NASS Geospatial Activities
Discussion Points

• National Agricultural Statistics Service (NASS)
  – Role, Mission
  – Research and Development Division

• Spatial Analysis Research Section (SARS)
  – Florida Citrus GIS
  – Extreme event monitoring
  – Crop Condition / Progress
  – Crop Yield
  – Map products
  – Regression-based Acreage Estimates

• Cropland Data Layer (CDL)
  – Resourcesat-1 AWiFS Imagery
  – Ground Truth
  – Methods
  – Kentucky
NASS Overview

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

- Improve efficiency of FASS citrus operations
  - Built operational Citrus GIS of entire commercial inventory
Flood impacts on NASS June Acreage Survey “Segments”
Corn Phenology – Annual differences
NASS CDL Indexed Yields vs. Official Yields
Soybeans - 2007 Illinois

\[ y = 1.1033x - 2.5698 \]

\[ R^2 = 0.8232 \]
Thematic Maps

Crop Progress and Condition Survey Data

Monthly Ag Yield Survey Data

Objective Yield Survey Data

Crop Condition (AVHRR)

County Estimate Survey Data

2002/2007 Census of Agriculture
Corn for Grain 2008
Production by County and Location of Ethanol Plants

Corn Production (Bushels)
- Not Estimated
- < 1,000,000
- 1,000,000 - 4,999,999
- 5,000,000 - 9,999,999
- 10,000,000 - 14,999,999
- 15,000,000 - 19,999,999
- 20,000,000 +

Ethanol Plants
- Construction
- Producing
- Not producing

U.S. Department of Agriculture, National Agricultural Statistics Service
Regression-based Acreage Estimator

Acreage not just about counting pixels

NASS Inputs
- June Survey summaries
- Area Sampling Frame
- CDLs
Cropland Data Layer (CDL) Program

- State specific land cover classifications emphasizing row crop agriculture
  - Some regions done annually (Corn Belt, The Delta)
  - Others “one-and-done” (California, Northwest)
- Within NASS, CDL used to
  - Increase precision on survey derived acreage estimates
  - Improve county level acreage estimates
## Creating a Land Cover Classification

<table>
<thead>
<tr>
<th><strong>Cropland</strong></th>
<th><strong>Non-Cropland</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Water</td>
</tr>
<tr>
<td>Soybeans</td>
<td>Developed</td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>Barren</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>Woodland</td>
</tr>
<tr>
<td>Cotton</td>
<td>Shrubland</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Grassland</td>
</tr>
<tr>
<td>Barley</td>
<td>Wetland</td>
</tr>
<tr>
<td>Oats</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td></td>
</tr>
<tr>
<td>Sunflowers</td>
<td></td>
</tr>
<tr>
<td>… and more</td>
<td></td>
</tr>
</tbody>
</table>
**Cropland Data Layer Uses**

**Within NASS**
- Refined state-wide acreage estimates
- Improved county-wide acreage estimates
- Tightened confidence intervals on all survey derived acreage estimates

**Outside NASS**
- Watershed runoff modeling
- Agribusiness planning
- Ground truth
- Change detection
- Water use mapping
- Epidemiological research
- Habitat monitoring
- Carbon sequestration analysis
- …..and more
Resourcesat-1

IRS-P6 THREE TIER IMAGING

AWIFS-(A) & (B) GSD: 56m
LISS-3° GSD: 23.5m
LISS-4 GSD: 5.8m

Department of Space
Indian Space Research Organisation
IRS Resourcesat-1 AWiFS Imagery
Primary Imagery Source

- 740 km swath width
- 5-day revisit
- 4 spectral bands
  - green
  - red
  - near-infrared
  - short-wave infrared
- 56 m ground sample resolution
Why NASS Likes AWiFS

- Large swath width
- Inclusion of red, NIR, SWIR spectral bands
- Tolerable spatial resolution at 56m
- Cost effectiveness
- 5-day or less revisit rate
- Operational nature
- Fast data delivery by vendor
- Healthy satellite
- Follow-on system (Resourcesat-2) already built
History of NASS AWiFS Use

- **2004**
  - Obtained AWiFS August imagery
  - Used to augment TM images collected during entire summer
- **2005**
  - Obtained AWiFS June and August imagery
  - Used to augment or replace TM
  - Assessed quantitative differences
- **2006**
  - Switched from Landsat to Resourcesat at a USDA-wide level
  - Obtained AWiFS during entire summer growing season
- **2007**
  - Obtained even more AWiFS during entire summer growing season
- **2008**
  - Utilized broader coverage of AWiFS to expand to more of US
- **2009**
  - Expecting to use more
  - Now with winter collects as well
Results of TM versus AWiFS

TM usually outperforms AWiFS.

Spatial resolution somewhat more important than loss of blue and mid-infrared bands.
AWiFS Imagery Time Series

May 20

July 2

July 31
June 16th data collects

IRS-P6 AWiFS

Terra MODIS
Imagery Comparison – June 16th

Landsat 5 TM

IRS P6 AWiFS

Terra MODIS (Rapid Response)
Ground truth - agriculture

Farm Service Agency (FSA)
- Common Land Unit (CLU)
- 578 reporting data

NASS June Agricultural Survey (JAS) data still used for acreage estimation
Ground truth – non agriculture

2001 National Land Cover Dataset
(brown = agriculture)
Classification Methodology

- Analyze areas by state
- “Stack” AWiFS, MODIS, and ancillary data layers within a raster GIS
  - 56 m grid cells, Albers Conic Equal Area projection
- Sample spatially from stack within known ground truth from FSA (for ag. categories) and NLCD (for non ag. categories)
- Data-mine samples using Boosted Classification Tree Analysis to derive best fitting decision rules
  - implemented with Rulequest See5.0
- Apply derived decision rules back to input data stack
- Create land cover map
- Create probability map
- Assess map accuracy
- Derive acreage estimates
  - utilizing customized SAS routines
Cropland Data Layer and Acreage Estimation Processing Flow

- Input Vector Data
  - NASS JAS segments
  - FSA CLU
  - USGS NLCD
  - IRS Resourcesat-1 raw AWIFS summer time series
  - NASA Terra MODIS 16-day NDVI prior fall and summer time series
  - USGS NLCD circa 2001 Impervious & Canopy
  - USGS NED Elevation

- Input Raster Data
  - IRS Resourcesat-1 raw AWIFS summer time series
  - NASA Terra MODIS 16-day NDVI prior fall and summer time series
  - USGS NLCD circa 2001 Impervious & Canopy

Tabular Data
- JAS eData
- FSA 578
- USGS NLCD
- Non-agricultural Ground truth

ESRI ArcGIS
- Link and assess data sets
- Extract JAS intersecting pixels
- Customized for acreage estimation

ERDAS IMAGINE®
- Manages and visualizes datasets
- Derives decision tree-based classification rules
- Generates rule set

-- Cropland Data Layer --

datagateway.nrcs.usda.gov

Output
- State and county crop acreage statistics
- Internal to NASS only
- Pixel count v. reported acreage

Diagnostics
- Accuracy Assessment
- Rulequest See5.0

United States Department of Agriculture
National Agricultural Statistics Service
Research and Development Division
Spatial Analysis Research Section

FSA CLU
Agricultural Ground truth
Confidence Layer

ESRI ArcGIS

Customized for acreage estimation
Example Classification Subset

CDL Classification

Resourcesat-1 AWiFS, 6 July 2007
Example State CDL

South Dakota 2007 Cropland Data Layer
## 2008 CDL Coverage

<table>
<thead>
<tr>
<th>Commodity</th>
<th>CDL States</th>
<th>US Total Acres (mill)</th>
<th>% US Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>18</td>
<td>78,177</td>
<td>92</td>
</tr>
<tr>
<td>Soybeans</td>
<td>18</td>
<td>74,374</td>
<td>91</td>
</tr>
<tr>
<td>Rice</td>
<td>5</td>
<td>2,924</td>
<td>82</td>
</tr>
<tr>
<td>Wheat</td>
<td>13</td>
<td>40,252</td>
<td>70</td>
</tr>
<tr>
<td>Cotton</td>
<td>4</td>
<td>7,755</td>
<td>66</td>
</tr>
<tr>
<td>Potatoes</td>
<td>11</td>
<td>1,058</td>
<td>34</td>
</tr>
</tbody>
</table>
# Accuracy Assessments

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Code</th>
<th>*Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>Kappa Accuracy</th>
<th>User's Accuracy</th>
<th>Commission Error</th>
<th>Condition Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Corn</td>
<td>1</td>
<td>2197719</td>
<td>96.58%</td>
<td>3.42%</td>
<td>0.9226</td>
<td>97.86%</td>
<td>2.14%</td>
<td>0.9509</td>
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<tr>
<td>Soybeans</td>
<td>5</td>
<td>1471094</td>
<td>96.24%</td>
<td>5.76%</td>
<td>0.9392</td>
<td>95.78%</td>
<td>4.42%</td>
<td>0.9320</td>
</tr>
<tr>
<td>IL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Corn</td>
<td>1</td>
<td>2258219</td>
<td>98.06%</td>
<td>1.94%</td>
<td>0.9527</td>
<td>98.58%</td>
<td>1.42%</td>
<td>0.9650</td>
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<tr>
<td>Soybeans</td>
<td>5</td>
<td>1339089</td>
<td>96.36%</td>
<td>3.64%</td>
<td>0.9438</td>
<td>97.96%</td>
<td>2.04%</td>
<td>0.9681</td>
</tr>
<tr>
<td>NE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>1856422</td>
<td>97.29%</td>
<td>2.71%</td>
<td>0.9605</td>
<td>97.32%</td>
<td>2.68%</td>
<td>0.9608</td>
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<tr>
<td>Soybeans</td>
<td>5</td>
<td>849249</td>
<td>95.83%</td>
<td>4.17%</td>
<td>0.9513</td>
<td>96.95%</td>
<td>3.05%</td>
<td>0.9643</td>
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<tr>
<td>SD</td>
<td></td>
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<tr>
<td>Corn</td>
<td>1</td>
<td>803251</td>
<td>94.29%</td>
<td>5.71%</td>
<td>0.9342</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9513</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>707383</td>
<td>95.03%</td>
<td>4.97%</td>
<td>0.9439</td>
<td>97.72%</td>
<td>2.28%</td>
<td>0.9741</td>
</tr>
</tbody>
</table>

**Producer's Accuracy:** relates to the probability that a ground truth pixel will be correctly mapped and measures errors of omission.

**Errors of Omission:** occur when a pixel is excluded from the correct category.

**User's Accuracy:** indicates the probability that a pixel from the classification actually matches the ground truth data and measures errors of commission.

**Errors of Commission:** occur when a pixel is included in an incorrect category.

**Kappa Coefficient:** A statistics measure of agreement, beyond chance, between two maps.
## Kentucky CDL Accuracy

**USDA, National Agricultural Statistics Service, 2008 Kentucky Cropland Data Layer**

STATEWIDE AGRICULTURAL ACCURACY REPORT

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Code</th>
<th>Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>Kappa Accuracy</th>
<th>User's Commission Error</th>
<th>Cond'l Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OVERALL ACCURACY</strong></td>
<td></td>
<td>383666</td>
<td>89.82%</td>
<td>10.18%</td>
<td>0.8638</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Crop-specific covers only

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Code</th>
<th>Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>Kappa</th>
<th>User's Commission Error</th>
<th>Cond'l Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1</td>
<td>141976</td>
<td>95.43%</td>
<td>4.57%</td>
<td>0.9472</td>
<td>95.21%</td>
<td>4.79%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>4</td>
<td>651</td>
<td>38.82%</td>
<td>61.18%</td>
<td>0.3878</td>
<td>97.02%</td>
<td>2.98%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>107429</td>
<td>92.28%</td>
<td>7.72%</td>
<td>0.9137</td>
<td>91.51%</td>
<td>8.49%</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>6</td>
<td>0</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Tobbaco</td>
<td>11</td>
<td>8</td>
<td>3.29%</td>
<td>96.71%</td>
<td>0.0329</td>
<td>21.62%</td>
<td>78.38%</td>
</tr>
<tr>
<td>Pop or Orn Corn</td>
<td>13</td>
<td>379</td>
<td>49.54%</td>
<td>50.46%</td>
<td>0.4952</td>
<td>95.47%</td>
<td>4.53%</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>24</td>
<td>442</td>
<td>16.03%</td>
<td>83.97%</td>
<td>0.1598</td>
<td>73.54%</td>
<td>26.46%</td>
</tr>
<tr>
<td>WW / Soybeans</td>
<td>26</td>
<td>55664</td>
<td>95.44%</td>
<td>4.56%</td>
<td>0.9518</td>
<td>89.76%</td>
<td>10.24%</td>
</tr>
<tr>
<td>Rye</td>
<td>27</td>
<td>6</td>
<td>8.70%</td>
<td>91.30%</td>
<td>0.0870</td>
<td>85.71%</td>
<td>14.29%</td>
</tr>
<tr>
<td>Oats</td>
<td>28</td>
<td>10</td>
<td>9.90%</td>
<td>90.10%</td>
<td>0.0990</td>
<td>66.67%</td>
<td>33.33%</td>
</tr>
<tr>
<td>Millet</td>
<td>29</td>
<td>0</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>36</td>
<td>945</td>
<td>23.80%</td>
<td>76.20%</td>
<td>0.2371</td>
<td>72.64%</td>
<td>27.36%</td>
</tr>
<tr>
<td>Other crops</td>
<td>44</td>
<td>1</td>
<td>4.55%</td>
<td>95.45%</td>
<td>0.0454</td>
<td>12.50%</td>
<td>87.50%</td>
</tr>
<tr>
<td>Misc. vegetables</td>
<td>47</td>
<td>0</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Clover / Wildflowers</td>
<td>58</td>
<td>5</td>
<td>1.93%</td>
<td>98.07%</td>
<td>0.0193</td>
<td>62.50%</td>
<td>37.50%</td>
</tr>
<tr>
<td>Seed/Sod Grass</td>
<td>59</td>
<td>177</td>
<td>16.36%</td>
<td>83.64%</td>
<td>0.1634</td>
<td>71.37%</td>
<td>28.63%</td>
</tr>
<tr>
<td>Idle / Fallow</td>
<td>61</td>
<td>9</td>
<td>4.84%</td>
<td>95.16%</td>
<td>0.0484</td>
<td>69.23%</td>
<td>30.77%</td>
</tr>
<tr>
<td>Peaches</td>
<td>67</td>
<td>0</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Apples</td>
<td>68</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
</tr>
<tr>
<td>Other tree nuts</td>
<td>71</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>92</td>
<td>0</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.0000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*Correct Pixels represents the total number of independent validation pixels correctly identified in the error matrix.
Obtaining Kentucky 2008 CDL

http://www.nass.usda.gov/research/Cropland/SARS1a.htm
Future CDLs, 2009 and beyond….

- **Expand geographic scope?**
  - Wheat states next priority
  - Mid-Atlantic region (often asked about)
  - “Manifest Destiny”

- **Improved categories?**
  - Grassland
    - Pasture (chewed grass)
    - Hay (cut grass)
    - Natural (quasi-native)

- **Imagery?**
  - More frugal use of
  - Future sensors
  - Finer resolution

- **Other ancillary data?**
  - Soils
  - Climate

- **Derivatives?**
  - Change detection
  - Crop rotation patterns
Thank You

dave_johnson@nass.usda.gov
703-877-8000 x169

www.nass.usda.gov
www.nass.usda.gov/research/Cropland/SARS1a.htm
datagateway.nrcs.usda.gov