Monitoring the Spatial Extent of Bioenergy Crops and Estimating Acreage with AWiFS Imagery

Special Session — Monitoring, Mapping, and Estimating the Bioenergy Domain

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National Agricultural Statistics Service

Bioenergy Support

- President Obama inaugural speech

  "We will harness the sun and the winds and the soil to fuel our cars and run our factories"

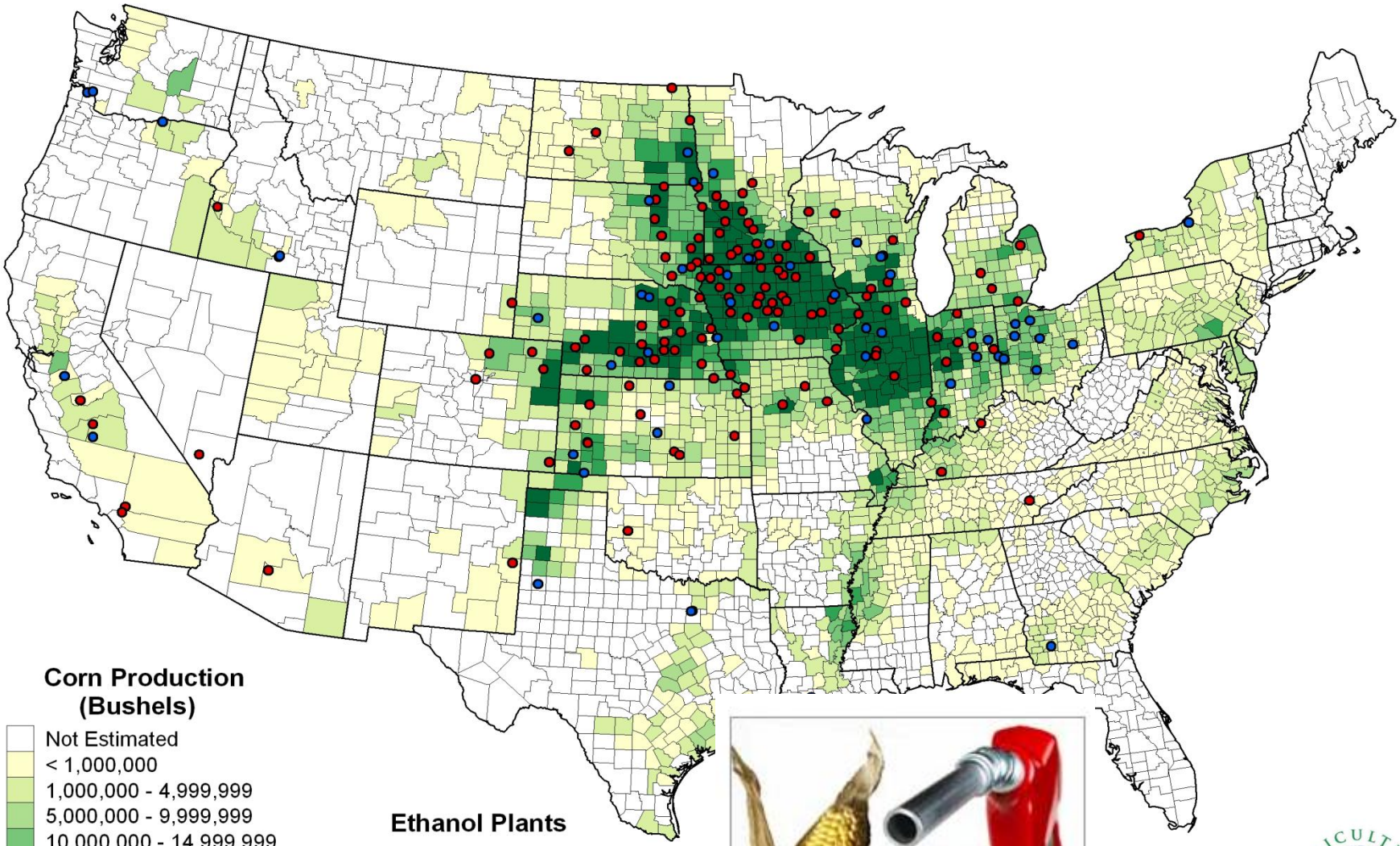
- USDA Secretary Tom Vilsak

  Advancing research and development and pursuing opportunities to support the development of biofuels

Biofuel Corn

- Technological wonder
  - Renewable fuel
  - Feed for many
  - Replicate itself
  - Increased productivity

Corn for Grain 2007
Production by County and Location of Ethanol Plants



Corn Production (Bushels)

- Not Estimated
- < 1,000,000
- 1,000,000 - 4,999,999
- 5,000,000 - 9,999,999
- 10,000,000 - 14,999,999
- 15,000,000 - 19,999,999
- 20,000,000 +

Ethanol Plants

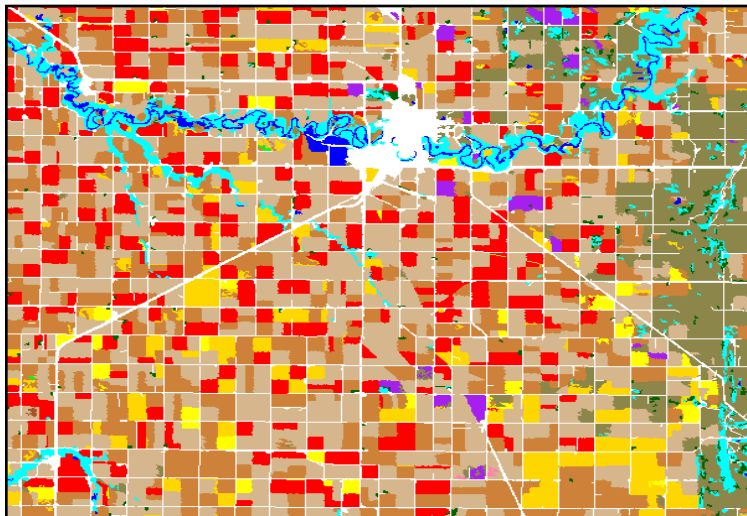
- Construction
- Producing

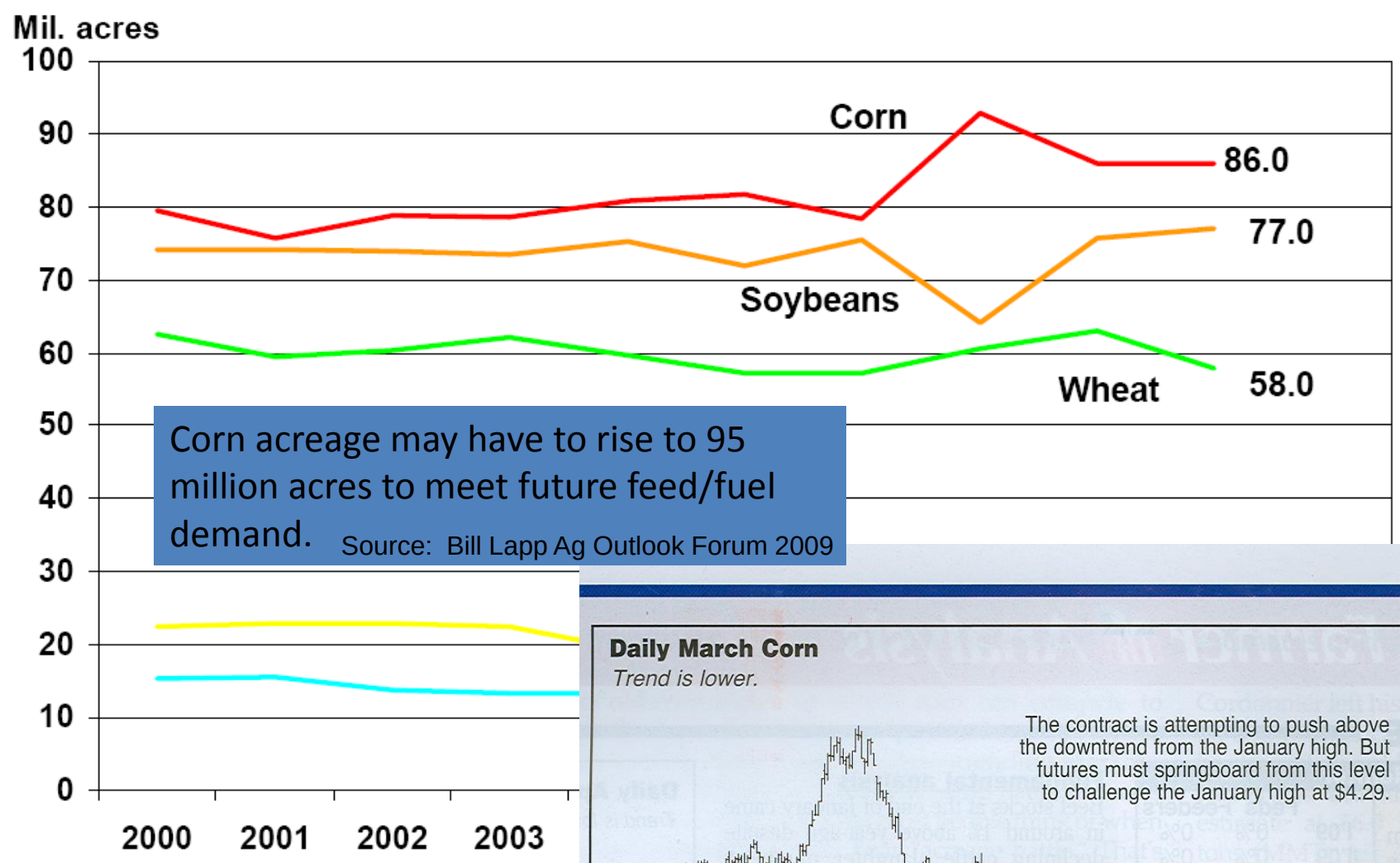
U.S. Department of Agriculture, National Agricultural Statistics Service

USDA AGRICULTURE NASS COUNTS

Biofuel Challenges

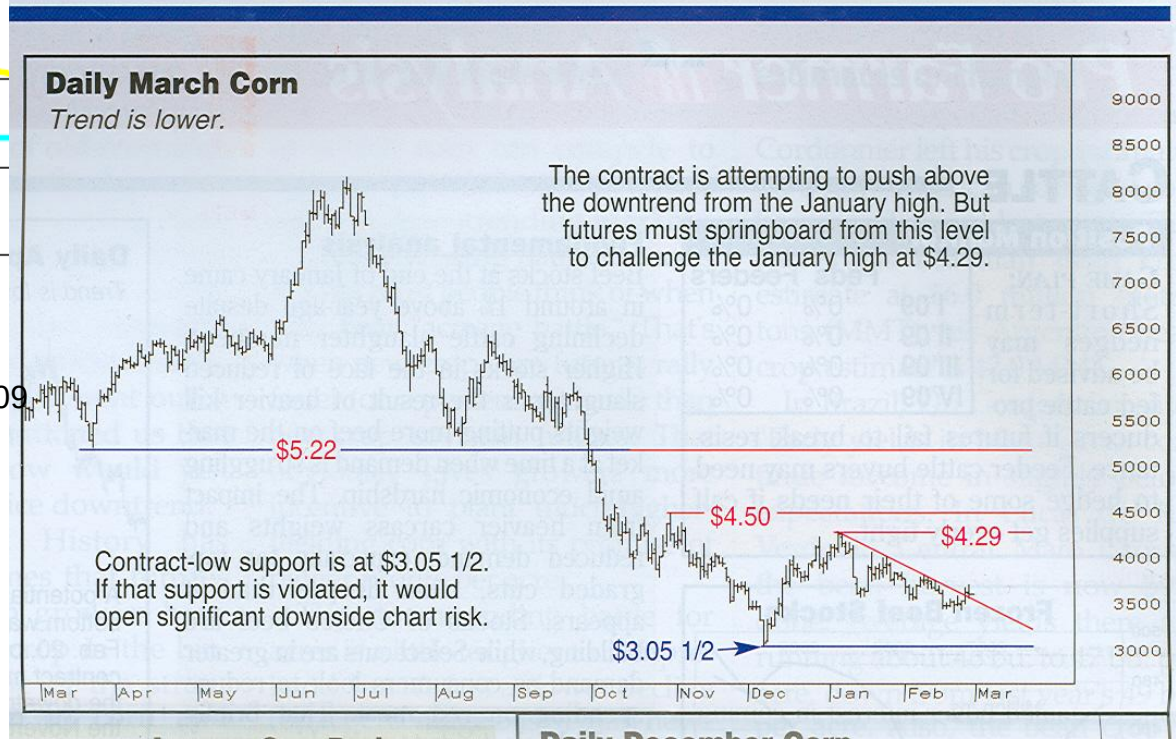
- Biofuel push
  - Mandated usage
  - Prices/costs/economics
  - Crop acreage expansion
    - CRP
    - Competing crops
  - Altered cropping patterns
  - Environmental challenges
    - Pesticides/fertilizer
    - Greenhouse gases
    - Carbon
  - Weather
- Biofuel pull
  - Conservation tillage
  - Crop management strategies
  - Productivity
  - Quality
  - Sustainability



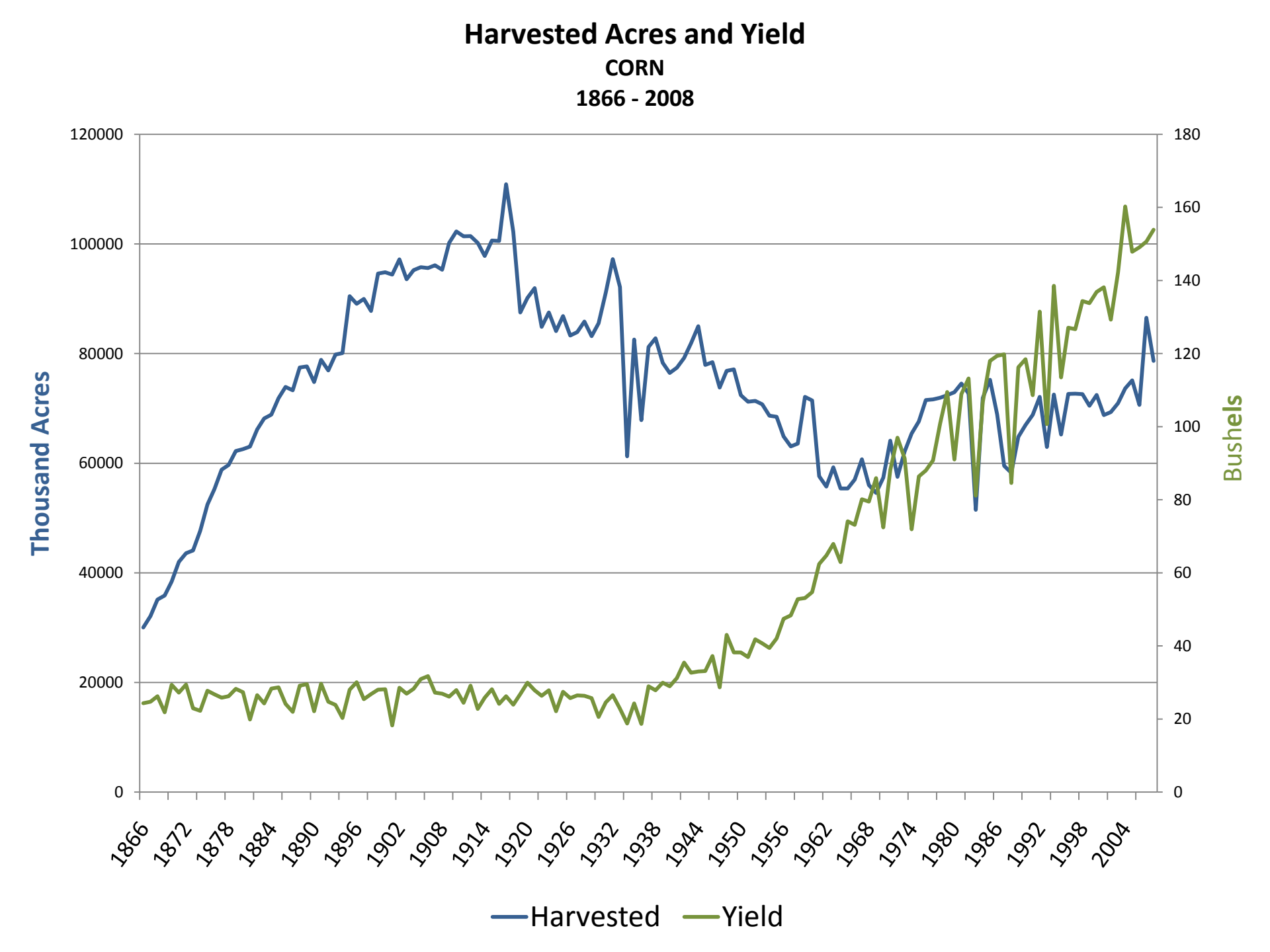


Corn acreage may have to rise to 95 million acres to meet future feed/fuel demand. Source: Bill Lapp Ag Outlook Forum 2009

Source: Joseph Glauber/Ag Outlook Forum 2009

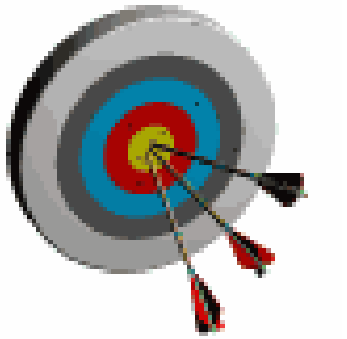


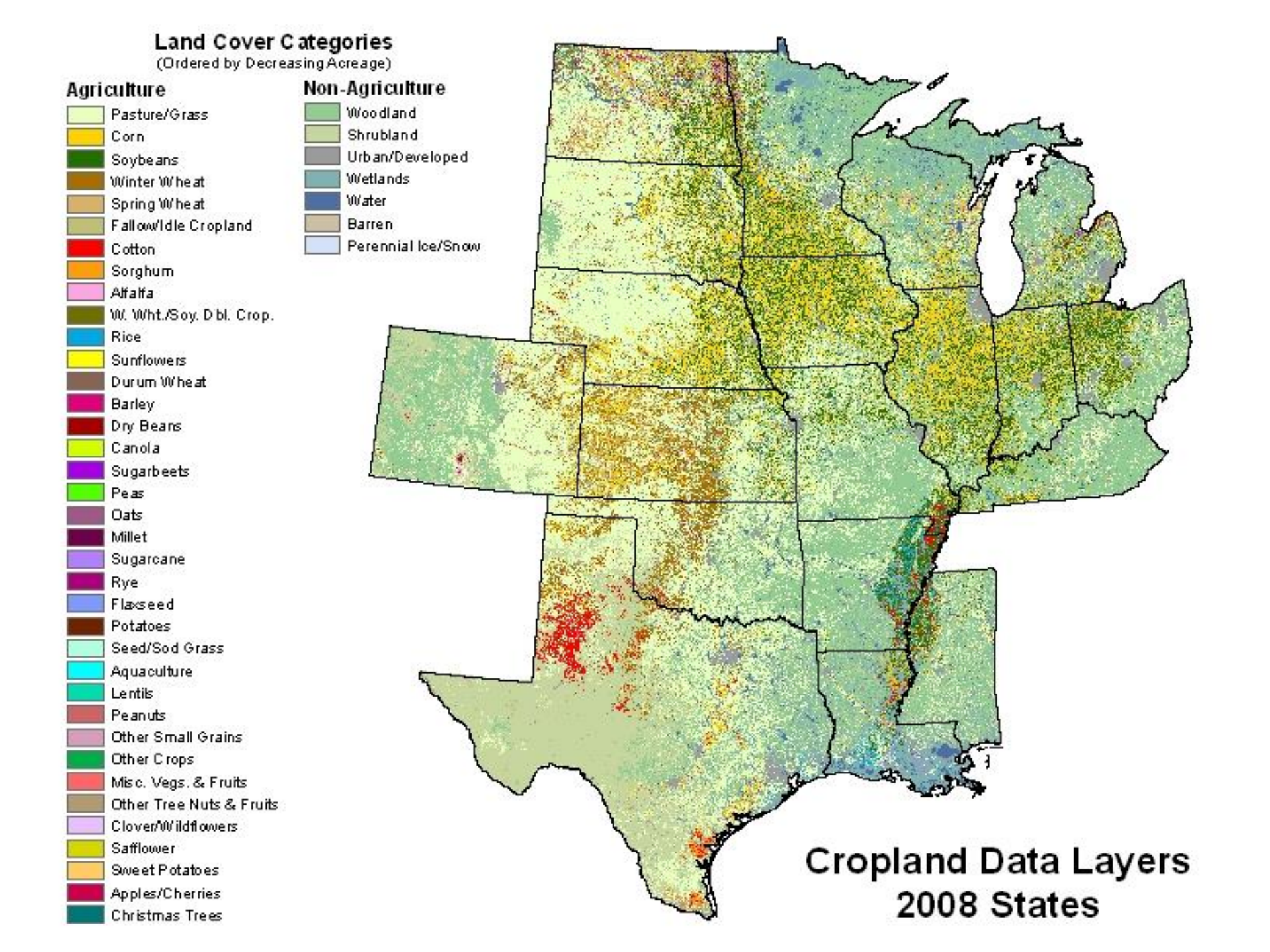
Source: Pro Farmer 3/2/09


Harvested Acres and Yield
CORN
1866 - 2008
Thousand Acres
Bushels
120000
100000
80000
60000
40000
20000
0
180
160
140
120
100
80
60
40
20
0
1866
1872
1878
1884
1890
1896
1902
1908
1914
1920
1926
1932
1938
1944
1950
1956
1962
1968
1974
1980
1986
1992
1998
2004
Harvested
Yield

Cropland Data Layer (CDL) Objective

- Deliver in-season acreage estimates
  - For June, August, and October stakeholder decision support
  - Update planted area
- Provide timely, accurate, useful indications
  - Measurable error
  - Unbiased/independent estimator
  - State, District, County
- Public domain crop specific
  - Land cover classification
  - Hosted @ NRCS Geospatial Data Gateway



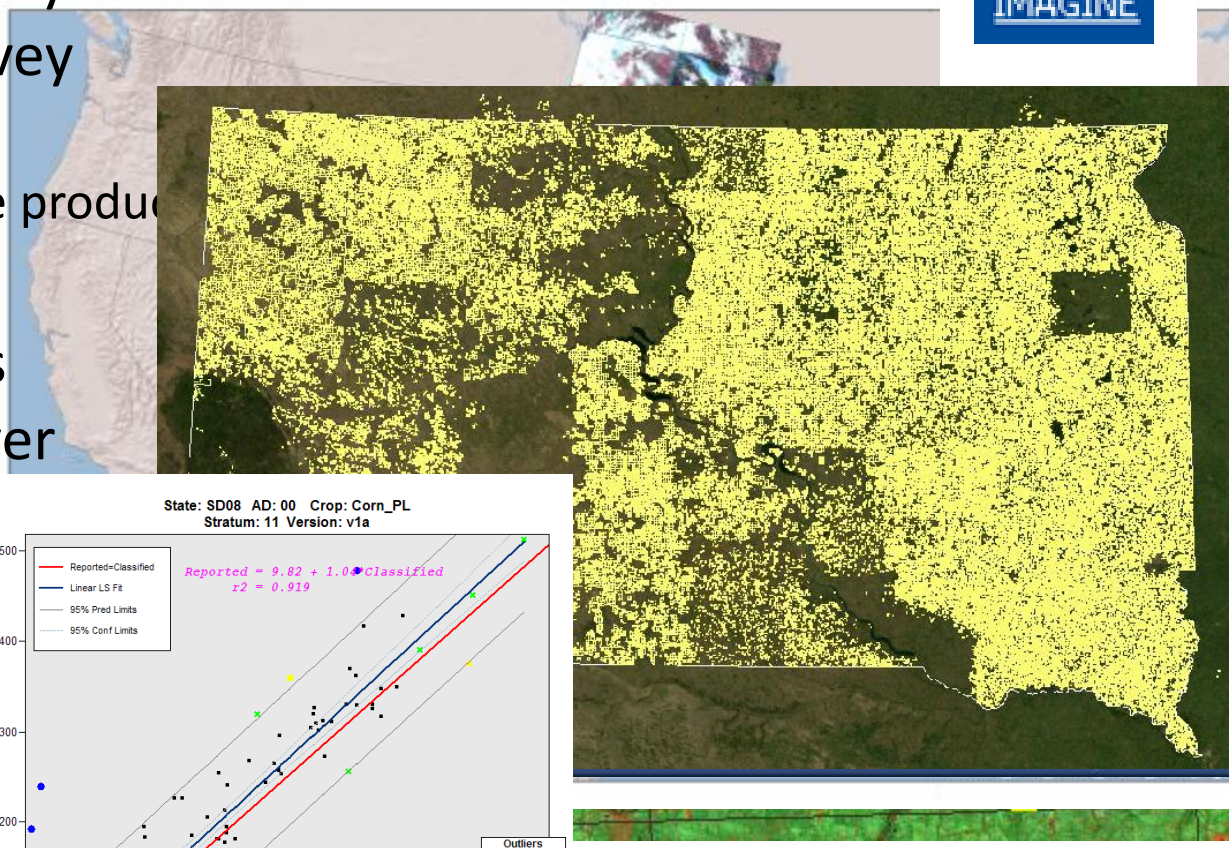

Land Cover Categories
(Ordered by Decreasing Acreage)
Agriculture
Pasture/Grass
Corn
Soybeans
Winter Wheat
Spring Wheat
Fallow/Idle Cropland
Cotton
Sorghum
Alfalfa
W. Wht./Soy. Dbl. Crop.
Rice
Sunflowers
Durum Wheat
Barley
Dry Beans
Canola
Sugarbeets
Peas
Oats
Millet
Sugarcane
Rye
Flaxseed
Potatoes
Seed/Sod 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

CDL Program

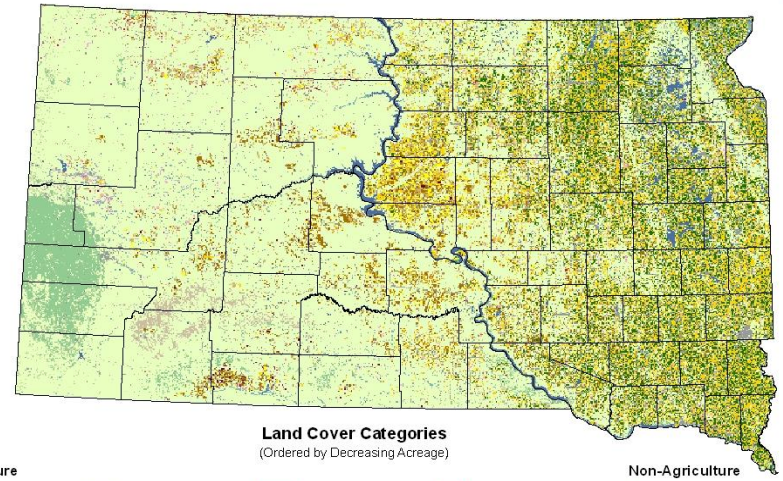
- Inputs
  - Resourcesat-1 AWiFS imagery
  - Farm Service Agency – Common Land Unit
  - NASS June Ag Survey
  - Ancillary data
    - NLCD & derivative produ
- Outputs
  - Acreage Estimates
  - Cropland Data Layer
- Process
  - Commercial soft



Data Partnerships

- Foreign Ag Service
  - Satellite Image Archive
    - Resourcesat-1 AWiFS
      - 5 day repeat/56 meter resolution/740 KM swath
- Farm Service Agency
  - Common Land Unit
- USGS/MRLC
  - National Land Cover Dataset

South Dakota 2008 Cropland Data Layer

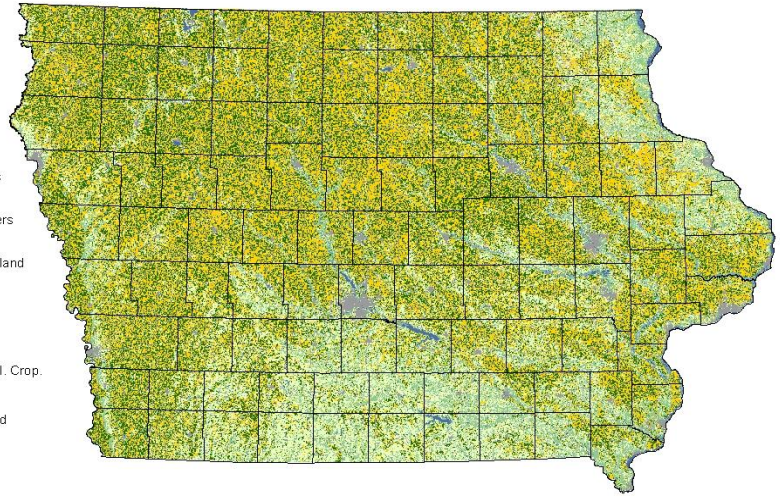


Land Cover Categories
(Ordered by Decreasing Acreage)

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

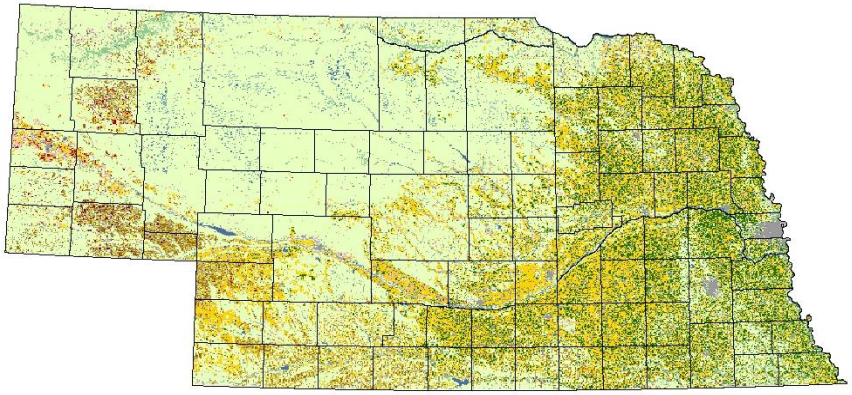


Land Cover Categories
(Ordered by Decreasing Acreage)

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

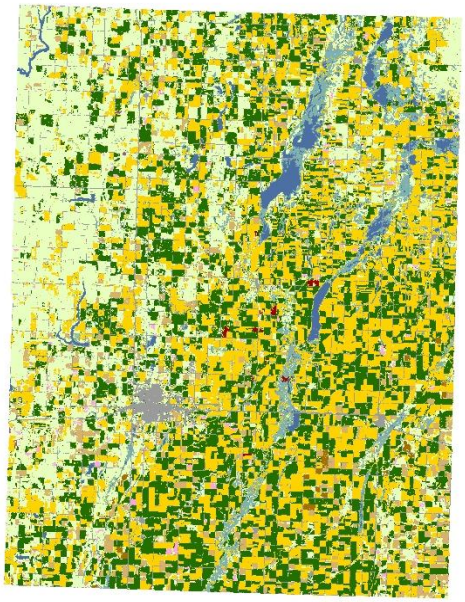
2008 Illinois Cropland Data Layer

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

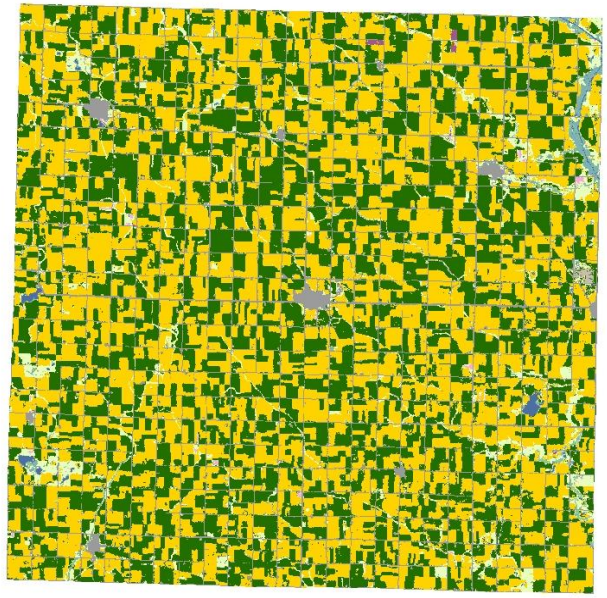


Land Cover Categories
(Ordered by Decreasing Acreage)

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

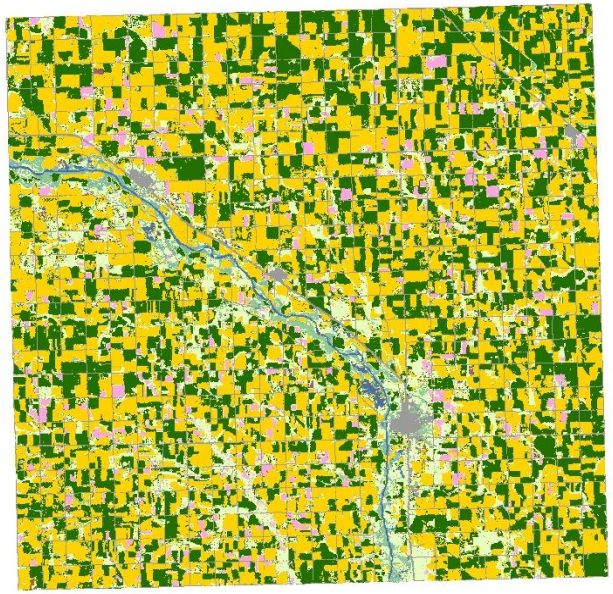


Land Cover Categories
(Ordered by Decreasing Acreage)

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

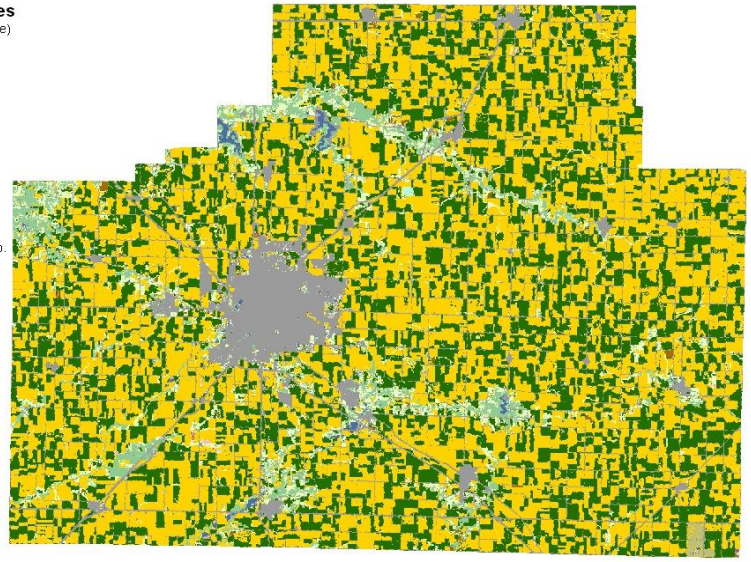


Land Cover Categories
(Ordered By Decreasing Acreage)

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

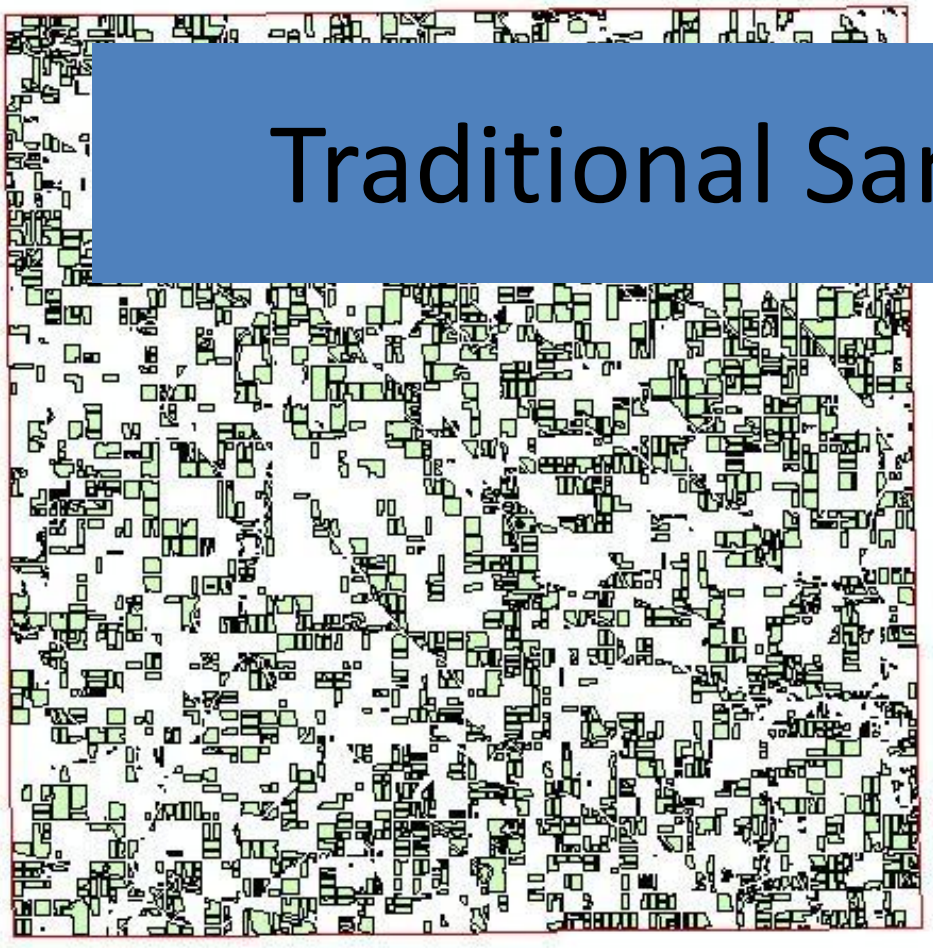
Accuracy Assessments

	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

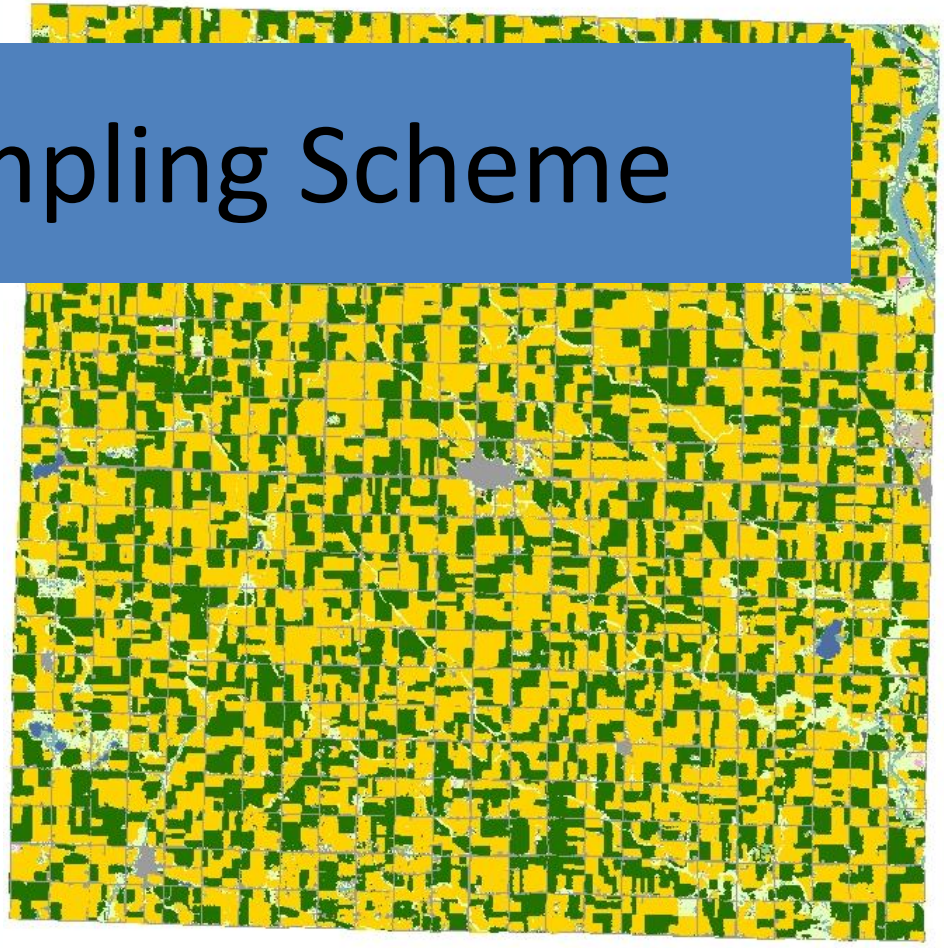
	Crop-specific covers only	*Correct	Accuracy	Error	Kappa
IA	OVERALL ACCURACY	3688803	95.74%	4.26%	0.9145
IL	OVERALL ACCURACY	3730093	97.05%	2.95%	0.9426
NE	OVERALL ACCURACY	3071960	94.05%	5.95%	0.8981
SD	OVERALL ACCURACY	2306428	87.51%	12.49%	0.8416

Producer's Accuracy: relates to the probability that a ground truth pixel will be correctly mapped and measures errors of omission.
Errors of Omission: occur when a pixel is excluded from the correct category.
User's Accuracy: indicates the probability that a pixel from the classification actually matches the ground truth data and measures errors of commission.
Errors of Commission: occur when a pixel is included in an incorrect category.
Kappa Coefficient: A statistics measure of agreement, beyond chance, between two maps.

Traditional Sampling Scheme



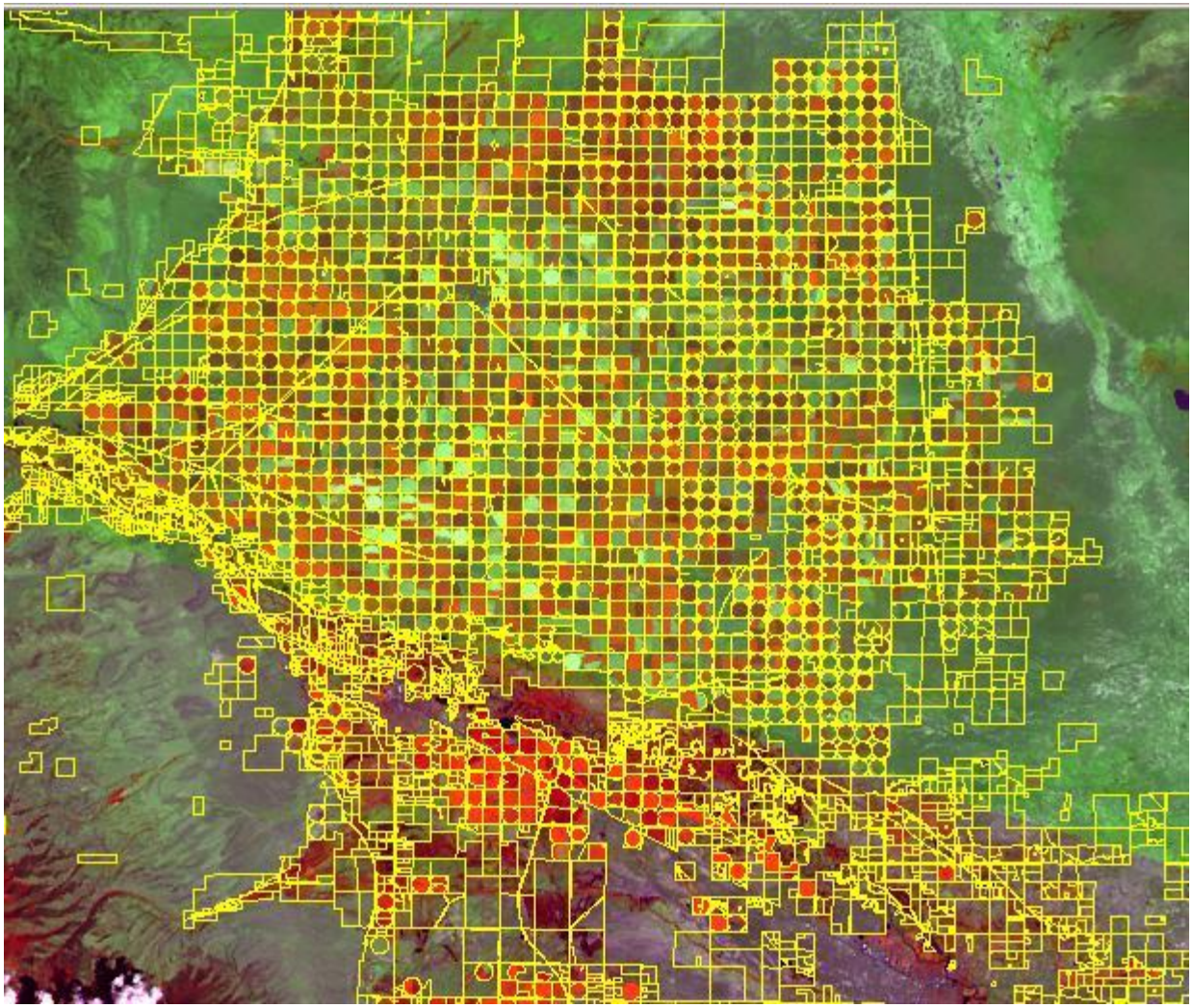
Matching CLU's used for sampling



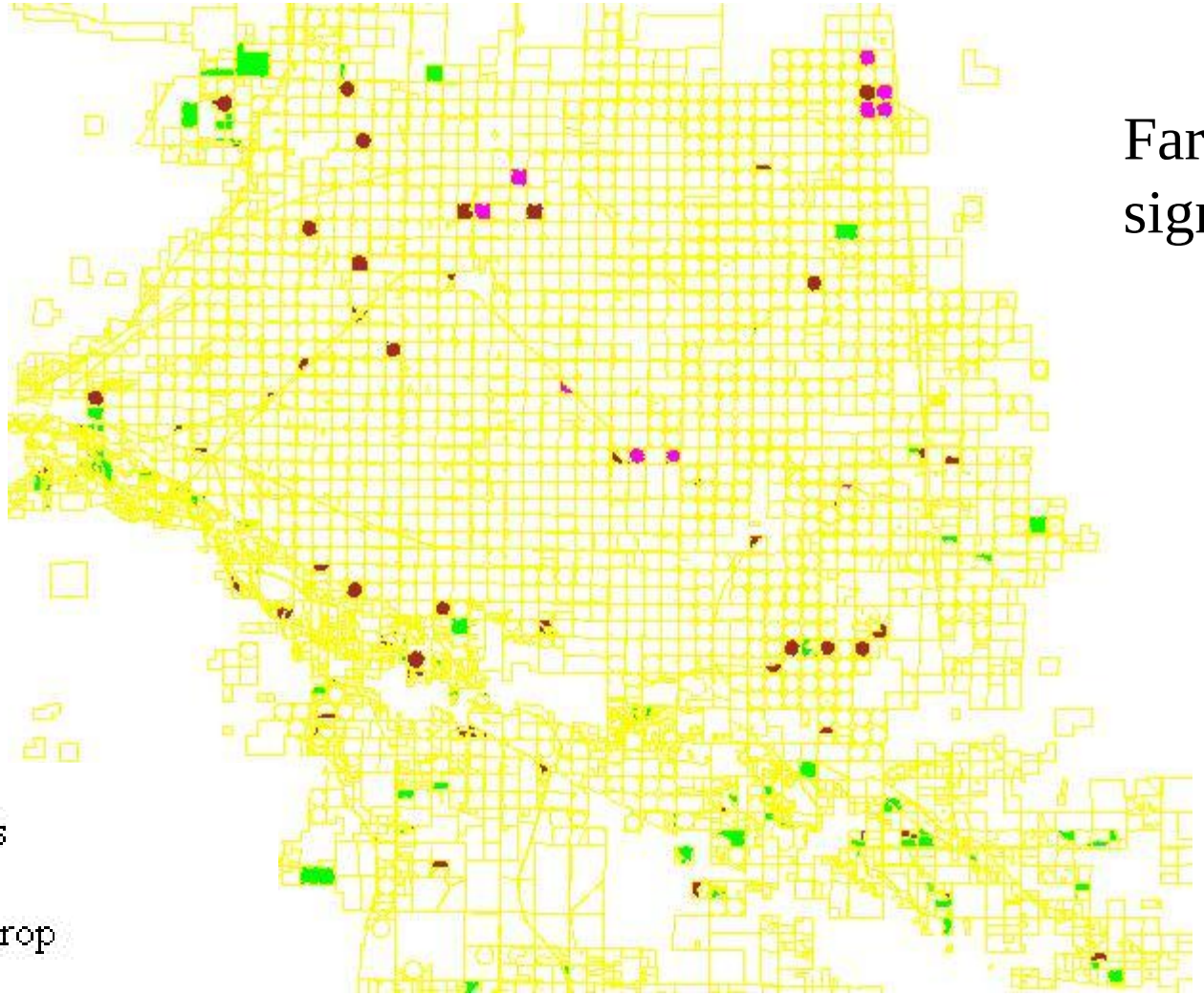
CDL Classification

½ sample for training & ½ sample for testing
Filter multi-field CLU/high acreage variance
Comprehensive **program crop** coverage

San Luis Valley Common Land Unit



San Luis Valley Common Land Unit



Farmer signups

Potatoes

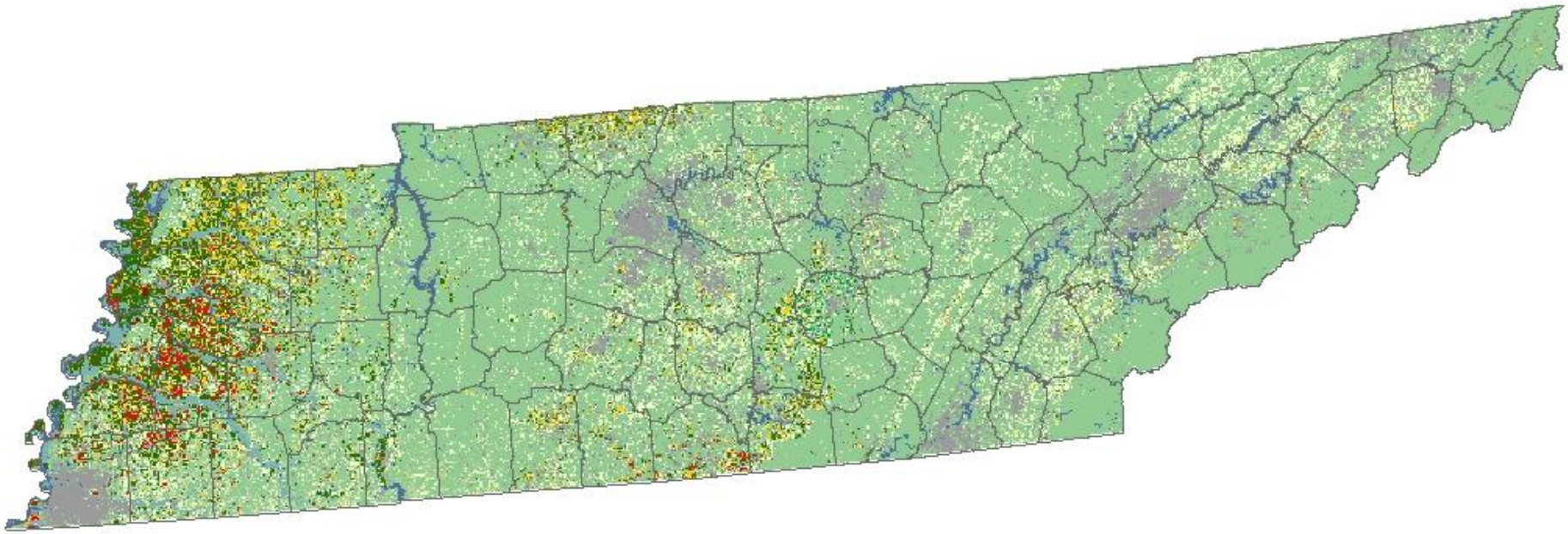
Other Crop

Grass/Pasture/Non Ag

Biofuel Switchgrass

- Non invasive
- Sustain wildlife
- Soil/climate adaptable
- Last 10-20 yrs/grows 5-10 ft tall
- Potential yield of 500 gal/acre
- One/two cuttings per year

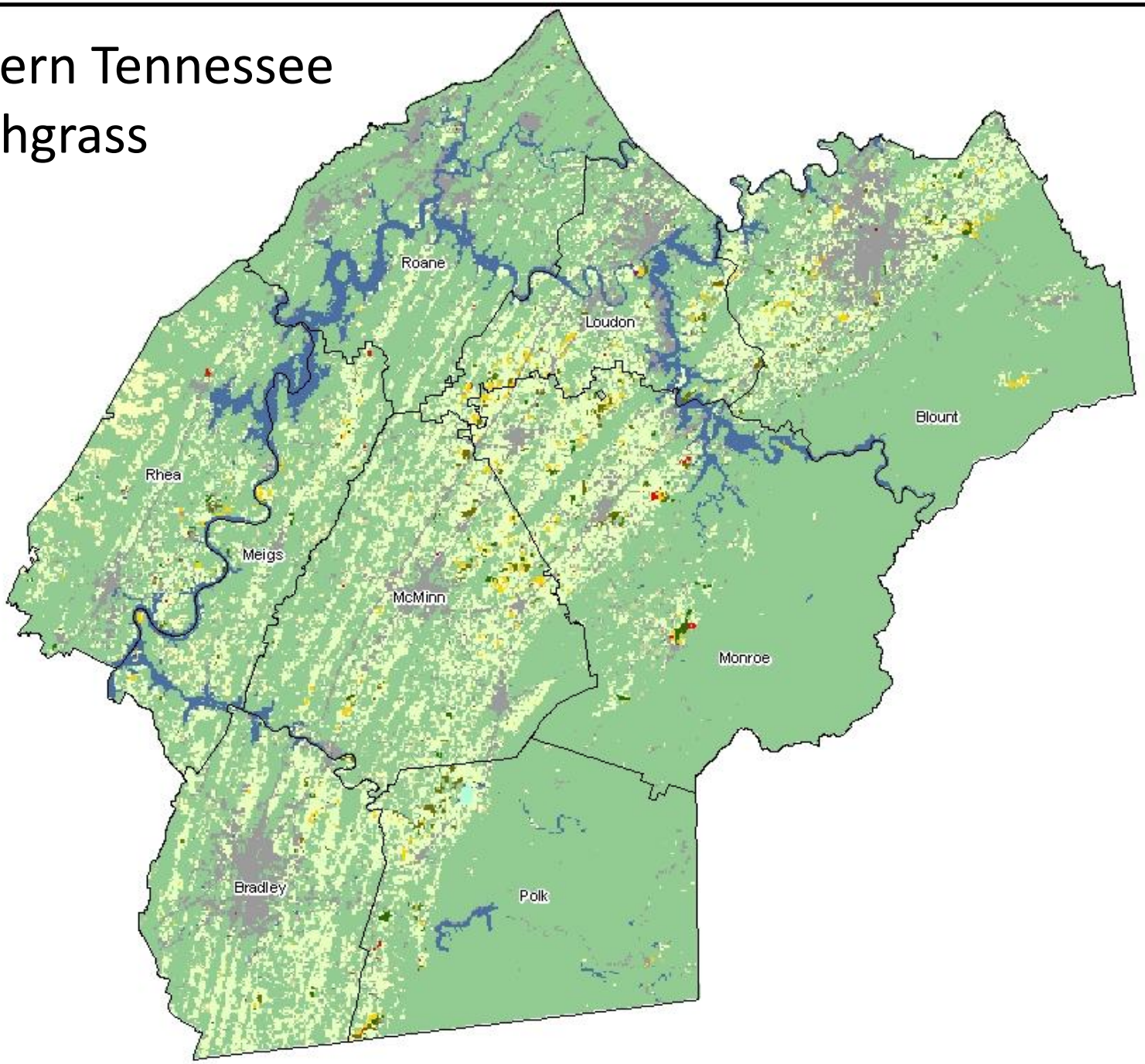
Tennessee 2008 CDL

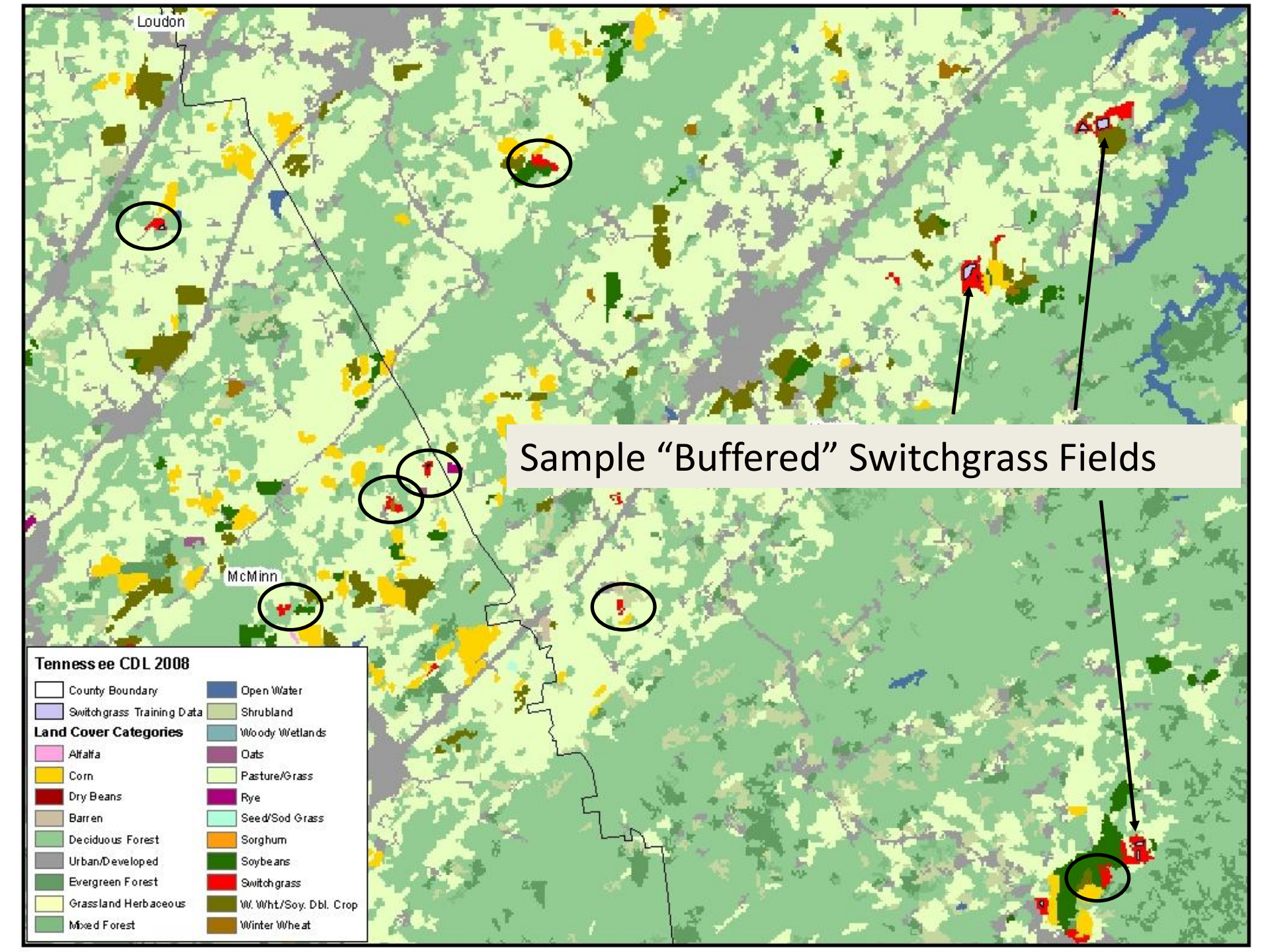


Land Cover Categories

Alfalfa	Barren	Pasture/Grass	Spring Wheat
Barley	Forest	Peaches	Sunflowers
Christmas Trees	Urban/Developed	Peas	Switchgrass
Corn	Grassland Herbaceous	Pop. or Orn. Corn	Tobacco
Cotton	Open Water	Rice	W. Wht./Soy. Dbl. Crop
Dry Beans	Shrubland	Rye	Watermelon
Grapes	Woody Wetlands	Seed/Sod Grass	Wetlands
Millet	Oats	Sorghum	Winter Wheat
Misc. Vegs. & Fruits	Other Crops	Soybeans	

2008 Eastern Tennessee CDL Switchgrass Region




Loudon
McMinn
Sample “Buffered” Switchgrass Fields
Tennessee CDL 2008
County Boundary
Switchgrass Training Data
Land Cover Categories
Alfalfa
Corn
Dry Beans
Barren
Deciduous Forest
Urban/Developed
Evergreen Forest
Grassland Herbaceous
Mixed Forest
Open Water
Shrubland
Woody Wetlands
Oats
Pasture/Grass
Rye
Seed/Sod Grass
Sorghum
Soybeans
Switchgrass
W. Wht/Soy. Dbl. Crop
Winter Wheat

	Correct	Total	Accuracy	Error	Kappa
Overall (FSA + NLCD)	687710	898662	76.53%	23.47%	0.7021
FSA Crops only	219563	249053	88.16%	11.84%	0.8374

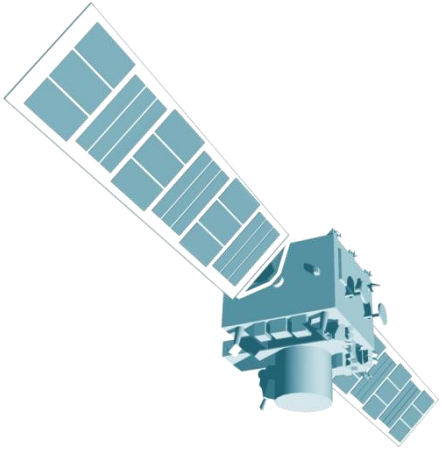
by Class	Total Pixels	Correct	Producer	Omission	Kappa	Classified	User	Commission	Kappa	Bias
Switchgrass	424	151	35.61%	64.39%	0.3531	181	83.43%	16.57%	0.8324	-57.3%

Total Pixels is the number of validation pixels we had. Of these 424 pixels of ground truth, we classified 151 of them as switch grass, so we are omitting a significant amount of switch grass.

In the entire regional map, we classified 181 pixels as switch grass. Of these 181 pixels, 83% were classified correctly.

We can say, then, that we feel fairly certain (83% certain) that any switch grass pixel on the map probably *is* switch grass. However, there are other switch grass pixels out there that remain unidentified.

Summary



- Corn the alternative fuel
- CDL covers majority of corn domain
  - High accuracy
- Other crops possible – provided ground truth
- Data partnerships key to continued success!
- “Manifest Destiny”