Remote Sensing of Agriculture

NASS' Cropland Data Layer Program

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USDA/NASS

NASS Overview

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

Research and Development Division

Geospatial Information Branch
Spatial Analysis Research

Remote Sensing Acreage Estimation Program Objectives

- "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 NRCS Geospatial Data Gateway or http://www.nass.usda.gov/research/Cropland/SARS1a.htm
  - Publish accuracy statistics/metadata
  - County and state level

Cropland Data Layers
1997 - 2008
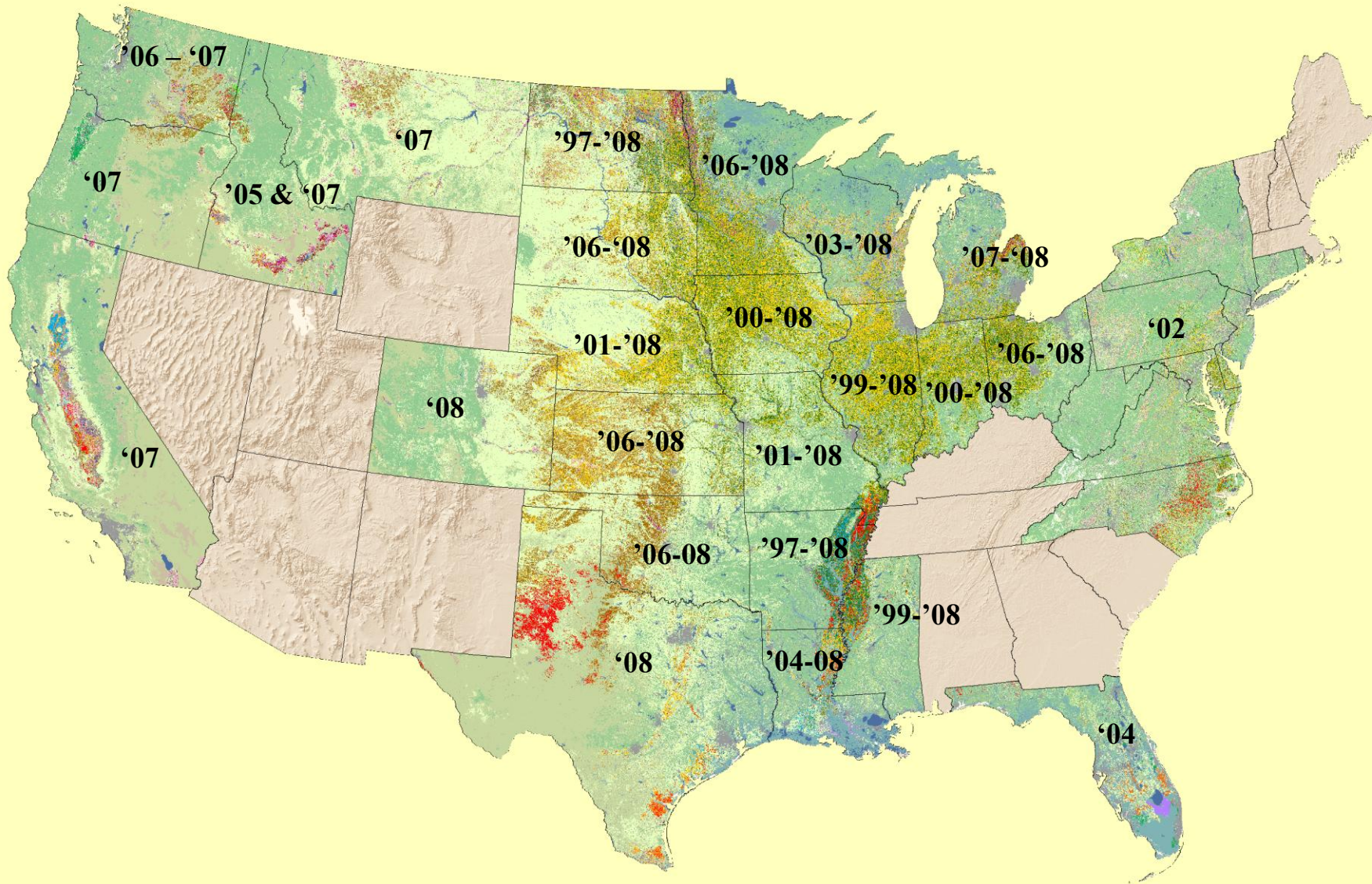
Kansas 2008 Cropland Data Layer
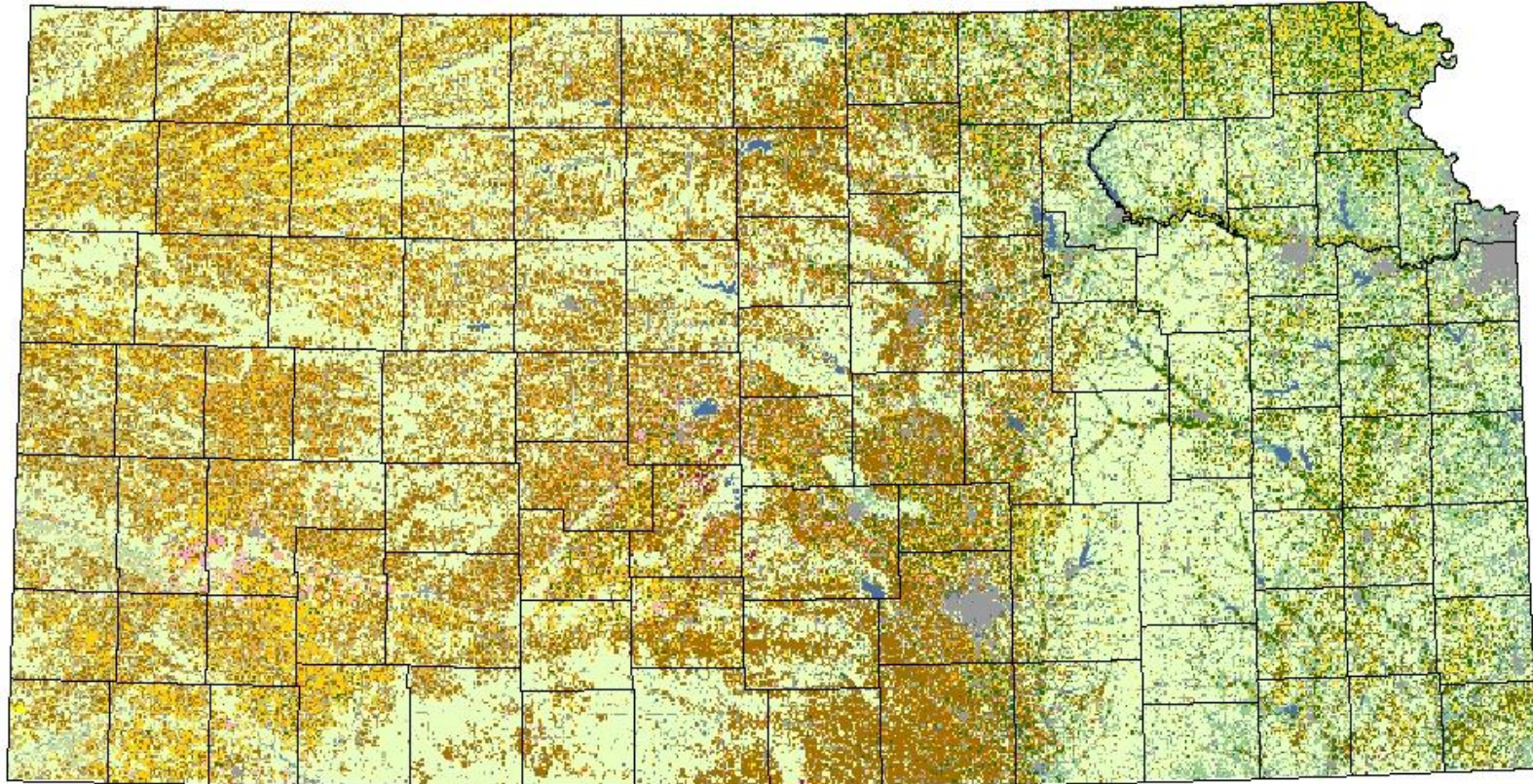
Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture

- Pasture/Grass
- Winter Wheat
- Corn
- Fallow/Idle Cropland
- Sorghum
- Soybeans
- Alfalfa

- W. Wht./Soy. Dbl. Crop.
- Sunflowers
- Rye
- Cotton
- Other Small Grains
- Clover/Wildflowers
- Oats

- Potatoes
- Seed/Sod Grass
- Canola
- Millet
- Other Crops
- Barley
- Other Tree Nuts & Fruits

Non-Agriculture

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

Cropland Data Layer Program Components

- Advanced Wide Field Sensor (AWiFS) data
- Ground truth: FSA/CLU + 578 & NLCD
- Ancillary data sets
- Commercial Software Suite
- See5 Decision Tree Methodology
- Estimation
- Research

Landsat Imagery 1997-2005

Landsat 5 launched 1984 (3 yr design life!)

- Thematic Mapper (TM) Sensor

Landsat 7 launched 1999 Thematic Mapper (ETM+) Sensor

The Landsat Data Gap

Landsat 7 ETM+

Landsat 5 TM

Source: USGS, Landsat Project:

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

Indian Remote Sensing Satellite: RESOURCESAT-1

Advanced Wide Field Sensor (AWiFS)

States Targeted for Data Collection in August 2004

➢**AWiFS:** Swath: 370 km each head, 740 km combined 56 m resolution at nadir, 70 m resolution at field edges

➢**Spectral Bands**

➢**B2: 0.52-0.59 (Visible Green)**

➢**B3: 0.62-0.68 (Visible Red)**

➢**B4: 0.77-0.86 (Near Infrared)**

➢**B5: 1.55-1.70 (Shortwave Infrared)**

➢**Temporal Resolution (5 Days)**
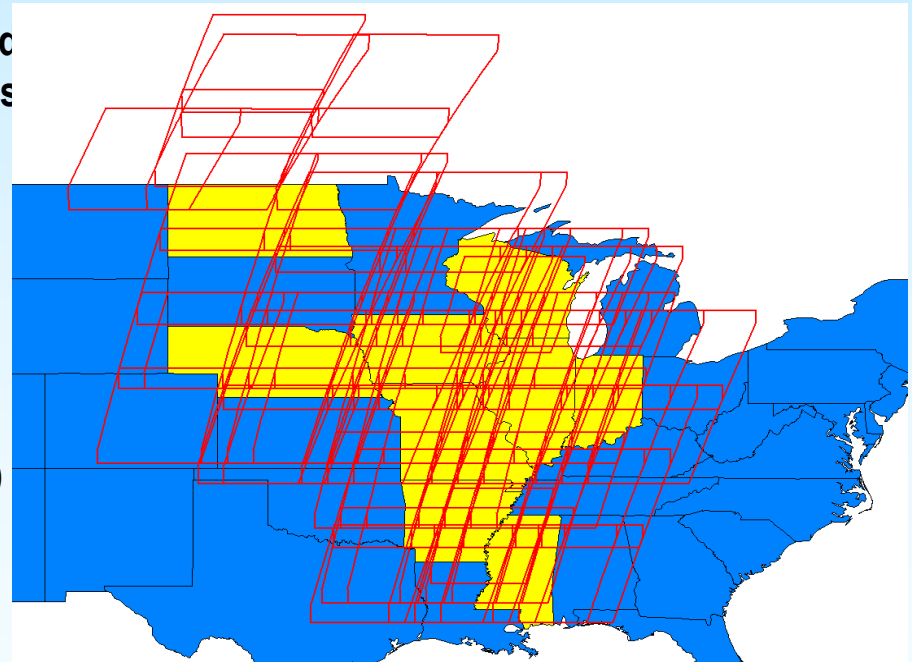
Sensor Specifications Compared

	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

Crop Acreage Estimation:
Landsat TM and AWiFS Assessments 2004-2005
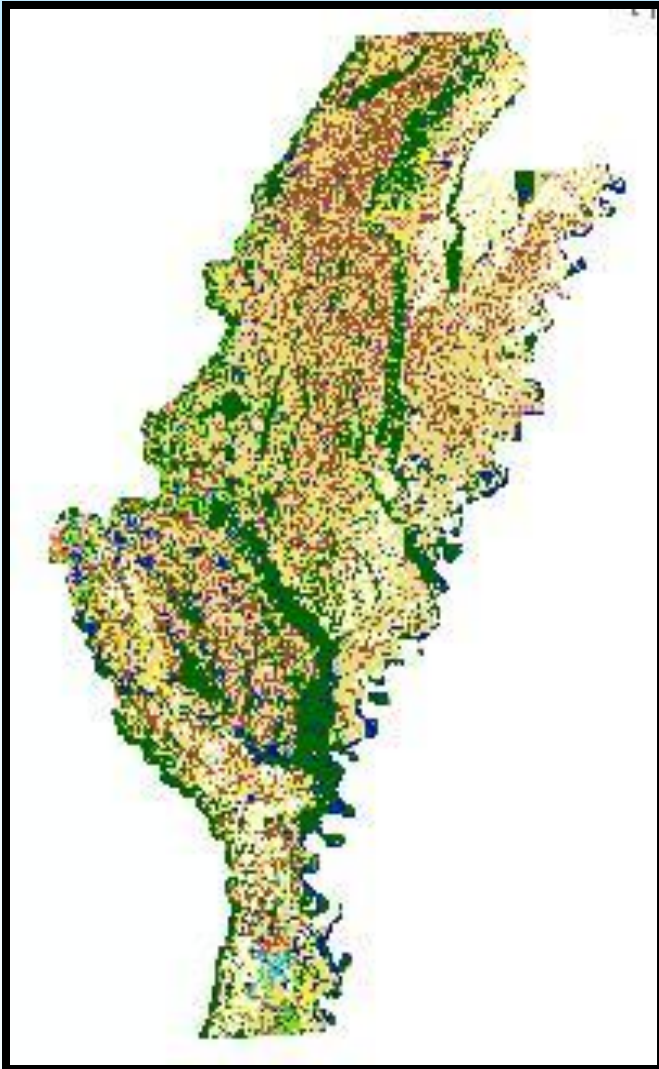
- Nebraska, 2004
- Arkansas (Delta Region), 2005
- Nebraska, 2005
- Coincident studies (AR, IL, IA) 2005

Coincident study sites

Three coincident areas chosen for analysis:

- Arkansas
  - 20 August 2005
- Iowa,
  - 18 August 2005
- Illinois
  - 29 August 2005

Need for Coincident Imagery

The best classification comparison would use not only data from the **same area** but from the **same time**. Thus controlling for variables including:

Atmospherics conditions
- Clouds
- Haze
- Smoke

Ground conditions
- Soil moisture
- Vegetation phenology

Sun angle
- Seasonal variation
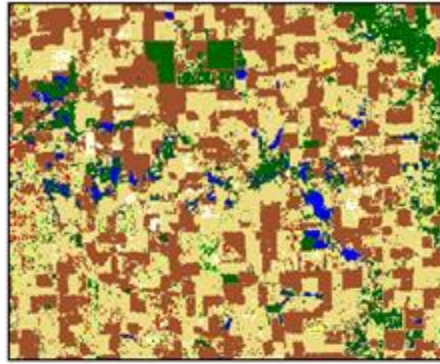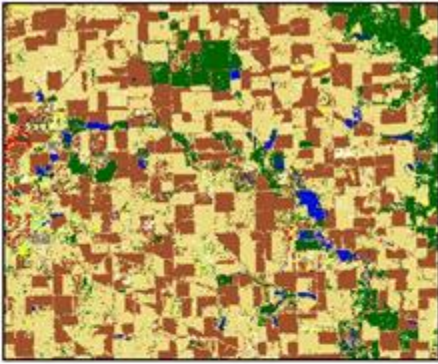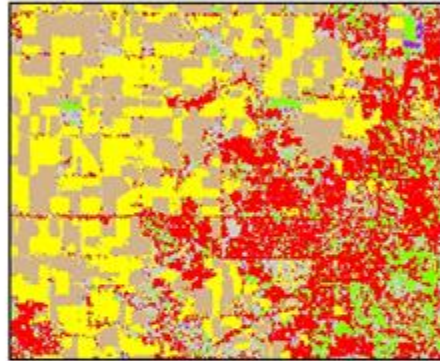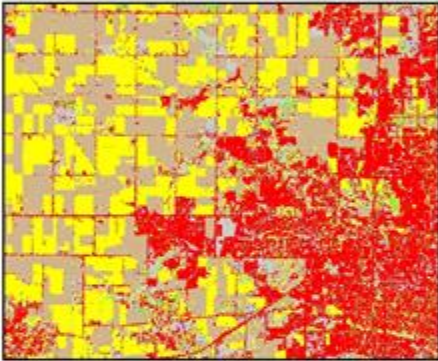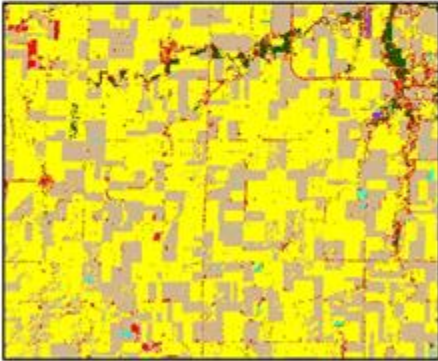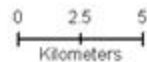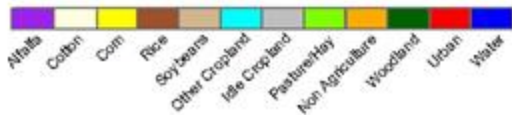
Results

Overall Accuracy
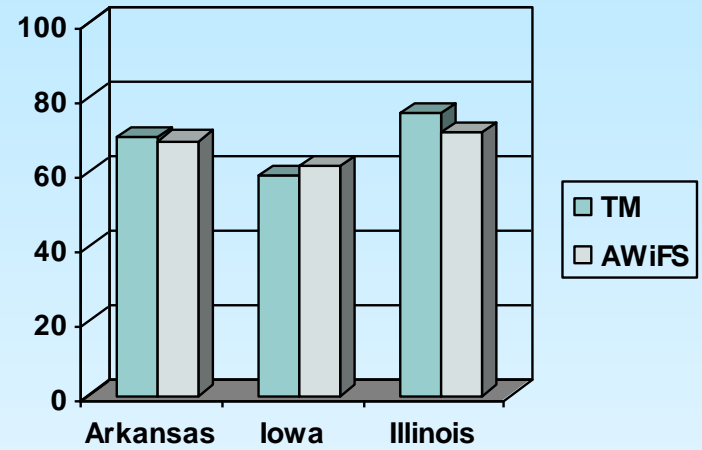
Overall Kappa
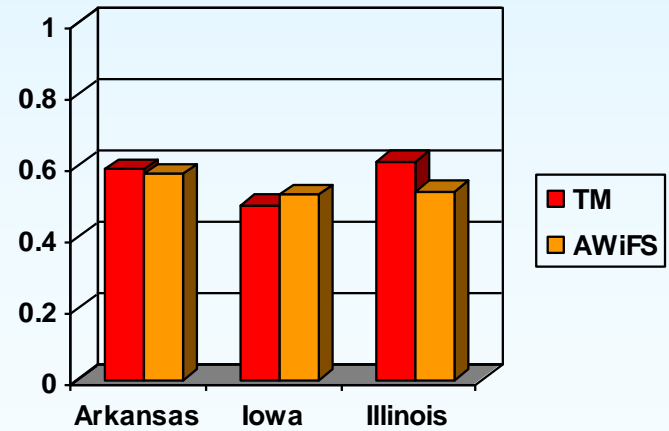
Conclusions:
AWiFS vs. TM evaluations 2004-2005

• AWiFS data are acceptable for crop acreage estimation over large crop areas such as the Midwest, the Delta and the Northern Great Plains.

• Improvements in classification accuracy are achieved due to increased temporal frequency of the AWiFS sensor (5 day) vs. the TM sensor (16 day) repeat cycle.

• The large footprint of the AWiFS sensor provides the opportunity to utilize training and ancillary data over large areas which leads to improved classification accuracies and production efficiencies.

IRS Resourcesat-1 AWiFS Imagery

340 km swath per head
740 km combined

5-day revisit

4 spectral bands
- B2: 0.52 - 0.59
- B3: 0.62 - 0.68
- B4: 0.76 – 0.86
- B5: 1.55 – 1.7

56 m nadir/70 m field edges

Data provided by Arctic Slope
Regional Corporation

ASRC
Management Services

ALTITUDE = 817 Km (Nominal)

GROUND TRACK

INCLINATION = 98.731

MEAN SOLAR TIME = 10.30 am

DIRECTION OF TRAVEL

ORBIT PERIOD = 101.35 minutes
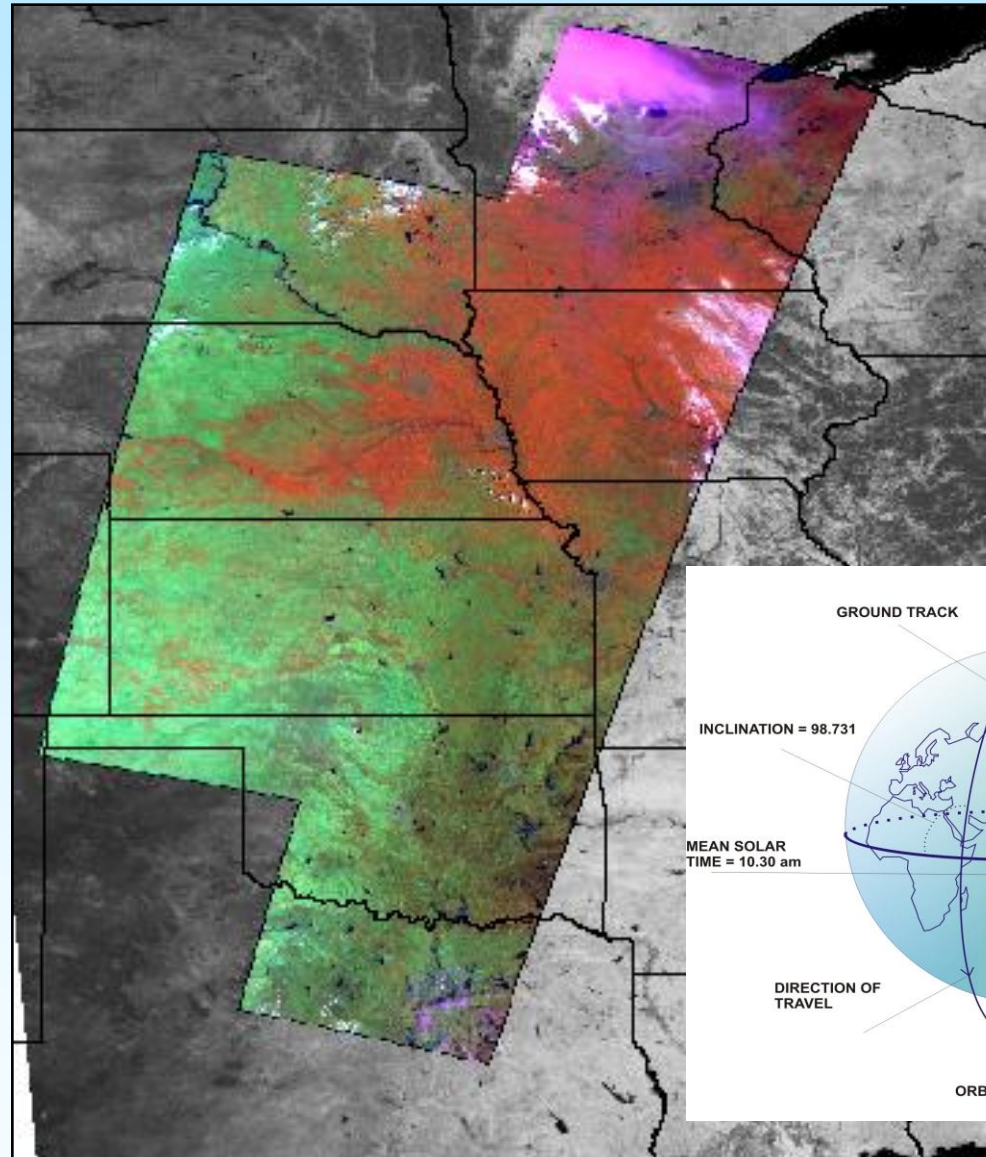
13 Aug 2007

Department of Space
Indian Space Research Organisation

IRS Resourcesat-1 AWiFS Imagery

> **The AWIFS camera is split into two separate electro-optic modules (AWiFS- A and AWiFS-B) tilted by 11.94 degrees with respect to nadir**
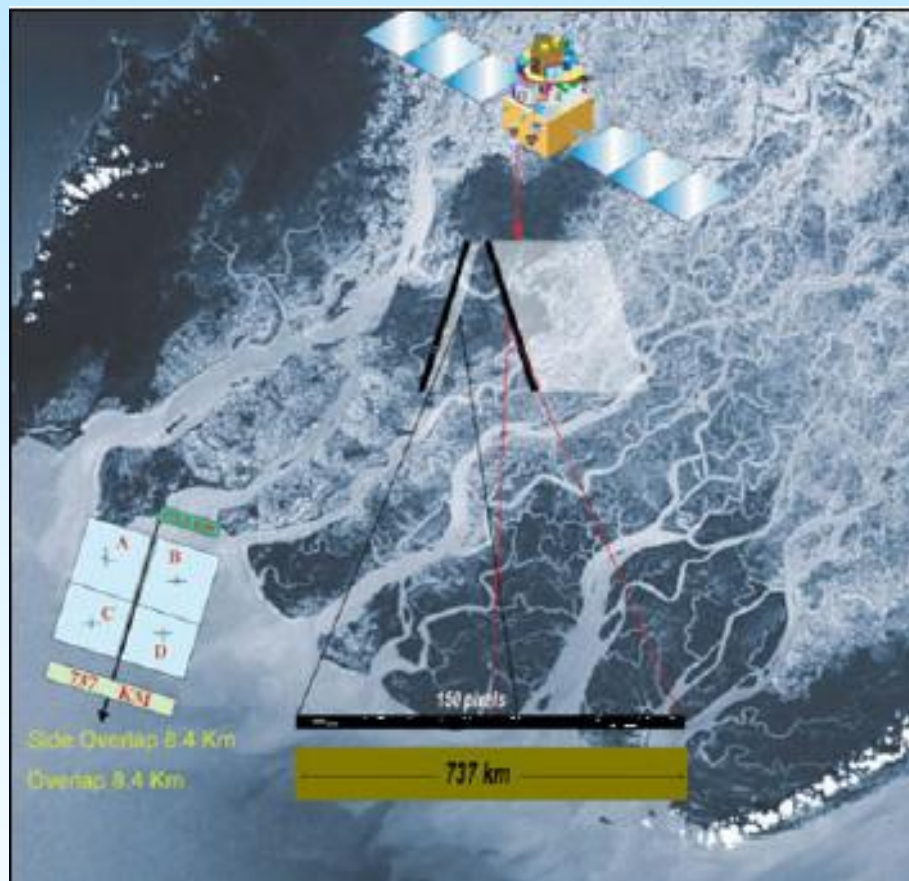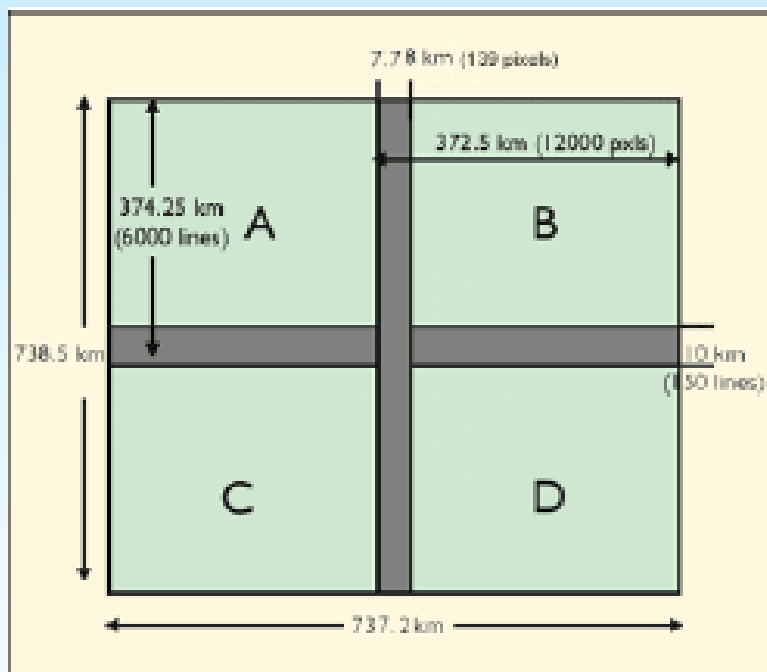
USDA Satellite Image Archive

Active Paths for P6-AWiFS CONUS

Legend

State and Provincial Boundaries

1 DAY Active Paths in April

USDA Satellite Imagery Archive
USDA-Foreign Agricultural Service
Robert Tetrault, Satellite Imagery Archive manager
(202) 690-0130, robert.tetrault@fas.usda.gov
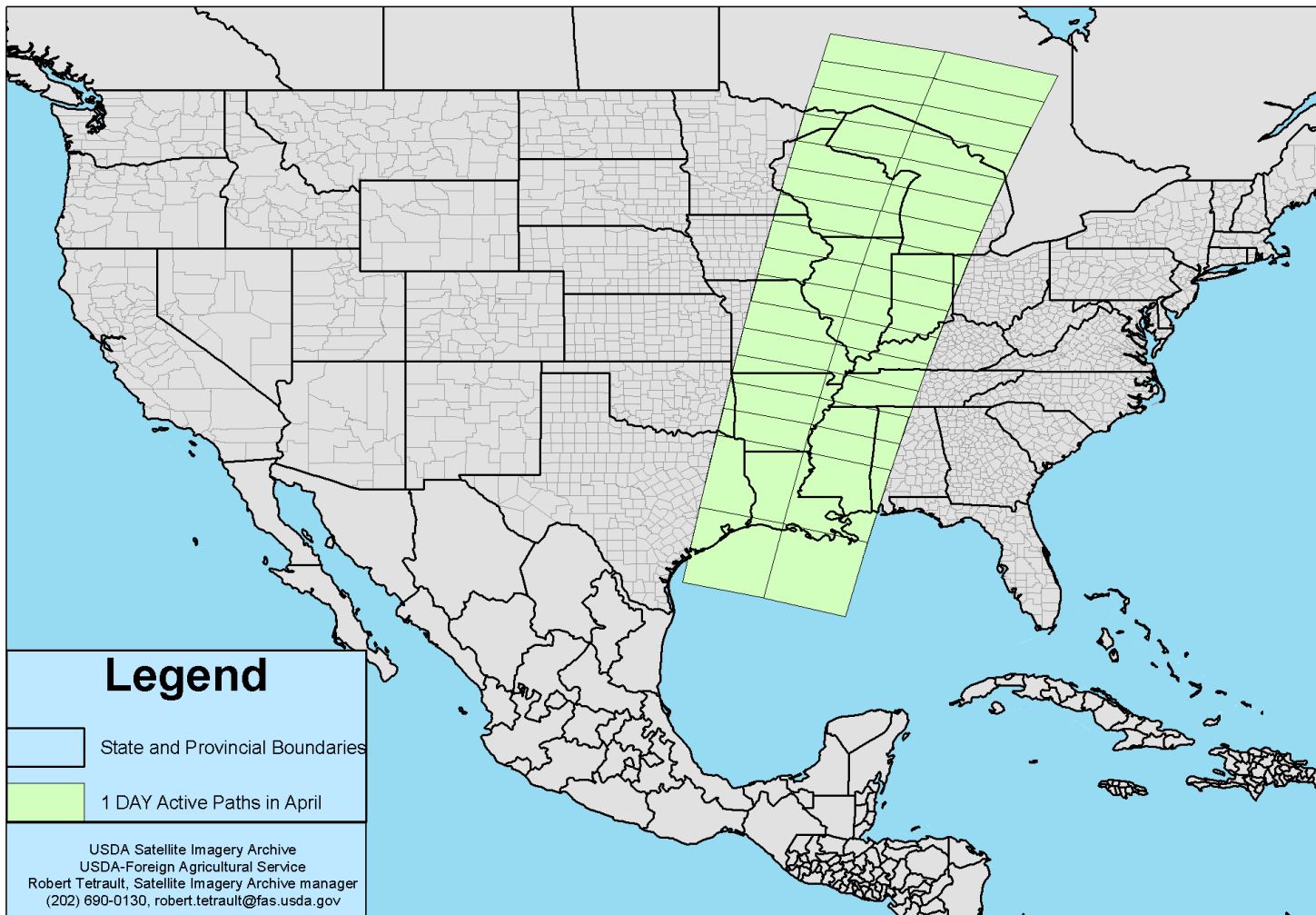
Image Timing

Crop Progress: Corn in Nebraska, 2007
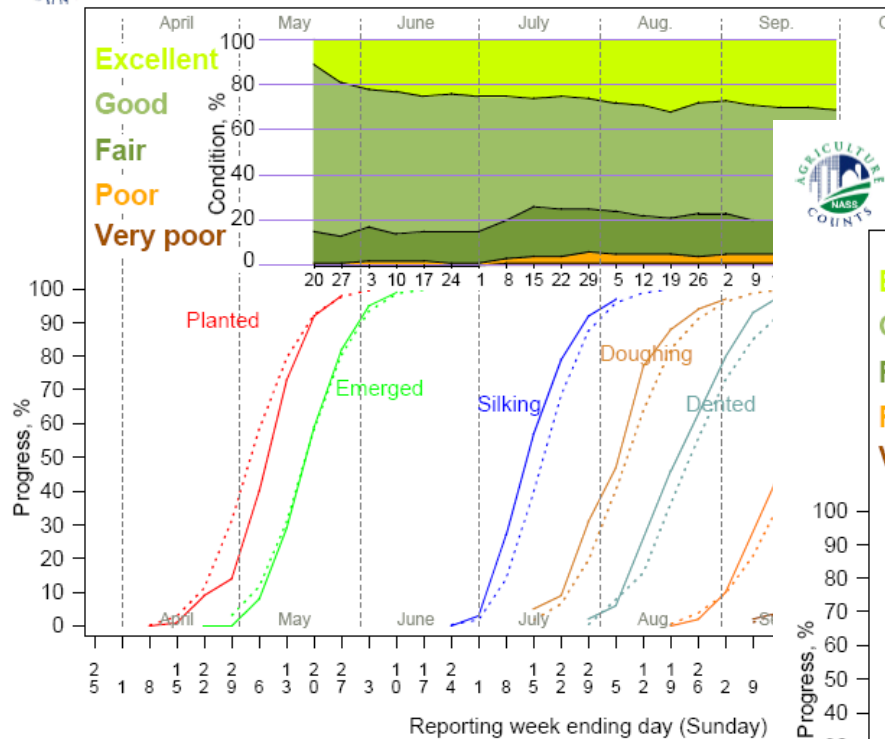
Crop Progress: Soybeans in Nebraska, 2007
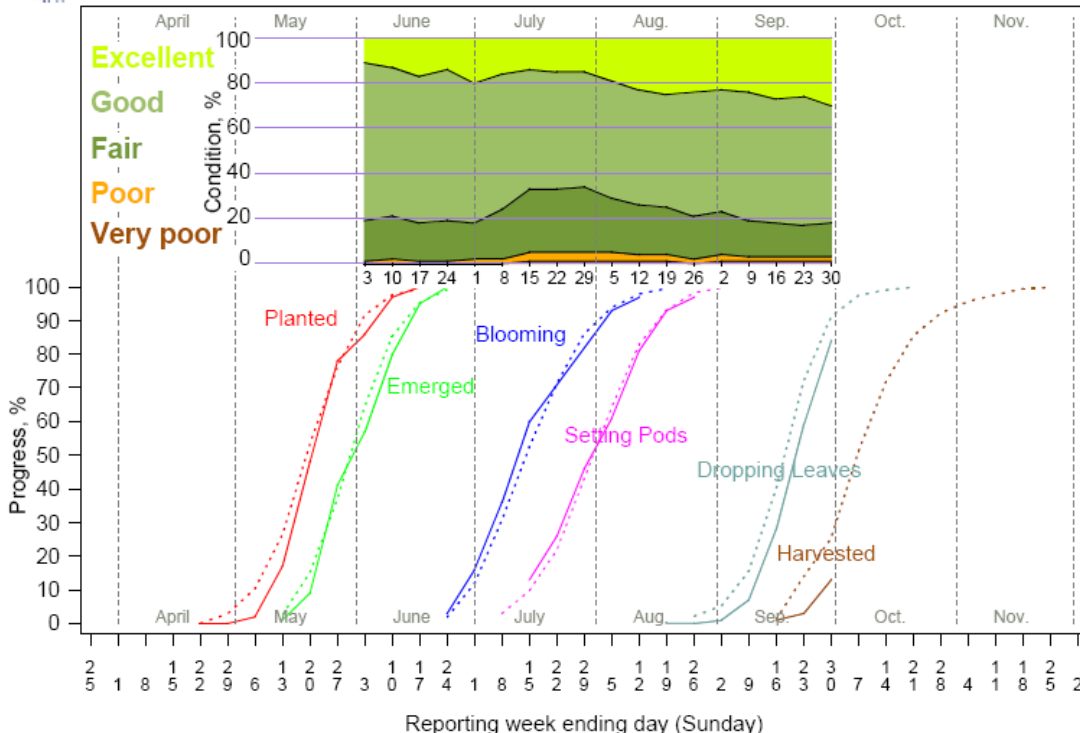
AWiFS Imagery Time Series
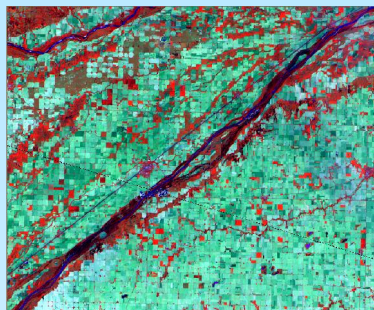
May 18
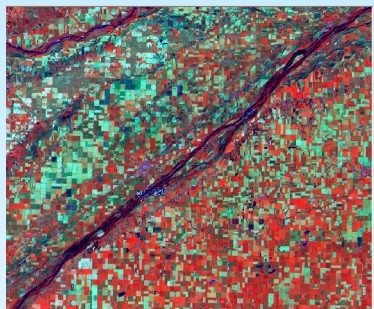
June 21
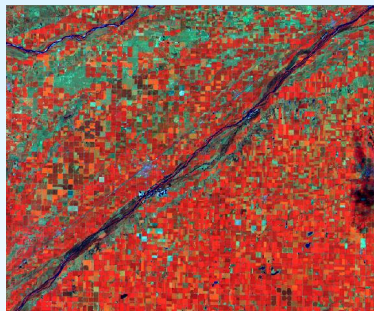
July 15
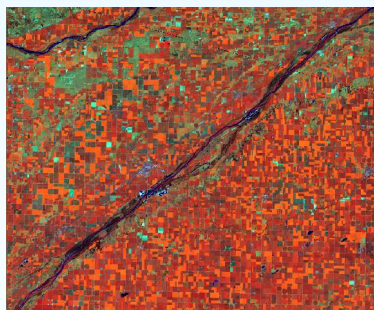
Aug 27
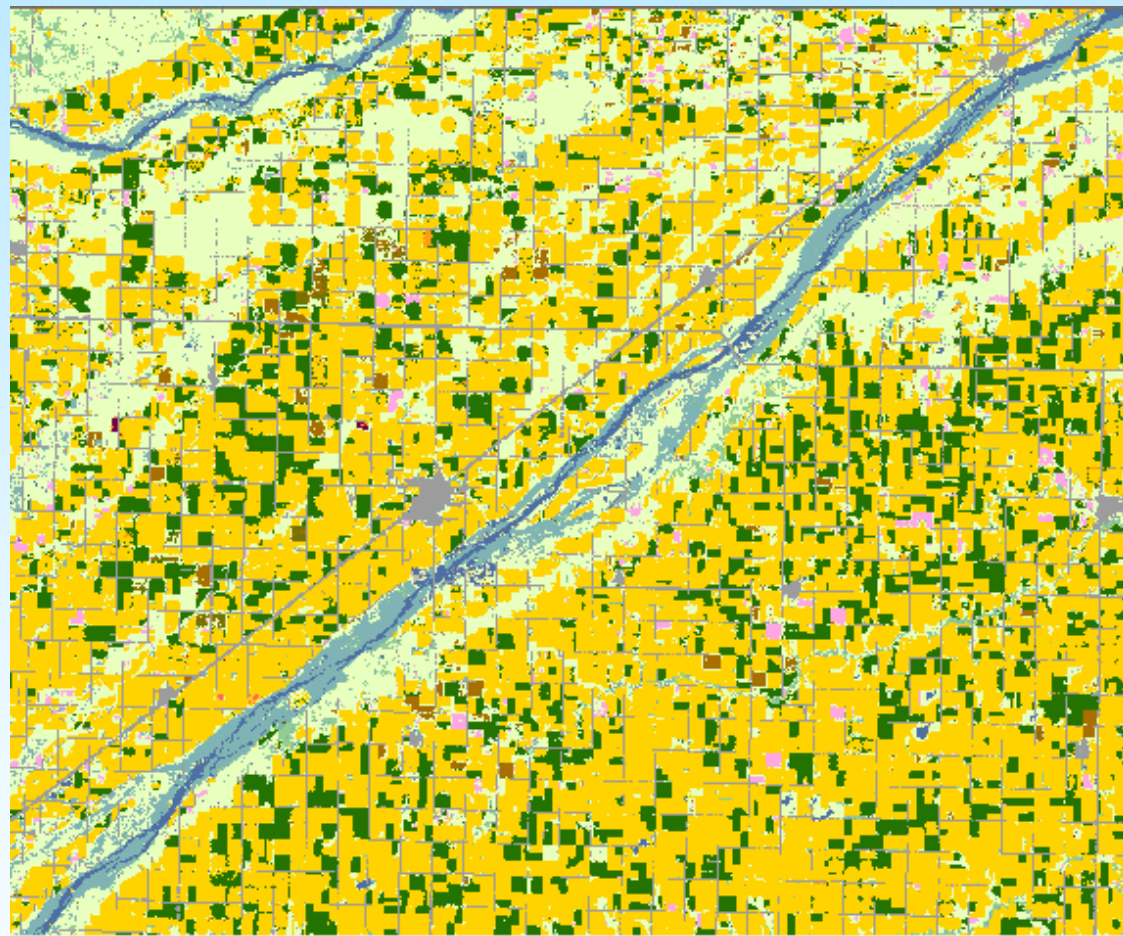
Cropland Data Layer Program Components

- Advanced Wide Field Sensor (AWiFS)
- Ground truth: FSA/CLU + 578 & NLCD
- Ancillary data sets
- Commercial Software Suite
- See5 Decision Tree Methodology
- Estimation
- Research

Ground Truth - Agriculture

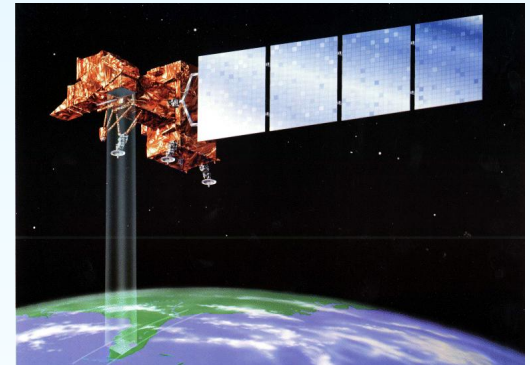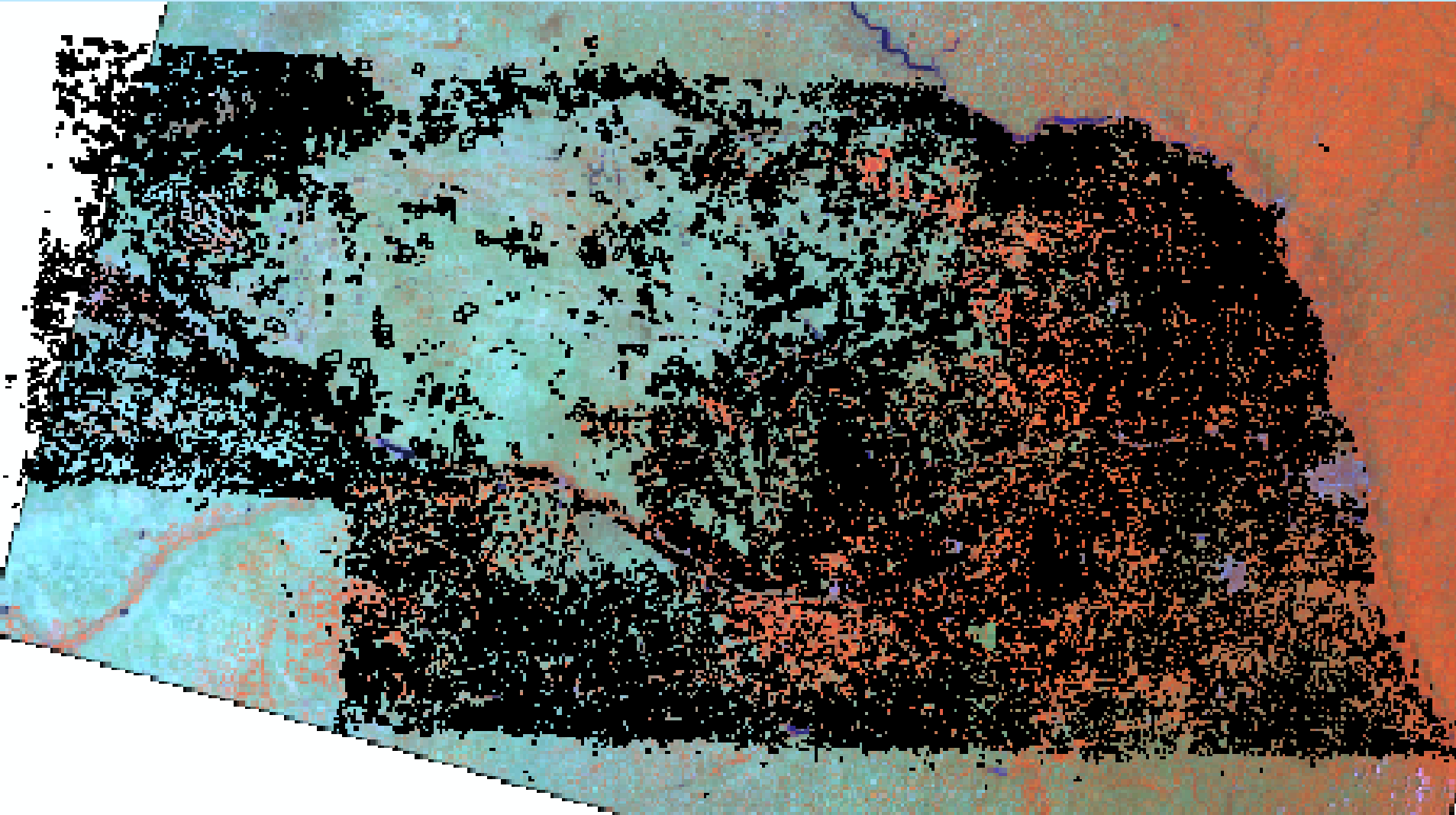NASS June Agricultural Survey (JAS) data still
used for acreage estimation
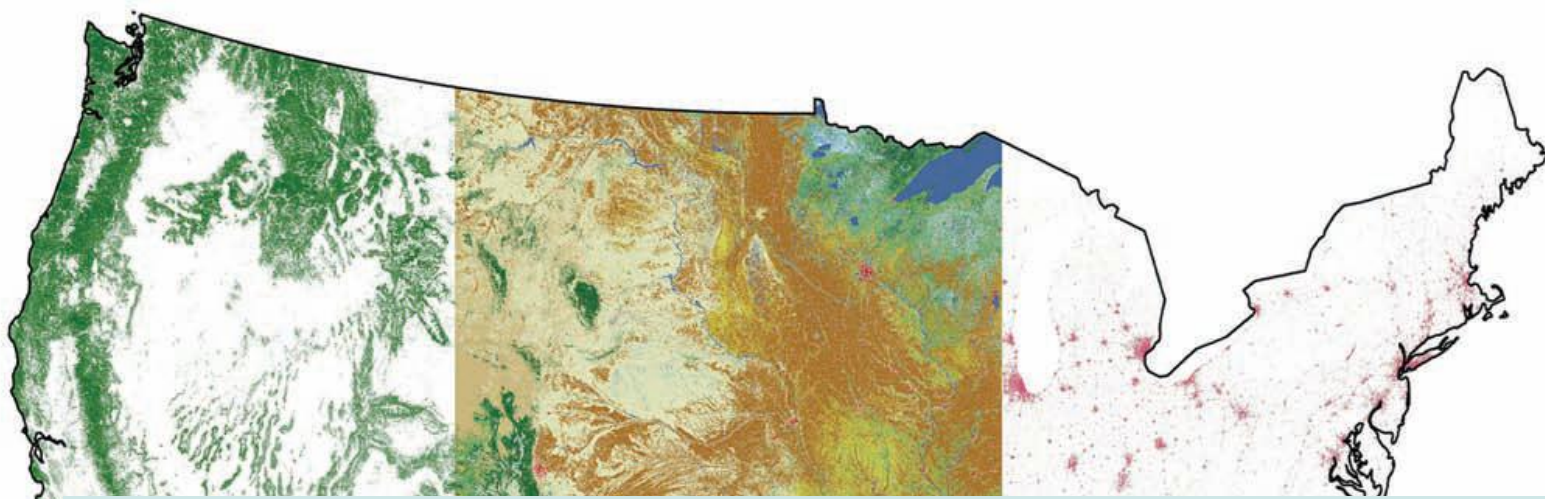
Non-Agricultural Ground Truth
USGS, National Land Cover Dataset 2001

Tree canopy
- 1 to 10%
- 11 to 20%
- 21 to 30%
- 31 to 40%
- 41 to 50%
- 51 to 60%
- 61 to 70%
- 71 to 80%
- 81 to 90%
- 91 to 100%
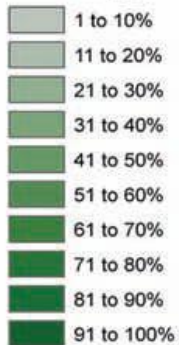
Land Cover Class Value and Description
- (11) Open Water
- (12) Perennial Ice/Snow
- (21) Developed, Open Space
- (22) Developed, Low Intensity
- (23) Developed, Medium Intensity
- (24) Developed, High Intensity
- (31) Barren Land
- (41) Deciduous Forest
- (42) Evergreen Forest
- (43) Mixed Forest
- (52) Shrub/Scrub
- (71) Grassland/Herbaceous
- (81) Hay/Pasture
- (82) Cultivated Crops
- (90) Woody Wetlands
- (95) Emergent Herbaceous Wetlands

Urban Imperviousness
- 1 to 10%
- 11 to 20%
- 21 to 30%
- 31 to 40%
- 41 to 50%
- 51 to 60%
- 61 to 70%
- 71 to 80%
- 81 to 90%
- 91 to 100%

Cropland Data Layer Program Components

- Landsat TM and ETM+ vs. Advanced Wide Field Sensor (AWiFS)

- Ground truth: FSA/CLU + 578 & NLCD

- Ancillary data

- Commercial Software Suite

- See5 Decision Tree Methodology

Ancillary Data – USGS/NASA Products
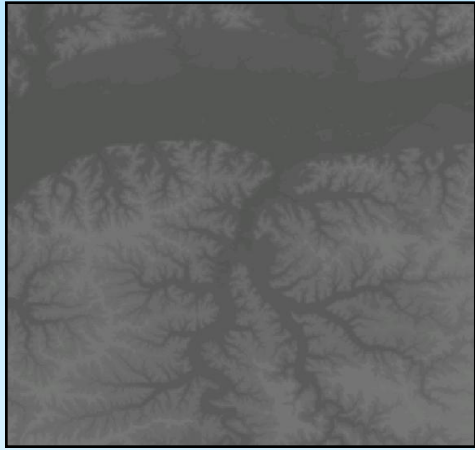
Elevation
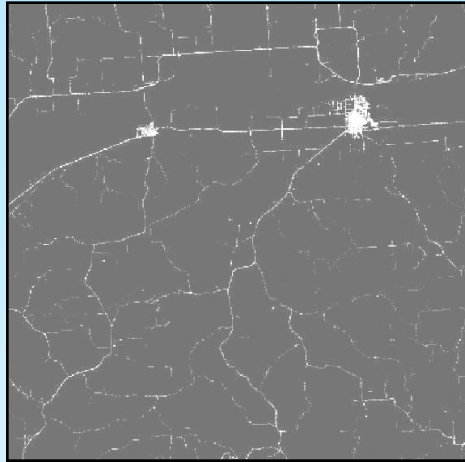
Imperviousness
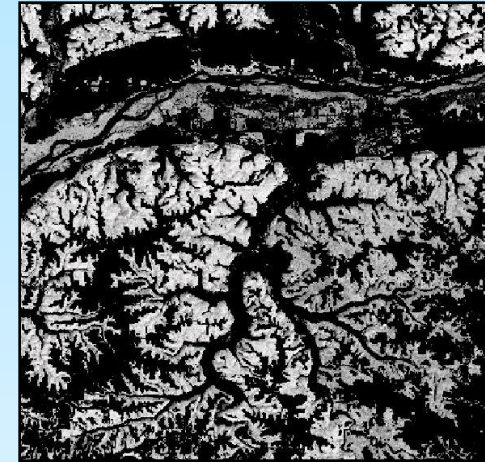
Forest Canopy

NASA MODIS Terra
(16-day NDVI composite)
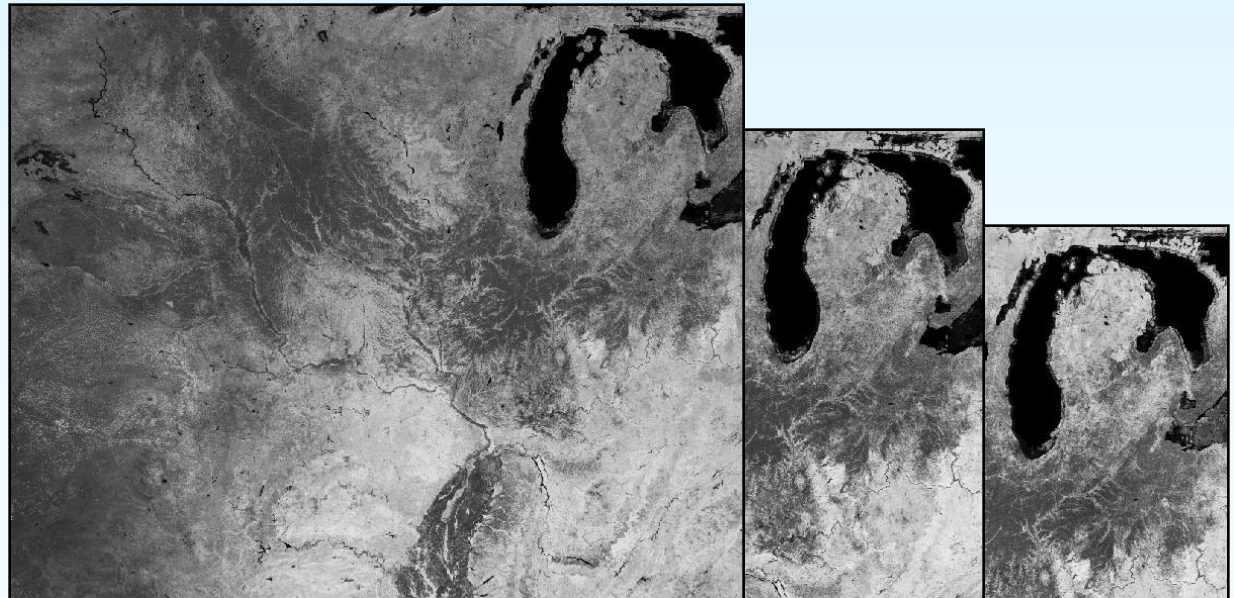
Cropland Data Layer Program Components

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Commercial Software Suite

- ## Imagery Preparation
  - Leica Geosystems ERDAS Imagine

- ## Image classification
  - Decision tree software
    - See5.0 www.rulequest.com

- ## Ground Truth Preparation
  - ESRI ArcGIS

- ## Acreage Estimation
  - SAS/IML workshop

See5 Decision Tree Classifier

State-of-the-art technique for image classification

- Relatively cheap ($750)

Incorporates a powerful ensemble method known as "boosting"

The "NLCD Mapping Tool" was integrated into ERDAS Imagine

- Provided gratis by USGS

5dates.out - WordPad

File Edit View Insert Format Help

```
See5 [Release 2.03]        Tue Dec 26 09:20:26 2006
-------------------

    Options:
      10 boosting trials

Class specified by attribute `dep'

Read 62526 cases (23 attributes) from 5dates.data

-----  Trial 0:  -----

Decision tree:

band15 > 59:
:...band14 <= 34:
:   :...band01 > 33:
:   :   :...band04 > 113: 8 (76)
:   :   :   band04 <= 113:
:   :   :   :...band07 > 105:
:   :   :       :...band05 <= 21: 3 (5/1)
:   :   :       :   band05 > 21:
:   :   :       :   :...band18 > 25: 1 (24
:   :   :       :       band18 <= 25:
:   :   :       :       :...band08 > 66: 1
:   :   :       :           band08 <= 66:
:   :   :       :           :...band08 <=
:   :   :       :               band08 > 6
:   :   :       band07 <= 105:
:   :   :       :...band14 > 27:
:   :   :           :...band06 <= 21: 3 (2
:   :   :               band06 > 21:
```

For Help, press F1

Classifier Construction Options

- [ ] Winnow attributes
- [ ] Rulesets
- [ ] Sort by utility   [ ] bands
- [ ] Boost   [ ] trials
- [ ] Subsets of values
- [ ] Use sample of   [ ] %
- [ ] Lock sample
- [ ] Cross-validate   [ ] folds
- [ ] Ignore costs file

Advanced options
- [ ] Fuzzy thresholds
- [x] Global pruning
  - Pruning CF   [25] %
  - Minimum   [2] cases

[OK] [Defaults] [Cancel]

See5

File Edit Help

hypothyroid

- class and attribute definitions (hypothyroid.names)
- training cases to be analyzed (hypothyroid.data)
- test cases (hypothyroid.test)
- misclassification costs (hypothyroid.costs)
- decision tree classifier (hypothyroid.tree)
- ruleset classifier (hypothyroid.rules)
- output file (hypothyroid.out)

RULEQUEST RESEARCH
data mining tools

NLCD Mapping Tool

- Percent Calculation ...
- NLCD Sampling Tool ...
- Cubist Classifier...
- See5 Classifier...
- Accuracy Assessment...
- Smart Eliminate...
- Cubist Info   See5 Info
- Close

See5 Decision Tree Classifier

Advantages

- Efficient to construct and capable of handling large and complex data sets
- Ingests up to 83 bands of data and three million sampling points
- Incorporates missing and non-continuous data
- Tolerant of outliers (i.e., clouds and errors in ground truth)
- Names files can be altered and different inputs run through classifier (Great for Testing!!)

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

Accuracy Assessment

```
Crop-specific covers only  *Correct  Accuracy   Error   Kappa
-----------------------    -------   --------   -----   -----
OVERALL ACCURACY            740009    93.56%    6.44%   0.8488
```

Cover Type	Attribute Code	*Correct Pixels	Producer's Accuracy	Omission Error	Kappa	User's Accuracy	Commission Error	Cond'l Kappa
Corn	1	28358	95.36%	4.64%	0.9528	93.08%	6.92%	0.9297
Cotton	2	11757	95.08%	4.92%	0.9505	94.59%	5.41%	0.9456
Rice	3	2	28.57%	71.43%	0.2857	66.67%	33.33%	0.6667
Sorghum	4	21251	89.85%	10.15%	0.8972	92.46%	7.54%	0.9236
Soybeans	5	12885	86.15%	13.85%	0.8604	88.61%	11.39%	0.8851
Sunflowers	6	102	89.47%	10.53%	0.8947	99.03%	0.97%	0.9903
Peanuts	10	512	90.14%	9.86%	0.9014	92.09%	7.91%	0.9208
Barley	21	785	71.95%	28.05%	0.7194	97.39%	2.61%	0.9739
Durum Wheat	22	48	42.86%	57.14%	0.4286	100.00%	0.00%	1.0000
Spring Wheat	23	205	56.47%	43.53%	0.5647	99.03%	0.97%	0.9903
Winter Wheat	24	580437	97.54%	2.46%	0.9631	94.00%	6.00%	0.9117
Other Small Grains	25	1120	56.97%	43.03%	0.5694	93.57%	6.43%	0.9356
Win Wht /Soyb Dbl Crop	26	14758	79.51%	20.49%	0.7932	90.06%	9.94%	0.8996
Rye	27	13249	66.90%	33.10%	0.6664	91.39%	8.61%	0.9129
Oats	28	2941	64.85%	35.15%	0.6479	95.18%	4.82%	0.9517
Millet	29	439	77.02%	22.98%	0.7701	96.48%	3.52%	0.9648
Canola	31	337	75.90%	24.10%	0.7590	98.83%	1.17%	0.9883
Alfalfa	36	19653	88.21%	11.79%	0.8807	91.78%	8.22%	0.9168
Dry Beans	42	115	88.46%	11.54%	0.8846	93.50%	6.50%	0.9350
Potatoes	43	49	96.08%	3.92%	0.9608	100.00%	0.00%	1.0000
Other Crops	44	50	45.87%	54.13%	0.4587	80.65%	19.35%	0.8064
Misc Vegs & Fruits	47	33	54.10%	45.90%	0.5410	86.84%	13.16%	0.8684
Watermelon	48	24	77.42%	22.58%	0.7742	85.71%	14.29%	0.8571
Peas	53	188	72.59%	27.41%	0.7258	96.91%	3.09%	0.9691
Clover/Wildflowers	58	21	36.21%	63.79%	0.3621	75.00%	25.00%	0.7500
Fallow/Idle Cropland	61	30612	69.78%	30.22%	0.6922	90.48%	9.52%	0.9025
Peaches	67	9	36.00%	64.00%	0.3600	100.00%	0.00%	1.0000
Other Tree Nuts & Fruit	71	69	33.82%	66.18%	0.3382	83.13%	16.87%	0.8313

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

Cropland Data Layer Program Components

- Advanced Wide Field Sensor (AWiFS)
- Ground truth: FSA/CLU + 578 & NLCD
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- Commercial Software Suite
- See5 Decision Tree Methodology
- Estimation
- Research

Arkansas Area Sampling Frame
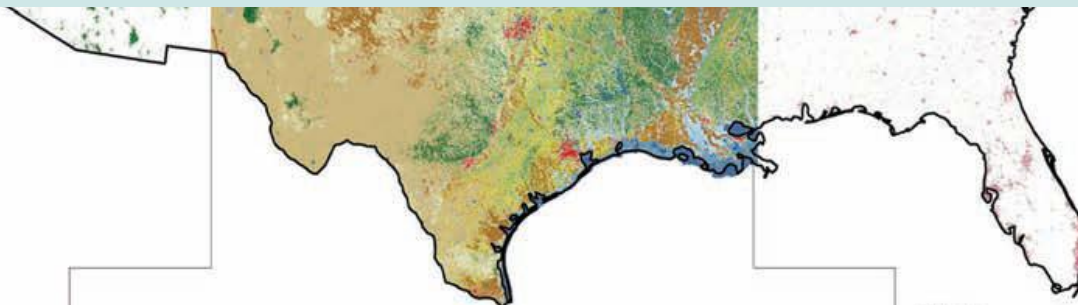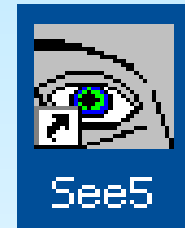
- 11: > 75% cultivated
- 21: 25 - 75% cultivated
- 31: Agri-Urban
- 32: Commercial
- 42: < 25% cultivated
- 50: Non-Agricultural
- 62: Water
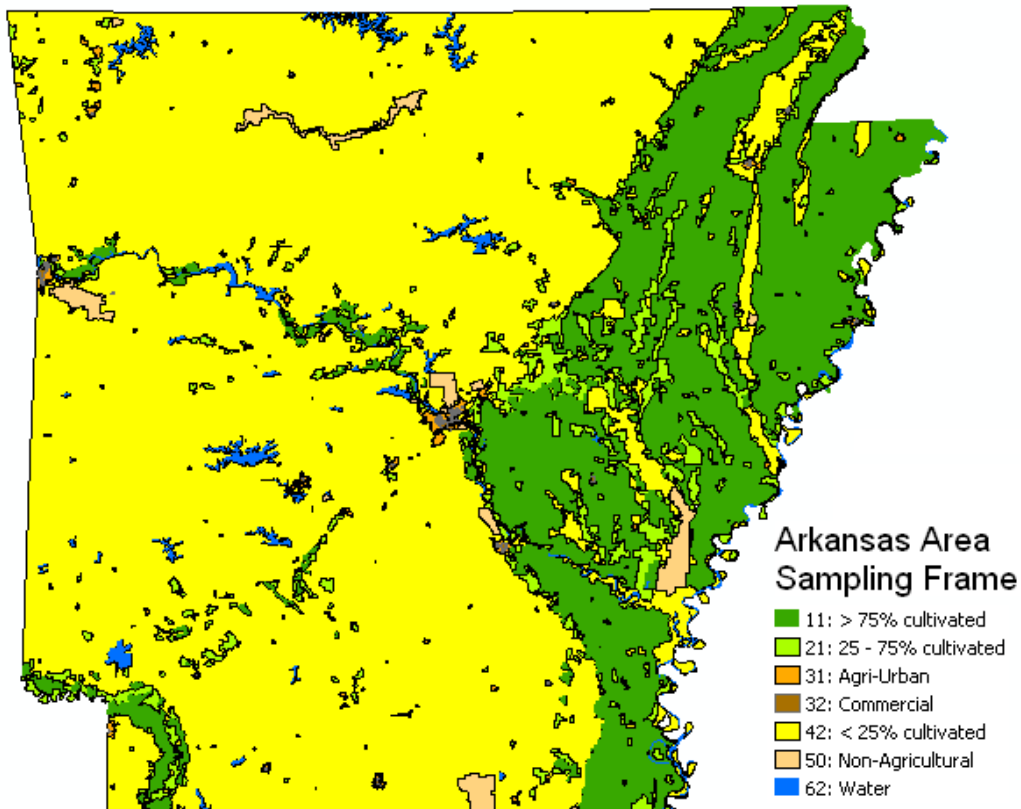
SECTION D - CROPS AND LAND USE ON TRACT

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	
1.	Total acres in field	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
6.	Pasture — Permanent (not in crop rotation)	842	842	842
		856	856	856

Estimation Components: Area Sampling Frame+ June Ag Survey+ Questionnaire

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
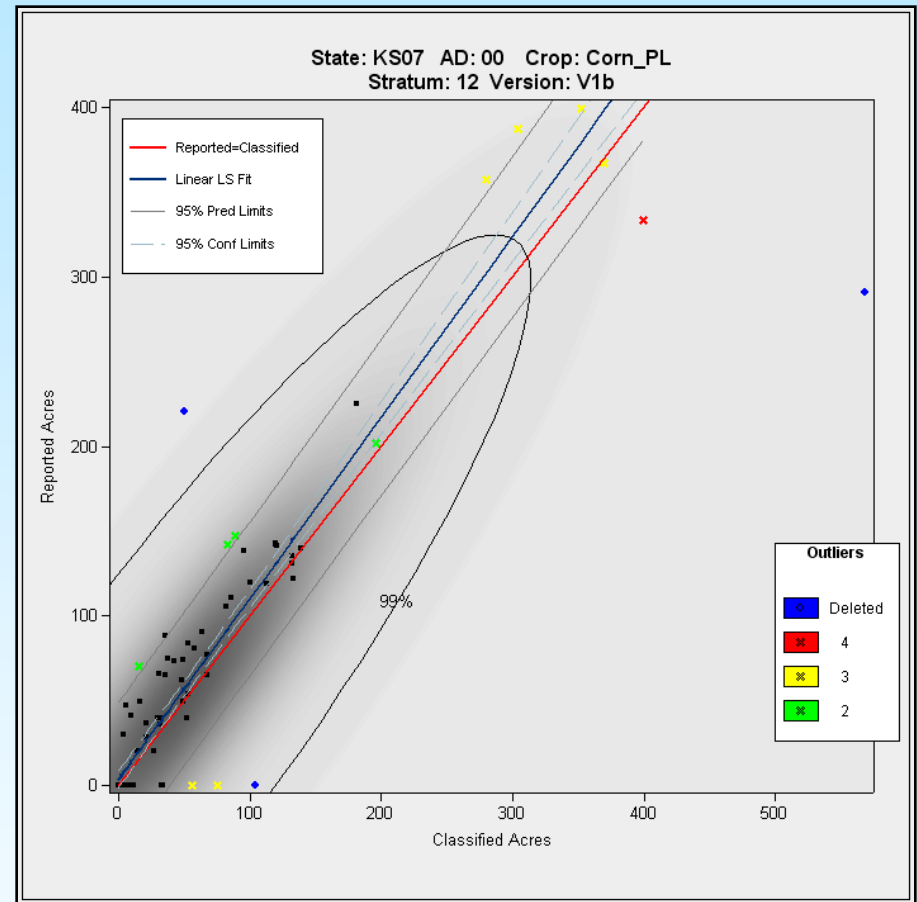
Acreage not just about counting pixels

Cropland Data Layer Summary

- **Operational Program, 2007**
  - Early delivery of estimates, 2008
    - Winter Wheat – June
    - Corn and Soybeans – August & October
  - Provides measureable statistical error
  - Results considered for setting national acreage estimate
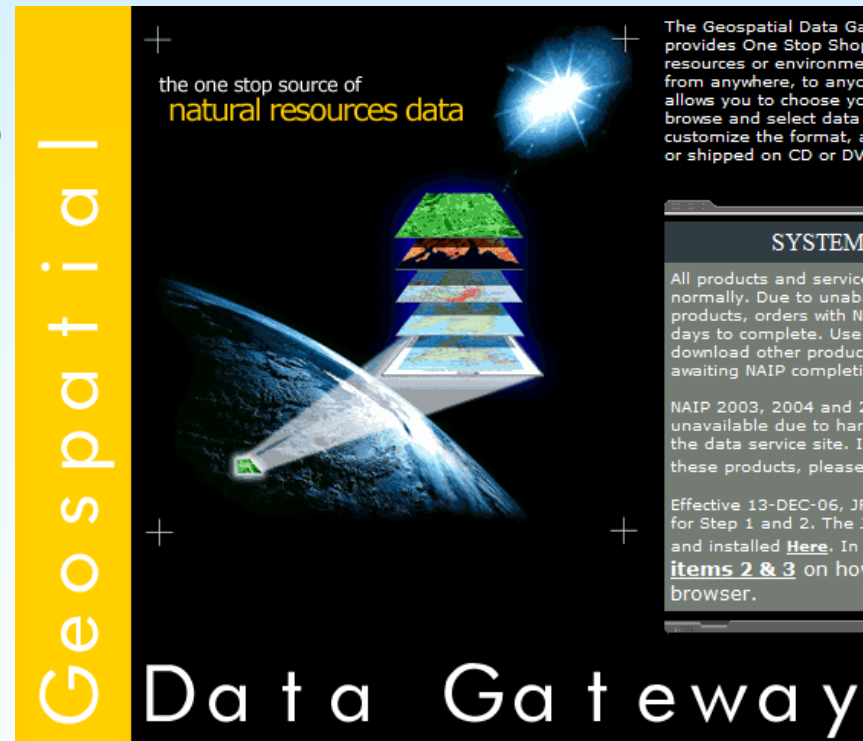
- **Components**
  - AWiFS/MODIS
  - Farm Service Agency
    - Common Land Unit (training/testing)
  - Commercial Software
  - June Agricultural Survey
    - Regression estimator

- **Distribution**
  - datagateway.nrcs.usda.gov

Cropland Data Layer Program Components

- Advanced Wide Field Sensor (AWiFS)
- Ground truth: FSA/CLU + 578 & NLCD
- Ancillary data sets
- Commercial Software Suite
- See5 Decision Tree Methodology
- Estimation
- Research

Research 2007-2008

AWiFS Essential Dates Assessment

Goal: To determine the necessary dates of AWiFS data for the identification of corn and soybean fields in the U.S. Heartland.
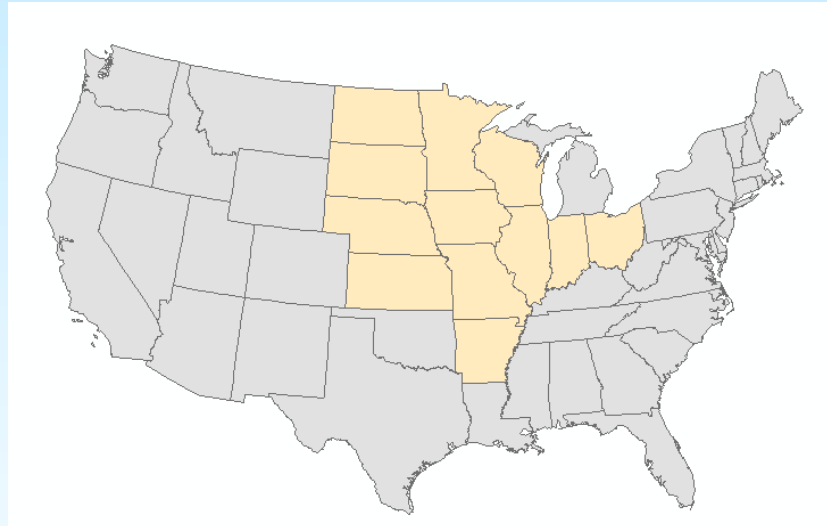
Corn

Soybeans

Methodology
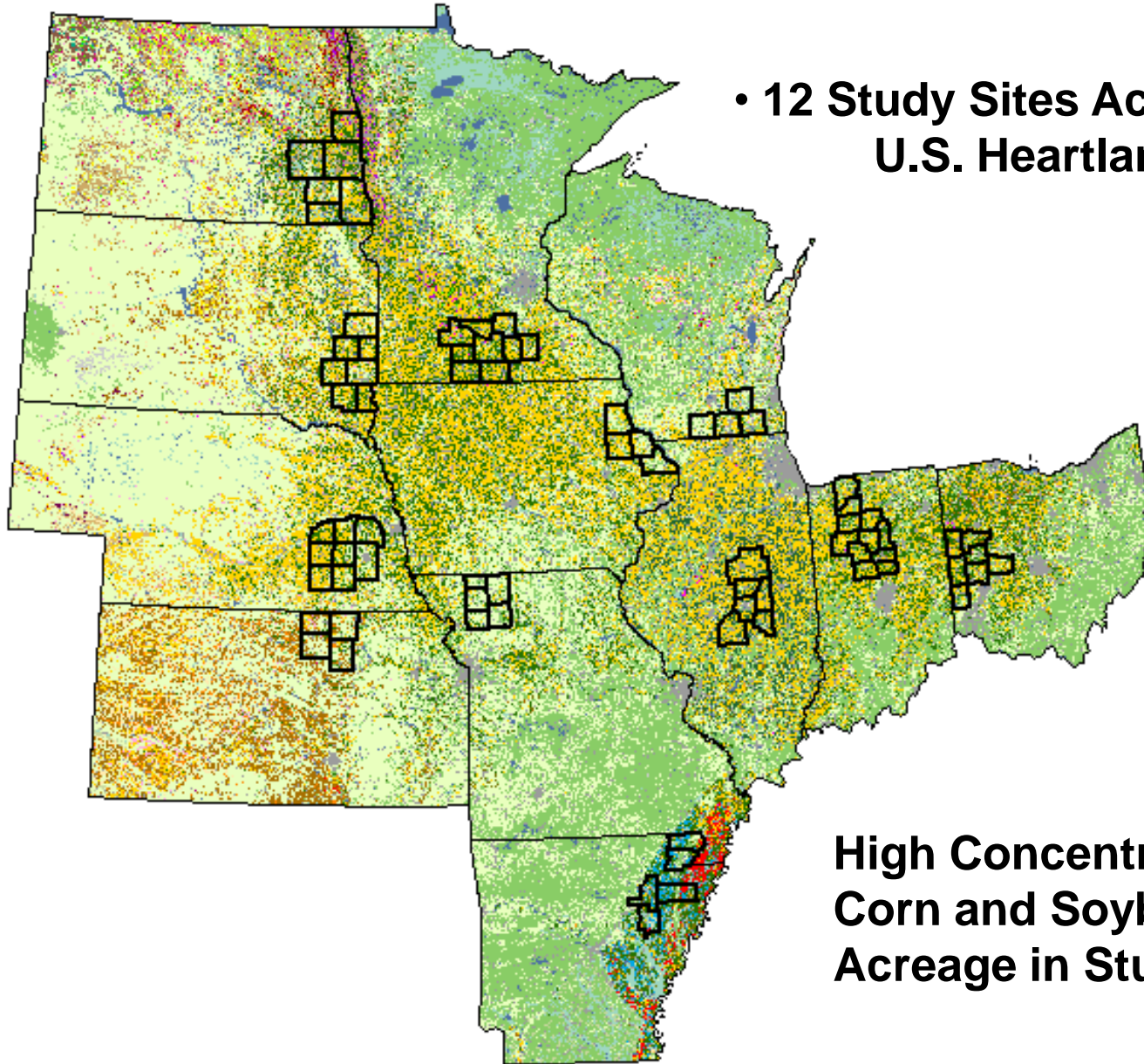
- **12 Study Sites Across the U.S. Heartland**

High Concentration of Corn and Soybean Acreage in Study Sites

Methodology

Identical Methodologies using ERDAS Imagine and See5 Decision Tree Software

Seven Classifications (per study site) vary only by the dates of AWiFS data used

4 dates- May, June, July, August

3 dates- May, June, July

2 dates- May, June

1 date - May

1 date - June

1 date - July

1 date - August

Average Corn and Soybean Accuracy U.S. Heartland

**Percentage loss in accuracy highlighted
from 4 date (May – Aug) classification**

May - Aug		May - July		May - June		May Only	
C. P	C.U.	C.P	C.U.	C.P	C.U.	C.P	C.U.
94.55%	94.48%	92.61%	93.07%	82.58%	82.10%	74.34%	66.48%
		(1.94%)	(1.41%)	(11.97%)	(12.38%)	(20.21%)	(28.00%)

May - Aug		May - July		May - June		May Only	
S. P	S.U.	S.P	S.U.	S.P	S.U.	S.P	S.U.
93.90%	92.81%	89.88%	88.88%	72.25%	74.51%	47.39%	62.04%
		(4.02%)	(3.93%)	(21.65%)	(18.30%)	(46.51%)	(30.77%)

Accuracy Measures

C.P. - Corn Producer   **S.P. - Soybean Producer**
C.U. - Corn User   **S.U. - Soybean User**

Conclusions

- **Without August AWiFS Data- Reductions in Accuracy**
  - **Corn: 1.41% - 1.94%**
  - **Soybeans: 3.93% – 4.02%**

- **Without July and August AWiFS Data-Reductions in Accuracy**
  - **Corn: 11.97% - 12.38%**
  - **Soybeans: 18.30% - 21.65%**

- **AWiFS collects through July are essential to produce highly accurate corn and soybean classifications.**

CDL Production Schedule

January
Su Mo Tu We Th Fr Sa
1 2 3 4 5

8:● 15:◐ 22:○ 30:◐

February
Su Mo Tu We Th Fr Sa
1 2

6:● 13:◐ 20:○ 28:◐

March
Su Mo Tu We Th Fr Sa
1

7:● 14:◐ 21:○ 29:◐

April
Su Mo Tu We Th Fr Sa
1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30

5:● 12:◐ 20:○ 28:◐

May
Su Mo Tu We Th Fr Sa
1 2 3
4 5 6 7 8 9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30 31

5:● 11:◐ 19:○ 27:◐

June
Su Mo Tu We Th Fr Sa
1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 (30)

3:● 10:◐

Crop Acreage Report CDL winter wheat

July
Su Mo Tu We Th Fr Sa
1 2 3 4 5

2:● 10:◐ 18:○ 25:◐

August
Su Mo Tu We Th Fr Sa
1 2
4 5 6 7 8 9
11 (12) 13 14 15 16
18 19 20 21 22 23
25 26 27 28 29 30
31

1:● 8:◐ 16:○ 23:◐ 30:●

Crop Production Report CDL all crops

September
Su Mo Tu We Th Fr Sa
1 2 3 4 5 6
7 8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
28 29 (30)

7:◐

Small Grains Annual Summary CDL small grains

October
Su Mo Tu We Th Fr Sa

7:◐ 14:○ 21:◐ 28:●

Crop Production Report CDL all crops

November
Su Mo Tu We Th Fr Sa

5:◐ 13:○ 19:◐ 27:●

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

December
Su Mo Tu We Th Fr Sa
3 4 5 6
10 11 12 13
17 18 (19) 20
24 25 26 27
31

5:◐ 12:○ 19:◐ 27:●

Research 2008-2009

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

Years
Planted
to Soybeans

1
2
3
4
5
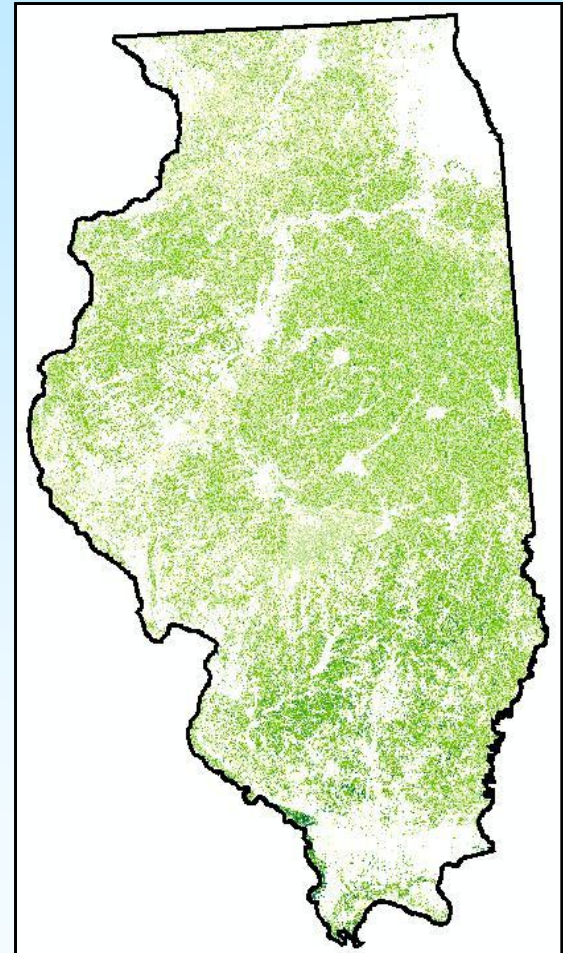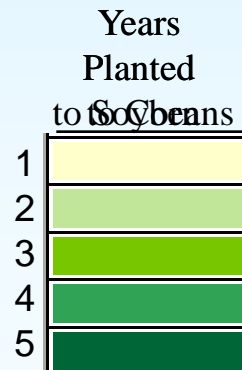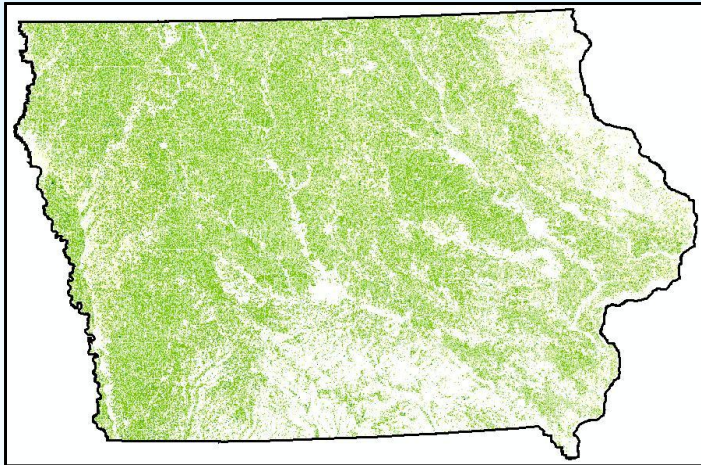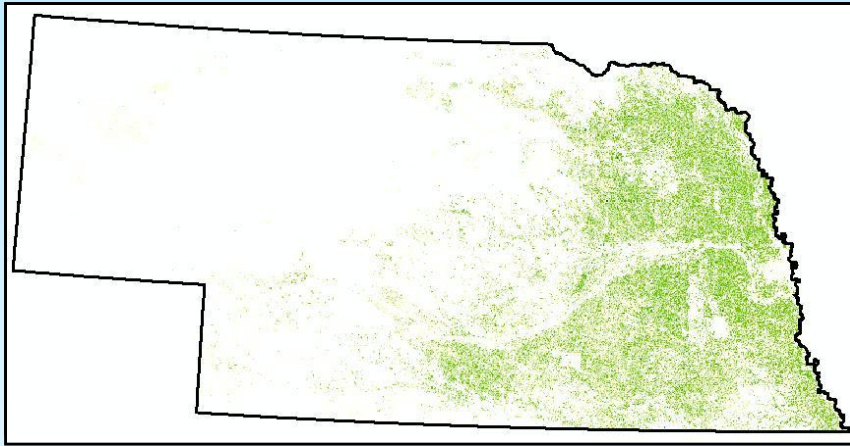
Corn Planting Intensity in Nebraska
2004 - 2008
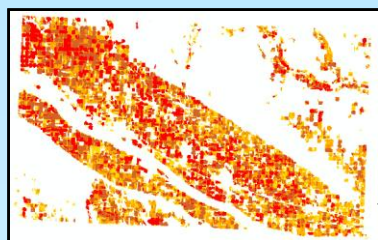
Dawson, NE
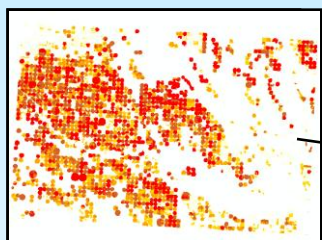
Chase, NE
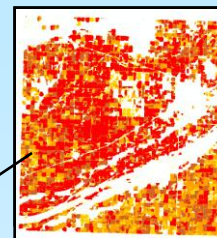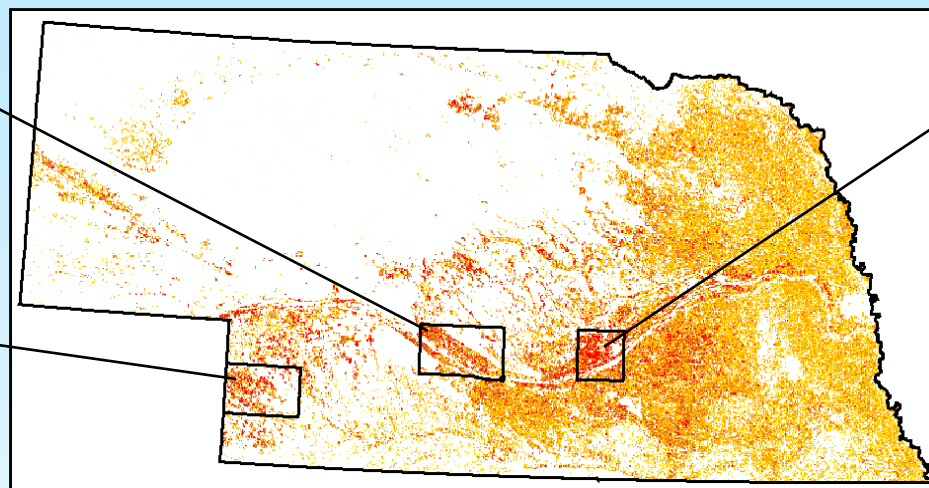
Hall, NE

Years Planted to Corn

Years Planted to Corn
0
1
2
3
4
5
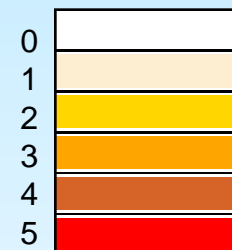
Hall County	Chase County	Dawson County	State Total
5 years in a row planted to corn: **43%**	5 years in a row planted to corn: **28%**	5 years in a row planted to corn: **21%**	5 years in a row planted to corn: **7%**
4 out of 5 years planted to corn: **22%**	4 out of 5 years planted to corn: **21%**	4 out of 5 years planted to corn: **29%**	4 out of 5 years planted to corn: **13%**

Crop Rotation Methodology

1. Inputs include: Cropland Data Layers (CDLs) for 2004 - 2008

2. CDLs are recoded to
   2008: Corn: 1, Soy: 2, Other: 3
   2007: Corn: 10, Soy: 20, Other: 30
   2006: Corn: 100, Soy: 200, Other: 300
   2005: Corn: 1,000, Soy: 2,000, Other: 3,000
   2004: Corn: 10,000, Soybeans: 20,000, Other: 30,000

3. The recoded CDLs are added together using the ERDAS Imagine Modeler

4. The output is the Crop Rotation Image which is ready for evaluation

Crop Rotation Results
Nebraska

**Crop Rotation Patterns (Corn and Soybean) 04- 08
As Percentage of
Total Cultivated Cropland**
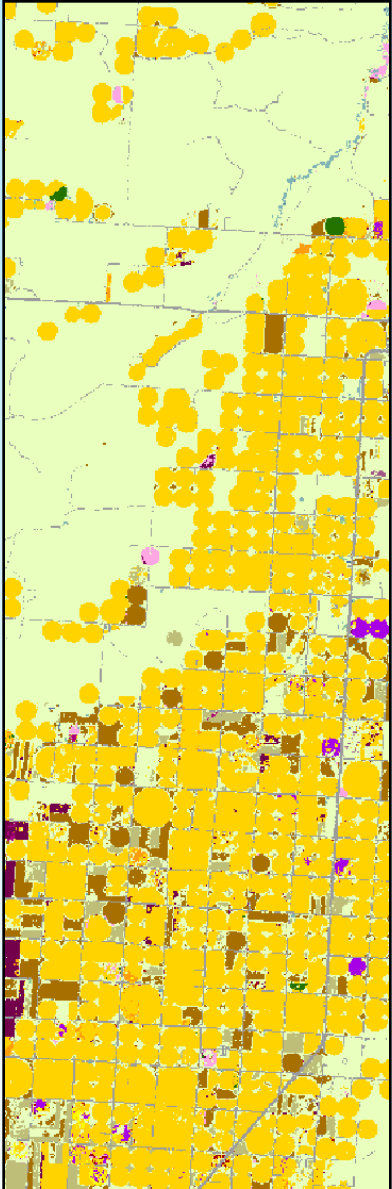
Corn (04), Soy (05), Corn (06), Soy (07), Corn (08)	**10.1%**
Soy (04), Corn (05), Soy (06), Corn (07), Soy (08)	**9.3%**
Corn (04), Corn (05), Corn (06), Corn (07), Corn (08) (.3% < than 2003-2007)	**7.5%**
Additional acreage into corn production (07):	**309,688** acres
Additional acreage into corn production (08):	**503,221** acres

Total Cultivated Cropland derived from NASS' Nebraska 2008 CDL

Additional Information and *Free* Downloads:
http://www.nass.usda.gov/research/

Proposed 2009 CDL States

Bureau Of The Census

Cartographer

SALARY RANGE: 43,521.00 - 95,026.00 USD per year

OPEN PERIOD: Thursday, April 02, 2009 to Thursday, April 23, 2009

SERIES & GRADE: GS-1370-07/12

POSITION INFORMATION: Full-Time

Type of Appointment: Competitive Service: Appointment may be permanent (career/career-conditional) or term (appointment not to exceed 2 years; may be extended an additional 2 years)

PROMOTION POTENTIAL: 12

DUTY LOCATIONS: vacancy(s) in one of the following locations: FEW vacancies - Washington, DC (Suitland, MD)

WHO MAY BE CONSIDERED:

Applications will be accepted from United States citizens.

Department of Commerce employees eligible for the Career Transition Assistance Program (CT

Applicants eligible for the Interagency Career Transition Assistance Program (ICTAP).

JOB SUMMARY:
POSITION AND SALARY: Cartographer

GS-1370-07 ($43,521-$53,574)

GS-1370-09 ($50,408-$65,531 per year)

GS-1370-11 ($60,989-$79,280 per year)

GS-1370-

Duty Loc

Federal Agencies Currently Hiring in the Geospatial Field

Economic Research Service

National Oceanic And Atmospheric Administration

U.S. DEPARTMENT OF THE INTERIOR
National Park Service

AFPC Air Force Personnel Center

USGS U.S. DEPARTMENT OF THE INTERIOR U.S. Geological Survey
science for a changing world

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY
Know the Earth ... Show the Way

USAJOBS "WORKING FOR AMERICA"

Thank You

Claire Boryan, Rick Mueller, Mike Craig, Dave Johnson, Bob Seffrin, Patrick Willis, Larry Beard, Zhengwei Yang and Lee Ebinger

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