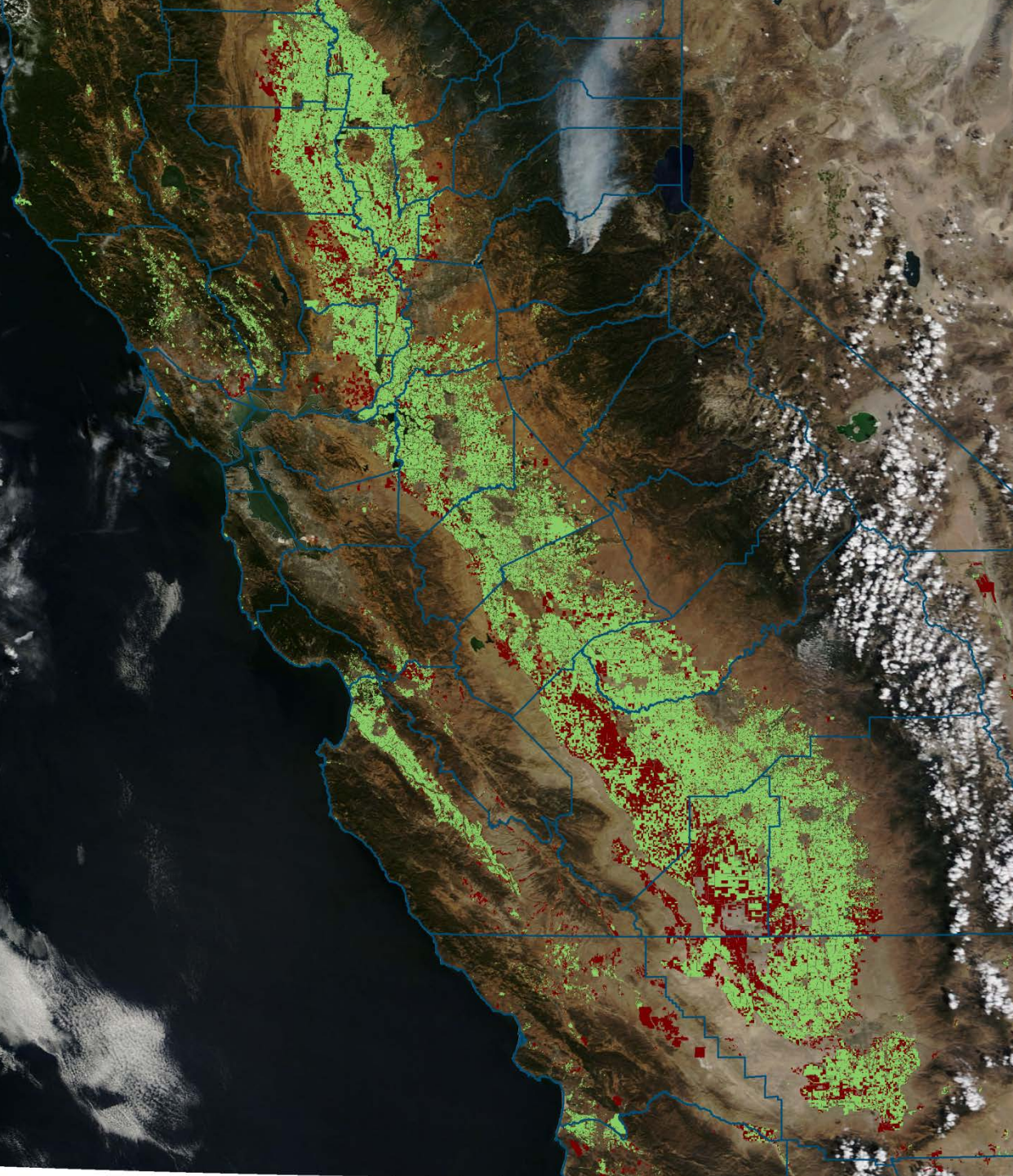
Sept 22, 2013  
Central Valley  
Summer Conditions  
(June 1 – Sept 22)



Data source: NASA /  
CSU Monterey Bay.  
Map derived from  
data from Landsat 7,  
Landsat 8, Terra and  
Aqua satellites.  
Satellite observations  
for ~200,000 fields  
obtained every 8  
days.

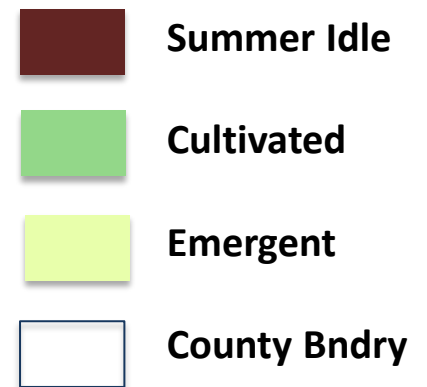


Sept 22, 2014  
Central Valley  
Summer Conditions  
(June 1 – Sept 22)



Data source: NASA /  
CSU Monterey Bay.  
Map derived from  
data from Landsat 7,  
Landsat 8, Terra and  
Aqua satellites.  
Satellite observations  
for ~200,000 fields  
obtained every 8  
days.

Sept 22, 2014  
San Joaquin Valley  
Summer Conditions  
(June 1 – Sept 22)



Data source: NASA /  
CSU Monterey Bay.  
Map derived from  
data from Landsat 7,  
Landsat 8, Terra and  
Aqua satellites.  
Satellite observations  
for ~200,000 fields  
obtained every 8  
days.

# Idle Acreage Summary

Central Valley, Total Idle Acreage		
Year	Summer Idle (idle Jun 1 – Sept 30)	Annual Idle (idle Jan 1 – Sept 30)
<b>2014</b>	1,713,838	1,201,472
<b>2013</b>	1,621,174	971,094
<b>2011</b>	1,213,682	321,865
<b>2014 – 2011 (change)</b>	<b>500,156</b>	<b>879,607</b>

- Data source: NASA Ames Research Center / CSU Monterey Bay
- Accuracy for the estimates from NASA is +/- 9.8%, based on comparisons with monthly field observations collected across the Central Valley from April-Sept, 2014.
- Data provided for current year (2014), previous year (2013), and most recent year with average or above average precip during winter (2011)



# Central Valley Summer Acreage Summary (2014 vs 2011)

	2014 Summer to Date (June 18 - Sept 30)					2011 Summer to Date (June 18 - Sept 30)			
COUNTY	Cropped	Emerg.	Idle	Total		Cropped	Emerg.	Idle	Total
ALAMEDA	2,443	740	5,139	7,582		4,278	322	3,304	7,582
AMADOR	4,565	0	748	5,313		5,093	0	221	5,313
BUTTE	204,177	1,228	29,436	233,614		226,452	410	7,162	233,614
CALAVERAS	1,869	29	1,175	3,044		1,697	65	1,347	3,044
COLUSA	245,969	1,037	61,017	306,986		276,687	433	30,299	306,986
CONTRA COSTA	32,399	389	2,504	34,902		31,660	86	3,242	34,902
EL DORADO	322	0		322		322	0		322
FRESNO	800,928	7,500	387,098	1,188,026		939,758	7,311	248,268	1,188,026
GLENN	213,660	0	52,135	265,795		231,902	0	33,893	265,795
KERN	672,803	5,263	307,819	980,622		717,620	20,145	263,002	980,622
KINGS	308,071	1,634	242,611	550,682		404,720	5,640	145,962	550,682
MADERA	294,429	297	49,968	344,397		299,126	1,272	45,271	344,397
MARIPOSA	187	0	362	548		186	0	362	548
MERCED	374,336	3,371	87,997	462,333		408,991	1,331	53,342	462,333
PLACER	19,433	360	17,461	36,893		22,163	57	14,730	36,893
SACRAMENTO	119,503	415	29,358	148,860		120,994	272	27,867	148,860
SAN JOAQUIN	426,808	1,981	50,186	476,995		427,291	114	49,704	476,995
SOLANO	116,118	190	42,596	158,714		117,951	790	40,764	158,714
STANISLAUS	291,771	1,699	25,649	317,420		300,724	151	16,696	317,420
SUTTER	215,513	1,312	43,710	259,223		242,251	87	16,972	259,223
TEHAMA*	6,146	0	1,185	7,332		5,712	0	1,620	7,332
TULARE	524,941	2,208	150,042	674,982		547,706	3,370	127,276	674,982
YOLO	223,827	2,406	112,985	336,812		264,371	1,120	72,441	336,812
YUBA	82,123	0	12,658	94,781		84,844	70	9,937	94,781
<b>Total Acres</b>	<b>5,182,340</b>	<b>32,058</b>	<b>1,713,838</b>	<b>6,896,179</b>		<b>5,682,497</b>	<b>43,047</b>	<b>1,213,682</b>	<b>6,896,179</b>

\* Data only available for southern Tehama County at this time. Estimate for Tehama County will be revised.

# Central Valley Summer Idle Acreage by Crop Type (June 1 – Sept 30)

	2014				
Commodity	Cropped	Emergent	Idle	Total Acres	2014 - 2011 Idle
Total, All Crops	4,970,545	32,058	1,706,038	6,708,641	692,805
MISC CROP, UNCULT. IN 2013	164,827	7,070	468,225	640,122	169,836
COTTON	267,434	4,089	144,858	416,381	108,079
ALFALFA	528,320	1,432	116,588	646,340	79,885
RICE	519,029	2,134	70,378	591,541	56,589
TOMATO PROCESS	122,886	2,541	57,106	182,532	47,799
WHEAT	174,556	287	276,919	451,763	30,378
BARLEY	32,588	229	56,469	89,287	24,024
CORN/WHEAT/OAT FOR FODDER	258,404	1,501	86,829	346,734	35,049
OTHER HAY/NON ALFALFA	38,800	840	26,553	66,193	14,018
SAFFLOWER	27,202	1,033	18,583	46,818	12,400
OATS	25,126	412	32,203	57,741	11,163
GRAPE, WINE	153,055	504	15,422	168,981	10,724
GRAPE, RAISIN	106,319	44	12,476	118,839	10,250
CARROT	13,371	588	20,798	34,758	9,156
CORN	72,121	374	16,968	89,463	8,678
DBL CROP WINWHT/CORN	52,632		10,928	63,560	6,858
GRAPE WINE	49,071	3	6,178	55,253	5,382
GARLIC	7,650	241	7,889	15,780	5,263
CANTALOUPE	7,435	241	6,576	14,251	4,323
POMEGRANATE	27,110	101	6,406	33,617	3,930
...	...	...	...	...	...

Idle acreage by crop type for summer 2014, and the difference between 2014 and 2011 summer idle acreage for the top 20 crop types by idle acreage. Data for additional crops available. Crop type for each field is based on 2013 data.

# Satellite Data



Landsat (TM / ETM+ / OLI)  
30m / 0.25 acres  
Overpass every 8-16 days



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

# Normalized Difference Vegetation Index

## Healthy Vegetation Reflectance

50% NIR      8% Red



NDVI = 0.72

## Stressed Vegetation Reflectance

40% NIR      30% Red



NDVI = 0.14

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

Credit: ODIS

Commonly used remote sensing index of vegetation condition

Username: Password: Login

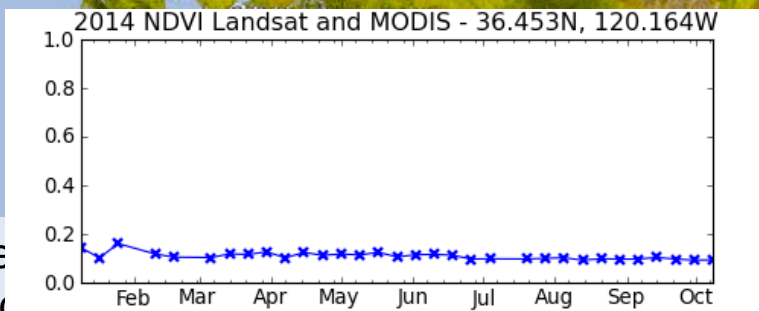
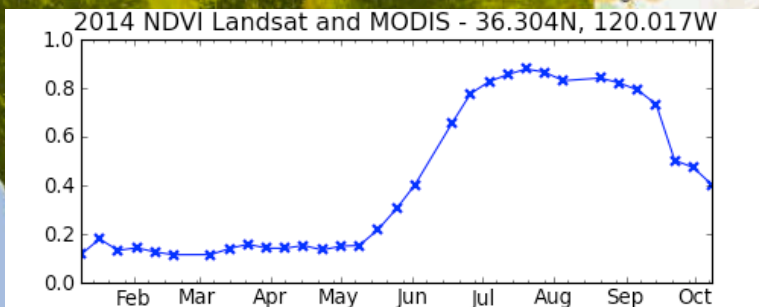


# TOPS Satellite Irrigation Management Support

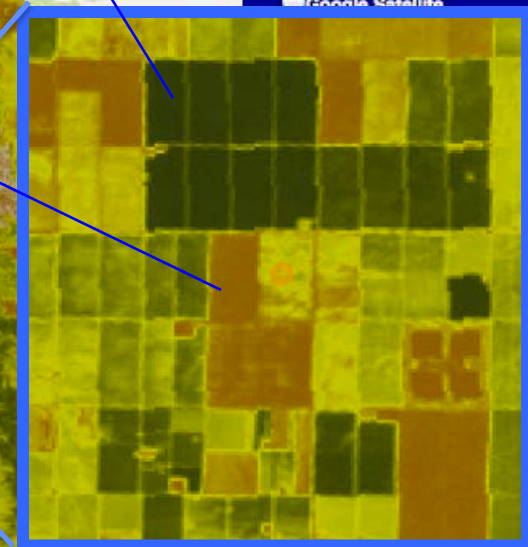
Go to: Search

[About](#) [Help](#)

Select Date: 2014-07-07



Normalized Difference Vegetation Index (NDVI); 8-day composite from Landsat and MODIS

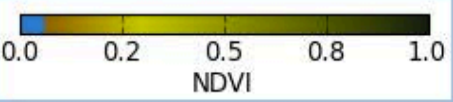


**SIMS Data Layers**

- ETcb
- Crop coefficient (Kcb)
- Veg. Index (NDVI) gapfilled
- Veg. Index (NDVI)

**Base Layer**

- Google Satellite



35.39402 N, -119.85320 W

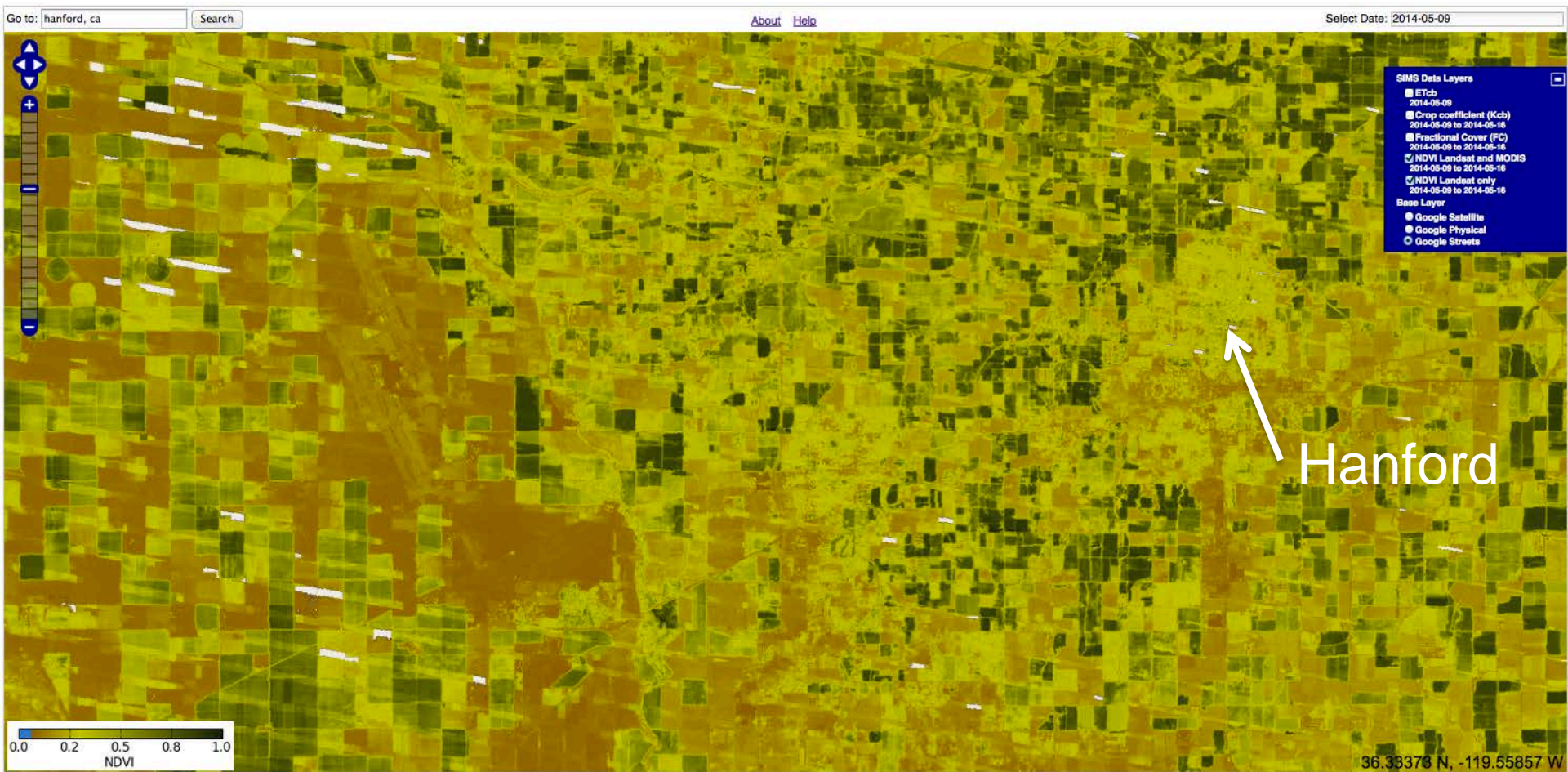
Disclaimer: This data is for research and evaluation purposes only.

NASA Official: Ramakrishna R.Nemani

Curator: Forrest Melton

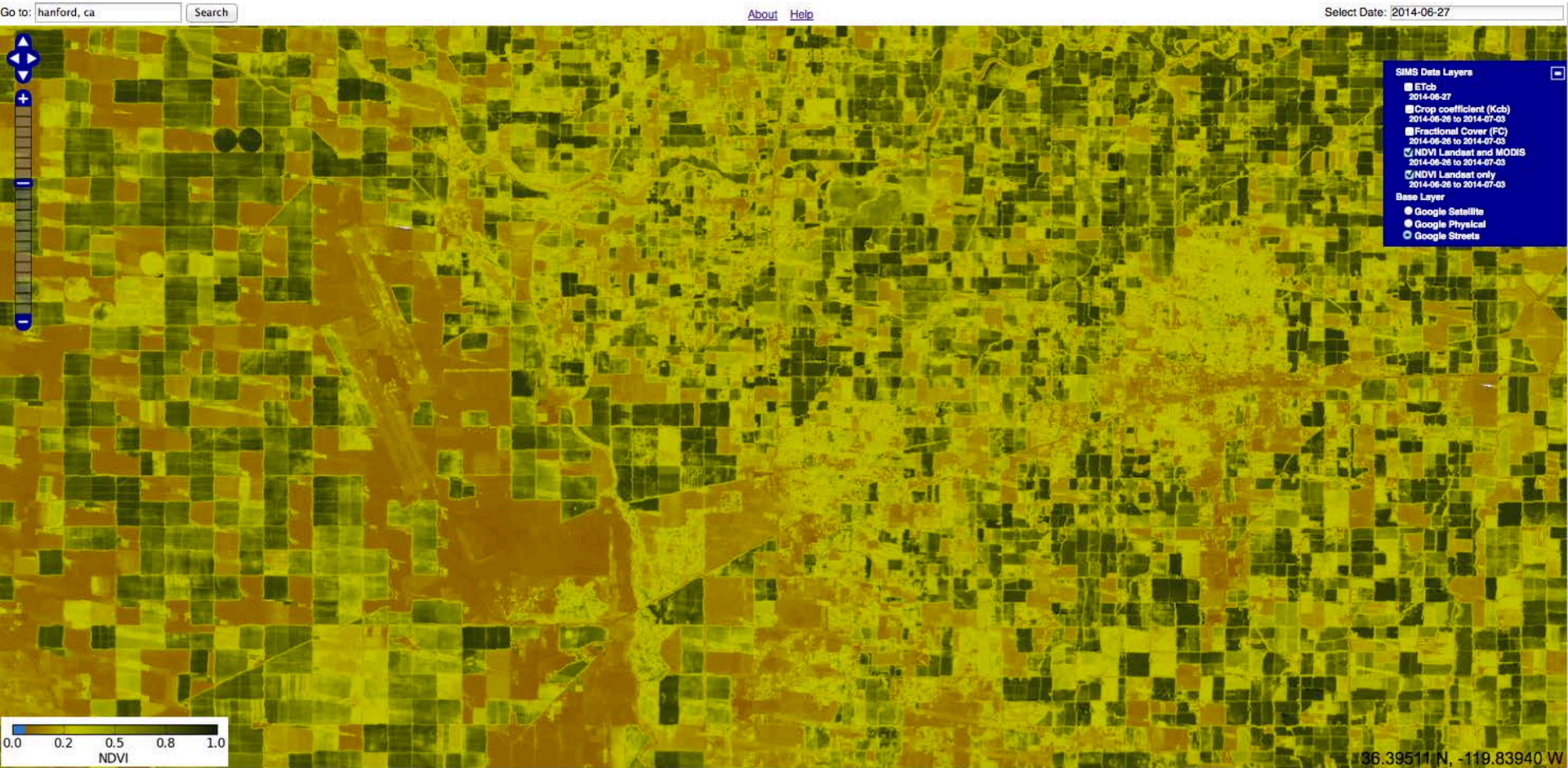
[Privacy Statement](#)

# The Satellite View



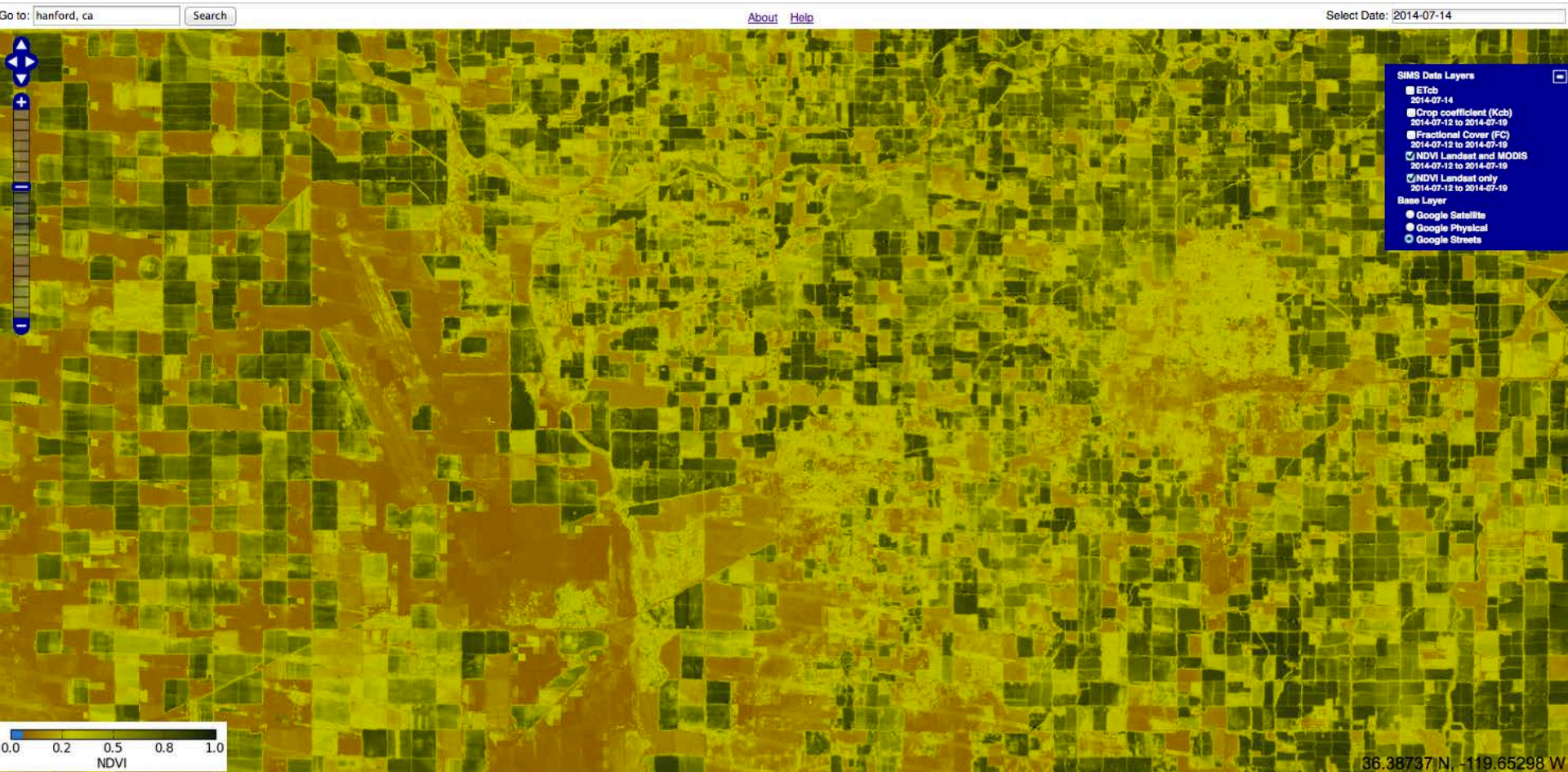
May, 2014

# The Satellite View



June, 2014

# The Satellite View



July, 2014

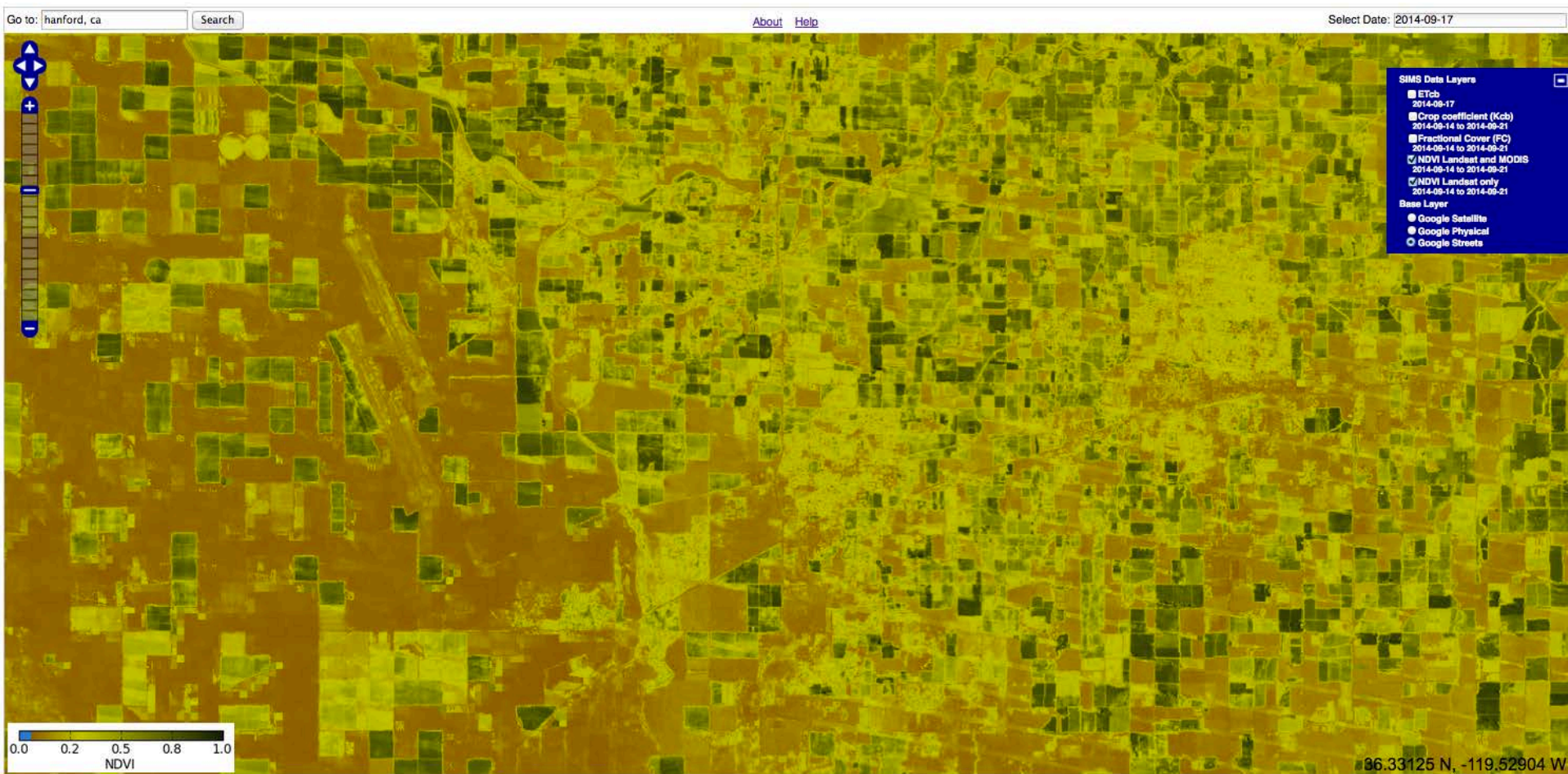


# The Satellite View



August, 2014

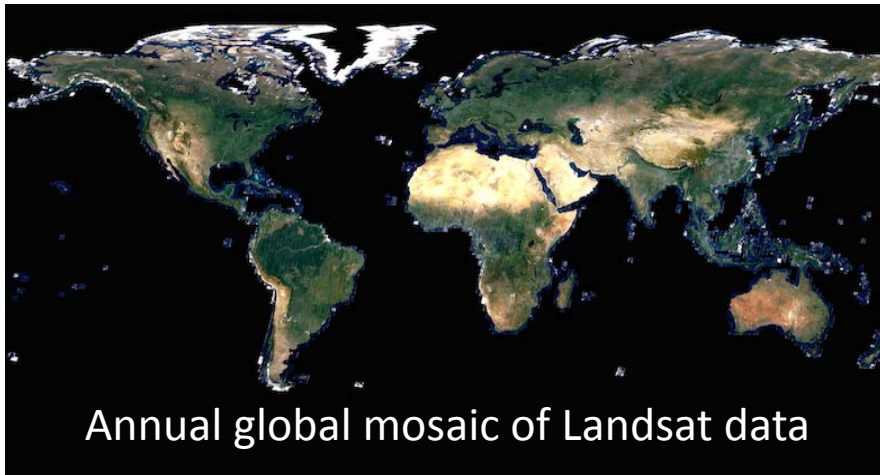
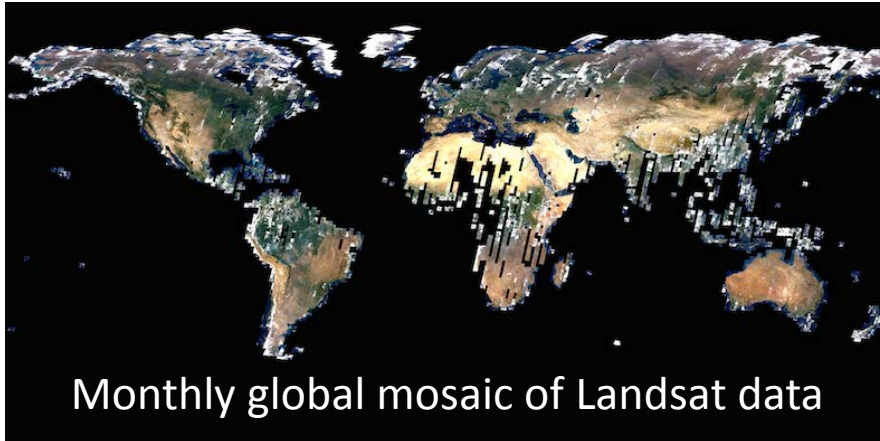
# The Satellite View



September, 2014

# Data Processing on the NASA Earth Exchange (NEX)

<http://nex.nasa.gov>



- Global processing of up to 18,000 scenes in less than 5 hours
- Input and output data volumes = 1PB
- 18 years of global Landsat science products with applications for ag, forestry, water mgmt, disaster mgmt, public health



**COLLABORATION** (over 340 members)

**COMPUTING** (9PB, 180,000 cores)

**Centralized Data Repository** (over 500 TB of data)

# Decision Tree Algorithm Example

Monthly Classification  
 T1 = most recent, T5 = 32 days prior

Mean-NDVI<sub>T1-T5</sub> < 0.34

Mean-NDVI<sub>T1-T5</sub> >= 0.34 &&  
 Mean-NDVI<sub>T1-T5</sub> < 0.6

Mean-NDVI<sub>T1-T5</sub> >= 0.6

Low Veg Cover (LV)

Med Veg Cover (MV)

High Veg Cover (HV)

IF Slope-NDVI<sub>T1-T5</sub> >= 0.1 OR  
 ((T1-T4)>=0.05) AND  
 (T4<T3<T2<T1)

EM

ELSIF (T6 OR T7 OR...T13  
 >0.75) OR  
 (>= 3 periods with NDVI >  
 .67 since Jan 1)

RH

ELSIF (NDVI for all periods since  
 Jan 1 <= 0.4)

Idle

ELSE

UD

IF Slope-NDVI<sub>T1-T5</sub> >= 0.05 OR  
 ((T1-T4)>=0.1) AND  
 (T4<T3<T2<T1) OR NDVI<sub>max</sub>  
 since Jan 1 > 0.75

C

ELSIF (Slope-NDVI<sub>T1-T5</sub> <= -0.05  
 ) OR ((T1-T5<=-.1) AND  
 (T4>T3>T2>T1))

Idle

ELSE

UD

IF (T1 OR T2 OR T3 OR T4  
 OR T5>.75) OR  
 (3 of last 5 NDVI values >= >  
 .67 ) OR  
 (slope T5:T1>=0.05) OR  
 ((T1-T5>=0.1) AND  
 (T4<T3<T2<T1)) OR NDVI<sub>max</sub>  
 since Jan 1 > 0.75

C

ELSIF (slope T5:T1<=-.05)  
 OR ((T1-T5<=-.1) AND  
 (T4>T3>T2>T1))

Idle

ELSE

UD

Additional algorithms  
 for perennials, rice,  
 alfalfa, pasture



# Field Survey Transects

California Central Valley



Survey transects, from April-May and May-June 2012. ~1000 fields total.  
March – Sept, 2014, 670 fields surveyed monthly

# Early Season Algorithm Accuracy Assessment

2014	March		April		May		June		July		Aug		Sept.	
	Crop	Idle	Crop	Idle	Crop	Idle	Crop	Idle	Crop	Idle	Crop	Idle	Crop	Idle
<b>Producer's Accuracy</b>	90%	93%	92%	91%	96%	92%	98%	97%	96%	89%	97%	91%	97%	92%
<b>User's Accuracy</b>	90%	94%	91%	90%	96%	91%	91%	85%	95%	86%	96%	89%	96%	89%
<b>Overall % Correct</b>	93%		91%		95%		93%		94%		95%		95%	

- Accuracy statistics derived from comparisons against field survey data collected in 2014 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

# 2015 Plans

- Monthly mapping throughout 2015, beginning in late March / early April
- Improvements for mapping of young perennials and partial fallowing
- Scoping of transition options for sustained operations



# Summary

- Collaborative, interagency effort between USGS, NASA, USDA, and CA DWR → responds to request from CA DWR
- 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 and delivered to DWR within two weeks of end of month.
- Overall accuracy has been approx. +/- 10% or better in all months.
- Mapping will continue in 2015

