An Overview of USA Crop Production Monitoring and the Role of Satellite Remote Sensing

International Meeting on Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013, Secure World Foundation, Brussels, Belgium
### Continuous Agricultural Statistics Programs

**Crops:**
- grains
- hay
- oilseeds
- cotton
- tobacco
- potatoes
- sugar
- other field crops
- citrus fruit
- non-citrus fruit
- nuts
- vegetables
- floriculture

**Livestock:**
- crop progress
- acreage
- - prospective plantings
- - planted
- - harvested
- yield & production
- - forecasts
- - final
- - by utilization
- stocks
- disposition
- processing
- prices received by farmers
- agricultural chemical use
- cattle
- hogs
- sheep
- goats
- equine
- poultry
- milk & dairy products
- aquaculture
- bees & honey mink

**Other:**
- inventory
- - total
- - by class
- - births
- - deaths
- - predator losses
- marketings
- slaughter
- production/disposition
- - meat
- - other products (milk, dairy products, wool, mohair, eggs, honey, etc.)
- prices received by farmers
- inventory/production values
- number of farms
- land in farms
- land values
- cash rents
- agricultural labor
  - number of workers
  - hours worked
  - wages paid
- cold storage
  - holdings
  - capacity
- cash receipts
- production expenditures

**Frequency:**
- weekly ~ monthly ~ quarterly ~ annually
Agricultural Census

- total area & land use
- irrigation
- land in government programs
- field & forage crops
- fruits, nuts & berries
- vegetables & melons
- horticultural specialties
- livestock & poultry
- animal specialties
- aquaculture
- production contracts
- gross value of sales
- direct sales to consumers
- government loans
- government program payments
- farm-related income
- grain storage capacity
- operator characteristics
- farm organization
- fertilizer & chemical use
- farm production expenses
- inventory & value of machinery & equipment
- market value of land & buildings
- farm labor

~ years ending in “2” & “7” ~

inventories as of December 31 ~ production, sales & other information for calendar year
The National Agricultural Statistics Service provides timely, accurate, and useful statistics in service to U.S. agriculture.

Today's Reports from NASS

Broiler Hatchery
Released at 3:00 P.M. ET

Headlines

New Classroom Lesson Uses Food Preference to Teach Statistical and Agricultural Literacy

NASS to Resume Milk Production Surveys in October

USDA Forecasts Record-High Corn Production in 2013

NASS to Release 2013 Farm Computer Usage Results on August 20

U.S. Farm Production Expenditures Keep Climbing

Historic Agricultural Data Now Online

Register for the 32nd Annual Morris Hansen Lecture
## Corn Dough – Selected States

*These 18 States planted 92% of the 2012 corn acreage*

<table>
<thead>
<tr>
<th>State</th>
<th>September 8, 2012 (percent)</th>
<th>September 1, 2013 (percent)</th>
<th>September 8, 2013 (percent)</th>
<th>2008-2012 Average (percent)</th>
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<tbody>
<tr>
<td>Colorado</td>
<td>98</td>
<td>87</td>
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<td>Nebraska</td>
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<tr>
<td>North Carolina</td>
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<tr>
<td>North Dakota</td>
<td>100</td>
<td>71</td>
<td>90</td>
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<td>South Dakota</td>
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<td>Tennessee</td>
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<td>Texas</td>
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<tr>
<td>Wisconsin</td>
<td>94</td>
<td>61</td>
<td>76</td>
<td>86</td>
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<tr>
<td><strong>18 States</strong></td>
<td><strong>99</strong></td>
<td><strong>84</strong></td>
<td><strong>92</strong></td>
<td><strong>94</strong></td>
</tr>
</tbody>
</table>
Corn Planted Acreage Up Slightly from 2012
Soybean Acreage Up 1 Percent
All Wheat Acreage Up 1 Percent
All Cotton Acreage Down 17 Percent

Corn planted area for all purposes in 2013 is estimated at 97.4 million acres, up slightly from the highest planted acreage in the United States since 1936 when an estimated 102 million acres were planted. Farmers expect to harvest 89.1 million acres for grain, up 2 percent from last year.

Soybean planted area for 2013 is estimated at a record high 77.7 million acres, up 1 percent from last year’s harvest, at 76.9 million acres, is up 1 percent from 2012 and will be a record high, if realized. Soybeans are estimated to be grown in 33 states and is estimated in New York, Pennsylvania, and South Dakota.

All wheat planted area for 2013 is estimated at 56.5 million acres, up 1 percent from last year. The planted area at 42.7 million acres, is 3 percent above last year and up 2 percent from about 29.4 million acres are Hard Red Winter, 9.96 million acres are Soft Red Winter, and about 11.7 million acres are Hard Red Spring wheat. The estimated Durum wheat planted area is 1.54 million acres, down 28 percent from the previous year.

All cotton planted area for 2013 is estimated at 10.3 million acres, 17 percent below the 12.6 million acres planted area in 2012. American Pima area is estimated at 10.6 million acres, down 17 percent from 2012.

Crop Production

Special Note
USDA’s National Agricultural Statistics Service is suspending a number of statistical surveys and reports for the remainder of the fiscal year resulting from reduced funding. Suspended commodity programs impacting the August Crop Production report are hogs, commercial apples, peaches, pears, and grapes. Check the NASS website at www.nass.usda.gov for any future updates to these programs.

Planted Acreage Update
Survey respondents who reported soybean acreage as not yet planted in Arkansas, Illinois, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, North Carolina, North Dakota, South Dakota, Tennessee, and Wisconsin due to the survey conducted in preparation for the Acreage report, released June 28, 2013 were re-contacted in July to determine how many of those acres were planted or still intended to be planted. Acreage estimates in this report reflect this updated information.

Corn Production Up 28 Percent from 2012
Soybean Production Up 8 Percent from 2012
Winter Wheat Production Down 25 Percent from 2012

Winter Wheat Production Down Slightly from July Forecast

Corn production is forecast at 13.8 billion bushels, up 28 percent from 2012. If realized, this will be a new record production for the United States. Based on conditions as of August 1, yields are expected to average 154.4 bushels per acre, up 31.0 bushels per acre from 2012. If realized, this will be the highest average yield since 2009. Area harvested for grain is forecast at 89.1 million acres, unchanged from the June forecast but up 2 percent from 2012.

Soybean production is forecast at 3.26 billion bushels, up 8 percent from last year. If realized, production will be the third largest on record. Based on August 1 conditions, yields are expected to average 42.6 bushels per acre, up 3 bushels from last year. If realized, the average yield will be the fifth highest on record. Area for harvest is forecast at 76.4 million acres, down less than 1 percent from June but up slightly from 2012. Planted area for the Nation is estimated at 77.2 million acres, down less than 1 percent from June.
**US crop area ranked statistics**

<table>
<thead>
<tr>
<th>Largest crops by area</th>
<th>mil. ha. (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>35.4</td>
</tr>
<tr>
<td>Soybeans</td>
<td>30.8</td>
</tr>
<tr>
<td>Wheat</td>
<td>19.8</td>
</tr>
<tr>
<td>(Winter, spring, durum)</td>
<td>(14.1, 4.9, 0.9)</td>
</tr>
<tr>
<td>Hay</td>
<td>22.8</td>
</tr>
<tr>
<td>(alfalfa, all other)</td>
<td>(7.0, 15.8)</td>
</tr>
<tr>
<td>Cotton</td>
<td>3.8</td>
</tr>
<tr>
<td>Sorghum</td>
<td>2.0</td>
</tr>
<tr>
<td>Barley</td>
<td>1.3</td>
</tr>
<tr>
<td>Rice</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*Figures established by a large “area frame” based survey conducted early each June*
Area trends of the top US 3 crops

United States Harvested Area (acres)

- Corn
- Soybeans
- Wheat
Annually derived Cropland Data Layer (CDL)
<table>
<thead>
<tr>
<th>Mapped Crop Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Corn</td>
</tr>
<tr>
<td>2. Cotton</td>
</tr>
<tr>
<td>3. Rice</td>
</tr>
<tr>
<td>4. Sorghum</td>
</tr>
<tr>
<td>5. Soybeans</td>
</tr>
<tr>
<td>29. Millet</td>
</tr>
<tr>
<td>34. Rape Seed</td>
</tr>
<tr>
<td>37. Other Hay</td>
</tr>
<tr>
<td>38. Camelina</td>
</tr>
</tbody>
</table>
2009 Cropland Data Layer
New England and Eastern States

Land Cover Categories
(by decreasing acreage)

Agriculture
- Pasture/Grass
- Other Hays
- Corn
- Soybeans
- Fallow/Idle Cropland
- Cotton
- W. Wht./Soy. Dbl. Crop
- Peanuts
- Winter Wheat
- Alfalfa
- Other Tree Nuts
- Misc. Vegs. & Fruits
- Seed/Sod Grass
- Other Small Grains
- Oats
- Potatoes/Sweet Potatoes
- Blueberry
- Other Crops
- Apples/Cherries
- Dry Beans
- Peaches/Plums/Apricots

Non-Agriculture
- Woodland
- Urban/Developed
- Wetlands
- Water
- Shrubland
- Barren

USDA
CDL generalities

- Annual land cover classification targeted to identifying *circa* summer cultivated crops
- Encompasses all of conterminous USA (since 2008, some states prior)
- 56m or 30m resolution
  - Depending on year but now all 30m
- Built with a supervised boosted classification tree methodology
  - Implemented with See 5.0
- Utilizes ground/training data from USDA Farm Service data and ancillary data from National Land Cover Database
- Highly robust for dominant crop types
  - corn, soybeans, wheat, rice, cotton, etc.
- Used internally by NASS to refine planted acreage estimates
- Derived primarily from
  - Resourcesat-1 AWiFS
  - Landsat-5 TM
  - DMC Deimos-1 and UK-2
  - Landsat-8 OLI and TIRS
DMC Deimos-1/UK2 Collections
Landsat 8 Collections

L8, 2013, Cycle 6, Jun 18 - Jul 03
Crop area mapping lessons learned

- Heavy volumes of time-series imagery important
  - Agriculture is a dynamic land cover
- Fine spatial resolution is somewhat important
  - Particularly if field sizes are relatively large
- Multi-spectral resolution least important
  - The time component reigns supreme
- Crop area estimation by “pixel counting” alone is not sufficient
  - A bias measurement of the classification is needed
  - “regression estimator”
- Some sort of reasonably accurate “ground truth” needed to drive the classifier
  - ~ 1% of land cover might be sufficient
Yields results primarily derived from two surveys

Agricultural Yield
- Farmer reported survey data of expected crop yields.
- Data obtained throughout the growing season.
- Conducted in all states except Alaska and Hawaii.
- Sample size in the 1000s per state.
- Farm operator contacts are selected from the March Crops/Stocks survey (small grains) and the June Crops/Stocks survey (late season crops and tobacco).
- Primarily telephone based.

Objective yield
- Corn, Cotton, Soybeans, Wheat, Potatoes.
- Only done in states where the commodities are primarily found.
- Samples selected from areas found in June Area Survey (“Acreage”).
- Performed at 100s of sample sites per state.
- Biophysical plant/seed measurements obtained.
- Each plot revisited a few times per season.
Remote Sensing Yield

Third method for yield estimates

• Premise
  – There is a Relationship between crop
    • Biomass, vigor, “greenness”, NDVI
      – and
    • Land surface temperature
  – And the resulting crop yield

• Utilize MODIS data to obtain biomass and temperature variables

• National, State, ASD, and County
  – Corn and Soybeans only
  – “Speculative” region only
    • i.e. Corn Belt
Moderate Resolution Imaging Spectroradiometer (MODIS)
Corn phenology fundamentals

Corn 5-year average 2006-2010

Terra MODIS mean NDVI

16-day composite median date

State
Arkansas
Illinois
Indiana
Iowa
Kansas
Louisiana
Minnesota
Missouri
Mississippi
North Dakota
Nebraska
Ohio
Oklahoma
South Dakota
Wisconsin


8/1 9/1 10/1
Corn yield dependence at county level speculative region, 2006-2011
Soybean yield dependence at county level speculative region, 2006-2011
Winter wheat yield dependence at county level
Kansas, 2006-2011
Estimated Corn Yield
October 1, 2012
Estimated Soybean Yield

October 1, 2012
MODIS-derived crop dynamics based on CDL areas

This type of information is directly related to crop yields.
This winter: Try to understand all common MODIS derived variables and how they relate to various crops’ yields

- Explore fully beyond only corn and soybeans
  - Wheat
  - Rice
  - Potatoes
  - Cotton
- Compare the full suite of common MODIS variables
  - NDVI
  - EVI
  - LAI
  - FPAR
  - LST (daytime and nighttime)
- Test Both Terra and Aqua platforms
  - Truly assess the AM vs PM overpass time
- Look at pixel scale issues
  - 250 m vs. 500 m vs. 1000 m (particularly for NDVI)
Final thoughts about crop production monitoring using earth observation satellites

• A wealth of satellite data already exists
  – Free and with significant history
    • Terra and Aqua MODIS
    • Landsat 7 and 8
  – Others are out there too to supplement
    • DMC, Rapideye, Digital Globe, SPOT, IRS, etc...
    • Plus those coming online like VIIRS, Sentinel II,

• Computing infrastructure can handle it
• .....and the research is there to guide best practices
Thank You

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www.nass.usda.gov
http://www.nass.usda.gov/Research_and_Science/
http://nassgeodata.gmu.edu/CropScape