Crop Acreage Estimation:
Landsat TM and Resourcesat-1 AWiFS Sensor Assessment
of the Mississippi River Delta, 2005
• Produce acreage estimates with reduced error rates over the June Agricultural Survey.

• Create and distribute the Cropland Data Layer Product.
2001 Wildlife Damage Survey

Maryland farmers lost $17.2 million of corn, soybeans and wheat to deer or geese during 2001. This translates to Maryland farmers losing 7.7 percent of the crop value to deer and geese. Soybeans accounted for the greatest economic loss, totaling $9.1 million, 11 percent. Corn losses were $6.6 million, 5.8 percent and wheat $1.5 million, 5.6 percent. Deer damage resulted in losses of $13.6 million, 6.1 percent, while geese losses were $3.6 million, 1.6 percent.

Production losses totaled 6.0 million bushels. Corn losses were 3.2 million bushels, soybean losses totaled 2.2 million bushels and wheat accounted for 0.6 million bushels. Production losses to deer were 4.7 million bushels and geese 1.3 million bushels.

In terms of yield, losses to deer were most severe in Central and Western Maryland, while geese damage was greater on the Eastern Shore. Corn yield losses of 9.6 bushels per acre and 7.4 bushels per acre were reported in Central and Western Maryland, respectively. The Lower Eastern Shore reported the highest soybean losses of 6.1 bushels per acre.

Sixty-two percent of farms reported deer or geese damage to one or more crop. Damage was reported on 61 percent of farms raising corn, 58 percent of farms growing soybeans and 27 percent of farms with wheat.

### Maryland 2001 Crop Loss from Deer

<table>
<thead>
<tr>
<th>Region</th>
<th>Crop</th>
<th>Acres Harvested</th>
<th>Harvested Yield (bu/acre)</th>
<th>Average Yield Loss (bu/acre)</th>
<th>Production Loss (bu)</th>
<th>Economic Loss ($)</th>
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</thead>
<tbody>
<tr>
<td>Western Maryland</td>
<td>Corn</td>
<td>5,400</td>
<td>104.2</td>
<td>7.4</td>
<td>40,700</td>
<td>82,420</td>
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<td></td>
<td>Soybeans</td>
<td>390</td>
<td>36.7</td>
<td></td>
<td>40,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>200</td>
<td>45.0</td>
<td>2.3</td>
<td>40,700</td>
<td>1,127</td>
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<tr>
<td>Central Maryland</td>
<td>Corn</td>
<td>1,250</td>
<td>99.2</td>
<td>9.2</td>
<td>1,201,200</td>
<td>2,243,976</td>
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<tr>
<td></td>
<td>Soybeans</td>
<td>92,500</td>
<td>34.0</td>
<td>3.2</td>
<td>36,750</td>
<td>641,072</td>
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<tr>
<td></td>
<td>Wheat</td>
<td>280</td>
<td>40.5</td>
<td>2.0</td>
<td>36,750</td>
<td>641,072</td>
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<tr>
<td>Southern Maryland</td>
<td>Corn</td>
<td>28,000</td>
<td>33.9</td>
<td>4.9</td>
<td>246,020</td>
<td>359,056</td>
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<td>Soybeans</td>
<td>92,400</td>
<td>38.0</td>
<td>3.3</td>
<td>342,260</td>
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<td>60.7</td>
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<td>23,520</td>
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<tr>
<td>Upper Shore</td>
<td>Corn</td>
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<td>157.2</td>
<td>5.0</td>
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<td>1,141,415</td>
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<tr>
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<td>39.9</td>
<td>2.4</td>
<td>556,800</td>
<td>2,283,860</td>
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<td>Wheat</td>
<td>86,000</td>
<td>64.0</td>
<td>1.1</td>
<td>56,250</td>
<td>233,118</td>
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<td>Lower Shore</td>
<td>Corn</td>
<td>32,000</td>
<td>150.7</td>
<td>4.2</td>
<td>379,280</td>
<td>677,465</td>
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<td>Soybeans</td>
<td>314,000</td>
<td>42.0</td>
<td>6.1</td>
<td>896,700</td>
<td>1,476,072</td>
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<tr>
<td></td>
<td>Wheat</td>
<td>34,000</td>
<td>61.0</td>
<td>2.9</td>
<td>30,600</td>
<td>64,970</td>
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<tr>
<td>Maryland</td>
<td>Corn</td>
<td>410,000</td>
<td>159.2</td>
<td>6.4</td>
<td>2,824,200</td>
<td>5,197,200</td>
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<tr>
<td></td>
<td>Soybeans</td>
<td>510,000</td>
<td>39.0</td>
<td>3.6</td>
<td>1,854,200</td>
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<tr>
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<td>Wheat</td>
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<td>61.0</td>
<td>1.5</td>
<td>262,500</td>
<td>461,125</td>
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<tr>
<td>All Crops</td>
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<td>7,740,000</td>
<td>159.2</td>
<td>6.4</td>
<td>5,700,000</td>
<td>10,123,725</td>
</tr>
</tbody>
</table>
Background on the Cropland Data Layer

– June Agricultural Survey (JAS) – National in Scope
  • 41,000 farms visited
  • 11,000 one-square mile sample area segments visited
  • Most states contain between 150 – 400 segments
  • Planted acreage estimate

– Cropland Data Layer depends on the JAS data
  • Unbiased statistical estimator of crop area
    – State and county level estimates
Purpose of the Cropland Data Layer

1. Combine remote sensing imagery and NASS survey data to produce *supplemental* acreage estimates for the state's major commodities

2. Production of a crop-specific digital land cover data layer for distribution in industry standard GeoTiff format
The Landsat Data Gap

Landsat 7 ETM+  Landsat 5 TM

Source: USGS, Landsat Project:

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.
Indian Remote Sensing Satellite: RESOURCESAT-1

Advanced Wide Field Sensor (AWiFS)

States Targeted for Data Collection

- **AWiFS**: Swath: 370 km each head, 740 km combined, 56 m resolution at nadir, 70 m resolution at field edges.
- **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)
Mississippi River Delta 2005
Cropland Classifications
using Classification Tree Analysis
(See5)
August 20, 2005 - Landsat-5 and Resourcesat-1 acquired same date imagery over Arkansas including the agriculturally intensive region of the Mississippi River Delta.
Coincident Landsat TM and AWiFS cropland classifications

- Imagery clipped to identical extent
- TM imagery analyzed at 30m, AWiFS at 56m resolution
- 2,000 (approx) randomly distributed polygons (100,000 acres) used for ground truth and validation from JAS 2005 survey
- Classification tree analysis (See5) performed
- Minimum mapping unit of 5 pixels applied
Subset example of cropland classification output

Landsat-5 TM

Resourcesat-1 AWiFS

Legend:
- Corn
- Cotton
- Rice
- Sorgum
- Soybean
- Winter Wheat
- Wheat/Soybean Double Crop
- Fallow
- Aquaculture
- Pasture
- Woodland
- Urban
- Water
Overall maps are similar
- General patterns are the same
- 73.5% of area classified identically
Kappa Statistics for Classifier Accuracy
Landsat TM and AWiFS Coincident imagery

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Landsat TM</th>
<th>AWiFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>.839</td>
<td>.933</td>
</tr>
<tr>
<td>Cotton</td>
<td>.901</td>
<td>.896</td>
</tr>
<tr>
<td>Soybeans</td>
<td>.949</td>
<td>.958</td>
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<tr>
<td>Sorghum</td>
<td>.392</td>
<td>.686</td>
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<tr>
<td>Rice</td>
<td>.940</td>
<td>.959</td>
</tr>
<tr>
<td>Other Crop</td>
<td>.180</td>
<td>.246</td>
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<tr>
<td>Non Crop</td>
<td>.805</td>
<td>.866</td>
</tr>
<tr>
<td>Overall</td>
<td>.889</td>
<td>.918</td>
</tr>
</tbody>
</table>

Kappa Statistics based on June Area Survey (JAS) ground truth data
Regression Analysis from Sample Estimation

Landsat TM Rice

- R-sq (11) = 0.893
- R-sq (21) = 0.912
- Slope (11) = 0.2343
- Slope (21) = 0.2095

AWiFS Rice

- R-sq (11) = 0.889
- R-sq (21) = 0.844
- Slope (11) = 0.2196
- Slope (21) = 0.1962

Pixel Sq meter/ acres - .2224
Pixel Sq meters/ acres - .2224
No Outliers Removed
Regression Analysis from Sample Estimation

Landsat TM Cotton

- R-sq (11) = 0.926
- R-sq (21) = 0.990
- Slope (11) = 0.2369
- Slope (21) = 0.2468

AWiFS Cotton

- R-sq (11) = 0.921
- R-sq (21) = 0.957
- Slope (11) = 0.2351
- Slope (21) = 0.2340

Pixel Sq meter/ acres - .2224

No Outliers Removed
Classification Accuracy Estimates

Overall
  TM = 67.9%
  AWiFS = 63.8%

Cropland Only
  TM = 76.3%
  AWiFS = 74.3%
Multitemporal Landsat TM and AWiFS Classifications of the Mississippi River Delta, 2005
Multitemporal Landsat TM and AWiFS cropland classifications

- All Imagery clipped to Zone 45: NLCD
- TM imagery analyzed at 30m
- AWiFS imagery resampled to 30m
- 5,000 (approx) randomly distributed polygons (280,000 acres) used for ground truth from JAS survey
- Classification tree analysis (See5) performed
- Minimum mapping unit of 5 pixels applied
AWiFS Time Series 2005

April 27
June 19
August 20
September 3
September 4
Kappa Statistics for Classifier Accuracy
Arkansas Region of Mississippi River Delta

<table>
<thead>
<tr>
<th></th>
<th>Landsat TM</th>
<th>AWiFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>.986</td>
<td>.985</td>
</tr>
<tr>
<td>Cotton</td>
<td>.990</td>
<td>.992</td>
</tr>
<tr>
<td>Soybeans</td>
<td>.978</td>
<td>.979</td>
</tr>
<tr>
<td>Sorghum</td>
<td>.953</td>
<td>.963</td>
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<tr>
<td>Rice</td>
<td>.979</td>
<td>.981</td>
</tr>
<tr>
<td>Other Crop</td>
<td>.793</td>
<td>.782</td>
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<tr>
<td>Non Crop</td>
<td>.629</td>
<td>.670</td>
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<tr>
<td>Overall</td>
<td>.917</td>
<td>.925</td>
</tr>
</tbody>
</table>

* Kappa Statistics based on June Area Survey (JAS) ground truth data
Regression Analysis from Sample Estimation

Landsat TM Rice

- R-sq (11) = 0.939
- R-sq (21) = 0.834
- Slope (11) = 0.2259
- Slope (21) = 0.1874

AWiFS Rice

- R-sq (11) = 0.950
- R-sq (21) = 0.913
- Slope (11) = 0.2234
- Slope (21) = 0.2057

Pixel Sq meter/acre - .2224
Pixel Sq meters/acre - .2224

No Outliers Removed
Regression Analysis from Sample Estimation

Landsat TM Cotton

Pixel Sq meter/acre - .2224

AWiFS Cotton

Pixel Sq meters/acre - .2224

No Outliers Removed

R-sq (11) = 0.960
R-sq (21) = 0.928
Slope (11) = 0.2097
Slope (21) = 0.2084

R-sq (11) = 0.967
R-sq (21) = 0.979
Slope (11) = 0.2109
Slope (21) = 0.2175
Arkansas State Level Estimates +/- 2 CV

% Over/Under ASB Final

Source of Estimate

June Ag
Landsat-TM
AWiFS

Corn
Cotton
Rice
Soybeans
Conclusions

AWiFS data are appropriate for crop acreage estimation over large, spectrally homogenous, crop areas such as the Mid-West, the Delta and the Northern Great Plains.

Regression and Kappa statistics for soybean, corn, cotton, rice and sorghum produced using both the Landsat TM and AWiFS data were very similar.

AWiFS data appear to be a suitable alternative or supplement to Landsat TM data for production of NASS’ Cropland Data Layer product.