Land Use Change Data and Ground Truthing

Presented to:
CRC Workshop

Presented by:
Ken Copenhaver,
Steffen Mueller

University of Illinois at Chicago
Energy Resources Center

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Presentation Overview

- Ground Truthing Considerations
- Land Use: What Lands are Available?
- Land Use Change: What Lands are Being Converted to Crop?
- Can current data accuracies measure land use or change?

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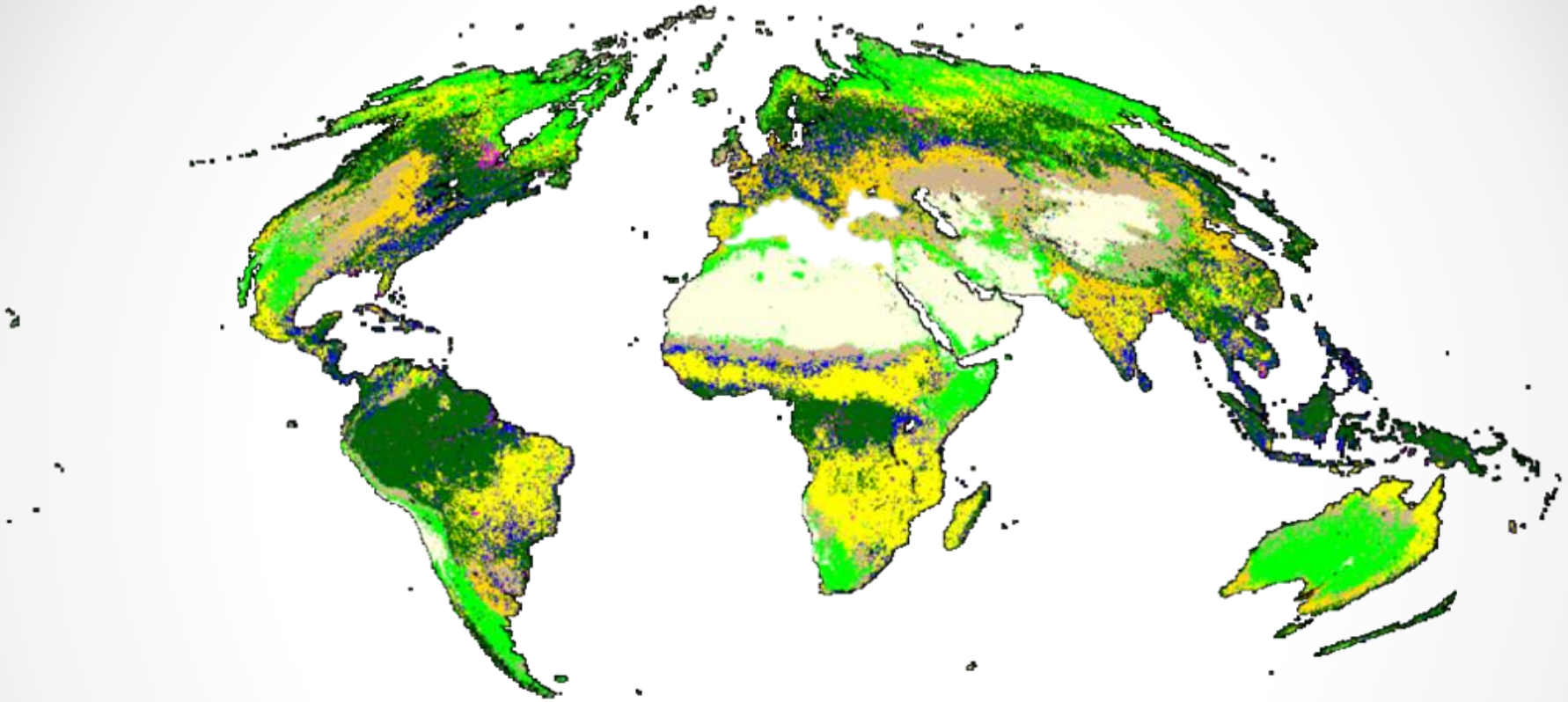
Ground Truthing the Earth



Land Area of the Earth: 148,300,000 km^2

Number of MODIS Pixels (500 meters): 593,200,000 pixels

Number of AWiFS pixels (56 meters): 5,296,428,571 pixels

Number of Quickbird pixels (2.4 meters): 1,235,833,333,333 pixels

How do you obtain enough samples to train and test that data?

A Definition of Ground Truth

- What is actually on the ground at a given location associated with a remotely sensed image.
- Ground Truth=Estimated Accuracy
  (Go to 100 sites, right 90 times, 90% accuracy)
- Should be done on date image collected.
- Requires a GPS to ensure location is correct (GPS can have accuracies from centimeters to several meters.)
- GPS should be accurate to less than ½ an image pixel
- When measuring land use change it is required that the same site be visited during both time periods.

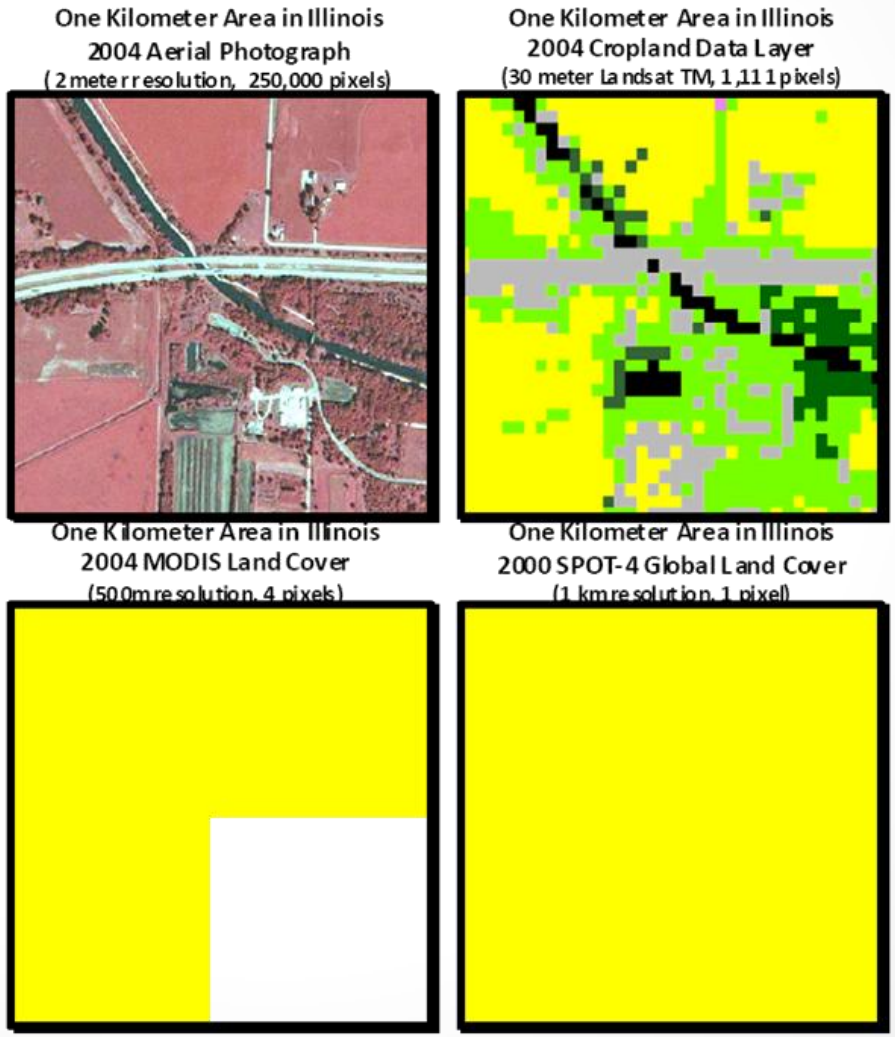
Remote Sensing Accuracy

- There are many ways to measure image accuracy (producer's accuracy, comission errors, Kappa statistics).
- The more points you collect the lower your standard error.
- Decision on how many points to collect is somewhat subjective.
- Need to collect points to train and to test the data.
- Surrogate methods for accuracy (ground truth) after classification
  - How well does acreage match tabular datasets (USDA, UN FAO)
  - How many pixels are in unrealistic land use changes (ex: forest-crop-forest)

Different Resolutions

(Need to Ground Truth Entire Pixel Area)

Land Cover Classifications Using Various Resolutions In a Heterogeneous Environment



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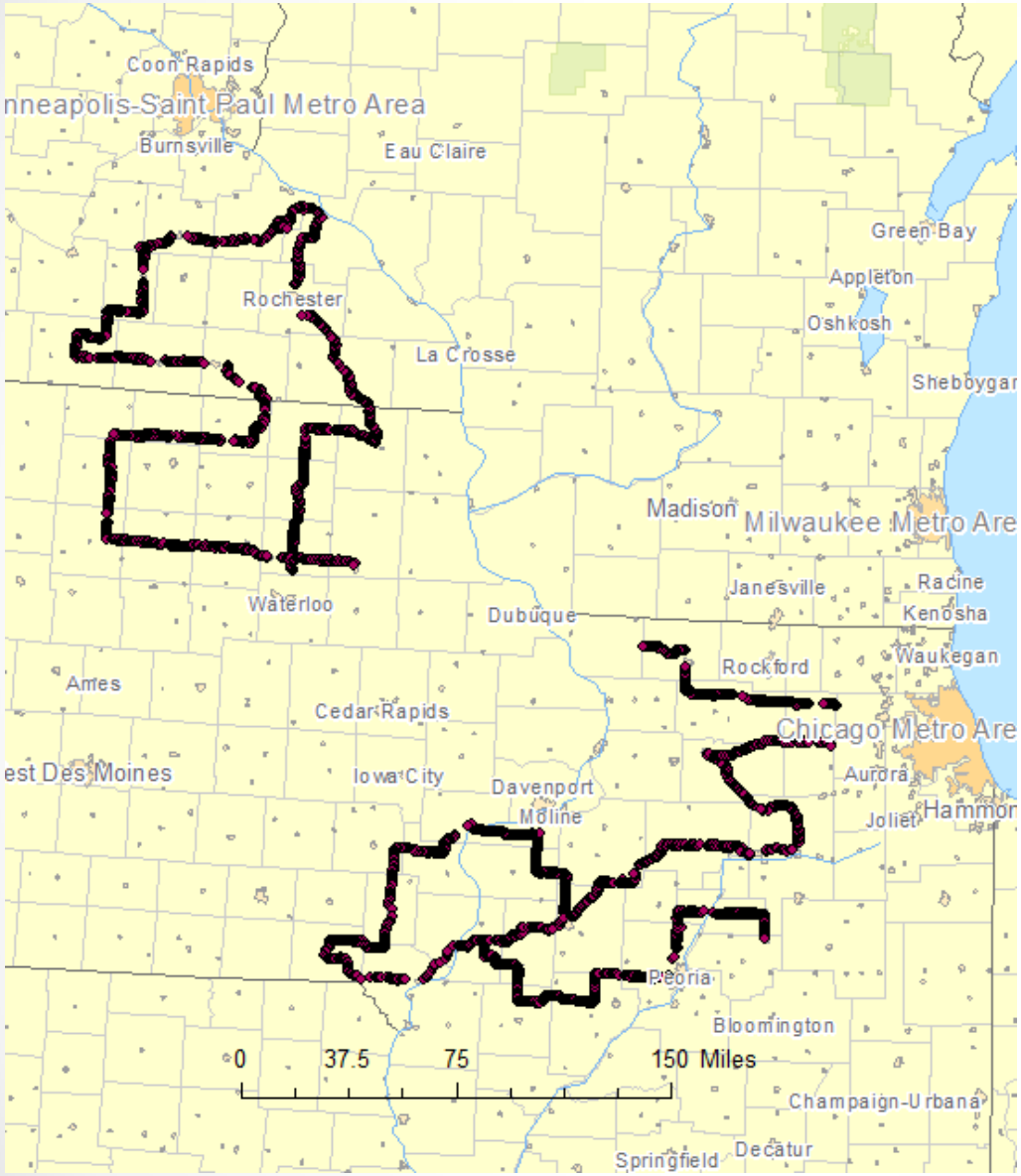
Ground Truthing: In Season Corn Acreage Prediction



With GPS smartphones, Automobile GPS, mobile mapping software, data can be collected rapidly.

2011 In-Season Planted Corn Acres Study:

Ground Truth Efforts: Multiple Days, Thousands of Data Points.

1,241 randomly surveyed points collected In less than 8 days.

Current Land Use Analysis

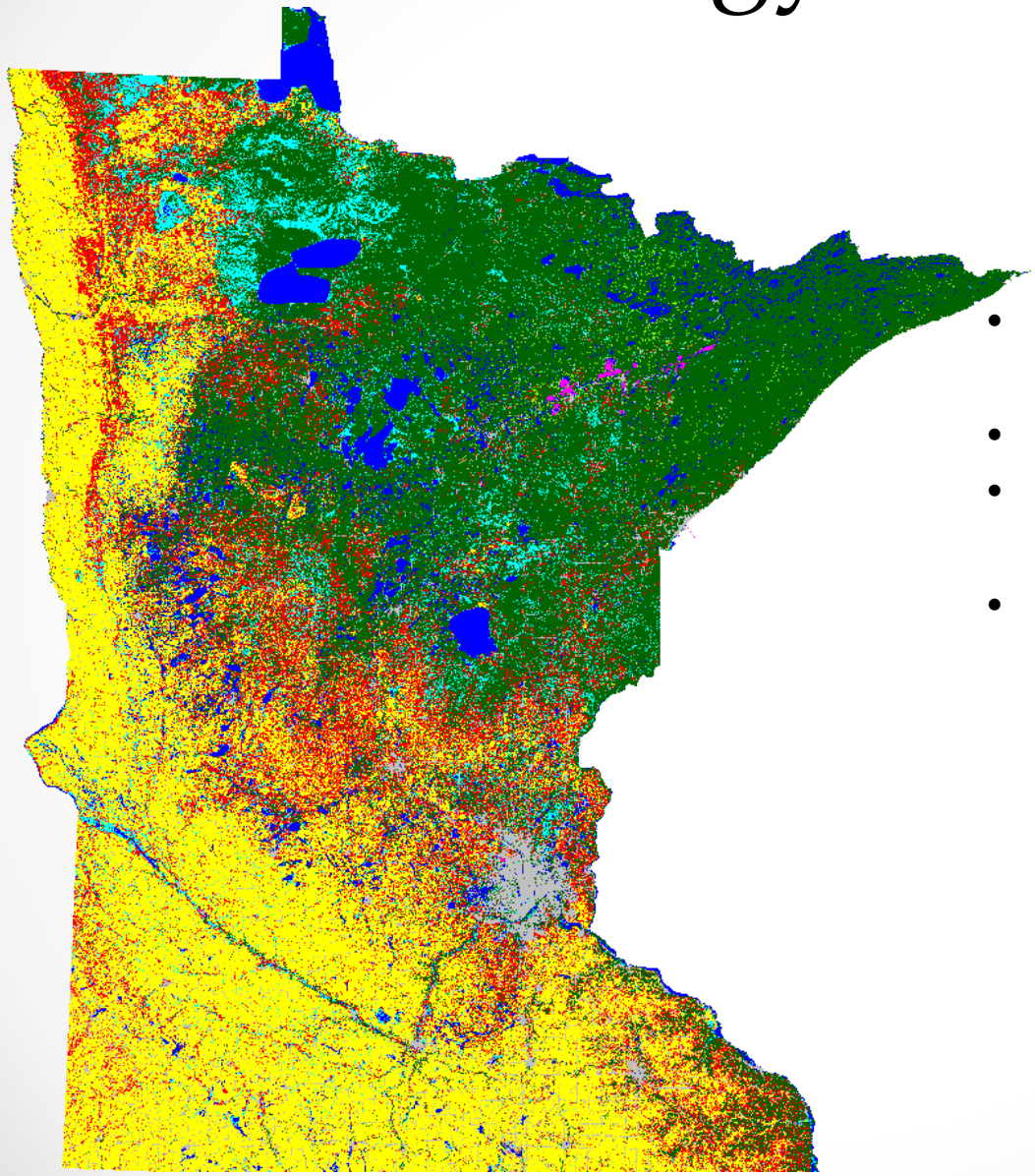
Lands Available for Conversion

by State, AEZ and for the U.S.

Methodology

- 2010 USDA NASS Cropland Data Layer
- Determined Available Lands (pasture, hay and grassland excluding less fertile herbaceous grassland) by State.
- Compared available lands to land use change predicted by GTAP for corn ethanol and switchgrass ethanol (Taheripour, Tyner, Wang, August 2011).

Methodology Continued



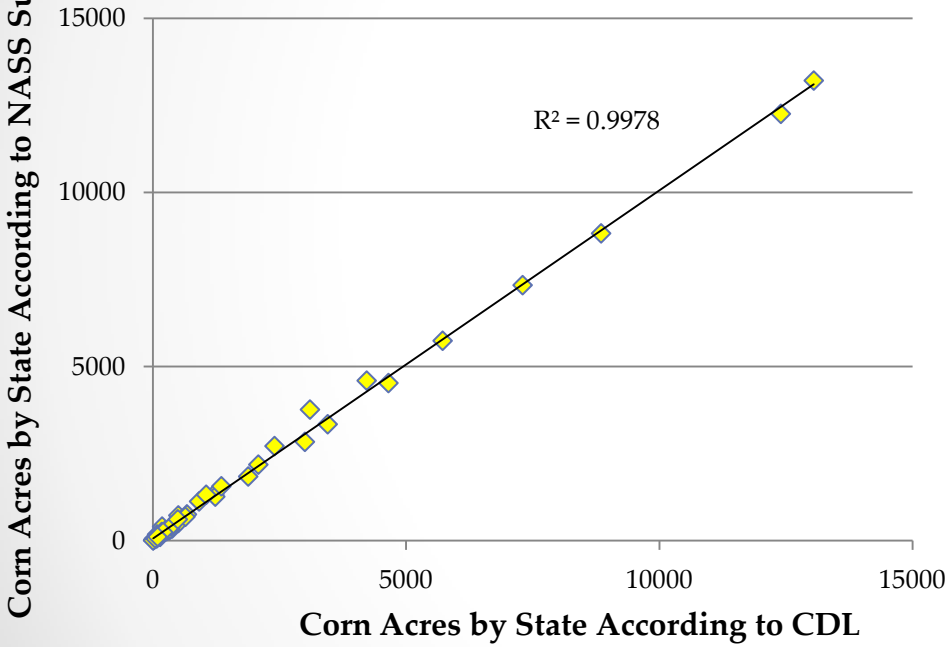
- Cropland Data Layer classes collated into below for study
- All crops merged into one class
- All hay, pasture and grasslands merged into available lands
- All forest merged into one class

Crop
Available Lands
Forest
Water
Urban
Barren
Shrub
Grassland Herbaceous
Wetlands

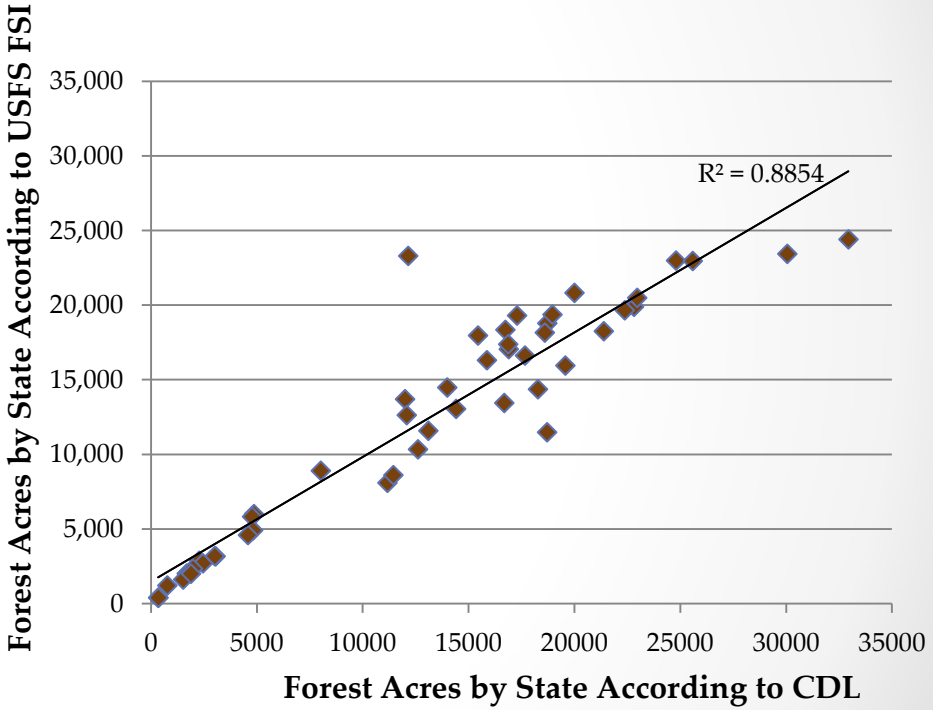
USDA Cropland Data Layer for Minnesota for 2010

Comparing USDA NASS Cropland Data Layer to USDA/USFS Survey Data

Comparison of Predicted Acres in Corn for NASS Survey Data and NASS Cropland Data Layer for All 48 States in 2010



Comparison of Predicted Acres in Forest for USFS Forest Service Inventories and NASS Cropland Data Layer for All 48 States in 2010*



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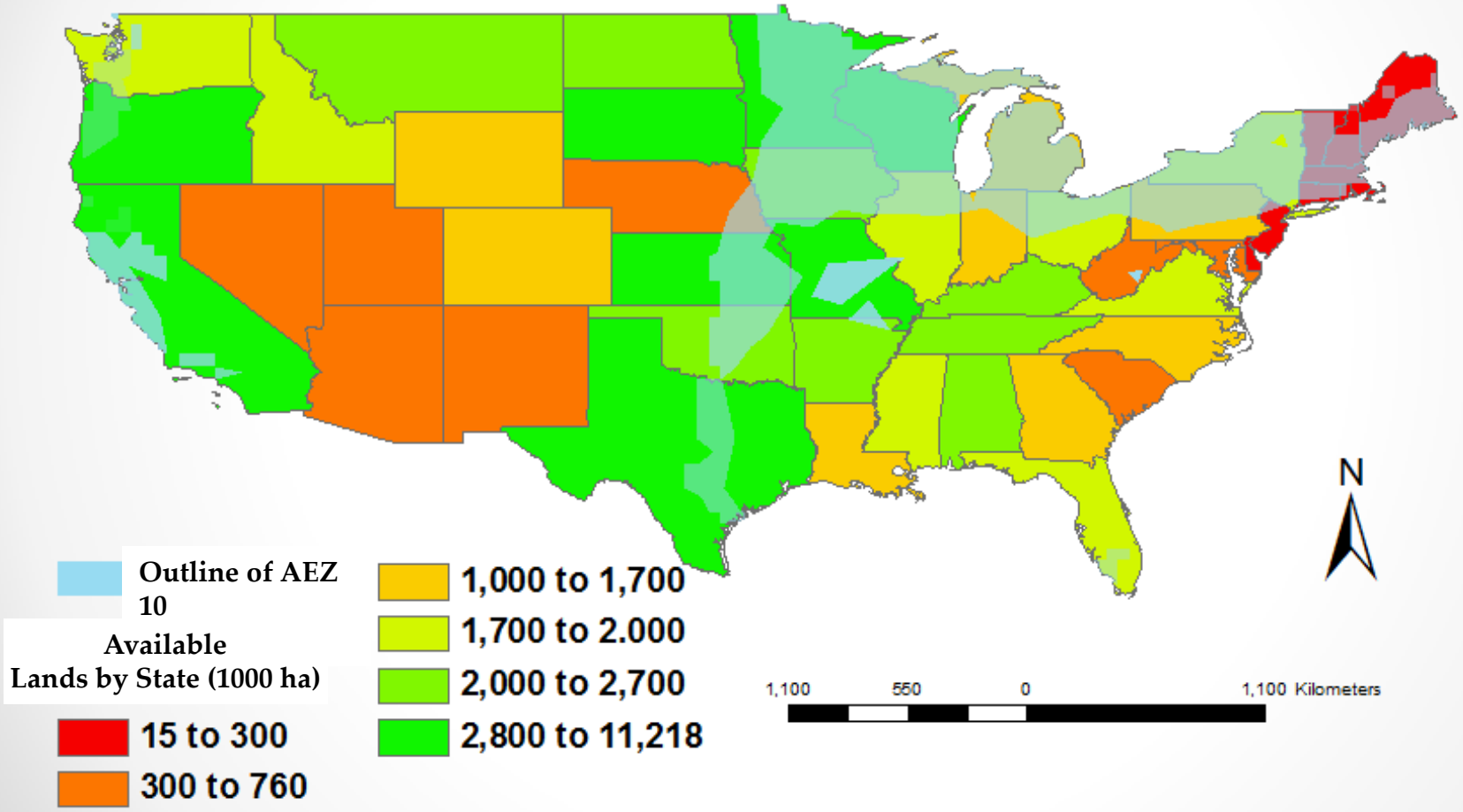
*Not all states had an inventory in 2010. Some inventories are from 2009 or older.

Available Lands Compared to GTAP LUC

	Cropland Data Layer	Corn Ethanol Land Demand (11.59 bg)			Switchgrass Ethanol Land Demand (7.03 bg)		
AEZ:	Available Lands (ha)	GTAP Forest (ha)	GTAP Pasture (ha)	GTAP Total Conversions (ha)	GTAP Forest (ha)	GTAP Pasture (ha)	Cropland Conversions (ha)
AEZ 7	19,079,808	-3,479	-340,320	343,724	-49,688	-16,432	66,464
AEZ 8	10,836,998	-16,931	-133,912	150,864	-79,870	81,132	-1,374
AEZ 9	4,515,799	-2,022	-10,238	12,264	-32,911	32,094	807
AEZ 10	23,737,634	-179,636	-82,626	262,264	-233,964	138,451	95,568
AEZ 11	19,834,096	-93,360	-42,881	136,244	-185,048	100,664	84,452
AEZ 12	11,946,038	-30,064	-14,111	44,179	-115,816	74,825	41,107
AEZ 13	1,299,687	-736	-11,662	12,399	-52,189	44,787	7,406
AEZ 14	1,107,565	-5,032	-3,518	8,549	-31,428	24,825	6,525
AEZ 15	263,517	-200	-214	418	-2,072	1,833	227
AEZ 16	47,396	-5	-3	10	-37	30	6.9
Total:	92,668,535	-331,465	-639,485	970,916	-783,023	482,209	301,189

Available Lands by State

Available Lands = Pasture, hay and grassland excluding less fertile herbaceous grassland



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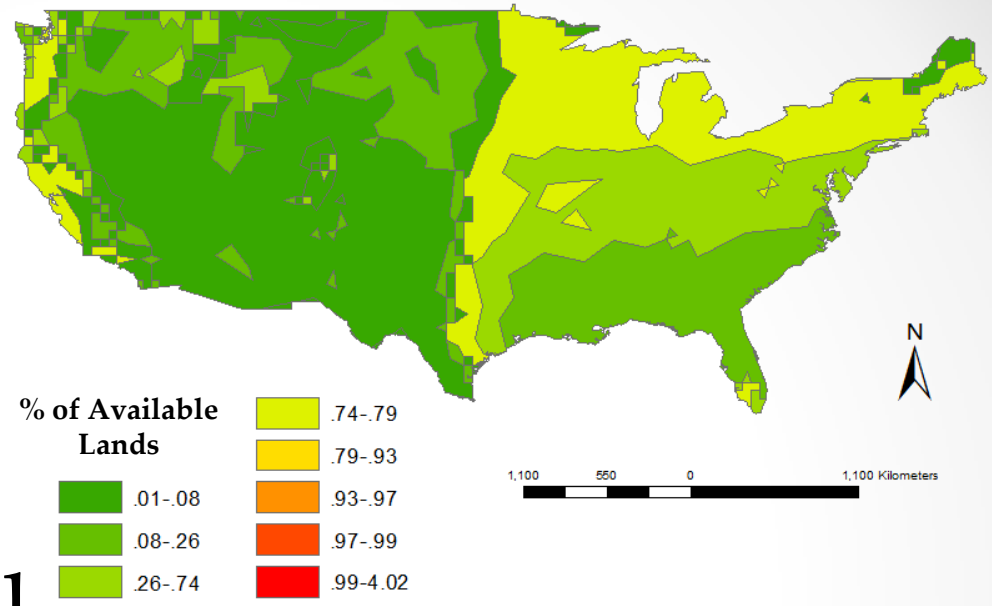
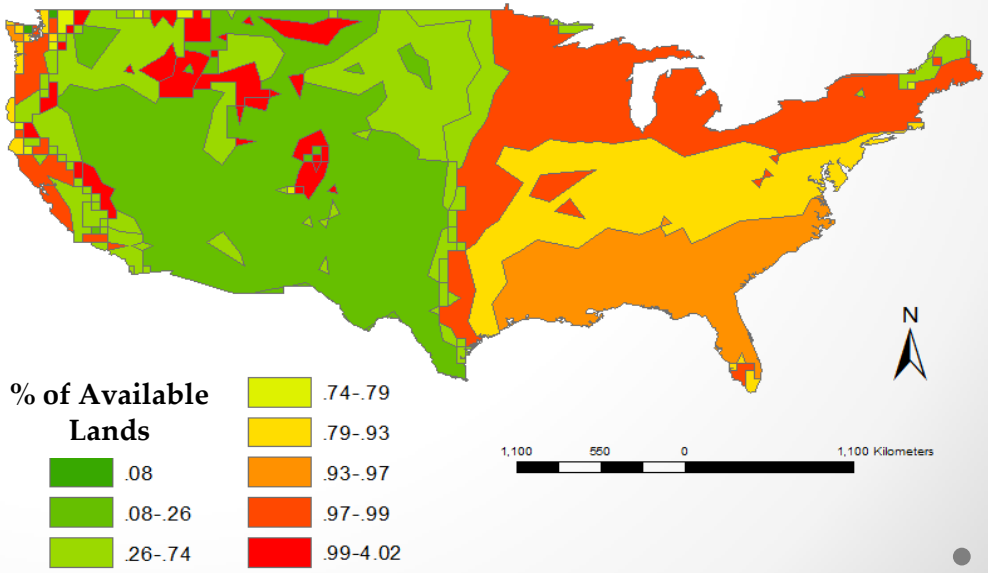
GTAP Forest Conversions as Percentage of Total Available Lands

For Corn Ethanol



For Switchgrass Ethanol



Conclusions

- In light of the available land, we would expect a low land use transition probability from forest
  - Further assessment would need to take into account conversion costs and land profit coefficients

- However, land use change predicted from biofuels scenarios (~1,000,000 hectare) are dwarfed by actually available lands in the United States of 92,000,000 hectare.

Considerations

- Are these available land parcels large enough for conversion? (preliminary study in northern Illinois indicates large % are).
- Are parcels fertile enough? Can be tested with spatially-explicit ecosystem models such as Century (Ogle) or Surrogate Century (Kwon).
- Many states with large available land acres (MN, KS, MO) also have existing crop acres.
- Will slope, emissions and water use prevent the adoption of these lands? Can also be tested with models.

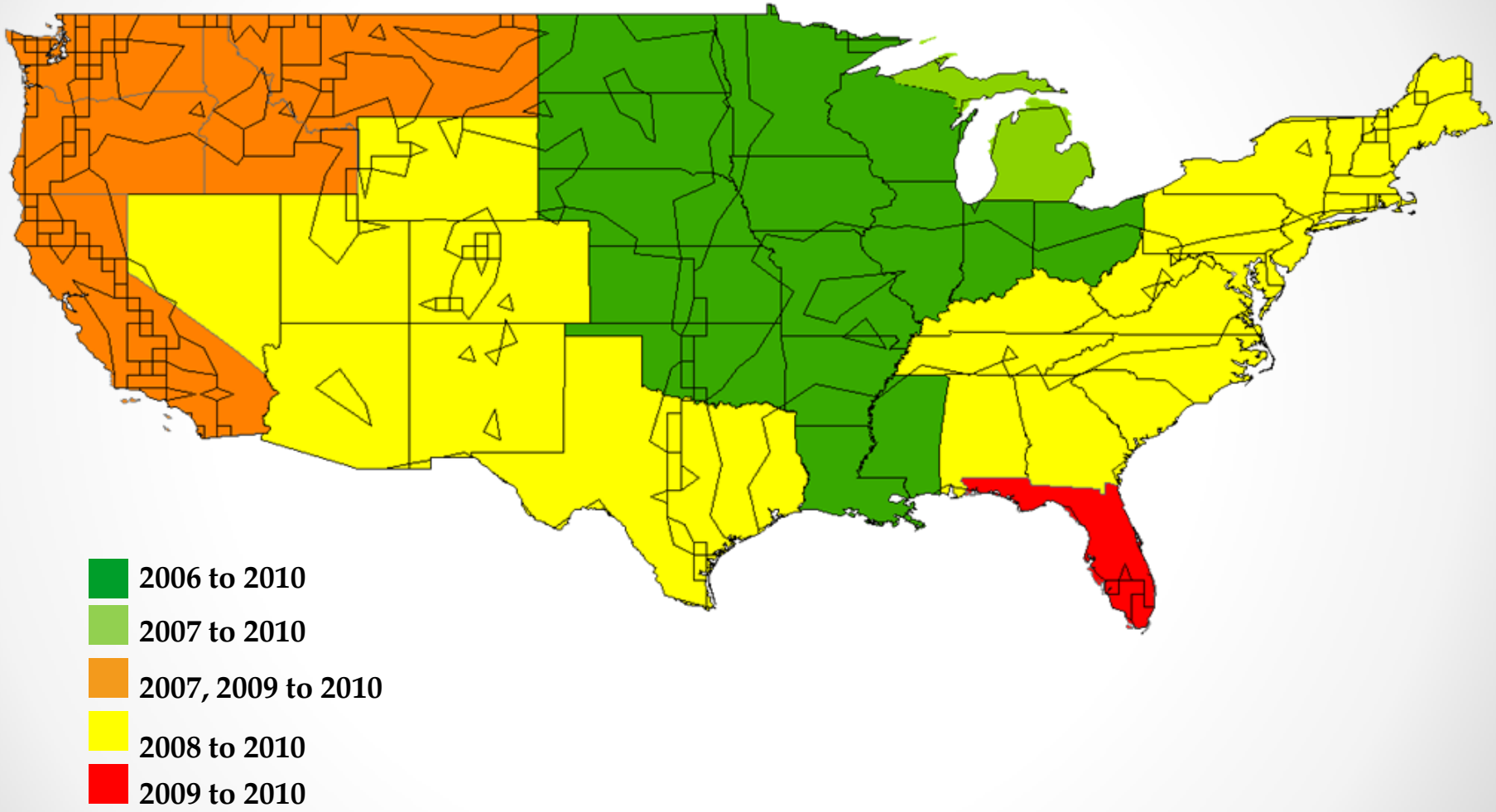
Land Use Change Detection

National and International

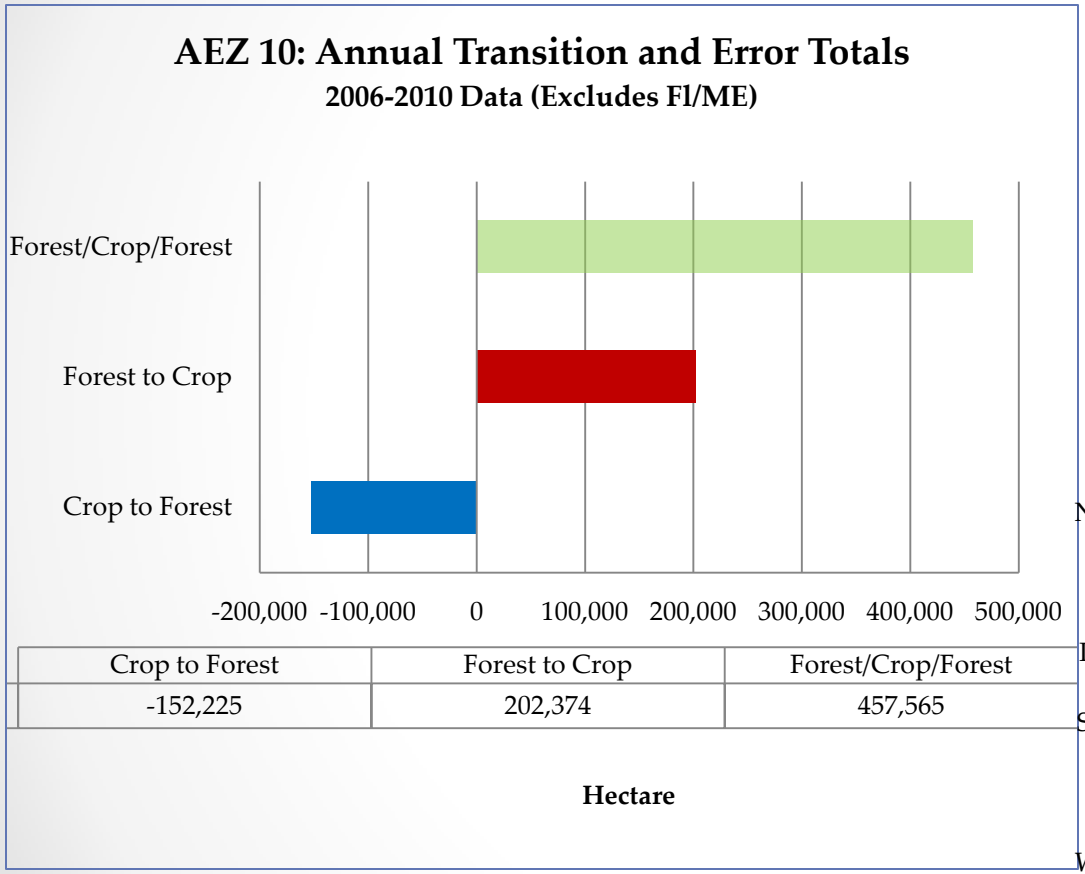
Methodology

- Determined change in land use from year to year using Cropland Data Layer
- Removed buffers along roadways (often erroneous classes)
- Considered unrealistic transitions (forest to crop to forest)
- Because cropland data layer not available in all states for all years, calculated annual transitions

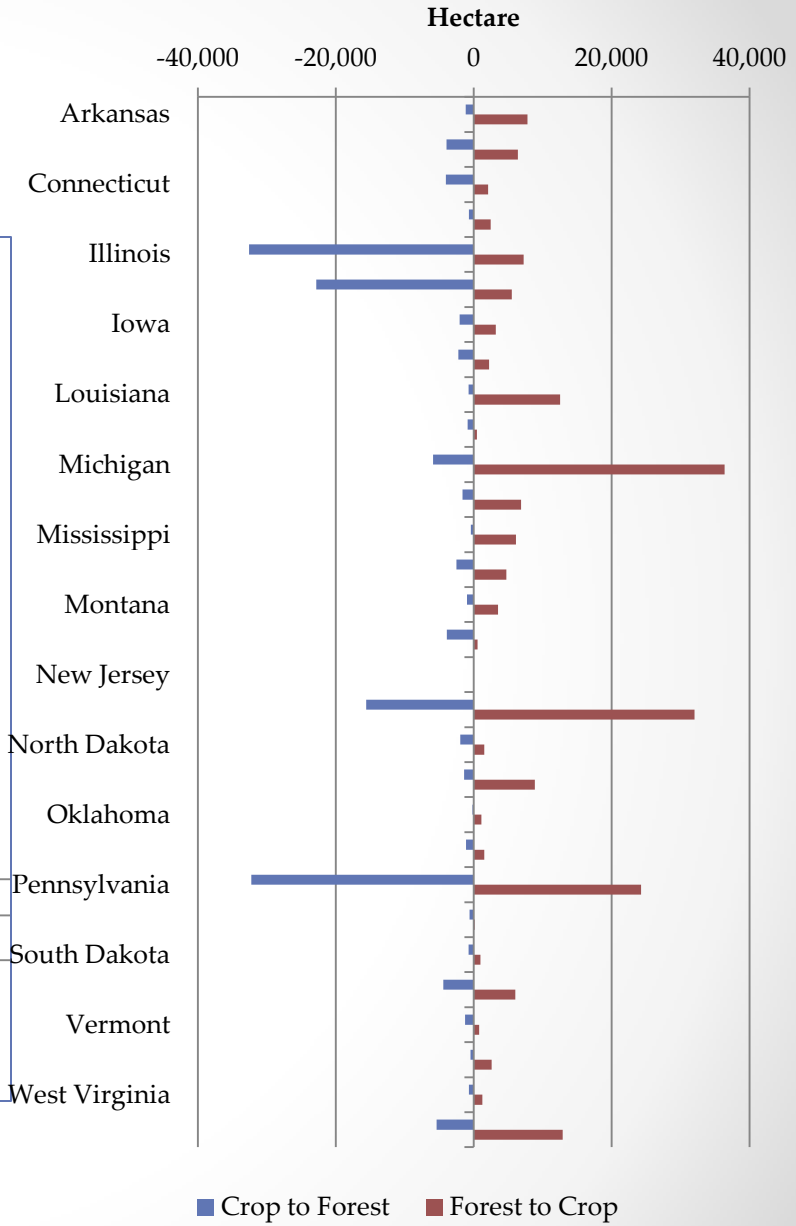
Cropland Data Layer Availability



CDL: 2006-2010 Land Use Change



Crop to Forest	Forest to Crop	Forest/Crop/Forest
-152,225	202,374	457,565



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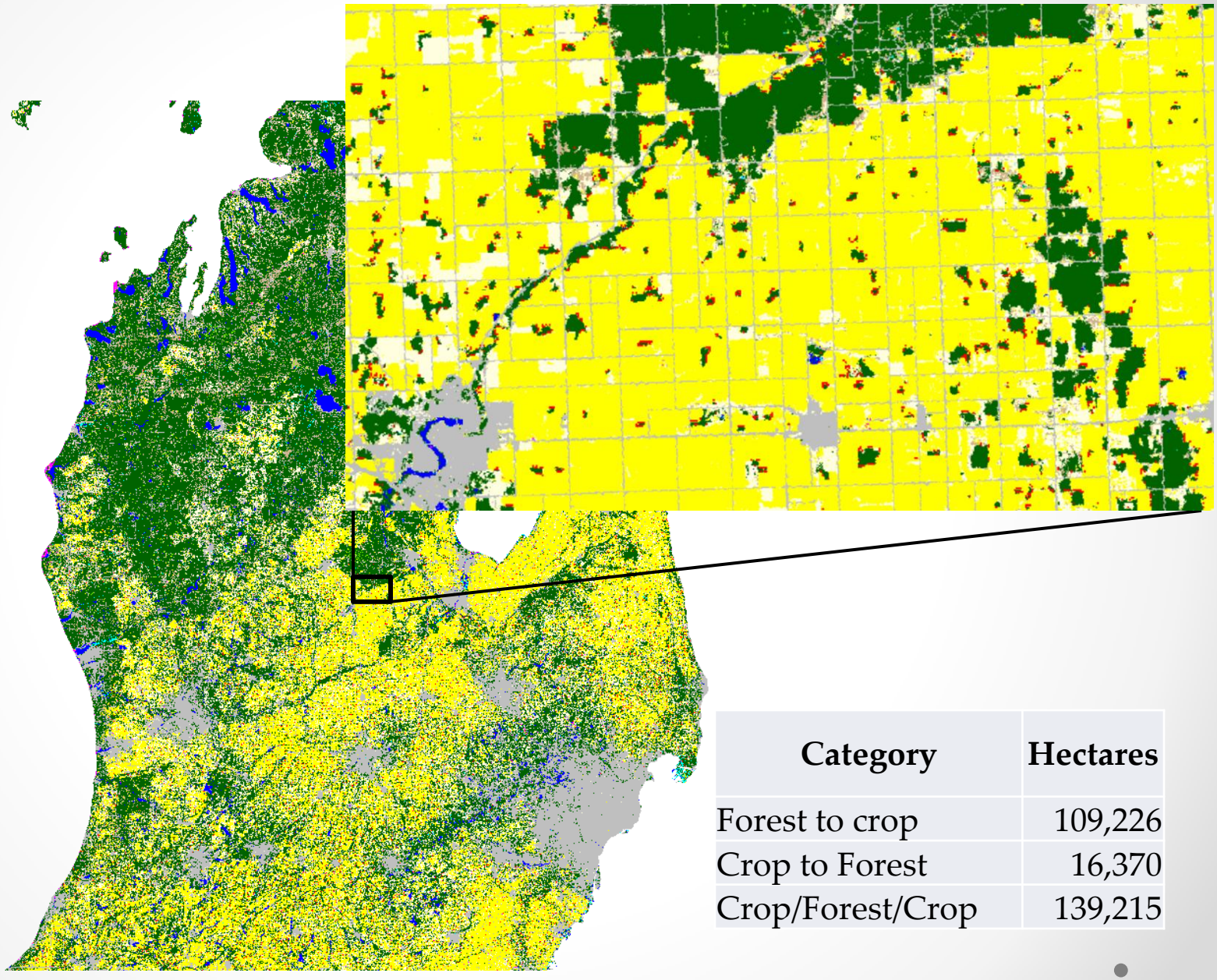
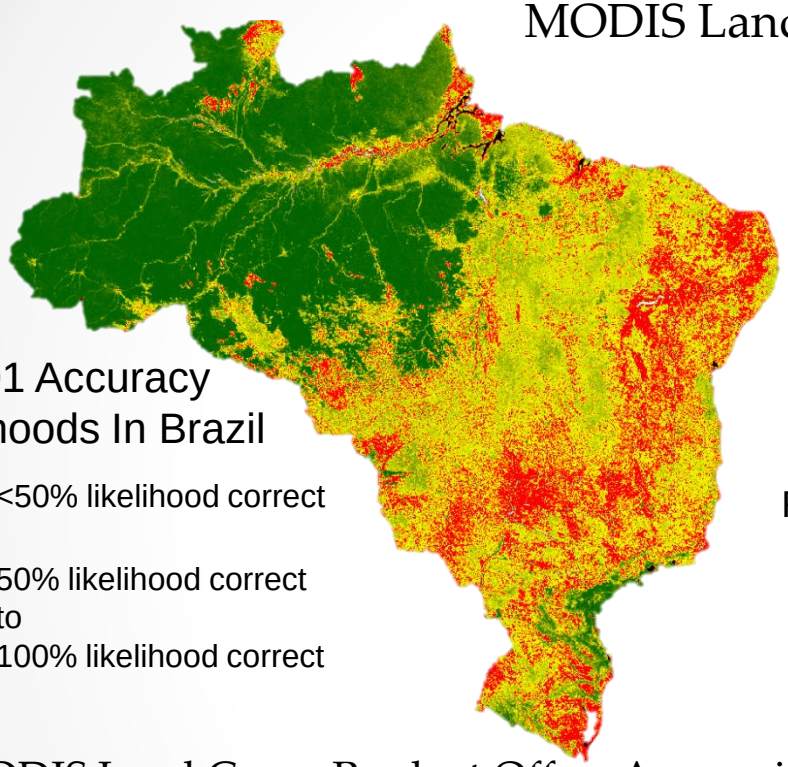
Transition Areas Are Also Error Prone



Category	Hectares
Forest to crop	109,226
Crop to Forest	16,370
Crop/Forest/Crop	139,215

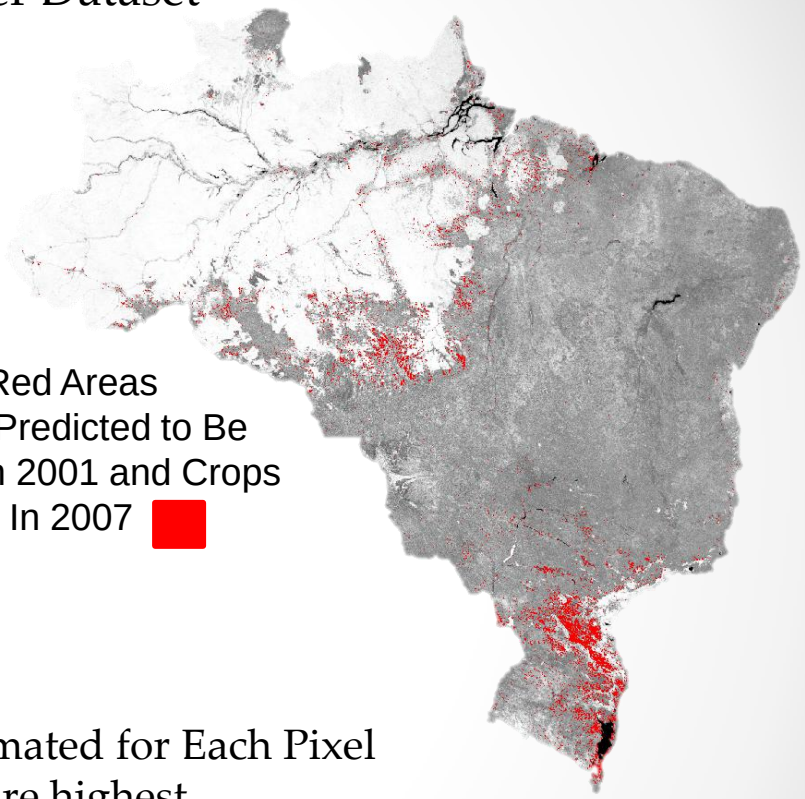
Actual Accuracy for Converted Areas with Brazil as an Example

MODIS Land Cover Dataset



2001 Accuracy Likelihoods In Brazil

- <50% likelihood correct
- 50% likelihood correct to 100% likelihood correct



Red Areas Were Predicted to Be Forest in 2001 and Crops In 2007

- MODIS Land Cover Product Offers Accuracies Estimated for Each Pixel
- Change is not predicted to occur where accuracies are highest
- EPA Stochastic Analysis performed using highest accuracies

Accuracy for **All Forests in Brazil 2001**: **90%**
Accuracy for Forests **Converted to Crop in Brazil 2001: 59%**

Accuracy for **All Crops in Brazil 2007: 69%**
Accuracy for **Crops Converted from Forest in Brazil 2007: 62%**

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Conclusions on Land Use Change

- Ground truth is an integral part of the use of remotely sensed data for land use change prediction.
- With new technologies (GPS, smart phones, internet software) ground truth can be collected rapidly but constraints on accuracy must be understood.
- Data products like the USDA Cropland Data Layer and MODIS annual land use maps can be used to better understand the use of national and international lands.
- However, the inherent noise in these datasets may over-ride the signal trying to be obtained (small scale land use change).
- Removing smaller parcels may reduce error.
- A detailed, high resolution dataset for transition areas is required to accurately determine predicted land use change.