David M. Johnson
Geographer

United States Department of Agriculture
National Agricultural Statistics Service
Research and Development Division
Spatial Analysis Research Section

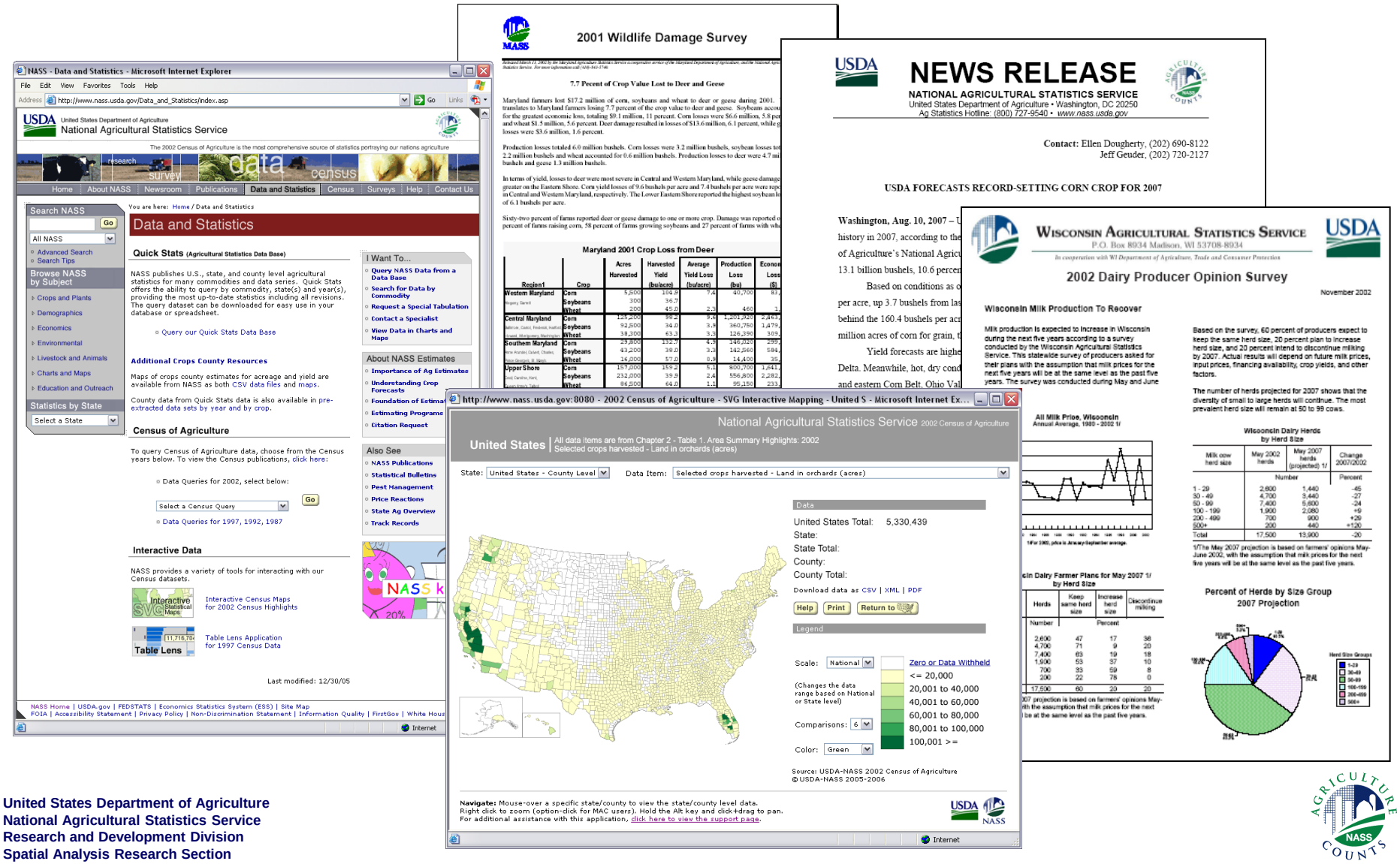
NASS Geospatial Activities

Discussion Points

- National Agricultural Statistics Service (NASS)
  - Role, Mission
  - Research and Development Division
- Spatial Analysis Research Section (SARS)
  - Florida Citrus GIS
  - Extreme event monitoring
  - Crop Condition / Progress
  - Crop Yield
  - Map products
  - Regression-based Acreage Estimates
- Cropland Data Layer (CDL)
  - Resourcesat-1 AWiFS Imagery
  - Ground Truth
  - Methods
  - Kentucky

NASS Overview

Provider of timely, accurate, and useful statistics in service to U.S. agriculture



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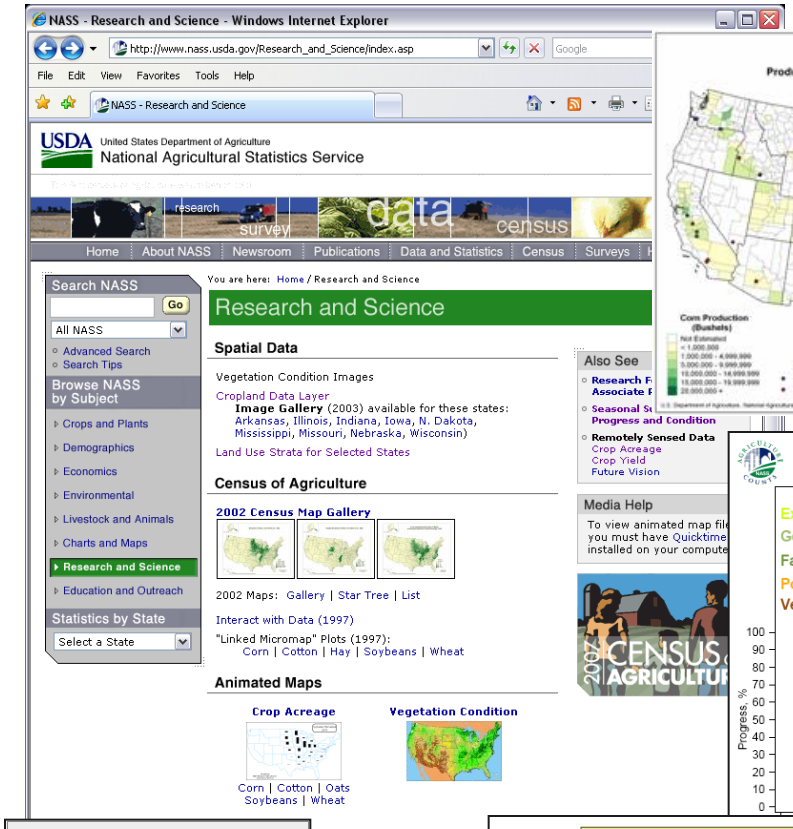
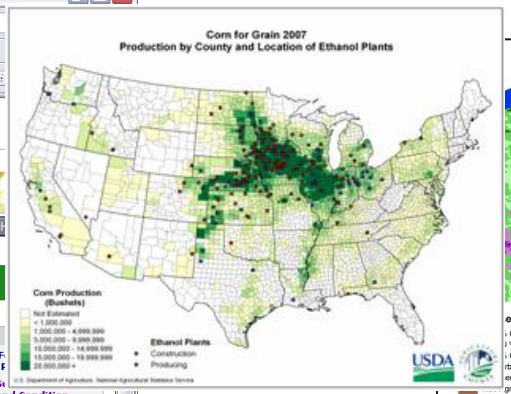
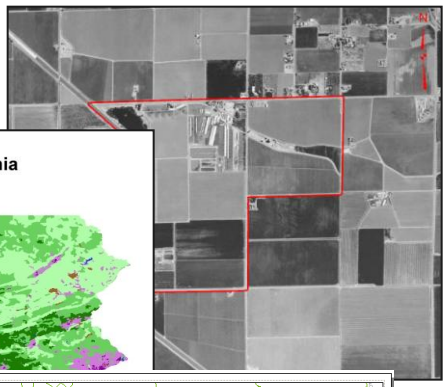
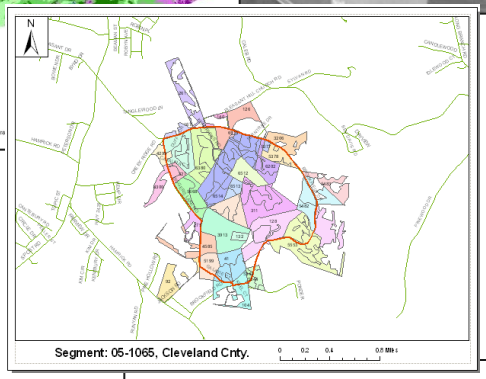
Research and Development Division

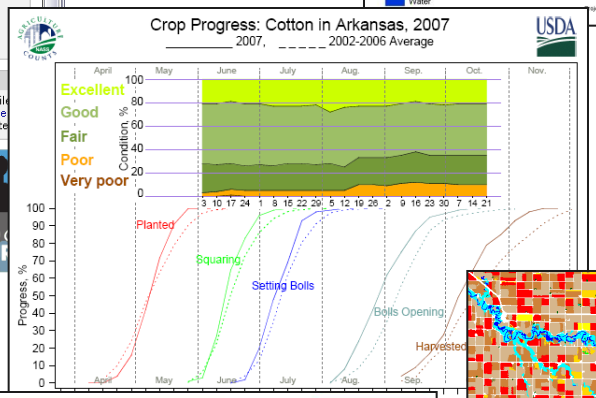
Geospatial Information Branch

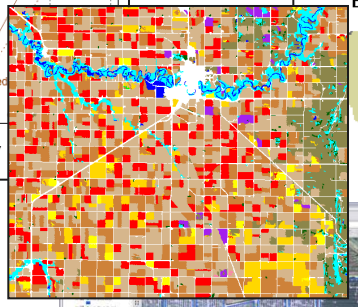


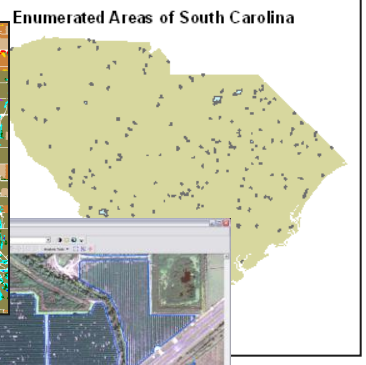


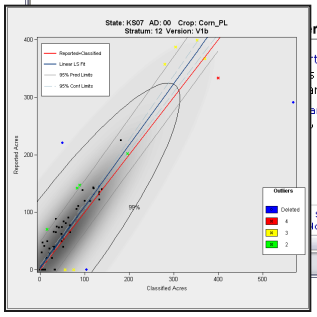


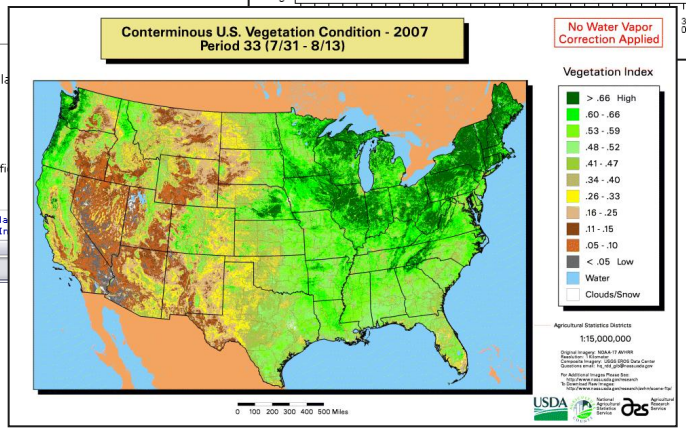


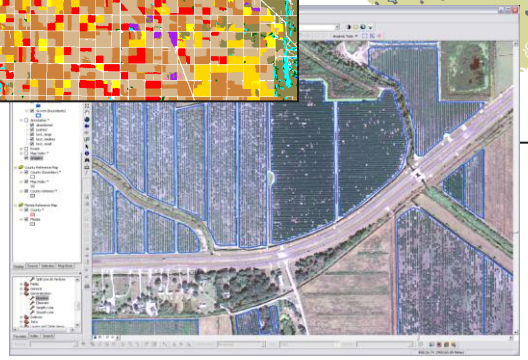












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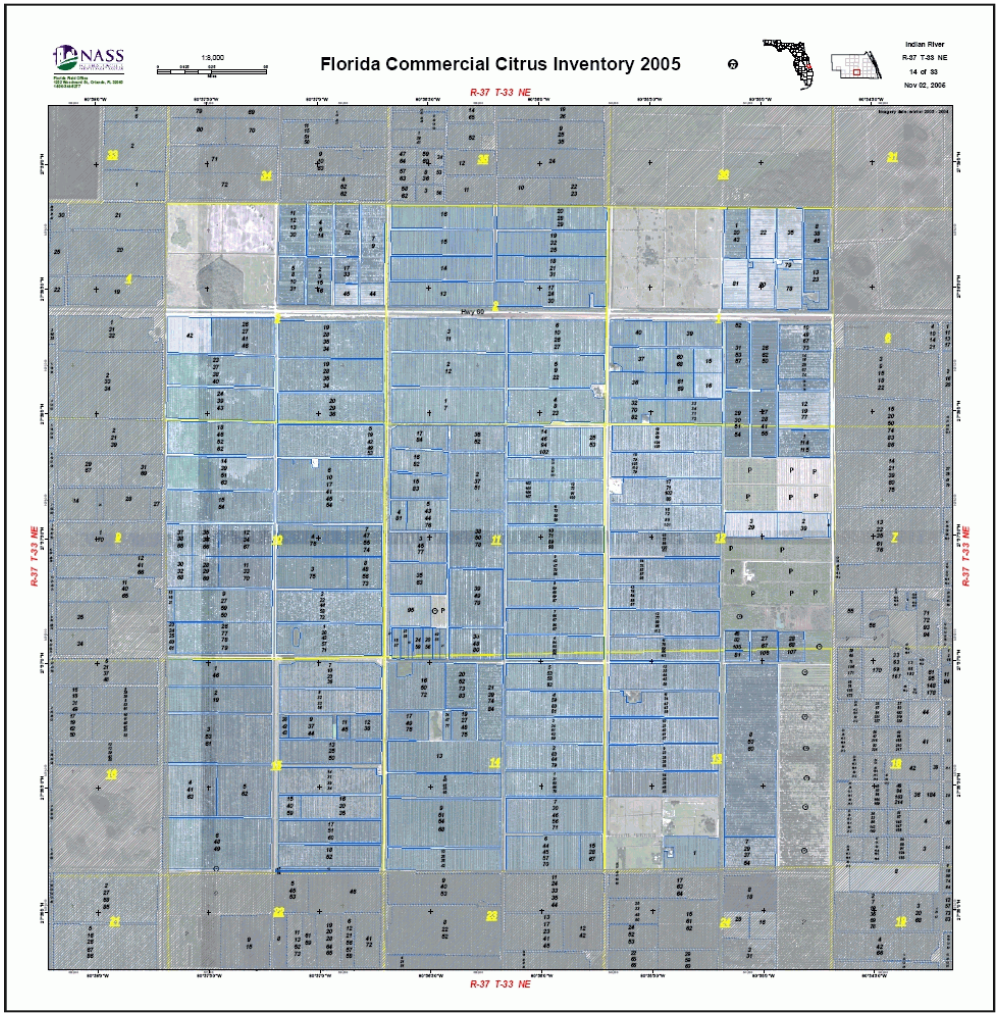
Florida Citrus GIS

- Improve efficiency of FASS citrus operations
  - Built operational Citrus GIS of entire commercial inventory



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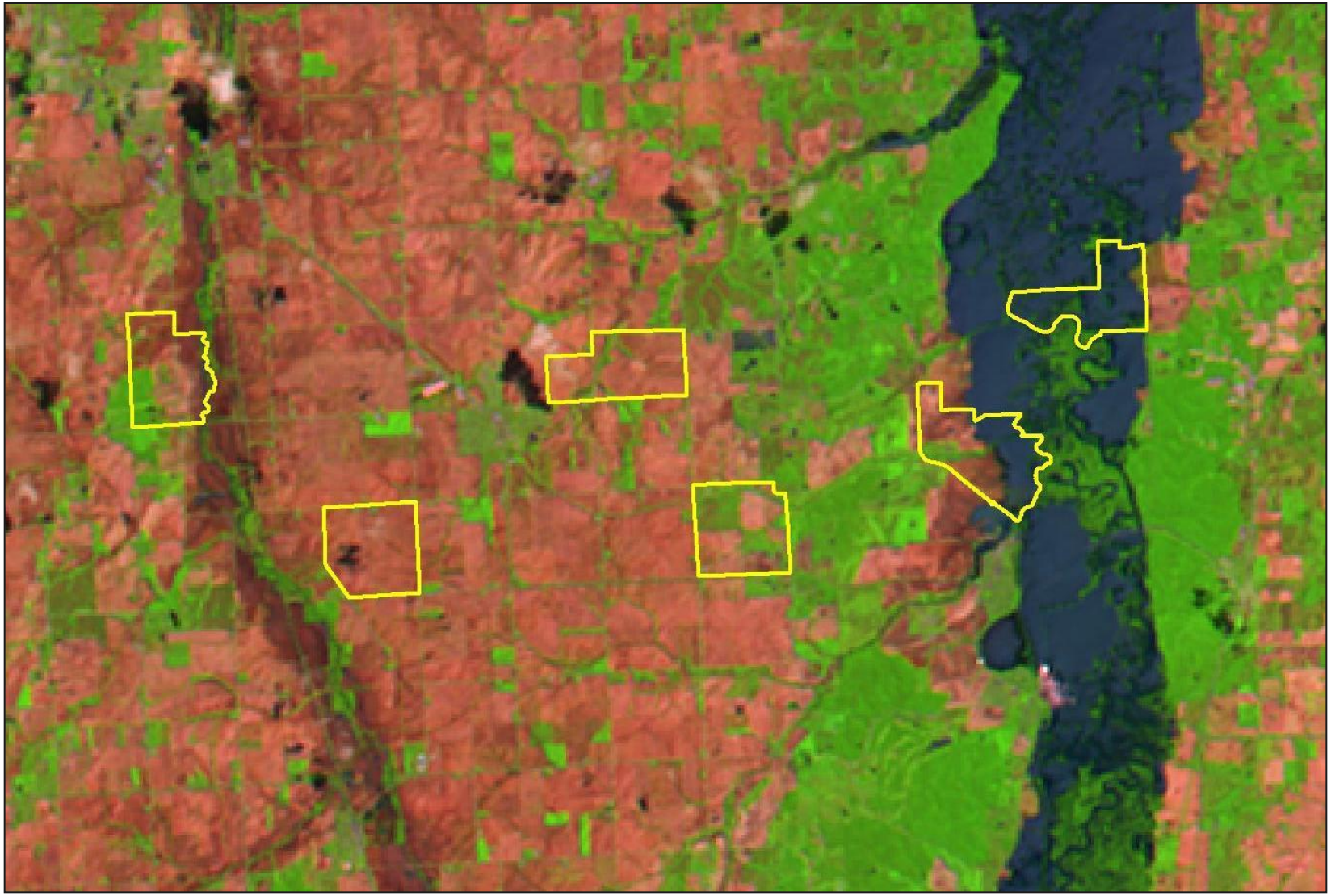
Flood impacts on NASS June Acreage Survey “Segments”



IRS-P6 AWiFS

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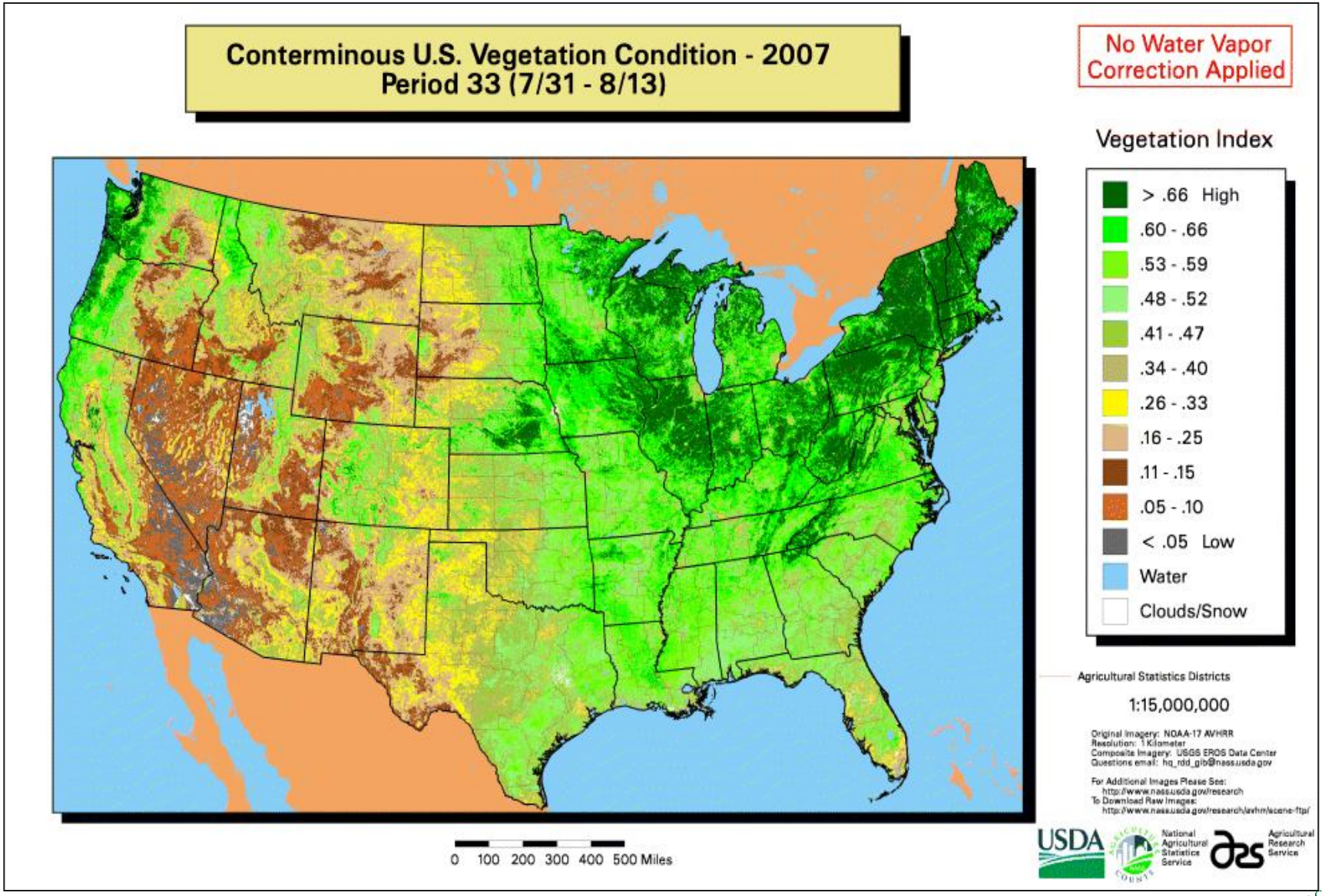
Vegetation Condition



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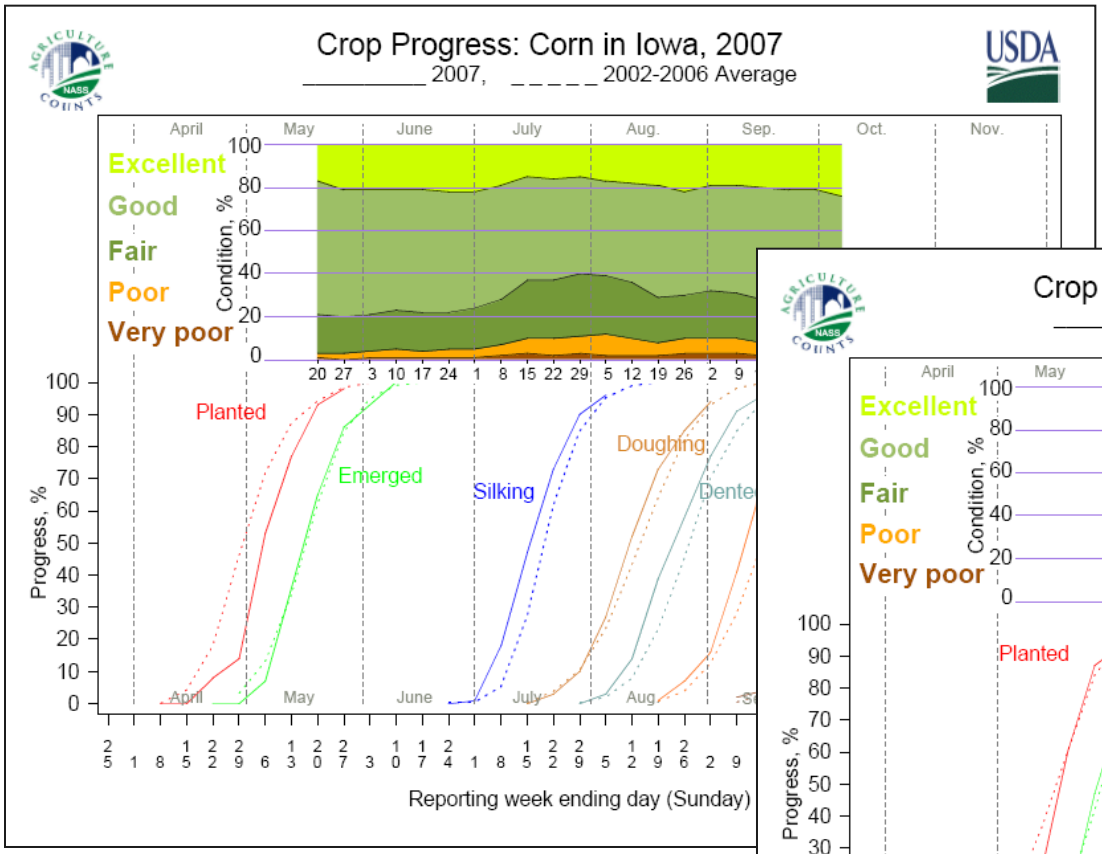
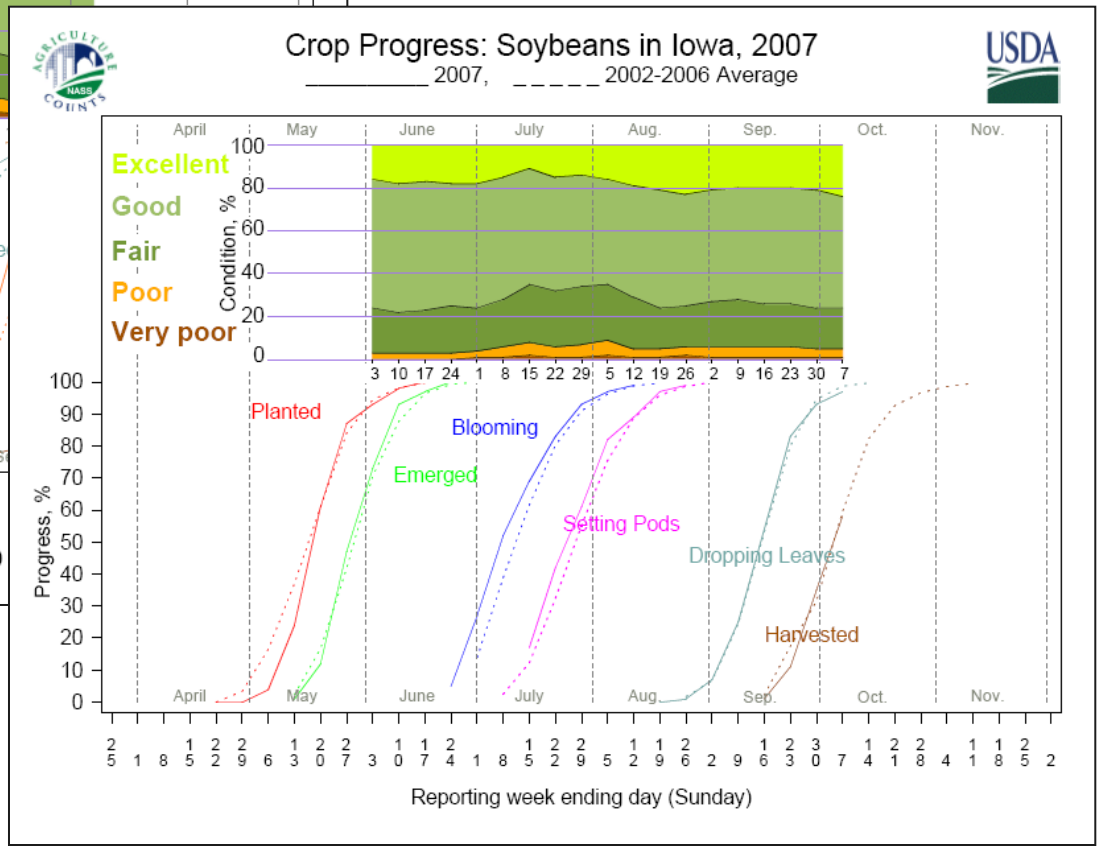
Crop Progress





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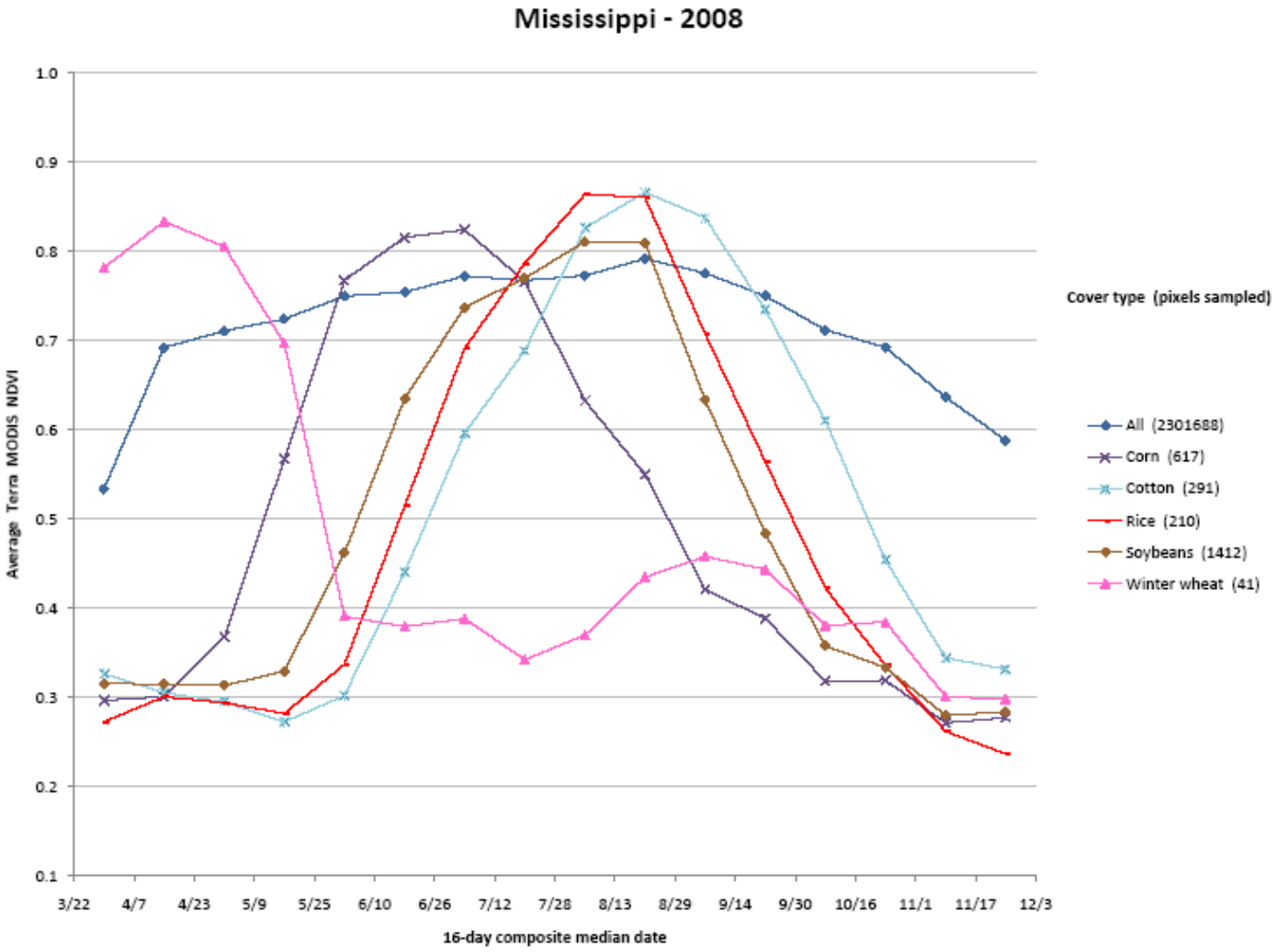
www.nass.usda.gov/research/CropProgress/cpindex.htm

Crop Phenology



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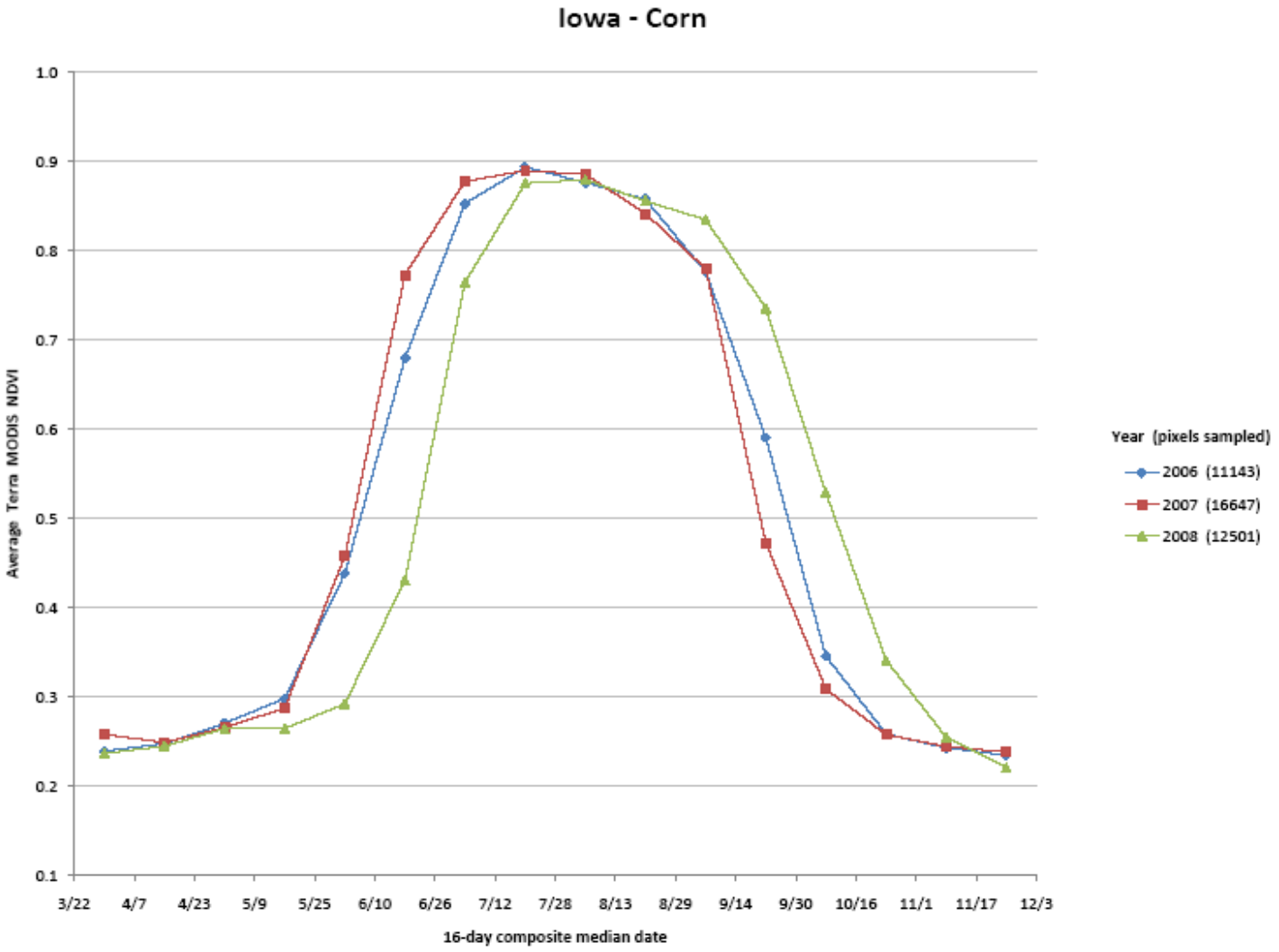
Corn Phenology – Annual differences



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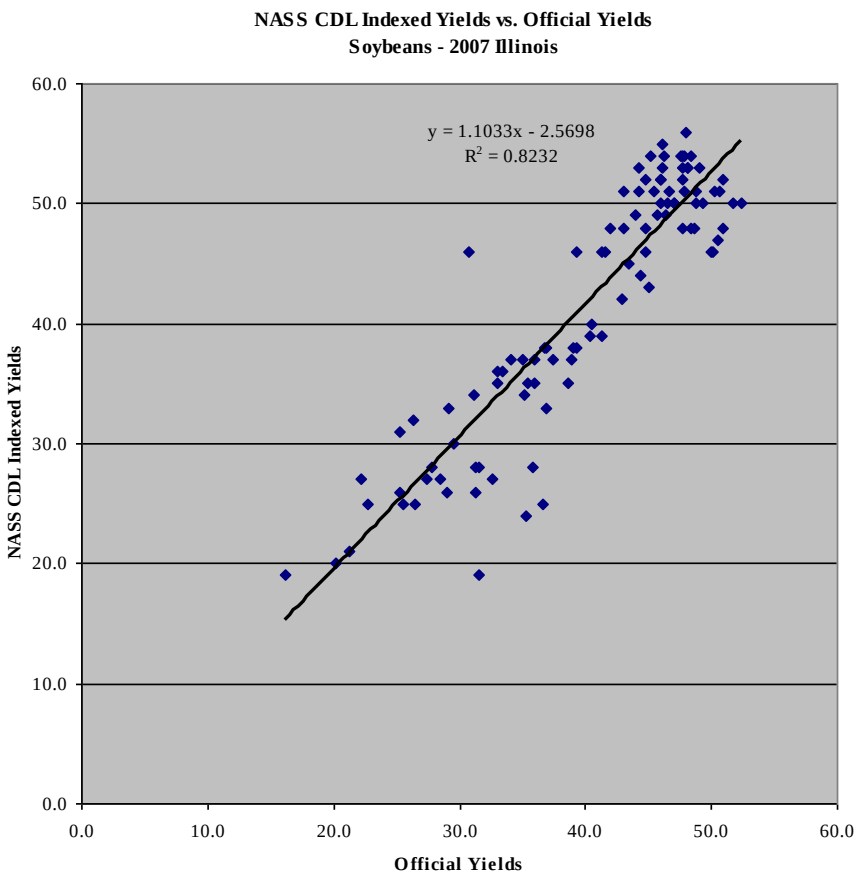
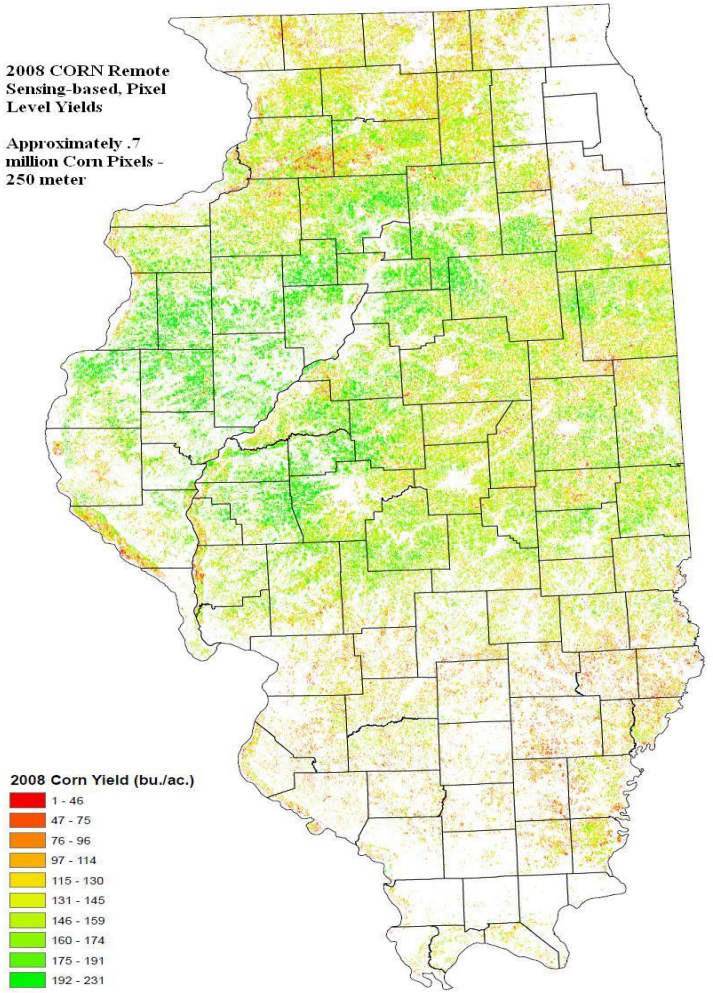
Yield





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Thematic Maps

Crop Progress and Condition Survey Data

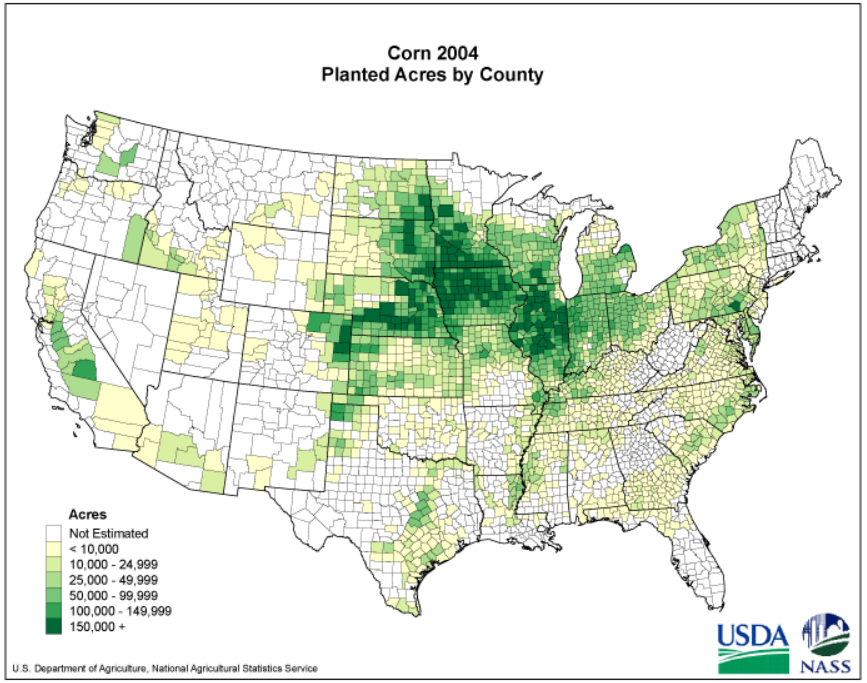
Monthly Ag Yield Survey Data

Objective Yield Survey Data

Crop Condition (AVHRR)

County Estimate Survey Data

2002/2007 Census of Agriculture



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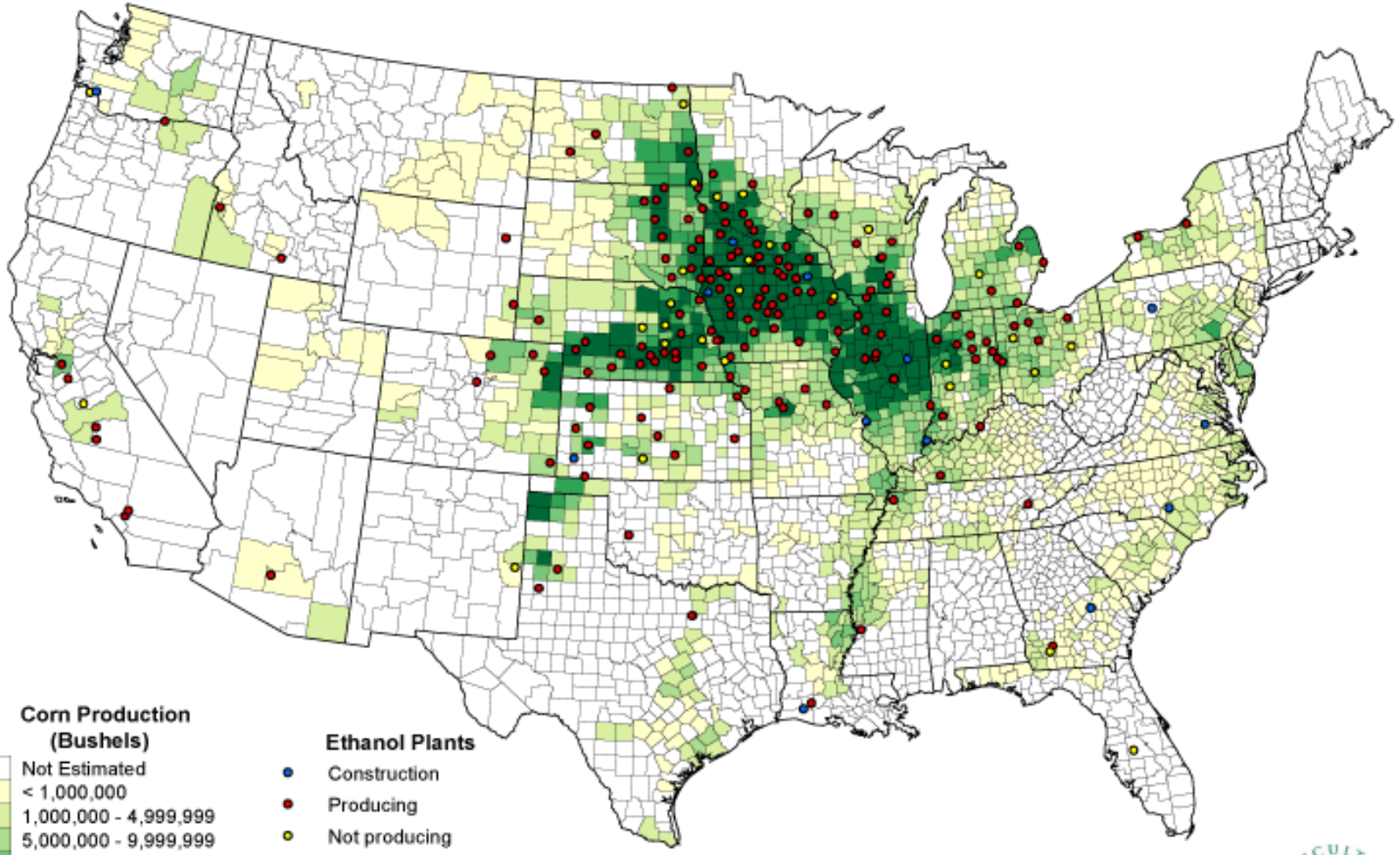
Corn for Grain 2008
Production by County and Location of Ethanol Plants

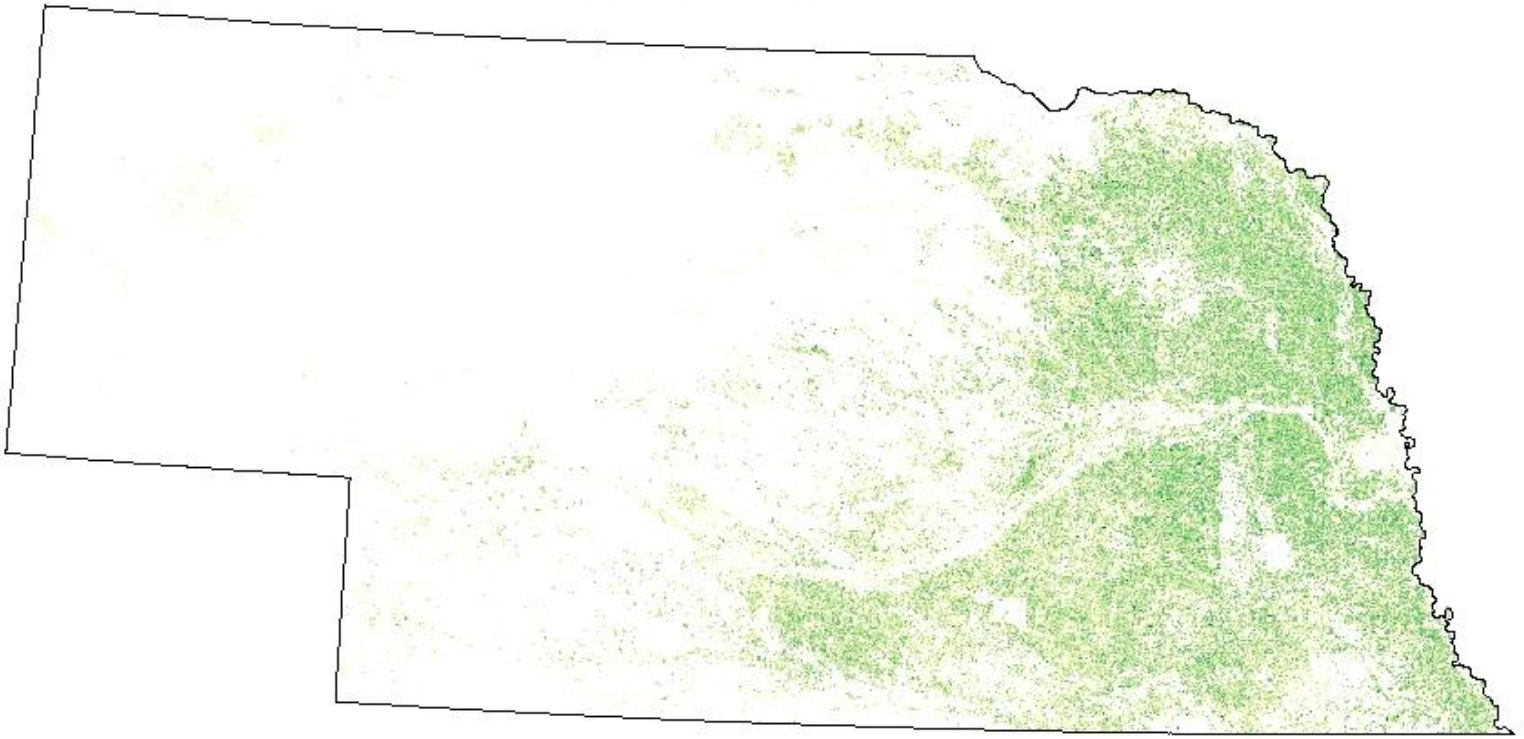


U.S. Department of Agriculture, National Agricultural Statistics Service

Nebraska

Continuous Years of Soybean Planting 2003-2007

CDL Derivative Products

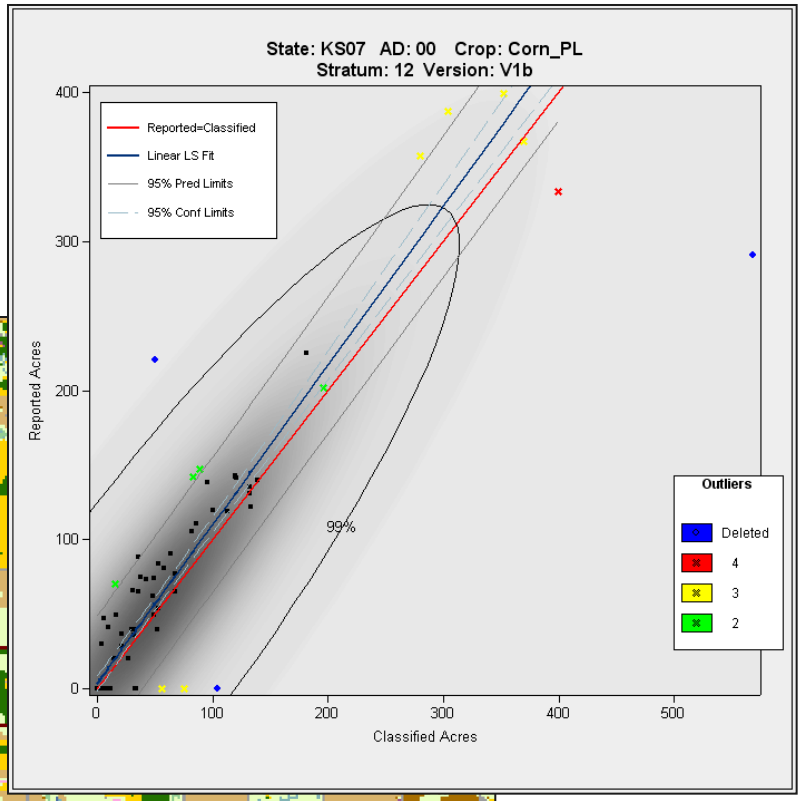


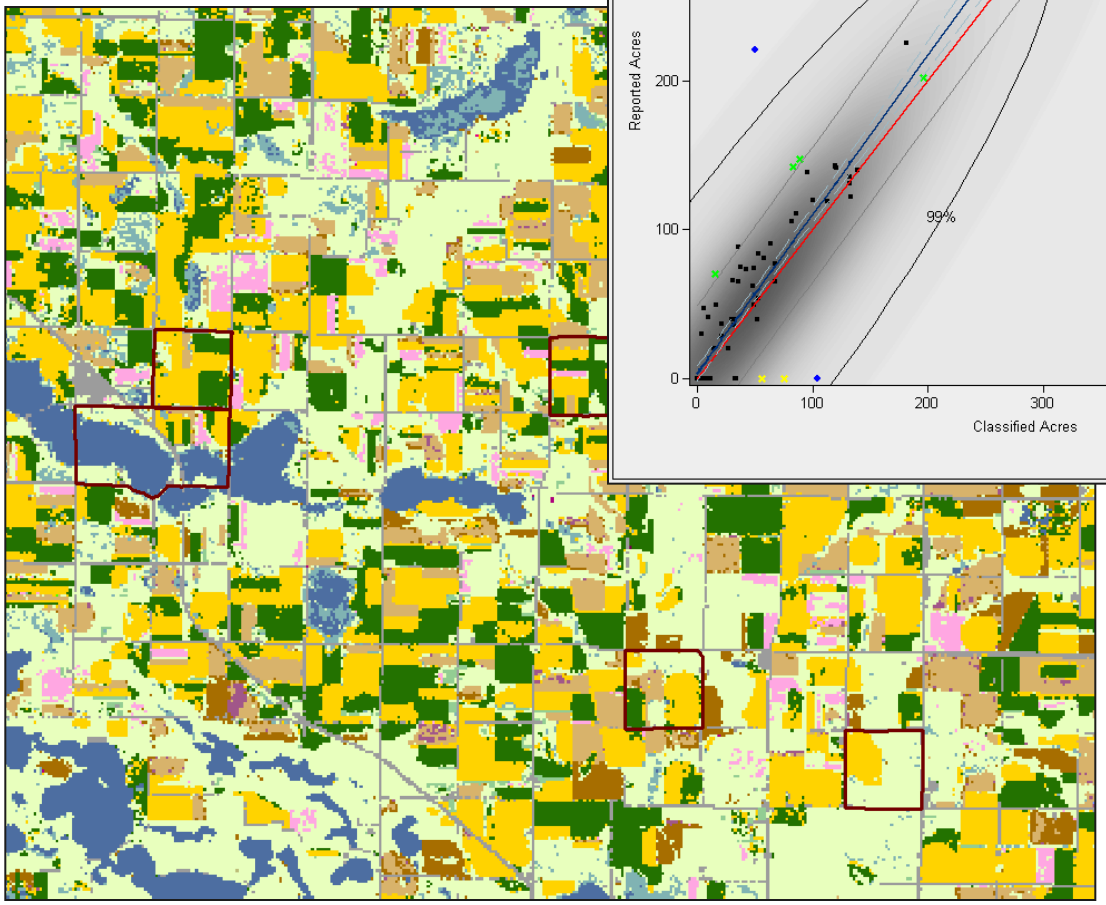
Years Identified as Planted to Soybeans

1 2 3 4 5

Regression-based Acreage Estimator

Acreage not just about counting pixels





NASS Inputs

- June Survey summaries
- Area Sampling Frame
- CDLs

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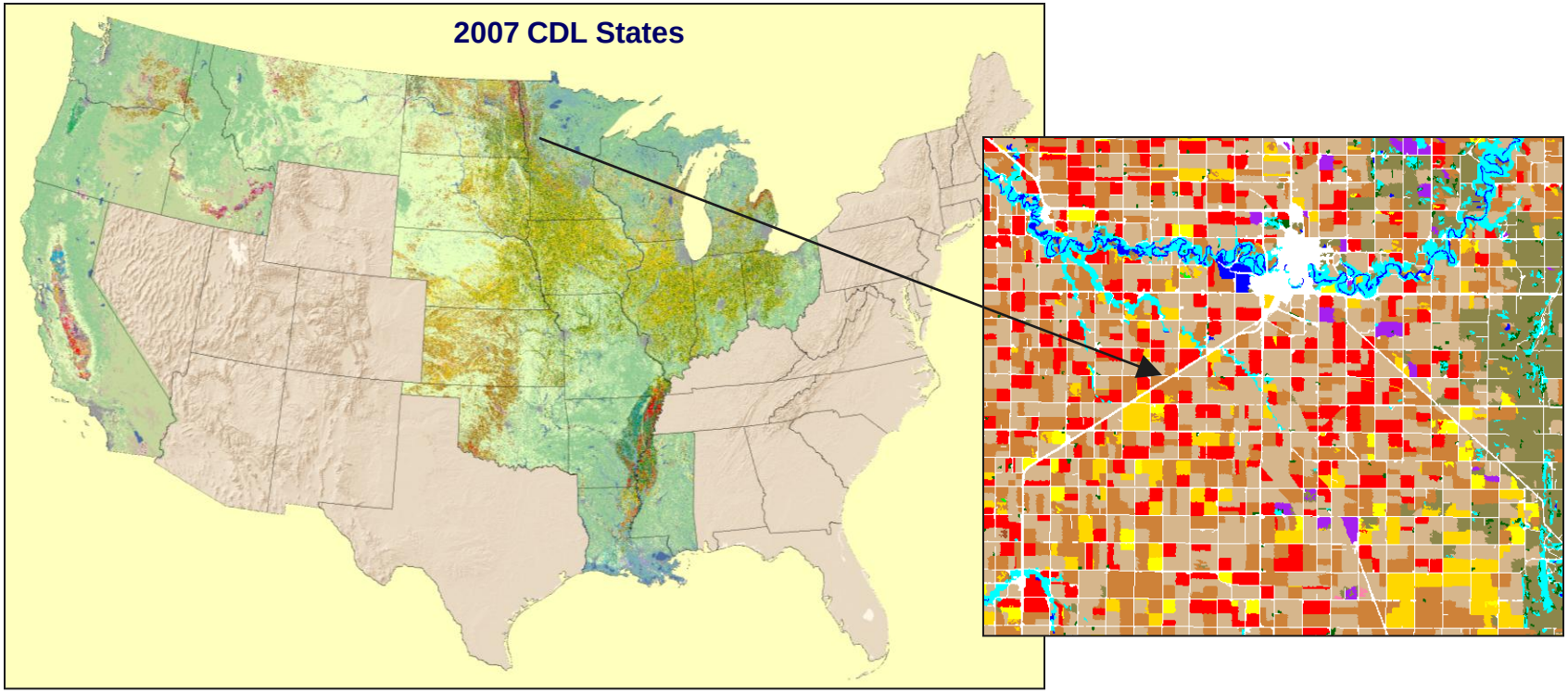
Cropland Data Layer (CDL) Program



- State specific land cover classifications emphasizing row crop agriculture
  - Some regions done annually (Corn Belt, The Delta)
  - Others “one-and-done” (California, Northwest)
- Within NASS, CDL used to
  - Increase precision on survey derived acreage estimates
  - Improve county level acreage estimates

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Creating a Land Cover Classification

Cropland

- Corn
- Soybeans
- Winter Wheat
- Spring Wheat
- Cotton
- Sorghum
- Barley
- Oats
- Rice
- Sunflowers
- … and more

Non-Cropland

- Water
- Developed
- Barren
- Woodland
- Shrubland
- Grassland
- Wetland

Cropland Data Layer Uses

Within NASS

- Refined state-wide acreage estimates
- Improved county-wide acreage estimates
- Tightened confidence intervals on all survey derived acreage estimates

Outside NASS

- Watershed runoff modeling
- Agribusiness planning
- Ground truth
- Change detection
- Water use mapping
- Epidemiological research
- Habitat monitoring
- Carbon sequestration analysis
- …..and more

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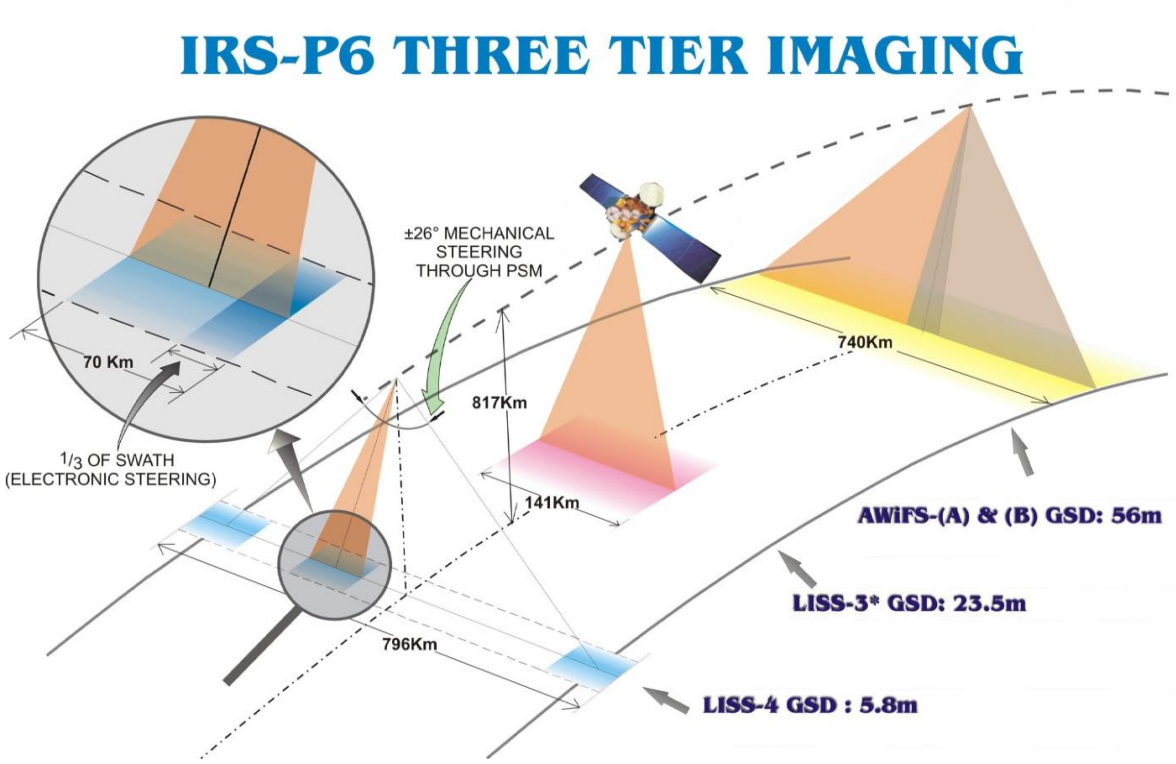
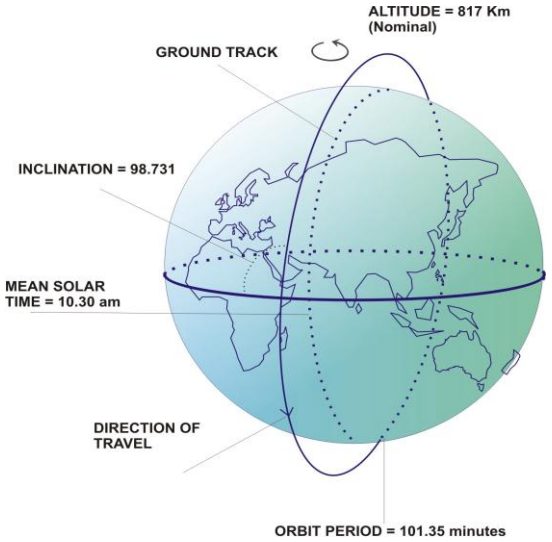
Resourcesat-1





ASRC

इसरो ISRO Department of Space
Indian Space Research Organisation

IRS Resourcesat-1 AWiFS Imagery

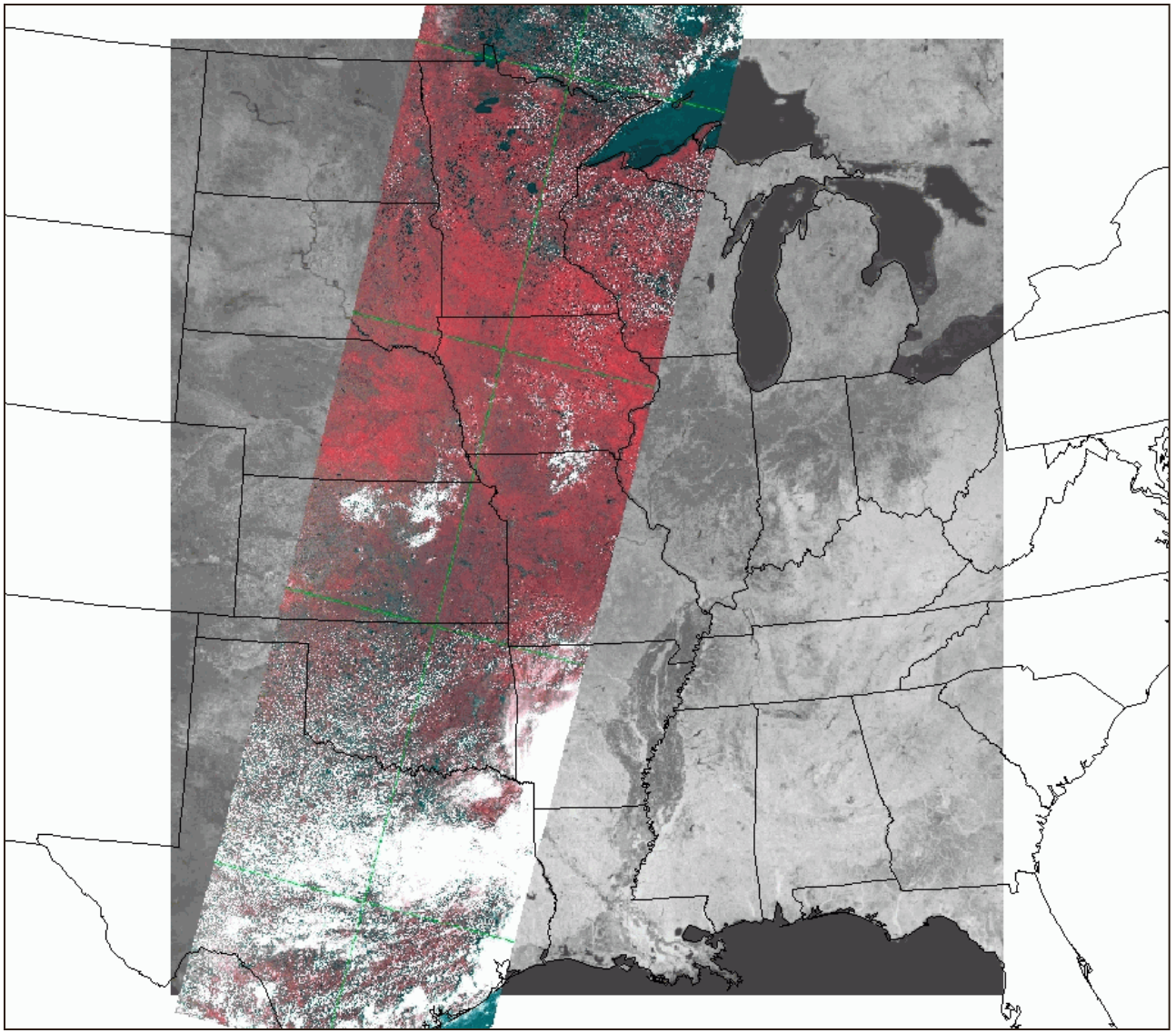
Primary Imagery Source

740 km swath width

5-day revisit

4 spectral bands
- green
- red
- near-infrared
- short-wave infrared

56 m ground sample resolution



6 July 2007

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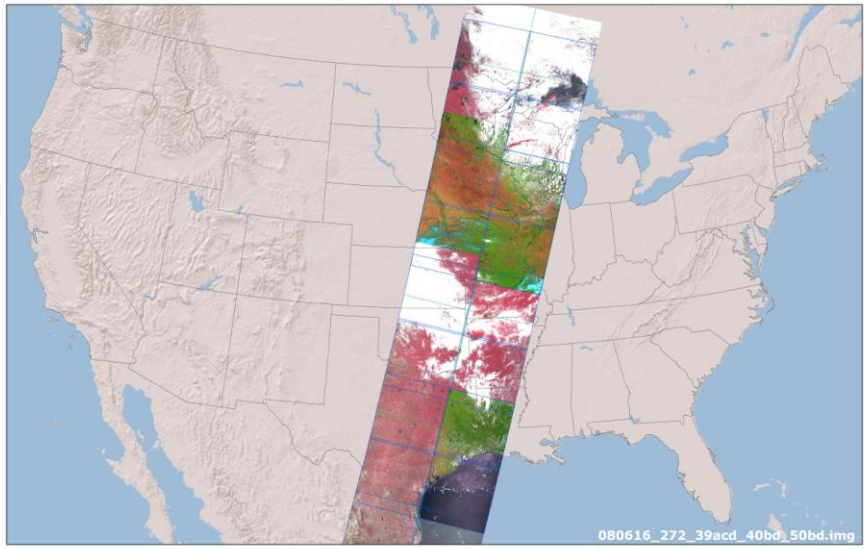
Why NASS Likes AWiFS

- Large swath width
- Inclusion of red, NIR, SWIR spectral bands
- Tolerable spatial resolution at 56m
- Cost effectiveness
- 5-day or less revisit rate
- Operational nature
- Fast data delivery by vendor
- Healthy satellite
- Follow-on system (Resourcesat-2) already built



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History of NASS AWiFS Use

- 2004
  - Obtained AWiFS August imagery
  - Used to augment TM images collected during entire summer
- 2005
  - Obtained AWiFS June and August imagery
  - Used to augment or replace TM
  - Assessed quantitative differences
- 2006
  - Switched from Landsat to Resourcesat at a USDA-wide level
  - Obtained AWiFS during entire summer growing season
- 2007
  - Obtained even more AWiFS during entire summer growing season
- 2008
  - Utilized broader coverage of AWiFS to expand to more of US
- 2009
  - Expecting to use more
  - Now with winter collects as well

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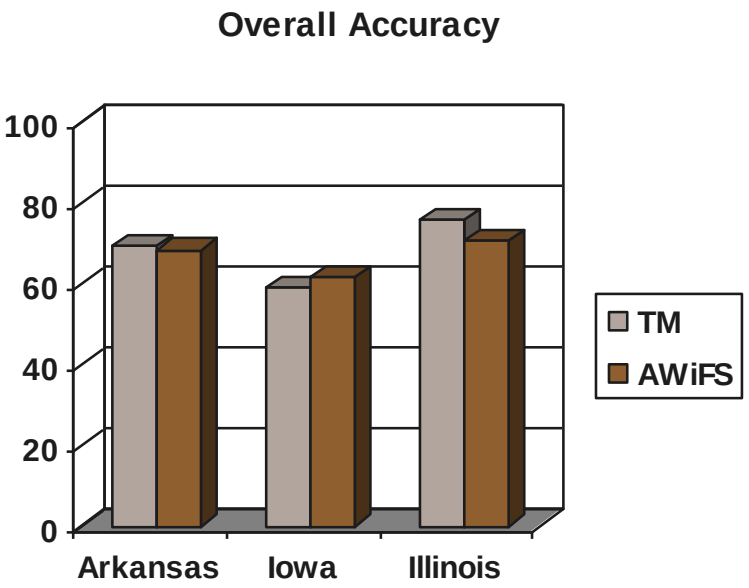
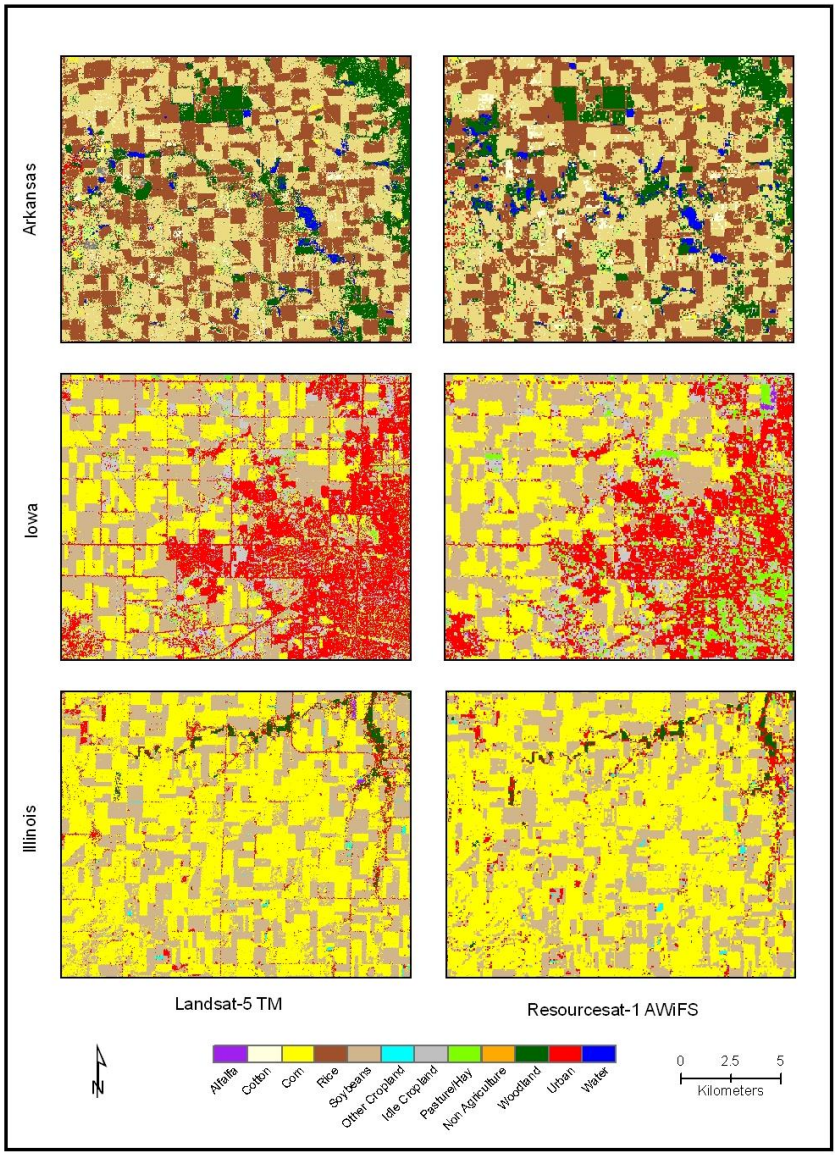
Results of TM versus AWiFS



TM usually outperforms AWiFS.

Spatial resolution somewhat more important than loss of blue and mid-infrared bands.



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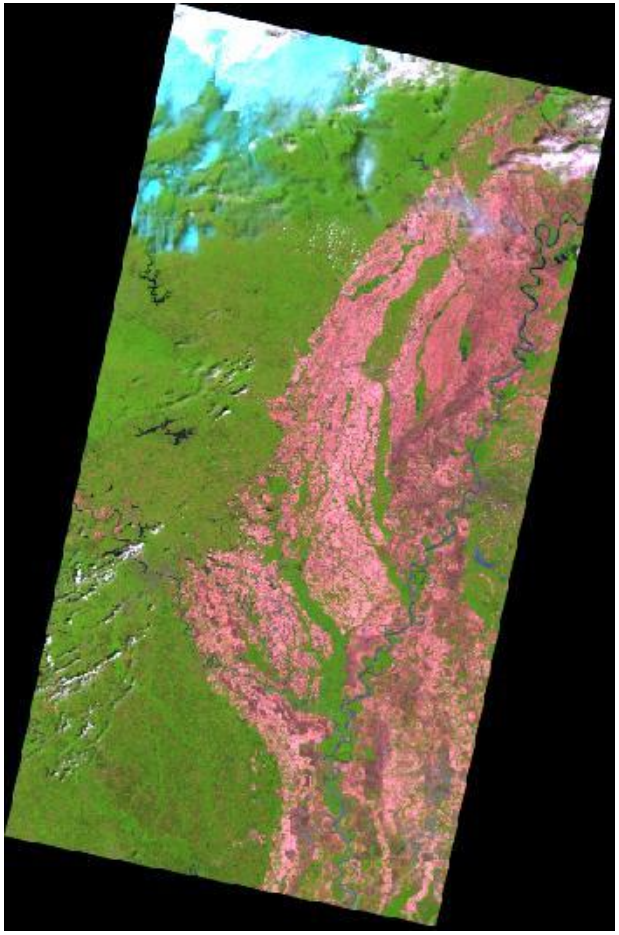
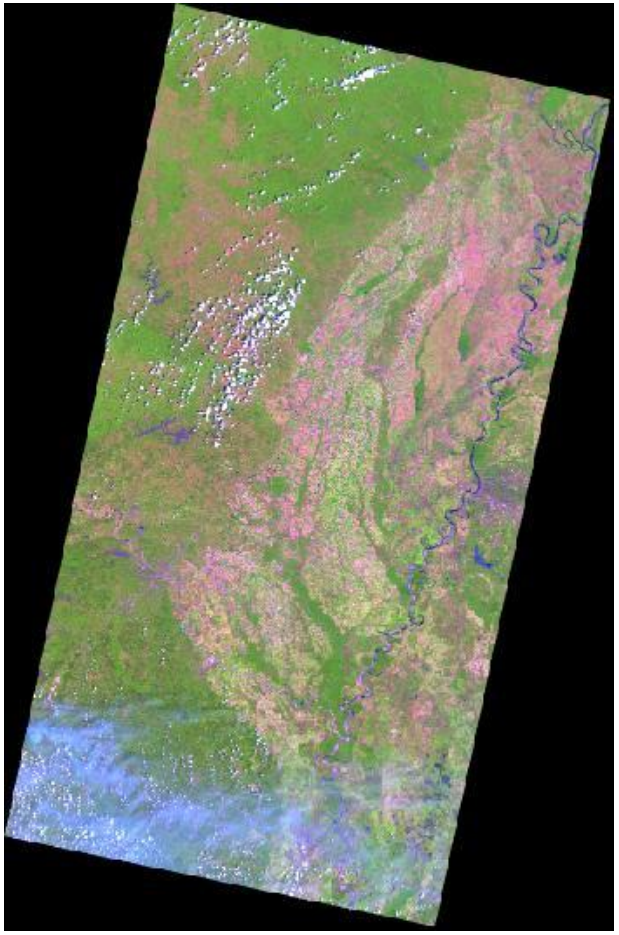
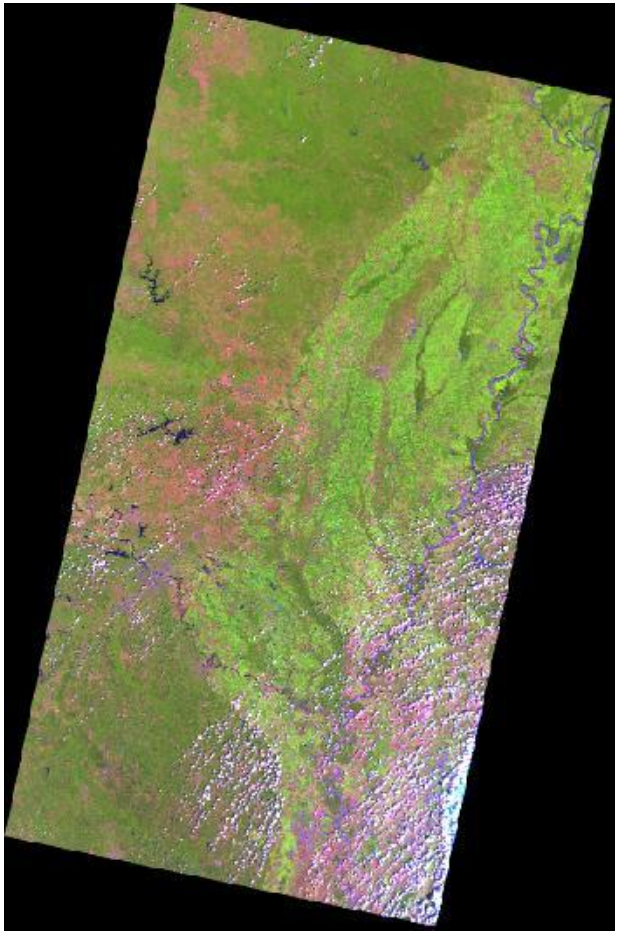
AWiFS Imagery Time Series



May 20



July 2



July 31

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AWiFS

April

June

August

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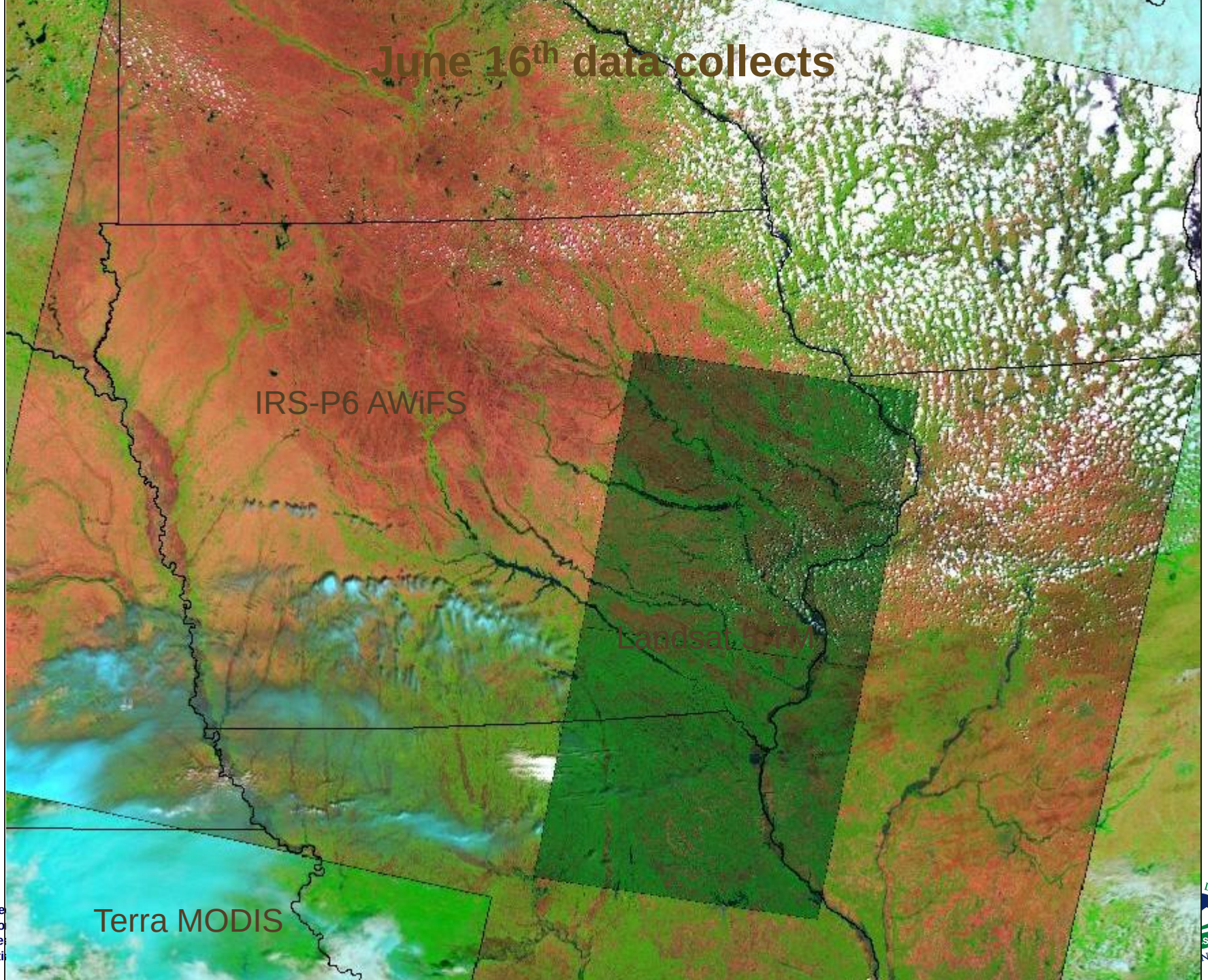
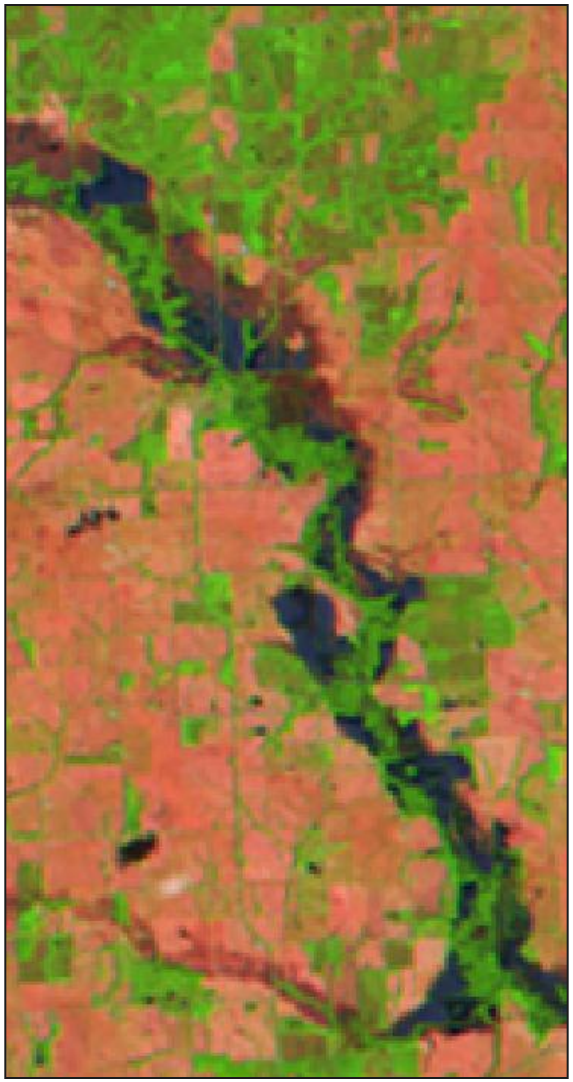

June 16th data collects
IRS-P6 AWiFS
Landsat 5 TM
Terra MODIS

Imagery Comparison – June 16th

Landsat 5 TM



IRS P6 AWiFS

Terra MODIS
(Rapid Response)

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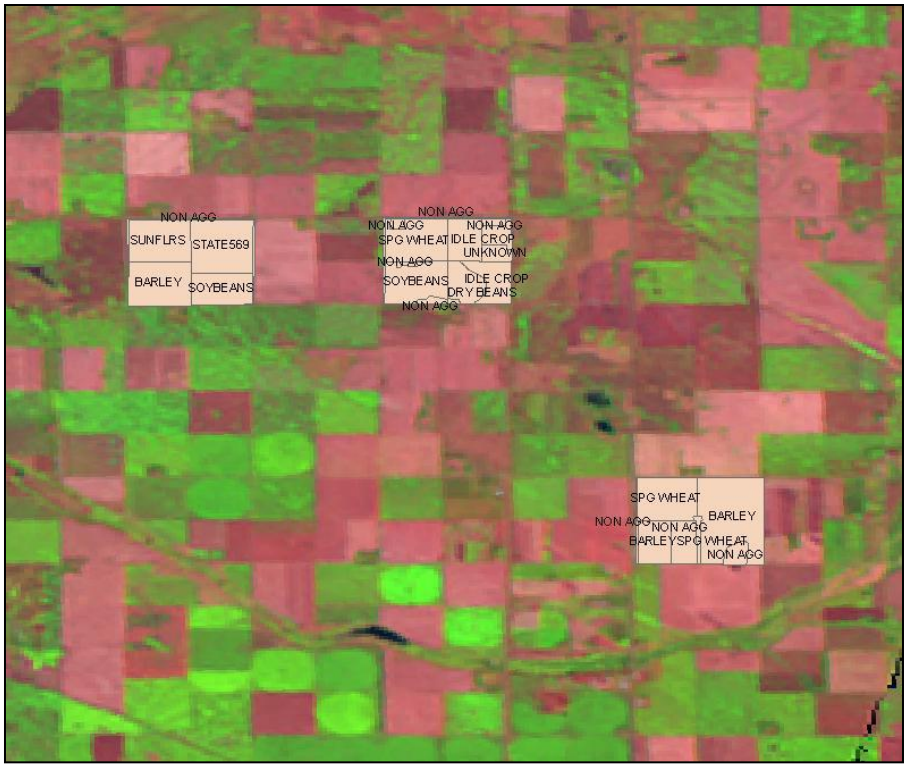
Ground truth - agriculture

Farm Service Agency (FSA)

- Common Land Unit (CLU)
- 578 reporting data

FSA



NASS

NASS June Agricultural Survey (JAS) data still used for acreage estimation

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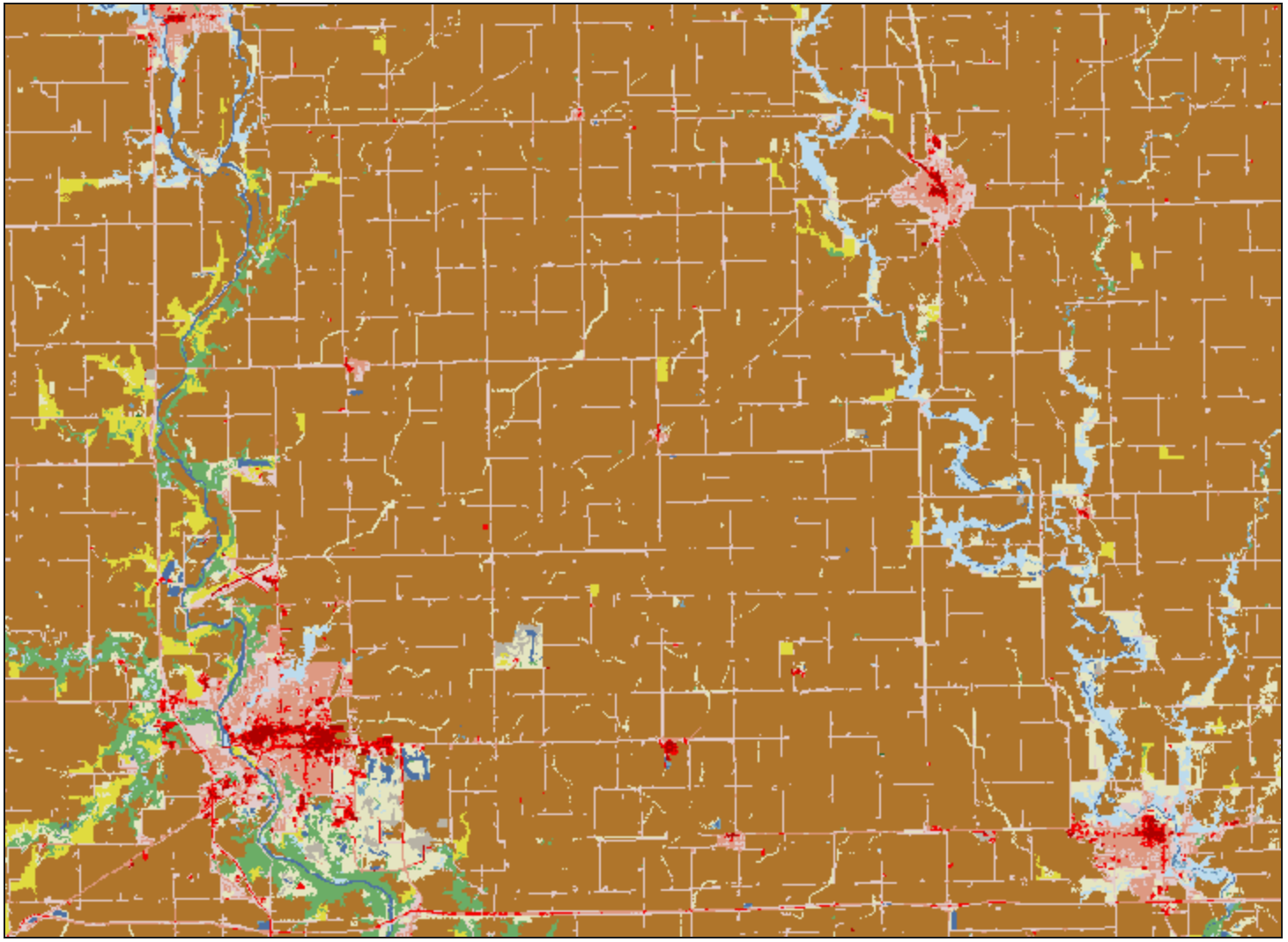
Ground truth – non agriculture



2001 National Land Cover Dataset

(brown = agriculture)

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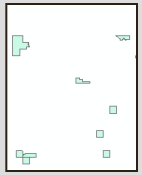
Classification Methodology

- Analyze areas by state
- “Stack” AWiFS, MODIS, and ancillary data layers within a raster GIS
  - 56 m grid cells, Albers Conic Equal Area projection
- Sample spatially from stack within known ground truth from FSA (for ag. categories) and NLCD (for non ag. categories)
- Data-mine samples using Boosted Classification Tree Analysis to derive best fitting decision rules
  - implemented with Rulequest See5.0
- Apply derived decision rules back to input data stack
- Create land cover map
- Create probability map
- Assess map accuracy
- Derive acreage estimates
  - utilizing customized SAS routines

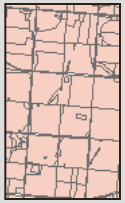
Cropland Data Layer and Acreage Estimation Processing Flow

Input Vector Data

NASS JAS segments



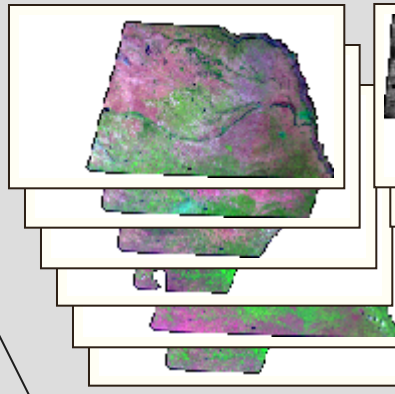
FSA CLU



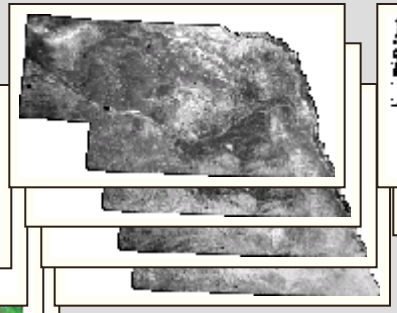
USGS NLCD

Input Raster Data

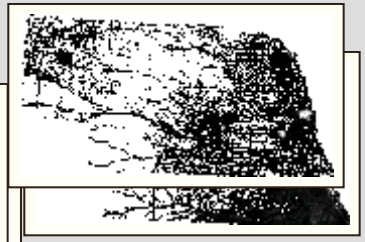
IRS Resourcesat-1 raw AWiFS summer time series



NASA Terra MODIS 16-day NDVI prior fall and summer time series



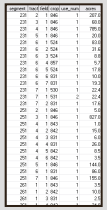
USGS NLCD circa 2001 Impervious & Canopy



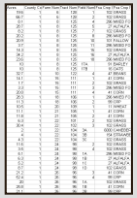
USGS NED Elevation

Tabular Data

JAS eData



FSA 578



Non-agricultural Ground truth

ESRI ArcGIS

Link and assess data sets

Agricultural Ground truth

ERDAS IMAGINE®

Manages and visualizes datasets

Rulequest See5.0

Derives decision tree-based classification rules

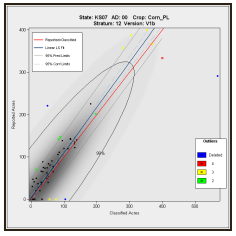
Generated rule set

ESRI ArcGIS

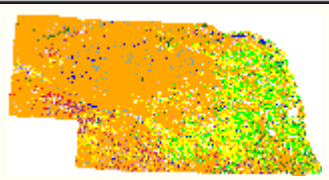
Extract JAS intersecting pixels

SAS

Customized for acreage estimation



Pixel count v. reported acreage



-- Cropland Data Layer --

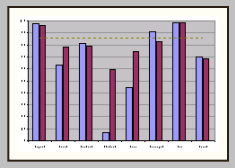
datagateway.nrcs.usda.gov

State and county crop acreage statistics

Internal to NASS only

Output

Confidence Layer



Accuracy Assessment

Diagnostics

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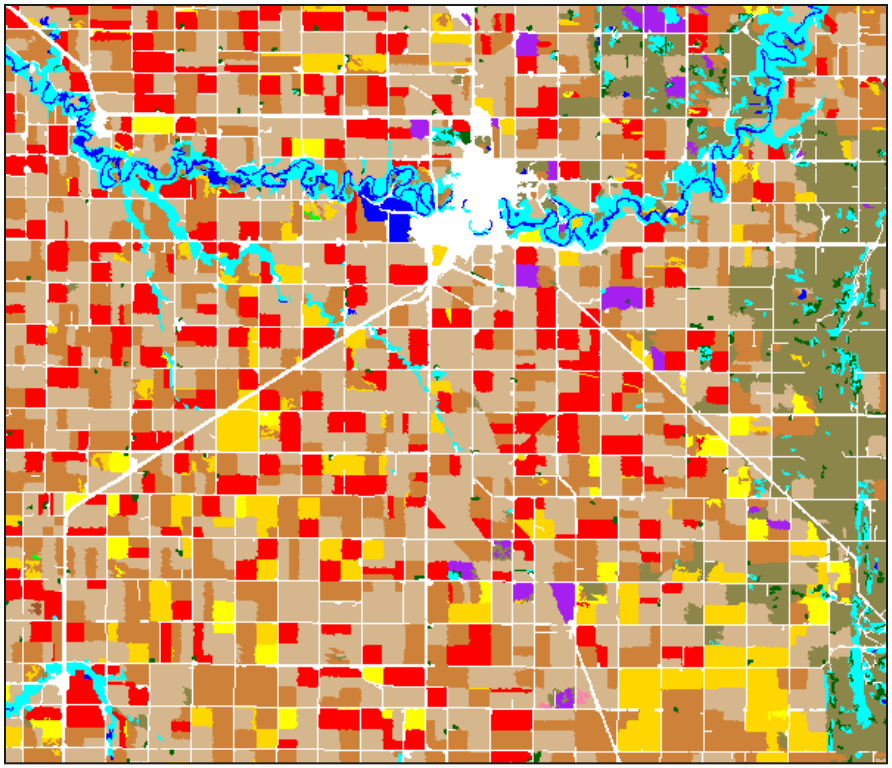
Example Classification Subset



CDL Classification

Resourcesat-1 AWiFS, 6 July 2007

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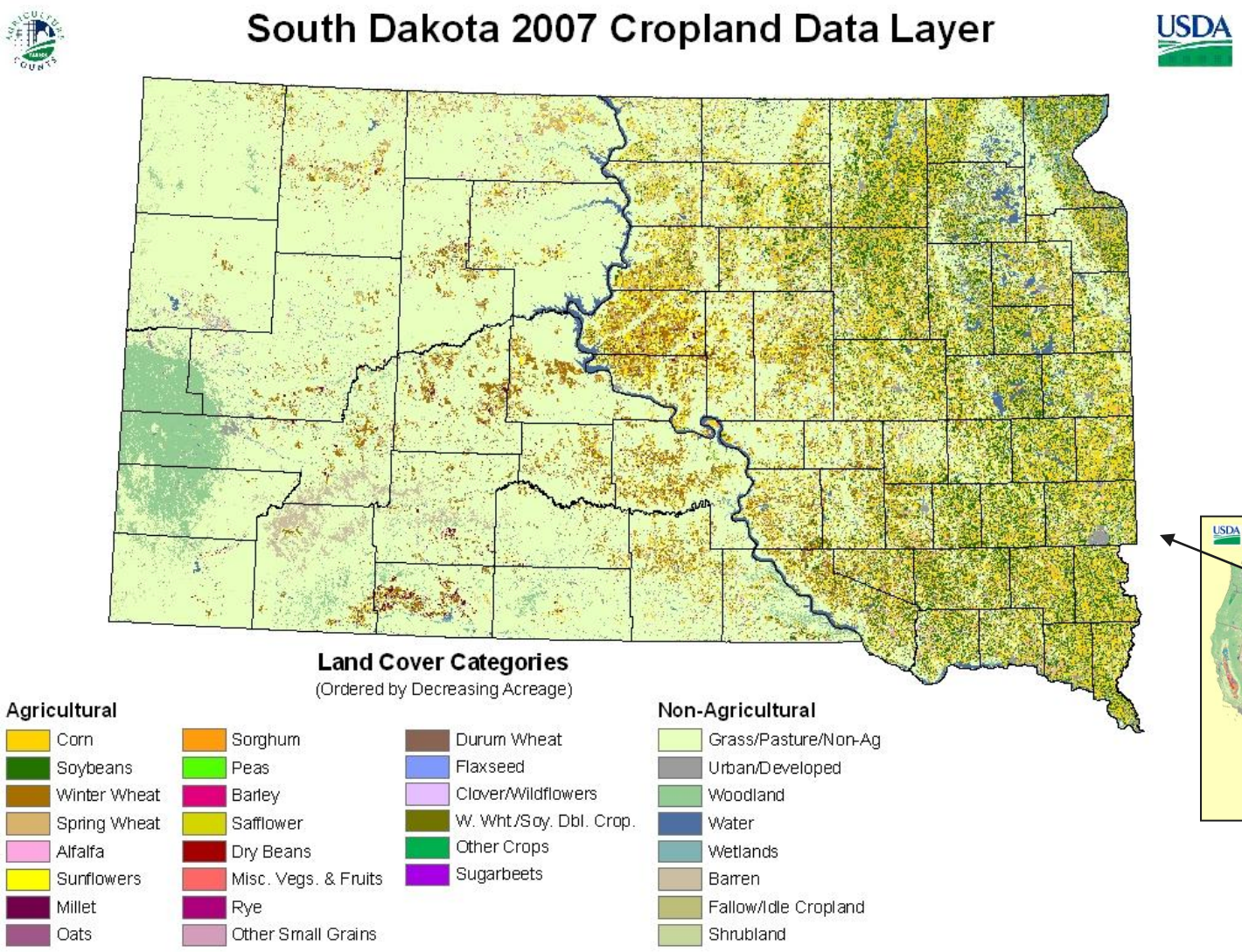
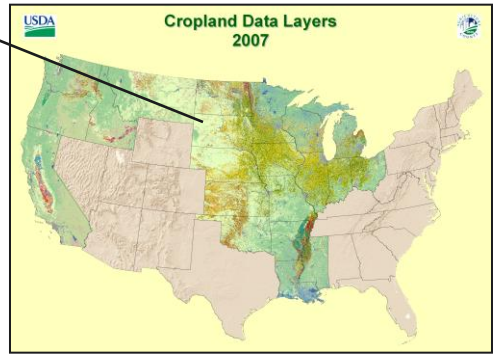
National Agricultural Statistics Service
Research and Development Division
Spatial Analysis Research Section

Example State CDL





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Research and Development Division
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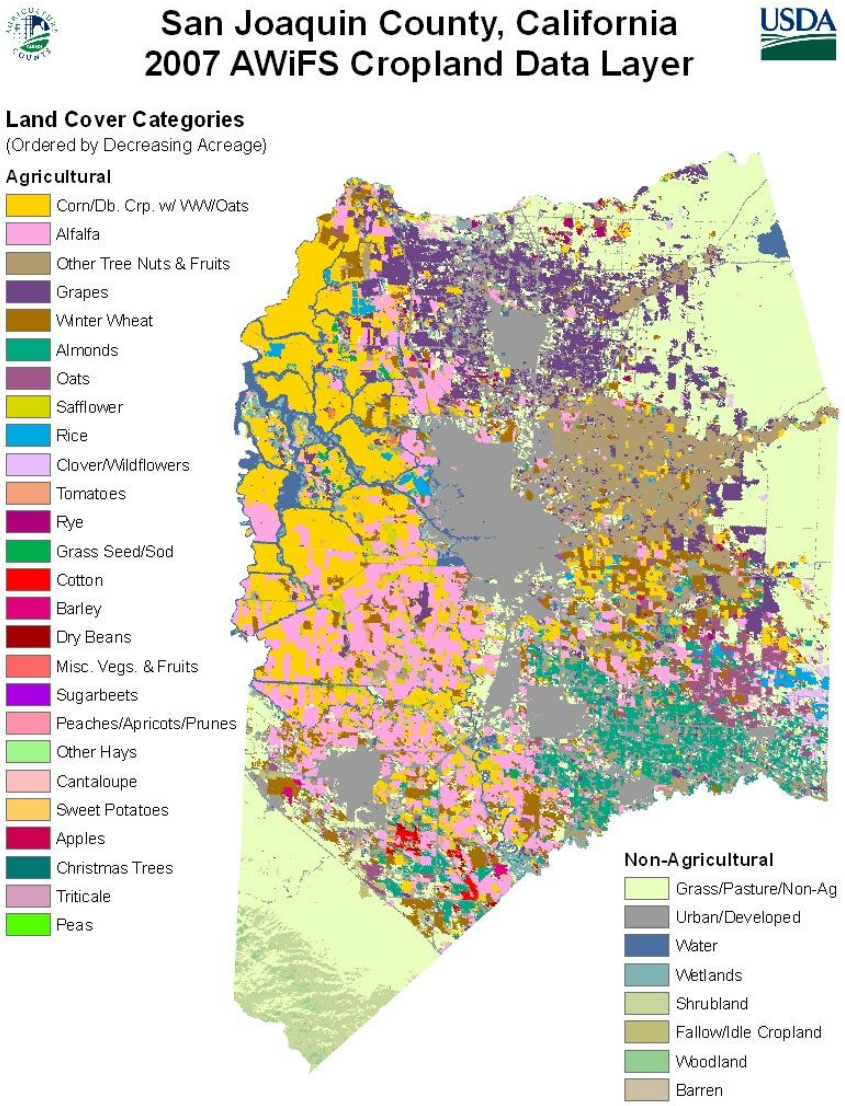
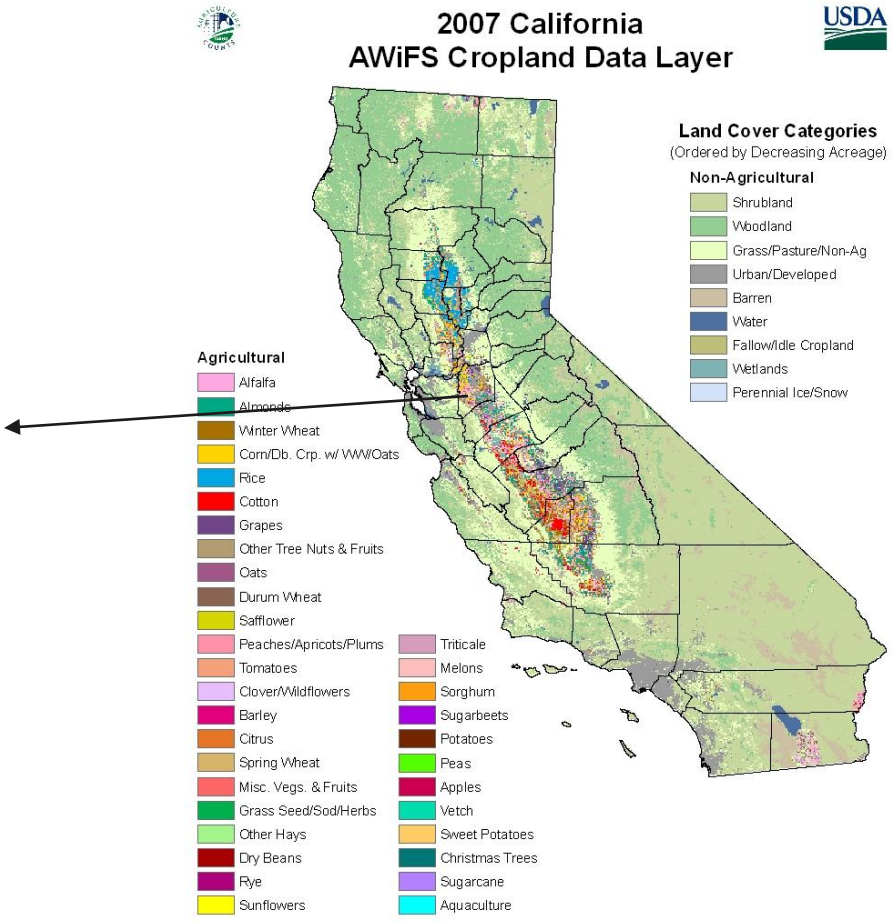
Example County CDL





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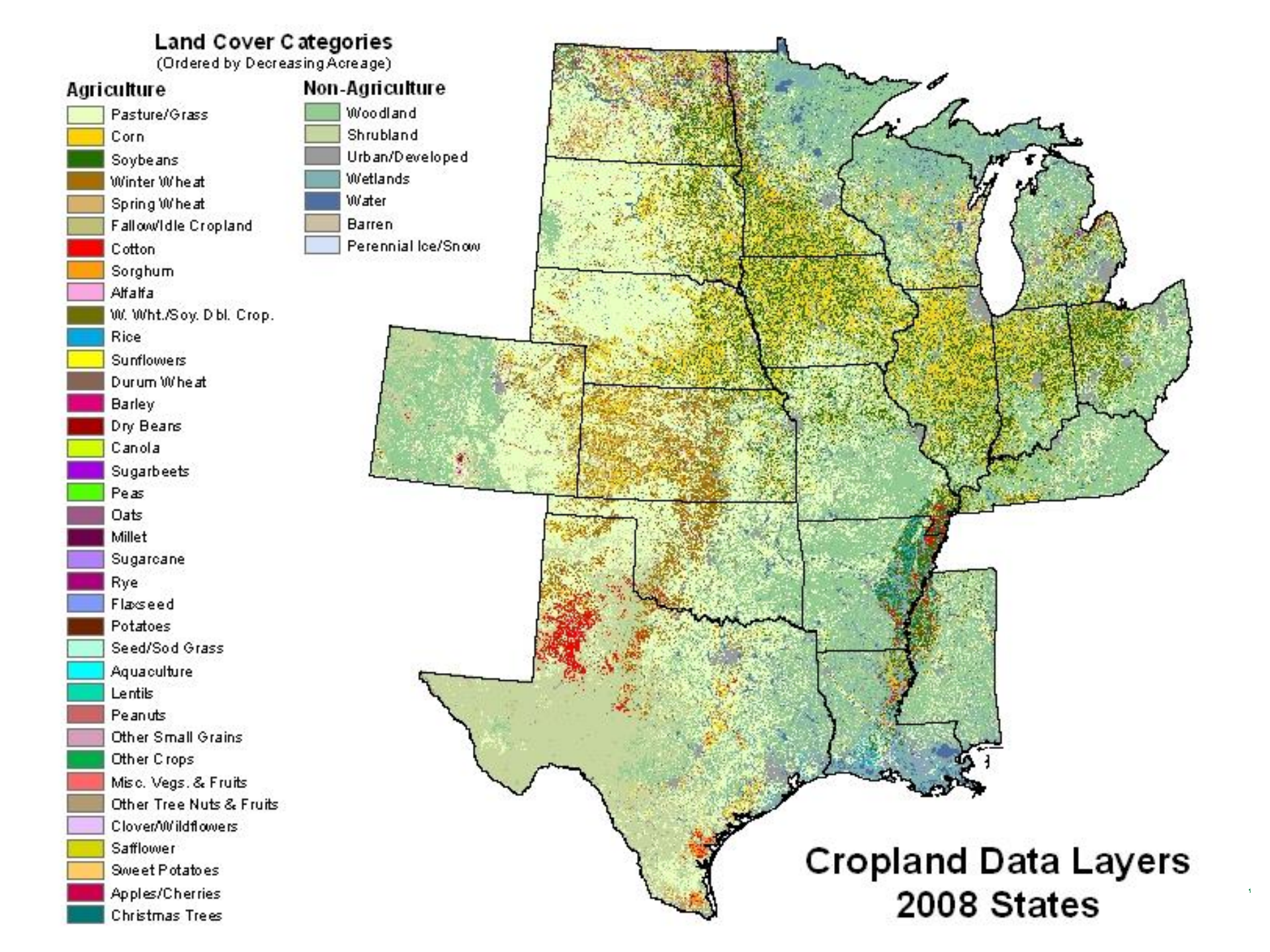
Land Cover Categories
(Ordered by Decreasing Acreage)
Agriculture
Pasture/Grass
Corn
Soybeans
Winter Wheat
Spring Wheat
Fallow/Idle Cropland
Cotton
Sorghum
Alfalfa
W. Wht./Soy. Dbl. Crop.
Rice
Sunflowers
Durum Wheat
Barley
Dry Beans
Canola
Sugarbeets
Peas
Oats
Millet
Sugarcane
Rye
Flaxseed
Potatoes
Seed/Sod Grass
Aquaculture
Lentils
Peanuts
Other Small Grains
Other Crops
Misc. Vegs. & Fruits
Other Tree Nuts & Fruits
Clover/Wildflowers
Safflower
Sweet Potatoes
Apples/Cherries
Christmas Trees
Non-Agriculture
Woodland
Shrubland
Urban/Developed
Wetlands
Water
Barren
Perennial Ice/Snow
Cropland Data Layers
2008 States

2008 CDL Coverage

Commodity	CDL States	US Total Acres (mill)	% US Total
Corn	18	78,177	92
Soybeans	18	74,374	91
Rice	5	2,924	82
Wheat	13	40,252	70
Cotton	4	7,755	66
Potatoes	11	1,058	34

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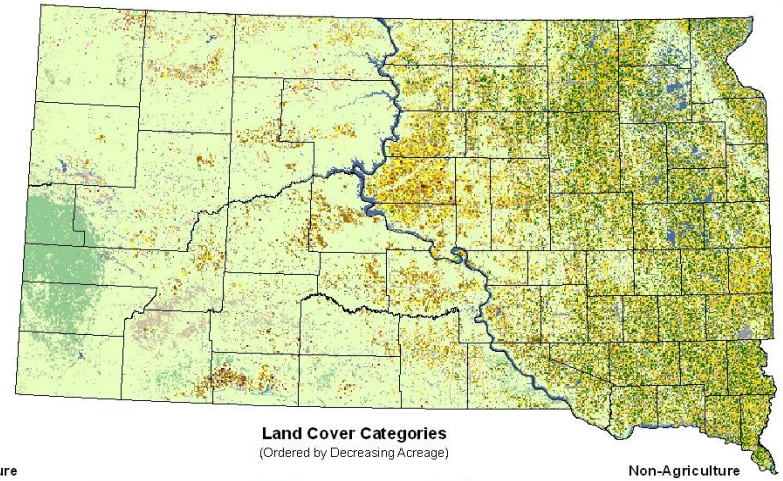
South Dakota 2008 Cropland Data Layer



Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Pasture/Grass
- Corn
- Soybeans
- Winter Wheat
- Spring Wheat
- Alfalfa
- Sunflowers
- Fallow/Idle Cropland
- Millet
- Sorghum
- Oats
- Barley
- Peas
- Safflower
- Dry Beans
- Durum Wheat
- Other Crops
- Seed/Sod Grass
- Other Small Grains
- Rye
- Flaxseed
- Lentils
- Clover/Wildflowers
- Sugarbeets
- W. Wht./Soy. Dbl. Crop.

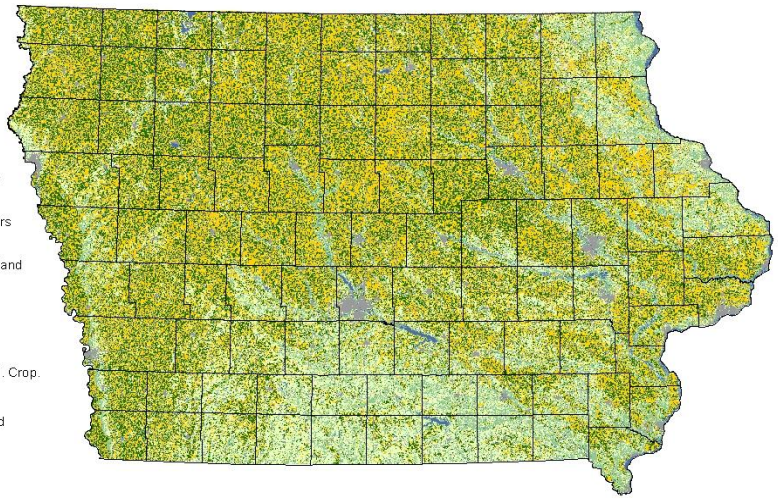
Non-Agriculture
- Woodland
- Urban/Developed
- Water
- Wetlands
- Barren
- Shrubland

Iowa 2008 Cropland Data Layer

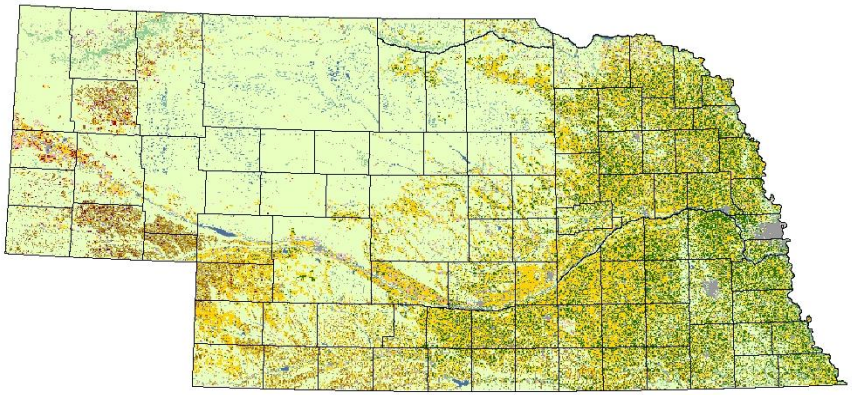
Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Corn
- Soybeans
- Pasture/Grass
- Alfalfa
- Oats
- Winter Wheat
- Spring Wheat
- Seed/Sod Grass
- Barley
- Clover/Wildflowers
- Other Crops
- Fallow/Idle Cropland
- Durum Wheat
- Sorghum
- Rye
- Dry Beans
- W. Wht./Soy. Dbl. Crop.

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



Nebraska 2008 Cropland Data Layer



Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Pasture/Grass
- Corn
- Soybeans
- Winter Wheat
- Fallow/Idle Cropland
- Alfalfa
- Sorghum
- Millet
- Dry Beans
- Oats
- Sunflowers
- Sugarbeets
- Potatoes
- Rye
- Spring Wheat
- Other Small Grains
- W. Wht./Soy. Dbl. Crop.
- Seed/Sod Grass
- Other Crops
- Barley
- Canola

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

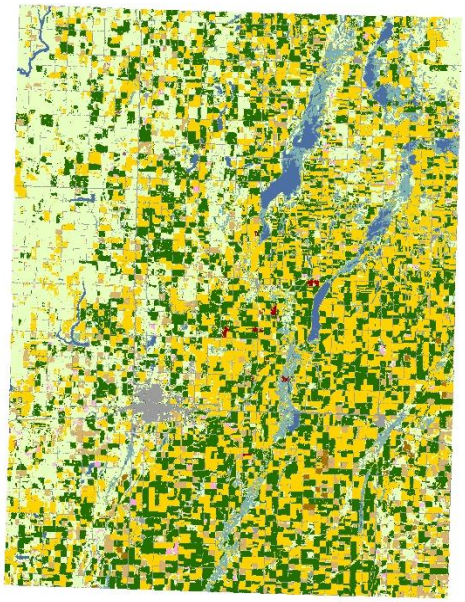
2008 Illinois Cropland Data Layer

Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Corn
- Soybeans
- Pasture/Grass
- W. Wht./Soy. Dbl. Crop.
- Winter Wheat
- Fallow/Idle Cropland
- Alfalfa
- Sorghum
- Misc. Vegs. & Fruits
- Seed/Sod Grass
- Dry Beans
- Other Crops
- Oats
- Clover/Wildflowers
- Potatoes
- Rice
- Sunflowers
- Rye
- Other Small Grains
- Peas

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

Brown County, South Dakota
2008 Cropland Data Layer

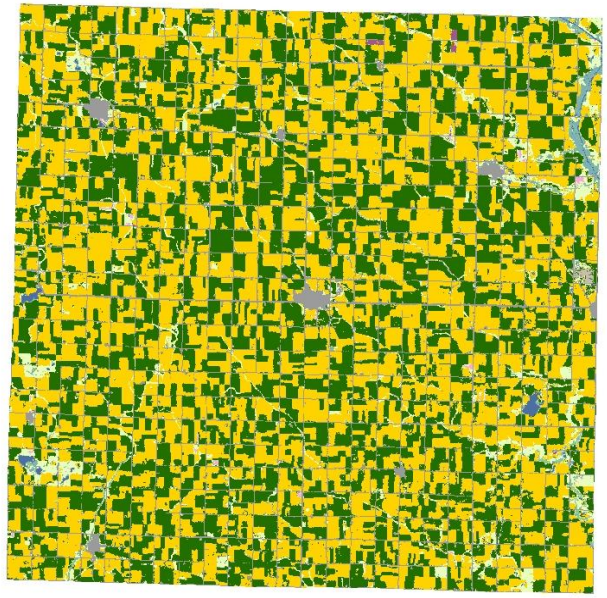


Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Corn
- Soybeans
- Spring Wheat
- Alfalfa
- Winter Wheat
- Dry Beans
- Sunflowers
- Oats
- Millet
- Sorghum
- Barley
- Rye
- Other Crops

Non-Agriculture
- Grass/Pasture/Non-Ag
- Urban/Developed
- Wetlands
- Water
- Woodland
- Fallow/Idle Cropland
- Barren
- Shrubland

Pocahontas County, Iowa
2008 Cropland Data Layer

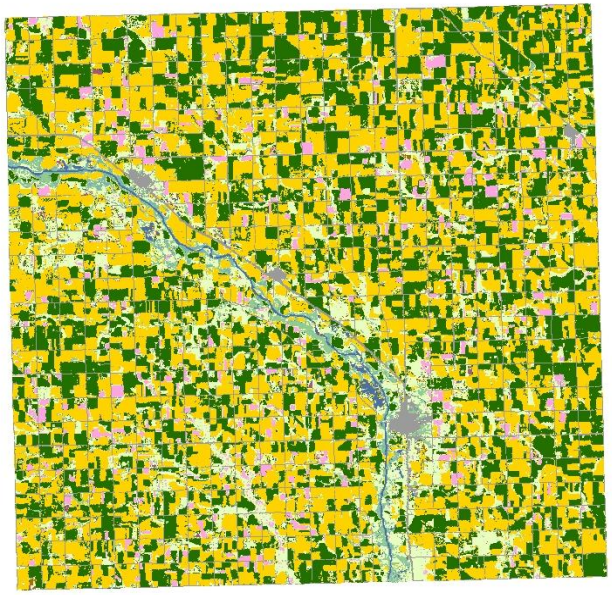


Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Corn
- Soybeans
- Pasture/Grass
- Alfalfa
- Oats
- Winter Wheat
- Spring Wheat
- Clover/Wildflowers

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

Cuming County, Nebraska
2008 Cropland Data Layer



Land Cover Categories
(Ordered By Decreasing Acreage)

Agriculture
- Corn
- Soybeans
- Pasture/Grass
- Alfalfa
- Oats
- Winter Wheat
- Fallow/Idle Cropland
- Sorghum
- Rye
- W. Wht./Soy. Dbl. Crop.
- Seed/Sod Grass

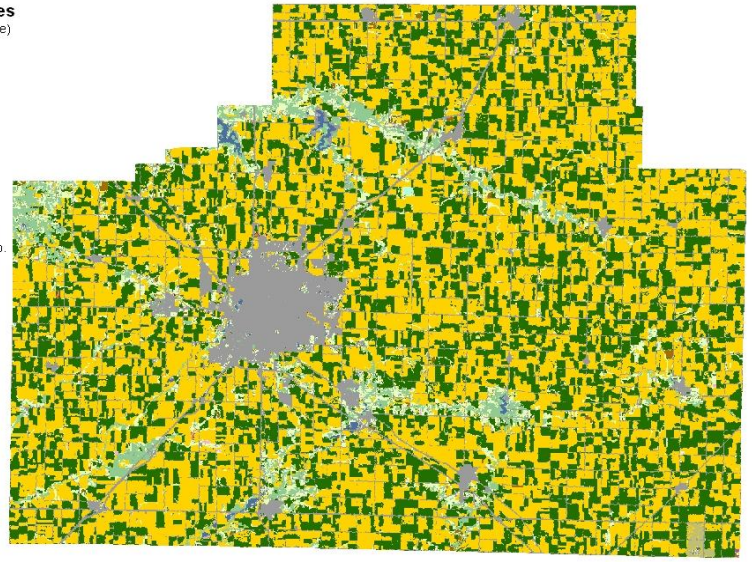
Non-Agriculture
- Urban/Developed
- Woodland
- Wetlands
- Water
- Barren
- Shrubland

McLean County, Illinois
2008 Cropland Data Layer

Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Corn
- Soybeans
- Pasture/Grass
- Winter Wheat
- Fallow/Idle Cropland
- Alfalfa
- Misc. Vegs. & Fruits
- Seed/Sod Grass
- W. Wht./Soy. Dbl. Crop.
- Oats
- Dry Beans
- Sorghum
- Clover/Wildflowers
- Sunflowers
- Rye
- Other Crops
- Peas

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



Accuracy Assessments

	Cover Type	Attribute Code	*Correct Pixels	Producer's Accuracy	Omission Error	Kappa	User's Accuracy	Commission Error	Cond'l Kappa
IA	Corn	1	2197719	96.58%	3.42%	0.9226	97.86%	2.14%	0.9509
	Soybeans	5	1471094	96.24%	3.76%	0.9392	95.78%	4.22%	0.9320
IL	Corn	1	2258219	98.06%	1.94%	0.9527	98.58%	1.42%	0.9650
	Soybeans	5	1339089	96.36%	3.64%	0.9438	97.96%	2.04%	0.9681
NE	Corn	1	1856422	97.29%	2.71%	0.9605	97.32%	2.68%	0.9608
	Soybeans	5	849249	95.83%	4.17%	0.9513	96.95%	3.05%	0.9643
SD	Corn	1	803251	94.29%	5.71%	0.9342	95.78%	4.22%	0.9513
	Soybeans	5	707383	95.03%	4.97%	0.9439	97.72%	2.28%	0.9741

	Crop-specific covers only	*Correct	Accuracy	Error	Kappa
IA	OVERALL ACCURACY	3688803	95.74%	4.26%	0.9145
IL	OVERALL ACCURACY	3730093	97.05%	2.95%	0.9426
NE	OVERALL ACCURACY	3071960	94.05%	5.95%	0.8981
SD	OVERALL ACCURACY	2306428	87.51%	12.49%	0.8416

Producer's Accuracy: relates to the probability that a ground truth pixel will be correctly mapped and measures errors of omission.

Errors of Omissions: 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.

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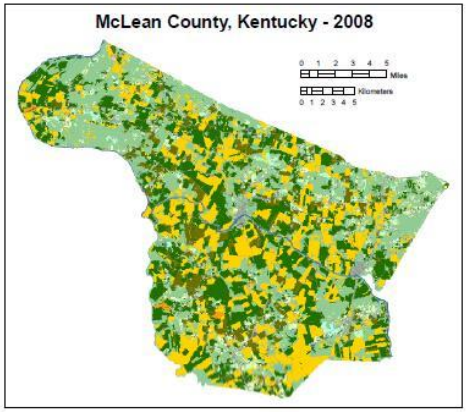
2008 Kentucky Cropland Data Layer



0 5 10 20 30 40 50
Miles
Kilometers
0 5 10 20 30 40 50

Data Source:
Resourcesat-1 AWiFS courtesy of USDA Foreign Agricultural Service.

Image Processing:
Rulequest See5 and ERDAS Imagine.

Ground Truth:
The Farm Service Agency Common Land Unit for crops classes, and 2001 National Land Cover Dataset (NLCD) for non-agricultural classes.

Ancillary Data: NLCD Impervious Surface, NLCD Forest Canopy, National Elevation Dataset, and Moderate Resolution Imagery Spectroradiometer (MODIS) 16 day Normalized Difference Vegetation Index (NDVI) composite.

Projection: UTM zone 16, WGS84 datum.

Map Production: ArcGIS 9.2.

Land Cover Categories

(Ordered by Decreasing Acreage)

Agriculture

- Pasture/Grass
- Corn
- Soybeans
- Winter Wheat
- Fallow/Idle Cropland
- Alfalfa
- Sorghum
- Millet
- Dry Beans
- Oats
- Sunflowers
- Sugarbeets
- Potatoes
- Rye
- Spring Wheat
- Other Small Grains
- W. Wht./Soy. Dbl. Crop.
- Seed/Sod Grass
- Other Crops
- Barley
- Canola

Non-Agriculture

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

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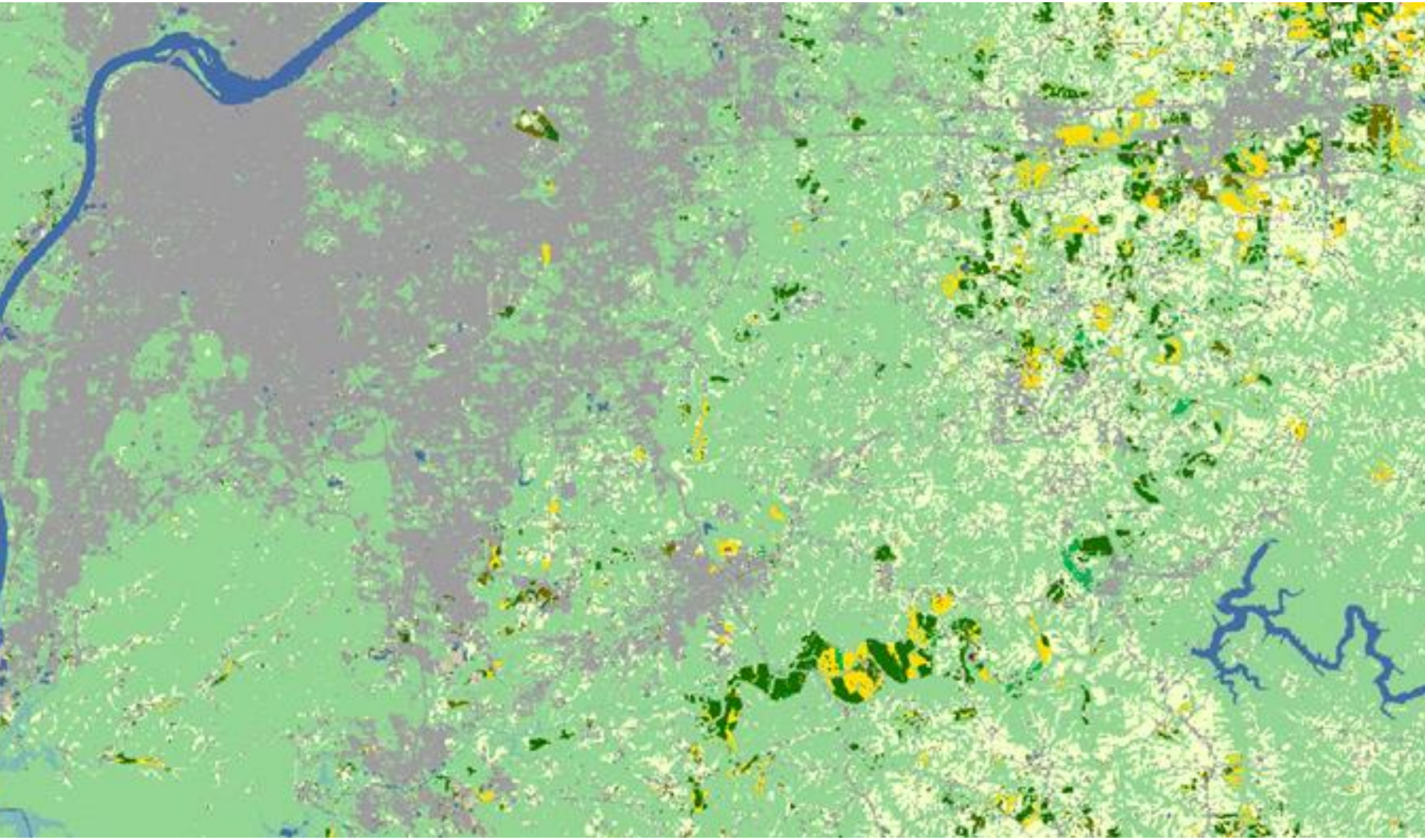
Louisville Area



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Kentucky CDL Accuracy

USDA, National Agricultural Statistics Service, 2008 Kentucky Cropland Data Layer
STATEWIDE AGRICULTURAL ACCURACY REPORT

Crop-specific covers only	*Correct	Accuracy	Error	Kappa
OVERALL ACCURACY	383666	89.82%	10.18%	0.8638

Cover Type	Attribute Code	*Correct Pixels	Producer's Accuracy	Omission Error	Kappa	User's Accuracy	Commission Error	Cond'l Kappa
Corn	1	141976	95.43%	4.57%	0.9472	95.21%	4.79%	0.9448
Sorghum	4	651	38.82%	61.18%	0.3878	97.02%	2.98%	0.9701
Soybeans	5	107429	92.28%	7.72%	0.9137	91.51%	8.49%	0.9052
Sunflowers	6	0	0.00%	100.00%	0.0000	n/a	n/a	n/a
Tobbaco	11	8	3.29%	96.71%	0.0329	21.62%	78.38%	0.2160
Pop or Orn Corn	13	379	49.54%	50.46%	0.4952	95.47%	4.53%	0.9546
Winter wheat	24	442	16.03%	83.97%	0.1598	73.54%	26.46%	0.7348
WW / Soybeans	26	55664	95.44%	4.56%	0.9518	89.76%	10.24%	0.8920
Rye	27	6	8.70%	91.30%	0.0870	85.71%	14.29%	0.8571
Oats	28	10	9.90%	90.10%	0.0990	66.67%	33.33%	0.6666
Millet	29	0	0.00%	100.00%	0.0000	n/a	n/a	n/a
Alfalfa	36	945	23.80%	76.20%	0.2371	72.64%	27.36%	0.7254
Other crops	44	1	4.55%	95.45%	0.0454	12.50%	87.50%	0.1250
Misc. vegetables	47	0	0.00%	100.00%	0.0000	n/a	n/a	n/a
Clover / Wildflowers	58	5	1.93%	98.07%	0.0193	62.50%	37.50%	0.6249
Seed/Sod Grass	59	177	16.36%	83.64%	0.1634	71.37%	28.63%	0.7134
Idle / Fallow	61	9	4.84%	95.16%	0.0484	69.23%	30.77%	0.6923
Peaches	67	0	0.00%	100.00%	0.0000	n/a	n/a	n/a
Apples	68	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Other tree nuts	71	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Aquaculture	92	0	0.00%	100.00%	0.0000	n/a	n/a	n/a

*Correct Pixels represents the total number of independent validation pixels correctly identifed in the error matrix.

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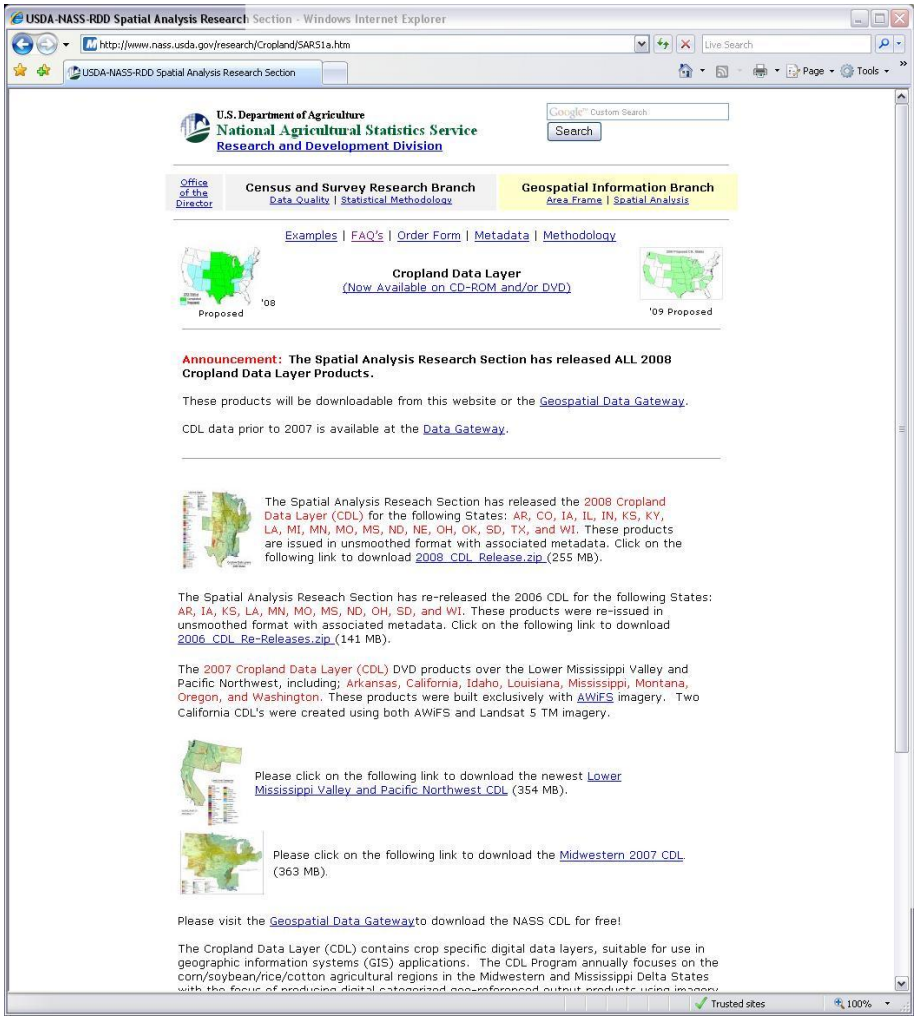
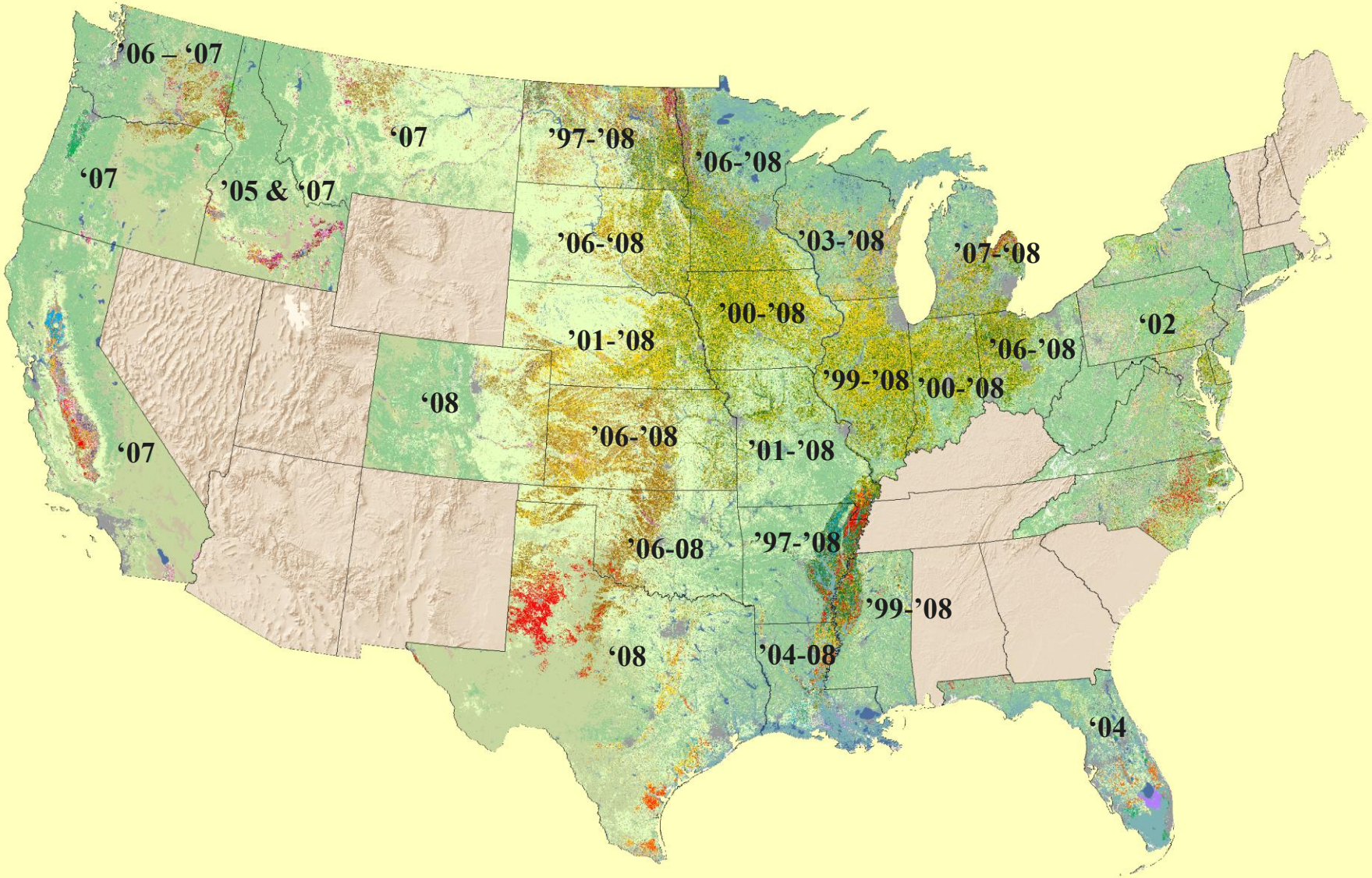
Obtaining Kentucky 2008 CDL

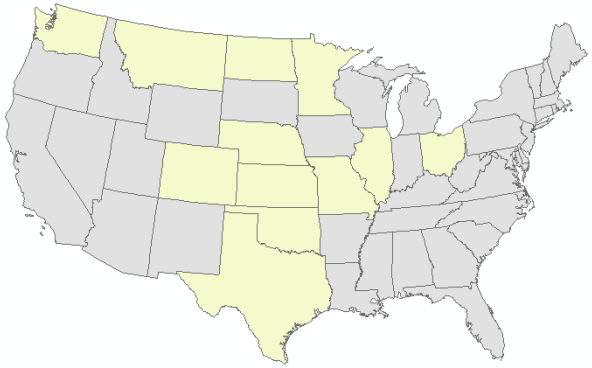


http://www.nass.usda.gov/research/Cropland/SARS1a.htm

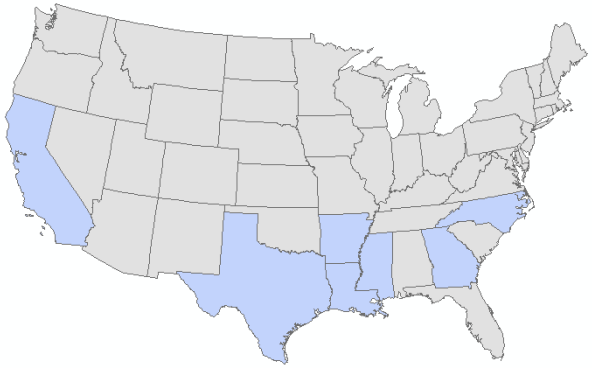
Cropland Data Layers
1997 - 2008



Future CDLs, 2009 and beyond….



Primary Wheat States



Primary Cotton States

- Expand geographic scope?
  - Wheat states next priority
  - Mid-Atlantic region (often asked about)
  - “Manifest Destiny”
- Improved categories?
  - Grassland
    - Pasture (chewed grass)
    - Hay (cut grass)
    - Natural (quasi-native)
- Imagery?
  - More frugal use of
  - Future sensors
  - Finer resolution
- Other ancillary data?
  - Soils
  - Climate
- Derivatives?
  - Change detection
  - Crop rotation patterns

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Thank You

dave_johnson@nass.usda.gov
703-877-8000 x169

www.nass.usda.gov
www.nass.usda.gov/research/Cropland/SARS1a.htm
datagateway.nrcs.usda.gov