Patrick Willis
Federal Contractor

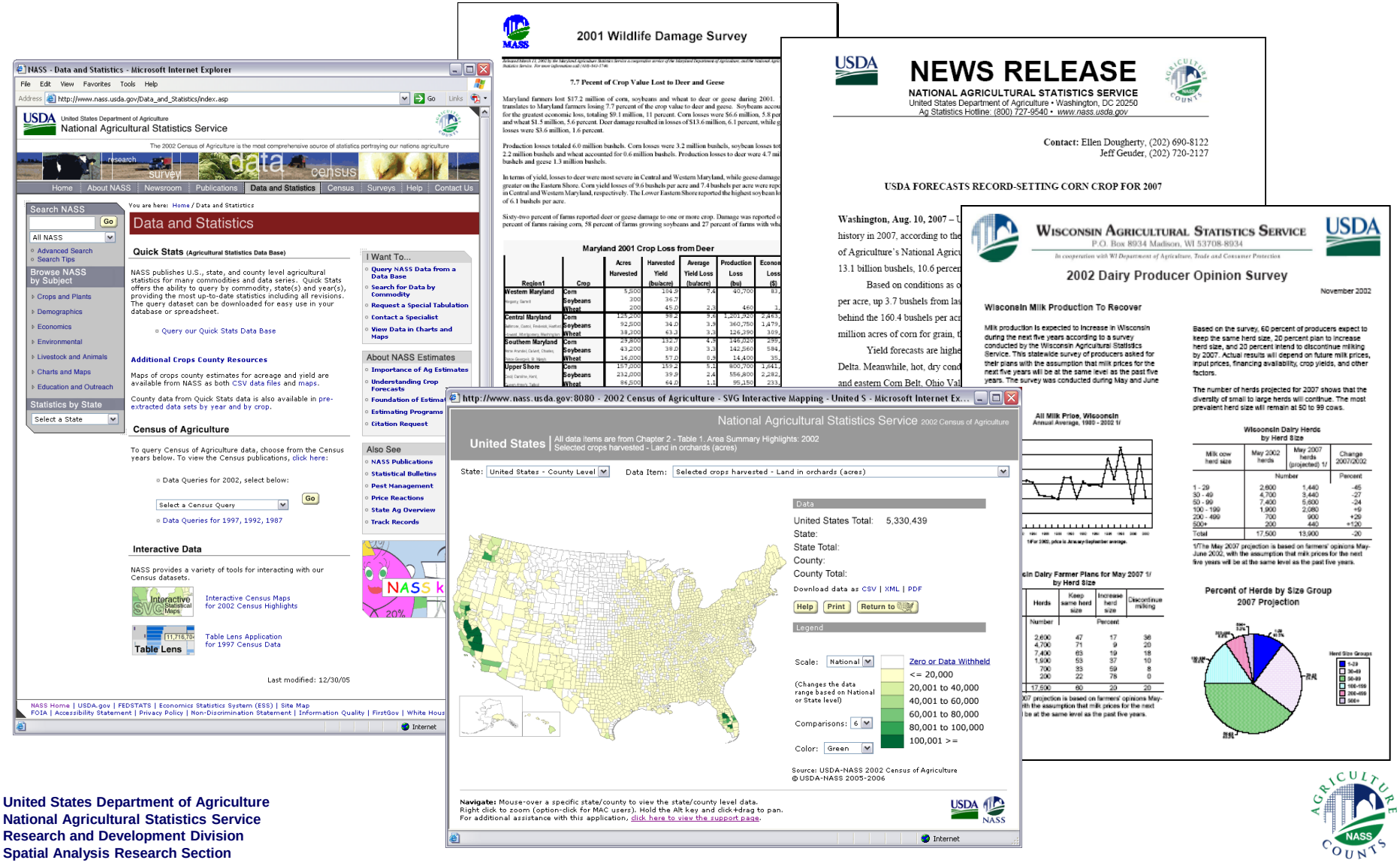
United States Department of Agriculture (USDA)
National Agricultural Statistics Service (NASS)
Research and Development Division (RDD)
Spatial Analysis Research Section (SARS)

Illinois Land Cover Mapping:
The USDA-NASS Cropland Data Layer

ILGISA Spring Conference – Champaign, 2009

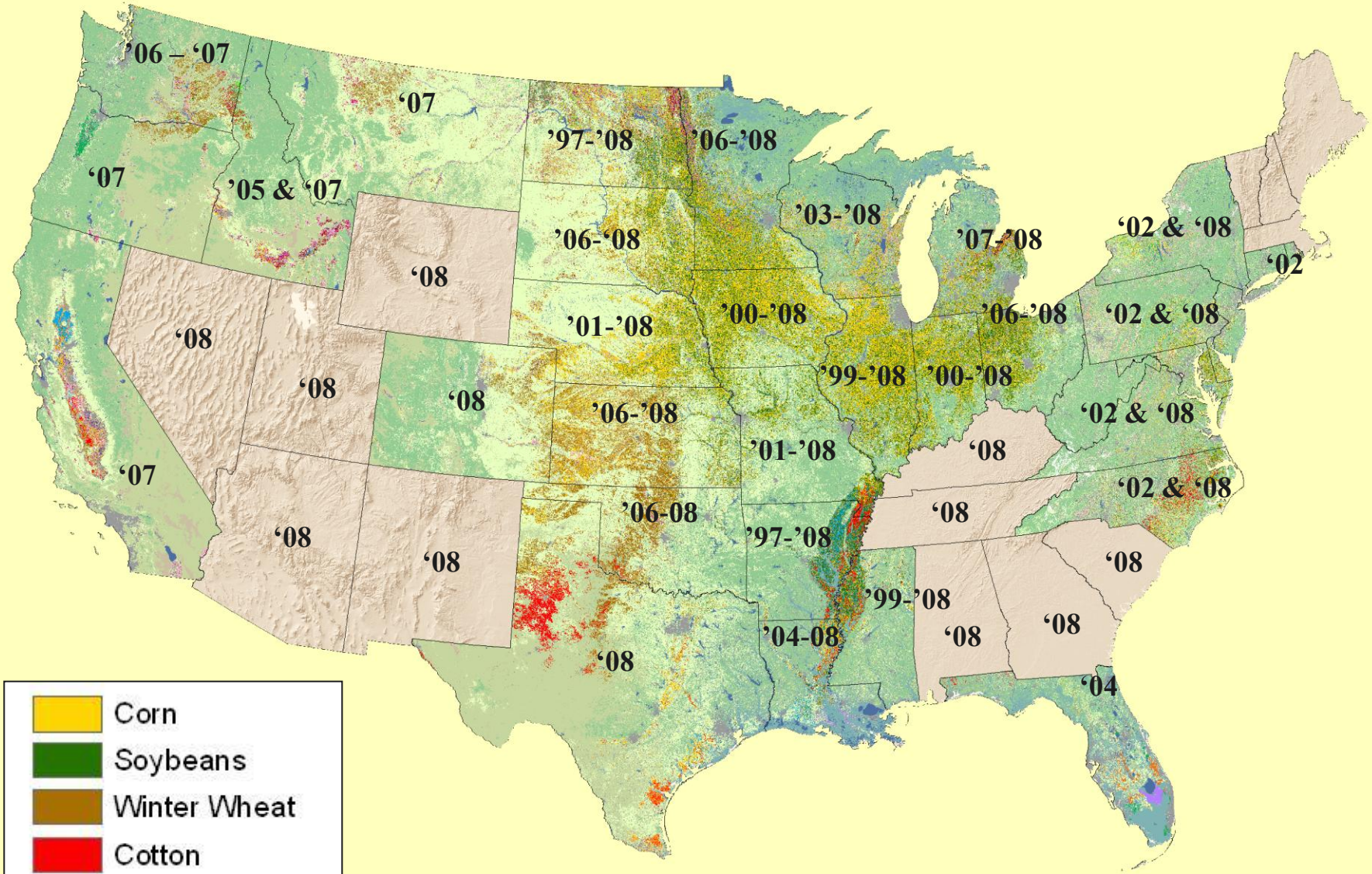
NASS Overview

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



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

Cropland Data Layers
1997 - 2008



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

Purpose of the Cropland Data Layer (CDL) Program

- "Census by Satellite"
  - Without area duplication
  - Major corn and soybean regions
- Provide timely, accurate, useful independent estimates
  - Measurable error
  - County and state level
- Output crop specific Cropland Data Layer
  - Distribute free to public
  - Publish accuracy statistics & metadata
  - County and state level

History of the Illinois CDL Program

- Began in 1999 as a interagency collaboration

  The Illinois Interagency Landscape Classification (IILC) Project

  – National Agricultural Statistics Service (NASS)
    - Provide supplemental acreage estimates for the state's major commodities.

  – Illinois Department of Natural Resources (IDNR)
    - On a recurring basis, update the Land Cover of Illinois statewide inventory published by IDNR in 1996.

  – Illinois Department of Agriculture (IDA)
    - Locate, quantify, and track changes in various land classes within the State of Illinois.

Current Data Partnerships

- Foreign Ag Service
  - Satellite Image Archive

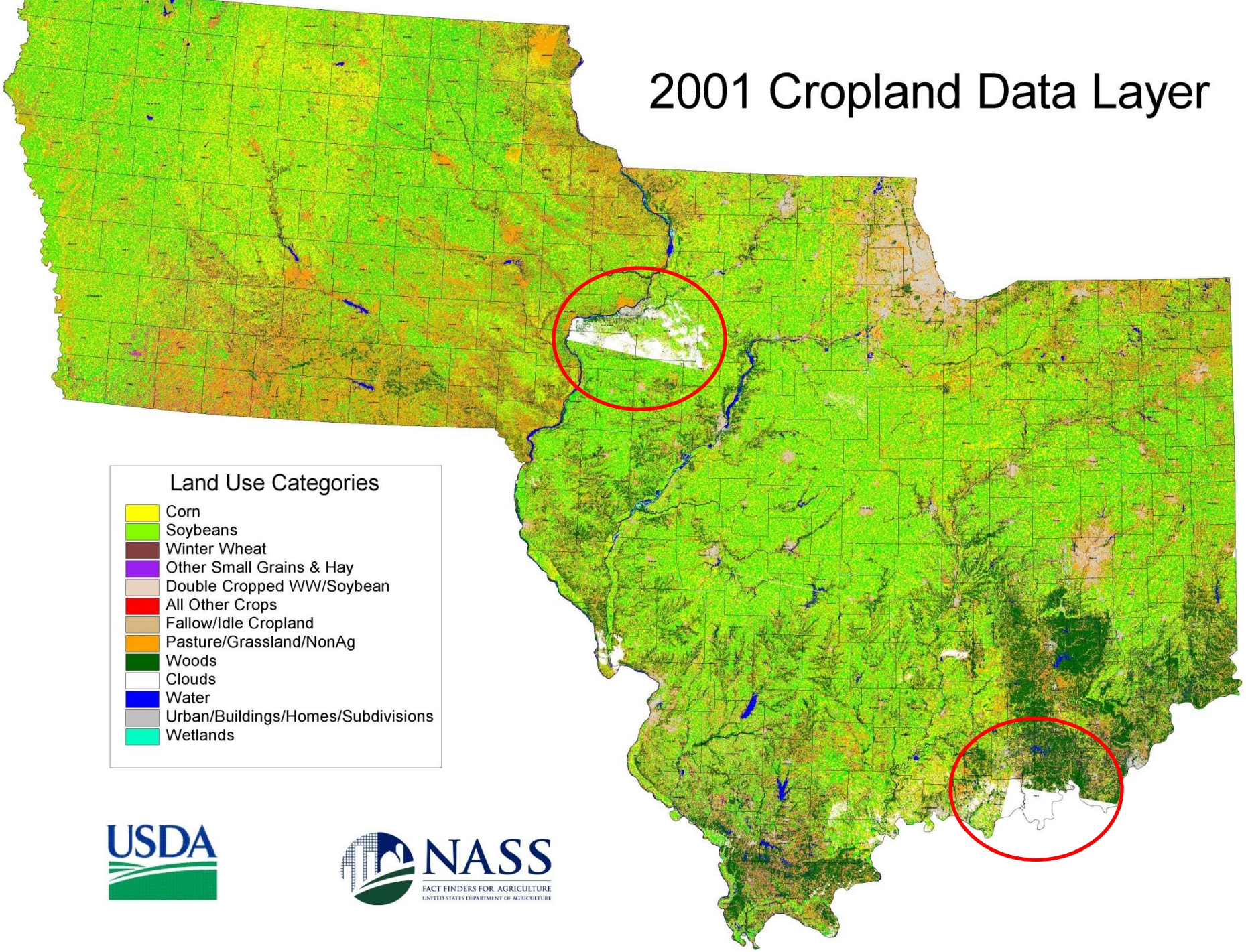
- Farm Service Agency
  - Common Land Unit

- USGS/MRLC
  - National Land Cover Dataset

Inputs & Methodology 1999 - 2005

- 30 meter ground resolution (Landsat Sensor)
  - 16 day revisit (cloud & coverage issues)
- Agricultural ground truth (June Area Survey)
  - Data preparation was very time and labor intensive
- In-house software (Peditor)
  - Legacy software with inherited technical limitations
  - Not user friendly

2001 Cropland Data Layer



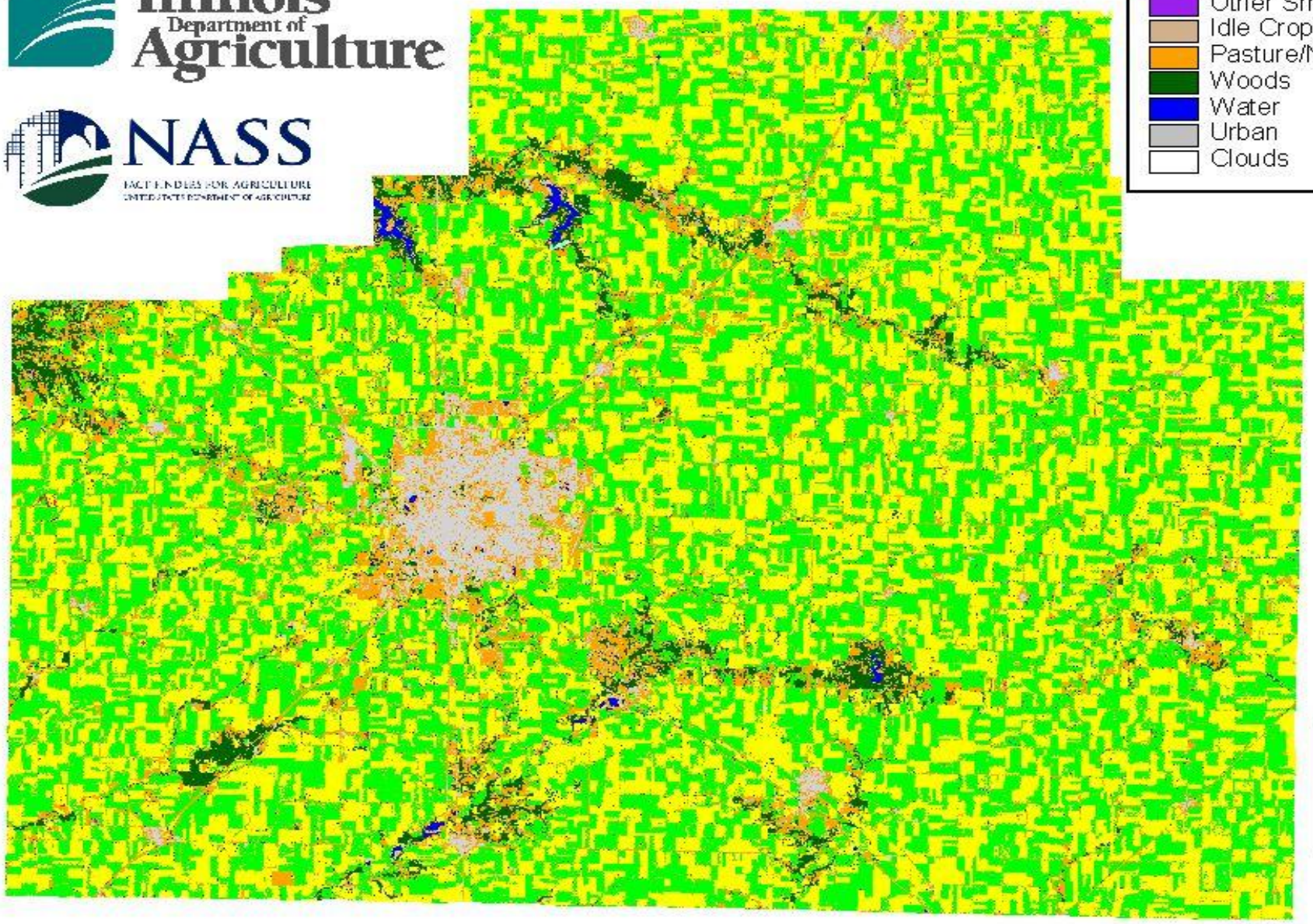
USDA

NASS
FACT FINDERS FOR AGRICULTURE
UNITED STATES DEPARTMENT OF AGRICULTURE

2001 McLean County, Illinois
Categorized Image

Illinois Department of Agriculture

NASS
FACT FINDERS FOR AGRICULTURE
UNITED STATES DEPARTMENT OF AGRICULTURE



ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES

New Inputs & Methodology 2006 - Current

- New satellite senor (AWiFS)
  - 56 meter
  - 5 day revisit

- New ground truth
  - Ag: USDA, Farm Service Agency, Common Land Unit
  - Nonag: USGS, 2001 National Land Cover Dataset

- New commercial software suite
  - Switched from a Maximum Likelihood Classifier to a Decision-Tree Classifier

The Landsat Data Gap

Landsat 7 ETM+

Landsat 5 TM

USGS
science for a changing world

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:
http://landsat.usgs.gov/slc_enhancements/slc_off_level1_standard.php

New Satellite Sensor

	1999 - 2005	2006 - Current
	TM	**AWiFS**
Altitude	705 km	817 km
Equatorial crossing time	9:45 ± 15 minutes	10:30 ± 5 minutes
Temporal Resolution	16 days	5 days
Spatial Resolution	30 x 30 m (reflective) 120 x 120 m (thermal)	56 x 56 m
Radiometric Resolution	8 bit (256)	10 bit (1024)
Spectral Resolution	6 (B, G, R, NIR, SWIR, MIR) + Thermal IR	4 (G, R, NIR,SWIR)
Swath wide	185 km	737 km
Scene size	184 x 152 km	370 x 370 km

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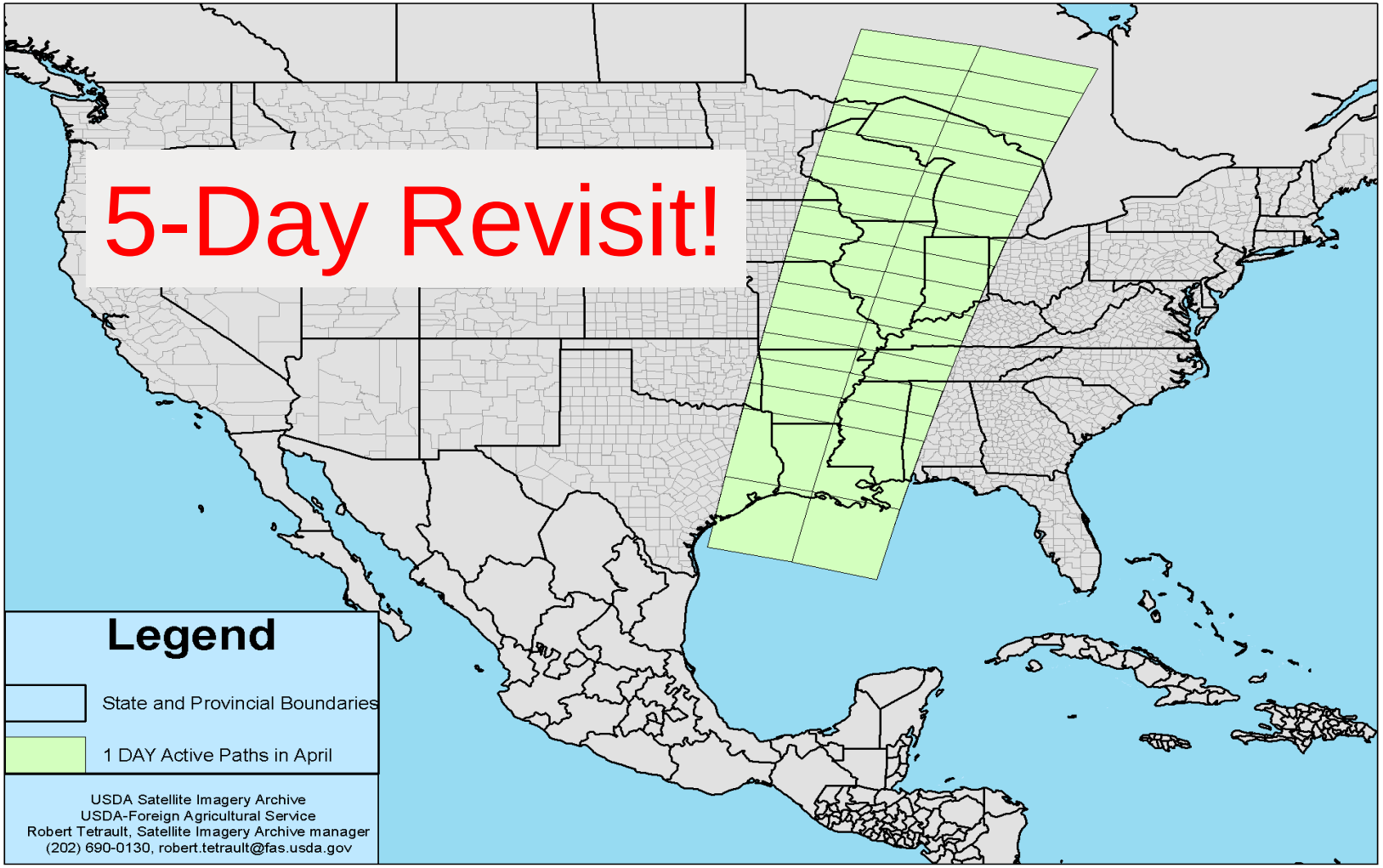
National Agricultural Statistics Service
Research and Development Division
Spatial Analysis Research Section

USDA Satellite Image Archive

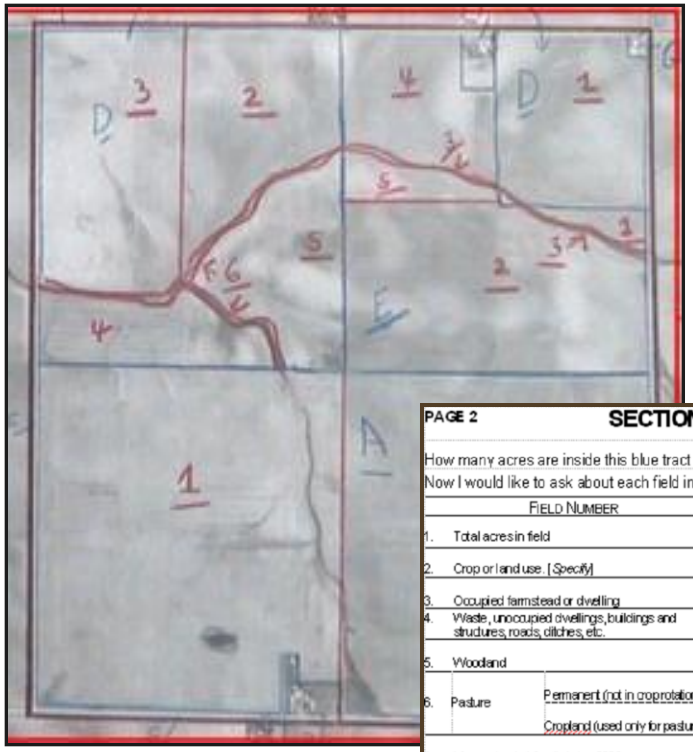
Active Paths for P6-AWiFS CONUS



New Ground Truth

- Agricultural Training & Validation
  - Farm Service Agency (FSA) Common Land Unit (CLU) Program
    - ½ used for training
    - ½ used for validation
- Non-Agricultural Training & Validation
  - USGS National Land Cover Dataset (NLCD) 2001
    - Sampled proportionate to the amount of agricultural training data

Old Ground Truth



June Agricultural Survey (JAS) – National in Scope

- 41,000 farms visited, 11,000 one-square mile sample area segments
- Illinois ~ 400 segments statewide

PAGE 2

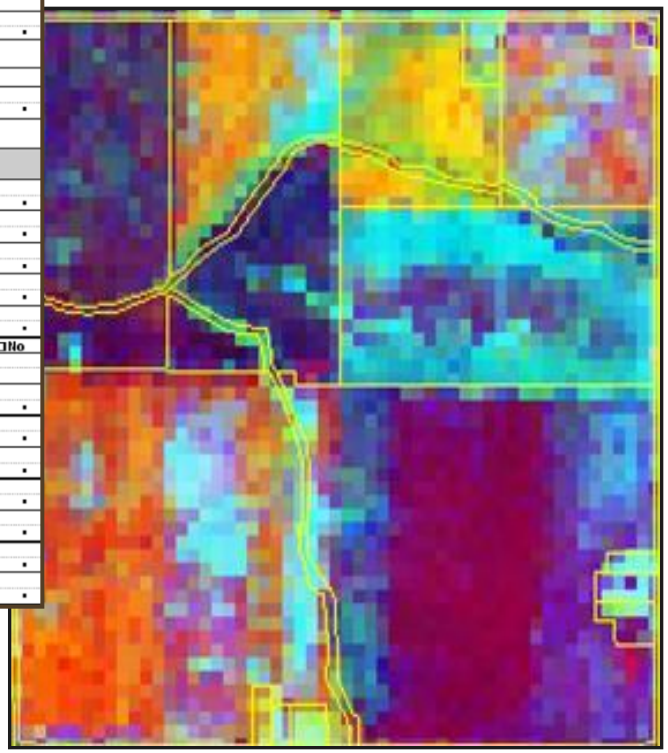
SECTION D - CROPS AND LAND USE ON TRACT

17

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.

FIELD NUMBER		01	02	03	04	05
1. Total acres in field		828	828	828	828	828
2. Crop or land use. [Specify]						
3. Occupied farmstead or dwelling		843				
4. Waste, unoccupied dwellings, buildings and structures, roads, ditches, etc.		---	---	---	---	---
5. Woodland		831	831	831	831	831
6. Pasture	Permanent (not in crop rotation)	842	842	842	842	842
	Cropland (used only for pasture)	856	856	856	856	856
8. Idle cropland - Idle all during 2000		857	857	857	857	857
9. Two crops planted in this field or two uses of the same crop.		☐Yes ☐No	☐Yes ☐No	☐Yes ☐No	☐Yes ☐No	☐Yes ☐No
	[Specify second crop or use]					
	Acres	844	844	844	844	844
10. Acres left to be planted		610	610	610	610	610
11. Acres irrigated and to be irrigated [If double cropped, include acreage of each crop irrigated]		620	620	620	620	620
16. Winter Wheat (Include cover crop)	Planted	540	540	540	540	540
17.	For grain or seed	541	541	541	541	541
18. Rye (Include cover crop) [Exclude ryegrass]	Planted	547	547	547	547	547
19.	For grain or seed	548	548	548	548	548



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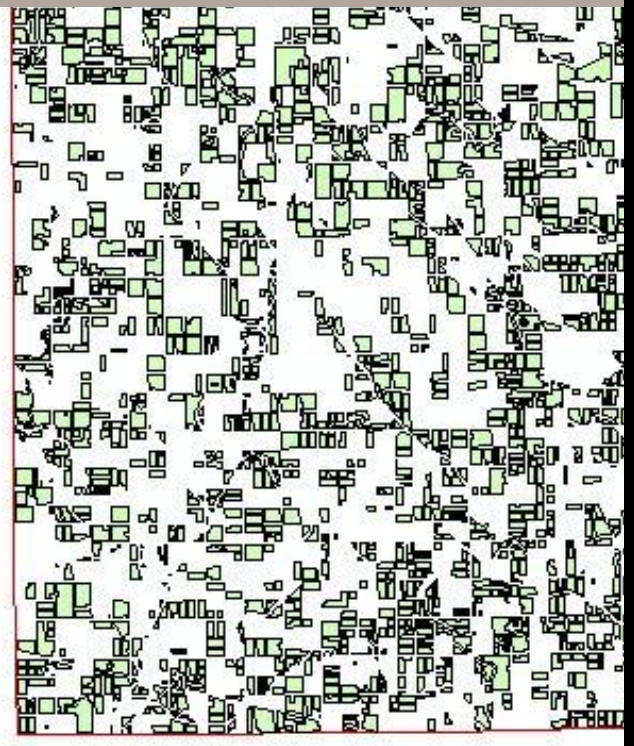
Ne



FSA CLU Training ification

- USDA
- Progra ops)
- GIS-re

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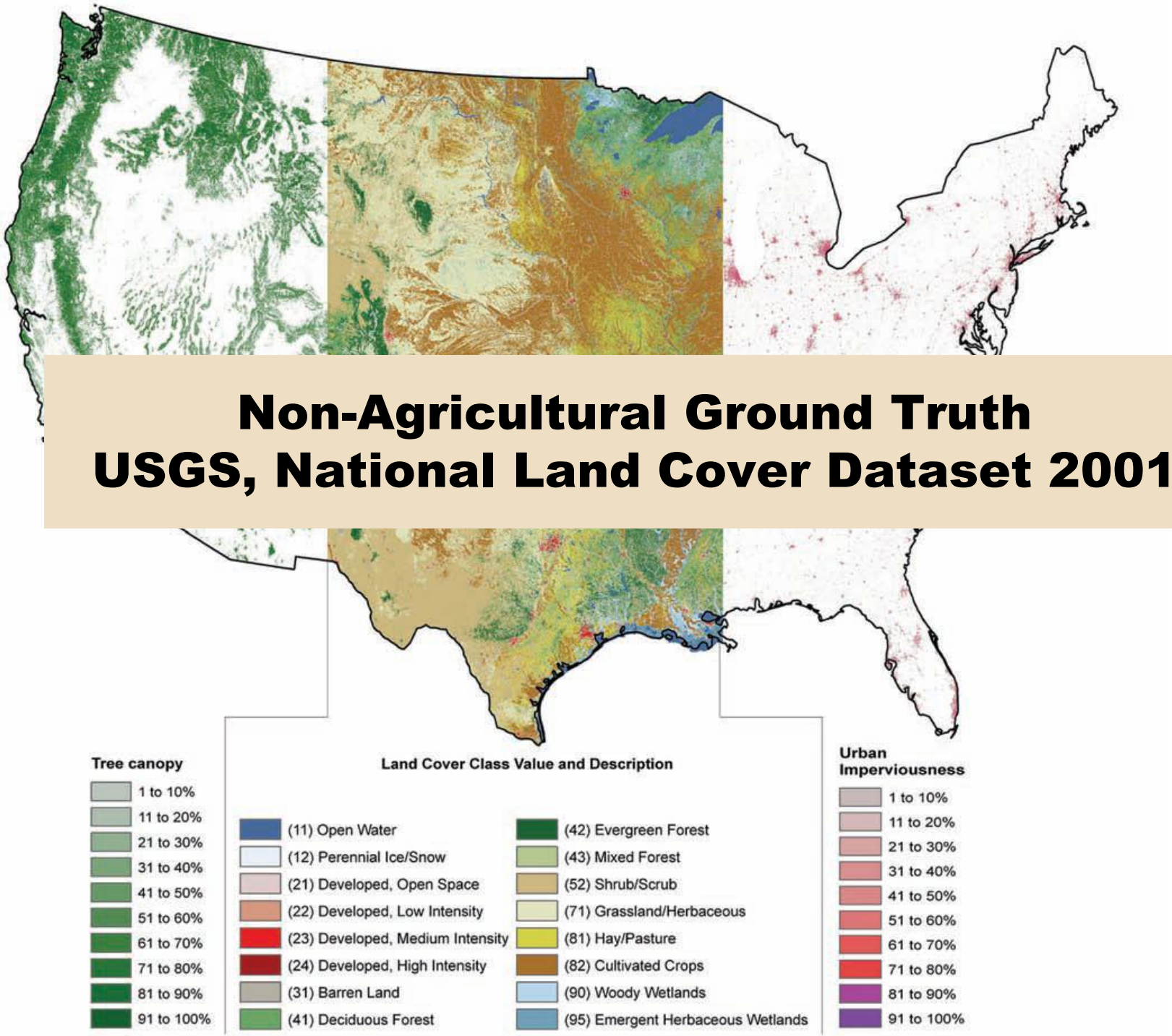
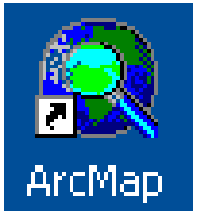


Non-Agricultural Ground Truth
USGS, National Land Cover Dataset 2001

New Commercial Software Suite

- Imagery Preparation
  - Leica Geosystems ERDAS Imagine
- Image classification
  - See5.0 www.rulequest.com
    - Decision tree software
- Ground Truth Preparation
  - ESRI ArcGIS
- Acreage Estimation
  - SAS/IML workshop



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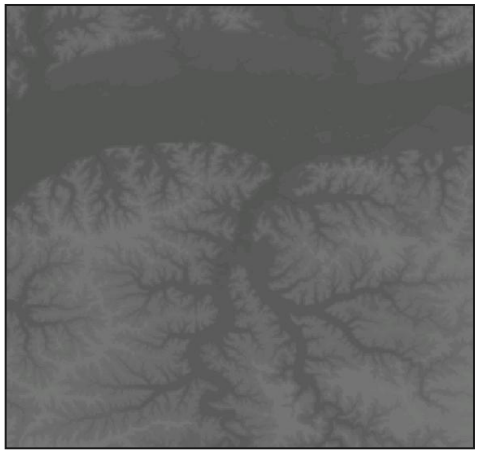
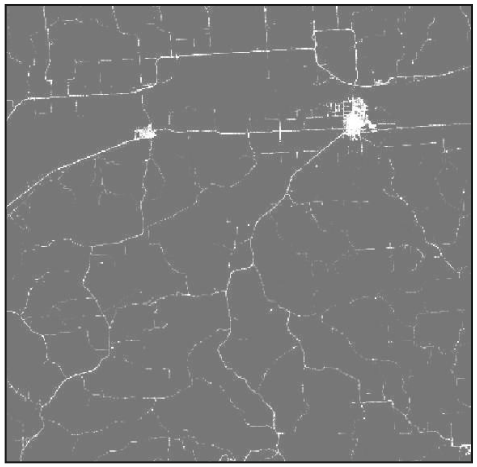
New Commercial Software Suite

- User-friendly
- Allows unlimited classification inputs
  - Peditor software was limited to two dates

Ancillary Data – USGS & NASA Products



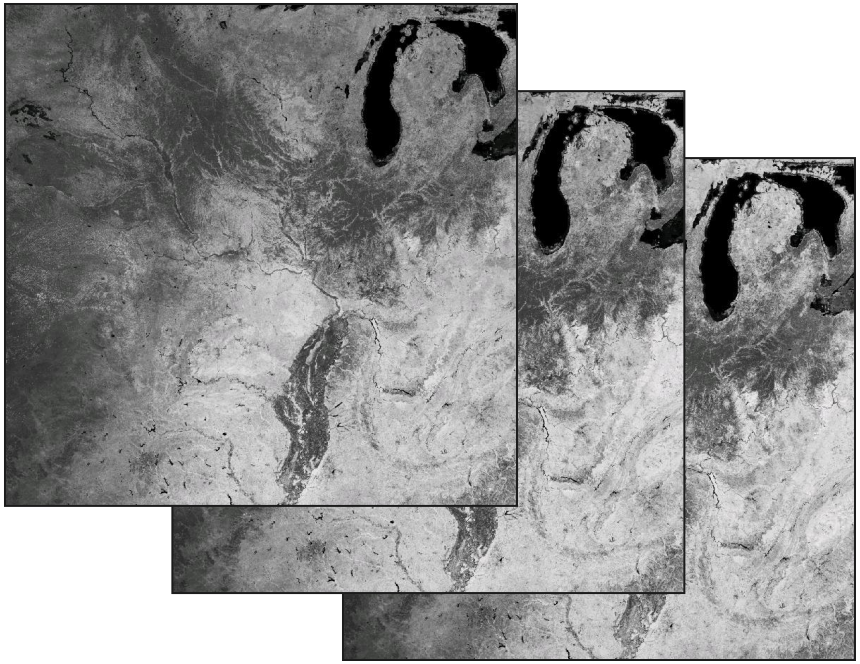
Elevation



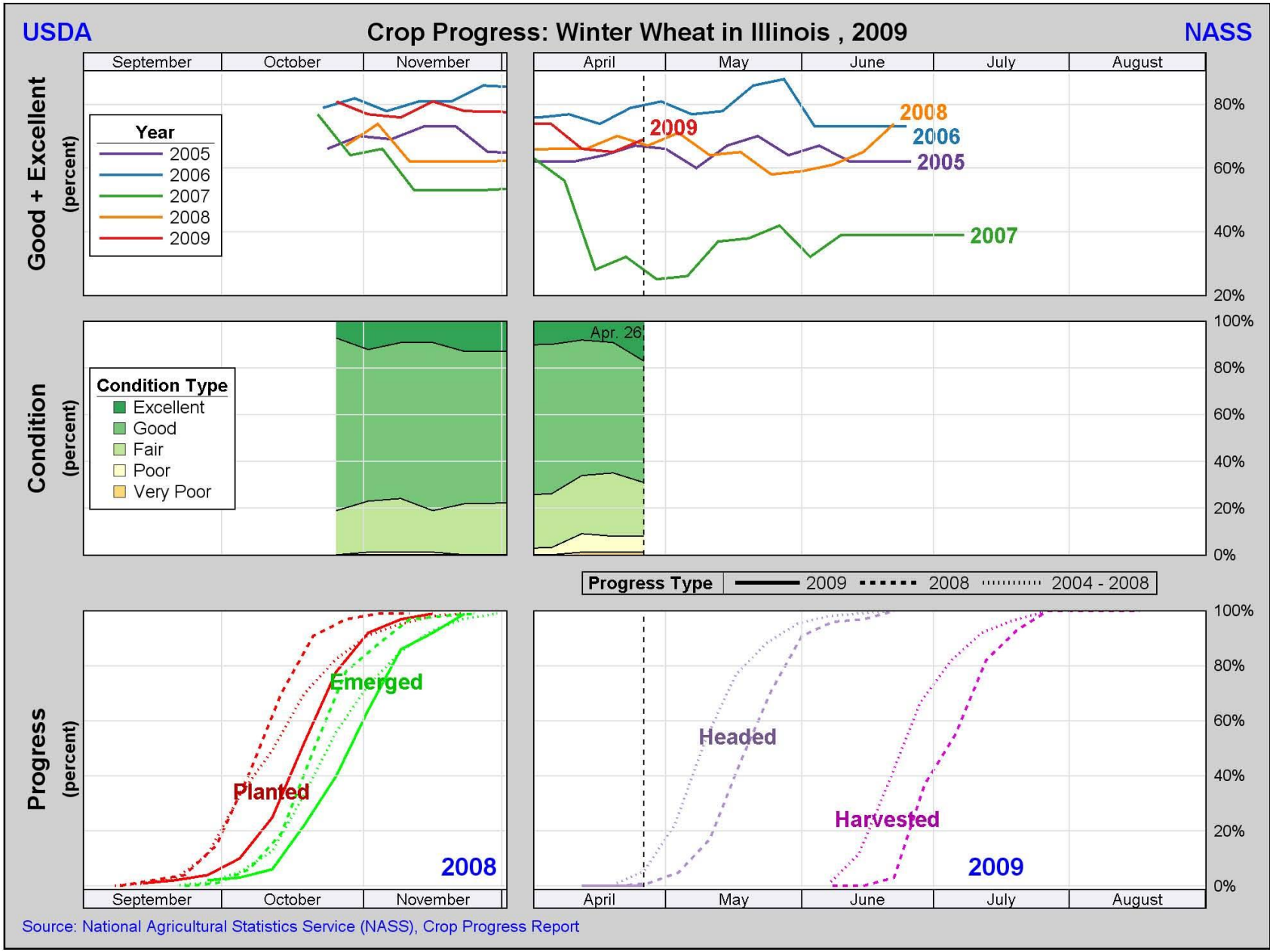
Imperviousness

Forest Canopy

- **NASA MODIS 16-day 250m NDVI composites**
- **Start in fall of previous year for winter wheat**



http://www.nass.usda.gov/Charts_and_Maps/Crop_Progress_&_Condition/



2008 Illinois CDL Inputs

15 Awifs scenes

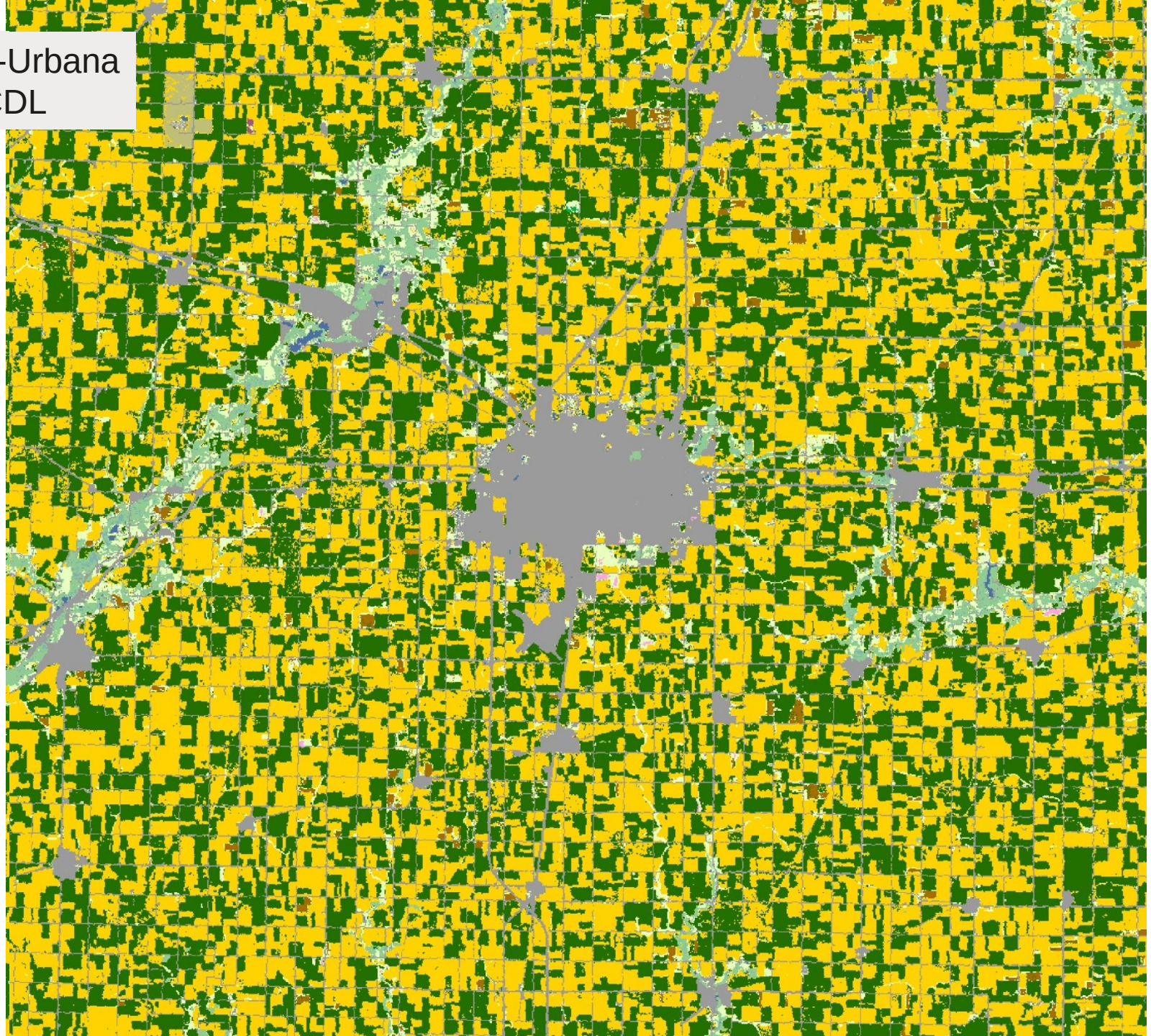
12 Modis NDVI scenes

3 Ancillary data layers

> 3 million acres of FSA training data

```
USDA, National Agricultural Statistics Service 2008 Illinois Cropland Data Layer

CLASSIFICATION INPUTS:
AWIFS DATE 20080415 PATH 274 ROW(S)&QUADRANT(S) 40BD 45BD 50B
AWIFS DATE 20080504 PATH 273 ROW(S)&QUADRANT(S) 40BD 45BD 50B
AWIFS DATE 20080528 PATH 273 ROW(S)&QUADRANT(S) 35D 40BD
AWIFS DATE 20080616 PATH 272 ROW(S)&QUADRANT(S) 39ACD 40BD 50BD
AWIFS DATE 20080621 PATH 273 ROW(S)&QUADRANT(S) 40BD 45B
AWIFS DATE 20080701 PATH 275 ROW(S)&QUADRANT(S) 35D 40BD 45D 50B
AWIFS DATE 20080706 PATH 276 ROW(S)&QUADRANT(S) 35D 40BD 45BD
AWIFS DATE 20080710 PATH 272 ROW(S)&QUADRANT(S) 40D 45D
AWIFS DATE 20080715 PATH 273 ROW(S)&QUADRANT(S) 35CD 40ABCD 45ABD 50B
AWIFS DATE 20080716 PATH 278 ROW(S)&QUADRANT(S) 40C 45ABC
AWIFS DATE 20080720 PATH 274 ROW(S)&QUADRANT(S) 40ACD 45ABCD 50B
AWIFS DATE 20080804 PATH 277 ROW(S)&QUADRANT(S) 35D 40C 45ABCD 50A
AWIFS DATE 20080823 PATH 276 ROW(S)&QUADRANT(S) 40D 45B
AWIFS DATE 20080827 PATH 272 ROW(S)&QUADRANT(S) 35D 40BD
AWIFS DATE 20080901 PATH 273 ROW(S)&QUADRANT(S) 35D 40BD 45B

MODIS 16 DAY NDVI COMPOSITE DATE 20071016
MODIS 16 DAY NDVI COMPOSITE DATE 20071101
MODIS 16 DAY NDVI COMPOSITE DATE 20071117
MODIS 16 DAY NDVI COMPOSITE DATE 20080406
MODIS 16 DAY NDVI COMPOSITE DATE 20080422
MODIS 16 DAY NDVI COMPOSITE DATE 20080508
MODIS 16 DAY NDVI COMPOSITE DATE 20080524
MODIS 16 DAY NDVI COMPOSITE DATE 20080609
MODIS 16 DAY NDVI COMPOSITE DATE 20080627
MODIS 16 DAY NDVI COMPOSITE DATE 20080711
MODIS 16 DAY NDVI COMPOSITE DATE 20080727
MODIS 16 DAY NDVI COMPOSITE DATE 20080812

USGS, NATIONAL ELEVATION DATASET ELEVATION
USGS, NATIONAL LAND COVER DATASET 2001 TREE CANOPY
USGS, NATIONAL LAND COVER DATASET 2001 IMPERVIOUSNESS

TRAINING AND VALIDATION:
USDA, FARM SERVICE AGENCY 2008 COMMON LAND UNITS
USGS, NATIONAL LAND COVER DATASET 2001

NOTE: The final extent of the CDL is clipped to the state boundary
even though the raw input data may encompass a larger area.
```

Champaign-Urbana
2008 CDL



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

Crop-specific covers only	*Correct	Accuracy	Error	Kappa
OVERALL ACCURACY	3730093	97.05%	2.95%	0.9426

Cover Type	Attribute Code	*Correct Pixels	Producer's Accuracy	Omission Error	Kappa	User's Accuracy	Commission Error	Cond'l Kappa
Corn	1	2258219	98.06%	1.94%	0.9591	97.29%	2.71%	0.9433
Rice	3	30	75.00%	25.00%	0.7500	14.42%	85.58%	0.1442
Sorghum	4	2454	89.99%	10.01%	0.8997	36.62%	63.38%	0.3658
Soybeans	5	1339089	96.36%	3.64%	0.9467	96.07%	3.93%	0.9426
Sunflowers	6	49	85.96%	14.04%	0.8596	25.65%	74.35%	0.2565
Tobbaco	11	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Sweet corn	12	612	85.36%	14.64%	0.8535	52.09%	47.91%	0.5208
Popcorn	13	3748	95.01%	4.99%	0.9500	62.59%	37.41%	0.6256
Barley	21	0	0.00%	100.00%	0.0000	0.00%	100.00%	0.0000
Spring wheat	23	0	0.00%	100.00%	0.0000	0.00%	100.00%	0.0000
Winter wheat	24	25086	82.73%	17.27%	0.8258	67.41%	32.59%	0.6719
Other grains	25	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
WW / Soybeans	26	95845	90.49%	9.51%	0.9025	87.32%	12.68%	0.8701
Rye	27	39	92.86%	7.14%	0.9286	14.18%	85.82%	0.1418
Oats	28	157	79.70%	20.30%	0.7969	19.36%	80.64%	0.1936
Millet	29	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Speltz	30	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Alfalfa	36	2898	78.81%	21.19%	0.7876	25.61%	74.39%	0.2555
Dry beans	42	28	60.87%	39.13%	0.6086	4.69%	95.31%	0.0469
Potatoes	43	3	60.00%	40.00%	0.6000	4.41%	95.59%	0.0441
Other crops	44	58	79.45%	20.55%	0.7945	11.55%	88.45%	0.1155
Misc. vegetables	47	932	87.35%	12.65%	0.8734	55.31%	44.69%	0.5530
Watermelon	48	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Peas	53	0	0.00%	100.00%	0.0000	0.00%	100.00%	0.0000
Herbs	57	49	66.22%	33.78%	0.6621	17.13%	82.87%	0.1713
Clover / Wildflowers	58	163	82.32%	17.68%	0.8232	13.38%	86.62%	0.1338
Seed / Sod Grass	59	609	91.58%	8.42%	0.9158	29.51%	70.49%	0.2950
Idle / Fallow / Flooded**	61	25	2.44%	97.56%	0.0239	1.19%	98.81%	0.0117
Peaches	67	0	0.00%	100.00%	0.0000	0.00%	100.00%	0.0000
Apples	68	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Grapes	69	0	n/a	n/a	n/a	0.00%	100.00%	0.0000
Christmas trees	70	0	n/a	n/a	n/a	0.00%	100.00%	0.0000

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

**In the 2008 Illinois Cropland Data Layer, category 61 represents drowned/flooded cropland in addition to idle and fallow cropland.

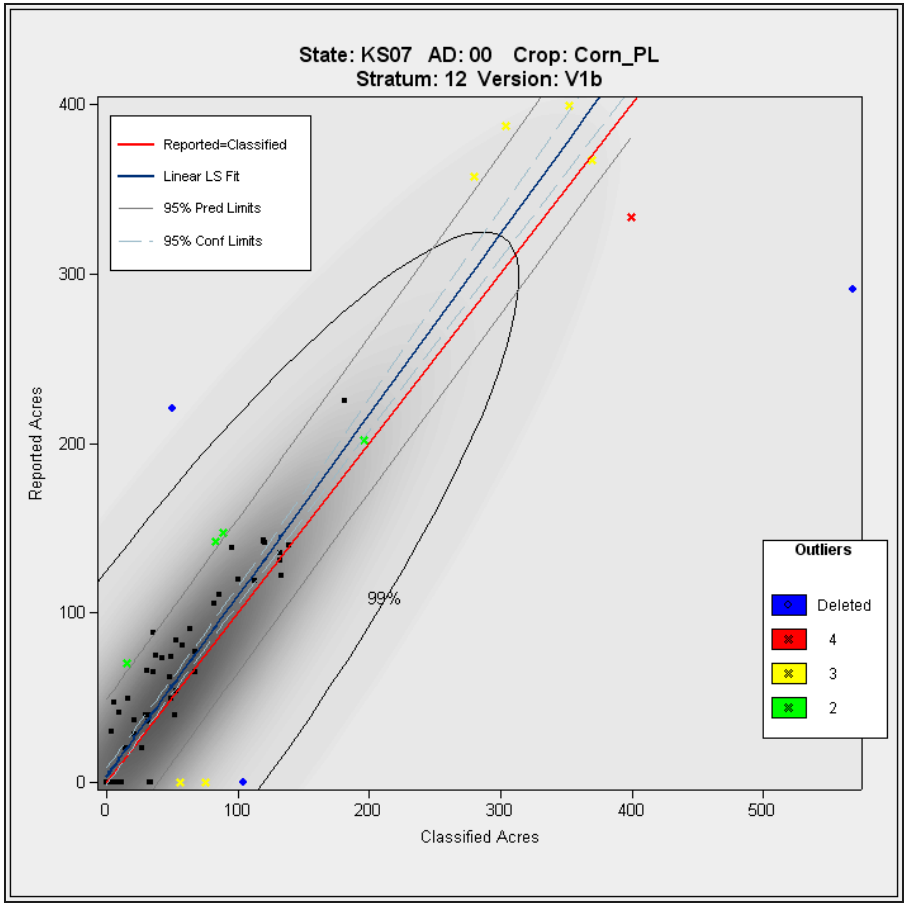
Regression-based Acreage Estimator

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**

Using both CDL and JAS acreage results in estimates with reduced error rates over JAS alone

Outlier segment detection - correction or removal from regression analysis



Acreage not just about counting pixels

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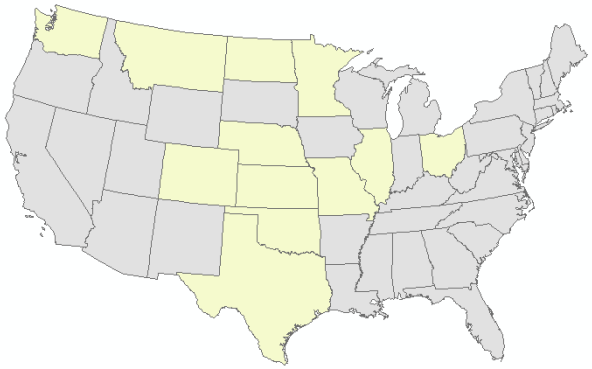
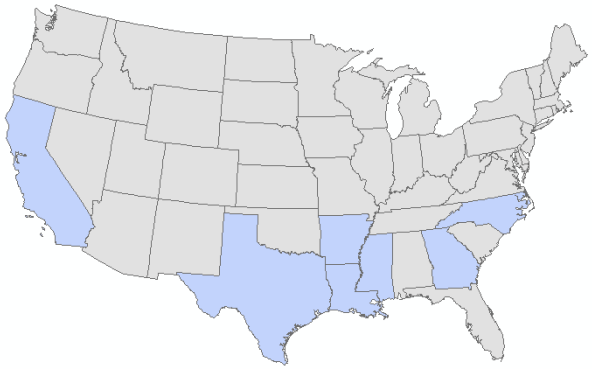
Research and Development Division
Spatial Analysis Research Section

Future of the CDL Program?



Primary Wheat States



Primary Cotton States

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

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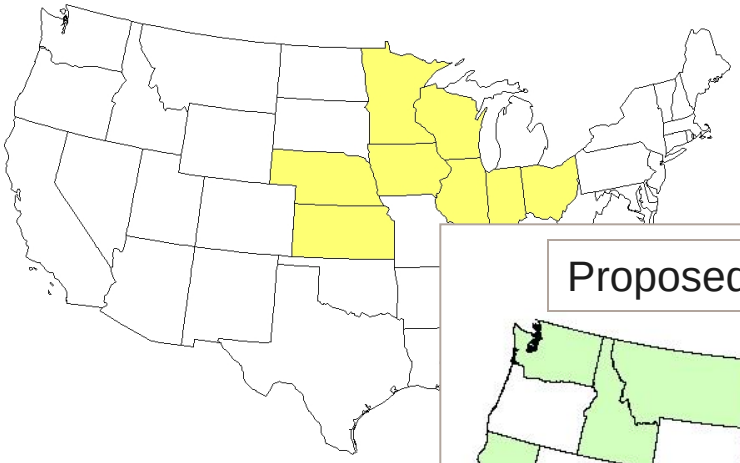
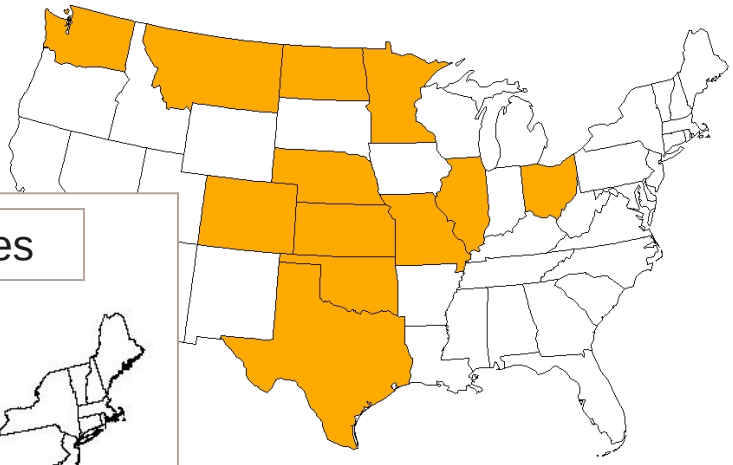
Research and Development Division
Spatial Analysis Research Section

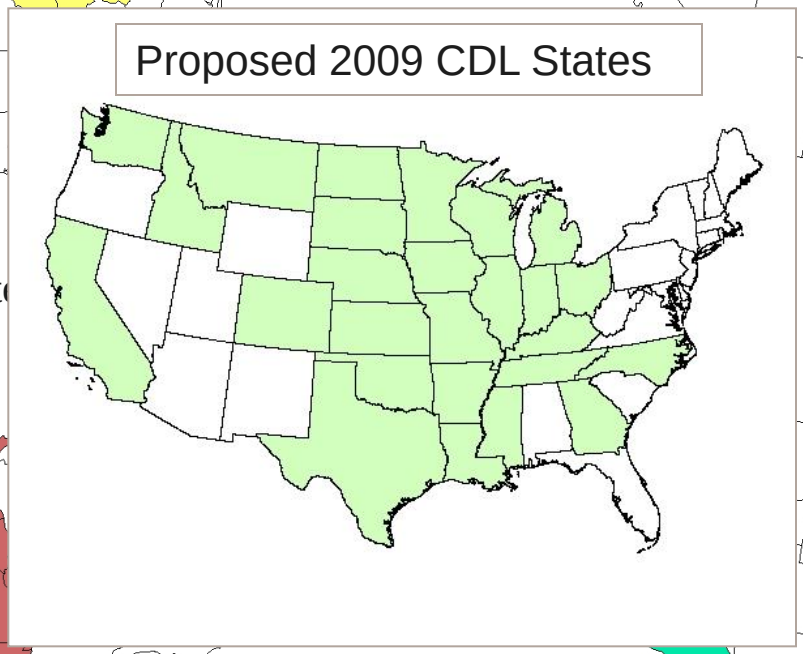
Expanding CDL Program Priorities

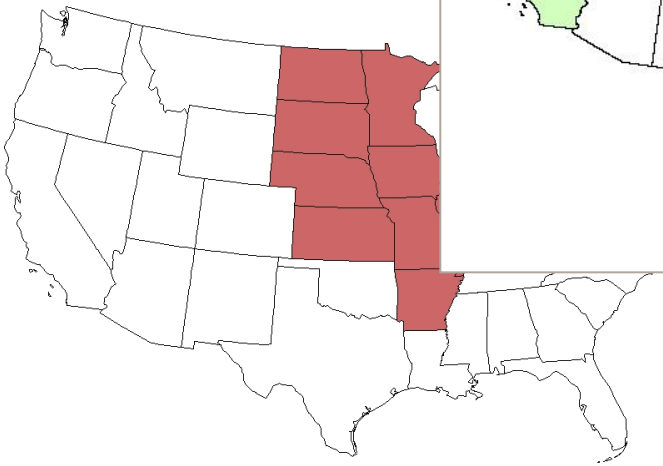


Speculative Corn State

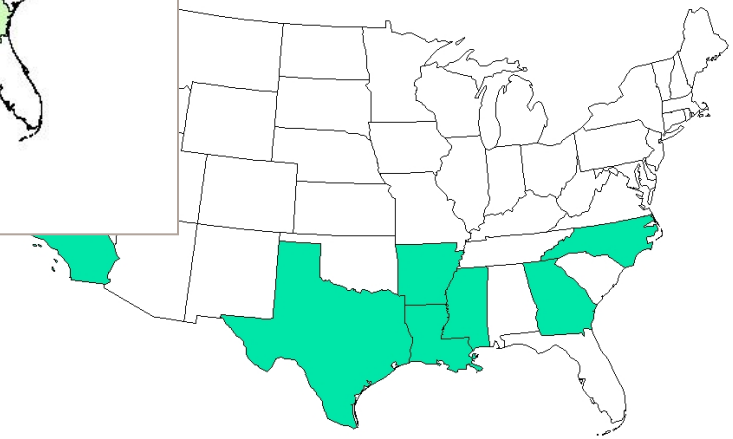


Speculative Wheat States



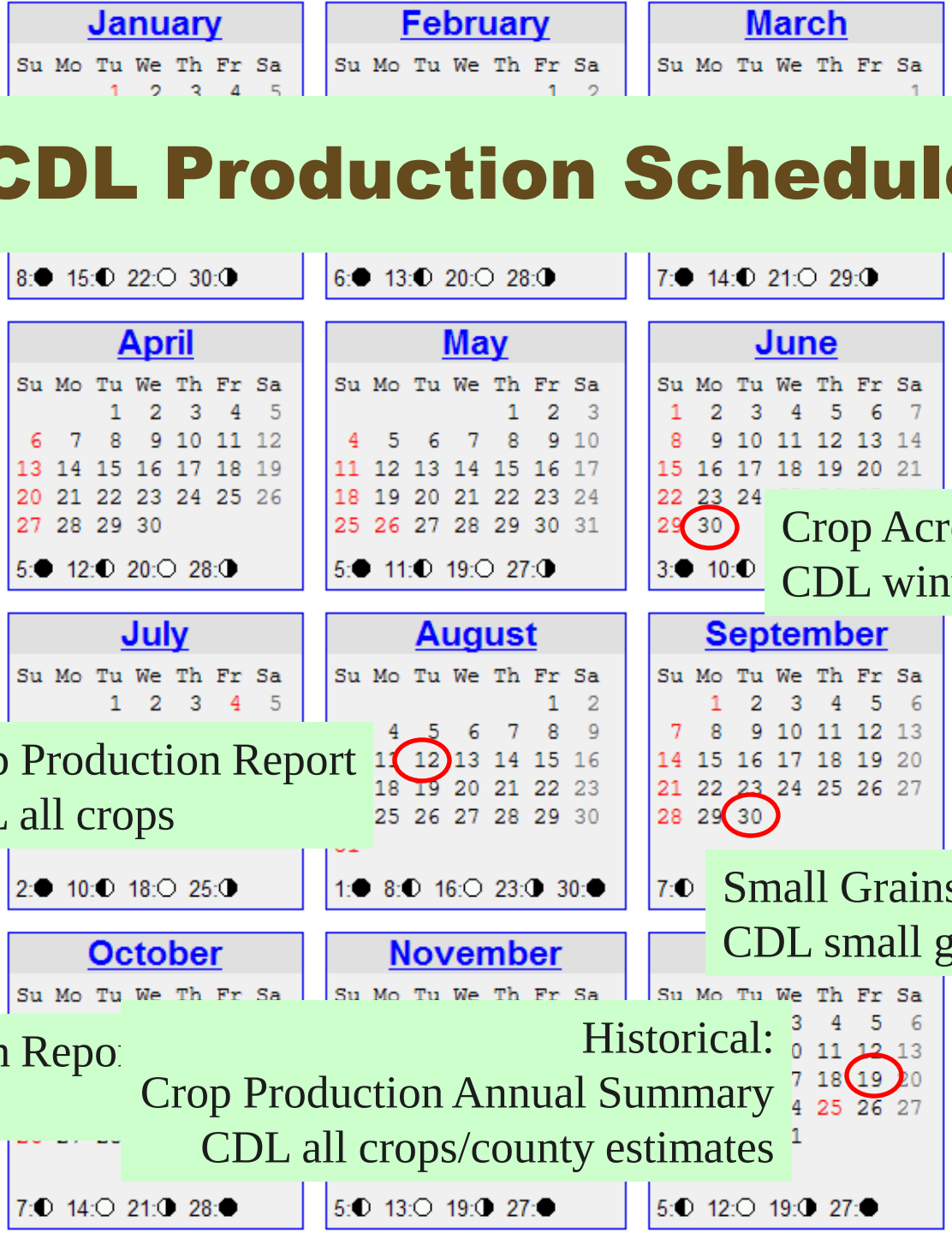


Speculative Soybean States



Speculative Cotton States

CDL Production Schedule



Crop Acreage Report
CDL winter wheat

Crop Production Report
CDL all crops

Small Grains Annual Summary
CDL small grains

Crop Production Repo
CDL all crops

Historical:
Crop Production Annual Summary
CDL all crops/county estimates

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

Free Downloadable Data

- The public release date starting in 2009
  - Mid-December of the same growing season
- Ortho-registered
- Consistent attribute codes
- Extensive metadata

Additional Information and ***Free*** Downloads:

http://www.nass.usda.gov/research/

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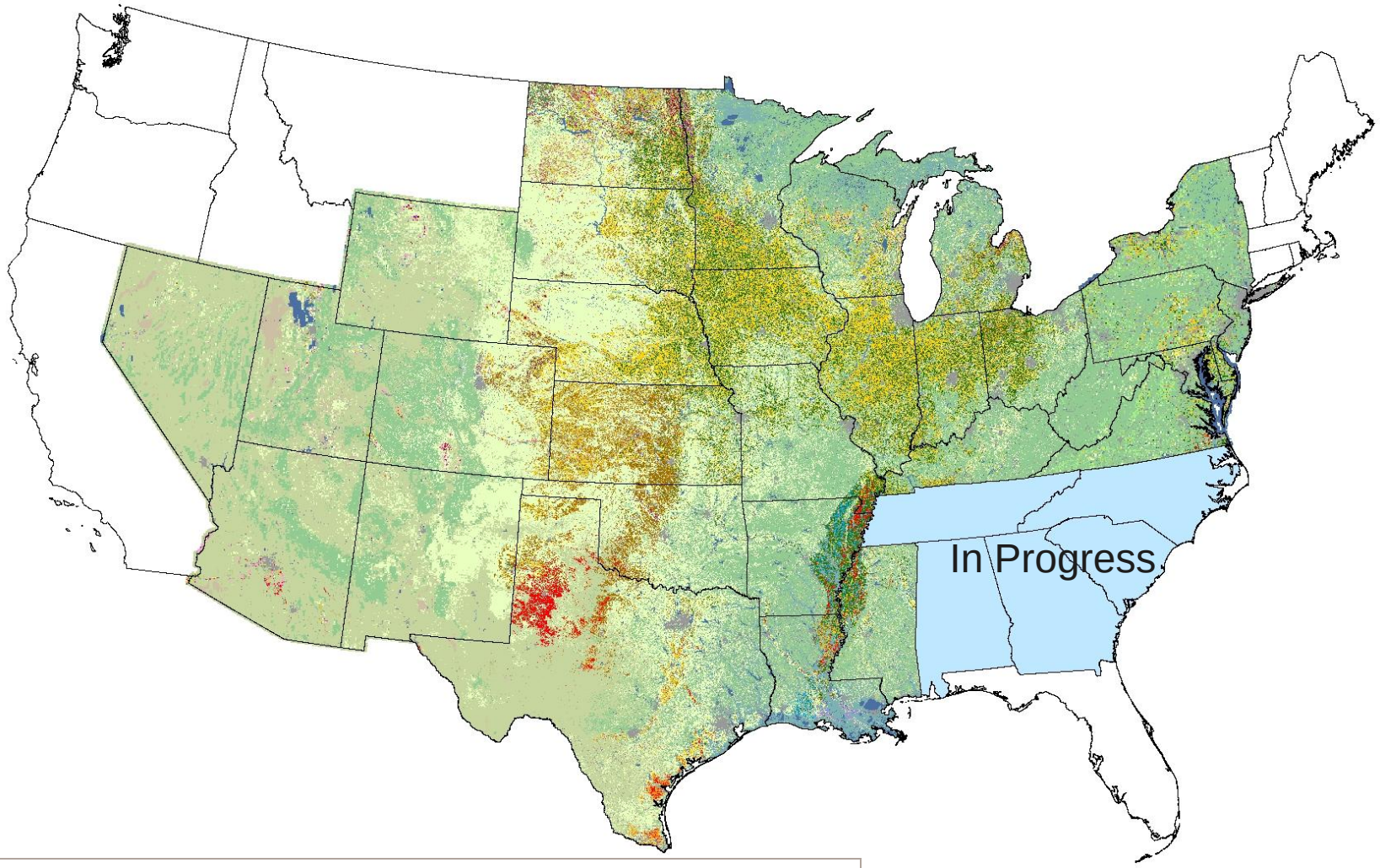
Spatial Analysis Research Section

2008 Cropland Data Layer Products



Additional Information and ***Free*** Downloads:

http://www.nass.usda.gov/research/

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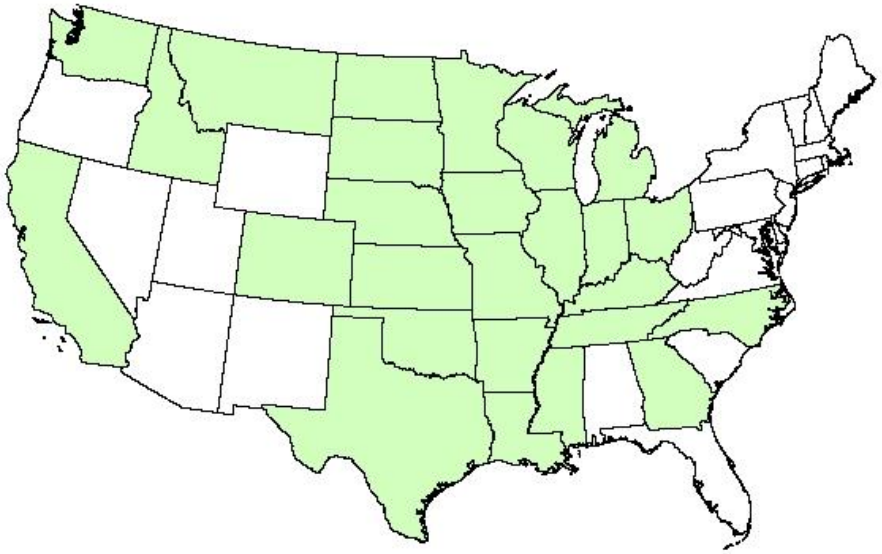
Proposed 2009 CDL States



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

Single Crop Planting Intensity and Crop Rotation Assessment

To determine the specific counties with high percentages of single crop planting intensity and derive the predominant crop rotation

Research done by Claire Boryan, presented at the ASPRS 2009 Conference

Corn

Soybeans

United States Department of Agriculture
National Agricultural Statistics Service
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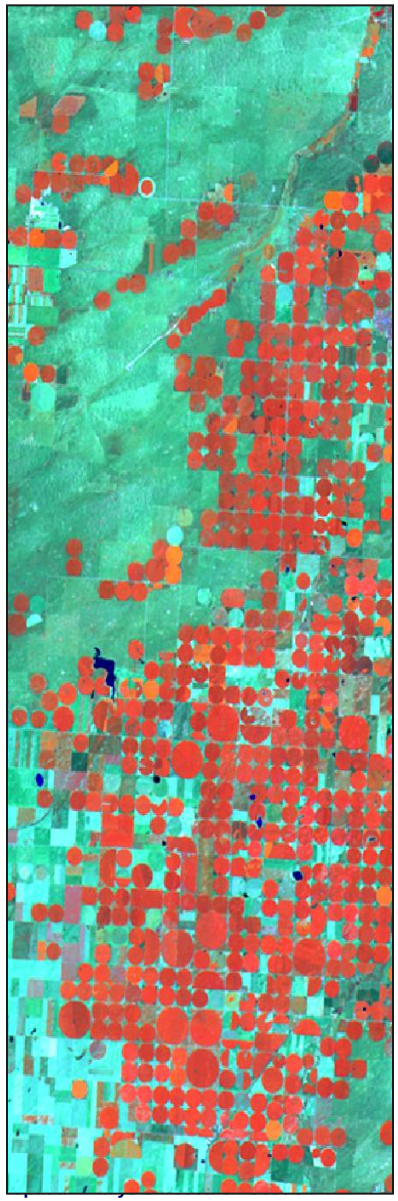
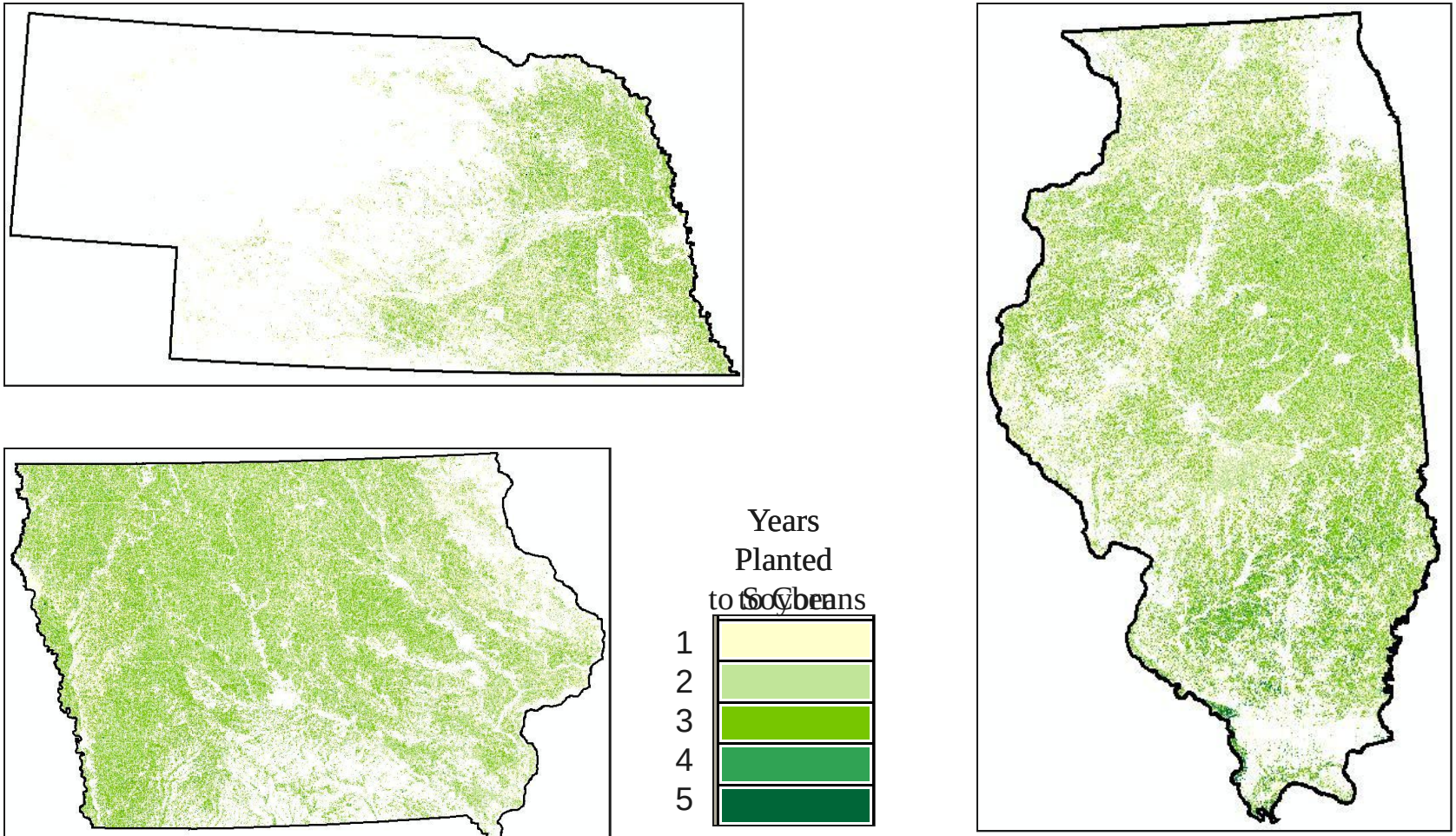
Single Crop Planting Intensity Methodology



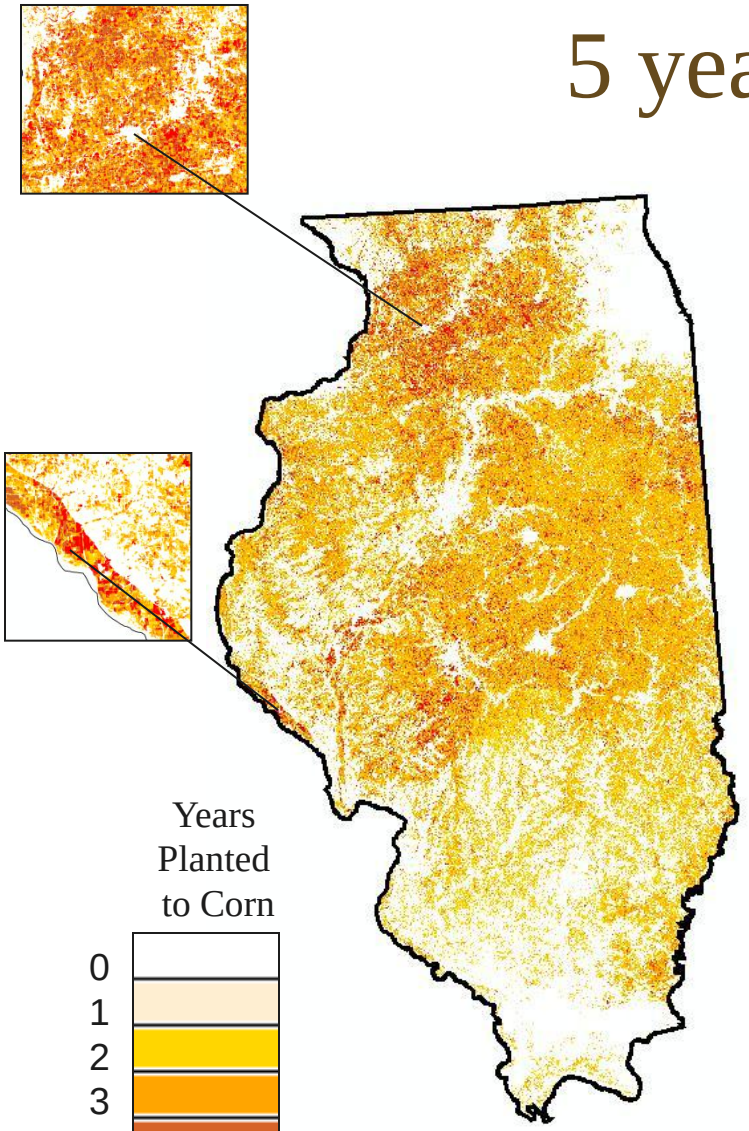
1. Inputs include: Cropland Data Layers (CDLs) for 2004-2008
2. CDLs are recoded such that crop under evaluation =1
3. The recoded CDL's are added together using the ERDAS Imagine Modeler
4. The output is the Crop Intensity Image which is ready for evaluation

Single Crop Planting Intensity, 2004 - 2008
Nebraska, Iowa and Illinois

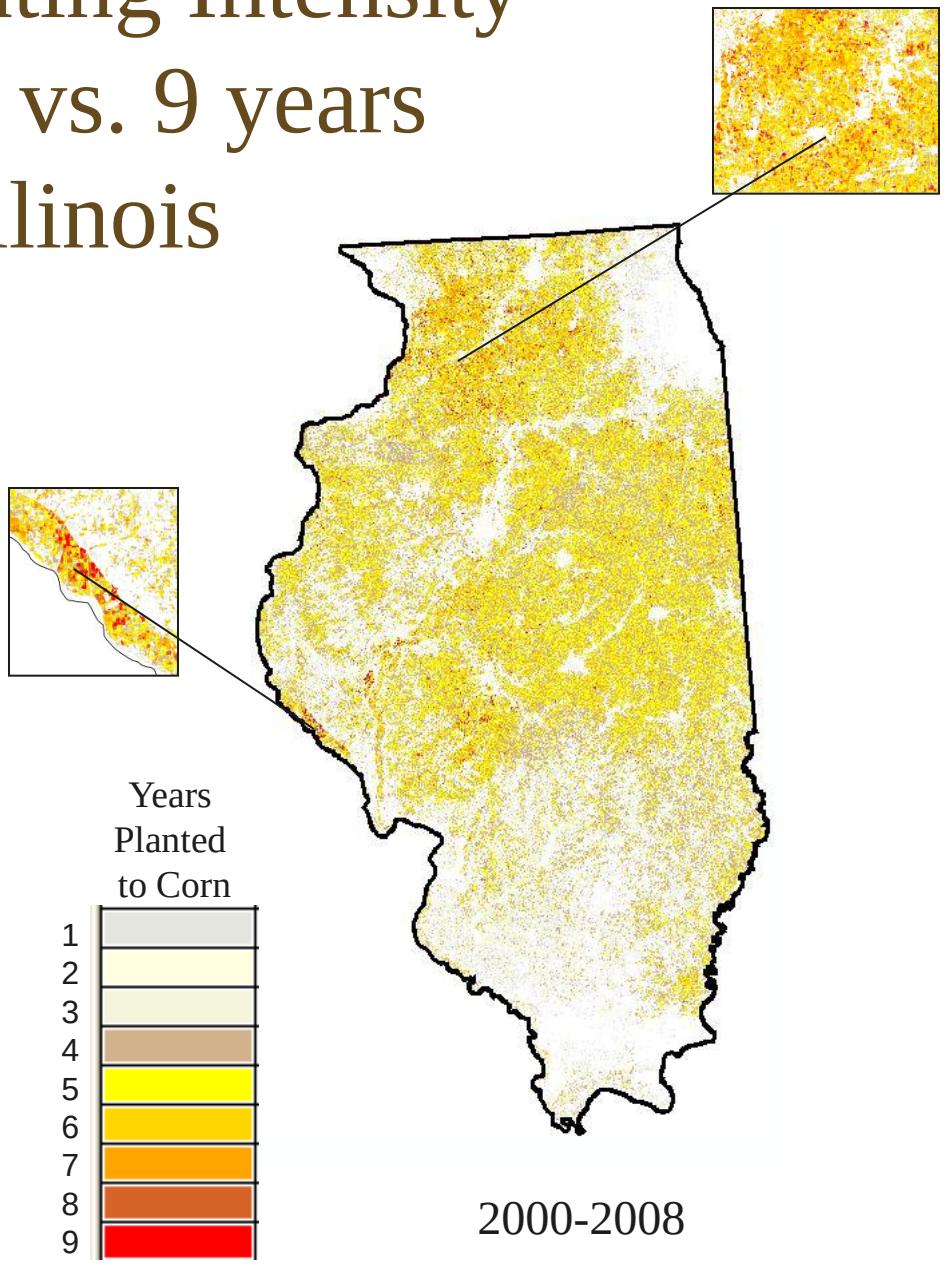


Cropland Data Layers (CDLs) utilized in assessment: 2004 - 2008

Corn Planting Intensity
5 years vs. 9 years
Illinois



2004-2008



2000-2008

Corn Planting Intensity in Illinois
2004 - 2008

Bureau County

5 years in a row planted to corn: **14%**
4 out of 5 years planted to corn: **20%**

Illinois County

5 years in a row planted to corn: **16%**
4 out of 5 years planted to corn: **26%**

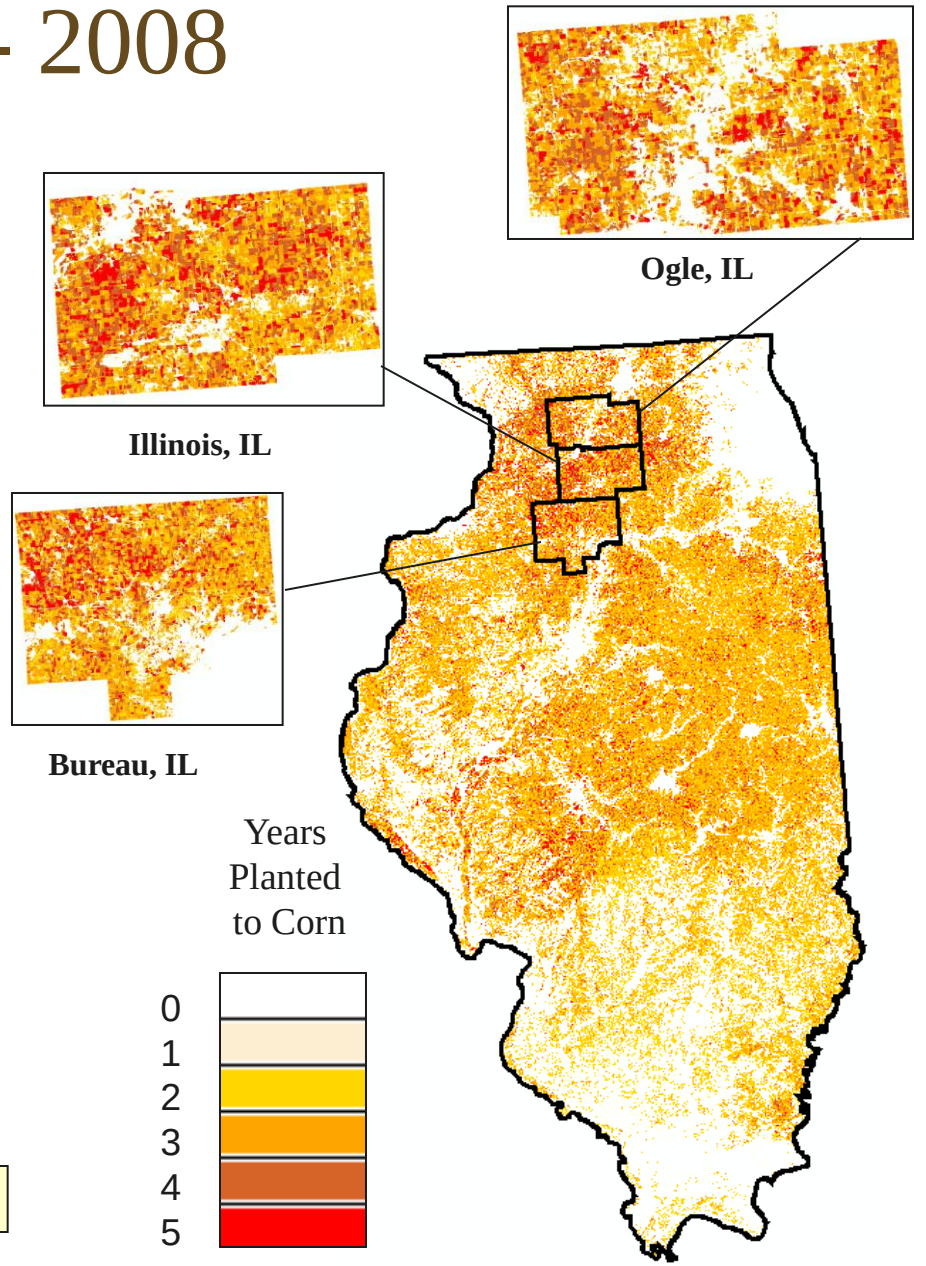
Ogle County

5 years in a row planted to corn: **13%**
4 out of 5 years planted to corn: **24%**

Illinois State Totals

5 years in a row planted to corn: **5%**
4 out of 5 years planted to corn: **10%**

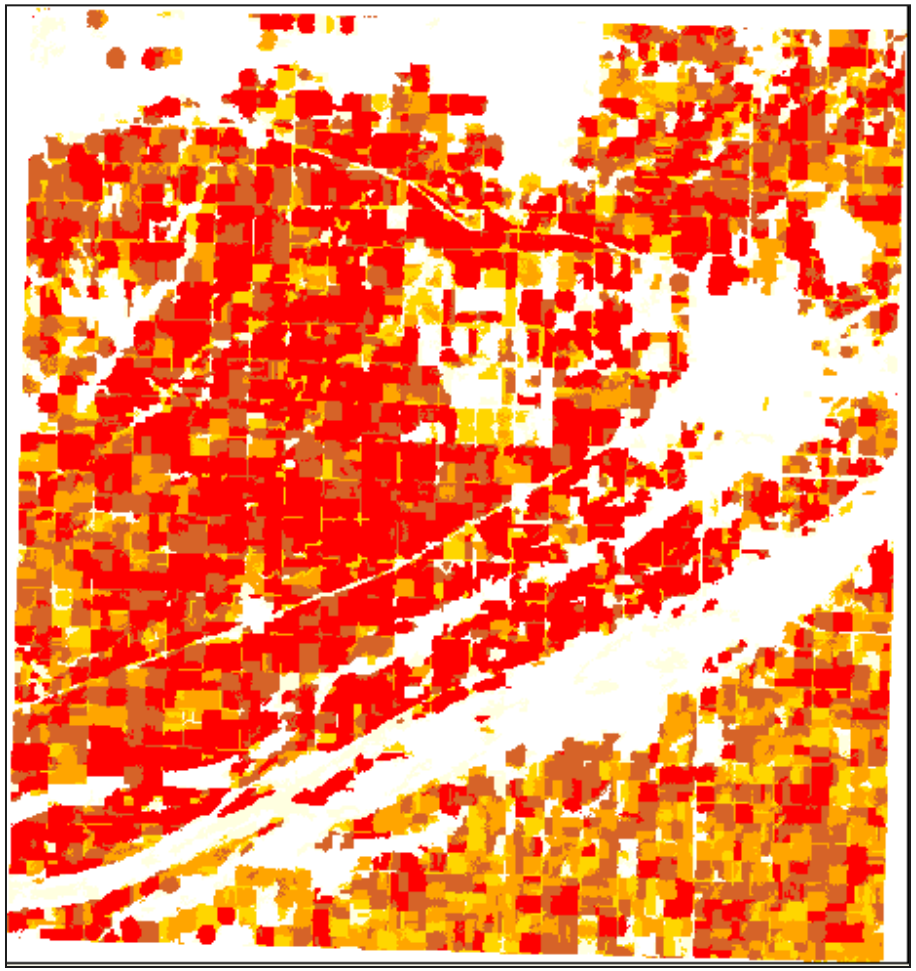
Percentages derived from total acreage in corn production

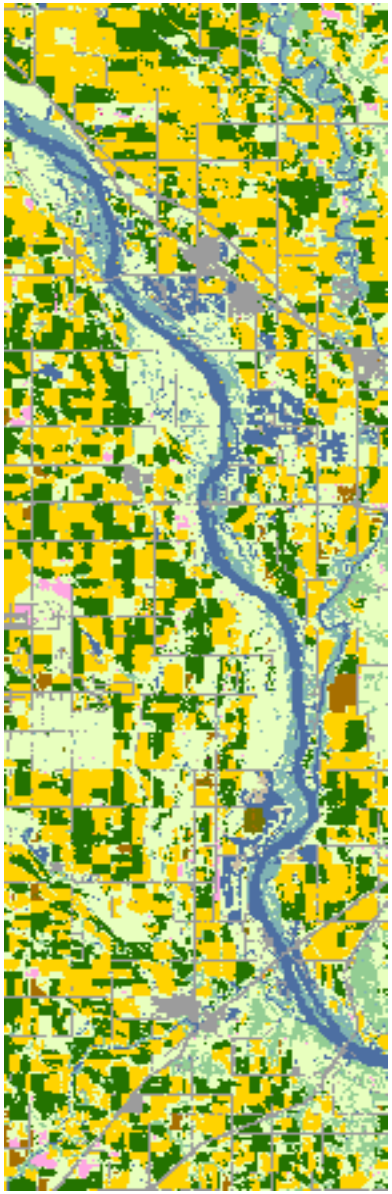


Trending toward increased levels of single crop planting to corn: 2004 - 2008

Percent increase - **5 years planted to corn**
from 2003-2007 assessment

- All States: 1%
- Nebraska:
  - Hall: 5%
  - Dawson: 1%
  - Chase: 2%
- Iowa:
  - Delaware: 5%
  - Hamilton: 1%
  - Dubuque: 2%
- Illinois:
  - Bureau: 3%
  - Illinois: 4%
  - Ogle: 3%





Crop Rotation Results
Illinois

Crop Rotation Patterns (Corn and Soybean) 04- 08
As Percentage of
Total Cultivated Cropland

Corn (04), Soy (05), Corn (06), Soy (07), Corn (08)	**16.7%**
Soy (04), Corn (05), Soy (06), Corn (07), Soy (08)	**16.5%**
Corn (04), Corn (05), Corn (06), Corn (07), Corn (08) (1.4% > than 2003-2007)	**5.26%**
Additional acreage into corn production (07):	**148,234 acres**
Additional acreage into corn production (08):	**112,758 acres**

Total Cultivated Cropland derived from NASS' Illinois 2008 CDL

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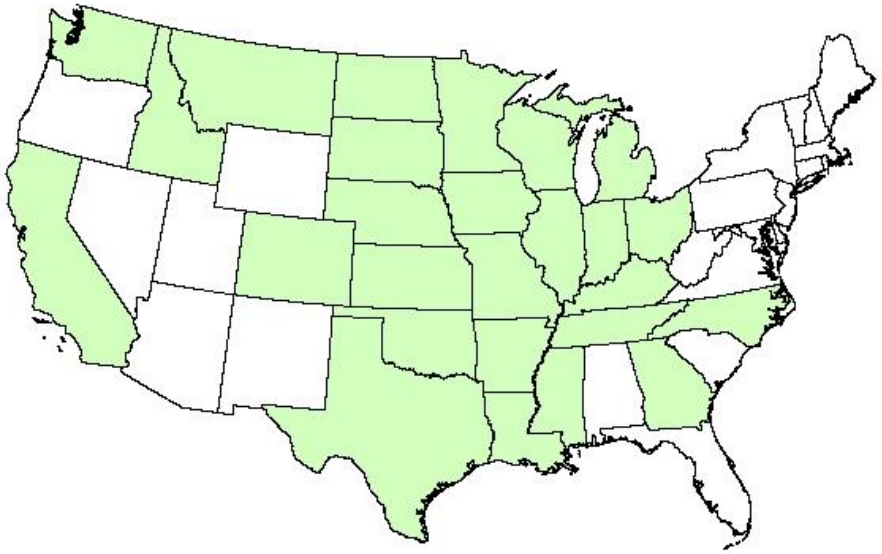

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Accuracy Measures

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

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

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