Integrating Agricultural Land Management into a Watershed Response Model

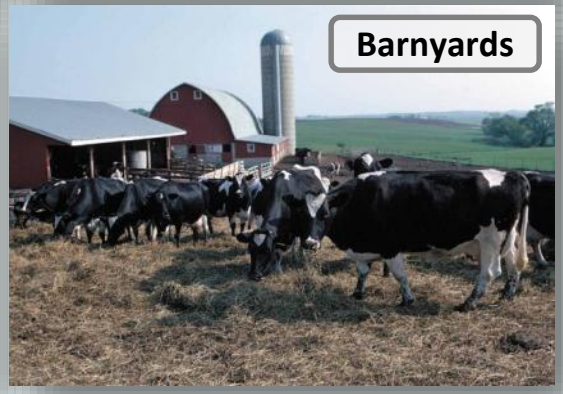
Adam Freihoefer, Tom Beneke, & Aaron Ruesch
Wisconsin Department of Natural Resources
AWRA - Wisconsin Section Annual Meeting
March 13, 2014

Algal blooms due to excessive phosphorus

WISCONSIN DEPT. OF NATURAL RESOURCES

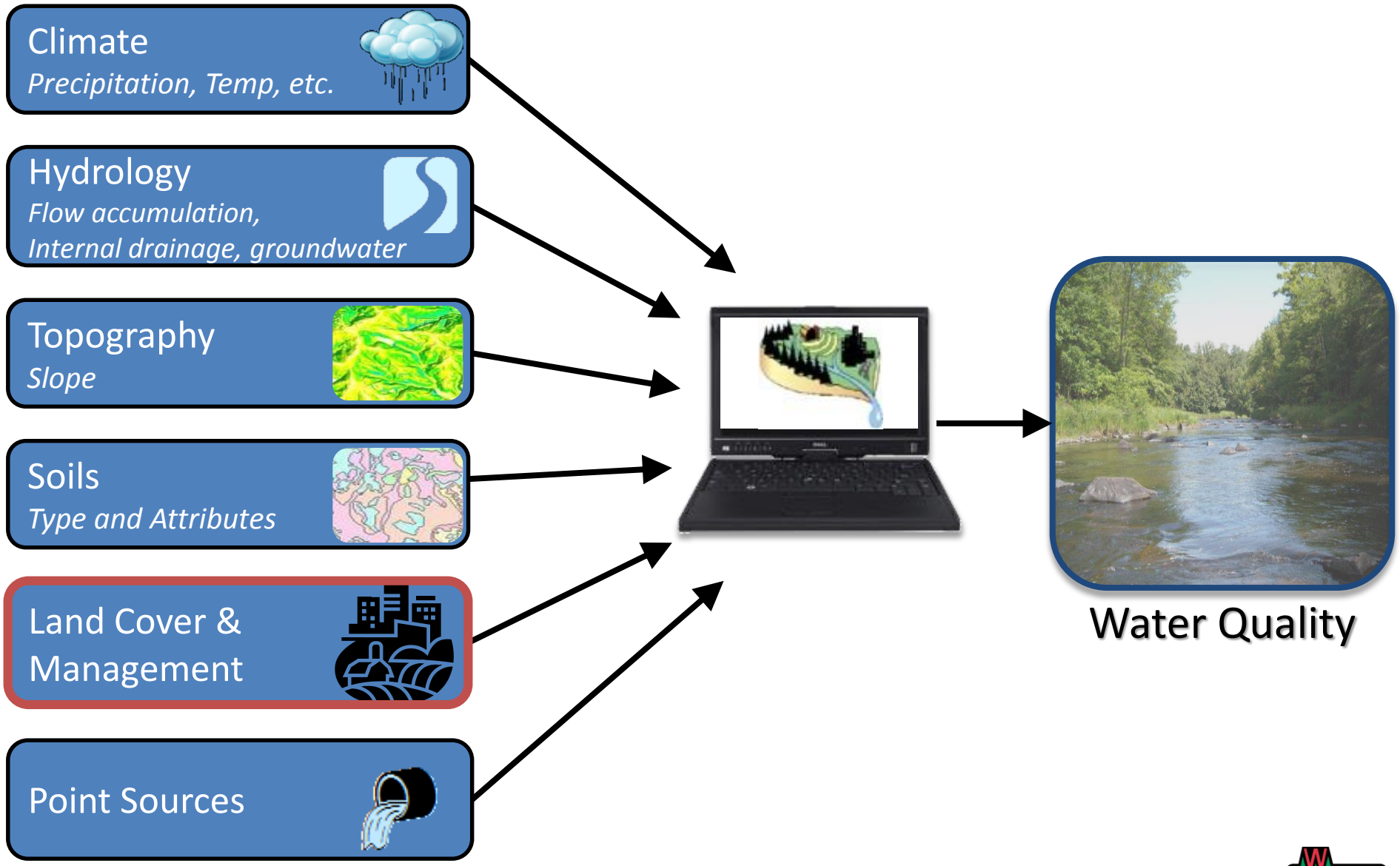
Typical Sources of Phosphorus

Nonpoint Sources



Point Sources

Simulating Water Quality with a Watershed Response Model



Agricultural Land Management in Wisconsin

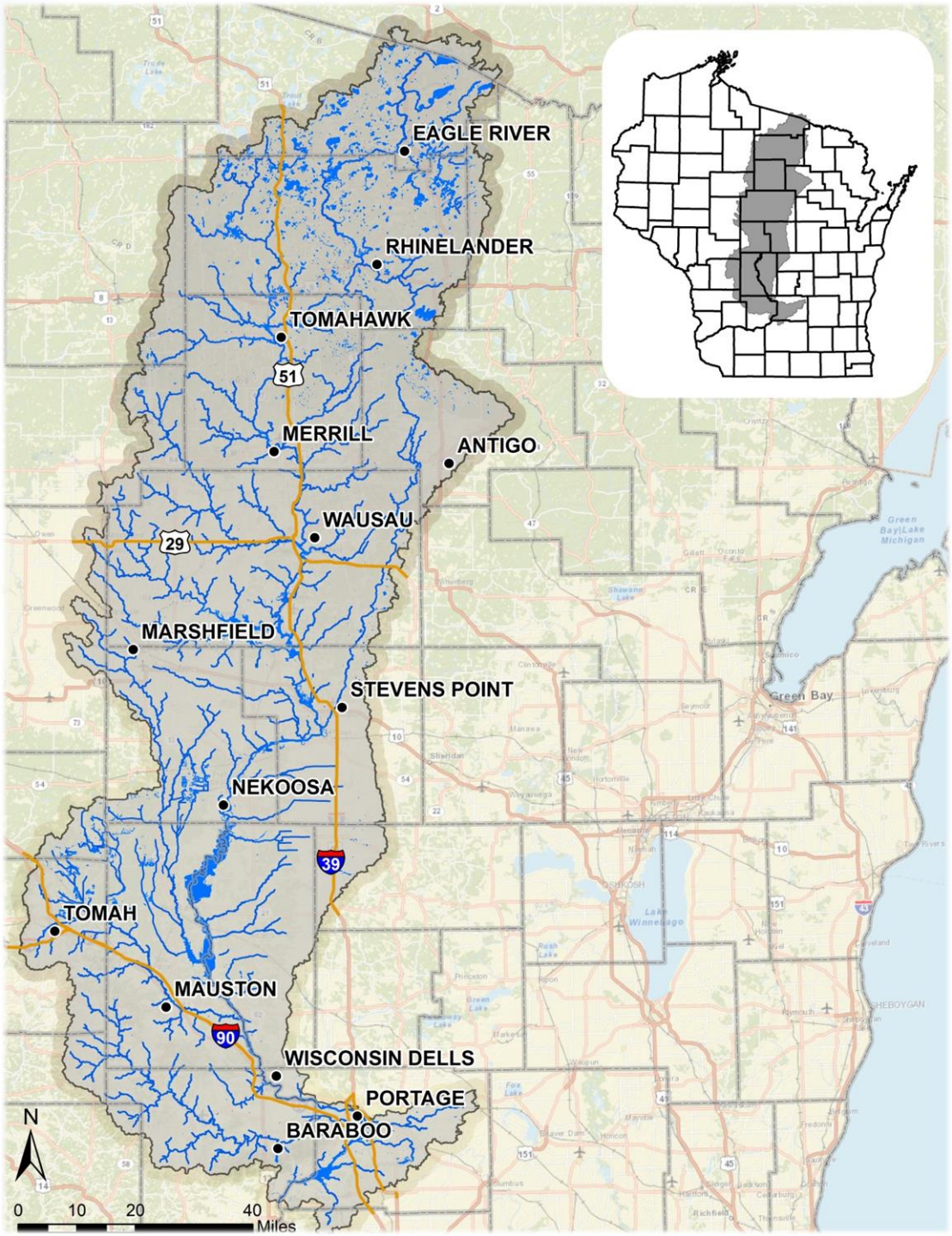
Agricultural Land Management Assessment Objective

Create a spatiotemporal definition
of crop rotations in the Wisconsin River Basin
(6-year crop sequence with associated tillage and nutrient applications)

Wisconsin River Basin

- 9,156 square miles of from the headwaters in Vilas County to Lake Wisconsin in Columbia County

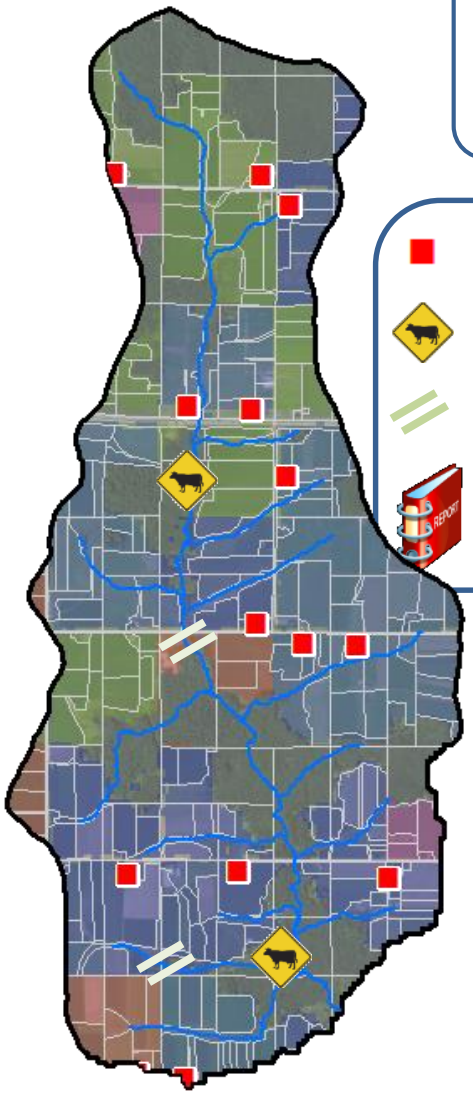
- Drains 14% of the state with contributions from 23 counties



Finding a Balance in Data Collection

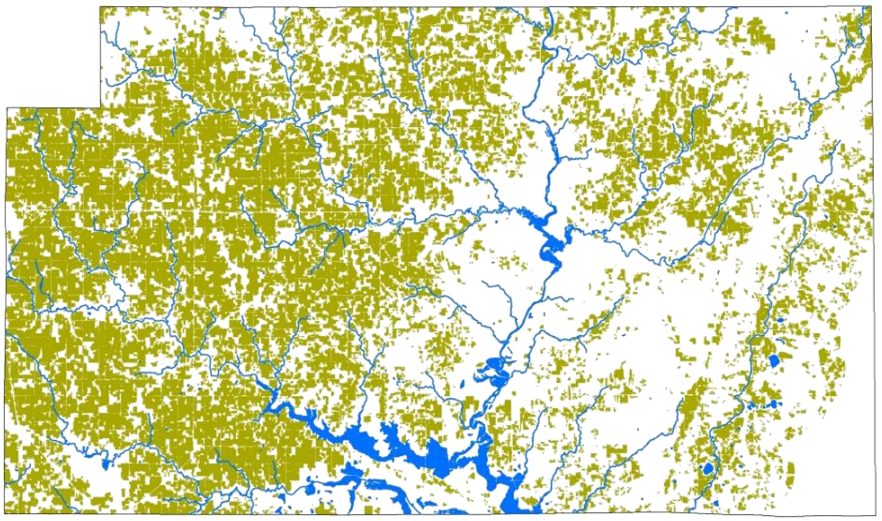
What scale are we working on?

Field < **Subwatershed** < County



- Barnyards
- Cattle Crossings
- Bank erosion sites
- Nutrient Management Plan

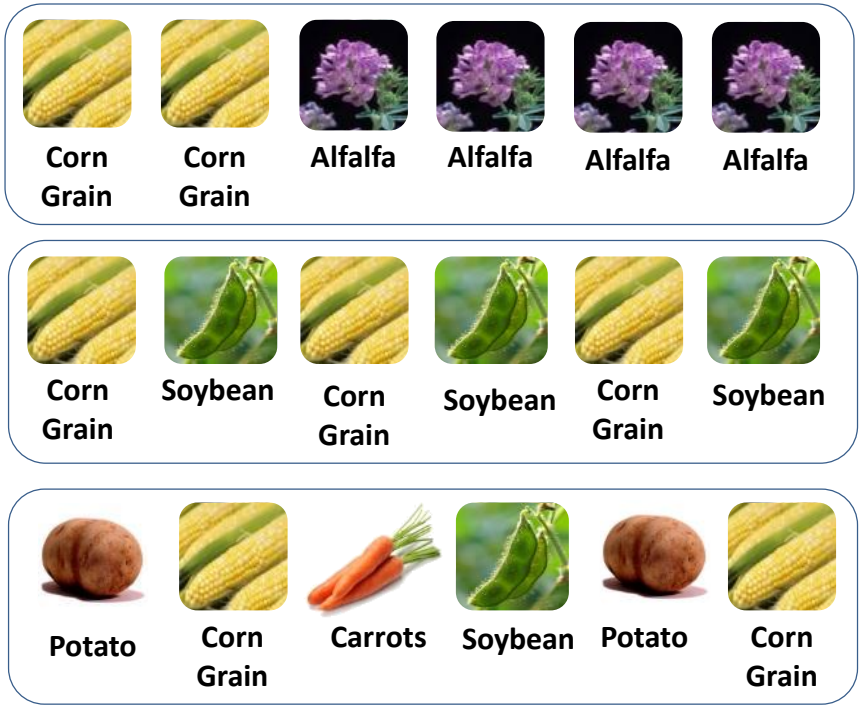
• Homogenous management operations



Field-scale **Countywide**

Information Needed for the Agricultural Assessment

Crop Sequence



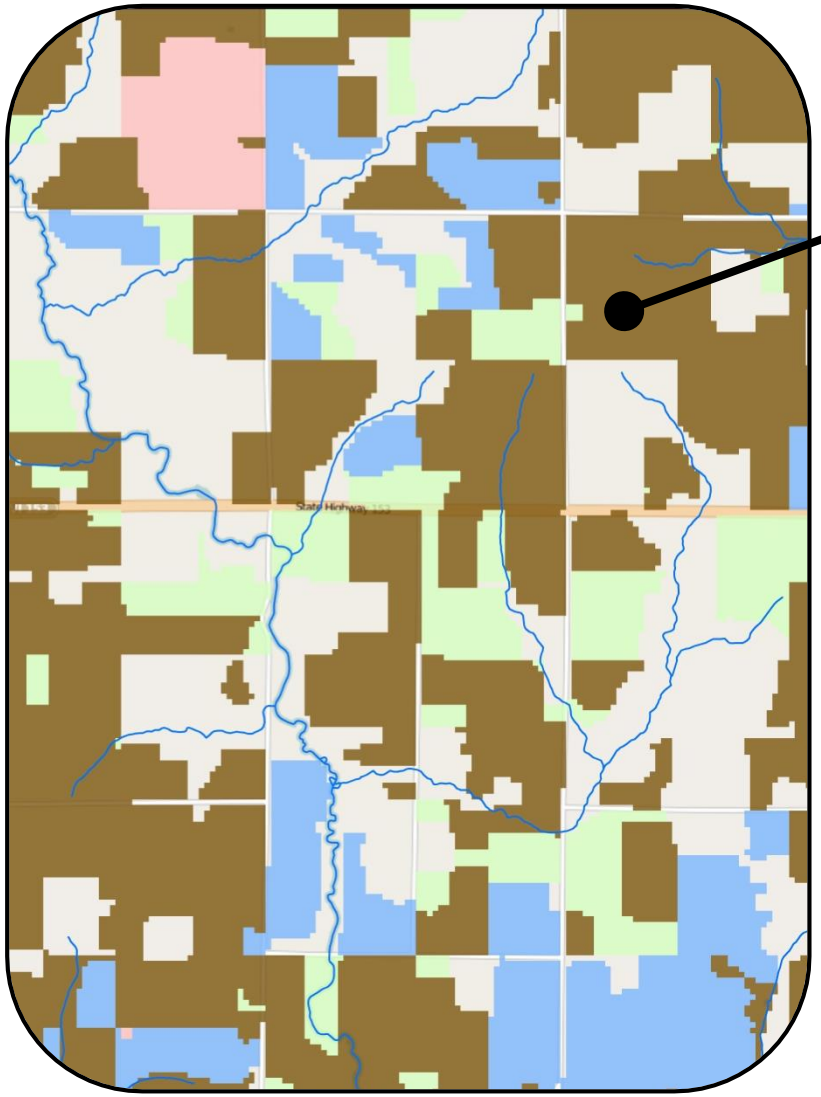
Timing

Tillage

Fertilizer

cows, application rate

Information Needed for the Agricultural Assessment



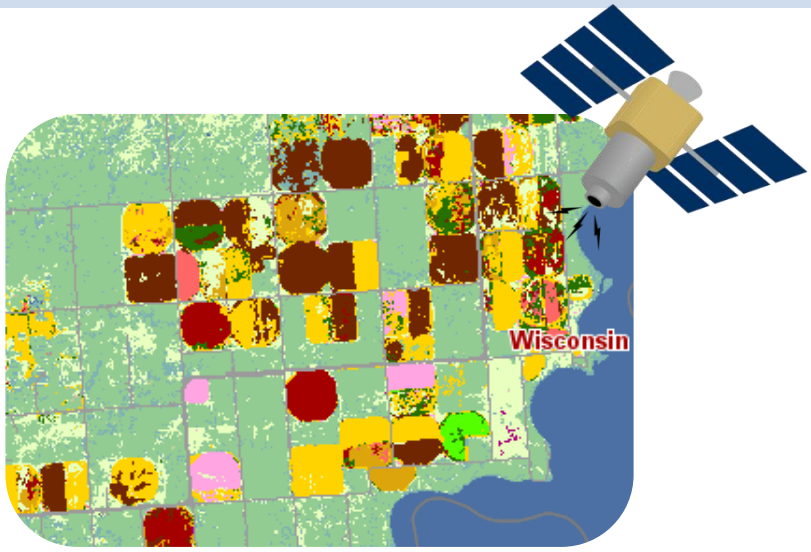
Year	Date	Operation	Crop / Type	Rate	Units
2008	4/29	Manure	Liquid	10,000	gallons/acre
2008	5/1	Tillage	Cultivator		
2008	5/15	Plant	Corn Grain		
2008	5/15	Fertilizer	9:23:30	200	lbs/acre
2008	11/1	Harvest	Corn Grain		
2008	11/10	Tillage	Chisel Plow		
2009	4/29	Manure	Liquid	10,000	gallons/acre
2009	5/1	Tillage	Cultivator		
2009	5/15	Plant	Corn Silage		
2009	5/15	Fertilizer	9:23:30	200	lbs/acre
2009	9/15	Harvest	Corn Silage		
2009	10/20	Tillage	Chisel Plow		
2010	4/29	Manure	Liquid	10,000	gallons/acre
2010	5/1	Tillage	Cultivator		
2010	5/15	Plant	Corn Silage		
2010	5/15	Fertilizer	9:23:30	200	lbs/acre
2010	9/15	Harvest	Corn Silage		
2010	10/20	Tillage	Chisel Plow		
2011	4/10	Manure	Liquid	10,000	gallons/acre
2011	4/12	Tillage	Cultivator		
2011	4/15	Direct Seed	Alfalfa		
2011	9/15	Harvest	Alfalfa		
2012	6/1	Harvest	Alfalfa		
2012	7/15	Harvest	Alfalfa		
2012	9/1	Harvest	Alfalfa		
2013	6/1	Harvest	Alfalfa		
2013	7/15	Harvest	Alfalfa		
2013	9/1	Harvest	Alfalfa		
2013	9/5	Manure	Liquid	10,000	gallons/acre
2013	9/7	Tillage	Chisel Plow		

WISCONSIN DEPT. OF NATURAL RESOURCES

How did we obtain the information?

1. Define agricultural extent

2. Identify & categorize crop change per parcel using satellite imagery



3. Assemble local information to further refine rotations

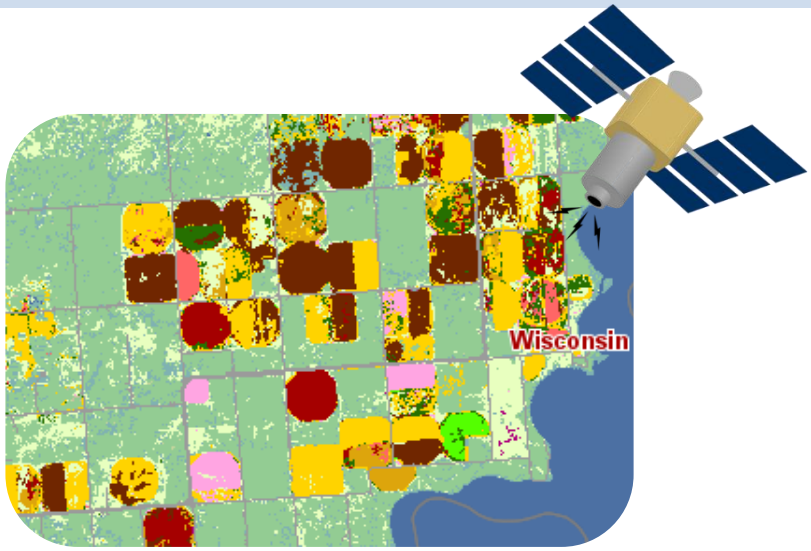
4. Integrate local information into rotation coverage

5. Confirm agricultural management with observed data

NASS

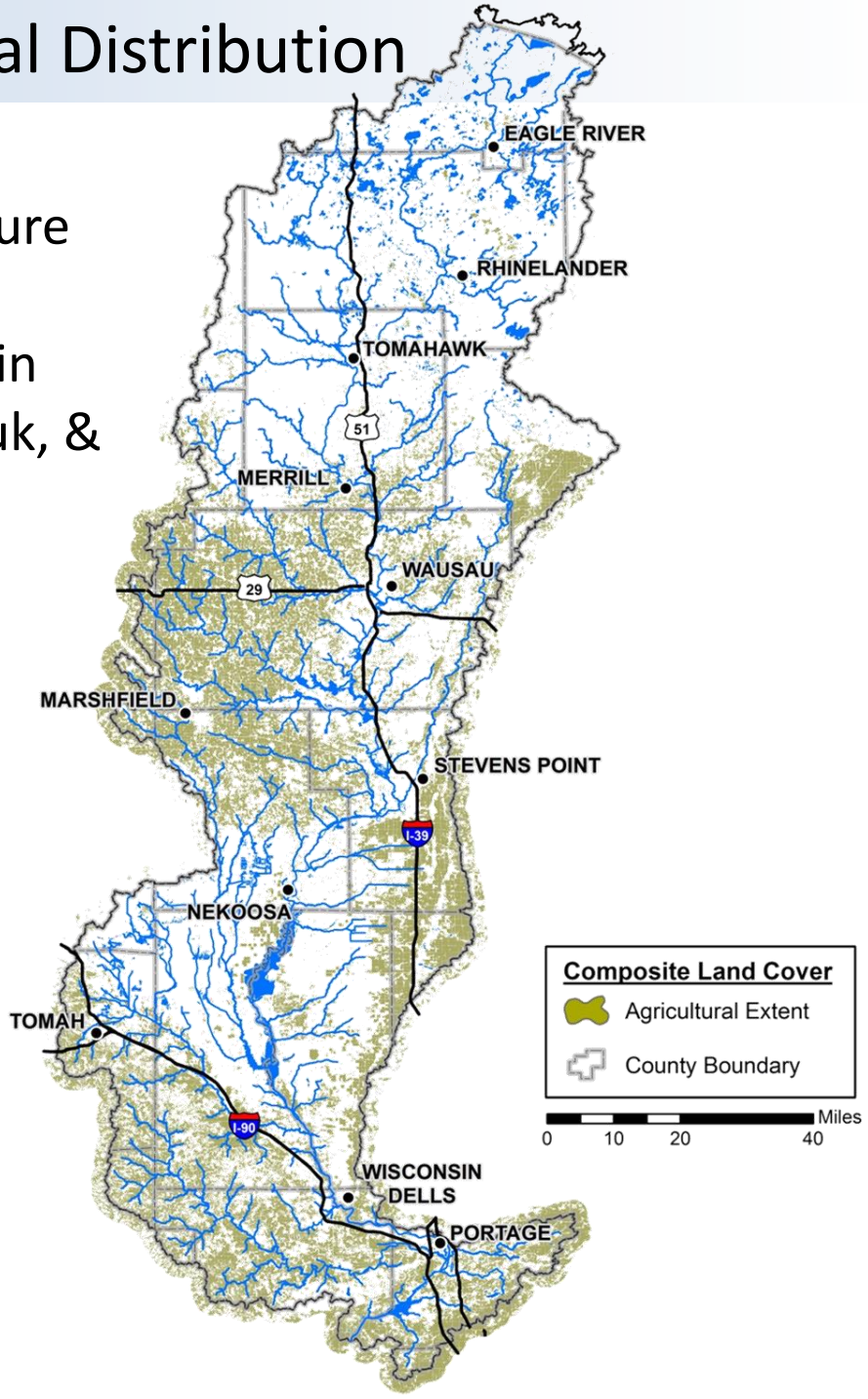
How did we obtain the information?

1. Define agricultural extent



Wisconsin River Basin Agricultural Distribution

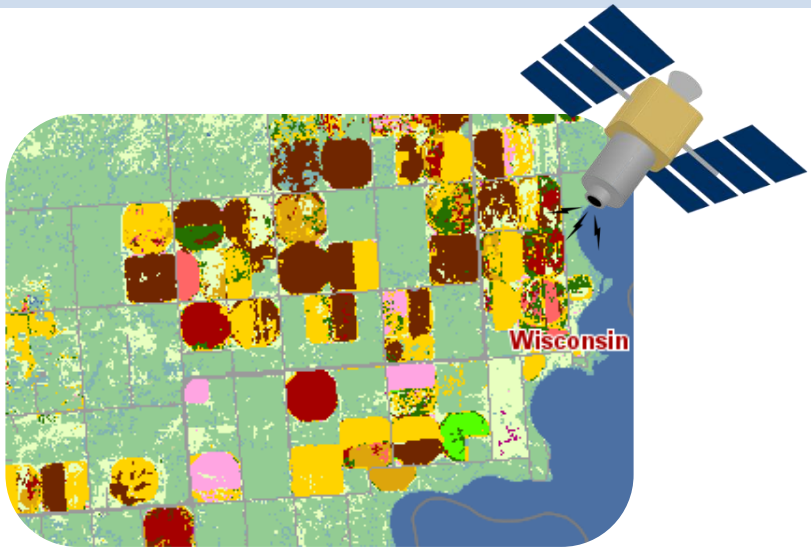
- 25% (2,300 mi^2) of the basin is agriculture
- Majority of agricultural acreage found in Marathon, Wood, Portage, Juneau, Sauk, & Columbia counties



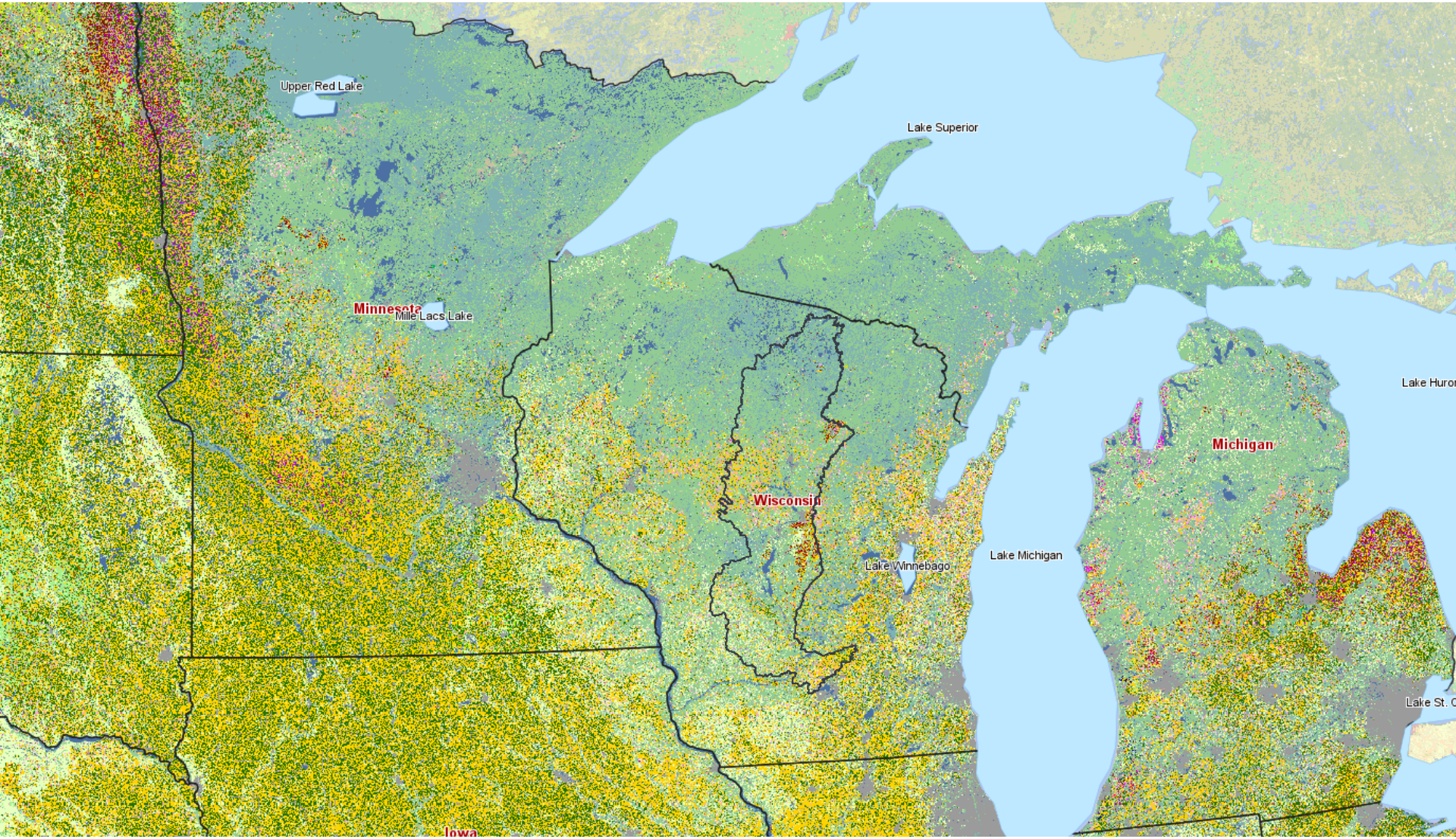
How did we obtain the information?

1. Define agricultural extent

2. Identify & categorize crop change per parcel using satellite imagery



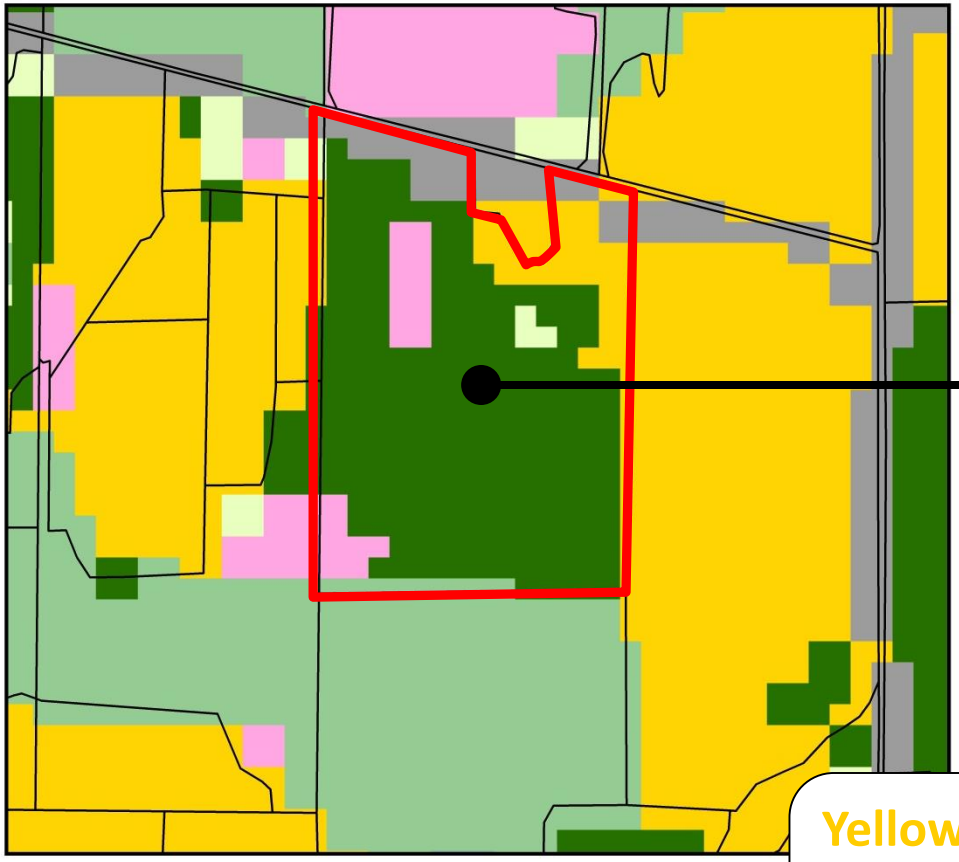
Using Satellite Imagery to Identify Cropping



USDA NASS Cropland Data Layer
http://nassgeodata.gmu.edu/CropScape/

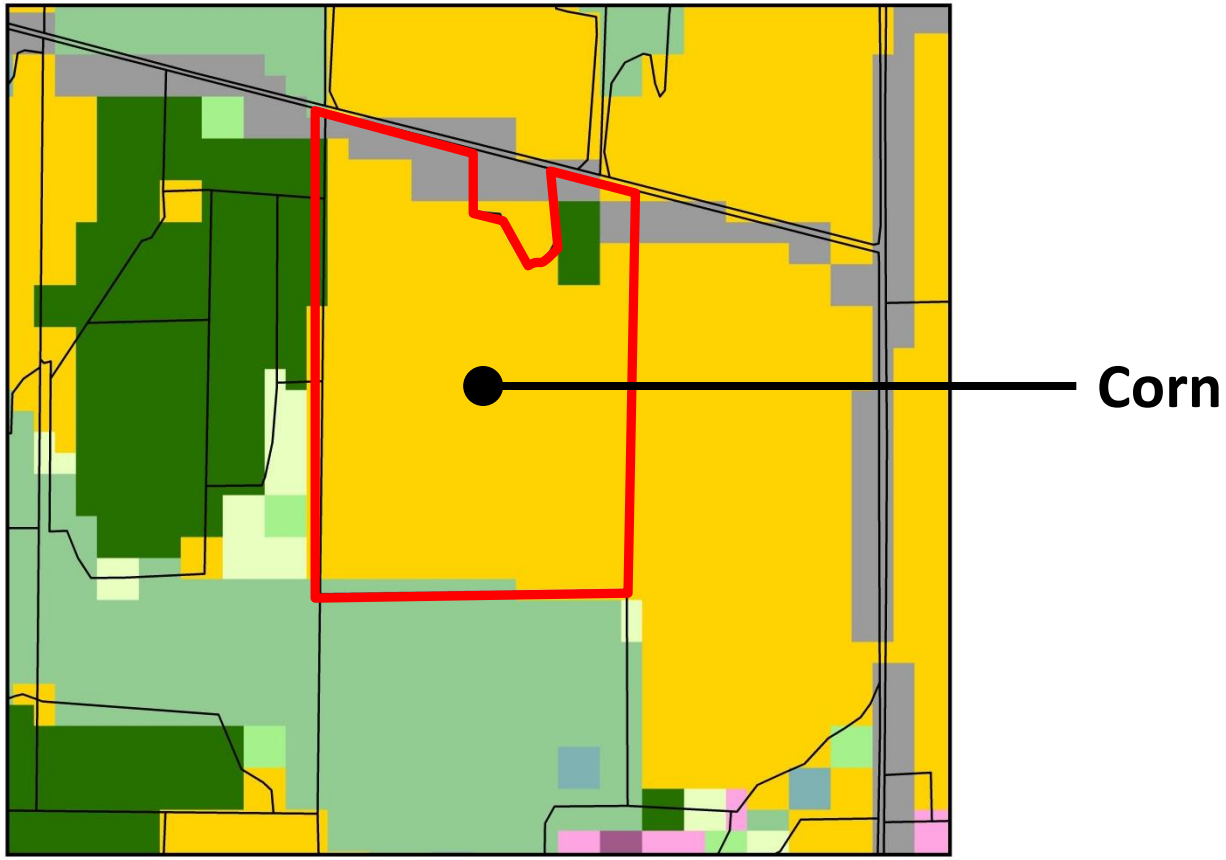
Using Satellite Imagery to Identify Cropping

2008



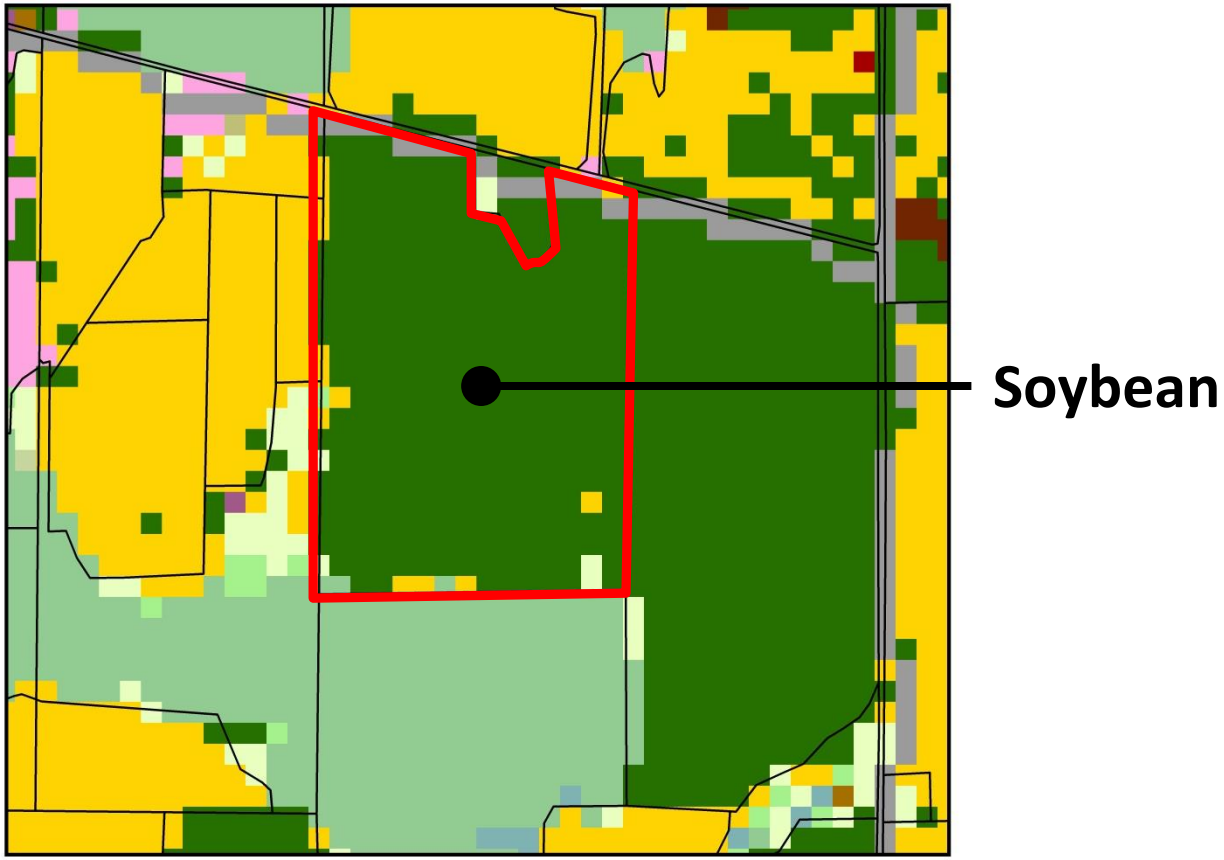
Using Satellite Imagery to Identify Cropping

2009



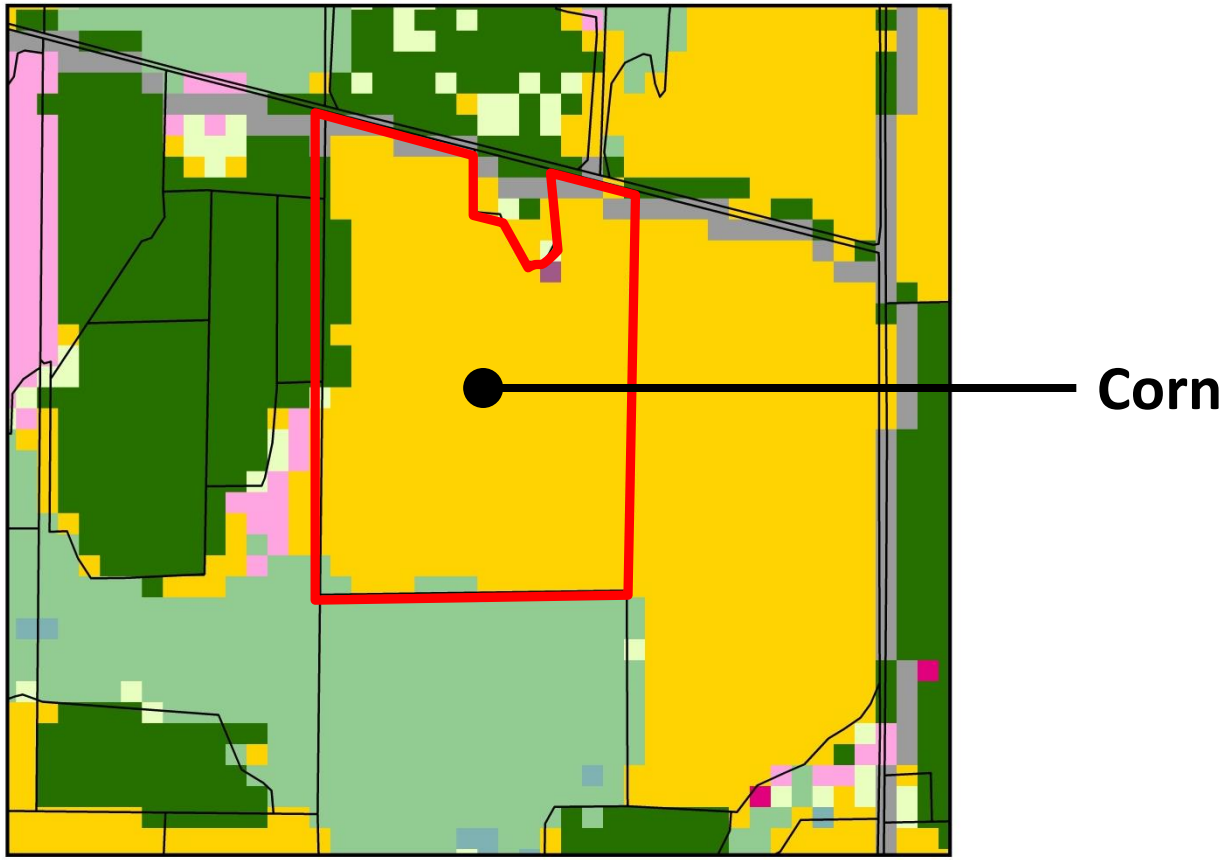
Using Satellite Imagery to Identify Cropping

2010



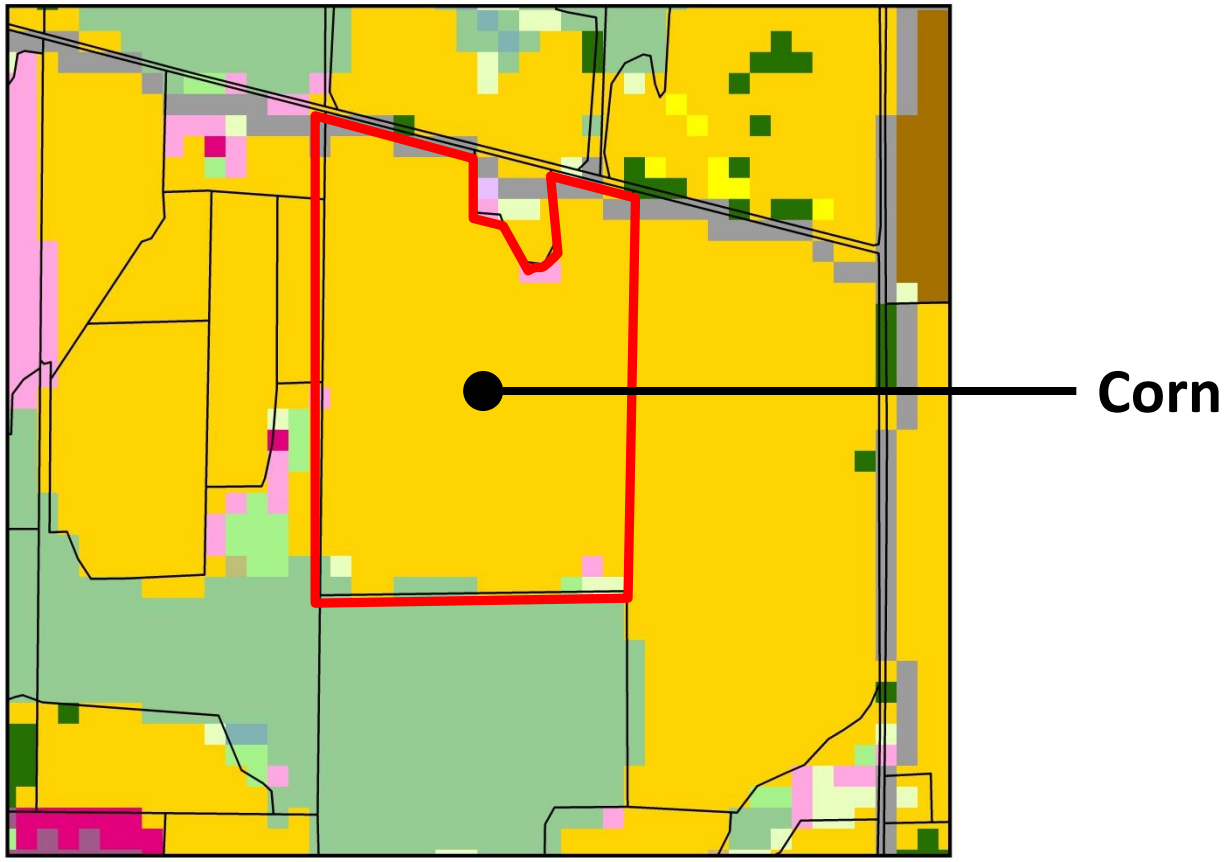
Using Satellite Imagery to Identify Cropping

2011

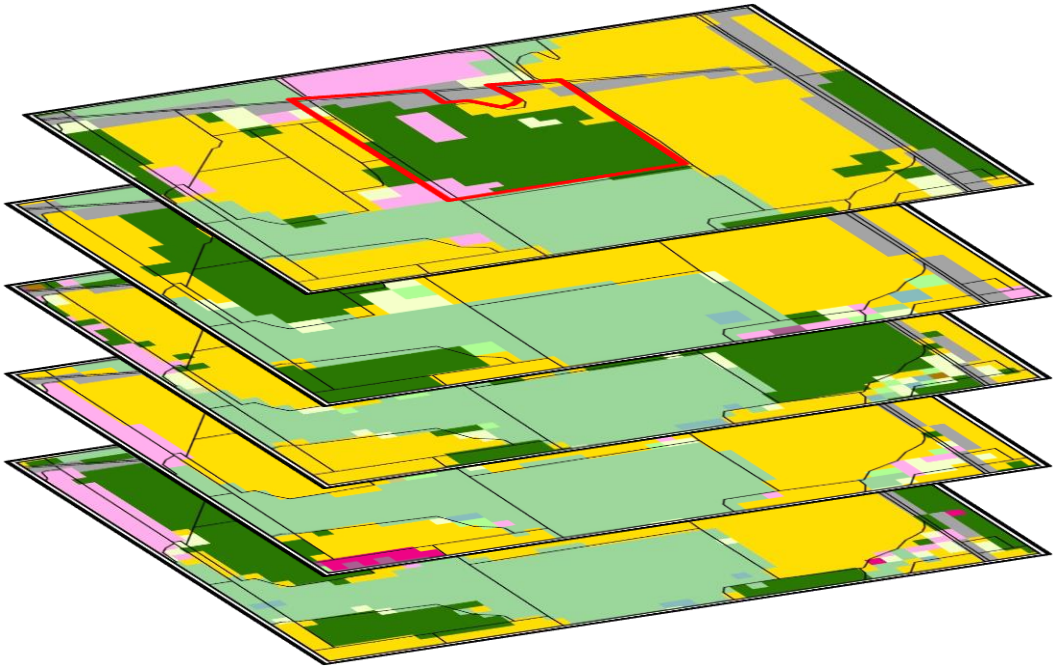


Using Satellite Imagery to Identify Cropping

2012



Using Satellite Imagery to Identify Cropping



Cash Grain

S-C-S-C-C, C-S-C-S-C, S-C-C-S-C, C-C-C-C-S, S-S-S-S-C

Types of Agriculture in the Wisconsin River Basin

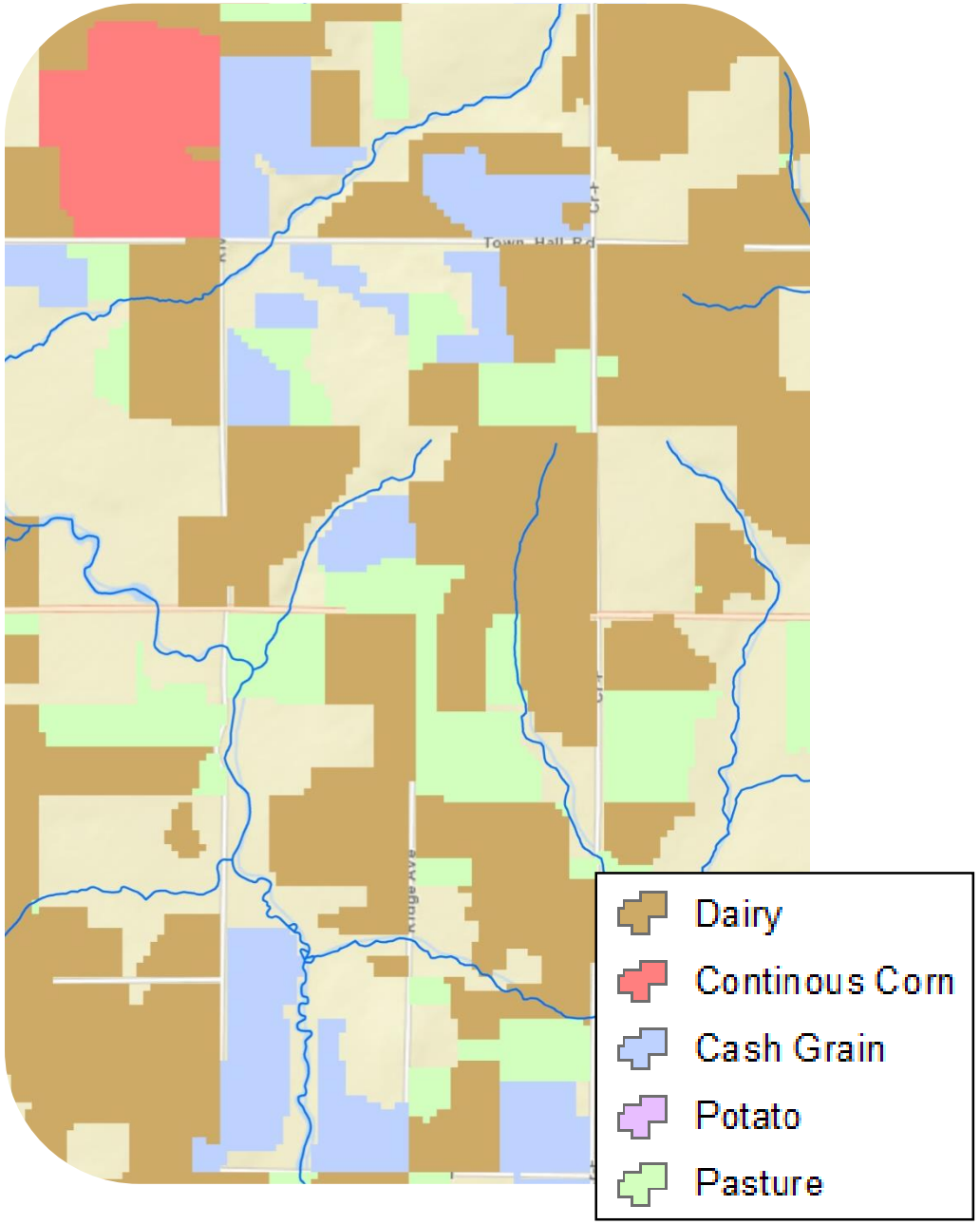
Dairy
Corn / Soybean / Alfalfa

Cash Grain
Corn / Soybean

Continuous Corn
Corn

Potato / Vegetable
Potato w/ Veggie and/or Corn

Pasture

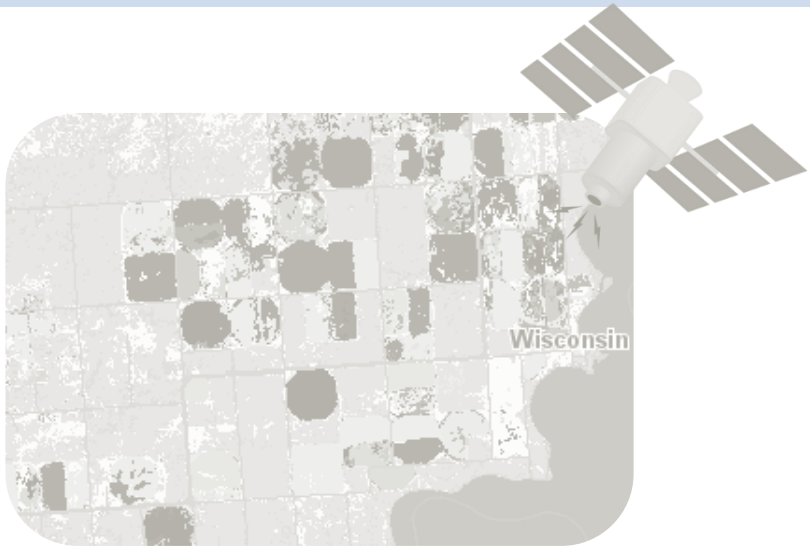


How did we obtain the information?

1. Define agricultural extent

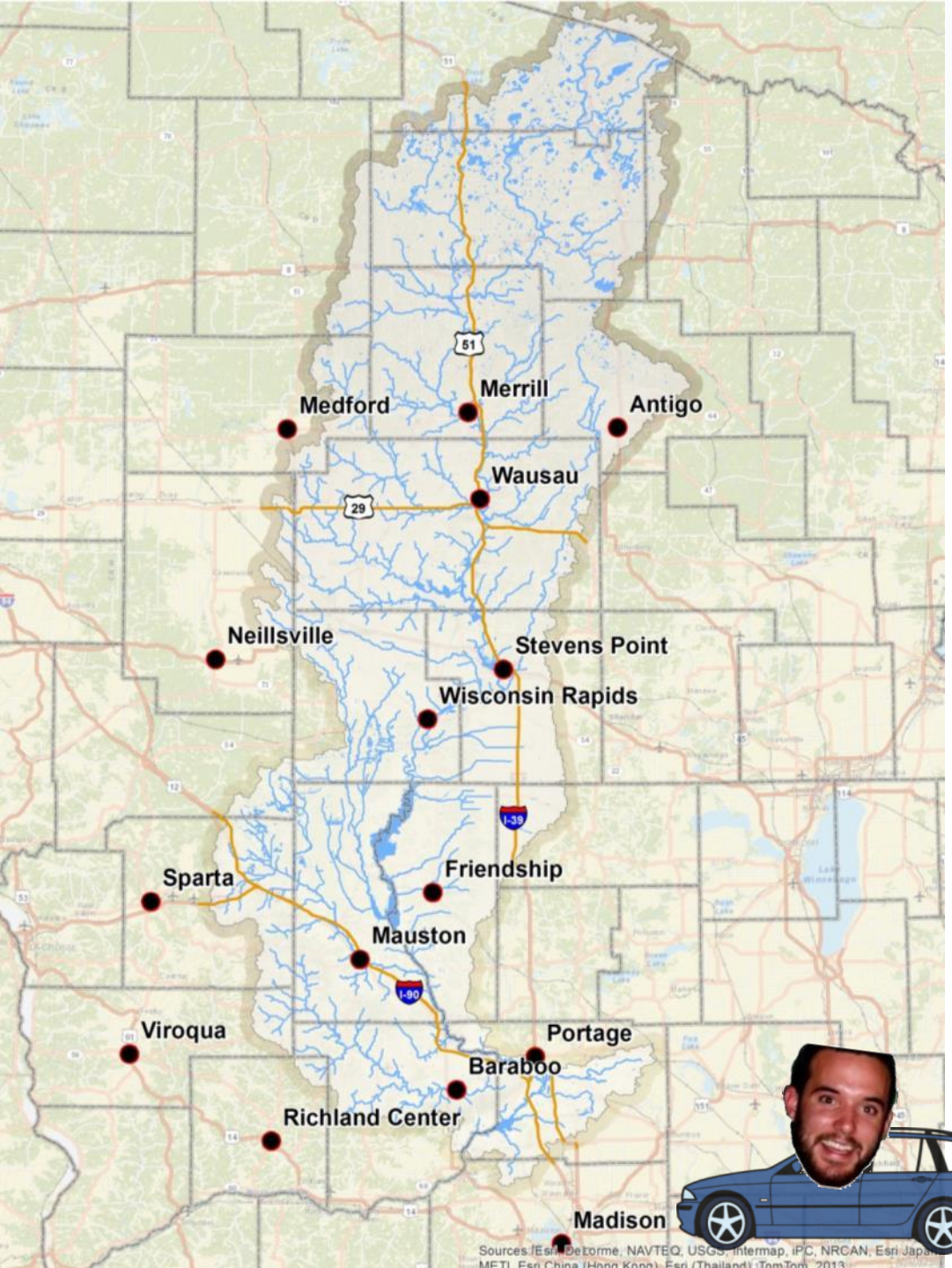
2. Identify & categorize crop change per parcel using satellite imagery

3. Assemble local information to further refine rotations

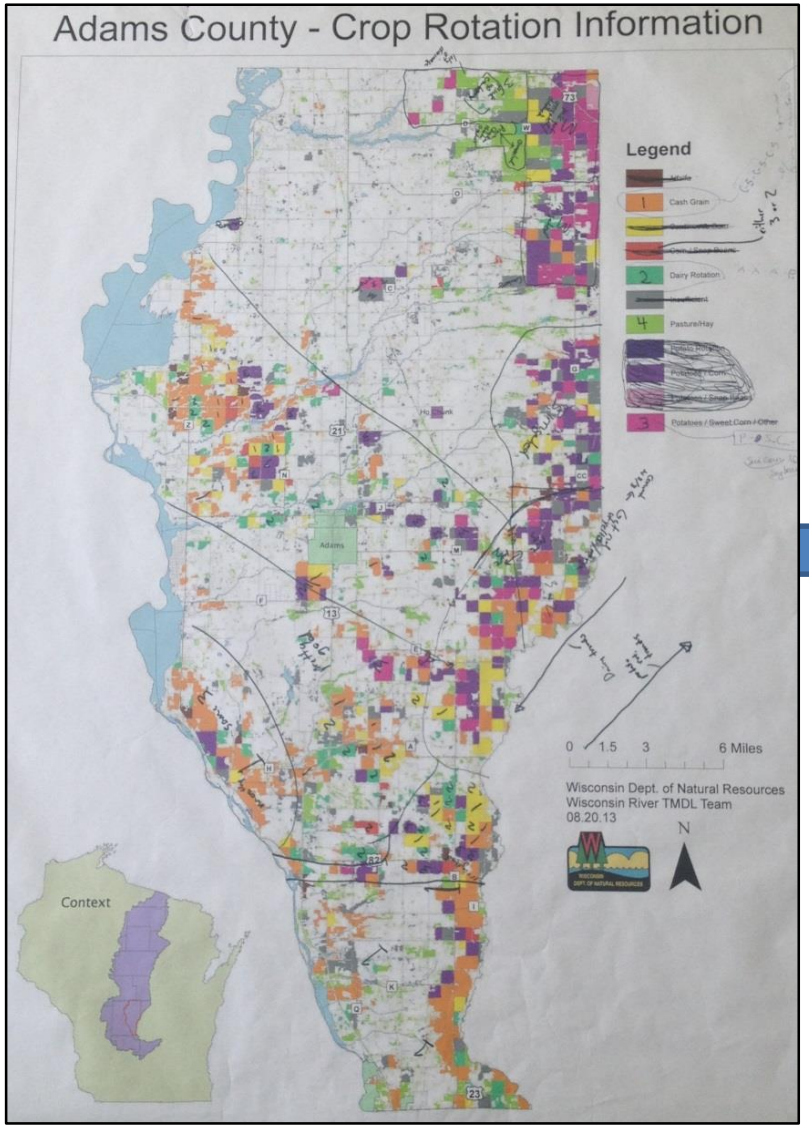


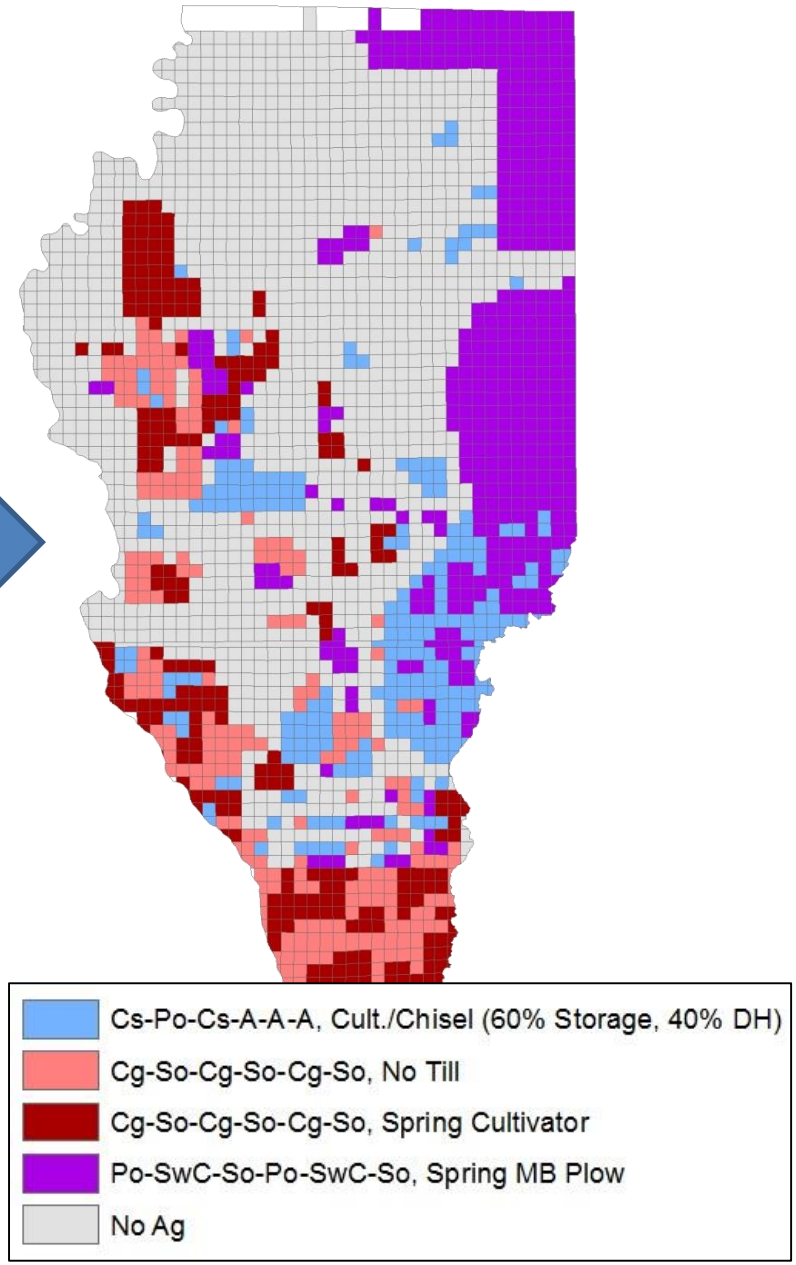
Using Local Information to Complete Crop Rotations

- Does our crop rotation map correctly depict rotations in your county?
- What is the type and timing of each rotation's tillage and nutrient applications?



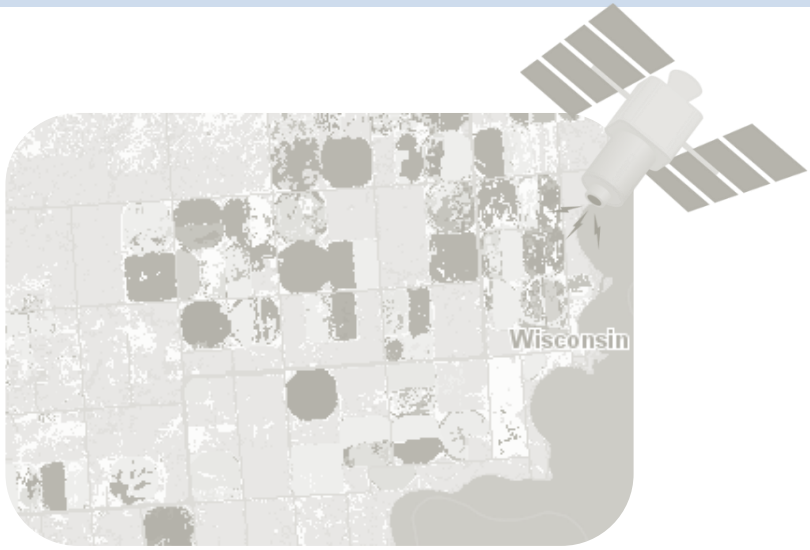
Digitizing County Land Management Information





How did we obtain the information?

1. Define agricultural extent
2. Identify & categorize crop change per parcel using satellite imagery
3. Assemble local information to further refine rotations
4. Integrate local information into rotation coverage

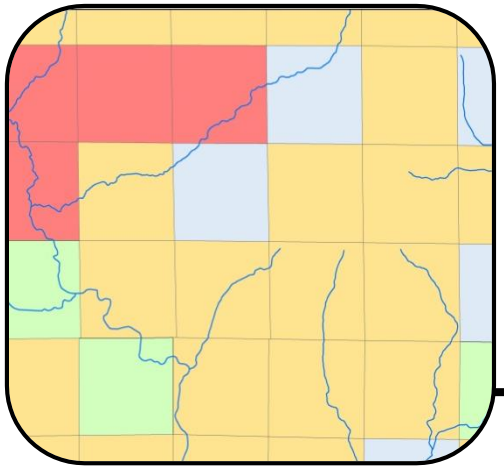


Generalization of a Dairy Rotation

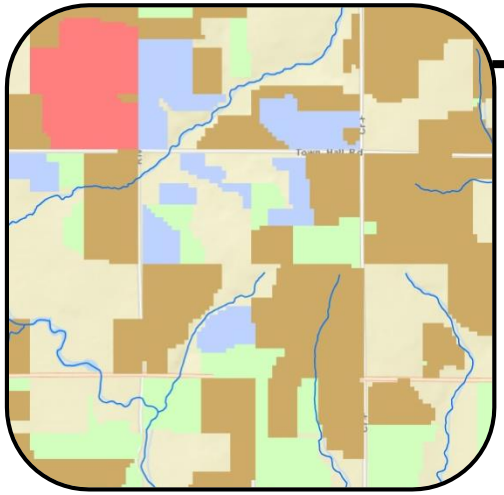
WDNR's Initial Idea	County Rotations	Generalized Rotations
Cropland Data Layer	***Local Knowledge***	***Model Integration***
2-3 Years CG, CS, SOY 3-4 Years Alfalfa Manure? Tillage?	3YR CS, 3 Alfalfa 10,000 GPA LQ Manure Spring Cultivator, Fall Chisel	2 CS, 1 CG, 3 Alfalfa 10,000 GPA LQ Manure (50% spring, 50% fall) Spring, Fall Moldboard
	1YR CG, 1 YR CS, 4 Alfalfa 12,000 GPA LIQ Manure Spring /Fall Moldboard	1YR CG, 1 YR CS, 4 Alfalfa 10,000 GPA LQ Manure (50% spring, 50% fall) Spring Disk / Fall Chisel
	2YR CS, 4 Alfalfa 15,000 GPA LQ Manure Spring Cultivator, Fall Chisel	
	2YR CS, 1 YR Oats, 3 Alfalfa 10 GPA LQ Manure Spring Cultivator, Fall Chisel	
	2YR CG, 1YR CS, 3 Alfalfa 11,000 GPA LIQ Manure Spring Disk, Fall Chisel	

WISCONSIN DEPT. OF NATURAL RESOURCES

Using Local Information to Complete Crop Rotations

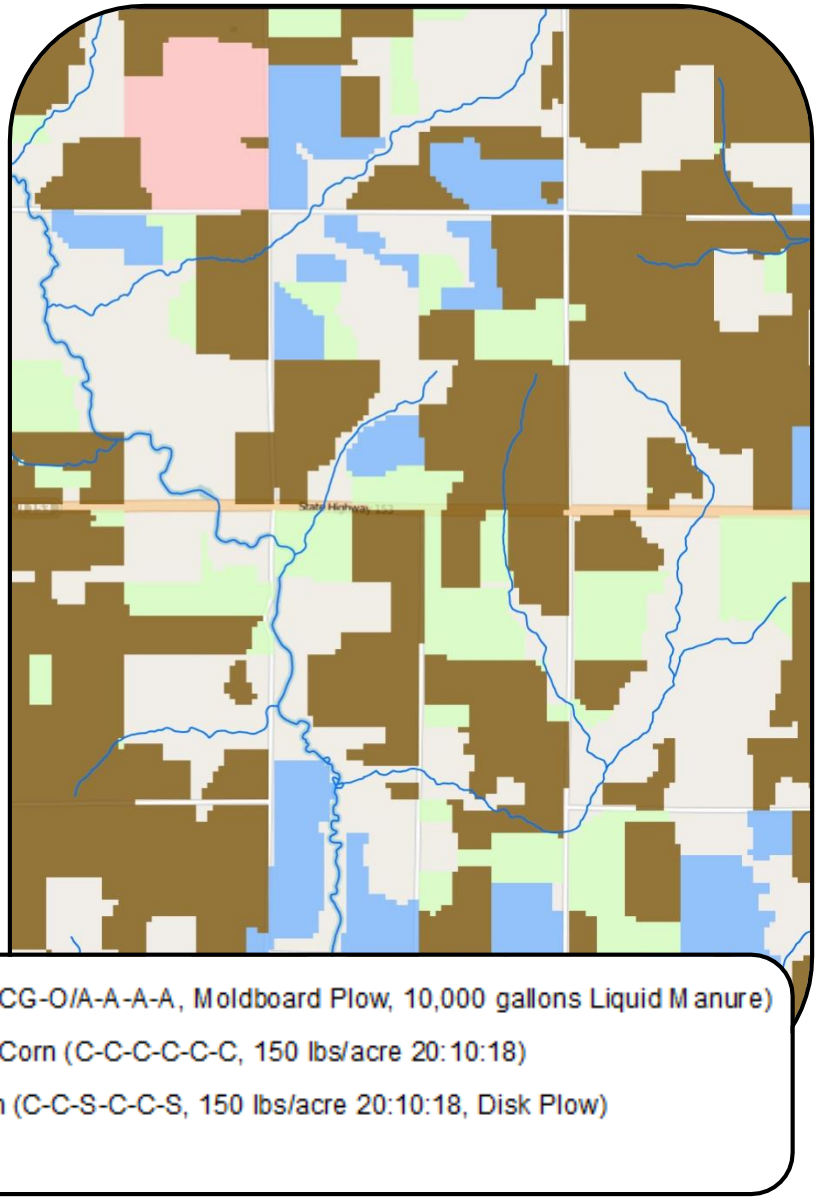


County-level tillage, fertilizer, manure, & timing Information per ¼ section



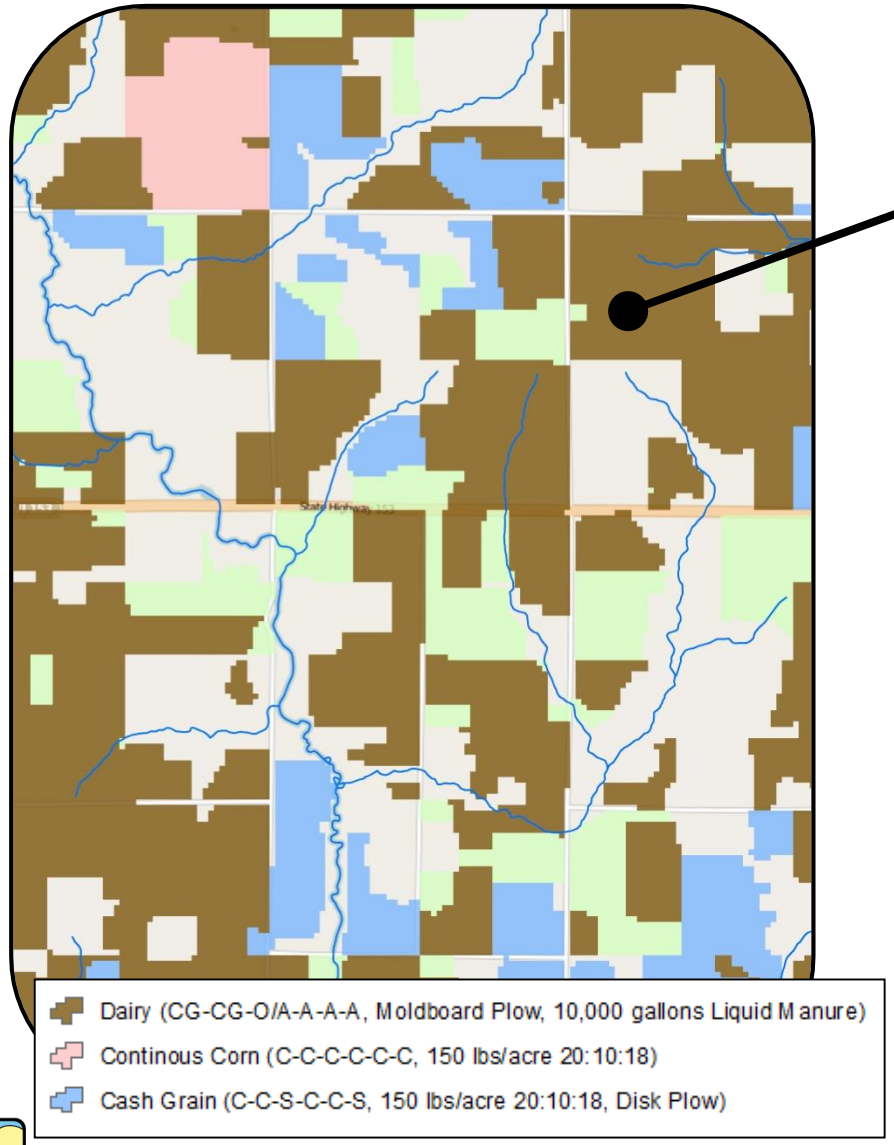
Rotations from cropland data layer analysis per parcel

Watershed Response Model Input



Using Local Information to Complete Crop Rotations

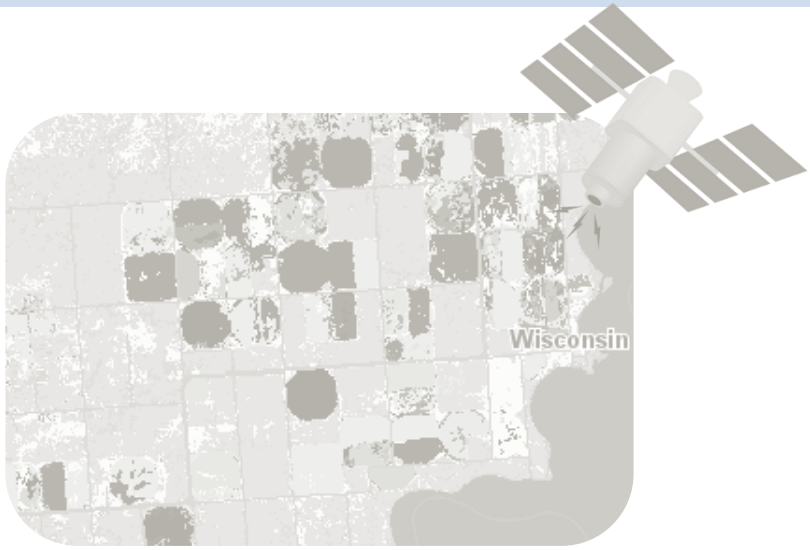
Watershed Response Model Input



Year	Date	Operation	Crop / Type	Rate	Units
2008	4/29	Manure	Liquid	10,000	gallons/acre
2008	5/1	Tillage	Cultivator		
2008	5/15	Plant	Corn Grain		
2008	5/15	Fertilizer	9:23:30	200	lbs/acre
2008	11/1	Harvest	Corn Grain		
2008	11/10	Tillage	Chisel Plow		
2009	4/29	Manure	Liquid	10,000	gallons/acre
2009	5/1	Tillage	Cultivator		
2009	5/15	Plant	Corn Silage		
2009	5/15	Fertilizer	9:23:30	200	lbs/acre
2009	9/15	Harvest	Corn Silage		
2009	10/20	Tillage	Chisel Plow		
2010	4/29	Manure	Liquid	10,000	gallons/acre
2010	5/1	Tillage	Cultivator		
2010	5/15	Plant	Corn Silage		
2010	5/15	Fertilizer	9:23:30	200	lbs/acre
2010	9/15	Harvest	Corn Silage		
2010	10/20	Tillage	Chisel Plow		
2011	4/10	Manure	Liquid	10,000	gallons/acre
2011	4/12	Tillage	Cultivator		
2011	4/15	Direct Seed	Alfalfa		
2011	9/15	Harvest	Alfalfa		
2012	6/1	Harvest	Alfalfa		
2012	7/15	Harvest	Alfalfa		
2012	9/1	Harvest	Alfalfa		
2013	6/1	Harvest	Alfalfa		
2013	7/15	Harvest	Alfalfa		
2013	9/1	Harvest	Alfalfa		
2013	9/5	Manure	Liquid	10,000	gallons/acre
2013	9/7	Tillage	Chisel Plow		

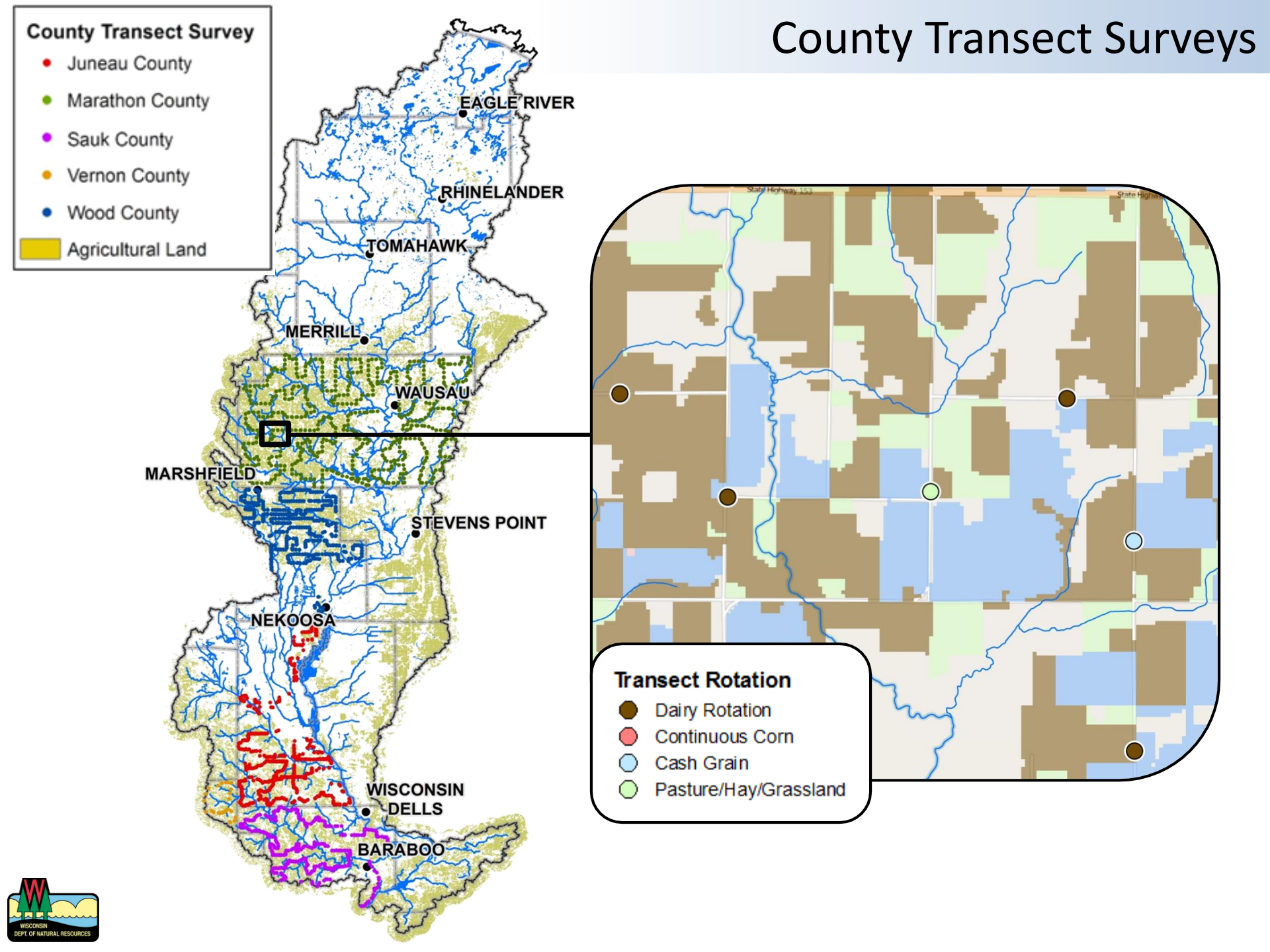
How did we obtain the information?

1. Define agricultural extent
2. Identify & categorize crop change per parcel using satellite imagery
3. Assemble local information to further refine rotations
4. Integrate local information into rotation coverage
5. Confirm agricultural management with observed data

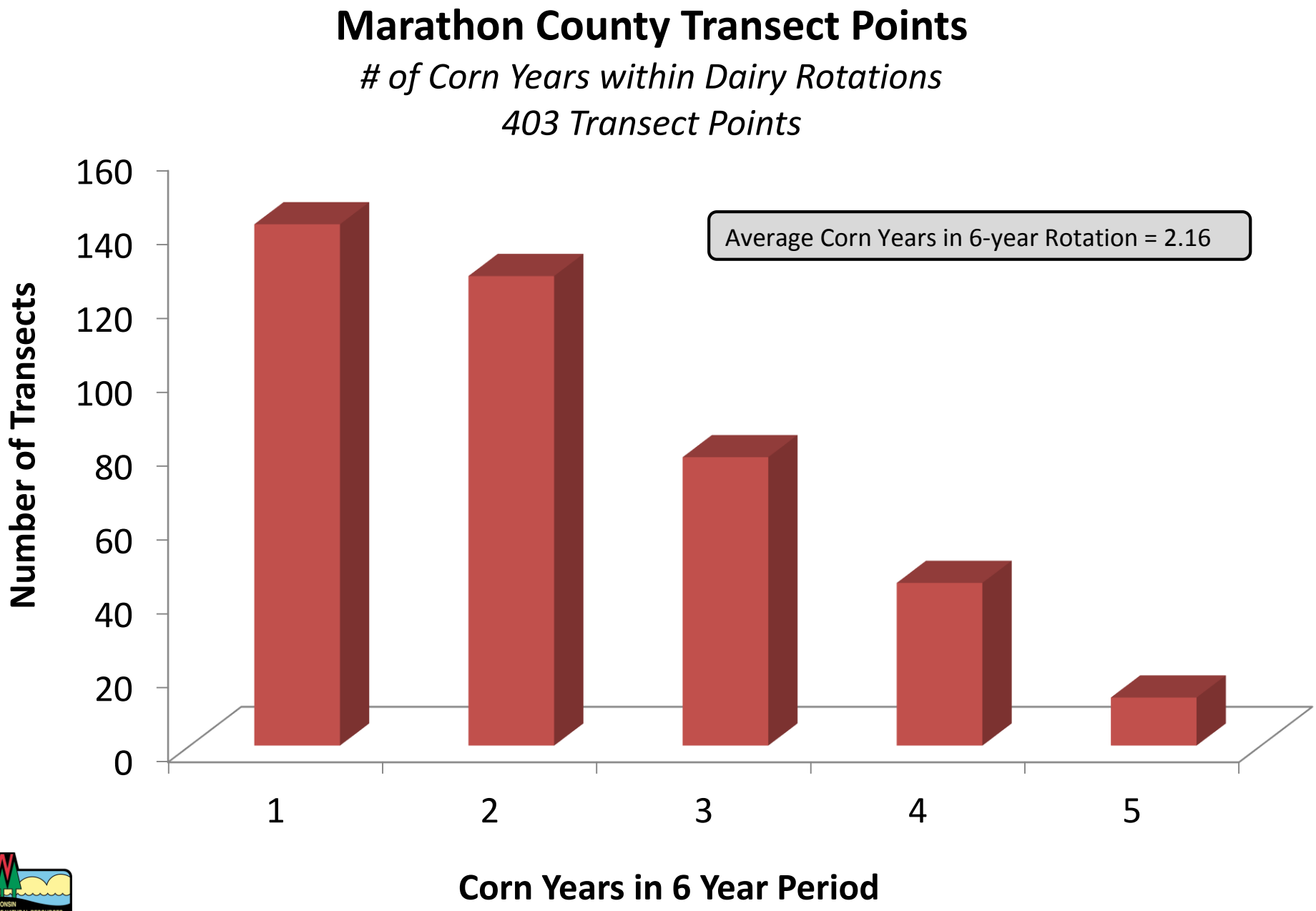


NASS

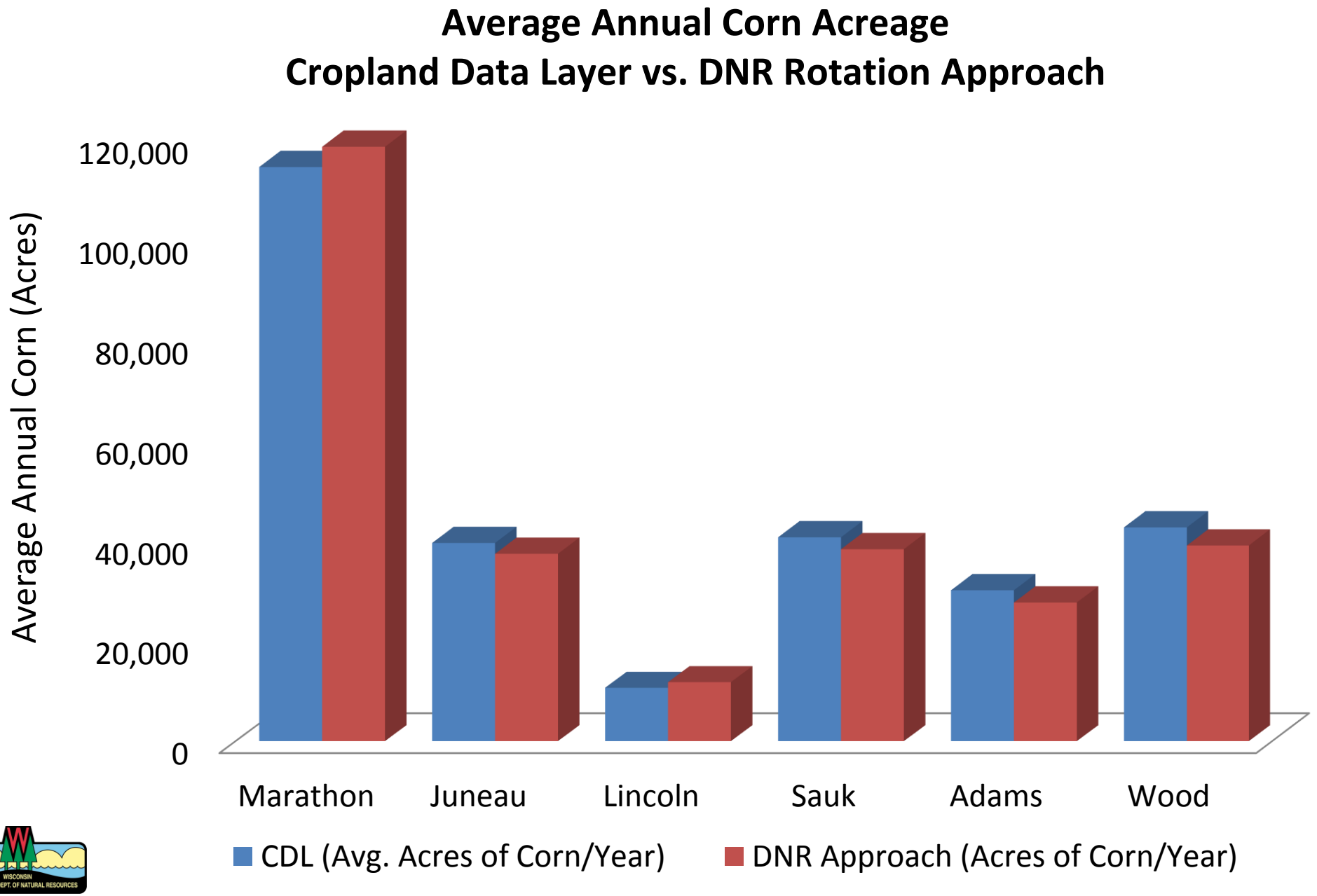
County Transect Surveys



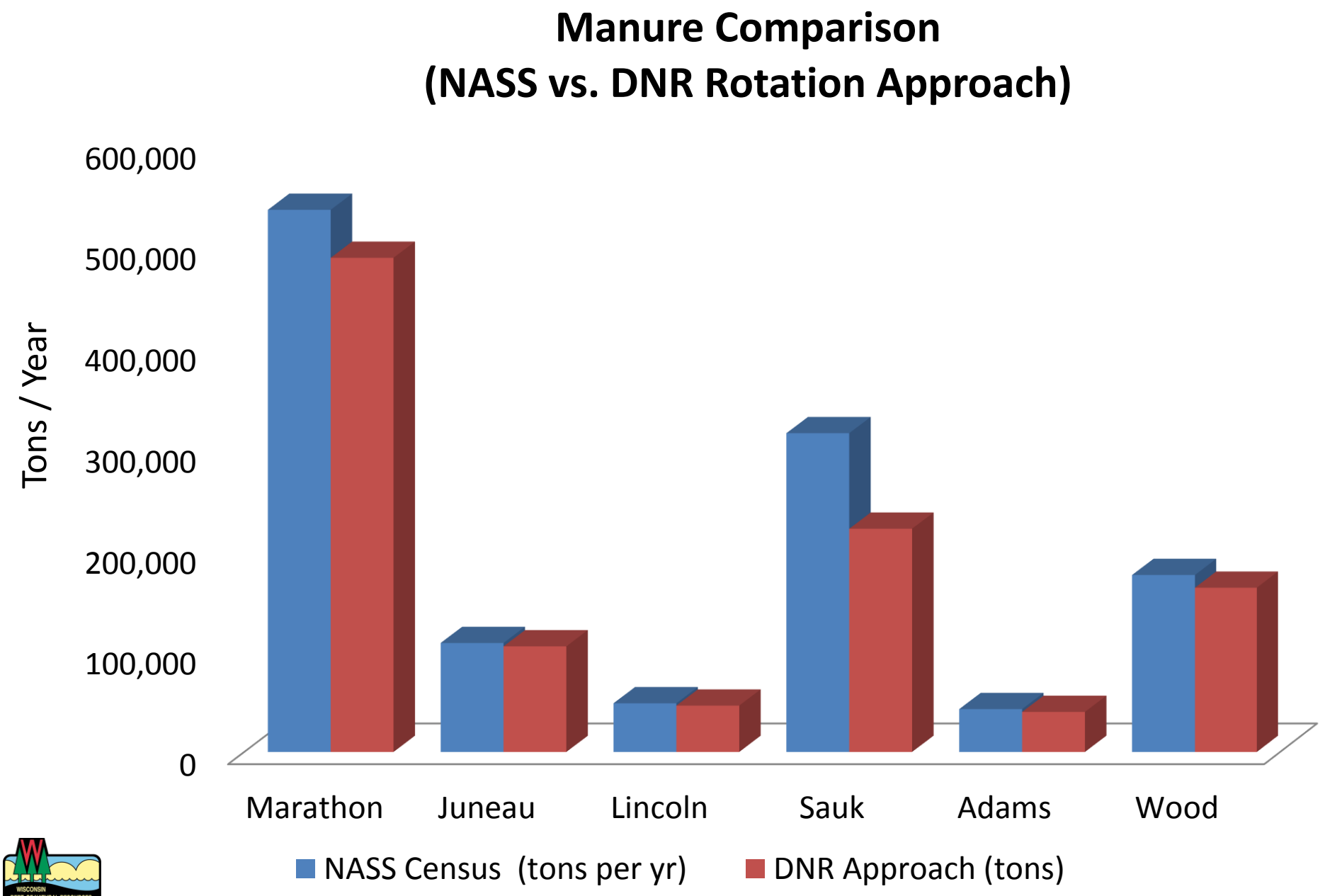
County Transect Surveys



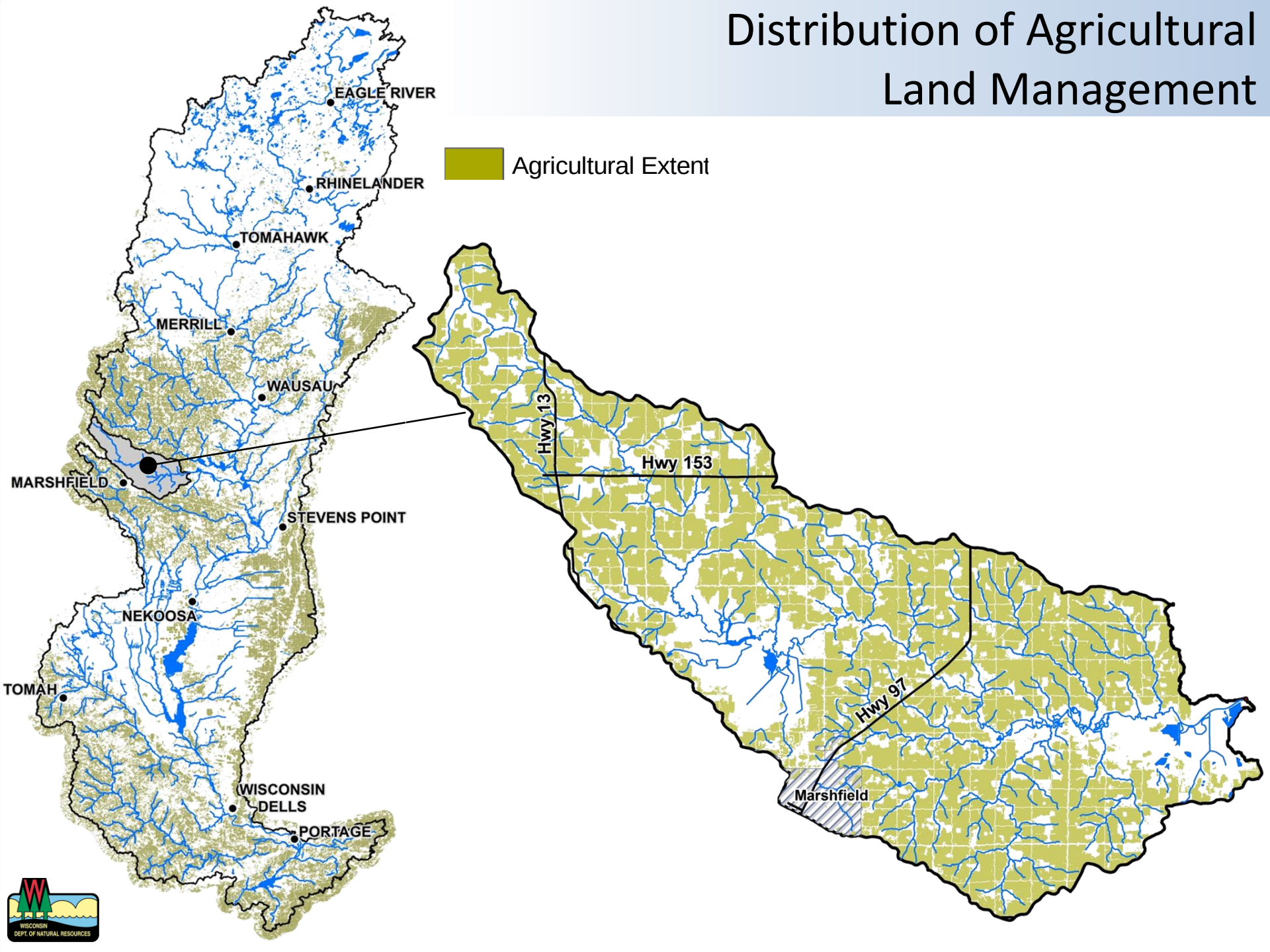
Crop Acreage



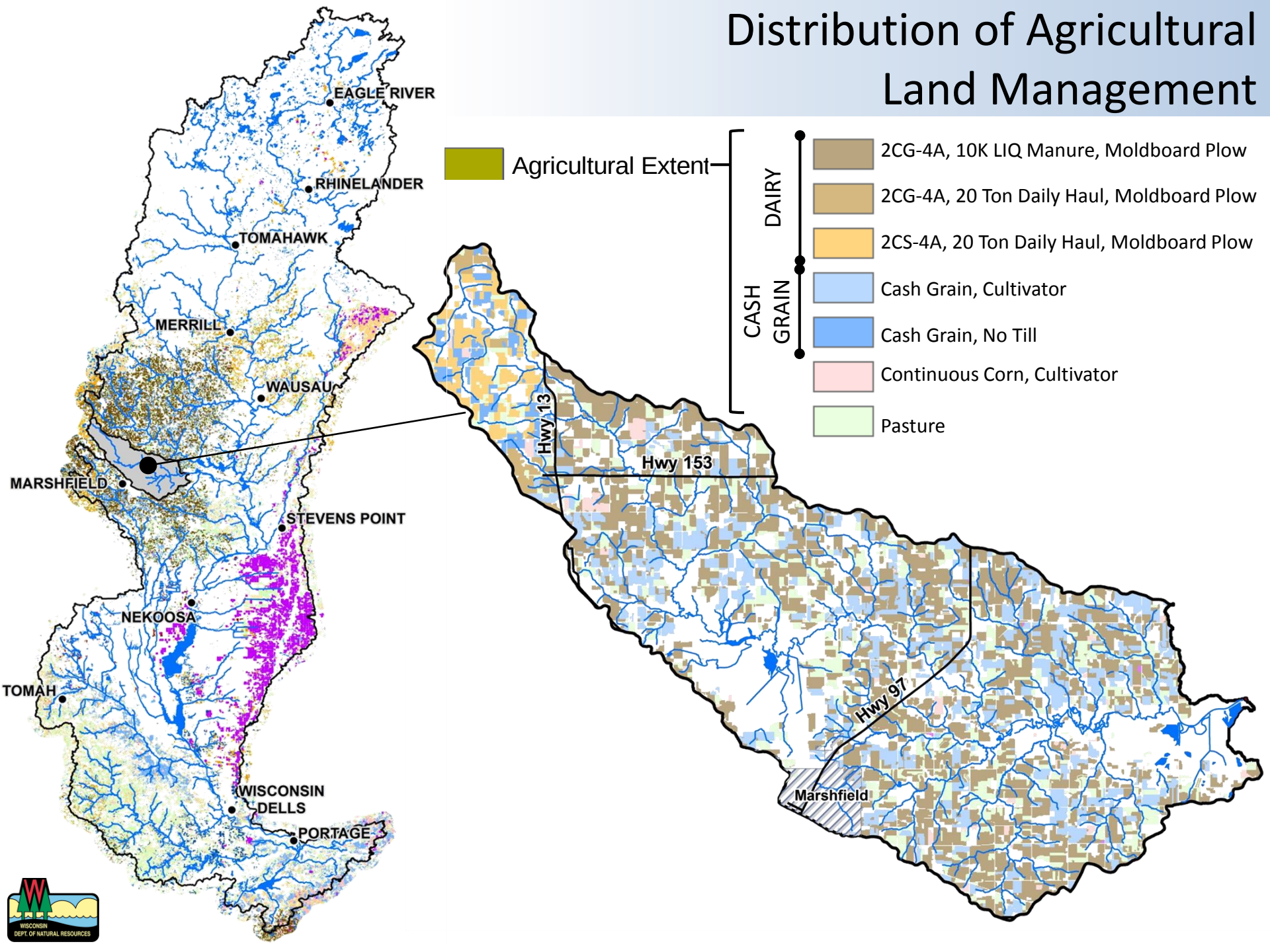
Manure


Manure Comparison
(NASS vs. DNR Rotation Approach)
Tons / Year
600,000
500,000
400,000
300,000
200,000
100,000
0
Marathon
Juneau
Lincoln
Sauk
Adams
Wood
NASS Census (tons per yr)
DNR Approach (tons)

Distribution of Agricultural Land Management



Distribution of Agricultural Land Management



Summary

- Method provides an efficient and replicable spatiotemporal definition of agricultural that supports nonpoint source mitigation
- Additional years and accuracy of the USDA Cropland Data Layer will improve analysis
- Supplemental datasets such as transects were valuable for confirming results
- While regional validation would be needed, approach could be applied statewide to support various water resource issues

Questions?

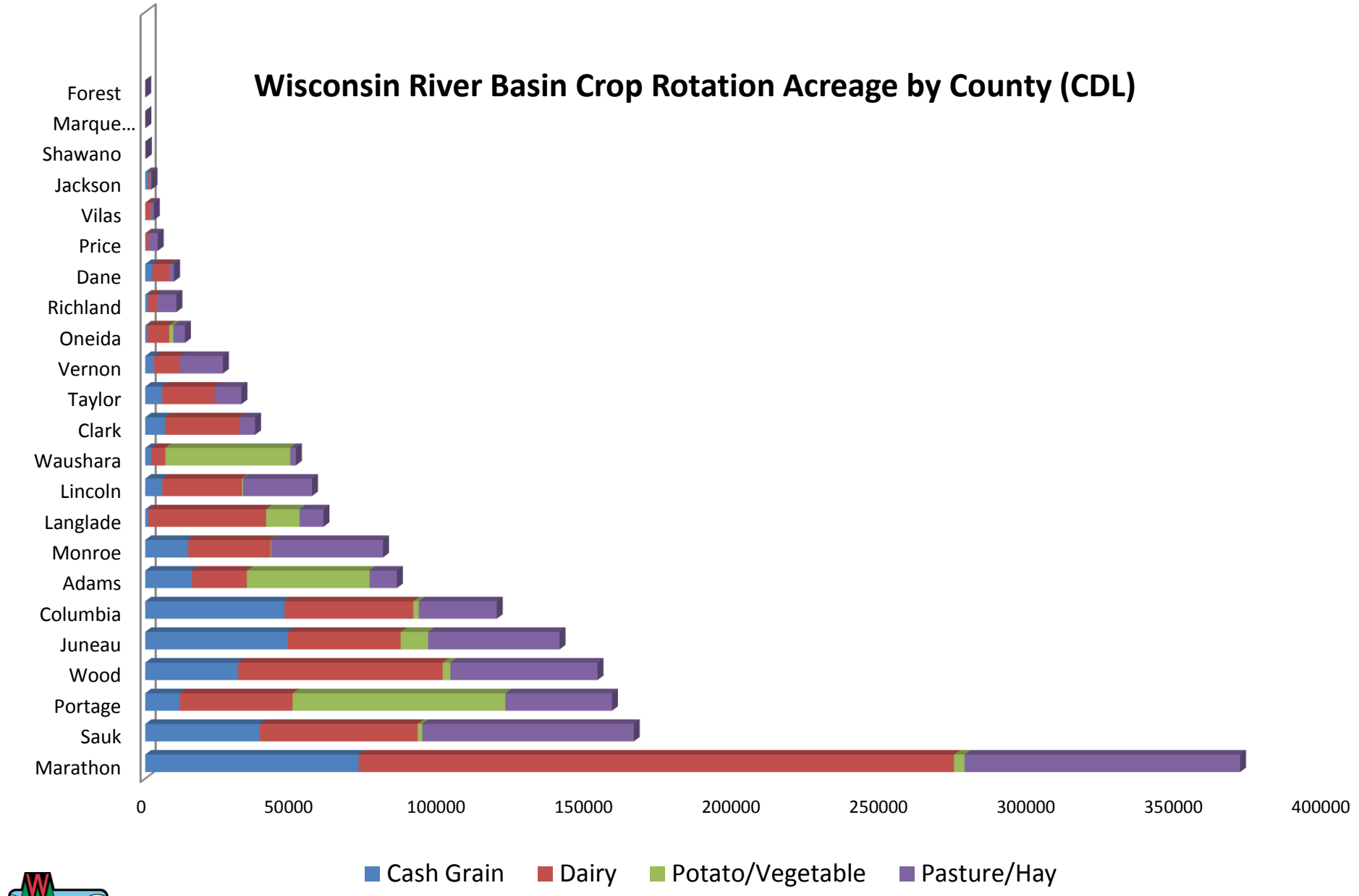
WISCONSIN DEPT. OF NATURAL RESOURCES

dnrwisconsinrivertmdl@wisconsin.gov

Manure Totals Analysis – Marathon County Example

CDL Dairy Acres	230,306
% Daily Haul Acres	0.60
% Storage Acres	0.40
% 6-Year Rotation Receiving Manure (corn years)	0.33
% Dry (Liquid)	0.06
% Dry (Solid)	0.24
Pounds manure per gallon liquid	8.34
Storage Application Rate - Corn Years (ga/acre/yr)	10,000
Storage Application Rate - 1st Year Alfalfa (ga/acre/yr)	3,000
DH Application Rate - Corn Years (tons/acre/yr)	25
DH Application Rate - 1st Year Alfalfa (tons/acre/yr	8
Cattle Census 2010 (head cattle)	139,500
Avg. manure output per year (tons/cow)	16
Census Dry Weight Output (lbs/6-year rotation)	6,428,160,000
CDL Rotation Dry Weight Total from DH (lbs/6-year rotation)	3,869,133,518
CDL Rotation Dry Weight Total from Storage (lbs/6-year rotation)	1,060,253,131
CDL Rotation Dry Wright Total from DH & Storage (lbs/6-year rotation)	4,929,386,649
Total Continuous Corn (Acres)	6,600
% Cont. Corn Assumed to be Dairy (Acres)	0.50
Dairy from Cont. Corn pixels (Acres)	3,300
CDL Rotation Dry Weight Total from DH (lbs/6-year rotation)	55,443,542
CDL Rotation Dry Weight Total from Storage (lbs/6-year rotation)	21,138,246
CDL Rotation Dry Wright Total from DH & Storage (lbs/6-year rotation)	76,581,788
Managed Grazed Land Area (Acres)	12,349
Managed Grazed Dry Weight Output - Assuming 1.5 cows per acre (lbs./6-year rotation)	853,562,880
NASS Census Dry Weight (lbs/6-year rotation)	6,428,160,000
CDL Dry Weight (lbs/6-year rotation)	5,859,531,317
Ratio (CDL:Census)\	0.91

Quantitative Validation - Crop Acreage



Total Maximum Daily Load (TMDL)

The amount of a pollutant a water body can receive and meet water quality standards

Each subwatershed is assessed for:

Load Allocation

- Runoff from the landscape

Background Load

- Naturally occurring from wetlands, forests

Waste Load Allocation

- Municipal Wastewater
- Industrial Wastewater
- Stormwater (MS4s)

TMDL

Load Allocation + Waste Load Allocation + Margin of Safety

Wisconsin River Basin Land Cover

2011 USDA Cropland Data Layer
[2011 cropland extent with 2006 NLCD defining remaining lands]

- Wisconsin Wetland Inventory
- *Hand Digitized Cranberry Bogs*
- *CRP and Managed Grazed Land*

→ Composite Land Cover