The USDA-NASS 2007 California Cropland Data Layer

ASPRS Annual Conference – Portland, 2008
NASS Overview

Provider of timely, accurate, and useful statistics in service to U.S. agriculture

2001 Wildlife Damage Survey

United States Department of Agriculture
National Agricultural Statistics Service
Research and Development Division
Spatial Analysis Research Section
Cropland Data Layers
1997 - 2007

Additional information & free downloads:
- www.nass.usda.gov/research/
- datagateway.nrcs.usda.gov
The purpose of the Cropland Data Layer (CDL) Program is to:

1) Combine remote sensing imagery, USDA/Farm Service Agency reported data and NASS survey data to produce *supplemental*, unbiased independent acreage estimates for the state’s major commodities.

2) Production of a crop-specific digital land cover data layer for distribution in industry standard formats.

Annual CDL states traditionally focused in the Midwest and Mississippi Delta States
- Corn, Cotton, Rice, Soybeans, Winter Wheat
Purpose of the Cropland Data Layer (CDL) Program

The 2007 California CDL intended as a one-time special project

- Done at the request of NASS’ Area Frame Section
- Update of the California area sampling frame
### Top 20 Commodities for 2004-2006

<table>
<thead>
<tr>
<th>Commodity</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk and Cream</td>
<td>5,365,992</td>
<td>5,223,062</td>
<td>4,492,229</td>
</tr>
<tr>
<td>Grapes, All</td>
<td>2,764,534</td>
<td>3,197,820</td>
<td>3,032,655</td>
</tr>
<tr>
<td>Nursery and Greenhouse Products</td>
<td>2,297,363</td>
<td>2,433,346</td>
<td>2,775,000</td>
</tr>
<tr>
<td>Almonds</td>
<td>2,189,005</td>
<td>2,525,909</td>
<td>2,040,357</td>
</tr>
<tr>
<td>Cattle and Calves</td>
<td>1,633,740</td>
<td>1,744,403</td>
<td>1,676,354</td>
</tr>
<tr>
<td>Lettuce, All</td>
<td>1,748,826</td>
<td>1,416,117</td>
<td>1,607,572</td>
</tr>
<tr>
<td>Strawberries, All</td>
<td>1,205,513</td>
<td>1,122,834</td>
<td>1,194,379</td>
</tr>
<tr>
<td>Tomatoes, A(^n)</td>
<td>1,103,257</td>
<td>910,280</td>
<td>1,129,441</td>
</tr>
<tr>
<td>Floriculture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay, All</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oranges, A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chickens, A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton, All</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnuts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots, All</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pistachios</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocados</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Counties**

- Fresno
- Tulare
- Monterey
- Kern
- Merced
- Stanislaus
- San Joaquin
- Ventura
- San Diego
- Imperial

- Almonds and By-Products, All Grapes, Milk, All Carrots, All citrus
- Milk, All chickens, Almonds, Cattle and Calves, All Tomatoes
- Milk, Almonds, Cattle and Calves, All chickens, Walnuts
- Milk, All Grapes, All tomatoes, Almonds, Walnuts
- Fresh Market Strawberries, Lemons, Celery, Woody Ornamentals, Tomatoes
- Flower and Foliage Plants, Trees and Shrubs, Bedding Plants, Azaleas, Tomatoes
- Cattle, Alfalfa Hay, Carrots, Leaf Lettuce, Head Lettuce

---

**USDA’s National Agricultural Statistics Service, California Field Office publications are available free-of-charge on the Internet at:**

www.nass.usda.gov/ca
Methodology

• “Stack” satellite imagery and ancillary data layers within a raster GIS
  – 30 meter grid cells, Albers Conic Equal Area projection

• Sample spatially from stack within known ground truth from FSA and NLCD

• Data-mine samples using Boosted Classification Tree Analysis to derive best fitting decision rules

• Apply derived decision rules back to input data stack

• Create land cover map

• Create probability map

• Assess map accuracy

• Derive acreage estimates

• Commercial Software
  – Ground Truth Preparation: ESRI ArcGIS 9.2
  – Imagery Preparation: Leica Geosystems ERDAS Imagine 9.1
  – Decision-Tree Classification Software: Rulequest See 5.0
Methodology

• Ground Truth
  – Agricultural training & validation
    • Farm Service Agency (FSA) Common Land Unit (CLU)
    • NASS June Agricultural Survey (JAS)
  – Non-Agricultural training & validation
    • USGS 2001 National Land Cover Dataset (NLCD)

• Satellite Imagery
  – Landsat 5 TM
  – IRS Resourcesat-1 AWiFS
  – NASA Terra MODIS 16-day composite NDVI

• Ancillary data layers
  – USGS National Elevation Dataset (NED)
  – USGS NLCD 2001 Impervious and Tree Canopy layers
  – Farmland Mapping and Monitoring Program (2004 FMMP)
Ground Truth

• Agricultural Training & Validation
  – Farm Service Agency (FSA) Common Land Unit (CLU) Program
    • ½ used for training
    • ½ used for validation
  – NASS June Agricultural Survey (JAS)

• Non-Agricultural Training & Validation
  – USGS National Land Cover Dataset (NLCD) 2001
    • Sampled proportionate to the amount of agricultural training data
Ground truth - Agricultural Training & Validation

June Agricultural Survey (JAS) – National in Scope
- 41,000 farms visited
  - 11,000 one-square mile sample area segments
- Most states contain 150 – 400 segments
California 404 segments
Farm Service Agency (FSA) Common Land Unit (CLU)
- USDA programs (crop subsidy, disaster relief)
- Program crops (may under report specialty crops)
- Much larger area of coverage than the JAS survey
- GIS-ready (less labor intensive for NASS)

JAS survey data is still used in the crop area estimation process
Ground truth - Agricultural Training & Validation

- **2007 California JAS summary**
  - 1,392 polygons
  - ~125,150 acres (50,650 hectares)

- **2007 California FSA CLU summary**
  - 51,479 polygons
  - ~2,413,500 acres (976,700 hectares)
Non-Ag Ground Truth – 2001 National Land Cover Dataset

- Proportional sampling approach
- Pasture/hay and cultivated categories ignored
2007 CDL Inputs

• Landsat 5 TM
  – Minimum of three scenes during growing season
• IRS Resourcesat-1 AWiFS Imagery (raw reflectance)
  – Added dates
• NASA MODIS Terra (16-day NDVI composite derivative)
  – Fall scenes from previous year
• USGS Ancillary datasets
  – National Land Cover Dataset (NLCD 2001)
    • Impervious
    • Canopy
  – National Elevation Dataset (NED)
    • Elevation
• Farmland Mapping and Monitoring Program
  – 2004 California prime farmland
USDA’s Satellite Imagery Archive (USDA-SIA)

- Cost-sharing program to maximize the cost effectiveness of USDA’s expenditures on satellite imagery
- Established March 16, 2000
- Affiliated with USGS/EROS
  - Broad MOU for cooperative efforts.
  - Based on subscription fees paid annually
- Reduce the per-image price paid by spreading acquisition costs over all USDA agencies
- Leverage the power of a single USDA purchasing body
## Sensor Specifications Compared

<table>
<thead>
<tr>
<th></th>
<th>TM</th>
<th>AWiFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>705 km</td>
<td>817 km</td>
</tr>
<tr>
<td>Equatorial crossing time</td>
<td>9:45 ± 15 minutes</td>
<td>10:30 ± 5 minutes</td>
</tr>
<tr>
<td>Orbit time</td>
<td>99 minutes</td>
<td>101 minutes</td>
</tr>
<tr>
<td>Pixel size</td>
<td>30 x 30 m (reflective) 120 x 120 m (thermal)</td>
<td>56 x 56 m</td>
</tr>
<tr>
<td>Quantization</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Spectral bands</td>
<td>6 (B, G, R, NIR, SWIR, MIR) + Thermal IR</td>
<td>4 (G, R, NIR, SWIR)</td>
</tr>
<tr>
<td>Field of view</td>
<td>14.7°</td>
<td>42.1°</td>
</tr>
<tr>
<td>Swath wide</td>
<td>185 km</td>
<td>737 km</td>
</tr>
<tr>
<td>Scene size</td>
<td>184 x 152 km</td>
<td>370 x 370 km</td>
</tr>
</tbody>
</table>
Ancillary - MODIS

- NASA MODIS 16-day 250m NDVI composites
- Start in fall of previous year for winter wheat
Crop Progress

Crop Progress: Winter Wheat in California, 2007

Crop Progress: Rice in California, 2007

Crop Progress: Cotton in California, 2007

http://www.nass.usda.gov/Charts_and_Maps/Crop_Progress&_Condition/
Ancillary – USGS Products

Elevation

Canopy

Impervious
California Farmland Mapping and Monitoring Program

- Produces maps and statistical data used for analyzing impacts on California’s agricultural resources
- Land is rated according to soil quality and irrigation status
- Maps are updated every two years with the use of aerial photographs, computer mapping, public review, and field work
San Joaquin County, California
## AGRICULTURAL ACCURACY REPORT (CENTRAL VALLEY ONLY)

### Overall Accuracy
- **Correct Pixels:** 409276
- **Accuracy:** 97.15%
- **Error:** 2.85%
- **Kappa:** 0.9657

### Crop-specific Covers Only

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>Kappa Accuracy</th>
<th>User's Commission</th>
<th>Error</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>126989</td>
<td>99.88%</td>
<td>0.12%</td>
<td>0.9987</td>
<td>99.36%</td>
<td>0.64%</td>
<td>0.9930</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>81423</td>
<td>99.16%</td>
<td>0.84%</td>
<td>0.9911</td>
<td>96.19%</td>
<td>3.81%</td>
<td>0.9597</td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>55422</td>
<td>98.46%</td>
<td>1.54%</td>
<td>0.9839</td>
<td>96.25%</td>
<td>3.75%</td>
<td>0.9610</td>
</tr>
<tr>
<td>Corn</td>
<td>35459</td>
<td>98.78%</td>
<td>1.22%</td>
<td>0.9875</td>
<td>97.76%</td>
<td>2.24%</td>
<td>0.9771</td>
</tr>
<tr>
<td>Almonds</td>
<td>23519</td>
<td>97.13%</td>
<td>2.87%</td>
<td>0.9708</td>
<td>95.94%</td>
<td>4.06%</td>
<td>0.9587</td>
</tr>
<tr>
<td>Oats</td>
<td>10934</td>
<td>92.65%</td>
<td>7.35%</td>
<td>0.9259</td>
<td>92.54%</td>
<td>7.46%</td>
<td>0.9248</td>
</tr>
<tr>
<td>Cotton</td>
<td>10531</td>
<td>98.89%</td>
<td>1.11%</td>
<td>0.9888</td>
<td>97.70%</td>
<td>2.30%</td>
<td>0.9768</td>
</tr>
<tr>
<td>Walnuts</td>
<td>9898</td>
<td>95.47%</td>
<td>4.53%</td>
<td>0.9543</td>
<td>94.43%</td>
<td>5.57%</td>
<td>0.9439</td>
</tr>
<tr>
<td>Barley</td>
<td>9247</td>
<td>94.84%</td>
<td>5.16%</td>
<td>0.9481</td>
<td>93.82%</td>
<td>6.18%</td>
<td>0.9378</td>
</tr>
<tr>
<td>Grapes</td>
<td>9094</td>
<td>96.82%</td>
<td>3.18%</td>
<td>0.9680</td>
<td>95.28%</td>
<td>4.72%</td>
<td>0.9525</td>
</tr>
<tr>
<td>Safflower</td>
<td>6631</td>
<td>97.37%</td>
<td>2.63%</td>
<td>0.9736</td>
<td>97.30%</td>
<td>2.70%</td>
<td>0.9729</td>
</tr>
<tr>
<td>Pistachios</td>
<td>5272</td>
<td>96.75%</td>
<td>3.25%</td>
<td>0.9674</td>
<td>97.02%</td>
<td>2.98%</td>
<td>0.9701</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>3348</td>
<td>96.35%</td>
<td>3.65%</td>
<td>0.9634</td>
<td>99.20%</td>
<td>0.80%</td>
<td>0.9920</td>
</tr>
<tr>
<td>Rye</td>
<td>2909</td>
<td>93.66%</td>
<td>6.34%</td>
<td>0.9364</td>
<td>95.57%</td>
<td>4.43%</td>
<td>0.9556</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>2748</td>
<td>97.07%</td>
<td>2.93%</td>
<td>0.9706</td>
<td>97.31%</td>
<td>2.69%</td>
<td>0.9730</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>2593</td>
<td>98.63%</td>
<td>1.37%</td>
<td>0.9863</td>
<td>96.90%</td>
<td>3.10%</td>
<td>0.9689</td>
</tr>
<tr>
<td>Prunes</td>
<td>2571</td>
<td>94.28%</td>
<td>5.72%</td>
<td>0.9427</td>
<td>93.66%</td>
<td>6.34%</td>
<td>0.9365</td>
</tr>
<tr>
<td>Triticale (Wheat Hybrid)</td>
<td>2198</td>
<td>90.98%</td>
<td>9.02%</td>
<td>0.9096</td>
<td>96.62%</td>
<td>3.38%</td>
<td>0.9661</td>
</tr>
<tr>
<td>Olives</td>
<td>1606</td>
<td>94.58%</td>
<td>5.42%</td>
<td>0.9458</td>
<td>92.03%</td>
<td>7.97%</td>
<td>0.9203</td>
</tr>
<tr>
<td>Double-crop Winwht/corn</td>
<td>1181</td>
<td>90.71%</td>
<td>9.29%</td>
<td>0.9070</td>
<td>97.28%</td>
<td>2.72%</td>
<td>0.9728</td>
</tr>
</tbody>
</table>

*Correct Pixels represents the total number of independent validation pixels correctly identified in the error matrix.
Regression-based Acreage Estimator

Acreage not just about counting pixels

NASS Inputs
- June Survey summaries
- Area Sampling Frame
- CDLs
California Cropland Data Layer

• Available July 2008
• Downloadable at USDA Geospatial Data Gateway
• Includes:
  – Cropland data layer
  – Confidence map
  – 30m resolution version
California Cropland Data Layer

- 2007 California CDL, one-time special project for NASS’ Area Frame Section
- Opportunity for program expansion via Federal, State and University cooperative partnering

**Current Cooperators:**

**Past Cooperators:**
CDL 2008?

- Expand geographic scope?
  - Wheat states next priority
  - Mid-Atlantic region (often asked about)
- Improved categories?
  - Grassland
    - Pasture (chewed grass)
    - Hay (cut grass)
    - Natural (quasi-native)
- Imagery?
  - More frugal use of
  - Future sensors
  - Finer resolution
- Derivatives?
  - Change detection
  - Crop rotation patterns
- Other ancillary data?
  - Soils
  - Climate
Thank You

Additional information & free downloads:
- www.nass.usda.gov/research/
- datagateway.nrcs.usda.gov