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Drought Impacts on Land Fallowing in California's Central Valley in 2015

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Abstract

We present data on monthly and seasonal land fallowing in 2015 in the California Central Valley during the ongoing drought. The datasets were produced using satellite observations as part of a joint effort by NASA, USDA and USGS in collaboration with the CA Department of Water Resources (CDWR) to provide timely and accurate assessments of land fallowing during drought events in California. This effort has used the CA Central Valley as a pilot region for the National Integrated Drought Information System (NIDIS) for the development and testing of an operational monitoring system. The ongoing drought in California substantially reduced surface water supplies for millions of acres of irrigated farmland in California's Central Valley. Rapid assessment of drought impacts on agricultural production can aid water managers in assessing mitigation options, and guide decision making with respect to mitigation of drought impacts. Satellite remote sensing offers an efficient and consistent way to provide quantitative assessments of drought impacts on agricultural production and increases in fallow acreage associated with reductions in surface water supplies. To provide quantitative measures of uncultivated agricultural acreage throughout the year, we developed a decision tree algorithm and applied it to timeseries data from Landsat TM, ETM+, OLI, and MODIS. Our effort has been focused on the development of indicators of drought impacts in the March – Sept. timeframe based on measures of crop development patterns relative to a reference period with average or above average rainfall. To assess the accuracy of the algorithms, monthly ground validation surveys were conducted across 650 fields from March - September in 2014 and 2015. We present the approach along with updated results from the accuracy assessment, and data and maps of land fallowing in the Central Valley in 2015 (Fig. 1).

Approach

Satellite Data and Mapping Approach

To support seasonal monitoring of fallowed acreage, we developed new algorithms to complement the annual fallow land class in the USDA Cropland Data Layer. Satellite data from Landsat TM, ETM+, and OLI were atmospherically corrected to surface reflectances using LEDAPS and L8SR and then used to calculate statewide composites of NDVI every 8 days. Gaps in the Landsat composites were filled using NDVI data calculated from MODIS MOD09 and MYD09 250m surface reflectance data. Data on field boundaries were compiled from County Agricultural Commissioners and used to extract timeseries of NDVI data for each of more than 220,000 agricultural fields in the state. Decision tree algorithms were trained against field observations for 1000 fields collected in 2012, and then applied to the NDVI timeseries in 2014 and 2015. Data was summarized each month and datasets, maps, and summary tables were provided to CDWR. Data was summarized for the winter (Jan 1 – May 31) and summer (June 1 – Sept 30) production seasons, as well as for the year-to-date (annual) conditions.

Field Data Collection and Algorithm Validation

To assess the accuracy of the monthly satellite-derived estimates of fallowed acreage provided to CDWR, the project team conducted monthly surveys of field conditions in the Central Valley from March through September 2014/2015. The field survey transects included 650 sites along eight east-west transects, and covered a mix of vegetable crops, winter grains, alfalfa, perennial crops including vineyards and orchards, and a number of sites that were fallow throughout the winter and/or summer growing seasons. The field data collected included information on crop presence or absence, crop type, crop height, visual estimates of canopy cover, soil condition, and observations of evidence of irrigation, weed control, or other field maintenance. Field data were summarized on a monthly and seasonal basis and compared against the satellite-derived data. Results from the accuracy assessment for 2015 are shown below. Accuracy results for 2014 were similar to those for 2015.

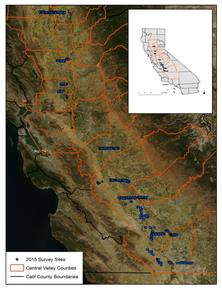
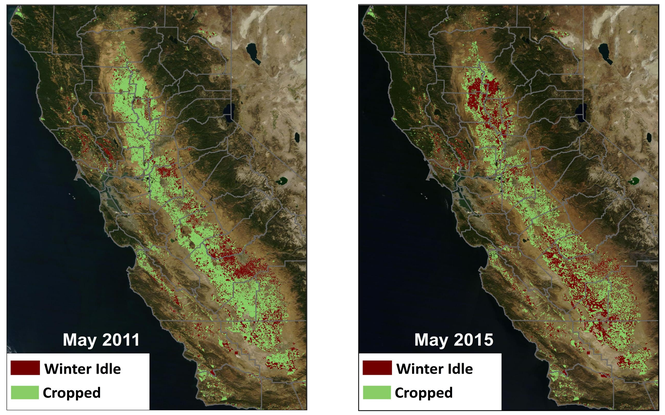


Table 1. Accuracy of satellite mapping approach in 2015 by production season.

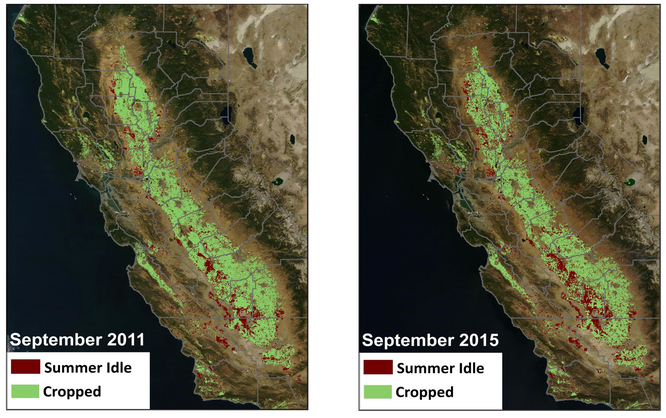
Season	Overall% correct	Cropped% correct	Fallow% correct	Cropped, producer's accuracy	Cropped, user's accuracy	Fallow, producer's accuracy	Fallow, user's accuracy
Winter	95%	97%	88%	97%	97%	88%	88%
Summer	96%	96%	95%	99%	96%	95%	88%

Figure 1. Maps of fallow (idle) acreage in California for 2015 for the winter (A), summer (B), and annual (C) time periods. Data for 2011 is provided as reference, as 2011 was the most recent year with average or above average precipitation across the state. The maps highlight the spatial patterns in land following during the drought, as well as the increase in fallowed acreage from 2011 to 2015.

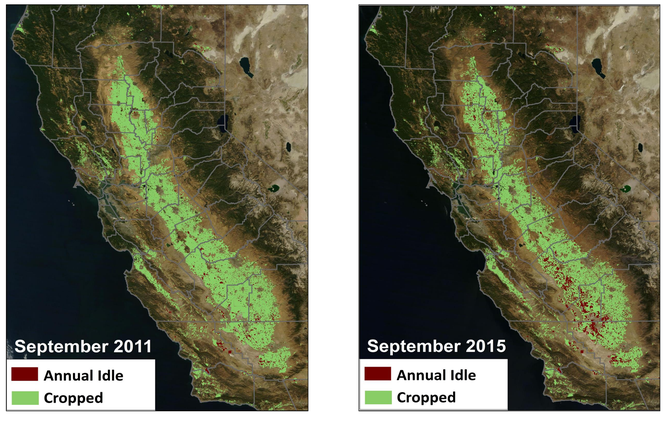
1.A Winter Conditions



1.B Summer Conditions



1.C Annual Conditions



Results

The overall classification accuracies for the algorithm was better than 90% in all months, and both the producer's and user's accuracies exceeded 85% in all months, exceeding the accuracy requirements established by CDWR (Table 1). Table 2 summarizes the extent of land fallowing in the California Central Valley through September 30, 2015, and includes winter fallowed acreage (fallow from January 1st to May 31st), summer fallowed acreage (fallow from June 1st to September 30th), and year-to-date annual fallowed acreage (fallow during both seasons). We used data from 2011 as the reference year to calculate the change in fallowed acreage during the drought, since 2011 was the last calendar year that followed a winter with average or above-average rainfall across most of California. The spatial patterns in land fallowing across California are shown in Figures 1A-1C, and Figure 2 provides a comparison between the USDA and NASA estimates for annual fallowed acreage for 2015, showing good overall agreement (difference of <1%) between the two algorithms. Data on land fallowing from USDA NASS is based on analysis of satellite data from April to September of each year, and is only available for annual fallowed acreage.

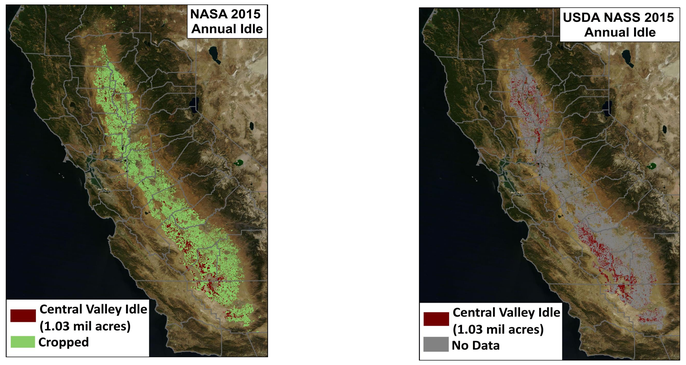


Figure 2. Comparison of estimates of annual idle acres in the Central Valley from NASA and USDA NASS data showing good agreement (within 1%).

Table 2. Estimates of land fallowing in the California Central Valley (acres).

Year	Winter	Summer	Annual
2015	1,778,174	1,917,058	1,032,508
2011	740,445	1,394,906	405,996
Change from 2011 to 2015	1,037,729	522,152	626,512
Estimate range based on accuracy assessment	913,000 to 1,162,000	459,000 to 553,000	551,000 to 664,000

Conclusion

The project team has demonstrated an approach for using data from NASA and USGS satellites (Landsat, Terra, Aqua) to provide timely and consistent information to water managers on land fallowing and reductions in planted acreage during droughts. The project team advance the availability of this information by >10 months. These datasets provide the basis for monthly county tabulations and maps that can be used by water managers to monitor fallowed land extent. This capability can provide early identification of changes in fallowed acreage due to water shortages during droughts, filling an important information gap and reducing ambiguity surrounding drought impact assessment and decision making for drought mitigation.

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For more information please see https://nex.nasa.gov/nex/projects/1372/ or contact Forrest Melton at forrest.s.melton@nasa.gov