The NASS Mission

“To provide timely, accurate, and useful statistics in service to U.S. agriculture”

- U.S. statistical system is decentralized.
- The Food & Fiber Sector is largest single component of US GDP.
- NASS is the official data collection (& dissemination) arm of USDA, providing the Official Statistics of and about US Agriculture.
- Most data series mandated by law.
- Crop monitoring & assessment is mandated, but NASS works closely with the public and agriculture sector to determine report content & scheduling.
- We’re a public information service, we don’t do much in the way of analyses, interpretation, or predictions.
- Literally billions of $$$ and millions of decisions are made based on NASS reports every year, a heavy responsibility to “get it right”.
- NASS is unique in that we are a federal, operational program, with a statistical research component, mandated by law.

My point – NASS acreage & crop reports are serious business, and the acceptance of remote sensing-based crop monitoring & assessments by the Agency is a major
NASS Estimation Systems

* NASS Uses Geospatial Decision Support Systems to provide updated information to the Ag Statistics Board and data users
Cropland Data Layer (CDL) Objectives

- “Census by Satellite”
  - Annually cover major program crops and regions
  - Crops accurately geo-located

- Deliver in-season remote sensing acreage estimates
  - NASS Official Reports
  - Update planted area
  - Reduce respondent burden from surveys

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

- Public domain crop specific crop classification
  - Hosted @ [NRCS Geospatial Data Gateway](http://www.nass.usda.gov/research/Cropland/SARS1a.htm) or
    [http://www.nass.usda.gov/research/Cropland/SARS1a.htm](http://www.nass.usda.gov/research/Cropland/SARS1a.htm) or
  - Google “Cropland Data Layer”
14 states – winter wheat

14 – corn & soybeans

15 – rice, cotton & peanuts

17 – all small grains

24 – all crops

27 – operational

CDL Crop Year 2010 Plans
### 2010 CDL Production Schedule

#### Acreage Report – Winter Wheat
- May
  - May 10

#### Crop Production Report – Corn & Soybeans
- July
  - July 12

#### Crop Production Report – CDL Cotton, Rice, & Peanuts
- September
  - September 26

#### Small Grains Summary
- November
  - November 10

#### Crop Production Report – All Crops
- December
  - December 28
Data Partnerships

Foreign Agricultural Service
Resourcesat-1 AWiFS

Farm Service Agency
Common Land Unit “ground truth”

US Geological Survey
National Land Cover Dataset

US Geological Survey/ NASA
Landsat TM 5
Data Inputs

Satellite Imagery - AWiFS & Landsat TM

Farm Service Agency – Common Land Unit

NLCD & Derivative products

NASS June Agriculture Survey
# Satellite Specifications Compared

<table>
<thead>
<tr>
<th></th>
<th><strong>TM</strong></th>
<th><strong>AWiFS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Altitude</strong></td>
<td>705 km</td>
<td>817 km</td>
</tr>
<tr>
<td><strong>Equatorial crossing time</strong></td>
<td>9:45 ± 15 minutes</td>
<td>10:30 ± 5 minutes</td>
</tr>
<tr>
<td><strong>Temporal Resolution</strong></td>
<td>16 days</td>
<td>5 days</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>30 x 30 m (reflective)</td>
<td>56 x 56 m</td>
</tr>
<tr>
<td></td>
<td>120 x 120 m (thermal)</td>
<td></td>
</tr>
<tr>
<td><strong>Radiometric Resolution</strong></td>
<td>8 bit (256)</td>
<td>10 bit (1024)</td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
<td>6 (B, G, R, NIR, SWIR, MIR) + Thermal IR</td>
<td>4 (G, R, NIR,SWIR)</td>
</tr>
<tr>
<td><strong>Swath wide</strong></td>
<td>185 km</td>
<td>737 km</td>
</tr>
<tr>
<td><strong>Scene size</strong></td>
<td>184 x 152 km</td>
<td>370 x 370 km</td>
</tr>
</tbody>
</table>
Software Suite

Ground Truth Preparation
• ESRI ArcMap

Image Preparation
• Leica Geosystems ERDAS Imagine 9.1

Image Classification
• See 5

Acreage Estimates
• SAS/IML Workshop
Ground Truth – Land Cover

Agriculture Ground Truth

Provided by Farm Service Agency
Identifies known fields and crops

Divide known fields into 2 sets
½ used for training software
½ used for validating results

Non-Agriculture Ground Truth

USGS National Land Cover Dataset

Identifies urban infrastructure and non-agriculture land cover
Forest, grass, water, cities
Ancillary datasets help separate the agricultural landscape; determining agricultural potential.
Processing a CDL

Satellite Imagery
Ancillary Data
MODIS Data
Ground Truth

See5

Decision Tree

Classification

2009 Washington Cropland Data Layer

Land Cover Categories (by decreasing acreage)

AGRICULTURE
Wooded
Vegetation
Urban Developed
Vegetation
Water
Mars

NON-AGRICULTURE
Wooded
Vegetation
Urban Developed
Vegetation
Water
Mars
Validating CDLs

We measure the accuracy of each CDL

Compare:
- Classified pixels from CDL
- Known pixels, not used for classifying imagery, from FSA

Track:
- Producer Accuracy - Errors of Omission - % of pixels from category missing
- User Accuracy - Errors of Commission - % of pixels from category that are over classified

Cropland Data Layer versus Groundtruth – ½ saved for validation
# Accuracy Assessments

Crop-specific covers only | Correct | Accuracy | Error | Kappa | User's | Commission | Cond'1 | Kappa

## OVERALL ACCURACY

<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'1 Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1</td>
<td>28358</td>
<td>95.36%</td>
<td>4.64%</td>
<td>0.9528</td>
<td>93.08%</td>
<td>6.92%</td>
<td>0.9297</td>
</tr>
<tr>
<td>Cotton</td>
<td>2</td>
<td>11757</td>
<td>95.08%</td>
<td>4.92%</td>
<td>0.9505</td>
<td>94.59%</td>
<td>5.41%</td>
<td>0.9456</td>
</tr>
<tr>
<td>Rice</td>
<td>3</td>
<td>2</td>
<td>28.57%</td>
<td>71.43%</td>
<td>0.2857</td>
<td>66.67%</td>
<td>33.33%</td>
<td>0.6667</td>
</tr>
<tr>
<td>Sorghum</td>
<td>4</td>
<td>12500</td>
<td>67.48%</td>
<td>32.52%</td>
<td>0.3207</td>
<td>59.00%</td>
<td>41.00%</td>
<td>0.5900</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>15983</td>
<td>85.15%</td>
<td>14.85%</td>
<td>0.8584</td>
<td>88.61%</td>
<td>11.39%</td>
<td>0.8851</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>6</td>
<td>102</td>
<td>89.47%</td>
<td>10.53%</td>
<td>0.8947</td>
<td>99.03%</td>
<td>0.97%</td>
<td>0.9930</td>
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<tr>
<td>Peanuts</td>
<td>10</td>
<td>512</td>
<td>90.14%</td>
<td>9.86%</td>
<td>0.9014</td>
<td>92.09%</td>
<td>7.91%</td>
<td>0.9208</td>
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<tr>
<td>Barley</td>
<td>21</td>
<td>785</td>
<td>71.95%</td>
<td>28.05%</td>
<td>0.7194</td>
<td>97.38%</td>
<td>2.61%</td>
<td>0.9739</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>22</td>
<td>45</td>
<td>42.56%</td>
<td>57.44%</td>
<td>0.4286</td>
<td>100.00%</td>
<td>0.00%</td>
<td>1.0000</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>53</td>
<td>186</td>
<td>56.17%</td>
<td>43.83%</td>
<td>0.5617</td>
<td>80.06%</td>
<td>19.95%</td>
<td>0.8006</td>
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<tr>
<td>Winter Wheat</td>
<td>74</td>
<td>380437</td>
<td>97.54%</td>
<td>2.46%</td>
<td>0.9631</td>
<td>94.00%</td>
<td>6.00%</td>
<td>0.9117</td>
</tr>
<tr>
<td>Other Small Grains</td>
<td>25</td>
<td>1120</td>
<td>56.97%</td>
<td>43.03%</td>
<td>0.5694</td>
<td>93.57%</td>
<td>6.43%</td>
<td>0.9356</td>
</tr>
<tr>
<td>Wtx Wht /Soyb Dbl Crop</td>
<td>26</td>
<td>14758</td>
<td>79.51%</td>
<td>20.49%</td>
<td>0.7952</td>
<td>90.06%</td>
<td>9.94%</td>
<td>0.8996</td>
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<tr>
<td>Rye</td>
<td>27</td>
<td>13249</td>
<td>66.90%</td>
<td>33.10%</td>
<td>0.6664</td>
<td>91.35%</td>
<td>8.65%</td>
<td>0.9129</td>
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<tr>
<td>Oats</td>
<td>28</td>
<td>2941</td>
<td>64.85%</td>
<td>35.15%</td>
<td>0.6479</td>
<td>95.18%</td>
<td>4.82%</td>
<td>0.9517</td>
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<tr>
<td>Millet</td>
<td>29</td>
<td>439</td>
<td>77.02%</td>
<td>22.98%</td>
<td>0.7701</td>
<td>96.48%</td>
<td>3.52%</td>
<td>0.9648</td>
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<tr>
<td>Canola</td>
<td>31</td>
<td>337</td>
<td>75.90%</td>
<td>24.10%</td>
<td>0.7590</td>
<td>98.83%</td>
<td>1.17%</td>
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<tr>
<td>Alfalfa</td>
<td>36</td>
<td>19653</td>
<td>88.21%</td>
<td>11.79%</td>
<td>0.8807</td>
<td>91.76%</td>
<td>8.22%</td>
<td>0.9168</td>
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<tr>
<td>Dry Beans</td>
<td>42</td>
<td>115</td>
<td>88.46%</td>
<td>11.54%</td>
<td>0.8846</td>
<td>93.50%</td>
<td>6.50%</td>
<td>0.9350</td>
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<tr>
<td>Potatoes</td>
<td>43</td>
<td>49</td>
<td>96.08%</td>
<td>3.92%</td>
<td>0.9608</td>
<td>100.00%</td>
<td>0.00%</td>
<td>1.0000</td>
</tr>
<tr>
<td>Other Crops</td>
<td>44</td>
<td>50</td>
<td>45.87%</td>
<td>54.13%</td>
<td>0.4587</td>
<td>80.65%</td>
<td>19.35%</td>
<td>0.8064</td>
</tr>
<tr>
<td>Misc Vgts &amp; Fruits</td>
<td>47</td>
<td>33</td>
<td>54.10%</td>
<td>45.90%</td>
<td>0.5410</td>
<td>86.84%</td>
<td>13.16%</td>
<td>0.8684</td>
</tr>
<tr>
<td>Watermelon</td>
<td>48</td>
<td>21</td>
<td>77.42%</td>
<td>22.58%</td>
<td>0.7742</td>
<td>95.71%</td>
<td>14.29%</td>
<td>0.8571</td>
</tr>
<tr>
<td>Peas</td>
<td>53</td>
<td>185</td>
<td>72.59%</td>
<td>27.41%</td>
<td>0.7258</td>
<td>96.91%</td>
<td>3.09%</td>
<td>0.9691</td>
</tr>
<tr>
<td>Clover/Wildflowers</td>
<td>55</td>
<td>21</td>
<td>36.21%</td>
<td>63.79%</td>
<td>0.3621</td>
<td>75.00%</td>
<td>25.00%</td>
<td>0.7500</td>
</tr>
<tr>
<td>Fallow/Idle Cropland</td>
<td>61</td>
<td>30612</td>
<td>69.78%</td>
<td>30.22%</td>
<td>0.6922</td>
<td>90.48%</td>
<td>9.52%</td>
<td>0.9025</td>
</tr>
<tr>
<td>Peaches</td>
<td>67</td>
<td>9</td>
<td>36.00%</td>
<td>64.00%</td>
<td>0.3600</td>
<td>100.00%</td>
<td>0.00%</td>
<td>1.0000</td>
</tr>
<tr>
<td>Other Tree Nuts &amp; Fruit</td>
<td>71</td>
<td>69</td>
<td>33.82%</td>
<td>66.18%</td>
<td>0.3382</td>
<td>83.13%</td>
<td>16.87%</td>
<td>0.8313</td>
</tr>
</tbody>
</table>

*Correct Pixels represents the total number of independent validation pixels correctly identified in the error matrix.
## Accuracy Assessments

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Type</th>
<th>Code</th>
<th>Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>User's Accuracy</th>
<th>Commission Error</th>
<th>Cond'l Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Corn</td>
<td>1</td>
<td>2197719</td>
<td>96.58%</td>
<td>3.42%</td>
<td>97.86%</td>
<td>2.14%</td>
<td>0.9509</td>
</tr>
<tr>
<td></td>
<td>Soybeans</td>
<td>5</td>
<td>1471094</td>
<td>96.24%</td>
<td>3.76%</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9320</td>
</tr>
<tr>
<td>IL</td>
<td>Corn</td>
<td>1</td>
<td>2258219</td>
<td>98.06%</td>
<td>1.94%</td>
<td>98.58%</td>
<td>1.42%</td>
<td>0.9650</td>
</tr>
<tr>
<td></td>
<td>Soybeans</td>
<td>5</td>
<td>1339089</td>
<td>96.36%</td>
<td>3.64%</td>
<td>97.96%</td>
<td>2.04%</td>
<td>0.9681</td>
</tr>
<tr>
<td>NE</td>
<td>Corn</td>
<td>1</td>
<td>1856422</td>
<td>97.29%</td>
<td>2.71%</td>
<td>97.32%</td>
<td>2.68%</td>
<td>0.9608</td>
</tr>
<tr>
<td></td>
<td>Soybeans</td>
<td>5</td>
<td>849249</td>
<td>95.83%</td>
<td>4.17%</td>
<td>96.95%</td>
<td>3.05%</td>
<td>0.9643</td>
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<tr>
<td>SD</td>
<td>Corn</td>
<td>1</td>
<td>803251</td>
<td>94.29%</td>
<td>5.71%</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9513</td>
</tr>
<tr>
<td></td>
<td>Soybeans</td>
<td>5</td>
<td>707383</td>
<td>95.03%</td>
<td>4.97%</td>
<td>97.72%</td>
<td>2.28%</td>
<td>0.9741</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>IA</td>
<td>3688803</td>
<td>95.74%</td>
<td>4.26%</td>
<td>0.9145</td>
</tr>
<tr>
<td>IL</td>
<td>3730093</td>
<td>97.05%</td>
<td>2.95%</td>
<td>0.9426</td>
</tr>
<tr>
<td>NE</td>
<td>3071960</td>
<td>94.05%</td>
<td>5.95%</td>
<td>0.8981</td>
</tr>
<tr>
<td>SD</td>
<td>2306428</td>
<td>87.51%</td>
<td>12.49%</td>
<td>0.8416</td>
</tr>
</tbody>
</table>

**State level accuracies are very high**

*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.
Remote Sensing
Regression Estimation
## SECTION D - CROPS AND LAND USE ON TRACT

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.

<table>
<thead>
<tr>
<th>FIELD NUMBER</th>
<th>01</th>
<th>02</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total acres in field</td>
<td>828</td>
<td>828</td>
</tr>
<tr>
<td>2. Crop or land use [Specify]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Occupied farmstead or dwelling</td>
<td>843</td>
<td></td>
</tr>
<tr>
<td>4. Waste, unoccupied dwellings, buildings and structures, roads, ditches, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Woodland</td>
<td>831</td>
<td>831</td>
</tr>
<tr>
<td>6. Pasture</td>
<td>866</td>
<td>866</td>
</tr>
</tbody>
</table>

Estimation Components: Area Sampling Frame+
June Area Segment+
Questionnaire
The Goal: Identify areas with defined acreage totals to compare CDL pixel counts

Current Solution: June Agriculture Survey Segments

Farmers within segment report 220 acres of corn

Vs.

Crop Land Data Layer

Pixel Counting estimates 180 acres of corn
Simple Linear Regression

Regression used to relate categorized pixel counts to the ground reference data

- \( (X) \) – Cropland Data Layer (CDL) classified acres
- \( (Y) \) – June Agricultural Survey (JAS) reported acres

Outlier segment detection - removal from regression analysis

Using regression results in estimates reduces error rates over using JAS alone
2008 State Level Estimates +/- 2 CVs

- Crop acreage reported by Ag Statistics Board
- Crop acreage estimated from June Ag Survey
- Crop acreage estimated using CDL & Regression techniques
- Number of pixels in CDL
- Coefficient of Variation

Things to note:

- Remote Sensing techniques (CDL & Regression) produce acreage estimates with smaller variability
- Pixel counting tends to underestimate crop acreage
## Number of CDL’s & Acreage Indications

<table>
<thead>
<tr>
<th>Item</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
</tr>
<tr>
<td>Total CDL’s</td>
<td>21</td>
</tr>
<tr>
<td>In Season State Level Estimates</td>
<td>15</td>
</tr>
<tr>
<td>Post Season County Level Estimates</td>
<td>15</td>
</tr>
<tr>
<td>Crops</td>
<td>9</td>
</tr>
</tbody>
</table>
Geospatial Decision Support Systems

- Cropland Data Layer
  - Area Sampling Frame
  - Geovisualization Web
    - NASA Crop Progress (George Mason U)
      - Climate Change Initiative (FY ‘11)
        - "Impact on agriculture"
  - Doraiswamy Yield Model

- Crop Progress
  - Crop Condition
  - Disaster Assessment & Monitoring
  - Soil Moisture
Doraiswamy Remote Sensing Yield Program

- Operational in 7 major corn & soybean states.
- Tech transfer from USDA/ARS complete
- MODIS sensors used, 8 day +7 day eMODIS; data are smoothed
- Cropland Data Layer platform for masks
- Operational processing – 2 week prototype development reduced to 2 days

Current issues include:
- August predictions unlikely with current methodology.
- Sept. R²’s ~0.850/state for corn
- Oct. R²’s ~0.93 for corn; 0.810 for soybeans
- NDVI a reliable predictor for corn yields; soybeans need NDVI/EVI + other variable(s)
Time Series Phenological Profiles

Extracting Yield Parameters from NDVI Profile

Averaged to state level

Iowa - Corn

2008
2007
2006

At the Pixel level

NDVI

Day of Year
Phenologies by Crop

North Dakota - 2008

16-day composite median date

Cover type (pixels sampled)

- All (3402805)
- Alfalfa (226)
- Barley (2356)
- Corn (6262)
- Durum wheat (2914)
- Dats (59)
- Soybeans (10444)
- Spring wheat (14114)
- Winter wheat (1068)
Operational Processing

CDL-based Corn and Soybean Classification Mask

MODIS -VIR/NIR 8-Day Composite 250 m

Data Processed, Masked and State/County Averaged

Yield Regression Equation
Yield = f (NDVI, Historic Yields, Time)

Current Year Yield

Corn Soybean
# Regression Equation: Current Results

<table>
<thead>
<tr>
<th>State/Corn</th>
<th>Coefficient of Determination (adj. R²) – October</th>
<th>Calculated Yield (Bu/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>0.9404</td>
<td>*</td>
</tr>
<tr>
<td>Illinois</td>
<td>0.9224</td>
<td>*</td>
</tr>
<tr>
<td>Indiana</td>
<td>0.9656</td>
<td>*</td>
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<tr>
<td>Minnesota</td>
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<td>*</td>
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<tr>
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<td>Ohio</td>
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<td>*</td>
</tr>
<tr>
<td>Kansas</td>
<td>0.9830</td>
<td>*</td>
</tr>
</tbody>
</table>

* Confidential (Remote sensing yield indications are generally within 10% of the official NASS Estimate)
Climate Change Initiative (FY '11)

Geospatial Decision Support Systems

Cropland Data Layer

Doraiswamy Yield Model

Area Sampling Frame

Geovisualization Web

NASA Crop Progress (George Mason U)

Climate Change Initiative (FY ‘11)

“Impact on agriculture”

Crop Progress

Crop Condition

Disaster Assessment & Monitoring

Soil Moisture
Design of Remote Sensing-Based U.S. National Crop Progress Monitoring System (NCPMS)

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Project Goals

- To support and enhance the operation of monitoring nationwide crop progress and conditions at NASS
  - Develop science based crop progress metrics
  - Develop and prototype an operational National Crop Progress Monitoring System (NCPMS)
- Develop NCPMS products that will be complementary to existing NASS Crop Progress products
- To enhance the NASS crop progress and condition data accessibility, interoperability and dissemination

Center for Spatial Information Science and Systems
Why does NASS need a Remote Sensing-Based Crop Progress Monitoring System?

- NASS currently conducts weekly, volunteer-based crop progress surveys, and publishes crop progress and condition reports.
- The current crop progress monitoring is:
  - point-based sampling
  - subjectively estimated
  - lacks spatial distribution information
  - Inconsistent results
- Remote sensing technology provides:
  - Objective, consistent, science-based, geospatially covered, time series observations.
Major System User Requirements

- Minimum reporting area enforced to guarantee privacy.
- Interactive crop progress map generated.
- Pixel-level or field level granularity
- On-the-fly presentation within user defined region.
- Geospatial query capability.
- Crop specific phenological information.
- Equal access and dissemination via spatially enabled Web-based systems.
Design Principles of Operational NCPMS

- The system should be able to assimilate and prepare Earth Observing data for use in agricultural crop growth monitoring and accuracy improving.
- The system should be capable of efficiently (timely) applying Earth Observing research results and data in crop growth development estimation.
- Advanced data mining algorithms and crop models should be implemented and can be plugged-in to readily take advantage of resources available in the system.
- Systematic approaches should be applied to
  - integrate data, services (Web computer software programs)
  - disseminate results through the Web
  - operate the national crop progress monitoring system in a standard-compliant virtual Web environment.
Data Dissemination & Visualization Example – Cropland Explorer
Remote Sensing-based Budget Initiative

Providing Foundational Data Needs for Monitoring and Assessment of the Effects of Climate Change on U.S. Agriculture

Geospatial Information Branch - Spatial Analysis Research Section (SARS), Fairfax, VA
Areas of Work-NASS & WAOB

- Expansion & Improvements of Existing Efforts
  - Cropland Data Layers and Acreage Estimation
  - Yield Estimation for state and county levels
- New Research & Development Areas
  - Crop Progress, Crop Condition, Soil Moisture, Disaster Monitoring and Assessments
- Create Digital GeoArchive
- Delivery of Products via Internet
New Research Areas

- **Crop Progress** – Provide quantitative assessments by stage of crop for each specific crop.

- **Crop Conditions** – Quantitatively assess the amount of a specific crop in very poor, poor, fair, good, and excellent condition.

- **Soil Moisture** - Monitoring and assessing Topsoil (surface to 6" depth) and Subsoil (>6" -- 3-4') moisture in categories similar to the following - Very short, Short, Adequate, Surplus.

- **Natural Disaster Monitoring & Assessment** - timely monitoring & assessing significant events affecting crop area, conditions and yield
Depiction of Soil Moisture

Current > Subjective-based

Future > Science-based

Corn 8-Day Available Transpirable Soil Water (ATSW), IL-2006

ATSW (mm)

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300

Weekly Weather and Crop Bulletin

August 8, 2006

Short Term Crop Need vs. Available Water in 5-ft. Soil Profile
Aug 5, 2006

North Dakota Crop Weather Report, Week Ending August 16, 2009

Topsoil Moisture Supplies North Dakota, August 16, 2009
Natural Disaster Assessments – Visual Reference

Resourcesat-1 AWIFS, August 12, 2009
Natural Disaster Assessments - Prototype Crop Yield Map

Raw AWiFS  
Yield Impact
Major Issues Facing Our Program

NEAR TERM

- Sensors, sensors, sensors!
  - Without Landsat TM, 2010 would have been a huge setback for remote sensing in NASS!
- AWiFS solar panel partial failure
- Future Use & Access to SPOT VEG unsure
- Resourcesat 2 launch, and priority for U.S. acquisitions?
- Flow of imagery must be uninterrupted during growing season

LONG TERM

- MRLI support to U.S. civilian agencies unclear.
- MODIS replacement (VIRS) a downgrade
- Operational needs have evolved beyond current strategies to support them.
- NASS will encourage USDA move to push for higher priority launch of HyspIRI sensor.
HyspIRI Thermal Infrared Multispectral (TIR) Science Measurements

Science Questions:
- TQ1. Volcanoes/Earthquakes (MA,FF)
  - How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?
- TQ2. Wildfires (LG,DR)
  - What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?
- TQ3. Water Use and Availability, (MA,RA)
  - How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?
  - How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?
- TQ5. Earth surface composition and change, (AP,JC)
  - What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

Multispectral Scanner
Schedule: 4 year phase A-D, 3 years operations
High Heritage

Measurement:
- 7 bands between 7.5-12 μm and 1 band at 4 μm
- 60 m resolution, 5 days revisit
- Global land and shallow water

Andean volcano heats up
Urbanization
Volcanoes
Water Use and Availability
Surface Temperature
Evapotranspiration
**HyspIRI compared with possible International Imaging Spectroscopy Missions**

Only HyspIRI provides the full spectrum of data required to address climate-carbon cycle feedbacks articulated in the NRC Decadal Survey.

HyspIRI Provides Seasonal and Annual Global Coverage that Uniquely Addresses Critical Gaps in Climate Research and Ecosystem Understanding.

>100 years for international mission to equal 1 year of HyspIRI

<table>
<thead>
<tr>
<th>Country</th>
<th>Instrument</th>
<th>Swath km</th>
<th>Pixel Size, m</th>
<th>Terrestrial Coverage in 19 days</th>
<th>Repeat interval, days</th>
<th>TIR capability</th>
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<tbody>
<tr>
<td>USA</td>
<td>HyspIRI</td>
<td>150</td>
<td>60</td>
<td>100%</td>
<td>19</td>
<td>8 TIR bands</td>
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<tr>
<td>Germany</td>
<td>EnMAP</td>
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<td>&lt;1%</td>
<td>–</td>
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<tr>
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<td>30</td>
<td>&lt;1%</td>
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<tr>
<td>India?</td>
<td>IMS Resource Sat-3</td>
<td>25</td>
<td>25</td>
<td>&lt;1%</td>
<td>–</td>
<td>1 TIR band</td>
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</tbody>
</table>

US, HyspIRI: a full spectral range (380 to 2500 at 10 nm), high SNR, uniform, 60m spatial with 150 km swath imaging spectrometer and multiband thermal imager (8 band thermal imager from 3-12 μm).

Other countries are occasionally mentioned (China, South Africa, South Korea, etc.). All are proposing first generation small sample process/application missions with scattered terrestrial coverage and no TIR imager.
Key Features of NASA HyspIRI

1) Hyperspectral: Visible ShortWave InfraRed (VSWIR) Imaging Spectrometer - Full spectrum 380 to 2500 nm, 60 m resolution, with 150 km swath, repeat coverage 19 days

2) Multispectral Thermal InfraRed (TIR) Scanner - 7 bands between 7.5-12 µm and 1 band at 4 µm, 60 m resolution, with 600 km swath, repeat coverage 5 days

Potential for climate/water/carbon/land use monitoring/wildfires/droughts
IN MEMORIAM

Dr. Paul C. Doraiswamy
April 7, 1948 - May 8, 2010
Friend and Colleague