

# How Can Remote Sensing Add to Crop Estimation?

- 1) Define a new, but completely known, total population
- 2) Compare the area sample to the known population
- 3) Create a relation between the sampled and known

## a) Simple Linear Regression

- 4) Apply the relation at any desired levels for estimation

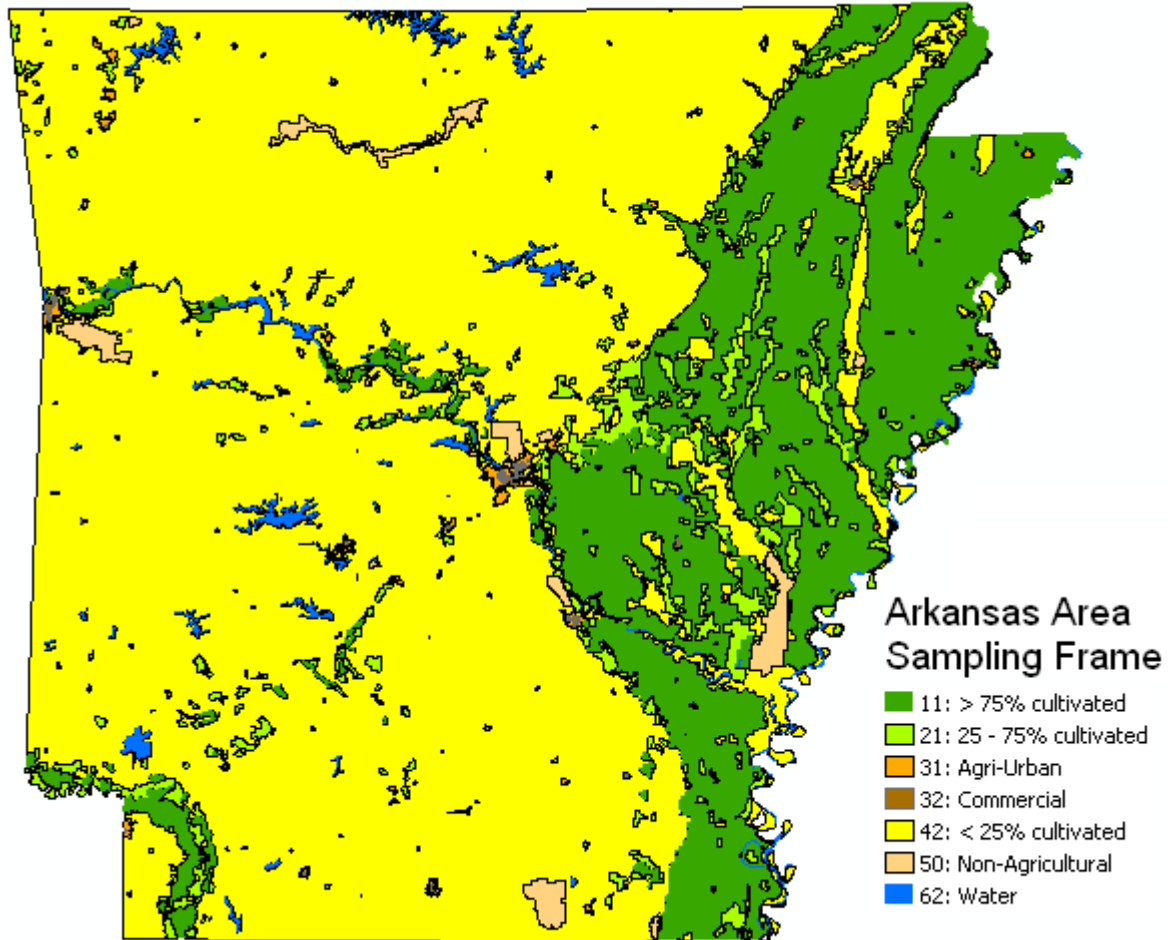
## a) At the State level:

- reduces variation of estimate(s)

## b) County, Sub-County, Watershed, ASD, ...

- With measurable variance estimates!

# Sampling Approach Based on Area Sampling Frames



# Arkansas 2006

Stratum	# Segs Popn	# Segs Sampled	Expans. Factor
11	11669	232	50
21	2718	32	85
31	1308	4	327
32	418	2	209
42	18571	56	332
50	35	2	18
State	34719	328	



N

CRAIGHEAD, AR

age

# JAS Questionnaire

- Enumerators account for all land usage in segment
  - Draw off field location by direct observation
  - Directly link questionnaire to segment photo
  - Able to ask questions not related to acreage

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

## Analysis Concepts

Direct Expansion (D.E.) = June Area Closed Estimator

Value representing the sampling unit's contribution to the population total.

D.E. = Reported Data X Expansion Factor

$$DE = \sum \frac{N}{n} x_i$$

# A Basic Satellite Remote Sensing Approach

- 1) Locate known ground areas in the digital satellite imagery
  - 'ground truth' or 'gtr'
- 2) Train a computer to recognize the 'cover' types
  - 'signatures' or 'decision trees'
- 3) Classify the entire area of interest (State, region, ...)
  - 'known population'
- 4) Compare sampled areas to classification of same areas
  - 'linear regression'
- 5) Create '**revised**' estimates based on this relationship

# Ground Truth Sources

- The June Area Survey itself
  - Digitize internal segment boundaries (fields)
- Analyst defined 'extra' categories
  -
- Farm Service Agency administrative data
  - Match Common Land Units with 578 data
  - Select polygons with only one cover type
- National Land Cover Database
  - Non-crop categories



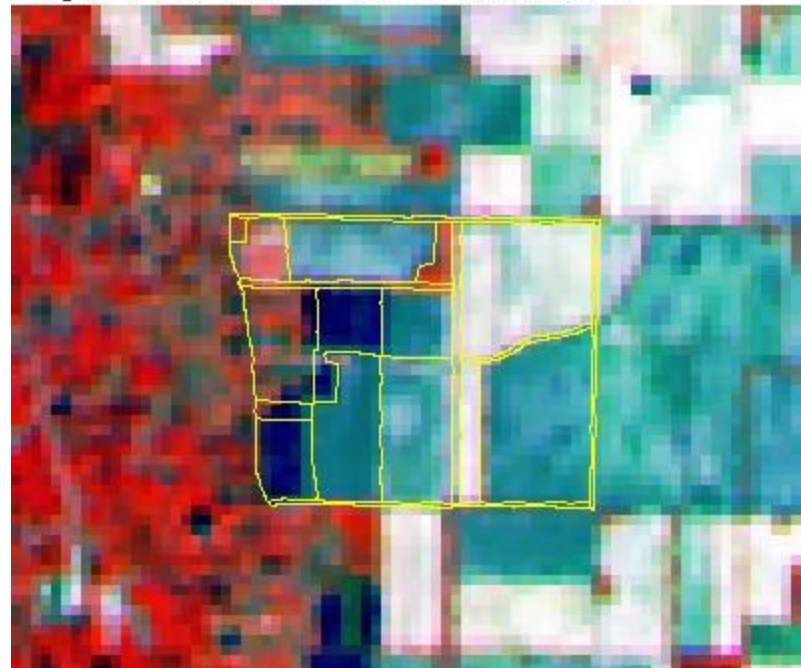
Segment 136

R = Rice  
S = Soyb  
W = Waste/FS

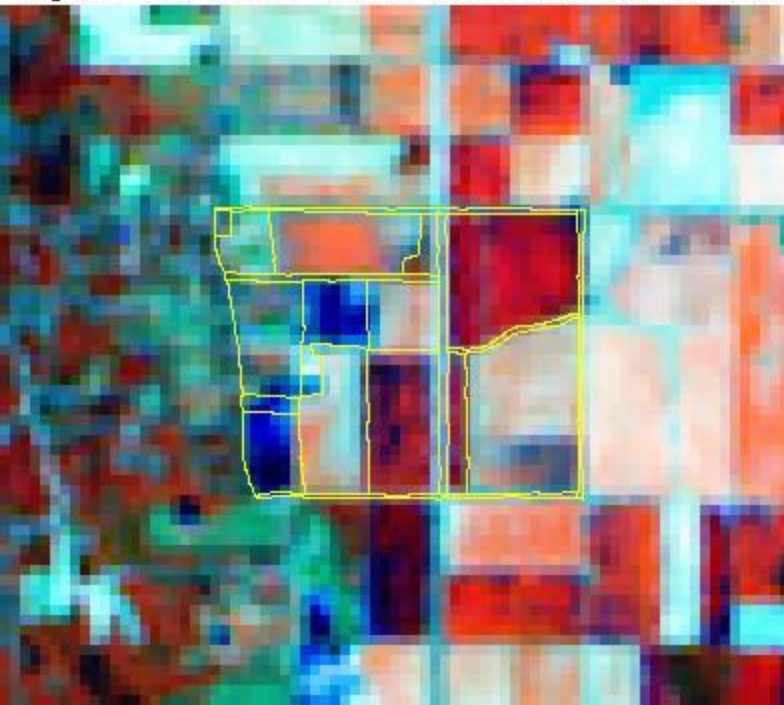
# JAS Segment



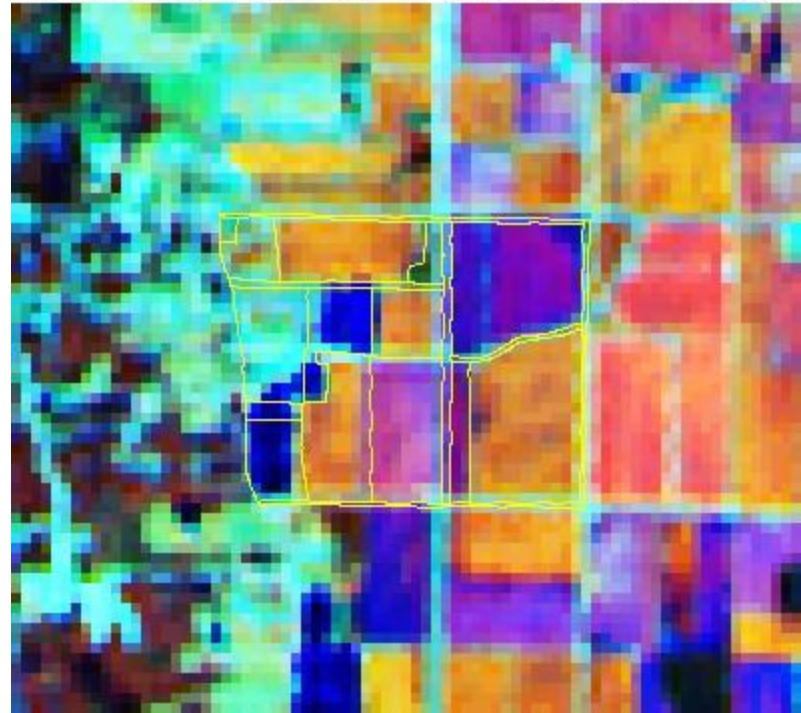
Segment 136 R=-0.40 C=0.80 74434-60520



Segment 136 R=0.00 C=0.40 73434-60702/74434-6073:



Segment 136 R=0.00 C=0.80 74434-60824/74434-6073:



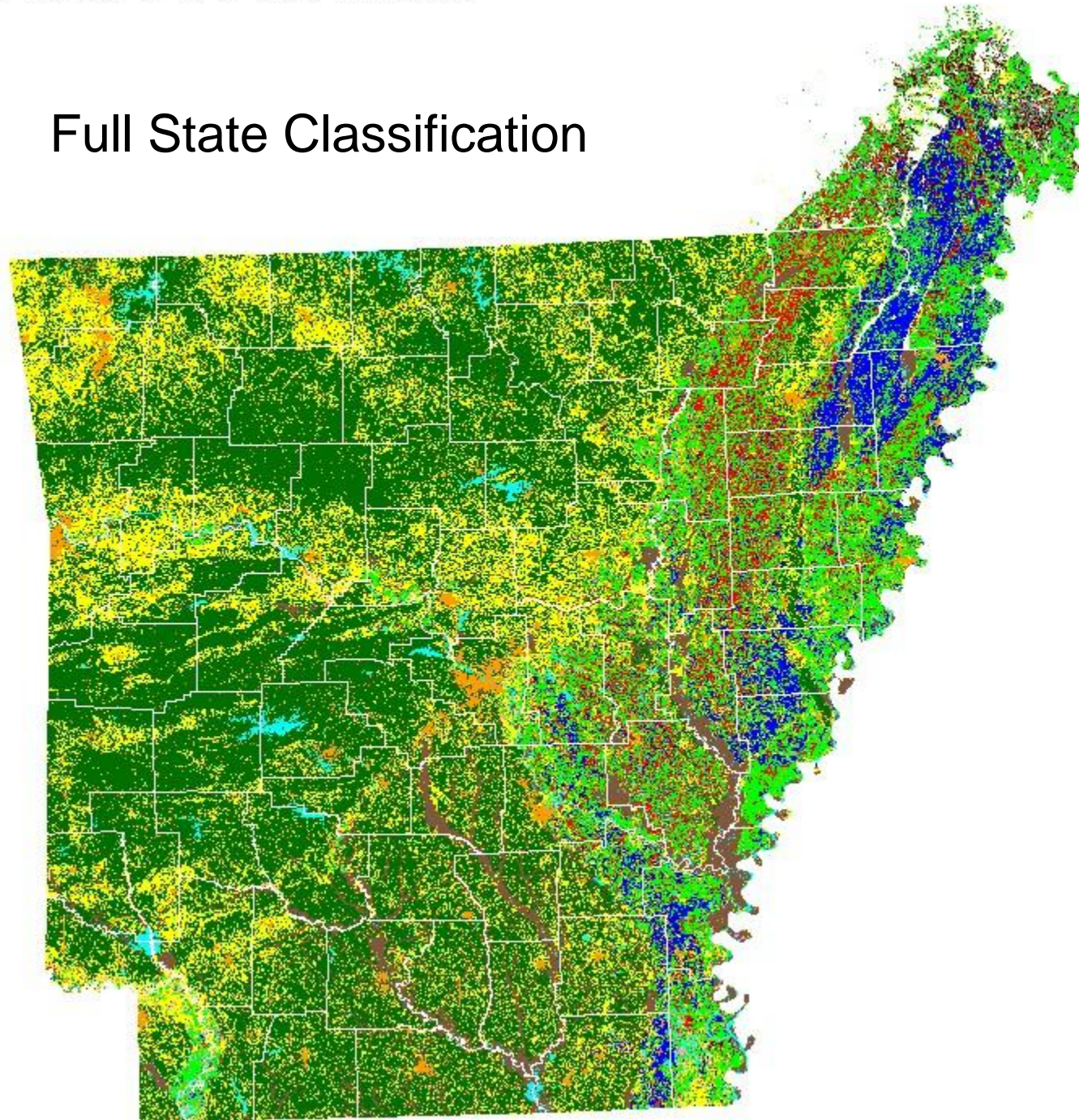
# CLU with Reported Crops and Landsat 30 Meter data



Renville County, MN Landsat 5, 8/02/2000

# Full State Classification

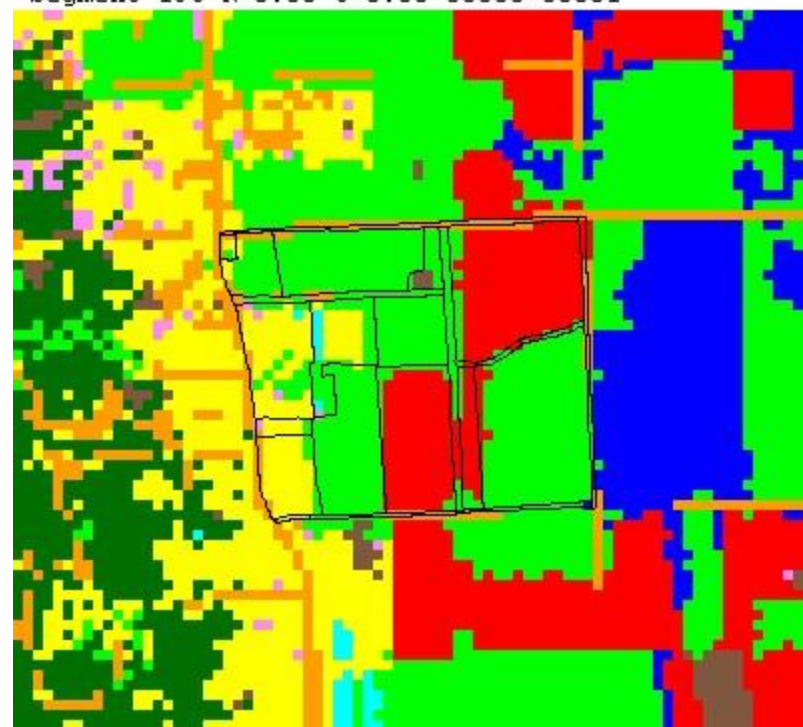
- SOYBEANS
- COTTON
- RICE
- WATER
- SORGHUM
- WIN WHEAT
- Non Ag
- Urban
- IDLE CROP
- Wetlands
- WINWSOYB
- CLOUDS/filler
- WOODS
- CORN
- O.CRPS



# Regression Estimator

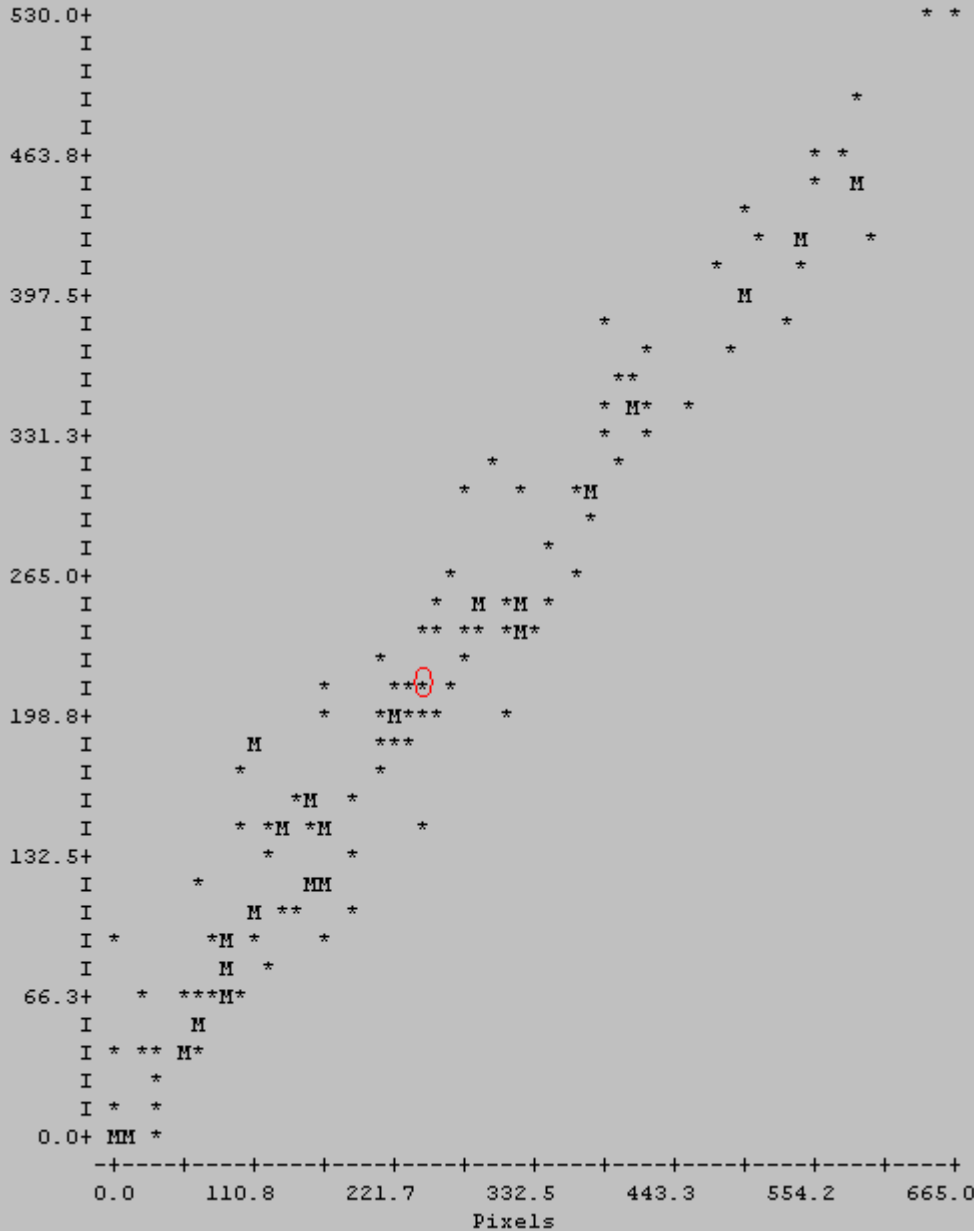
- Regression used to relate categorized pixel counts to the ground reference data
  - Independent variable - satellite data - pixels
  - Dependent variable - JAS acreage estimate
- Satellite data - lower variance than with only JAS
- Outlier segment detection - correction or removal from regression analysis

R = Rice  
 S = Soyb  
 W = Waste/FS



Crop Type	Y	X
	Enumerated JAS Acres	Classified Pixels
Rice	227.0	273
Soybean	337.0	541

Plot of RICE Pixels(X) Reported(Y)  
Strata 11



$$R^2 = 0.971$$

$$a = \text{intercept} = 7.11$$

$$b = \text{slope} = 0.802$$

-----  
Linear Regression

$$y = a + bx$$

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Seg 136 (x=273, y=227)

$$y = 226.11$$

Plot of SOYBEANS Pixels(X) Reported(Y)  
Strata 11



$$R^2 = 0.901$$

$$a = \text{intercept} = -49.93$$

$$b = \text{slope} = 0.8008$$

Linear Regression

$$y = a + bx$$

Seg 136 (x=541, y=337)

$$y = 383.30$$

# Regression Estimator

$$\hat{Y}_{ca(\text{reg})} = \sum_{h=1}^{H_a} N_{ah} [\bar{y}_{cah} + \hat{b}_{cah} (\bar{X}_{cah} - \bar{X}_{cah})]$$

$N_{ah}$  = Number of frame units in stratum  $h$  in analysis region  $a$

$\bar{y}_{cah}$  = mean acres per segment from the June Area Frame Survey

$\bar{X}_{cah}$  = mean categorized pixel count (segments)

$\hat{b}_{cah}$  = coefficient from regression of acres on pixel counts

$\bar{X}_{cah}$  = mean categorized pixel count (scenes)

$c$  = crop

$a$  = analysis region

$h$  = stratum



# Acreage Estimation Methods

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- Outlier segment detection - correction or removal from regression analysis
- Using pixel estimation in areas with satellite coverage but too few segments
- Using direct expansion/proration to fill in holes in satellite coverage (clouds, bad dates)

# Ratio Estimators in General

## List and Area

A ratio is an estimate of a mean, a proportion or a percent change in level. It usually takes the form of a ratio of two means or two direct expansions. The estimated ratio can then be multiplied by a "known base" to estimate a total. The general form is:

$$Y = \frac{\bar{y}}{\bar{x}} X$$

# Pixel Estimator

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$$\hat{Y}_{ca(\text{pix})} = \sum_{h=1}^{H_a} \lambda (m_{cal} / m_{cak}) X_{cah}$$

$\lambda$  = Conversion factor (areal units per pixel)

$m_{cal}$  = Marginal total pixels labeled to desired crop in segments

$m_{cak}$  = Marginal total pixels categorized to desired crop in segments

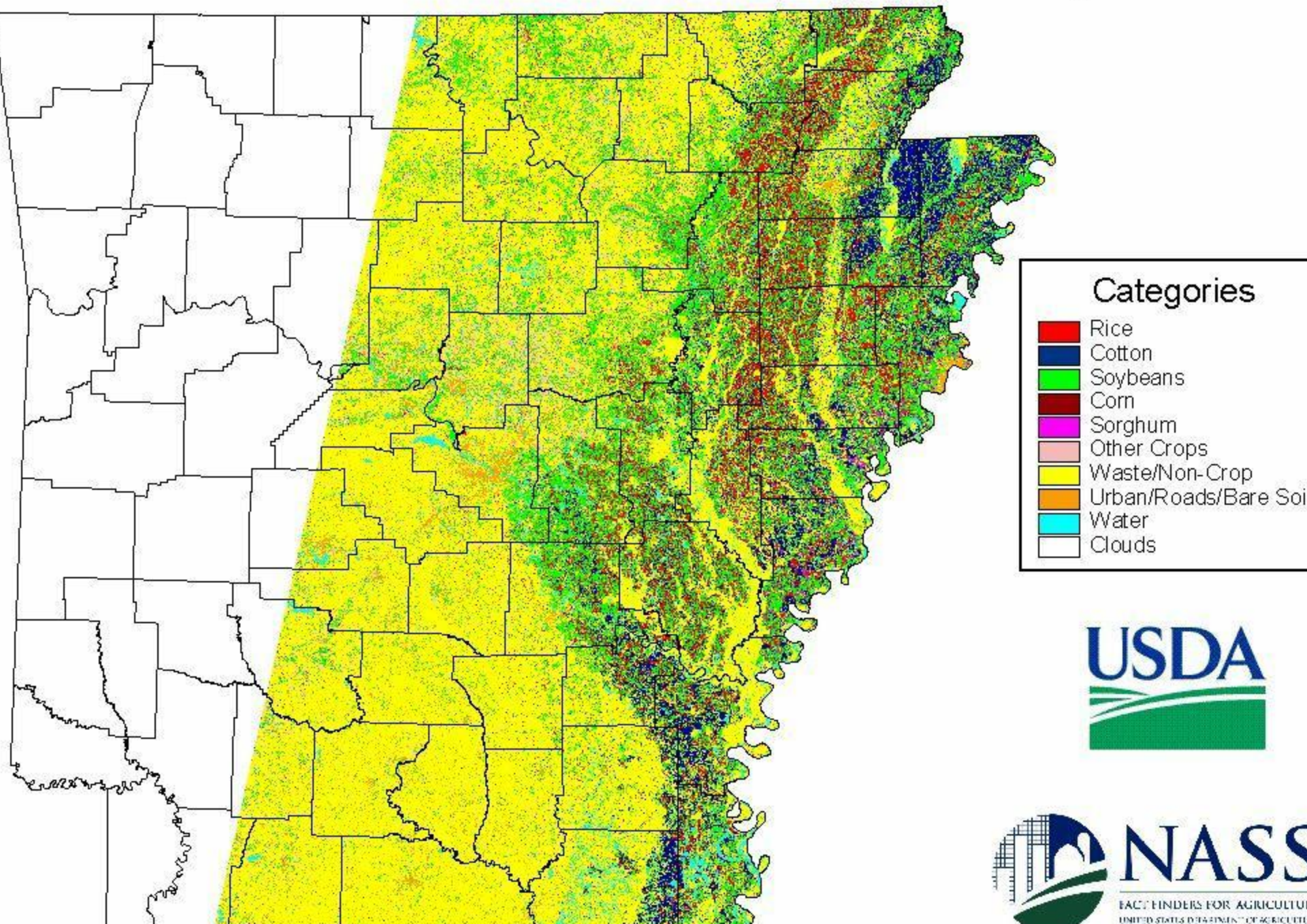
$X_{cah}$  = Number of pixels categorized to the desired crop

c = crop

a = analysis region

h = stratum

# 2002 Arkansas Cropland Data Layer



# Direct Expansion

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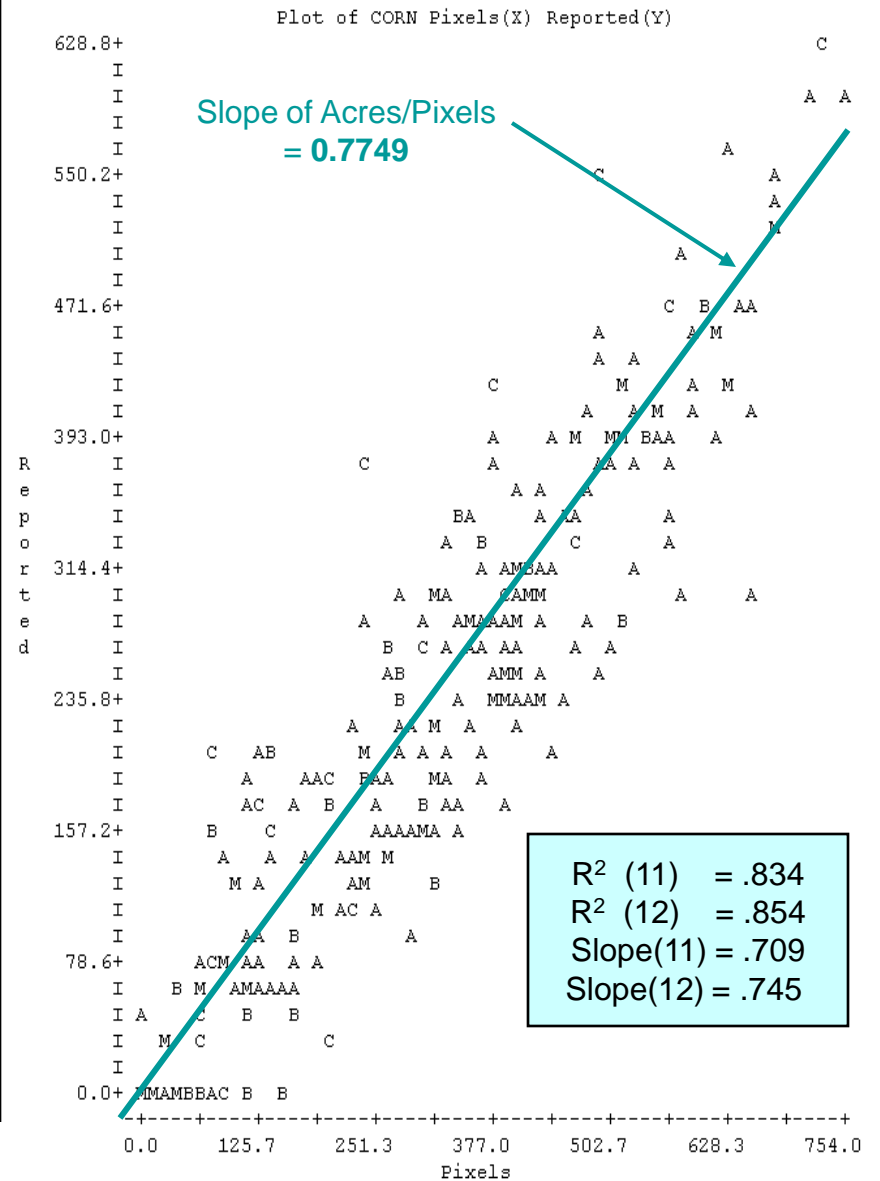
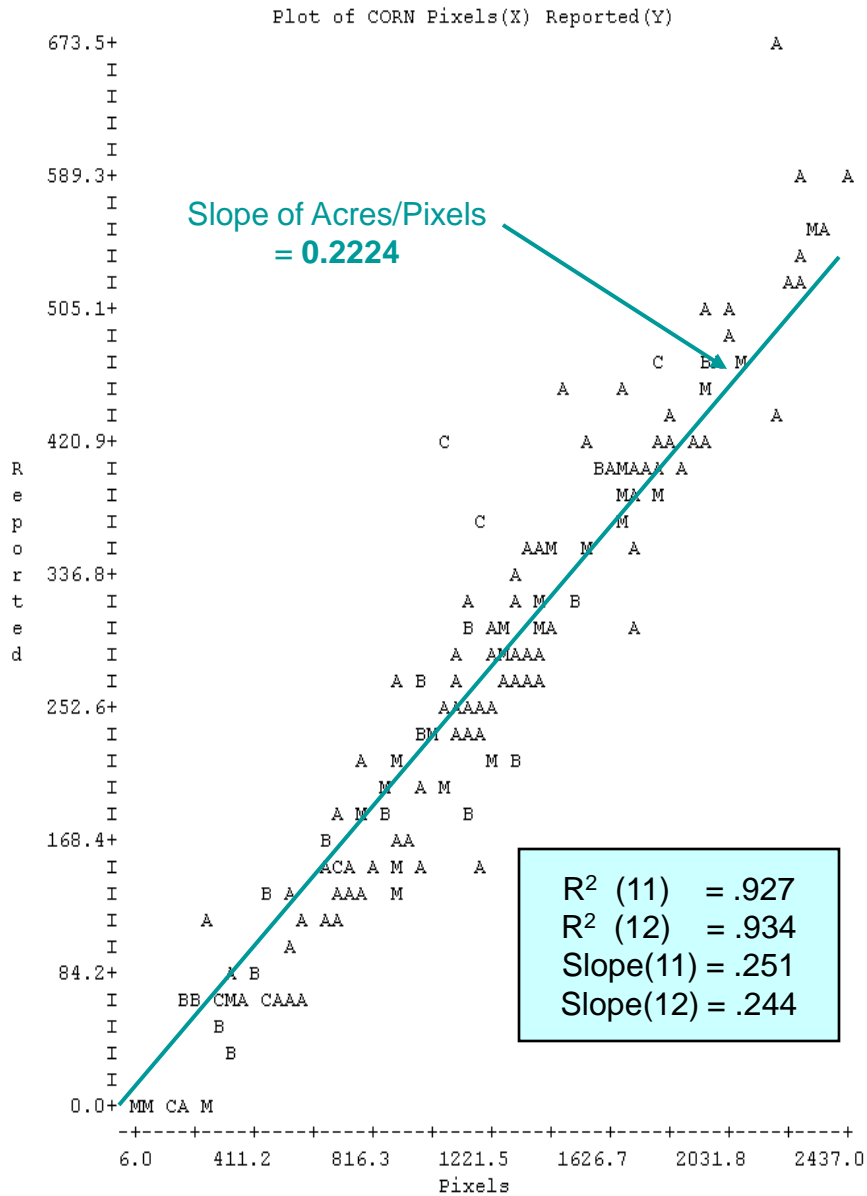
$$\hat{Y}_{ca(\text{dir})} = \sum_{h=H_a+1}^H N_{ah} / n_{ah} \sum_{j=1}^{n_{ah}} y_{cahj}$$

c = crop

a = analysis region

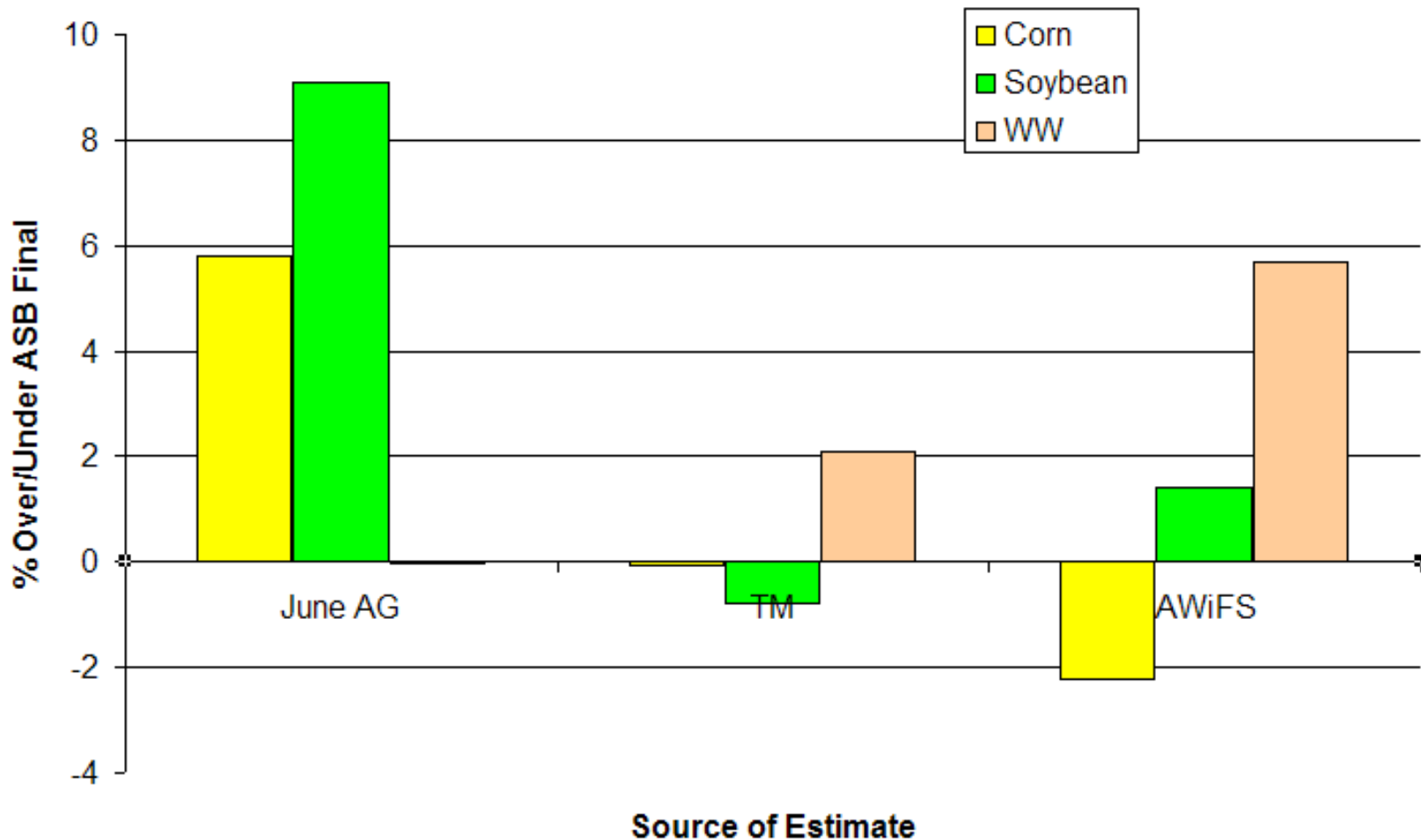
h = stratum

j = segment

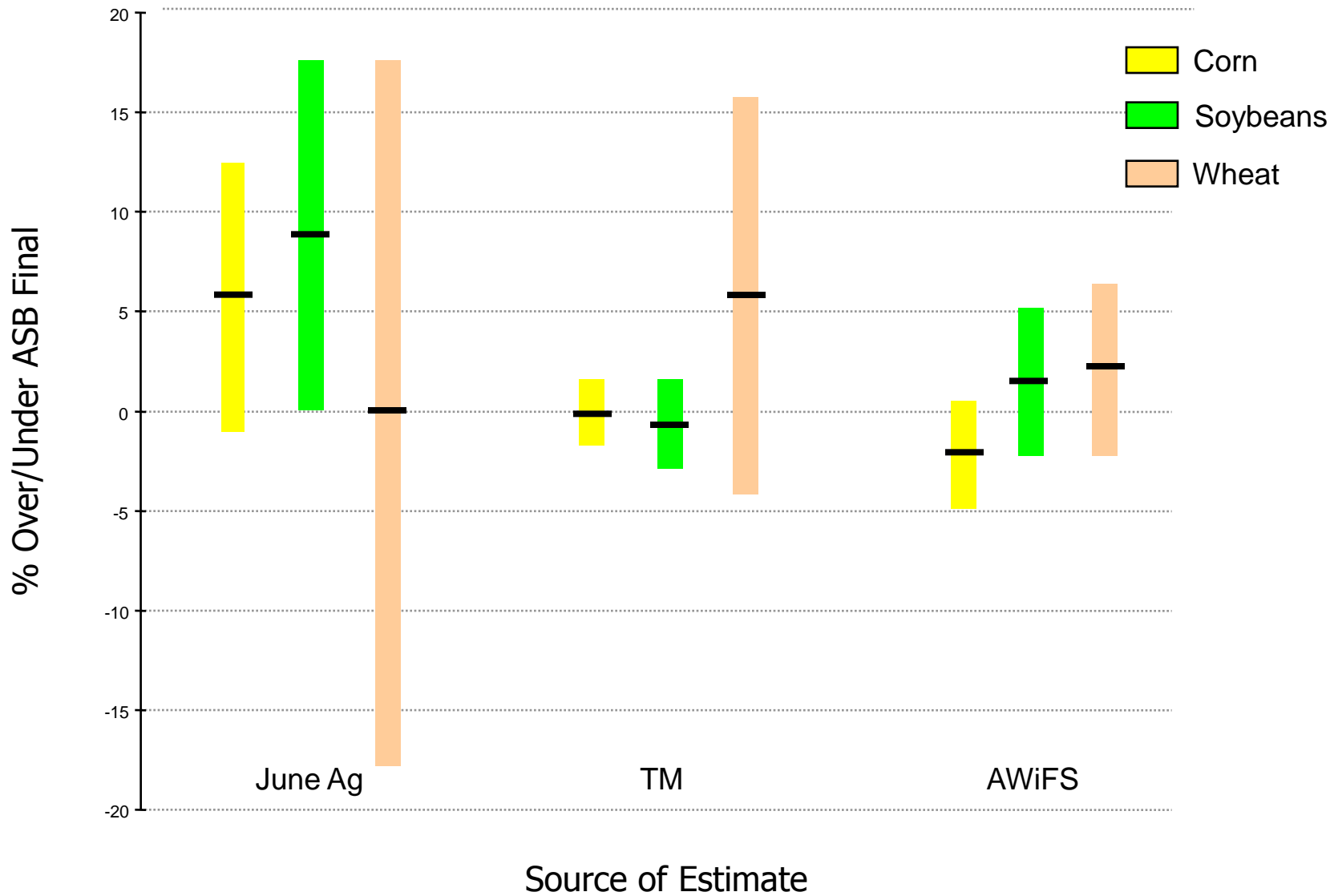


# Nebraska 2005 State Level Estimates as % Over/Under Agricultural Statistics Board (ASB)

## Nebraska State Level Estimates as % Over/Under Agricultural Statistics Board (ASB)

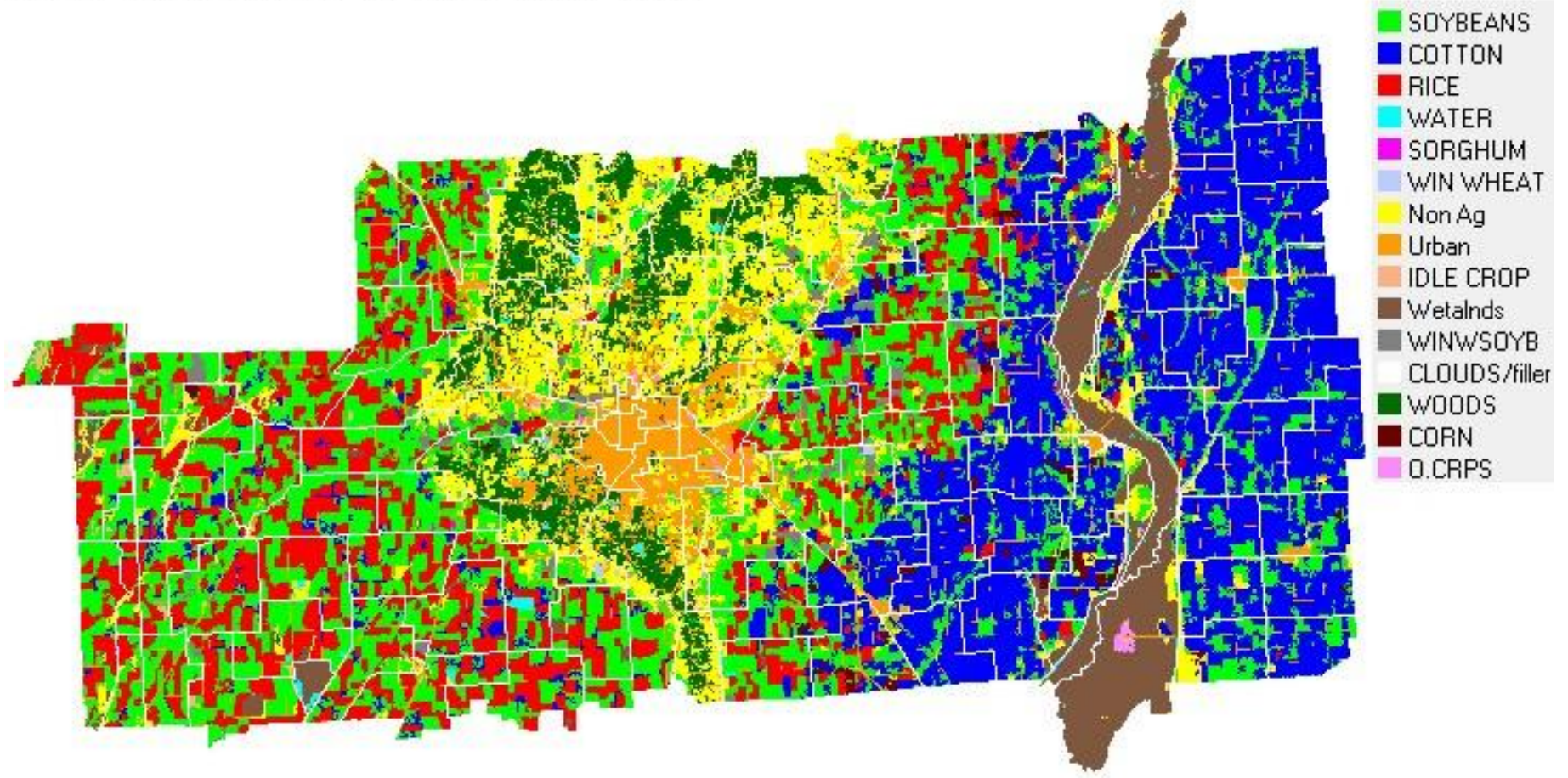


# Nebraska 2005 State Level Estimates +/- 2% CVs (Coefficient of Variation)





County CRAIGHEAD(31) AR Scene 55555-00001

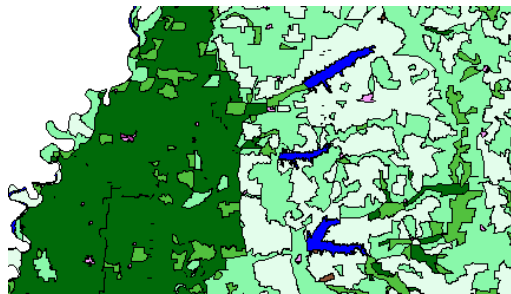


# Program Summary

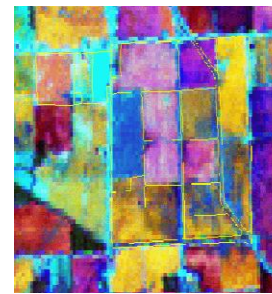
Raw Satellite Images



Area Sampling Frame With PSU's



Segment Boundaries or CLU Polygons



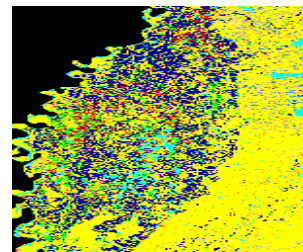
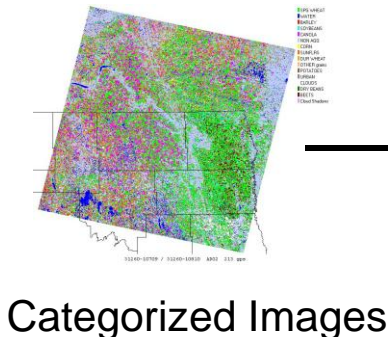
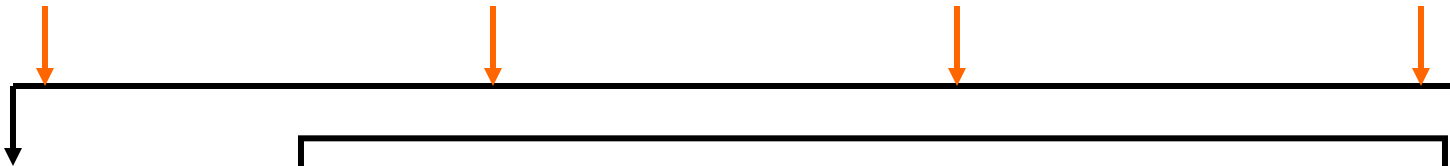
JAS Questionnaire or 578 attributes

PAGE 2 SECTION D - CROPS AND LAND USE ON TRACT 1:

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 # (in acres)	01	02	03	04	05
1. Total cropland area (in acres)	028	028	028	028	028
2. Cropland use (in acres)					
3. Cropland use (in acres)	061				
4. Field: cropland use (in acres) (building and structures, roads, ditches, etc.)	000	000	000	000	000
5. Woodland	062	062	062	062	062
6. Pasture	066	066	066	066	066
7. Other (land only or pasture)	067	067	067	067	067
8. Use (crop) - Use in 2000					
9. Use (crop) - Use in 2000					
10. Acreage to be planted	060	060	060	060	060
11. Acreage to be planted (if you are not sure, include it in the crop use)	060	060	060	060	060
12. Use (crop) - Use in 2000	060	060	060	060	060
13. Use (crop) - Use in 2000	060	060	060	060	060
14. Use (crop) - Use in 2000	060	060	060	060	060
15. Use (crop) - Use in 2000	060	060	060	060	060
16. Use (crop) - Use in 2000	060	060	060	060	060
17. Use (crop) - Use in 2000	060	060	060	060	060
18. Use (crop) - Use in 2000	060	060	060	060	060
19. Use (crop) - Use in 2000	060	060	060	060	060



soybeans	2001	AR	Clay	21	129000	127000
soybeans	2001	AR	Conway	29	21000	20000
soybeans	2001	AR	Craighead	31	87000	85500
soybeans	2001	AR	Crawford	33	13000	12500
soybeans	2001	AR	Crittenden	35	166000	162500
soybeans	2001	AR	Cross	37	150000	149000
soybeans	2001	AR	Desha	41	87000	86000
soybeans	2001	AR	Drew	43	21000	20500
soybeans	2001	AR	Faulkner	45	7000	7000
soybeans	2001	AR	Franklin	47	2000	2000

Estimates