Monitoring the Spatial Extent of Bioenergy Crops and Estimating Acreage with AWiFS Imagery

Special Session — Monitoring, Mapping, and Estimating the Bioenergy Domain

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National Agricultural Statistics Service
Bioenergy Support

• President Obama inaugural speech
  “We will harness the sun and the winds and the soil to fuel our cars and run our factories”

• USDA Secretary Tom Vilsak
  Advancing research and development and pursuing opportunities to support the development of biofuels
Biofuel Corn

• Technological wonder
  – Renewable fuel
  – Feed for many
  – Replicate itself
  – Increased productivity
Corn for Grain 2007
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

U.S. Department of Agriculture, National Agricultural Statistics Service
Biofuel Challenges

• Biofuel push
  – Mandated usage
  – Prices/costs/economics
  – Crop acreage expansion
    • CRP
    • Competing crops
  – Altered cropping patterns
  – Environmental challenges
    • Pesticides/fertilizer
    • Greenhouse gases
    • Carbon
  – Weather

• Biofuel pull
  – Conservation tillage
  – Crop management strategies
  – Productivity
  – Quality
  – Sustainability
Corn acreage may have to rise to 95 million acres to meet future feed/fuel demand. 

Source: Bill Lapp Ag Outlook Forum 2009
Cropland Data Layer (CDL) Objective

- Deliver in-season acreage estimates
  - For June, August, and October stakeholder decision support
  - Update planted area

- Provide timely, accurate, useful indications
  - Measurable error
  - Unbiased/independent estimator
  - State, District, County

- Public domain crop specific
  - Land cover classification
  - Hosted @ NRCS Geospatial Data Gateway
# 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>
CDL Program

- **Inputs**
  - Resourcesat-1 AWiFS imagery
  - Farm Service Agency – Common Land Unit
  - NASS June Ag Survey
  - Ancillary data
    - NLCD & derivative products

- **Outputs**
  - Acreage Estimates
  - Cropland Data Layer

- **Process**
  - Commercial software
Data Partnerships

• Foreign Ag Service
  – Satellite Image Archive
    • Resourcesat-1 AWiFS
      – 5 day repeat/56 meter resolution/740 KM swath

• Farm Service Agency
  – Common Land Unit

• USGS/MRLC
  – National Land Cover Dataset
## 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</th>
<th>User's Accuracy</th>
<th>Commission Error</th>
<th>Cond'l Kappa</th>
</tr>
</thead>
<tbody>
<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>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>1471094</td>
<td>96.24%</td>
<td>3.76%</td>
<td>0.9392</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9320</td>
</tr>
<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>
</tr>
<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>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>
</tr>
<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>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop-specific covers only</th>
<th>*Correct Pixels</th>
<th>Accuracy</th>
<th>Error</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL ACCURACY</td>
<td>3688803</td>
<td>95.74%</td>
<td>4.26%</td>
<td>0.9145</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>3730093</td>
<td>97.05%</td>
<td>2.95%</td>
<td>0.9426</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>3071960</td>
<td>94.05%</td>
<td>5.95%</td>
<td>0.8981</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>2306428</td>
<td>87.51%</td>
<td>12.49%</td>
<td>0.8416</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.
Matching CLU’s used for sampling

½ sample for training & ½ sample for testing
Filter multi-field CLU/high acreage variance
Comprehensive program crop coverage
San Luis Valley Common Land Unit
San Luis Valley Common Land Unit

Farmer signups

Potatoes
Other Crop
Grass/Pasture/Non Ag
Biofuel Switchgrass

• Non invasive
• Sustain wildlife
• Soil/climate adaptable
• Last 10-20 yrs/grows 5-10 ft tall
• Potential yield of 500 gal/acre
• One/two cuttings per year
<table>
<thead>
<tr>
<th></th>
<th>Correct</th>
<th>Total</th>
<th>Accuracy</th>
<th>Error</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall (FSA + NLCD)</td>
<td>687710</td>
<td>898662</td>
<td>76.53%</td>
<td>23.47%</td>
<td>0.7021</td>
</tr>
<tr>
<td>FSA Crops only</td>
<td>219563</td>
<td>249053</td>
<td>88.16%</td>
<td>11.84%</td>
<td>0.8374</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Total Pixels</th>
<th>Correct</th>
<th>Producer</th>
<th>Omission</th>
<th>Kappa</th>
<th>Classified</th>
<th>User</th>
<th>Commission</th>
<th>Kappa</th>
<th>Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Switchgrass</strong></td>
<td>424</td>
<td>151</td>
<td>35.61%</td>
<td>64.39%</td>
<td>0.3531</td>
<td>181</td>
<td>83.43%</td>
<td>16.57%</td>
<td>0.8324</td>
<td>-57.3%</td>
</tr>
</tbody>
</table>

Total Pixels is the number of validation pixels we had. Of these 424 pixels of ground truth, we classified 151 of them as switch grass, so we are omitting a significant amount of switch grass.

In the entire regional map, we classified 181 pixels as switch grass. Of these 181 pixels, 83% were classified correctly.

We can say, then, that we feel fairly certain (83% certain) that any switch grass pixel on the map probably is switch grass. However, there are other switch grass pixels out there that remain unidentified.
Summary

• Corn the alternative fuel
• CDL covers majority of corn domain
  – High accuracy
• Other crops possible – provided ground truth
• Data partnerships key to continued success!
• “Manifest Destiny”