

Defining and Integrating Spatiotemporal Agricultural Land Management into SWAT

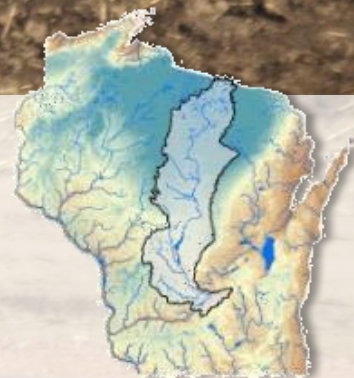


Adam Freihoefer, Tom Beneke, & Aaron Ruesch

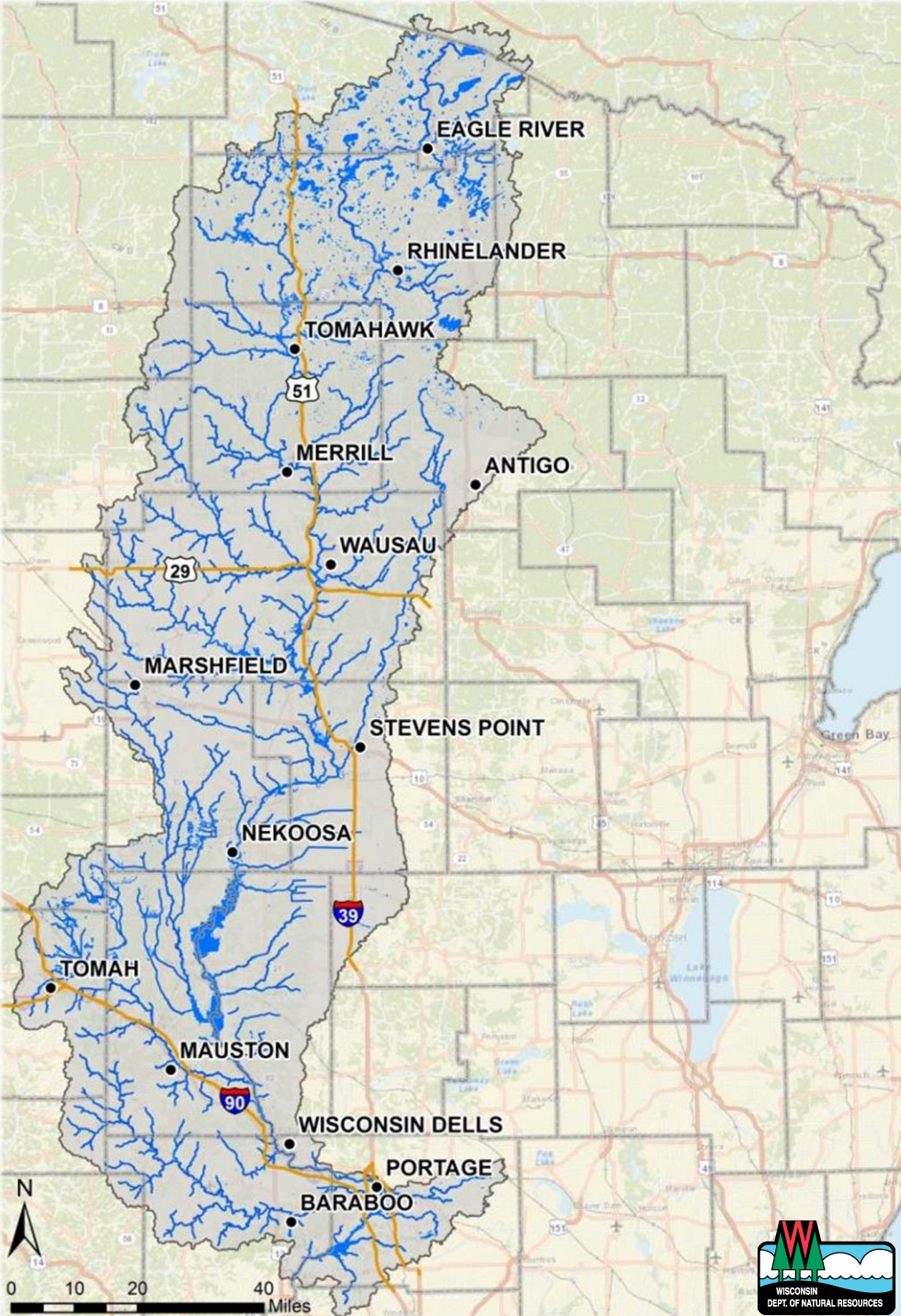
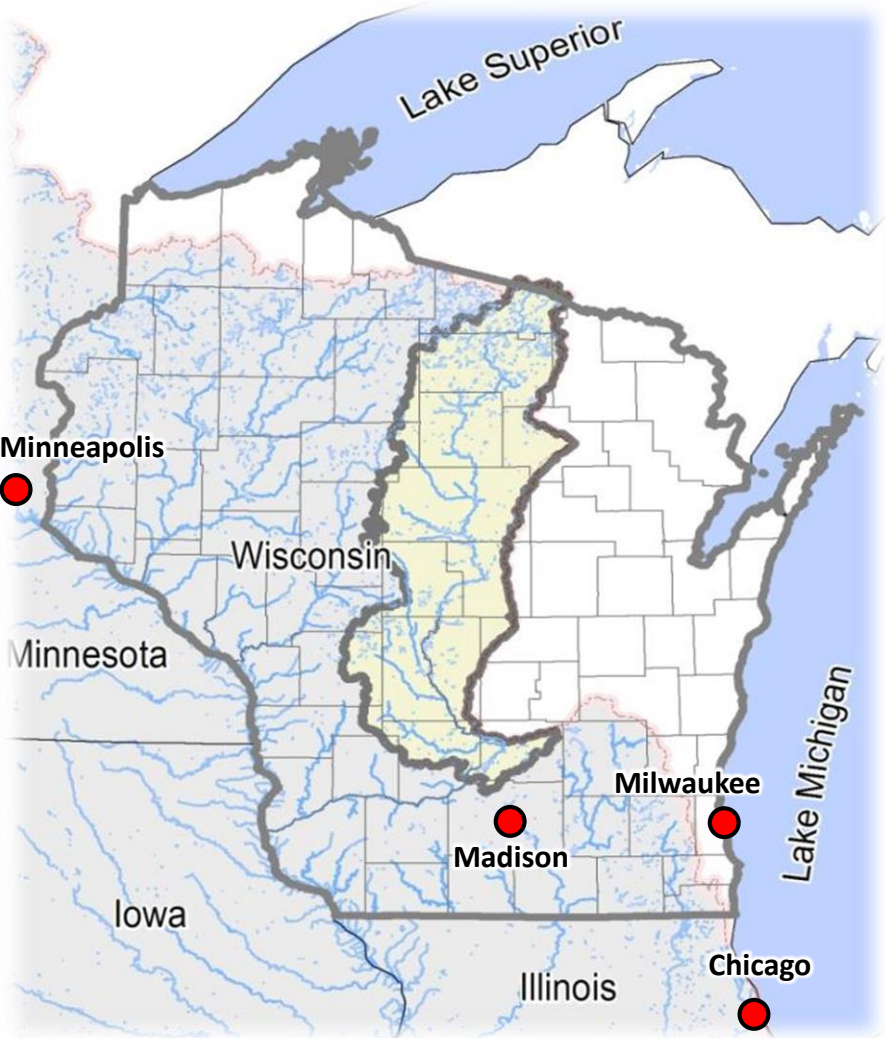
Wisconsin Department of Natural Resources

2015 SWAT International Conference,

October 14, 2015 (Session C3: Model Development)



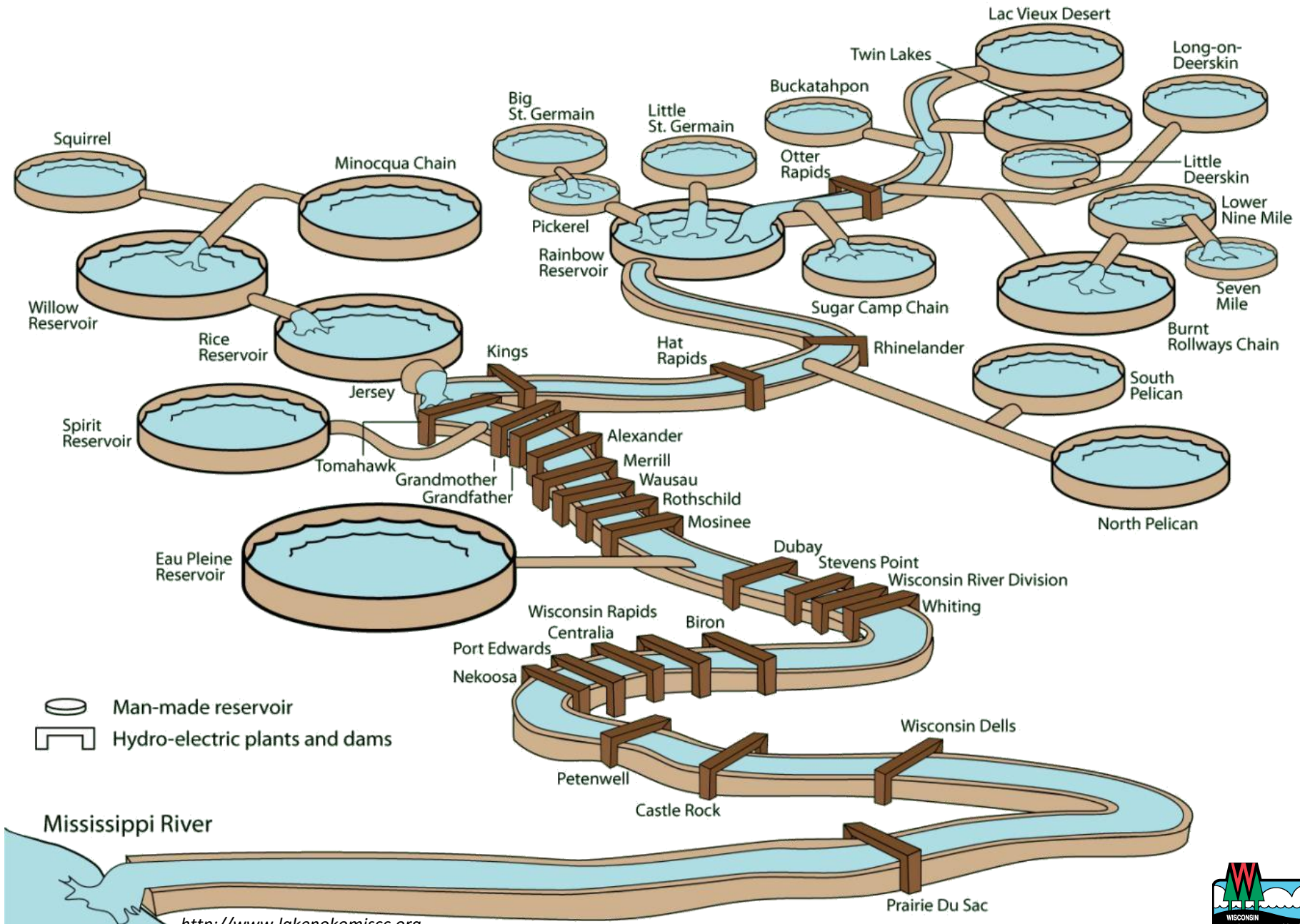
Upper Wisconsin River Basin



- UWRB drains 14% of the state with contributions from 23 counties



Upper Wisconsin River Basin



Algal blooms due to excessive phosphorus



Petenwell Lake



Developing Total Maximum Daily Loads for Impaired Waters

Each subwatershed is assessed for:



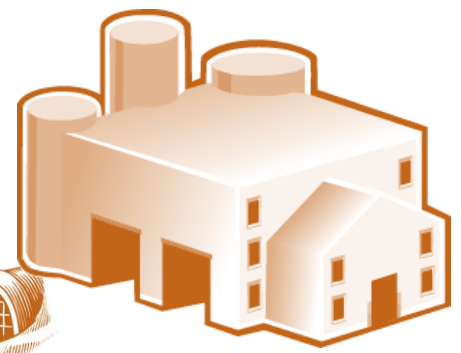
Load Allocation

- Runoff from the landscape



Background Load

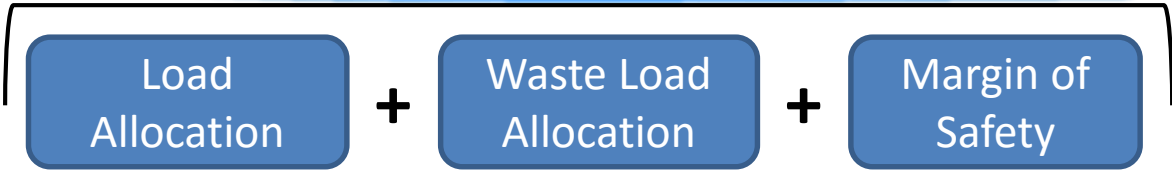
- Naturally occurring from wetlands, forests



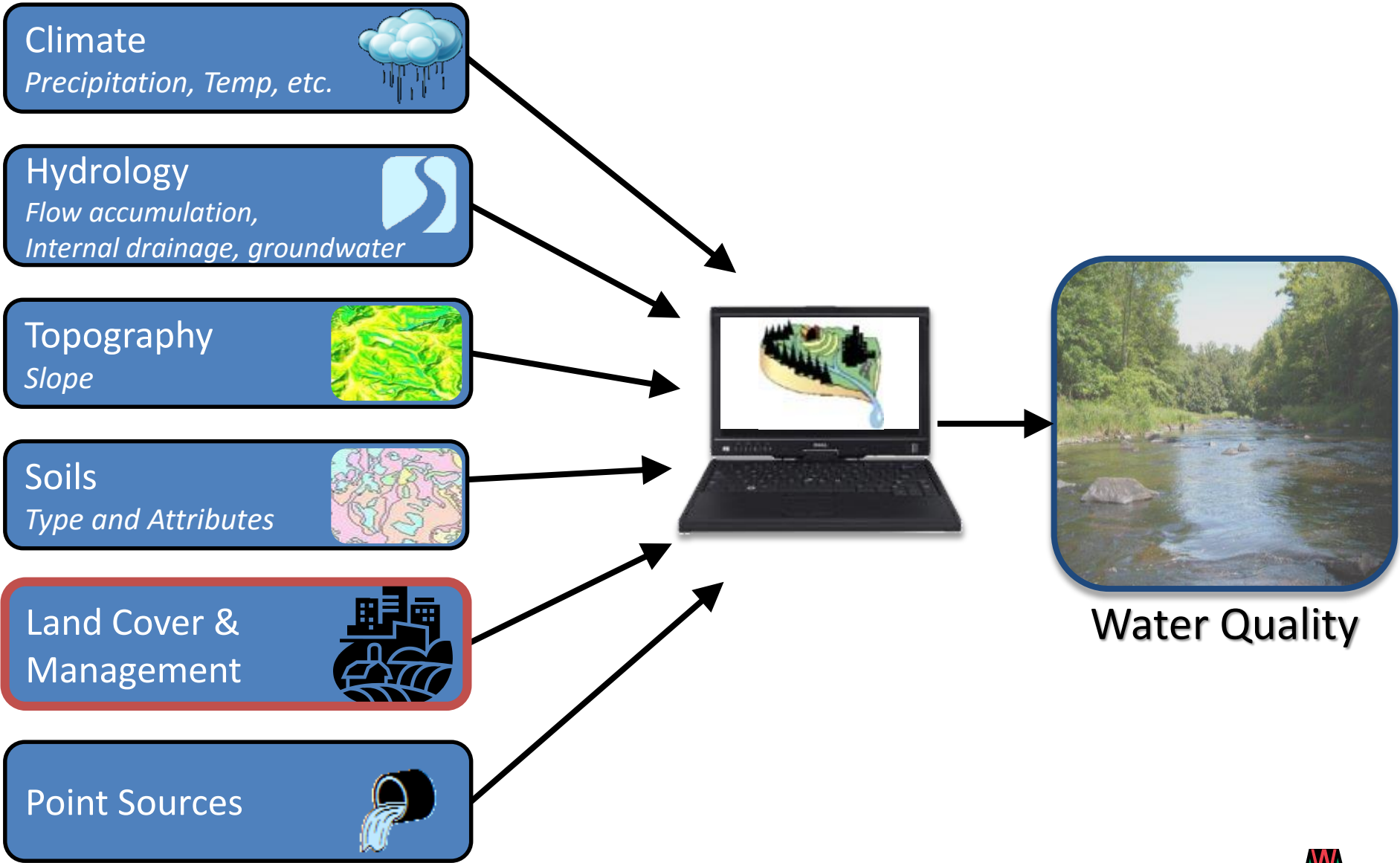
Waste Load Allocation

- Municipal Wastewater
- Industrial Wastewater
- Permitted Municipal Storm Sewer Systems
- CAFO Production Areas

TMDL



Simulating Water Quality with SWAT



Agricultural Land Management in the UWRB

Dairy Farming



<http://sauk.uwex.edu/files/2012/07/Hay.jpg>

Irrigated Cropland



Managed Grazing



www.rivercountryrco.org

Cranberry Harvest



Tillage



<http://reveg-catalog.tamu.edu>

Manure Application



<http://www.toytractortimes.com/>

Agricultural Land Management Assessment Objective

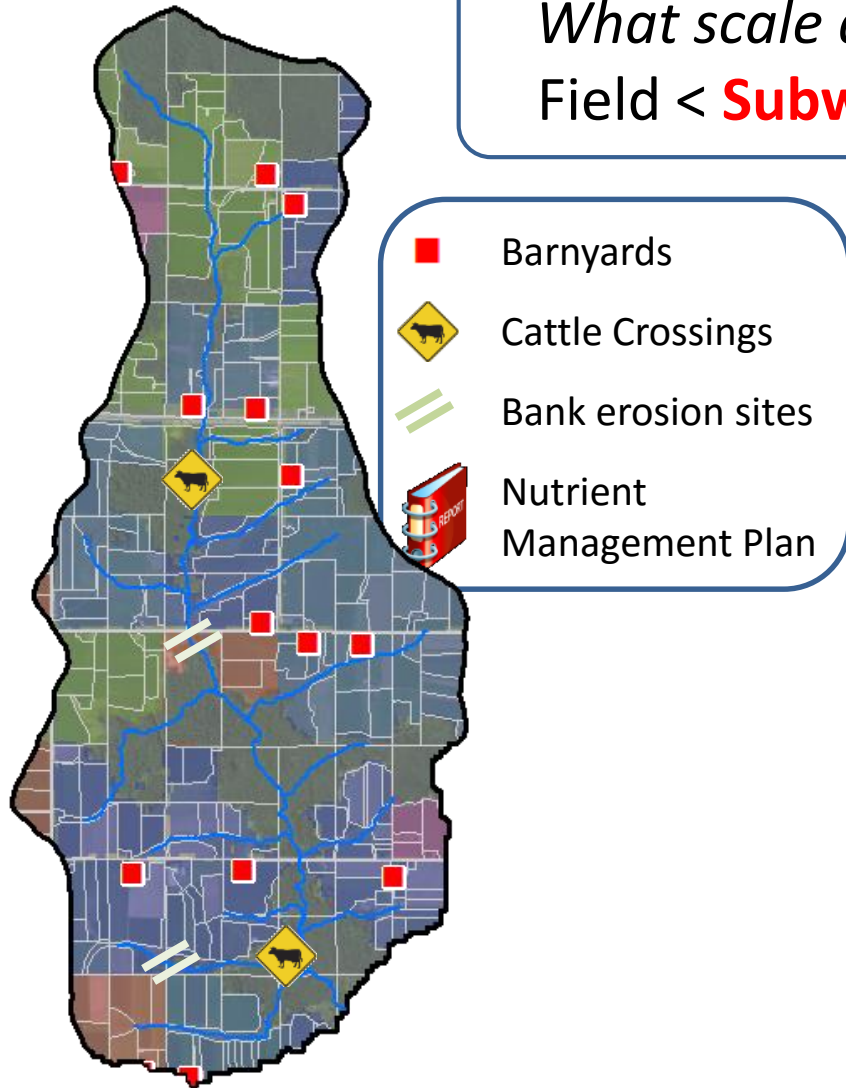
Create a spatiotemporal definition
of crop rotations in the Wisconsin River Basin

(6-year crop sequence with associated tillage and nutrient applications)

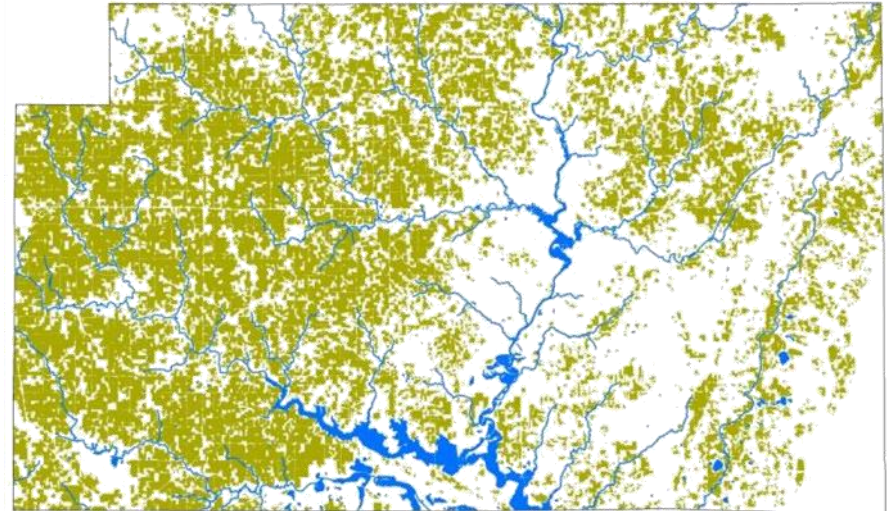


Finding a Balance in Data Collection

What scale are we working on?
Field < **Subwatershed** < County



- Homogenous management operations



Field-scale

Countywide



Information Needed for the Agricultural Assessment

Crop Sequence

Corn Grain Corn Grain Alfalfa Alfalfa Alfalfa Alfalfa
 Corn Grain Soybean Corn Grain Soybean Corn Grain Soybean
 Potato Corn Grain Carrots Soybean Potato Corn Grain

January						
				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

Timing

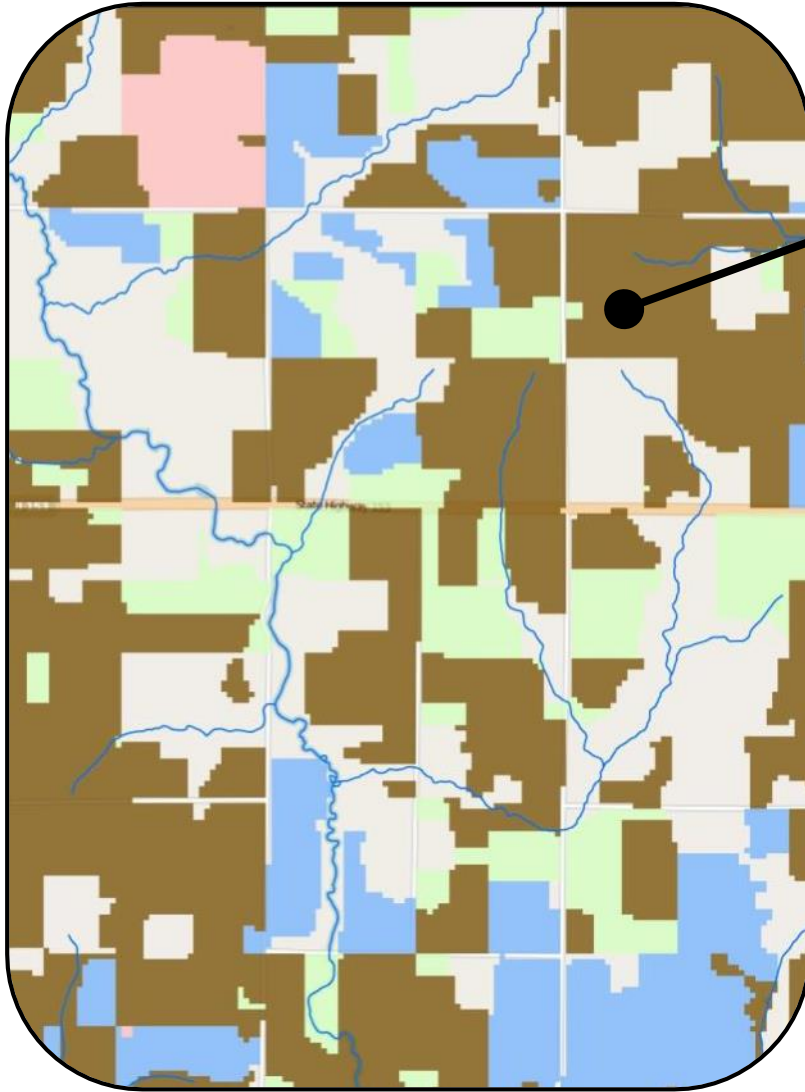
Tillage



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		
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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?

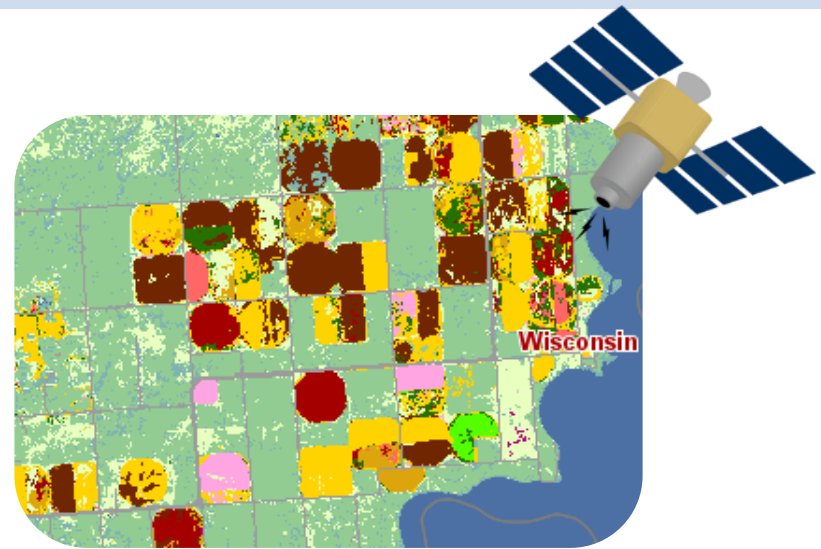
1 Define agricultural extent

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

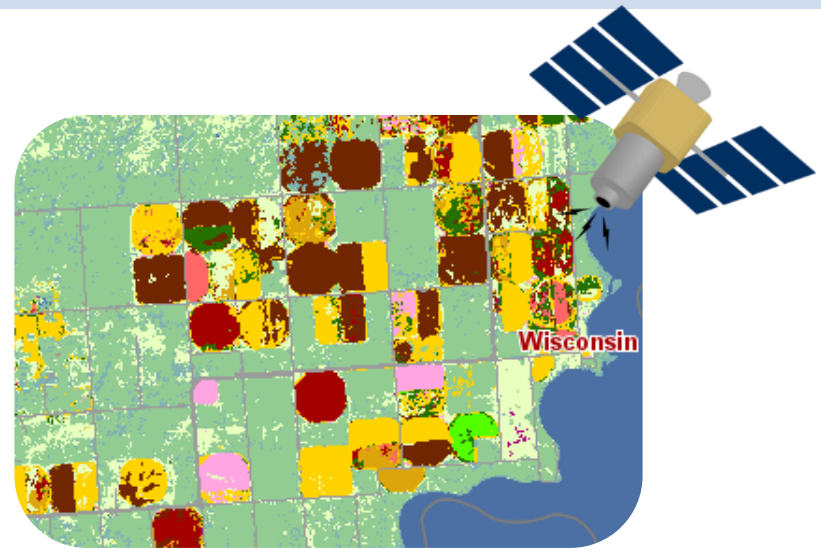
5 Confirm agricultural management with observed data



How did we obtain the information?

1

Define agricultural extent



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

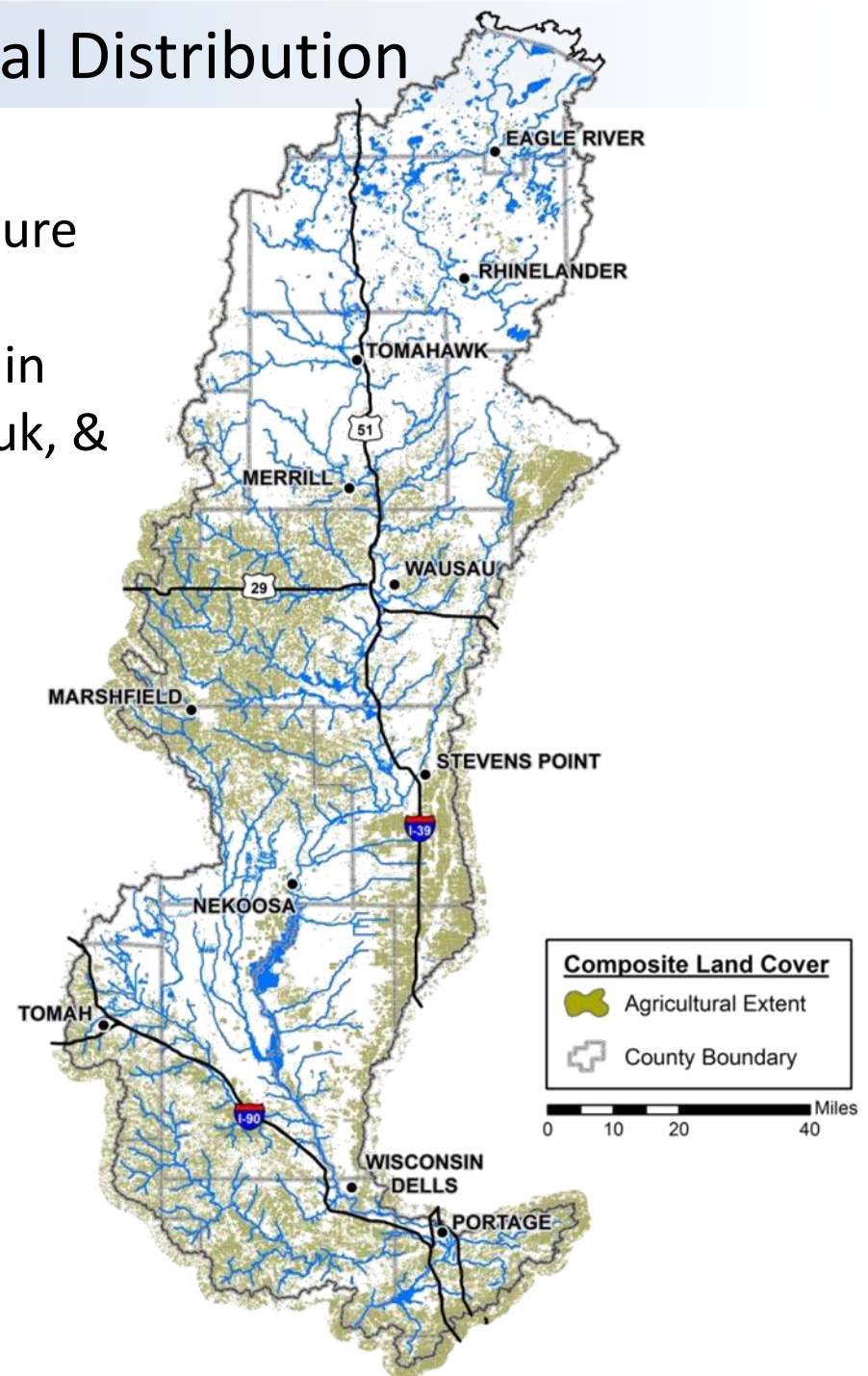
+ CRP and Managed Grazed Land

Composite Land Cover



Wisconsin River Basin Agricultural Distribution

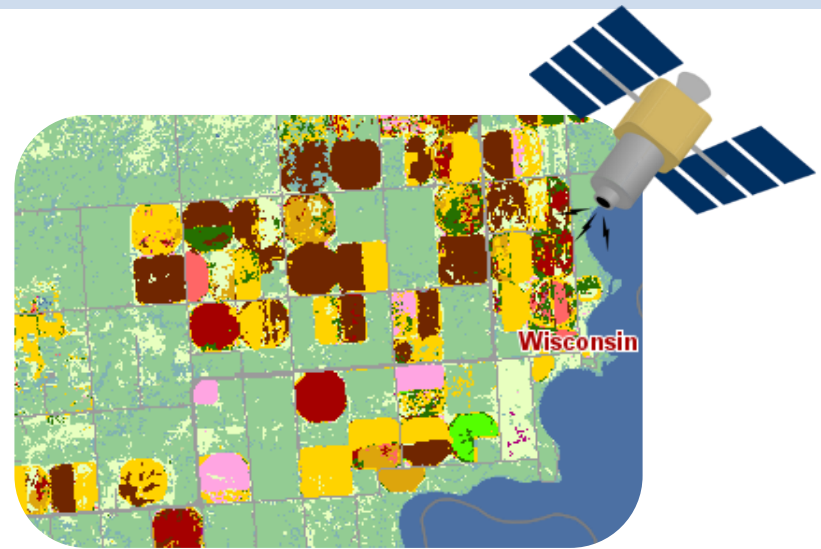
- 25% (2,300 mi²) of the basin is agriculture
- Majority of agricultural acreage found in Marathon, Wood, Portage, Juneau, Sauk, & Columbia counties



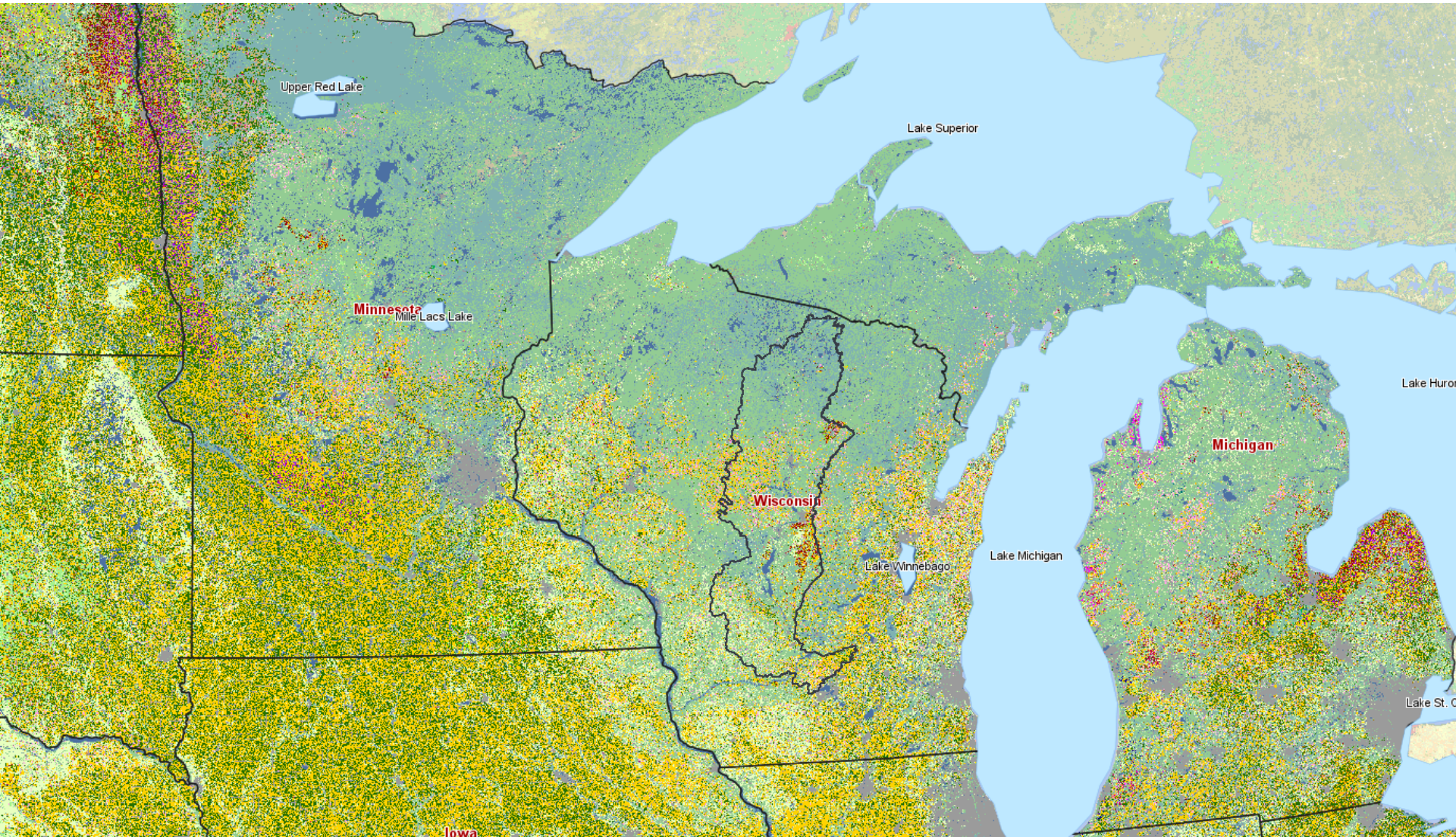
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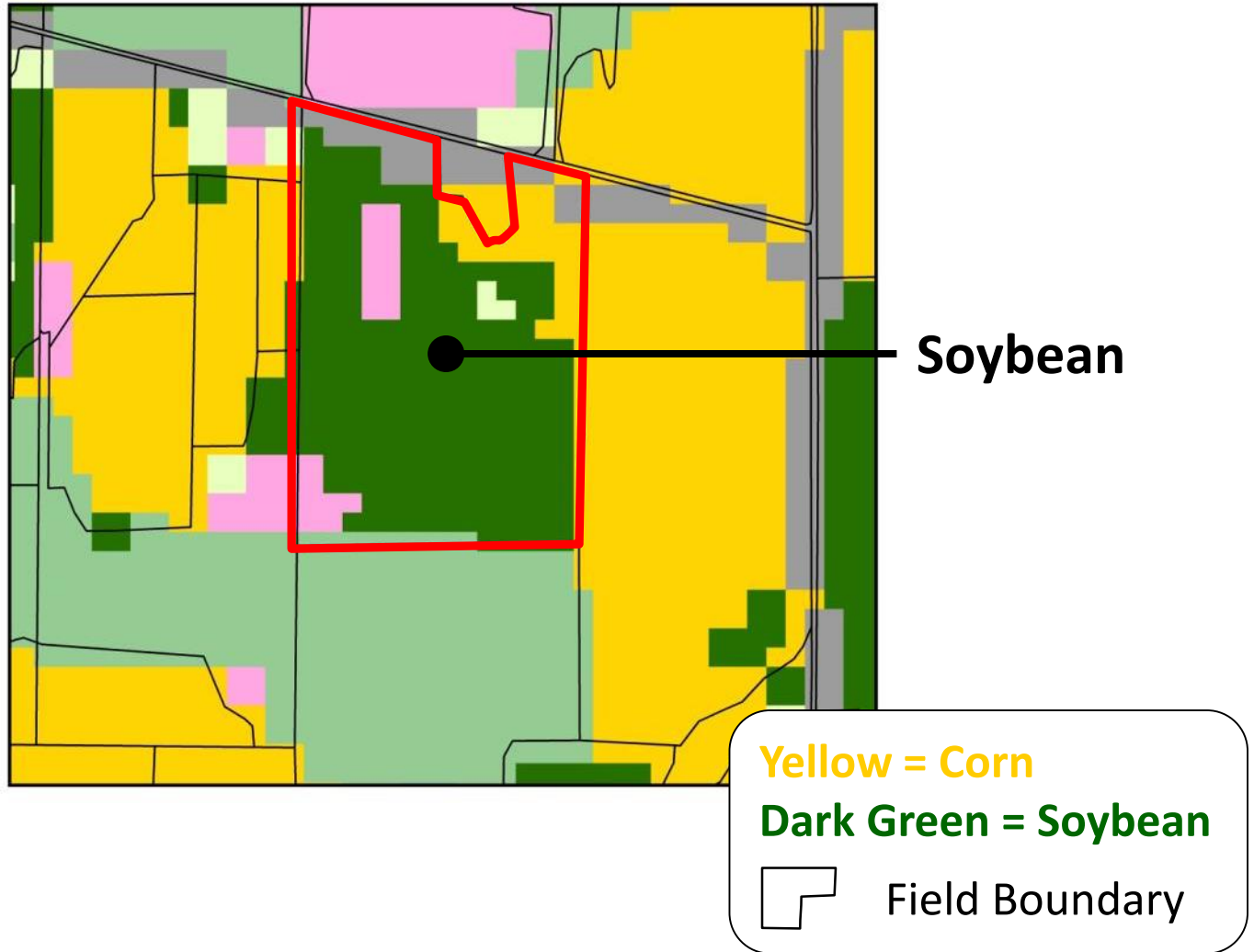
Using Satellite Imagery to Identify Cropping



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

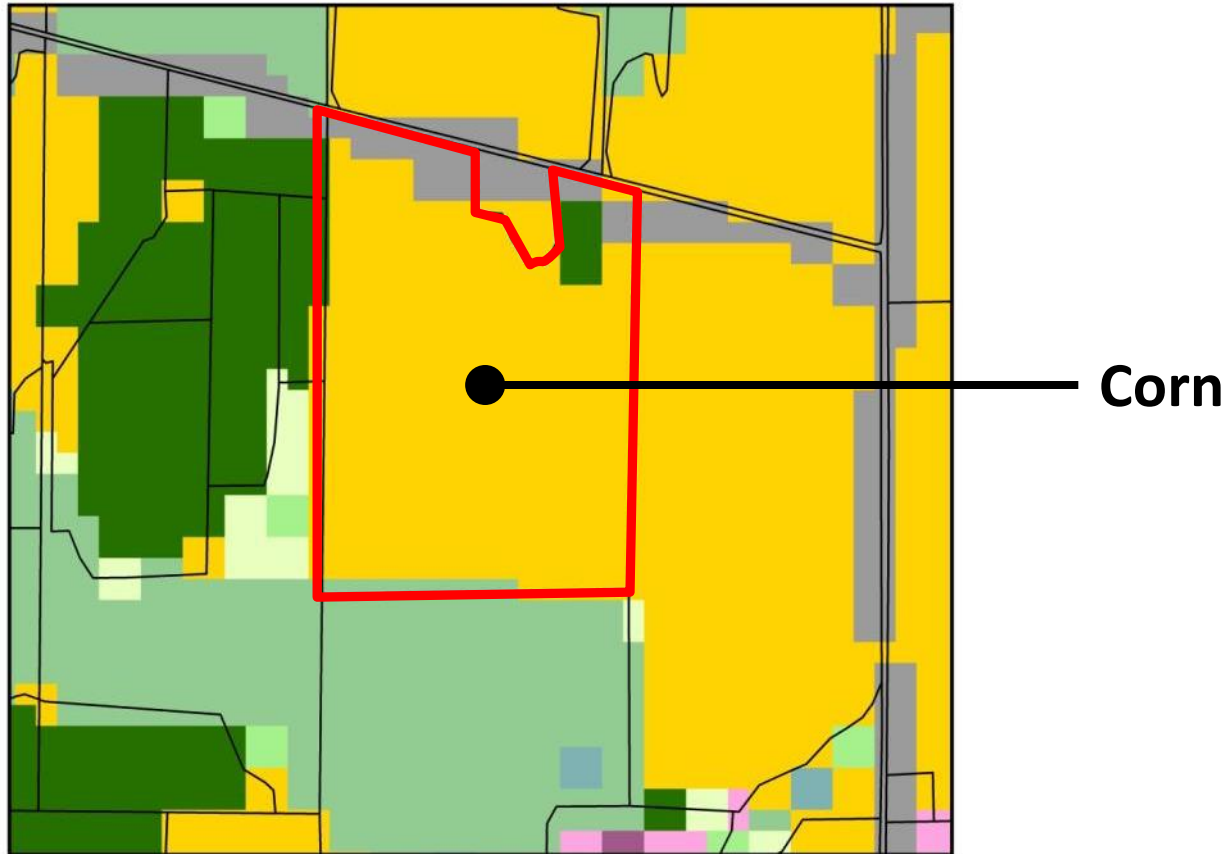
Using Satellite Imagery to Identify Cropping

2008



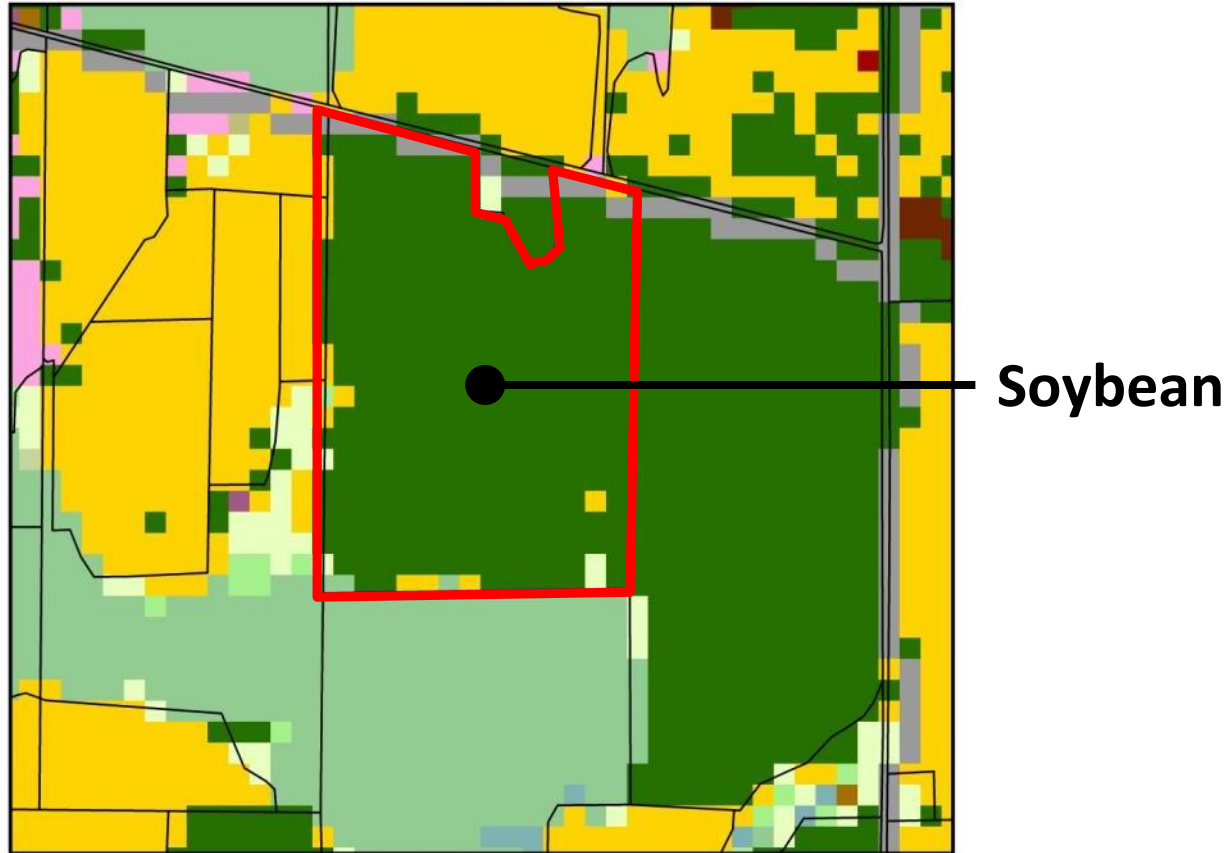
Using Satellite Imagery to Identify Cropping

2009



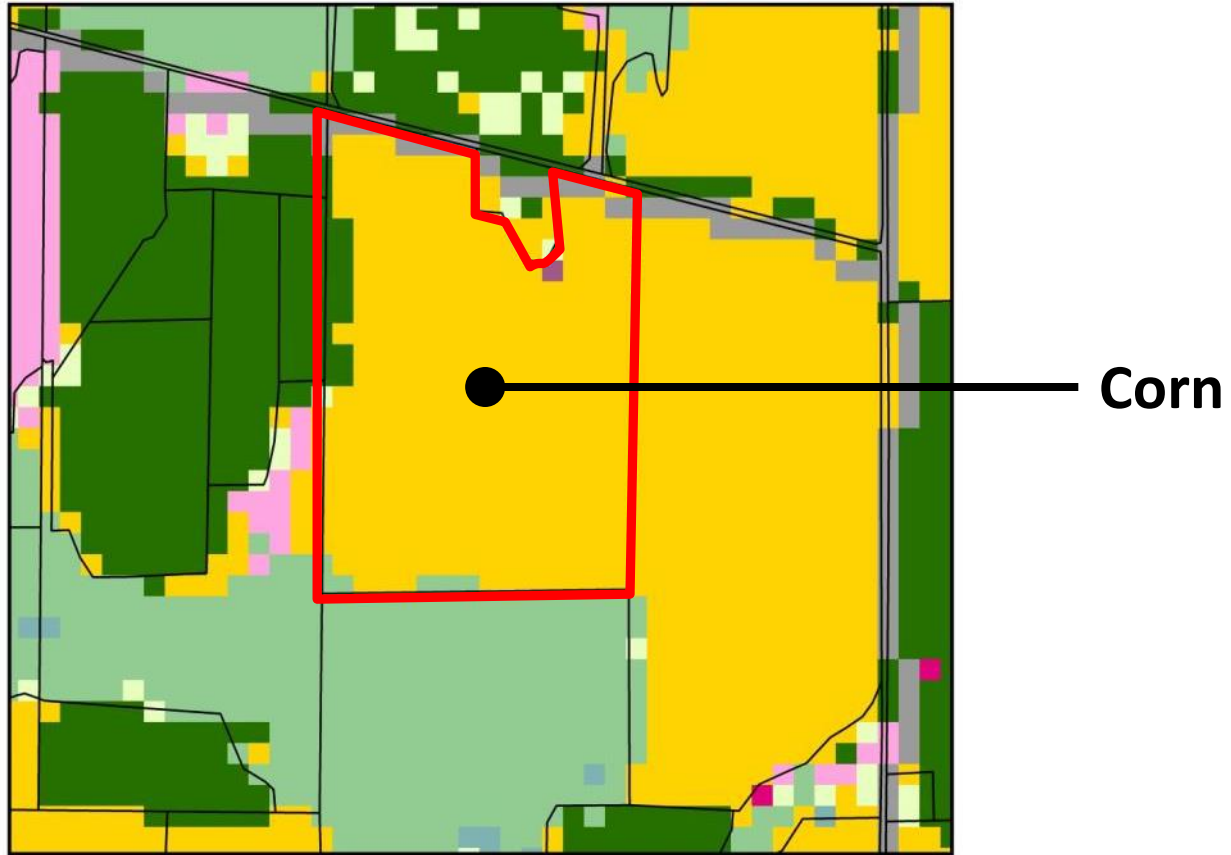
Using Satellite Imagery to Identify Cropping

2010



Using Satellite Imagery to Identify Cropping

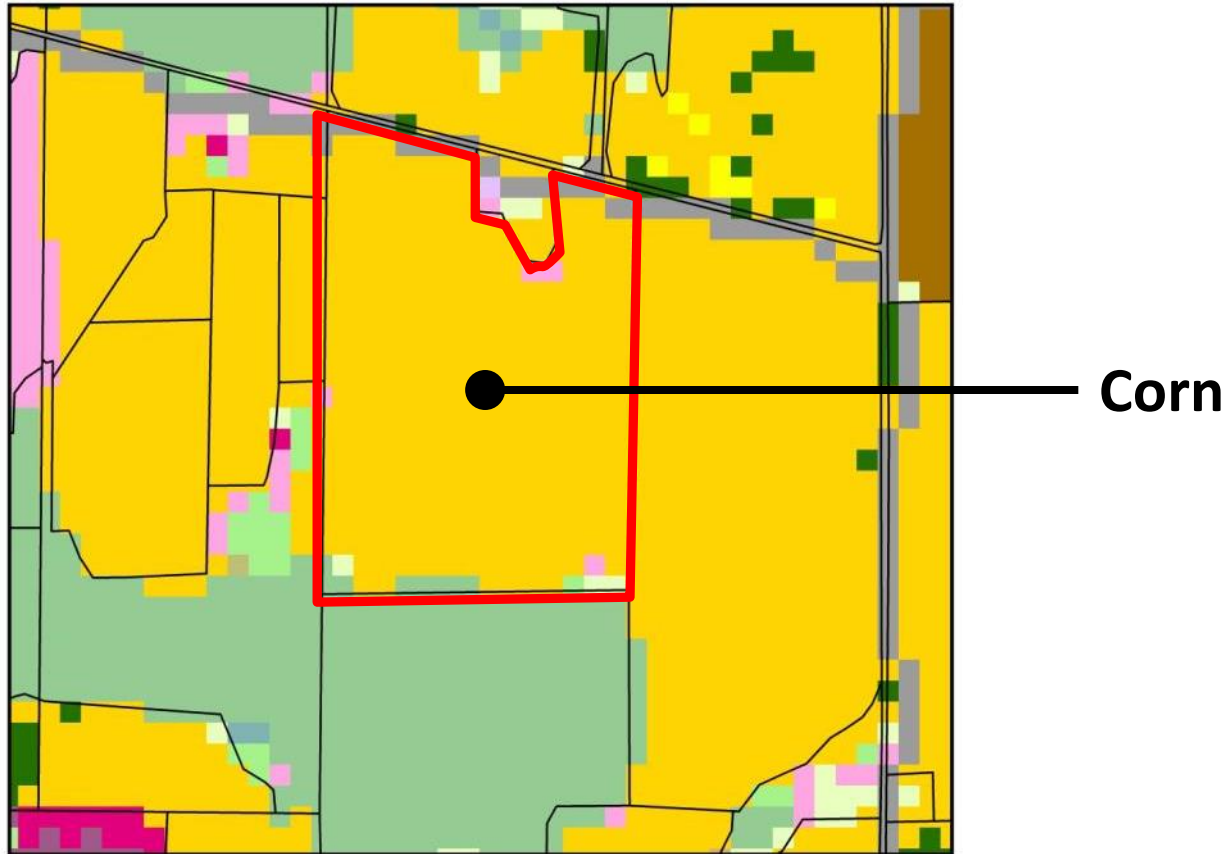
2011



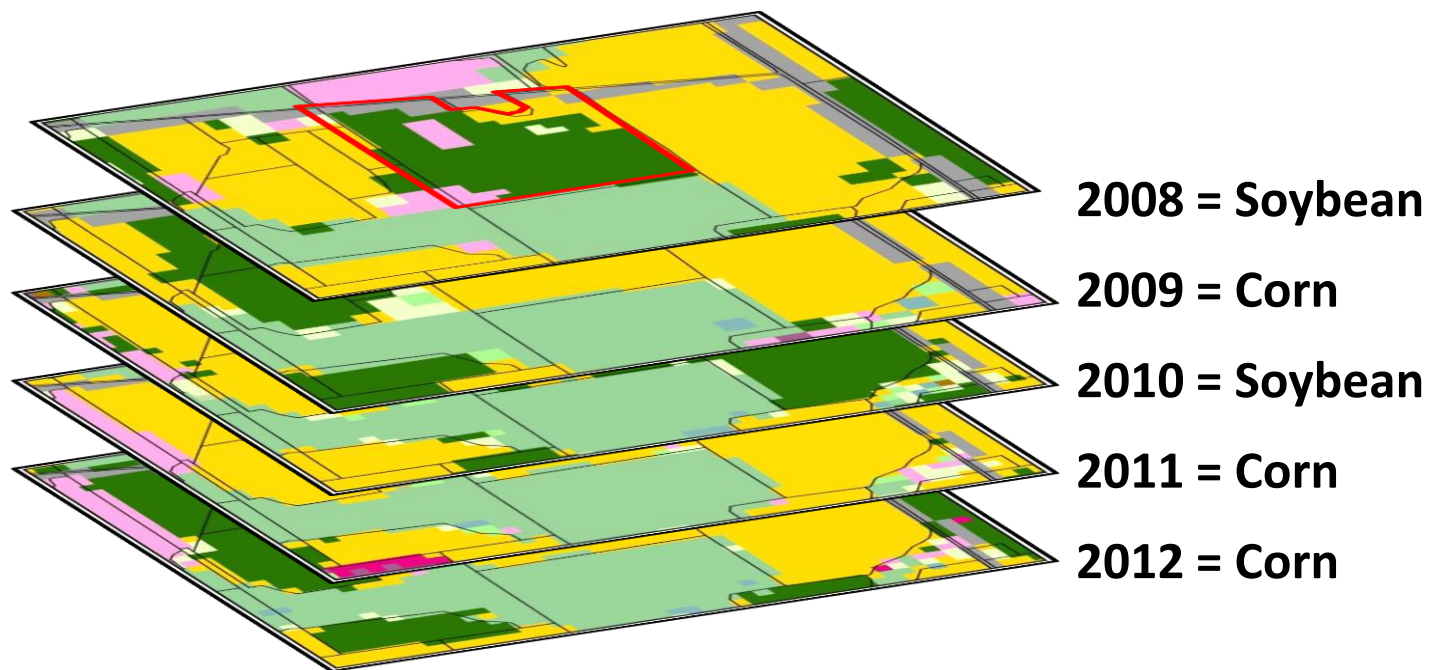
Corn

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

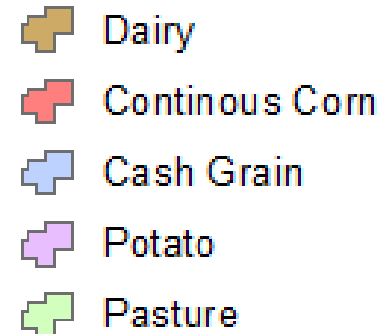
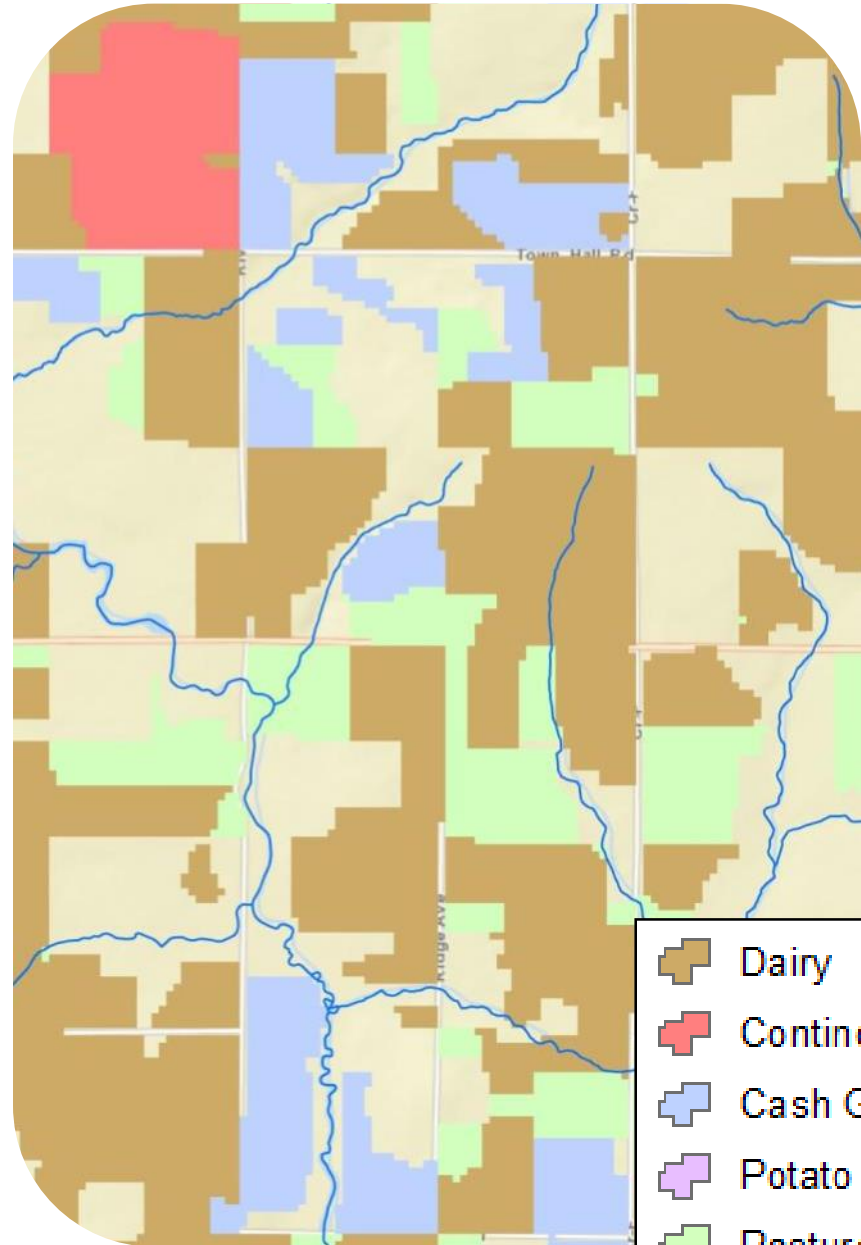
Continuous Corn

Corn

Potato / Vegetable

Potato w/ Veggie and/or Corn

Pasture

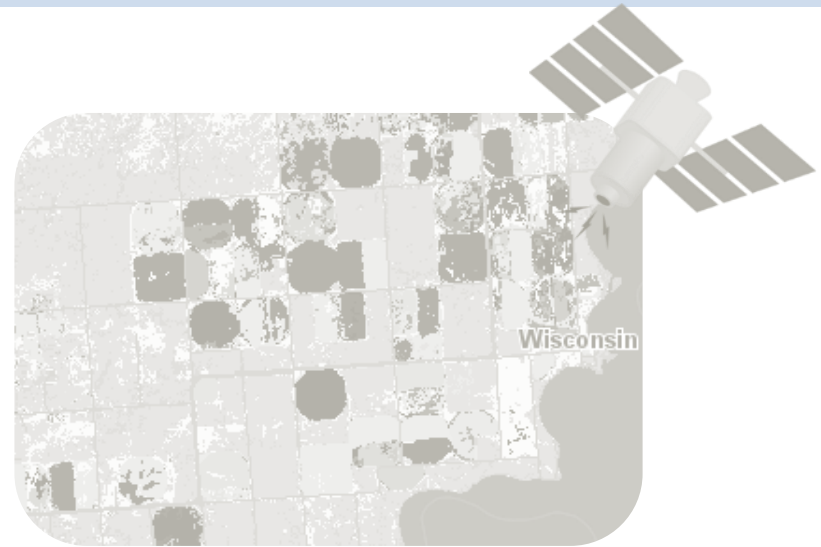


How did we obtain the information?

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2 Identify & categorize crop change per parcel using satellite imagery

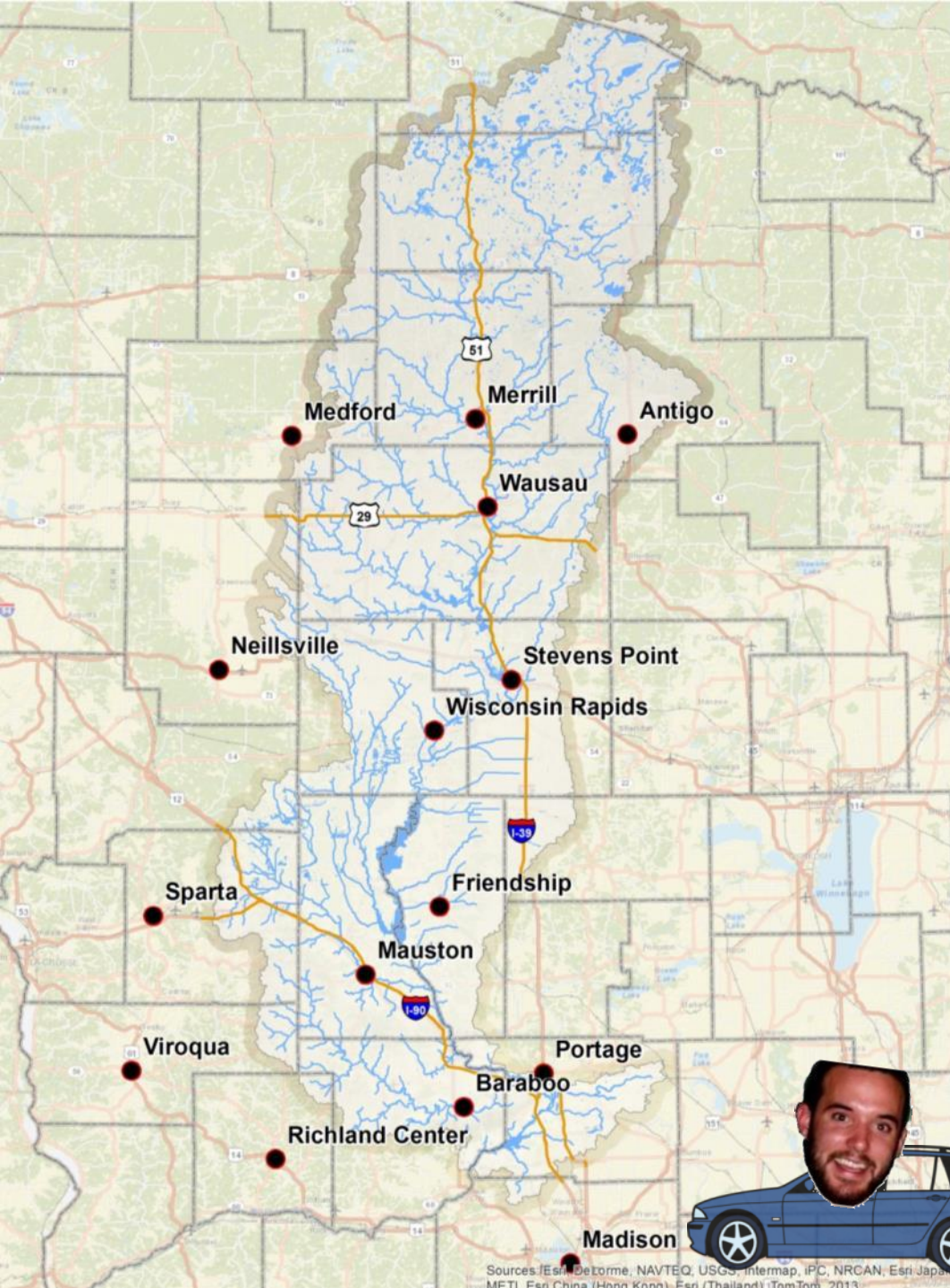
3 Assemble local information to further refine rotations



Using Local Information to Complete Crop Rotations

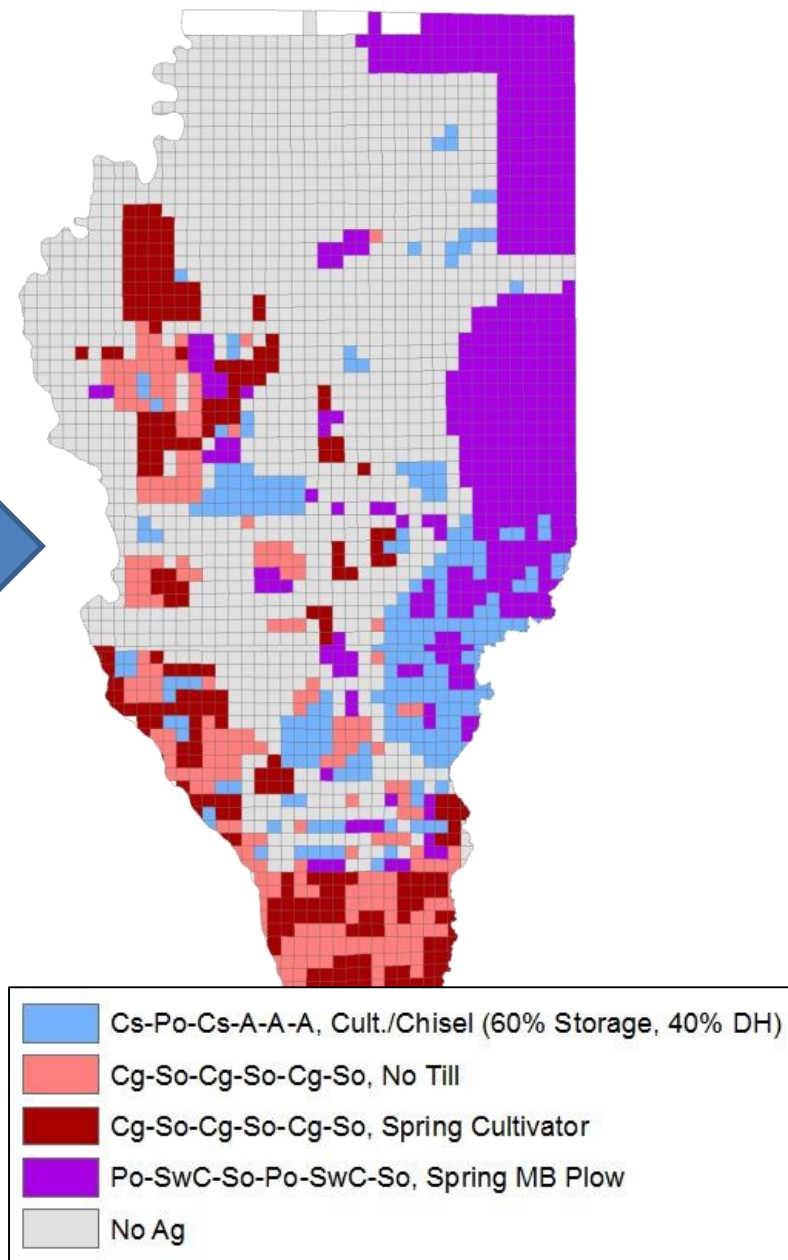
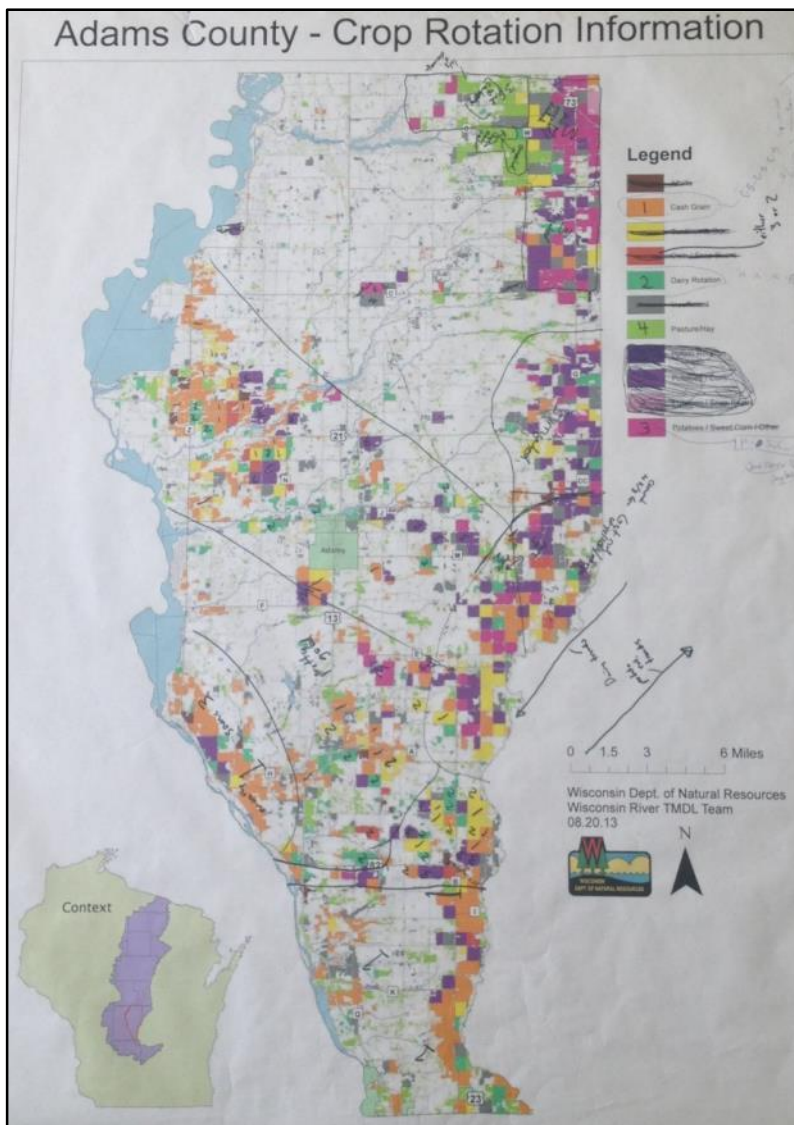


- Does our crop rotation map correctly depict rotations in your county?
- What is the type and timing of each rotation's tillage and nutrient applications?



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Jap., METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Digitizing County Land Management Information



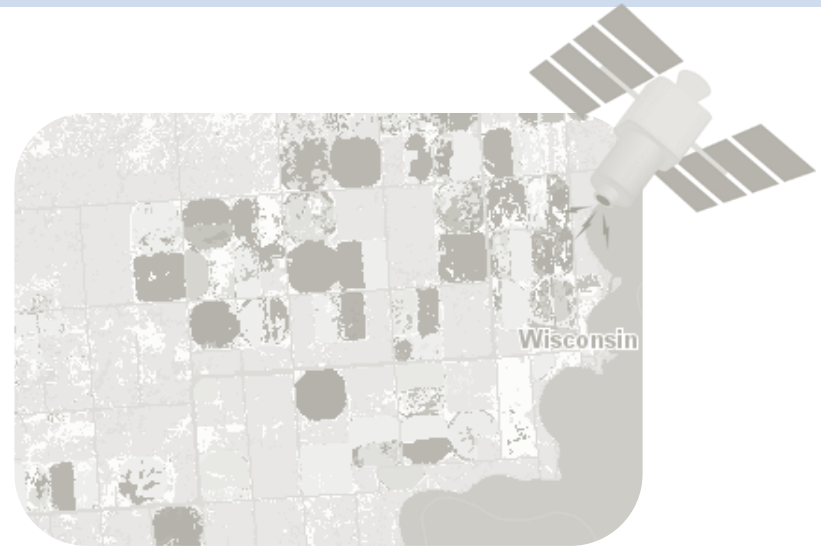
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4 Integrate local information into rotation coverage



Generalization of a Dairy Rotation

WDNR's Initial Idea

Cropland Data Layer

2-3 Years CG, CS, SOY
3-4 Years Alfalfa
Manure?
Tillage?

County Rotations

Local Knowledge

3YR CS, 3 Alfalfa
10,000 GPA LQ Manure
Spring Cultivator, Fall Chisel

1YR CG, 1 YR CS, 4 Alfalfa
12,000 GPA LIQ Manure
Spring /Fall Moldboard

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

Generalized Rotations

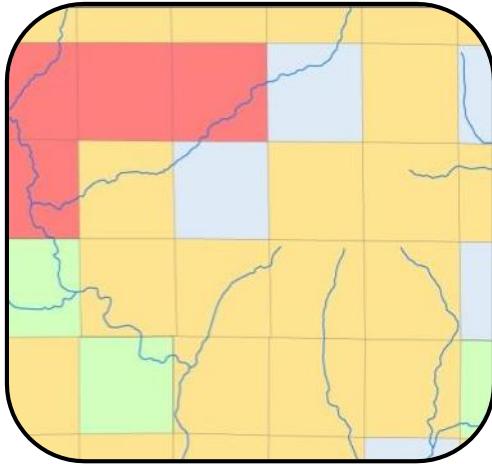
Model Integration

2 CS, 1 CG, 3 Alfalfa
10,000 GPA LQ Manure
(50% spring, 50% fall)
Spring, Fall Moldboard

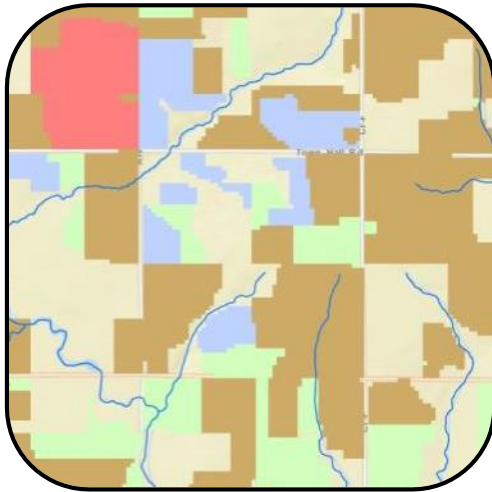
1YR CG, 1 YR CS, 4 Alfalfa
10,000 GPA LQ Manure
(50% spring, 50% fall)
Spring Disk / Fall Chisel

Using Local Information to Complete Crop Rotations

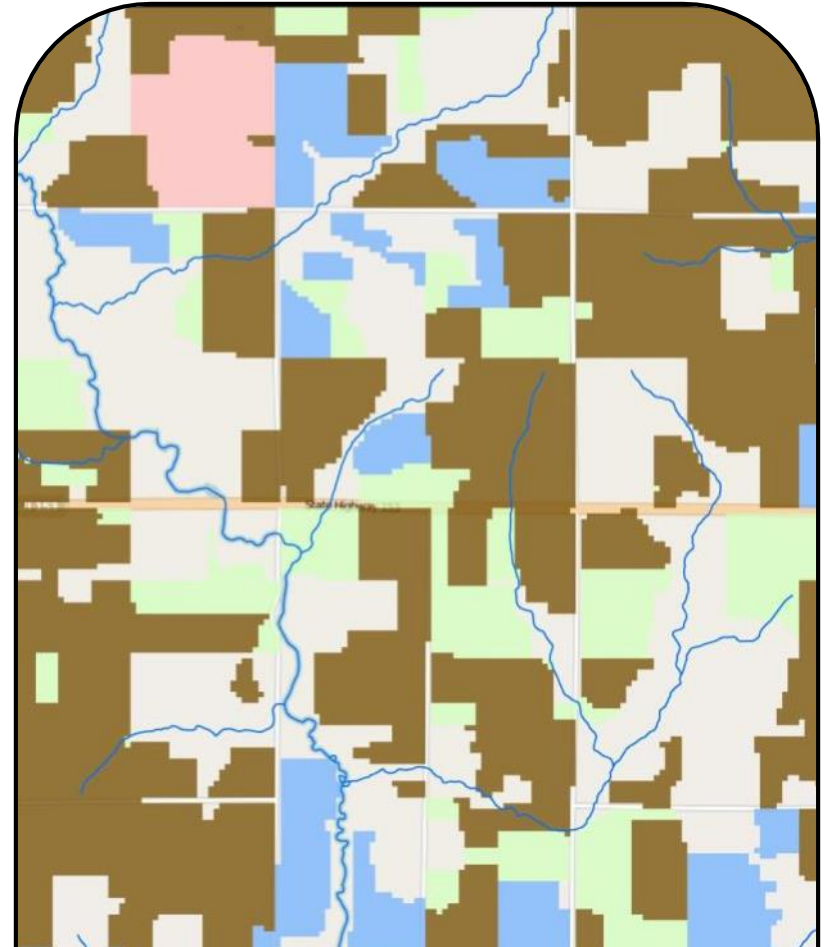
Watershed Response Model Input







County-level
tillage, fertilizer,
manure, & timing
Information per 1/4
section



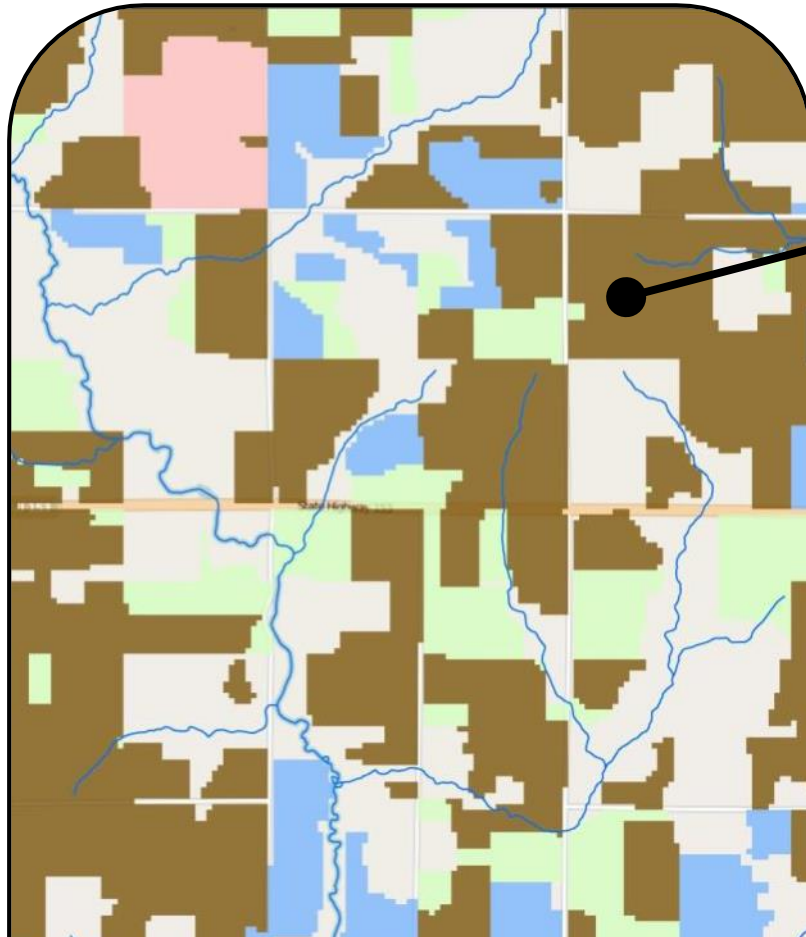
Rotations from
cropland data
layer analysis
per parcel






-  Dairy (CG-CG-O/A-A-A-A, Moldboard Plow, 10,000 gallons Liquid Manure)
-  Continuous Corn (C-C-C-C-C-C, 150 lbs/acre 20:10:18)
-  Cash Grain (C-C-S-C-C-S, 150 lbs/acre 20:10:18, Disk Plow)
-  Pasture

Using Local Information to Complete Crop Rotations

Watershed Response Model Input



-  Dairy (CG-CG-O/A-A-A-A, Moldboard Plow, 10,000 gallons Liquid Manure)
-  Continuous Corn (C-C-C-C-C-C, 150 lbs/acre 20:10:18)
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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 our information Compare to Other Datasets?

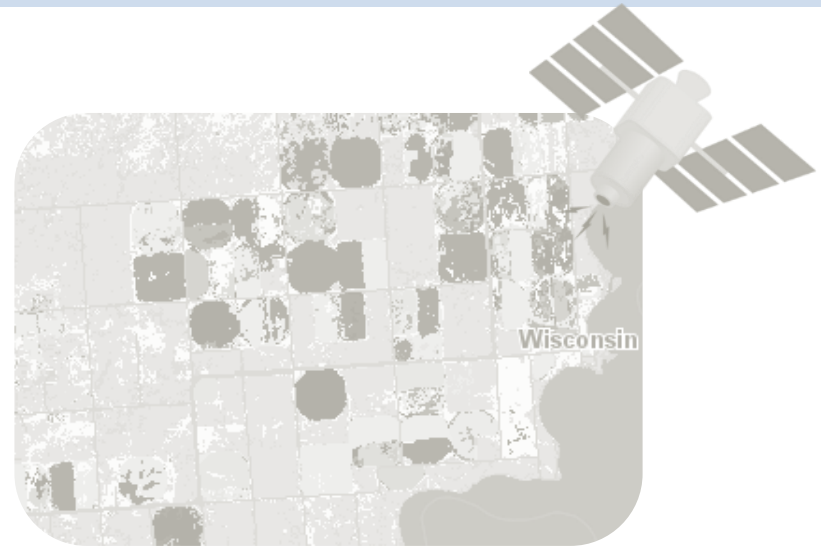
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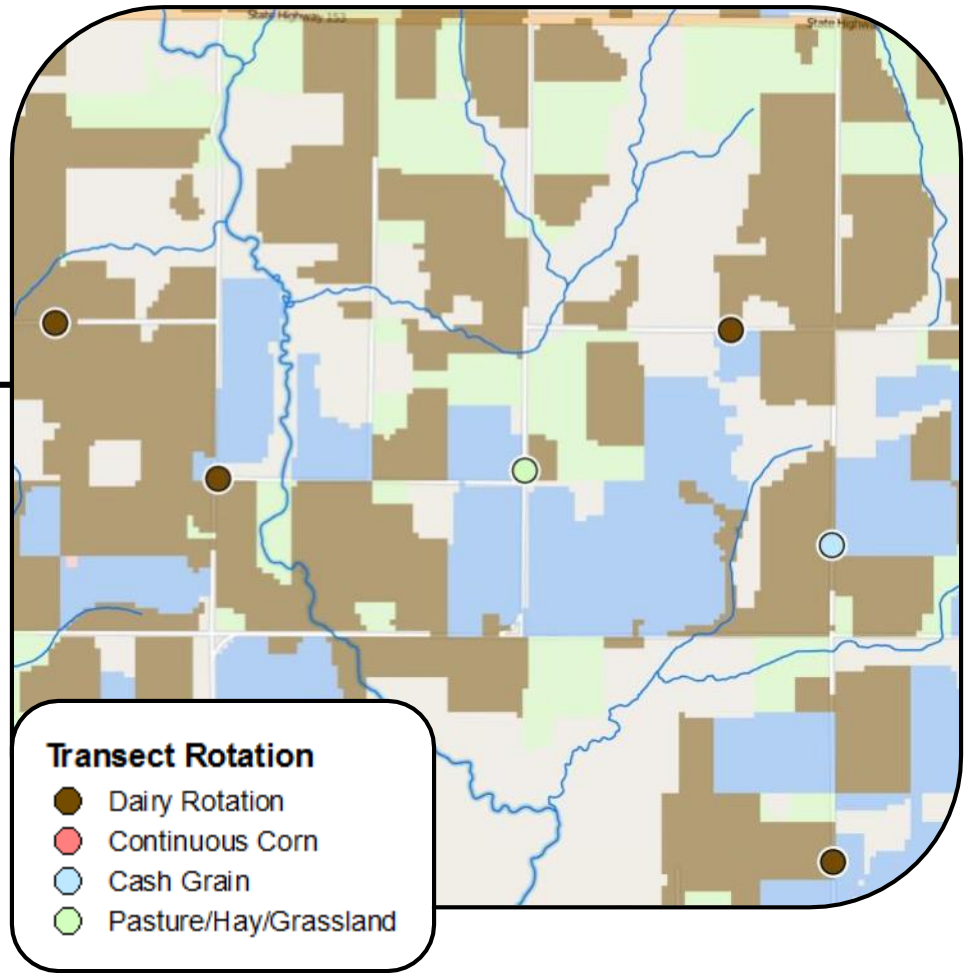
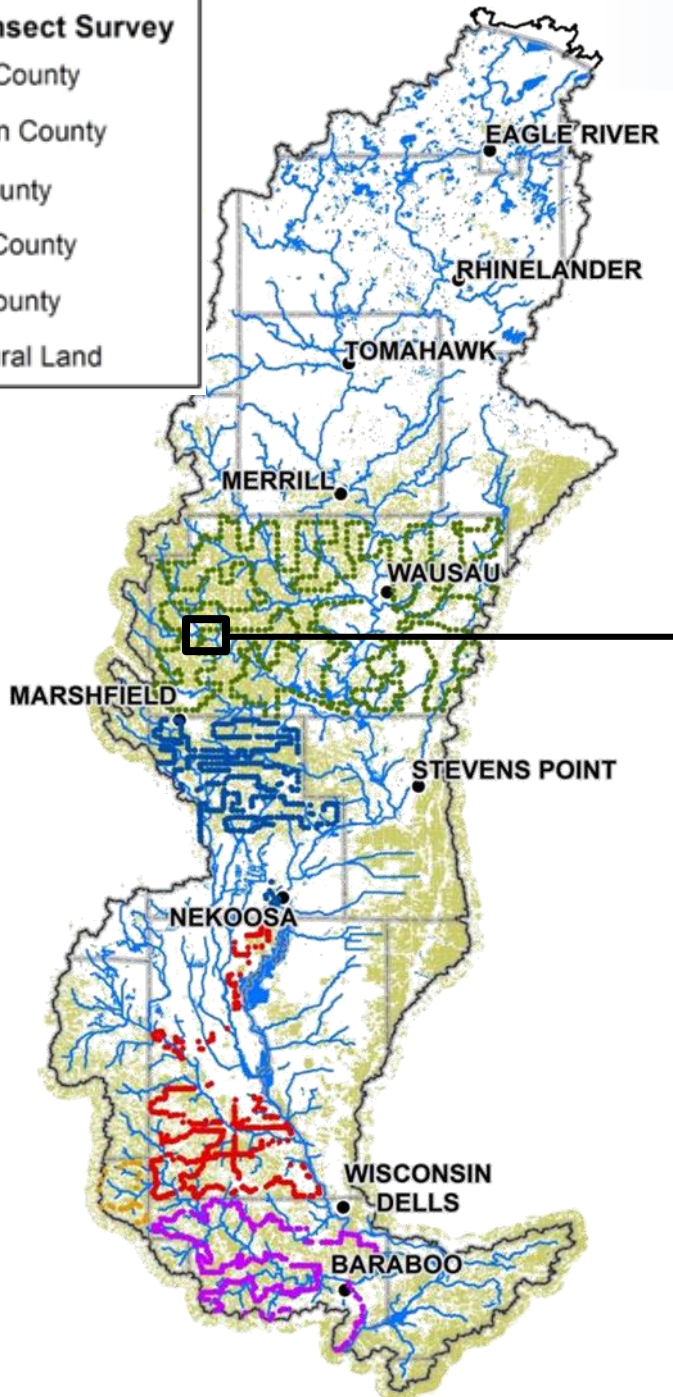
4 Integrate local information into rotation coverage

5 Confirm agricultural management with observed data



County Transect Surveys

- County Transect Survey**
- Juneau County
 - Marathon County
 - Sauk County
 - Vernon County
 - Wood County
 - Agricultural Land

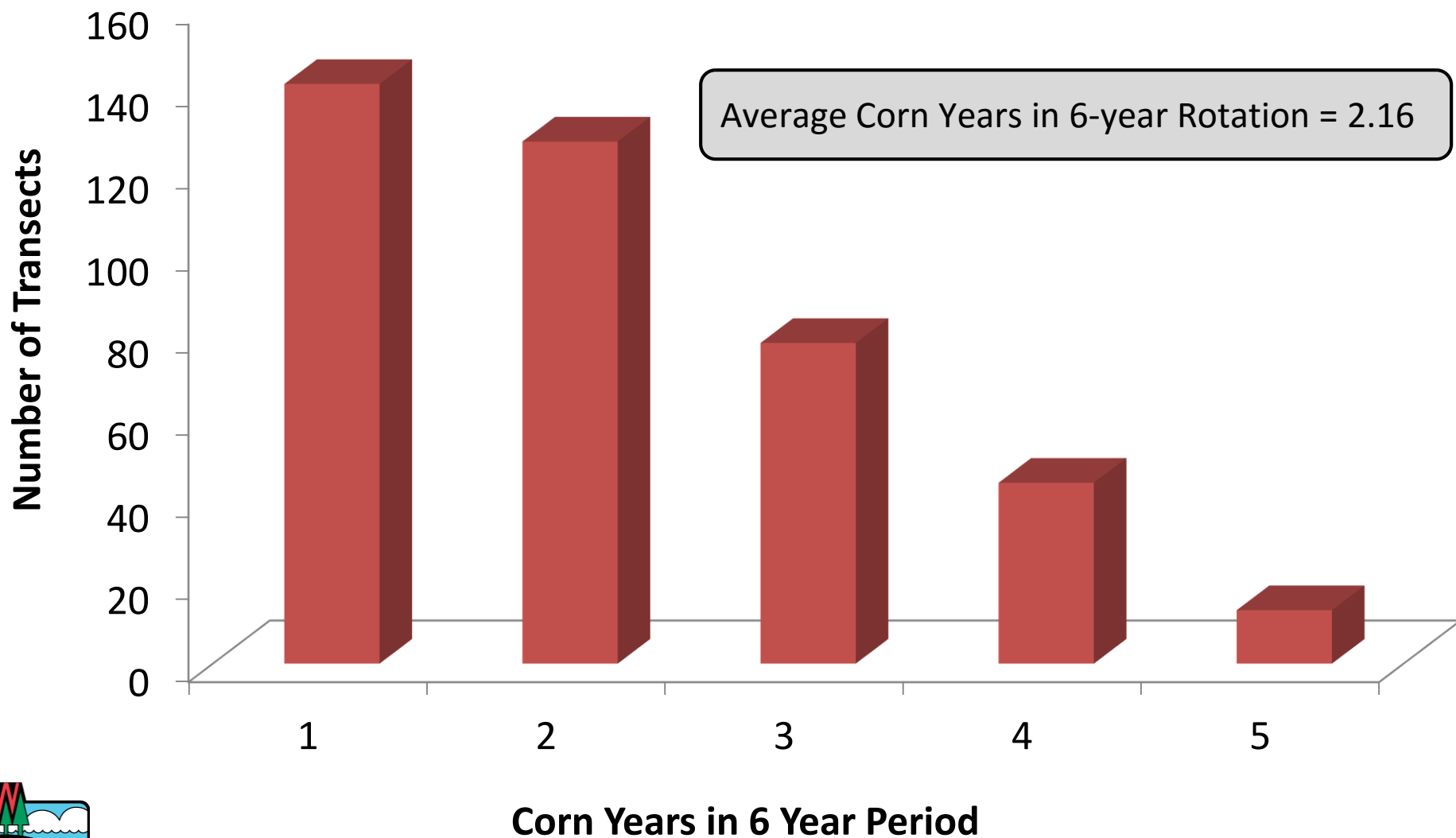


County Transect Surveys: Cropping

Marathon County Transect Points

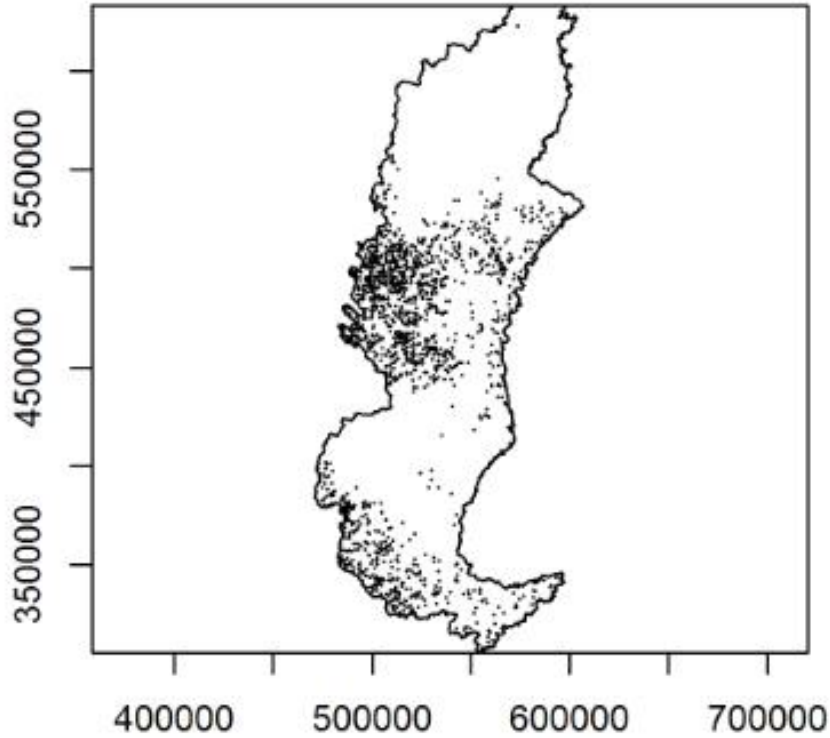
of Corn Years within Dairy Rotations

403 Transect Points

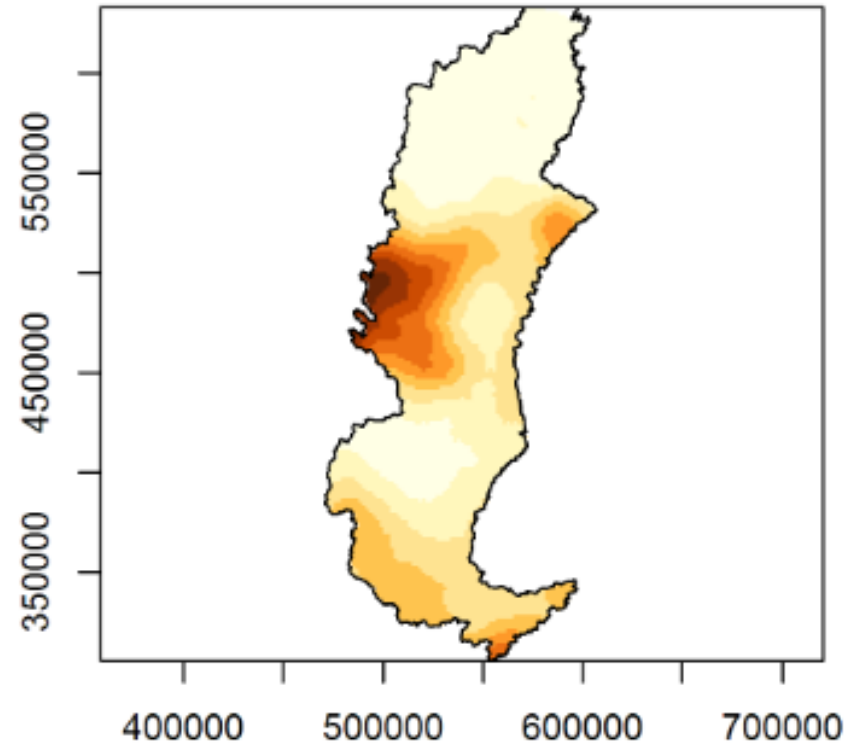


Dairy Rotation vs. Dairy Producers

DATCP dairy producers

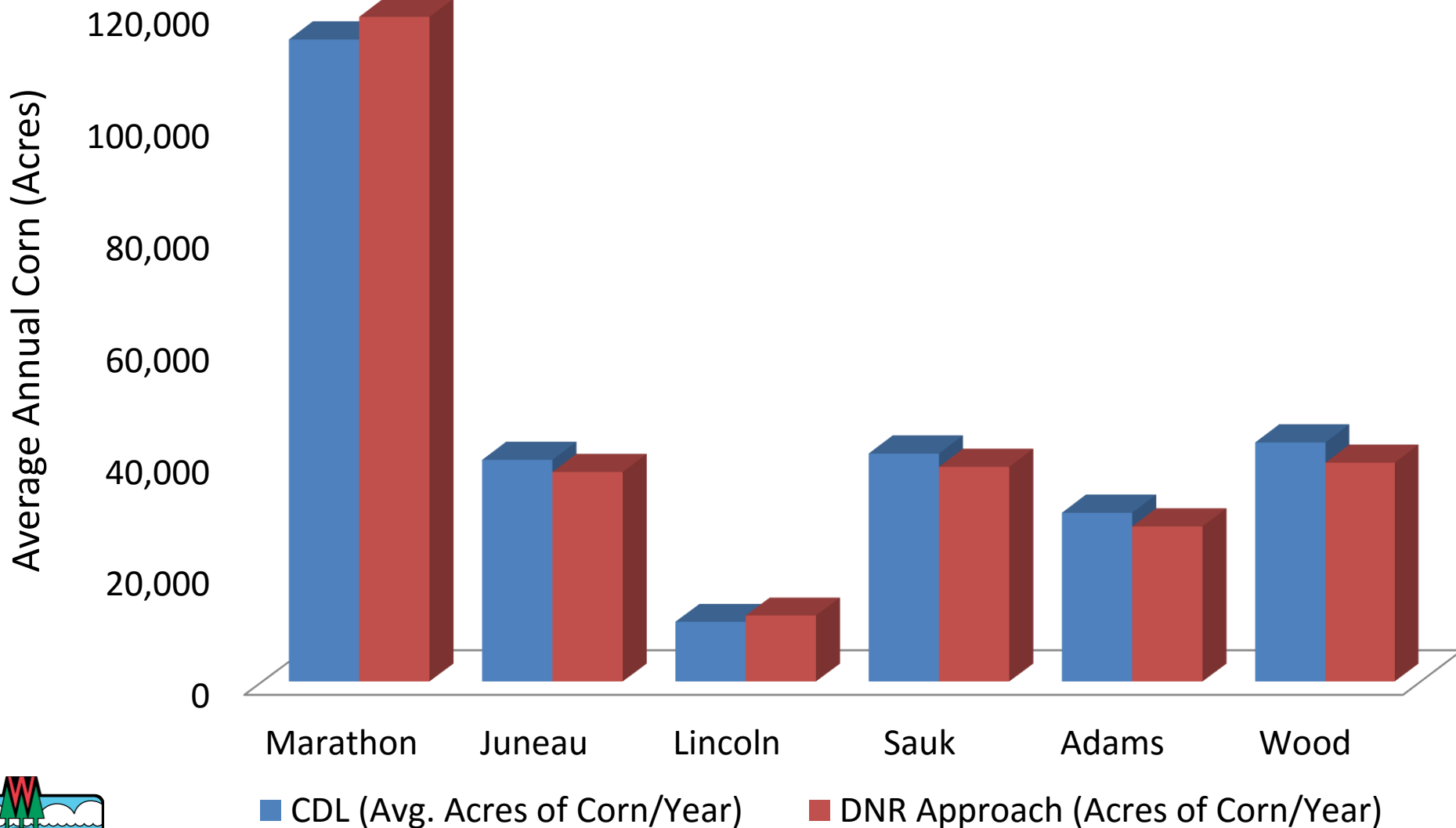


CDL dairy rotation density



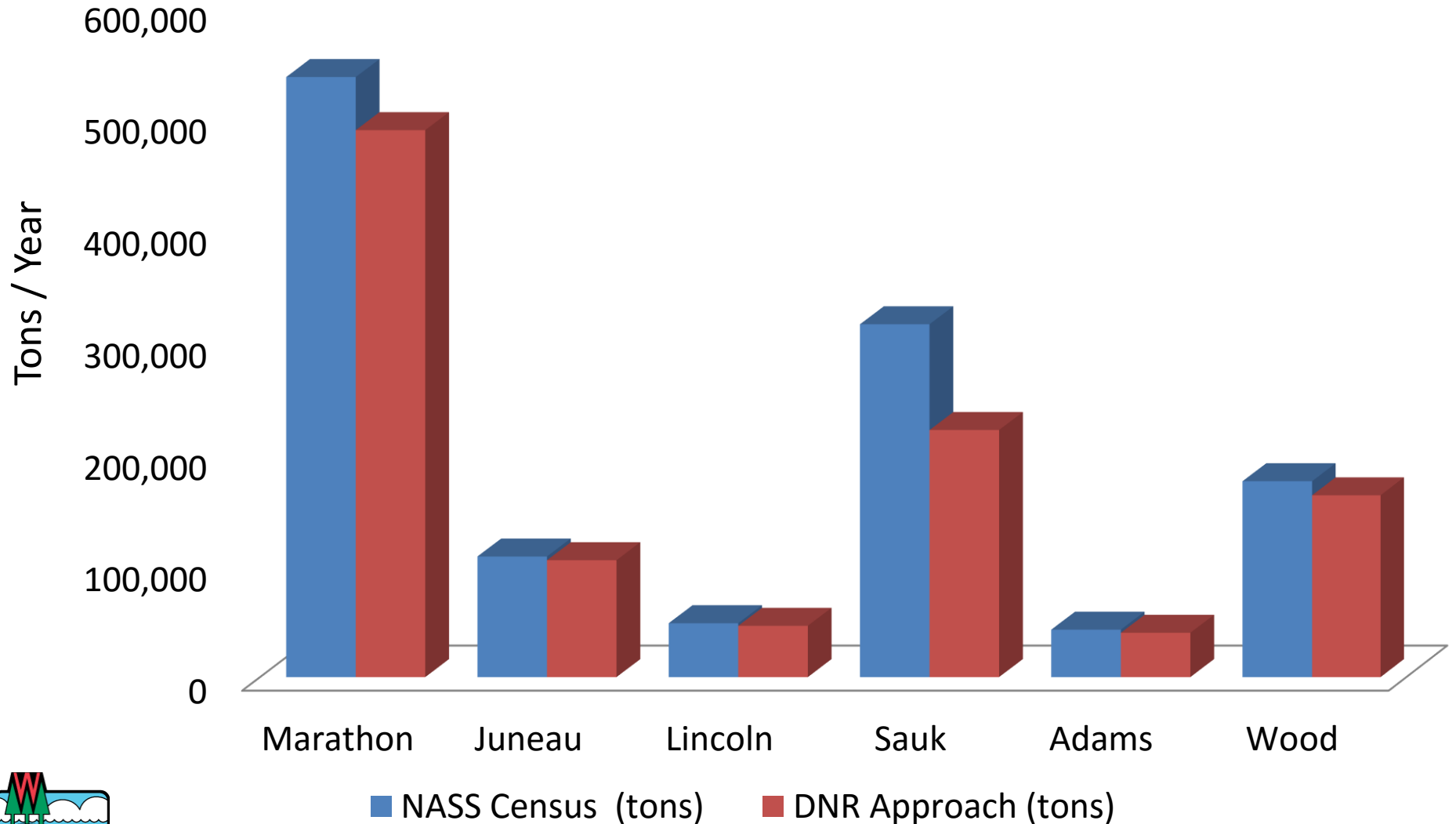
Crop Acreage

Average Annual Corn Acreage Cropland Data Layer vs. DNR Rotation Approach



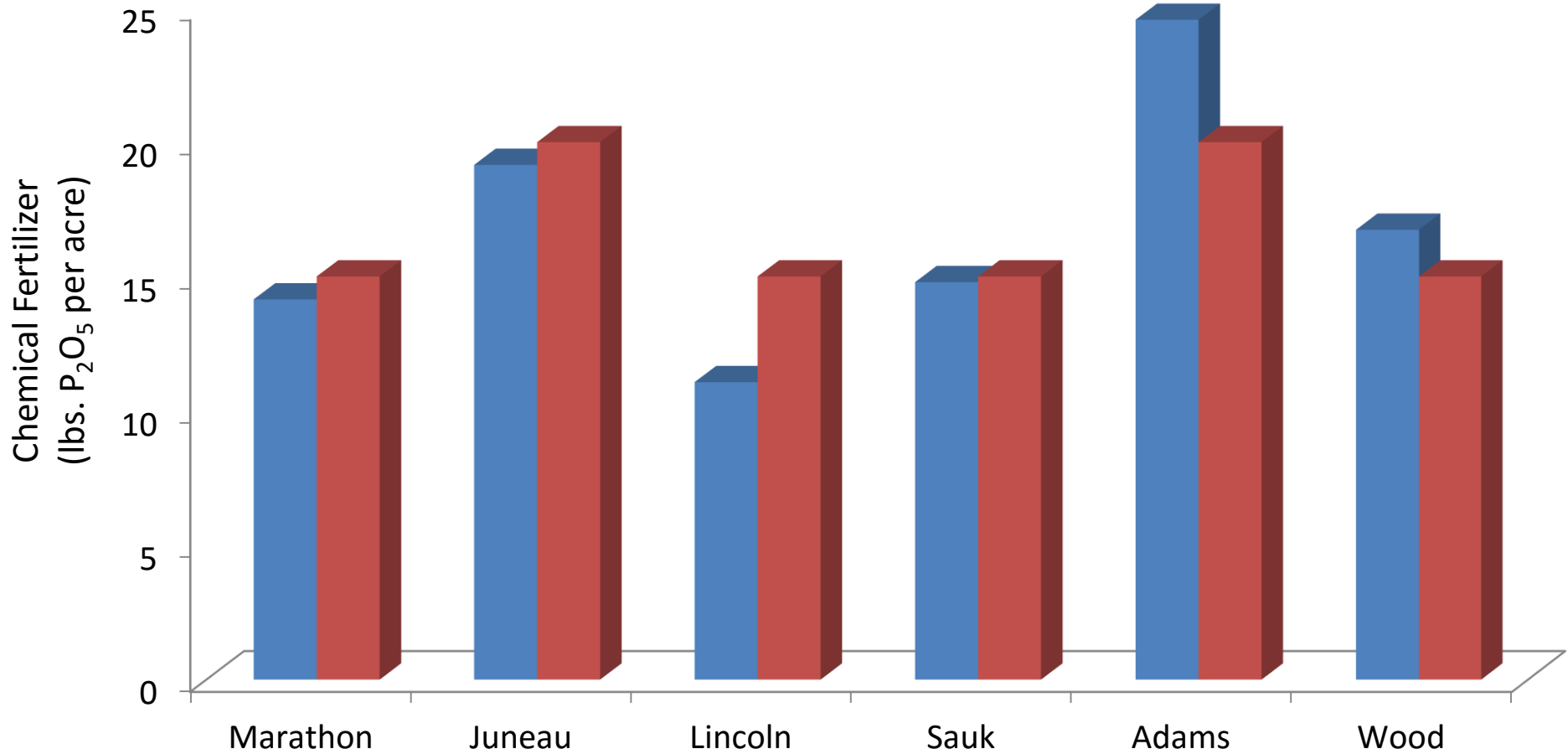
Manure

Manure Comparison (NASS vs. DNR Rotation Approach)



Fertilizer

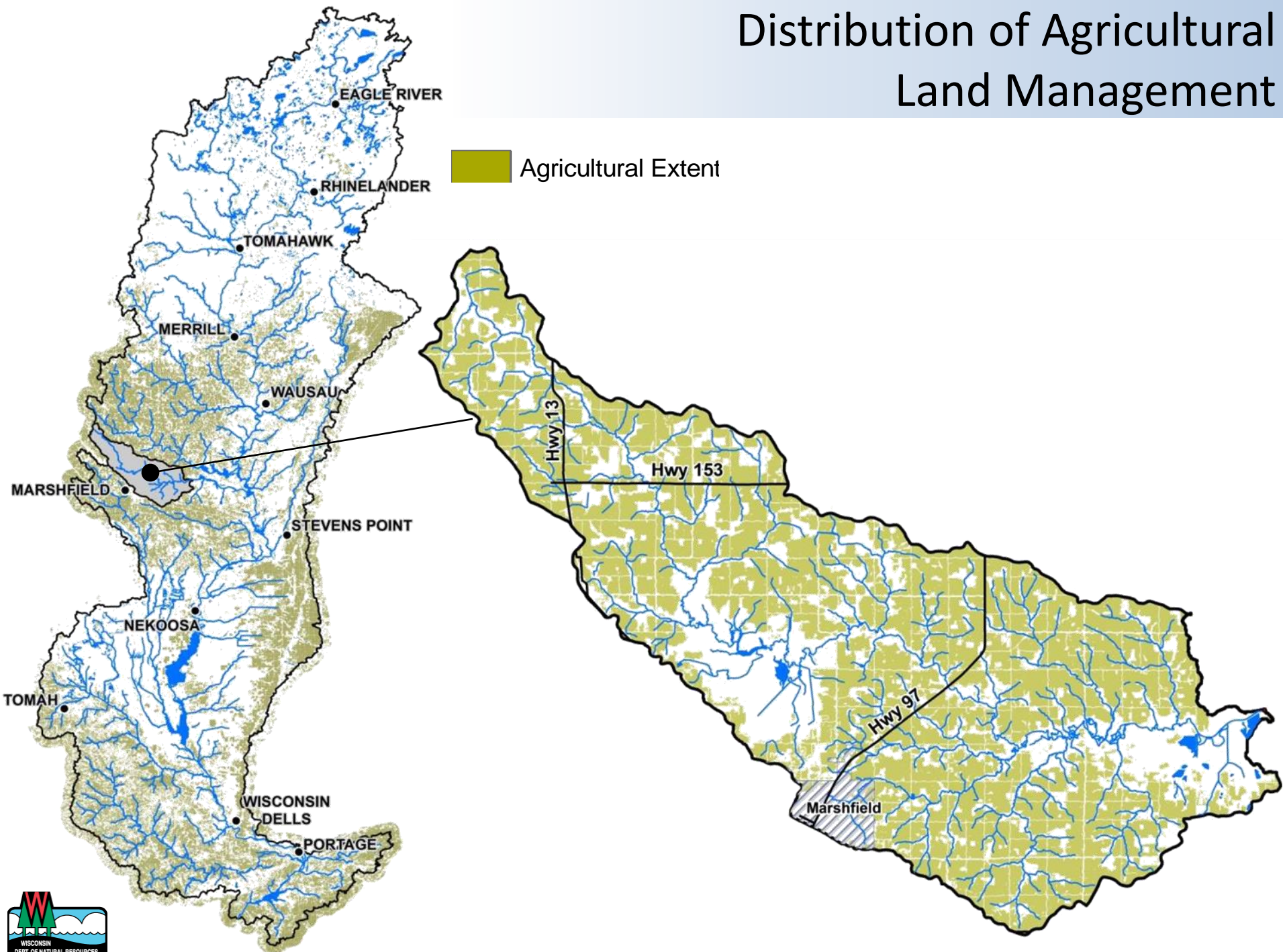
Fertilizer Comparison (NuGIS vs. DNR Approach)



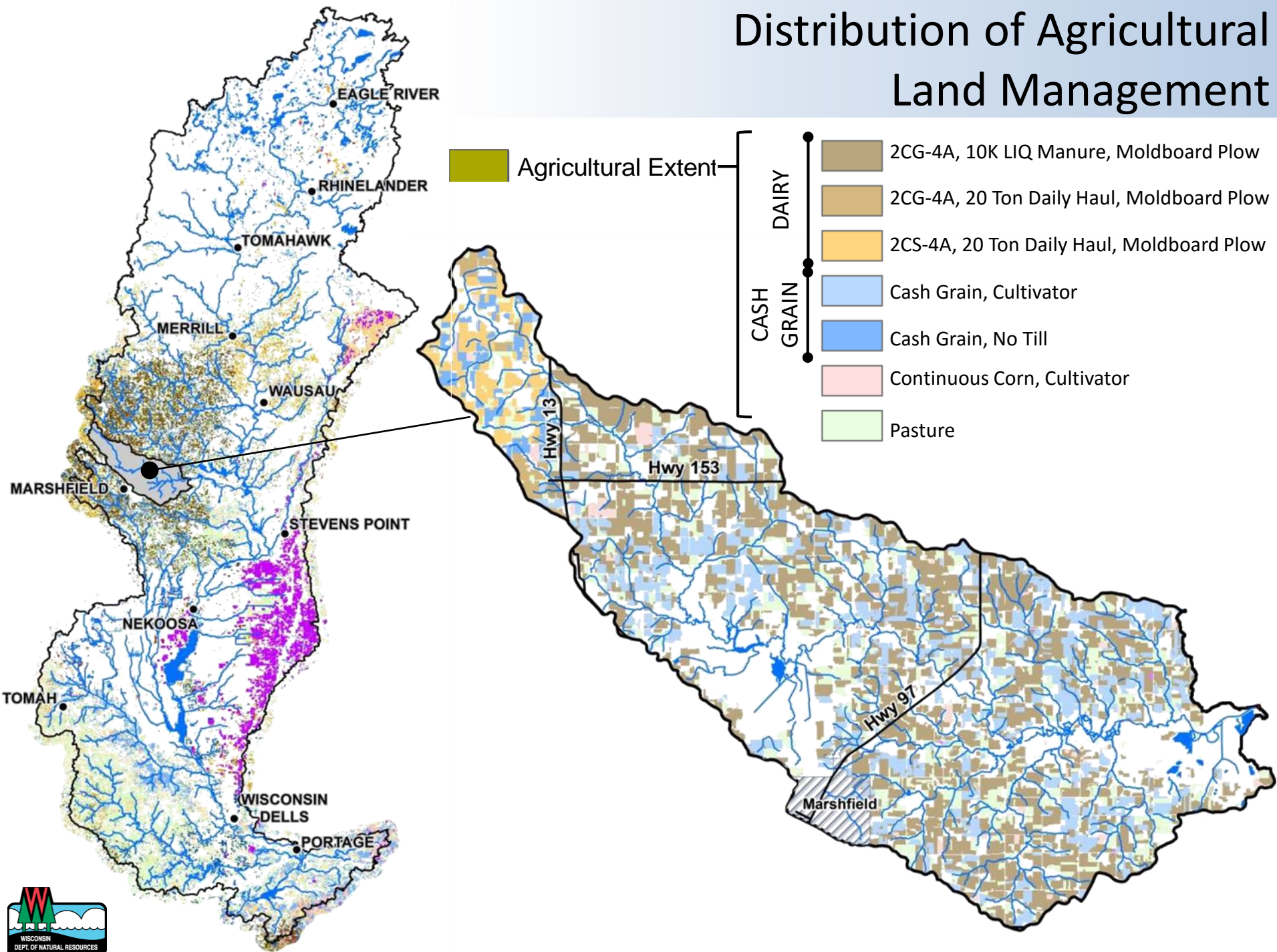
■ NuGIS Fertilizer App Rate (lbs. P₂O₅ per acre) ■ DNR Estimation (lbs. P₂O₅ per acre)



Distribution of Agricultural Land Management

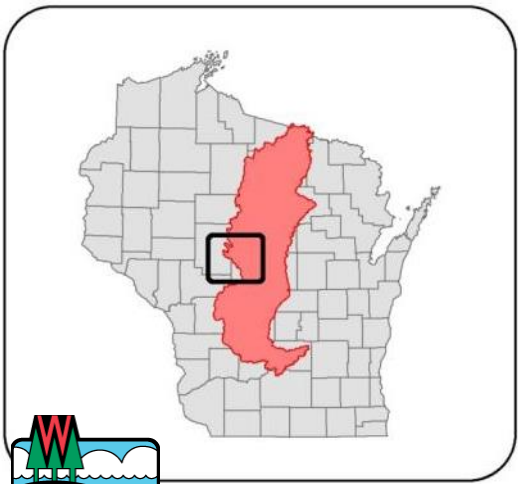
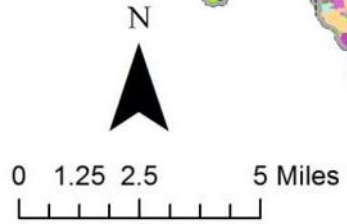
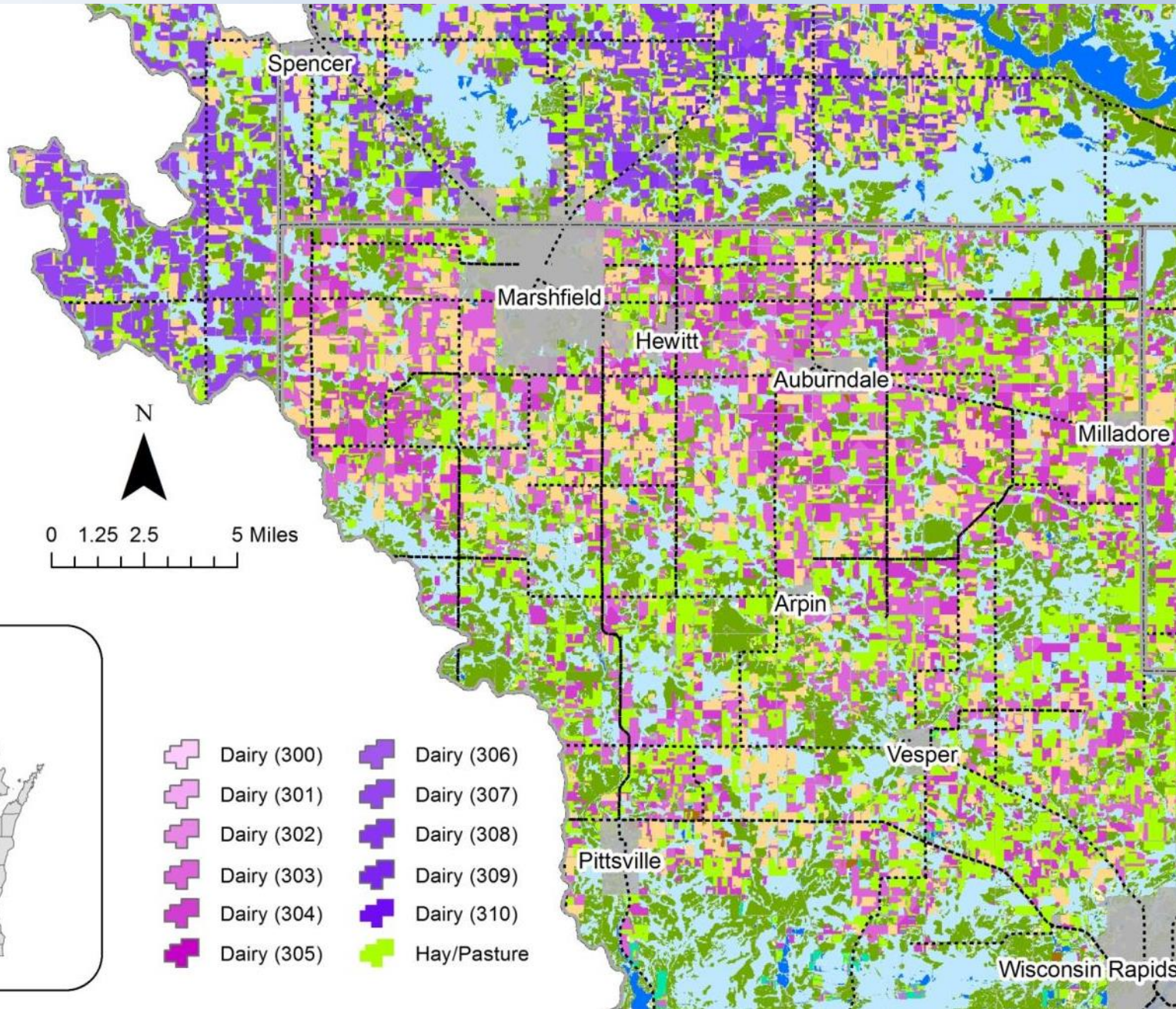


Distribution of Agricultural Land Management



Distribution of Land Management Grid Codes

-  Major Roads
-  County Boundaries
-  Open Water
-  Urban / Developed
-  Grassland
-  Deciduous Forest
-  Woody Wetlands
-  Cash Grain (400)
-  Cash Grain (401)
-  Cash Grain (402)
-  Potato/Veggie (500)
-  Cranberries



-  Dairy (300)
-  Dairy (301)
-  Dairy (302)
-  Dairy (303)
-  Dairy (304)
-  Dairy (305)
-  Dairy (306)
-  Dairy (307)
-  Dairy (308)
-  Dairy (309)
-  Dairy (310)
-  Hay/Pasture

Summary

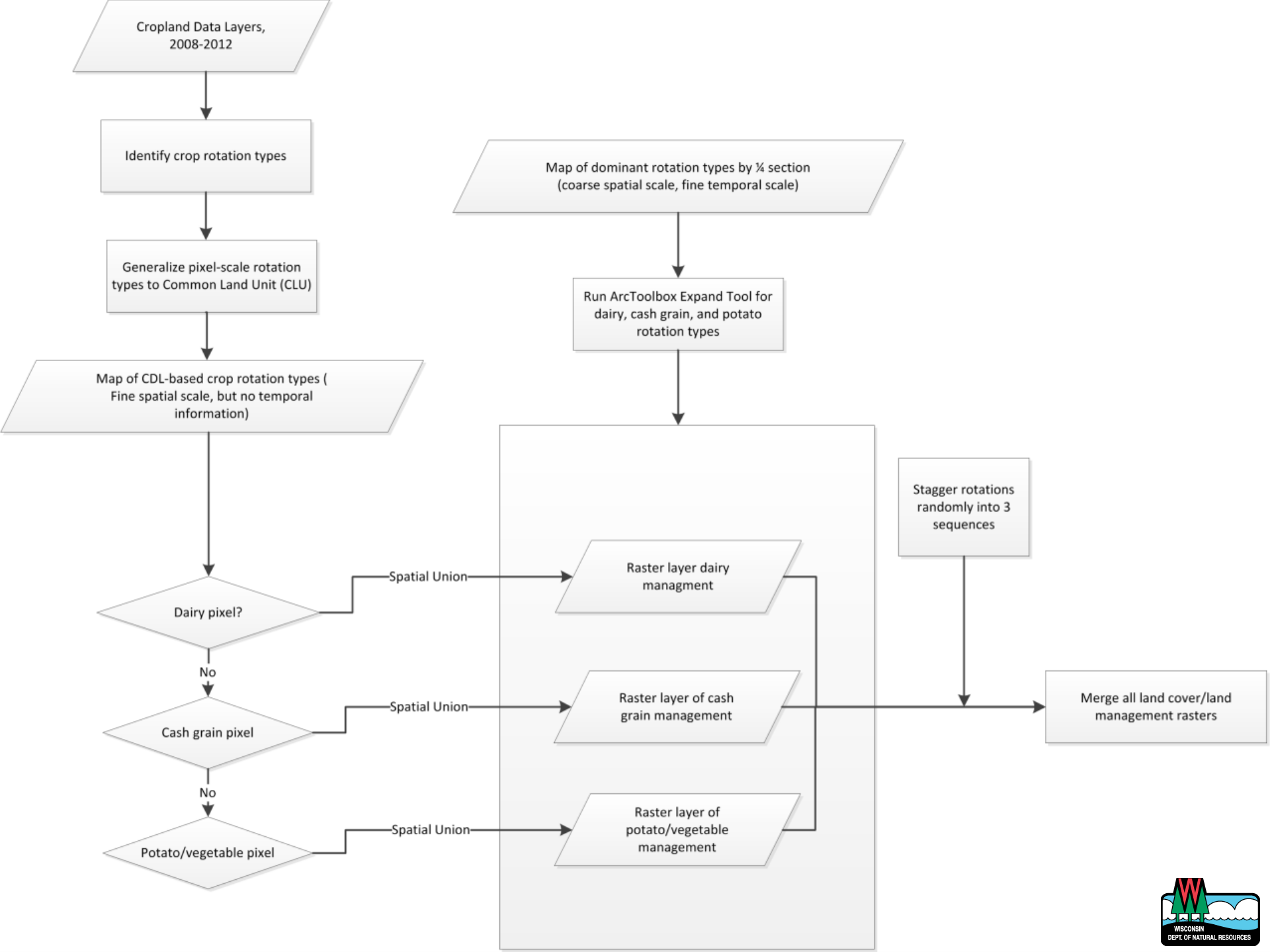
- Method provides an efficient and replicable spatiotemporal definition of agricultural that supports nonpoint source mitigation
- Integration of local knowledge improves participation in TMDL development and implementation process
- Additional years and accuracy of the USDA Cropland Data Layer will 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?



dnrwisconsinrivertmdl@wisconsin.gov

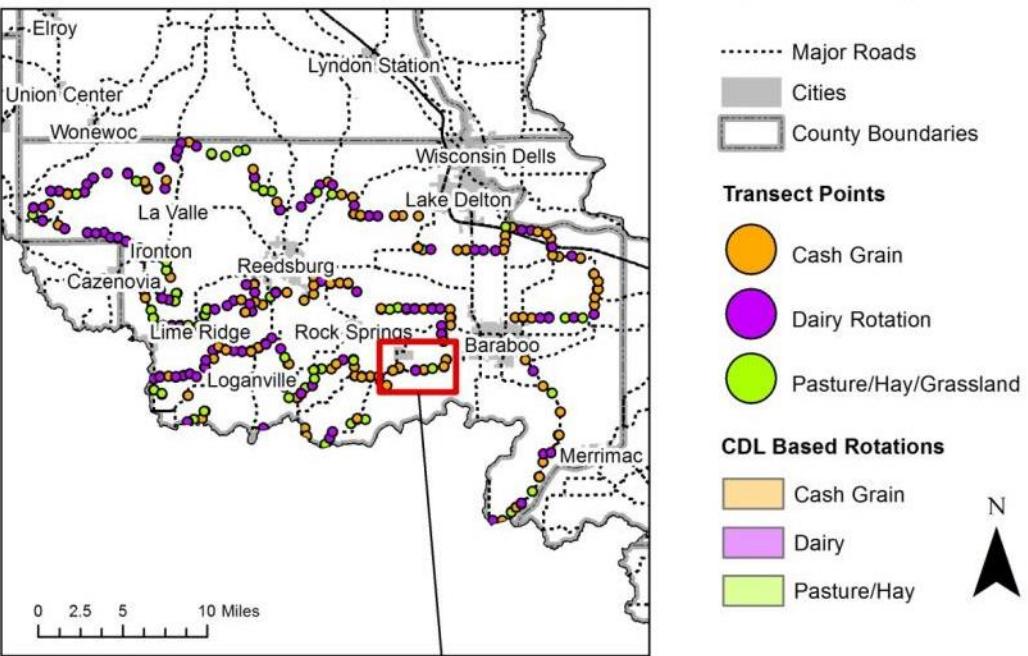




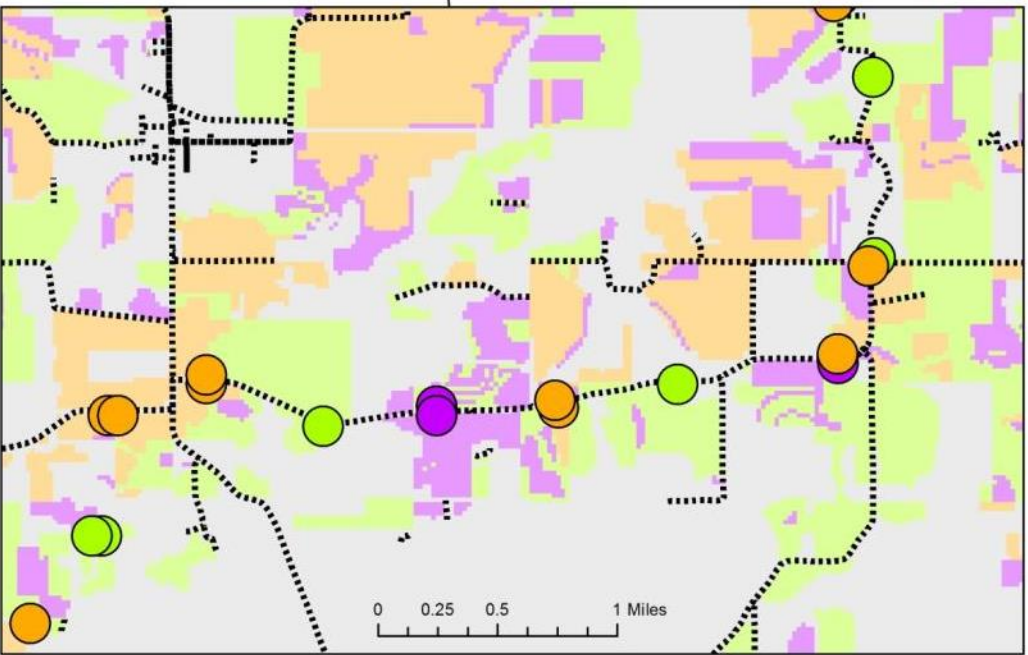
Manure Totals Analysis – Marathon County Example

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 Weight 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 Weight 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

Crop Rotations Categorized by Transect Survey Points (Sauk County)



Comparison of CDL and Transect Based Crop Rotations (Sauk County)



Examples of Crop Rotation Rule Set

Rotation	Pre-Local Knowledge Ruleset	Post-Local Knowledge Ruleset
Continuous Corn	C >= 4 year	C >= 3 years No S, P, V, A, Pas
Cash Grain	C >=1 year S >= 1 year C and S >= 3 year	C and S >= 2 years No P, V, A, Pas
Dairy (Generic)	NA	A and Pas >= 1 year C and S >= 1 year
Dairy (1 yr C, 1 yr S)	C = 1 year S = 1 year A => 1 year No P, V, DB	NA
Dairy (2 yr C)	C = 2 years A => 1 years No P, V, DB	NA
Dairy (1 yr C, 2 Yr S)	C = 1 years S => 2 years A => 1 of 5 years No P, V, DB	NA
Dairy (2 yr C, 1 Yr S)	C >= 2 years S >= 1 year C and S >= 2 years A => 1 year No P, V, DB	NA
Dairy (3 yr C)	C = 3 years A >= 1 year No P, V, DB	NA
Dairy (No Corn)	S >= 1 year A >= 1 year No C, P, V, DB	NA
Dairy/Potato	C>= 1 year P >= 1 year A >= 1 year No S, V, DB	P >= 1 year A >= 1 year No V

Quantitative Validation - Crop Acreage

Wisconsin River Basin Crop Rotation Acreage by County (CDL)

