Agricultural Statistics and Remote Sensing

Remote Sensing for Agricultural Statistics in the USA

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USDA/National Agricultural Statistics Service
Program Agenda

- Acreage
- Operational Cropland Data Layer Program
- Scope & method
- Assessment and accuracy of indications
- Yield
- Operational crop monitoring & production assessment
- Method overview
- Evaluation of crop model yield indications
Corn: The inflation crop

The U.S. is set to report a jump in acreage planted as farmers feed the ethanol machine. One byproduct: rising food prices.

By Jeff Cox, CNNMoney.com contributing writer
March 28 2007: 7:20 AM EDT

NEW YORK (CNNMoney.com) -- It's no secret that the rush to ethanol and other alternative fuels has made corn the rock star of the Farm Belt.

That newfound prominence has big implications for the nation's economy, experts say. Soaring corn prices are pushing up the tab for everything from candy to corn flakes, moribund land values have jumped in many Midwestern farming communities and the crop has become the lynchpin for the budding $40 billion ethanol industry.
Remote Sensing Program Objectives

- Census by satellite
- Provide timely, accurate, useful indications
  - Measurable error
  - Unbiased estimator
NASS Operational Needs

- **Timeliness**
  - Must meet NASS report deadlines
  - Processing capabilities must match crop phenology

- **Accuracy**
  - What is the truth?
  - 10% rule
  - Trends/History

- **Reliability**
  - Satellite/sensor, or climatic disturbances cannot delay estimate delivery
  - Contingency plans essential - must have alternative indicators available

- **Consistency**
  - Standard methodology across States/crops
  - Quality assurance
  - Adopt a standard processing platform
  - Transition to new sensors
2007 Cropland Data Layer Coverage
Cropland Data Layer Components

- AWiFS sensor
The Landsat Data Gap

Landsat 7 ETM+

Landsat 5 TM

News Release

November 30, 2005  Ron Beck

Landsat 5 Experiencing Technical Difficulties

On November 26, 2005, the back-up solar array drive on Landsat 5 began exhibiting unusual behavior. The solar array drive maintains the proper pointing angle between the solar array and the sun. The rotation of the solar array drive became sporadic and the solar array was not able to provide the power needed to charge the batteries. Maintaining power to the batteries is critical to sustain proper operation of the spacecraft. The primary solar array drive failed under similar circumstances last January. As a result of this current situation, imaging operations will be suspended for at least the next two weeks or until attempts to solve the problem have been resolved.

Source: USGS, Landsat Project:
Resourcesat-1 AWiFS Sensor

- Launched 2003
- 370 km swath per quad
- 740 km combined
- 56 m resolution at nadir
- 70 m resolution at scene edges
Advanced Wide Field Sensor (AWiFS)

Spectral Bands:

- **B2**: 0.52-0.59 (Visible Green)
- **B3**: 0.62-0.68 (Visible Red)
- **B4**: 0.77-0.86 (Near Infrared)
- **B5**: 1.55-1.70 (Middle Infrared)

5 day repeat cycle
Cropland Data Layer Components

- AWiFS sensor
- Common Land Unit/578 Admin Data
  - USDA/Farm Service Agency
    - Training/testing datasets
Cropland Data Layer Components

- AWiFS sensor
- Common Land Unit/578 Admin Data
  - USDA/Farm Service Agency
- ERDAS Imagine/See5
  - Image Processing/Classification
ERDAS Imagine & See5

- Derivation of decision tree classification rules
  - Boosting & smart eliminate
    - www.rulequest.com
- Sample non-ag areas
  - National Land Cover Dataset (USGS)
- Ancillary datasets
  - DEM & prior CDL
- Phenological profiles with AWiFS
Cropland Data Layer Components

- AWiFS sensor
- Common Land Unit/578 Admin Data
  - USDA/Farm Service Agency
- ERDAS Imagine/See5
  - Image Processing/Classification
- Acreage Estimator
  - June Agricultural Survey
### Estimation Components:
- Area Sampling Frame
- June Ag Survey
- Questionnaire

#### SECTION D - CROPS AND LAND USE ON TRACT

<table>
<thead>
<tr>
<th>FIELD NUMBER</th>
<th>01</th>
<th>02</th>
<th>03</th>
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<tbody>
<tr>
<td>1. Total acres in field</td>
<td>828</td>
<td>828</td>
<td>828</td>
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<tr>
<td>2. Crop or land use. [Specify]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Occupied farmstead or dwelling</td>
<td>843</td>
<td></td>
<td></td>
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<tr>
<td>4. Waste, unoccupied dwellings, buildings and structures, roads, ditches, etc.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5. Woodland</td>
<td>831</td>
<td>831</td>
<td>831</td>
</tr>
<tr>
<td>6. Pasture</td>
<td></td>
<td></td>
<td></td>
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</table>

How many acres are inside this blue tract boundary drawn on the photo (map)? .................

Now I would like to ask about each field inside this blue tract boundary and its use during 2000.
Regression Estimator

- Relate categorized pixel counts to the ground reference data
  - Independent variable - satellite data - pixels
  - Dependent variable - JAS acreage estimate
- Satellite data - lower variance than with only JAS
- Outlier segment detection
  - Correction or removal from regression analysis
<table>
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<tr>
<th>Crop Type</th>
<th>Y</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>227</td>
<td>273</td>
</tr>
<tr>
<td>Soybean</td>
<td>337</td>
<td>541</td>
</tr>
</tbody>
</table>
$R^2 = 0.971$

$a = \text{intercept} = 7.11$

$b = \text{slope} = 0.802$

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Linear Regression

$y = a + bx$

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Seg 136 (x=273, y=227)

$y = 226.11$
Craighed County, Arkansas 2005

Cropland Data Layer
Cropland Data Layer Summary

- Operational estimates in corn/soybean region 2007
  - Provides measurable statistical error
  - Indication considered for national acreage estimate

- Components
  - AWiFS
  - Farm Service Agency
    - Common Land Unit (training/testing)
  - Commercial Software ERDAS/See5
  - June Agricultural Survey
    - Regression estimator

- Distribution
  - datagateway.nrcs.usda.gov
Remote Sensing Support for Crop Monitoring and Assessment

The Next Generation of Yield Estimates

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Develop an algorithm for operational classifications of corn and soybean fields in the U.S. Corn Belt

1) Agrometerological crop model with remote sensing
2) Simplified remote sensing algorithm
3) Agrometerological (only) crop yield model

Provide timely and accurate information
-> NASS’s operational program
NDVI Time Series from the MODIS-Terra 8-day Composite Product
The Savitzky-Golay Filter is used to account for negatively biased noise. The result produces a smoothed curve adapted to the upper NDVI value in a time series.

Separation of Corn and Soybean Crops

- The first step is distinguishing the “crop pixels” from others. Condition used is that NDVI value in day of year (DOY) 129 (May 9) must be less than 0.40 and in DOY 209 (July 28) must be higher than 0.78.

- The second step of the classification is separation of corn and soybean pixels.
  - Profile fit to a third degree polynomial
  - The mean value of the second derivatives of the polynomial between DOY 169 and 177 are used.
  - Green up rate for corn pixels on that DOY begins to decrease and NDVI profile is convex.
  - For soybean pixels, green up rate is increasing and NDVI profile is concave
Classification of Corn and Soybean Crops - Iowa, 2005

Resolution: 250 m

Corn
Soybean

100 km
Operational Algorithm

MODIS – VIS-NIR
Corn and Soybean Classification Mask

MODIS – VIR/NIR 8-Day Composite 250 m

MODIS-Thermal 8-Day Composite 1 Km

Data Masked and County Averaged

County Yield Algorithm
Yield = f (NDVI, Ts)

Yield Index

Corn
Soybean
2003-05 Iowa Corn County Yield Comparisons

Difference Between Official and Predicted Yields for Iowa 2003 Corn
RMSE=12.73

Difference Between Official and Predicted Yields for Iowa 2005 Corn
RMSE=10.02

Difference Between Official and Predicted Yields for Iowa 2004 Corn
RMSE=10.53
2003-05 Iowa Soybean County Yield Comparisons

Difference Between Official and Predicted Yields for Iowa 2003 Soybeans
RMSE=3.95

Difference Between Official and Predicted Yields for Iowa 2005 Soybeans
RMSE=2.70

Difference Between Official and Predicted Yields for Iowa 2004 Soybeans
RMSE=3.01
2003-05 Illinois Soybean County Yield Comparisons

Difference Between Official and Predicted County Yields for Illinois 2005 Soybeans
RMSE=4.31

Difference Between Official and Predicted County Yields for Illinois 2003 Soybeans
RMSE=6.69

Difference Between Official and Predicted County Yields for Illinois 2004 Soybeans
RMSE=3.57
2003-05 Illinois Corn County Yield Comparison

Difference Between Official and Predicted County Yields for Illinois 2005 Corn
RMSE=11.06

Difference Between Official and Predicted County Yields for Illinois 2004 Corn
RMSE=11.85

Difference Between Official and Predicted County Yields for Illinois 2003 Corn
RMSE=13.56
Model vs. USDA/Risk Management Agency vs. Official County Yield Estimates

2005 Iowa Soybean County Yields - BD. vs RMA

2005 Iowa Soybean County Yields - Model vs. RMA
Model vs. Risk Management Agency vs. Official County Yield Estimates

2005 Illinois Corn County Yields - BD vs. RMA

2005 Illinois Corn County Yields - Model vs. RMA
Remote Sensing Support

Corn Yield at 10 km, 2006, IL
No Remote Sensing. Sowing Doy = 120. Density = 8 plants/m²

Corn Yield, bu/ac
- Mean = 175 bu/ac

Min = 147 bu/ac
Max = 190 bu/ac
Mean = 175 bu/ac
St. Dev. = 10

Corn Yield (Without Remote Sensing Input), IL-2006

- 141 - 164
- 165 - 175
- 176 - 181
- 182 - 184
- 185 - 191
- 147 - 167
- 168 - 175
- 176 - 181
- 182 - 183
- 184 - 190

Min = 147 bu/ac
Max = 190 bu/ac
Mean = 175 bu/ac
St. Dev. = 10
Operational Considerations

Advantages

- Statistical quality defined for both State & County
- Standardized methodology, being automated
- Staffing requirements are minimal
- Potential for reduced respondent burden
- Potential for reduced data collection costs
- Geo-referenced, digital data format
  - Estimates or GIS applications for other than political boundaries
- Farmer and courtroom defensible
- Potential for large area assessments
- Has significant international potential
Operational Considerations
Disadvantages

- Technology dependent
- Climate dependent
- Represents significant change
- Requires new staff knowledge, skills & abilities
- Farming practices
Yield Summary

**State-Level**

- Remote sensing yields have been timely, mid-August, mid-September
- Program history is limited (03-06), so trends remain to be seen
  - Indications come with variance statistics
- Remote Sensing yield indications look as good or better than most other early season survey-based indicators
- RS yields are “bottom up”, derived from every square mile of crop in a state/county

**County-Level**

- Great majority (>85%) of county indications are within 10% of Official Estimates
- Majority of counties with >10% difference are those with small # of fields, i.e., few reports
- Remote sensing county yields are available with the State yields…..mid-August, early September
- Definitional differences exist. Remote Sensing indications offer the most precise placement of yield within a county
Obrigado