WATERSHED MODELING

APPROACH AND PRELIMINARY RESULTS

2013-2014 Cayuga Lake Study

NYS DEC - MEG/TAC CLMP update meeting
Cayuga Lake Modeling Project
November 5, 2014
Ithaca, NY

Ultimate Goals and Objectives

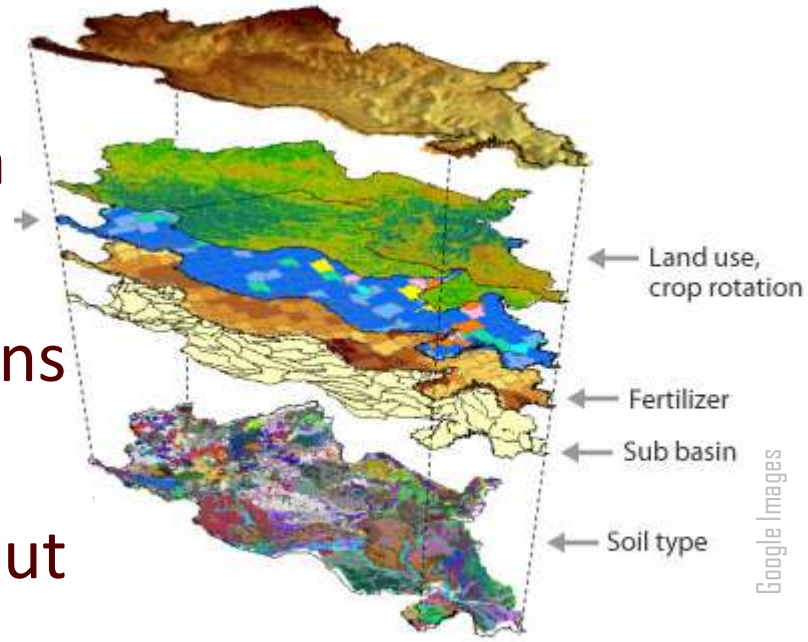
- Estimate phosphorus loads from the watershed to the lake:
  - Establish baseline
  - Input to the lake model
- Management scenario testing and forecasting

Update Points

- **Review hydrological modeling approach**
- **Testing the modeling framework**
  - Stream flow
  - Storm runoff
- **Incorporating agricultural management** (mostly dairy manure)

Model Choice and Rationale

- **Soil Water Assessment Tool (SWAT)**
  - Developed by USDA-ARS, Texas AM
  - Widely used in TMDL-type projects
  - Simulates TDP and TP
  - We have Experience with the model
  - Adaptable to NE conditions (sort of)
  - Flexible management input



Adapting SWAT to the Northeastern US

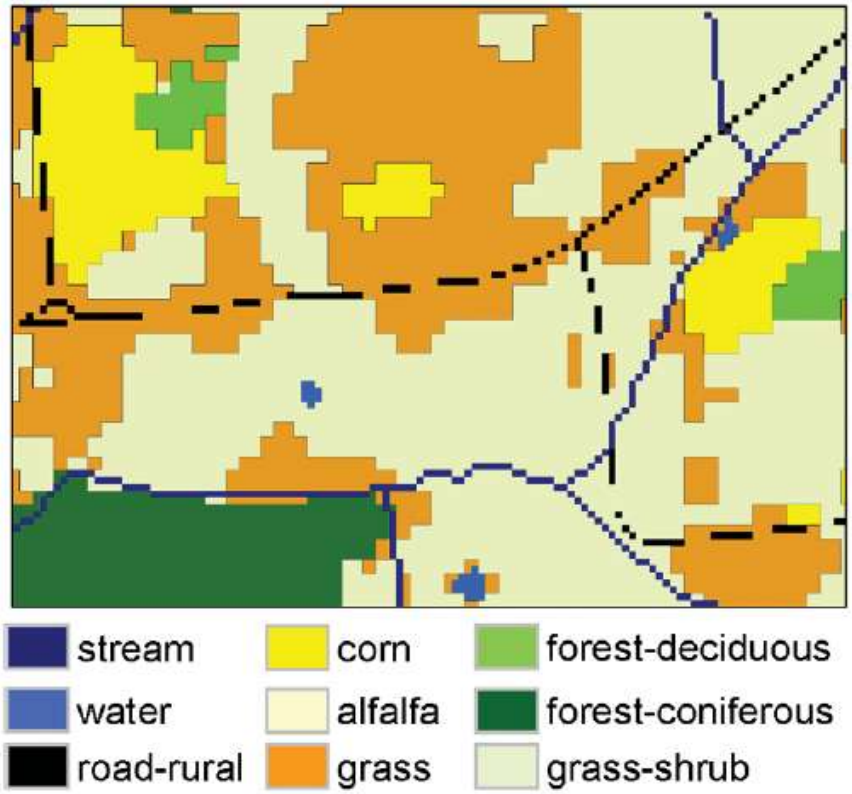
SWAT's hydrology is predicated on the assumption that the landscape's infiltration capacity controls storm runoff

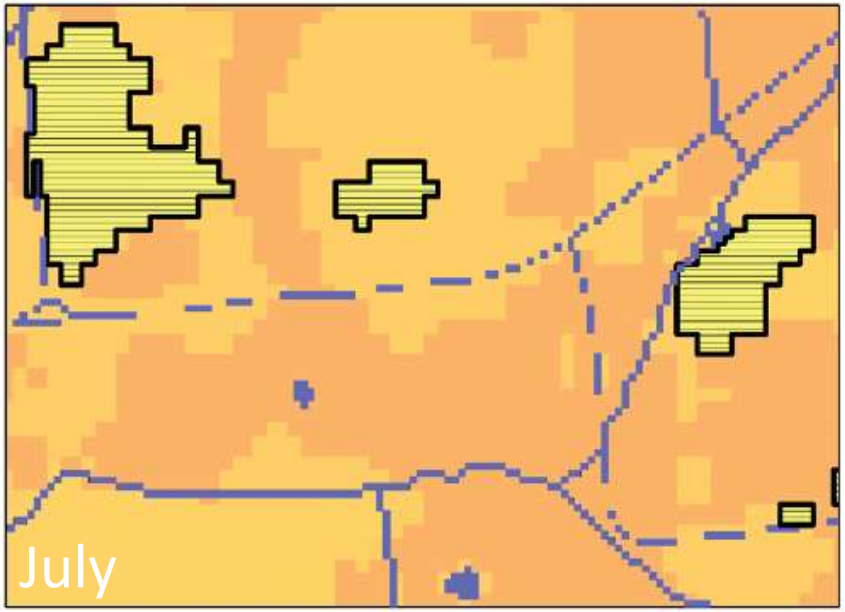
Source: http://stream2.cma.gov.cn

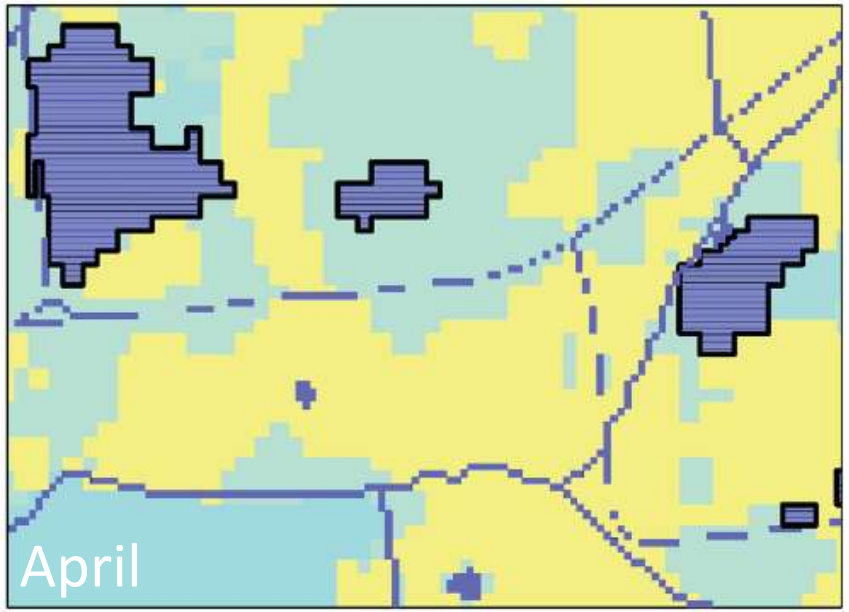
Primary factors:

Soil permeability

Land use / Land cover





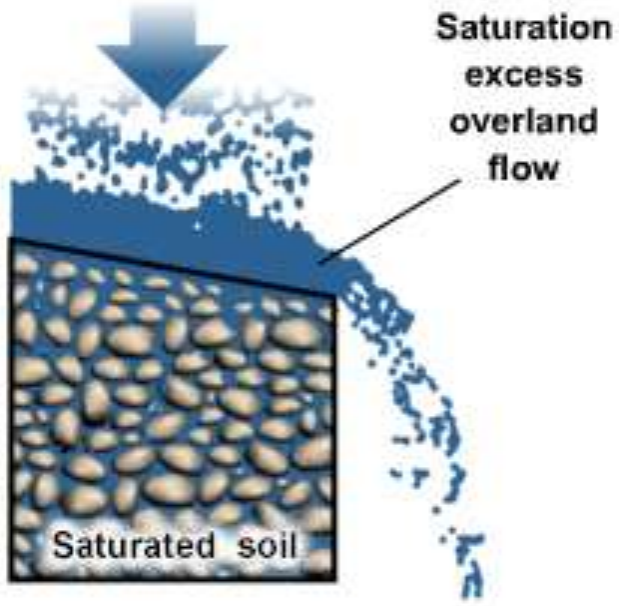


Schneiderman et al. 2007. *Hydrological Processes* 21(25): 3420-3430.

Adapting SWAT to the Northeastern US

Our infiltration capacities are usually much higher than our rainfall intensities.

Storm runoff is mostly generated by wet parts of the landscape.



Source: http://stream2.cma.gov.cn

Primary factors:

Landscape position

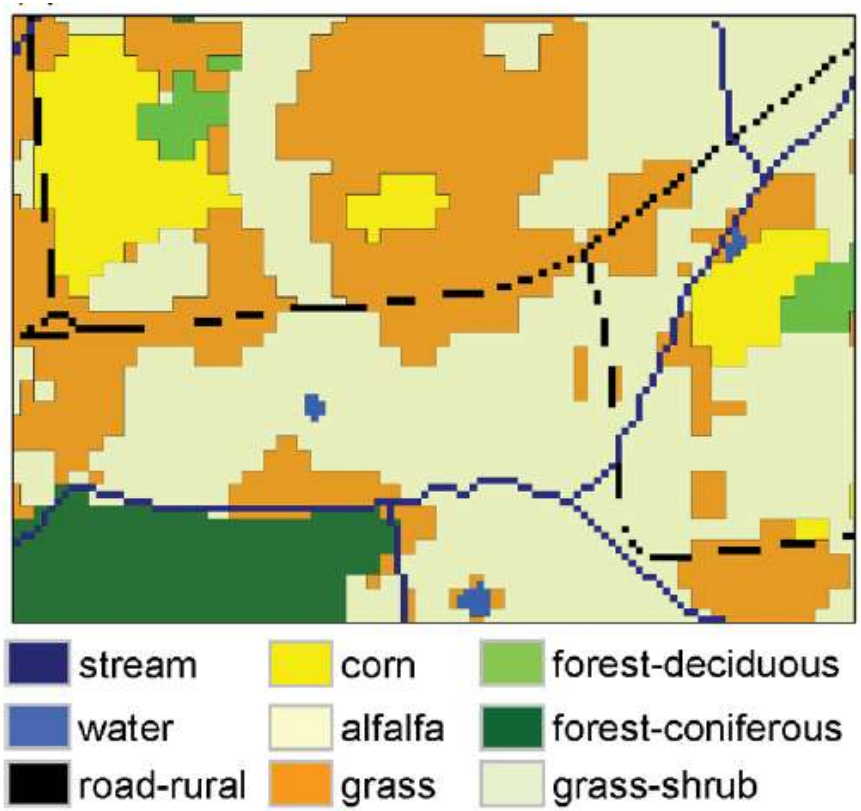
Soil water holding capacity

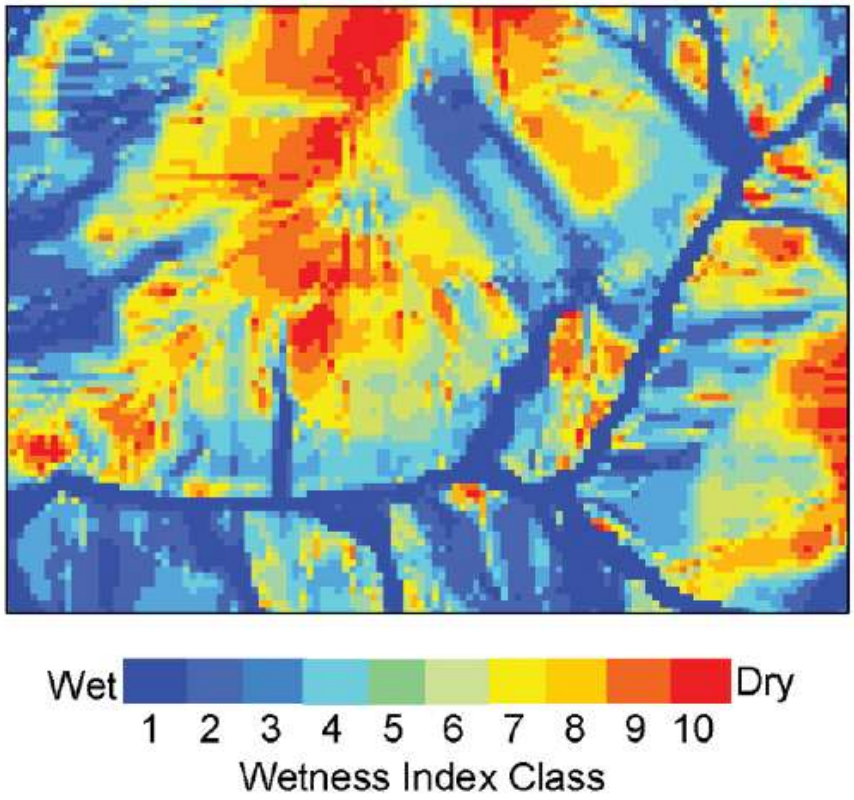
Local slope

Wet-prone areas

Adapting SWAT to the Northeastern US

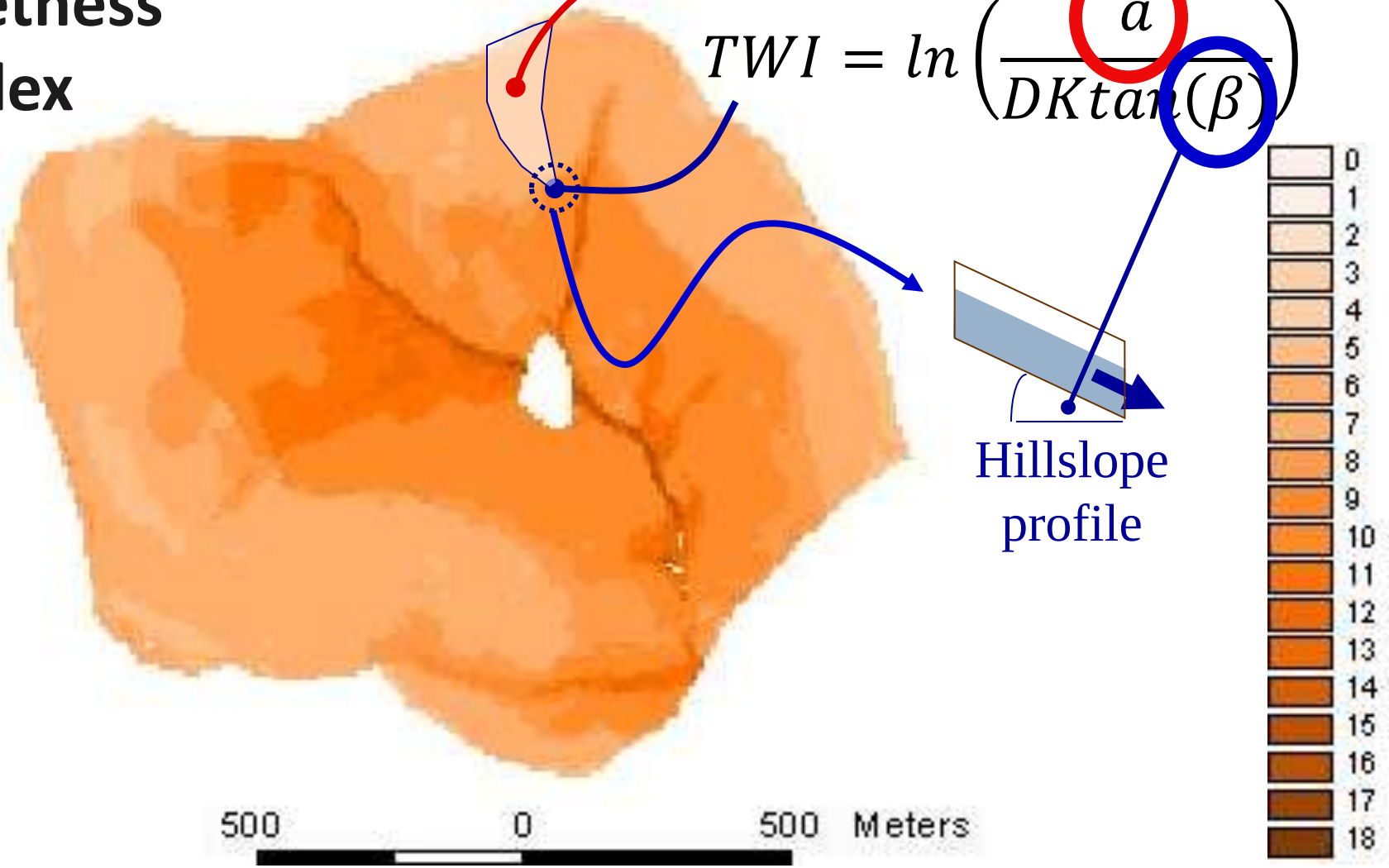
Replace soil-land use units with topography-soils based units: Topographic Wetness Indices





Topographic Wetness Index

$$TWI = ln\left(\frac{a}{DK tan(\beta)}\right)$$



Testing the Topographic Wetness Index

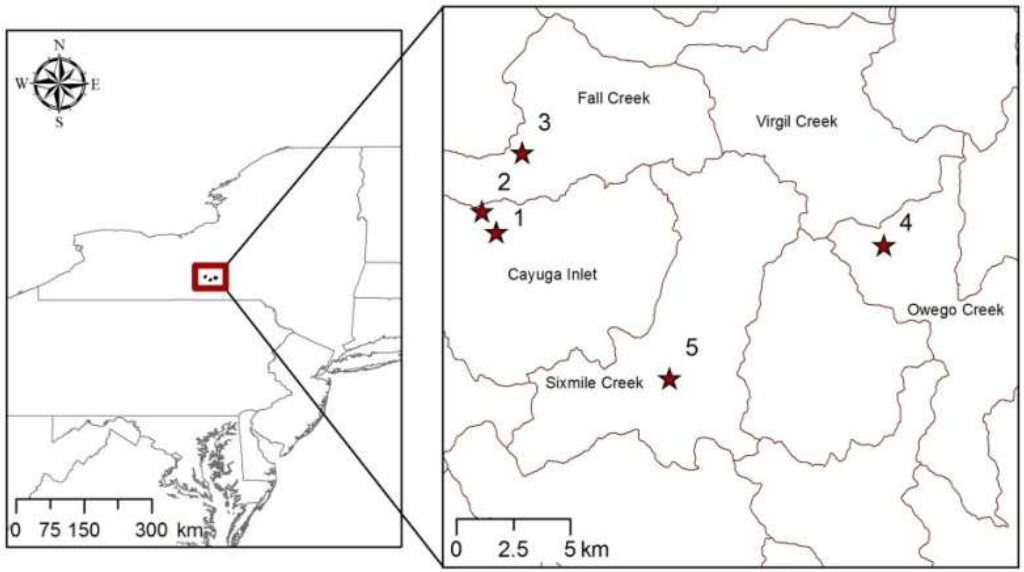
We found over 300 different ways to calculate the topographic wetness index:

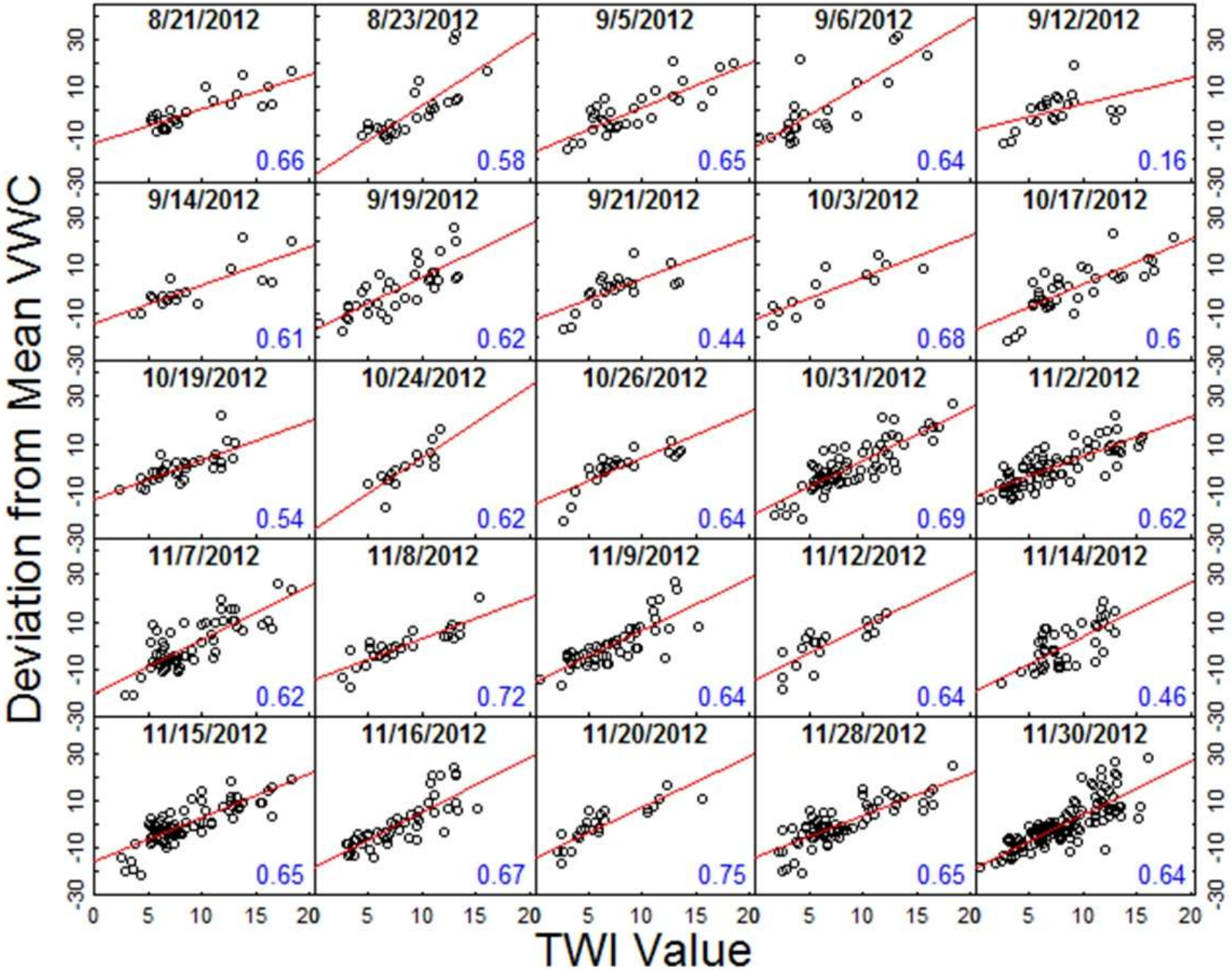
- Two sources of topography data
- Two data-resolutions (3 m, 10 m)
- Incorporate Soils data or not
- Six ways to calculate *a*
- Four methods to calculate slope
- Two smoothing algorithms

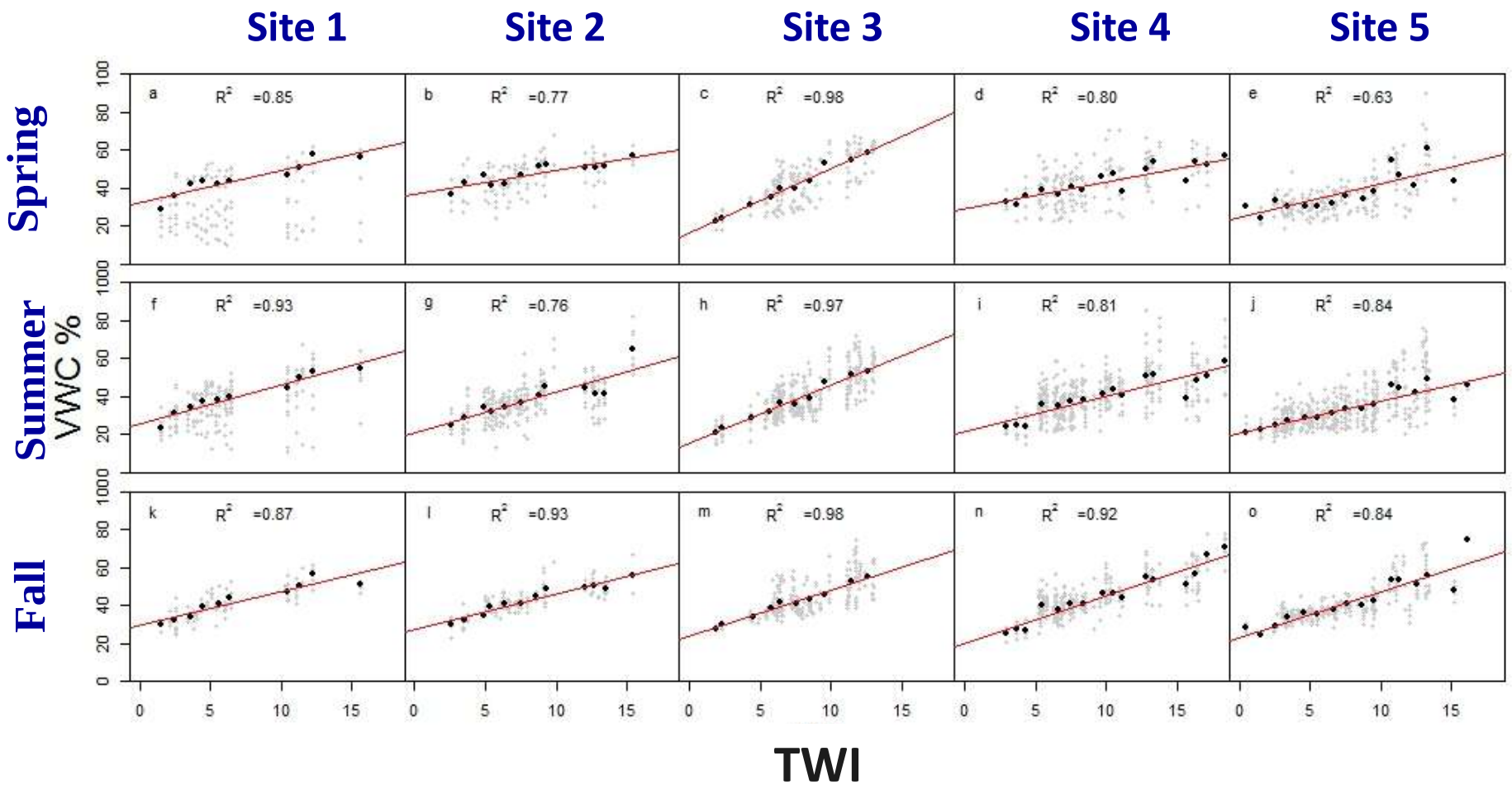
Testing the Topographic Wetness Index

Field Sampling

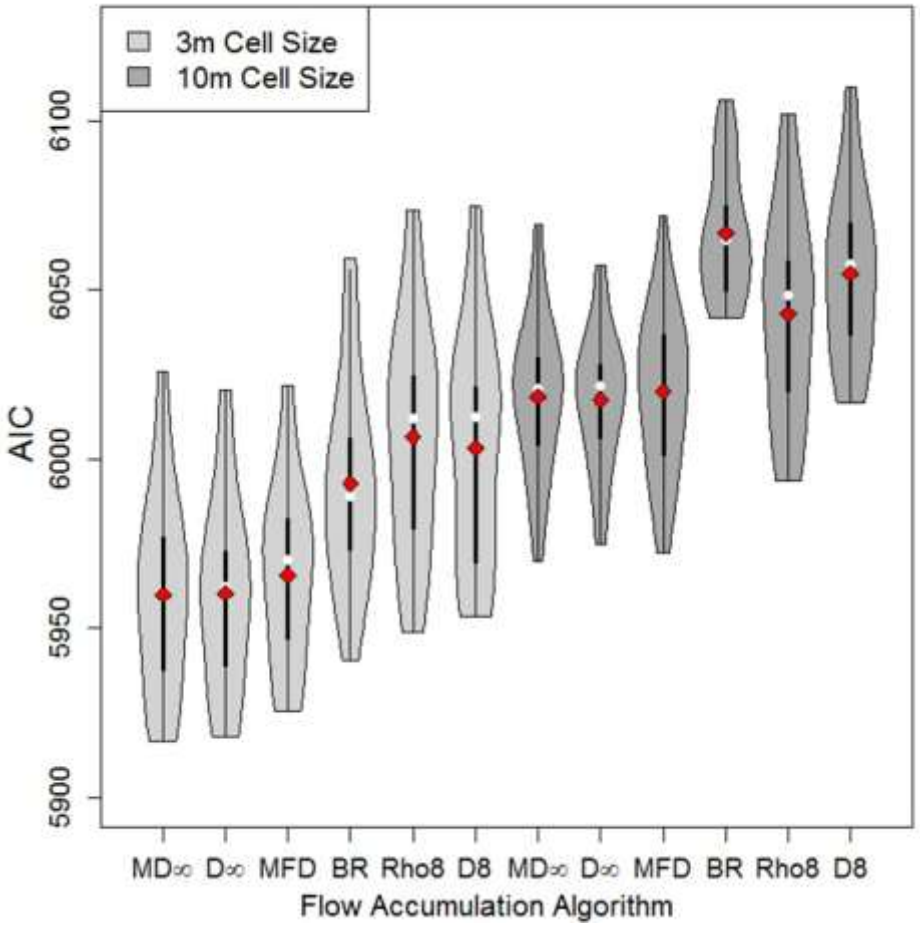
- Manual soil moisture probes across gradients of TWIs, land use, soil types.
- Soil cores for TDR calibration
- Examine strengths of correlations

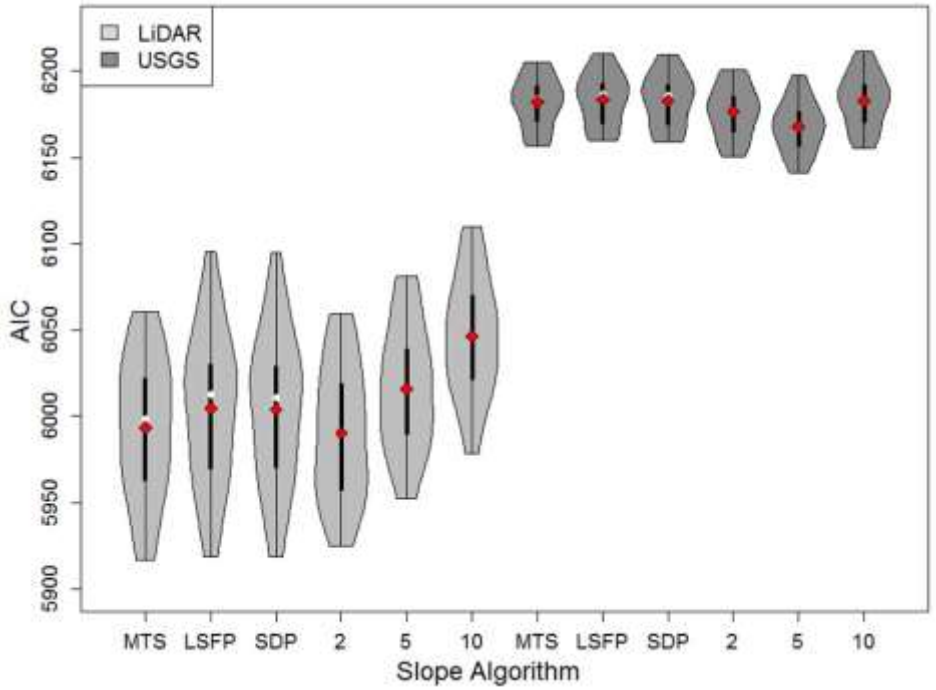



Deviation from Mean VWC
TWI Value
8/21/2012
0.66
8/23/2012
0.58
9/5/2012
0.65
9/6/2012
0.64
9/12/2012
0.16
9/14/2012
0.61
9/19/2012
0.62
9/21/2012
0.44
10/3/2012
0.68
10/17/2012
0.6
10/19/2012
0.54
10/24/2012
0.62
10/26/2012
0.64
10/31/2012
0.69
11/2/2012
0.62
11/7/2012
0.62
11/8/2012
0.72
11/9/2012
0.64
11/12/2012
0.64
11/14/2012
0.46
11/15/2012
0.65
11/16/2012
0.67
11/20/2012
0.75
11/28/2012
0.65
11/30/2012
0.64
30
10
-10
-30
0
5
10
15
20

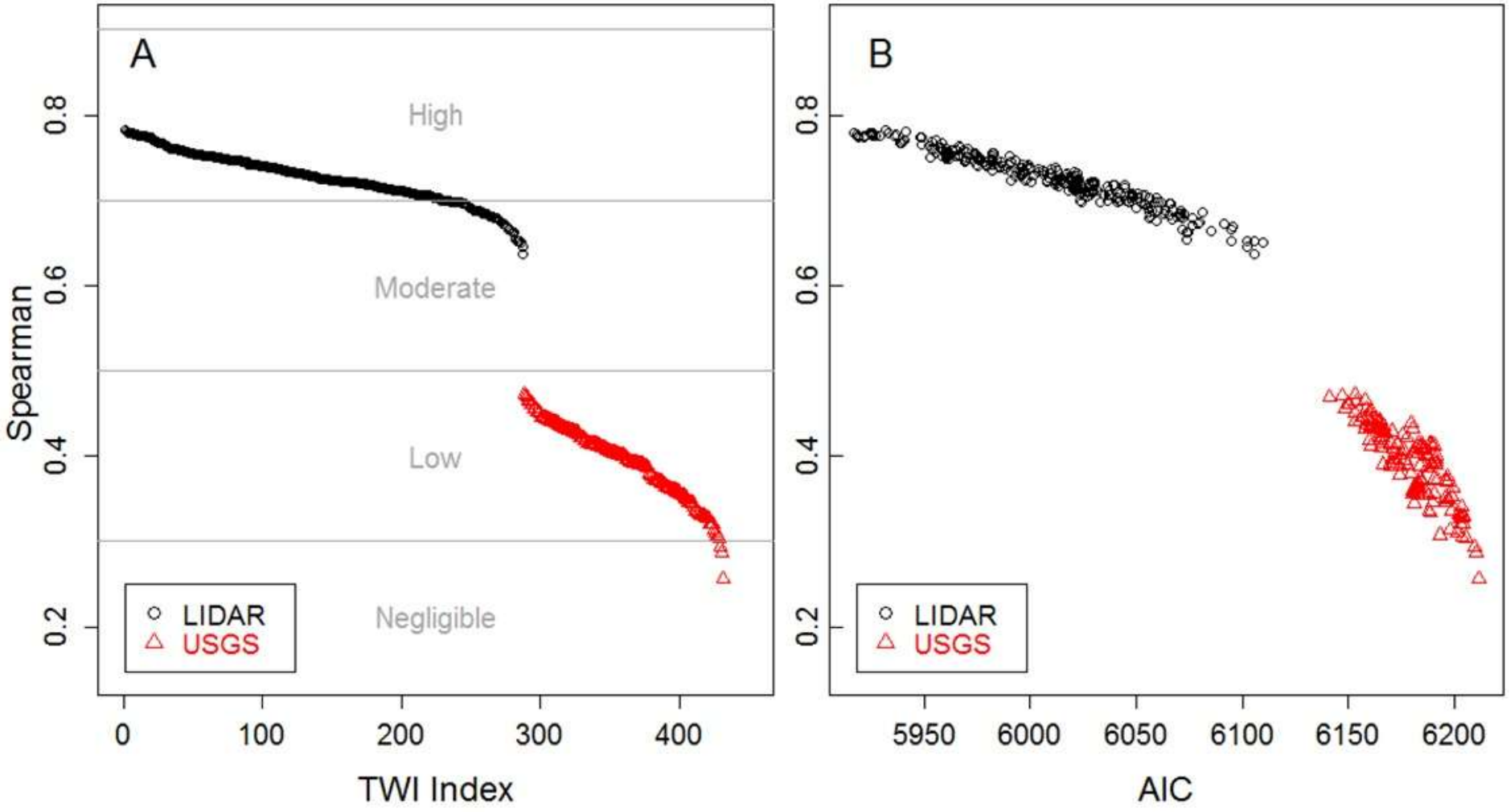

Site 1
Site 2
Site 3
Site 4
Site 5
Spring
Summer
Fall
VWC %
TWI
a R² =0.85
b R² =0.77
c R² =0.98
d R² =0.80
e R² =0.63
f R² =0.93
g R² =0.76
h R² =0.97
i R² =0.81
j R² =0.84
k R² =0.87
l R² =0.93
m R² =0.98
n R² =0.92
o R² =0.84

Testing the Topographic Wetness Index





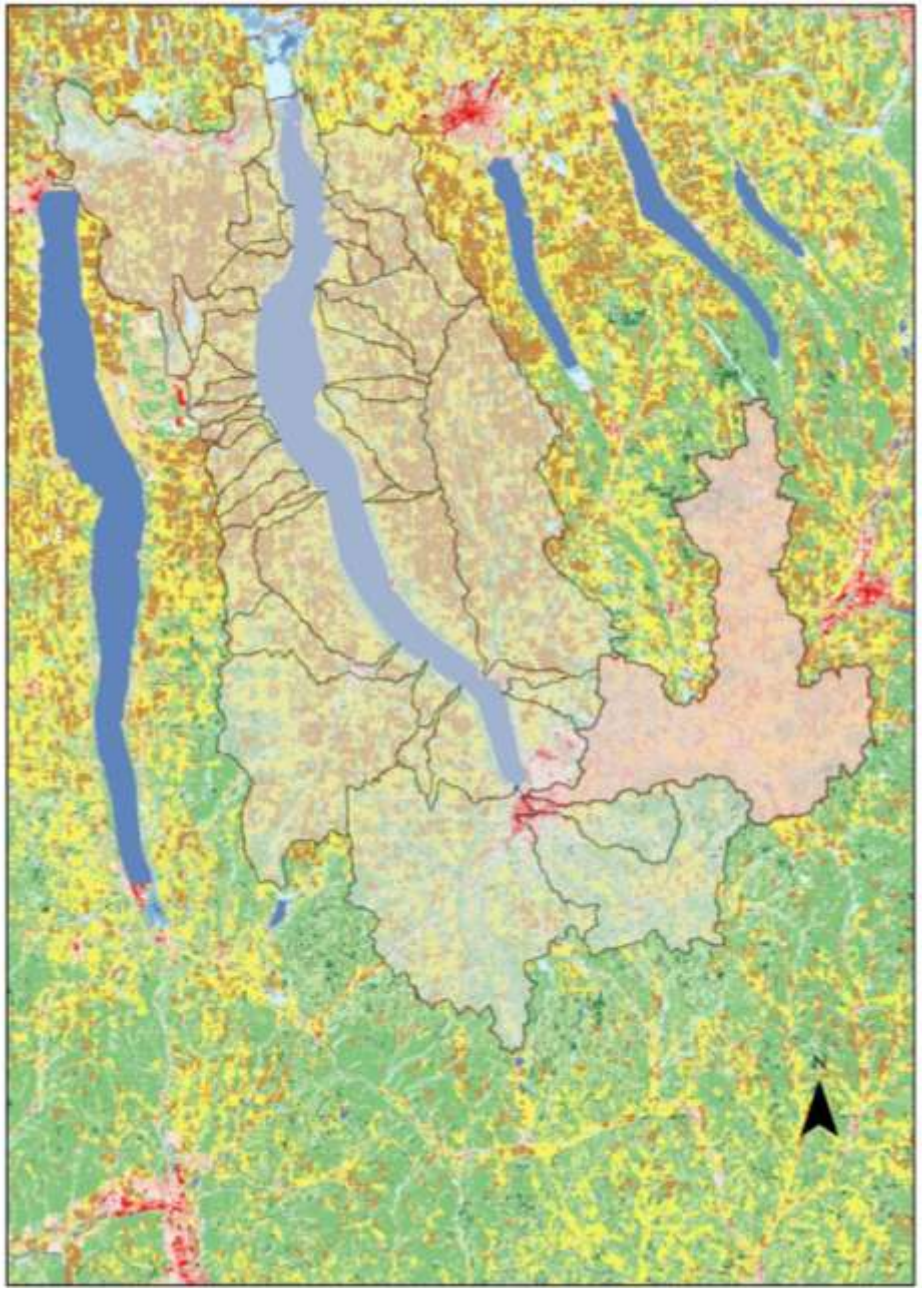
Testing the Topographic Wetness Index

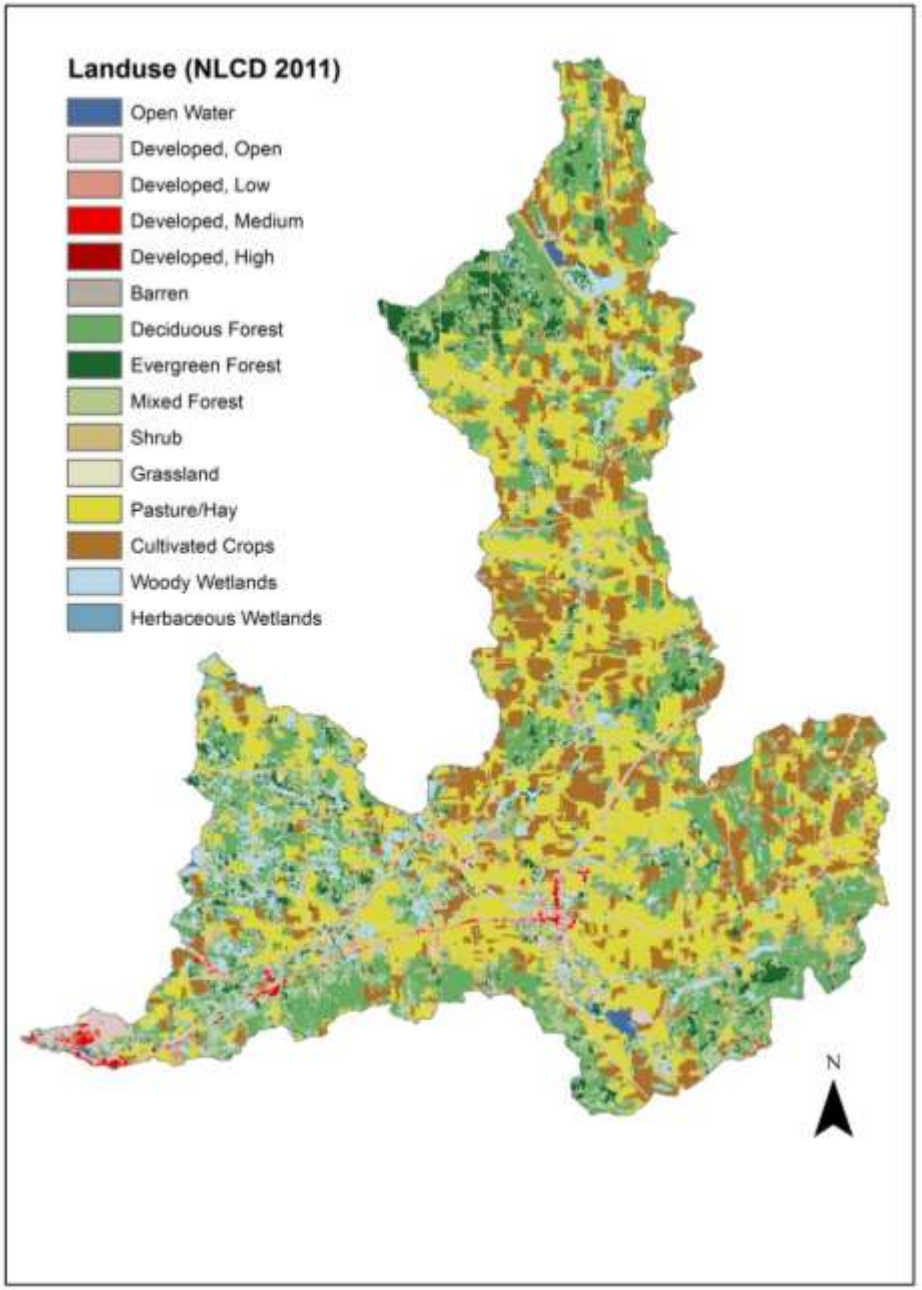


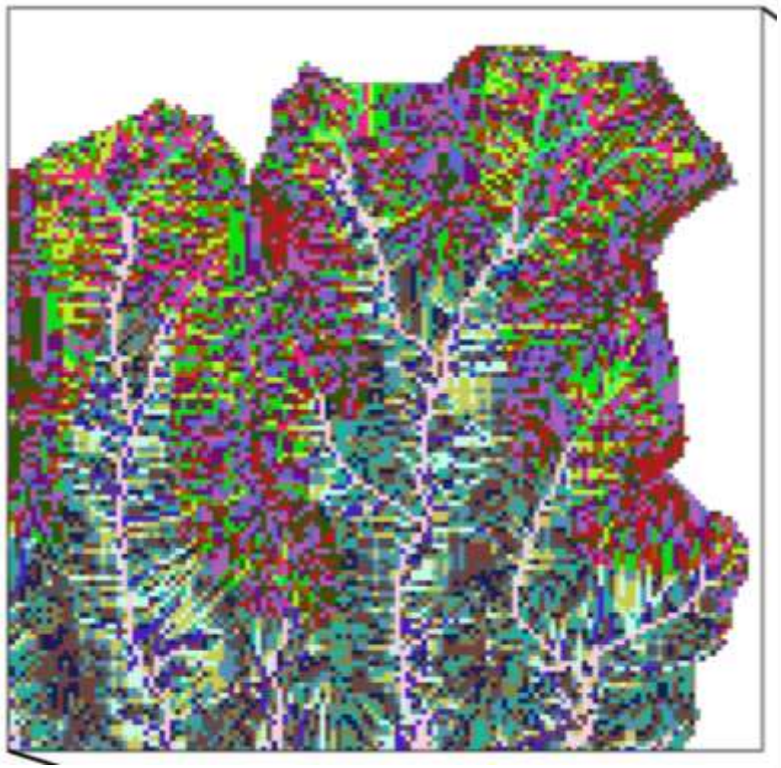
Buchanan et al. 2014. *Hydrology and Earth System Science* (HESS). 18: 3279-3299

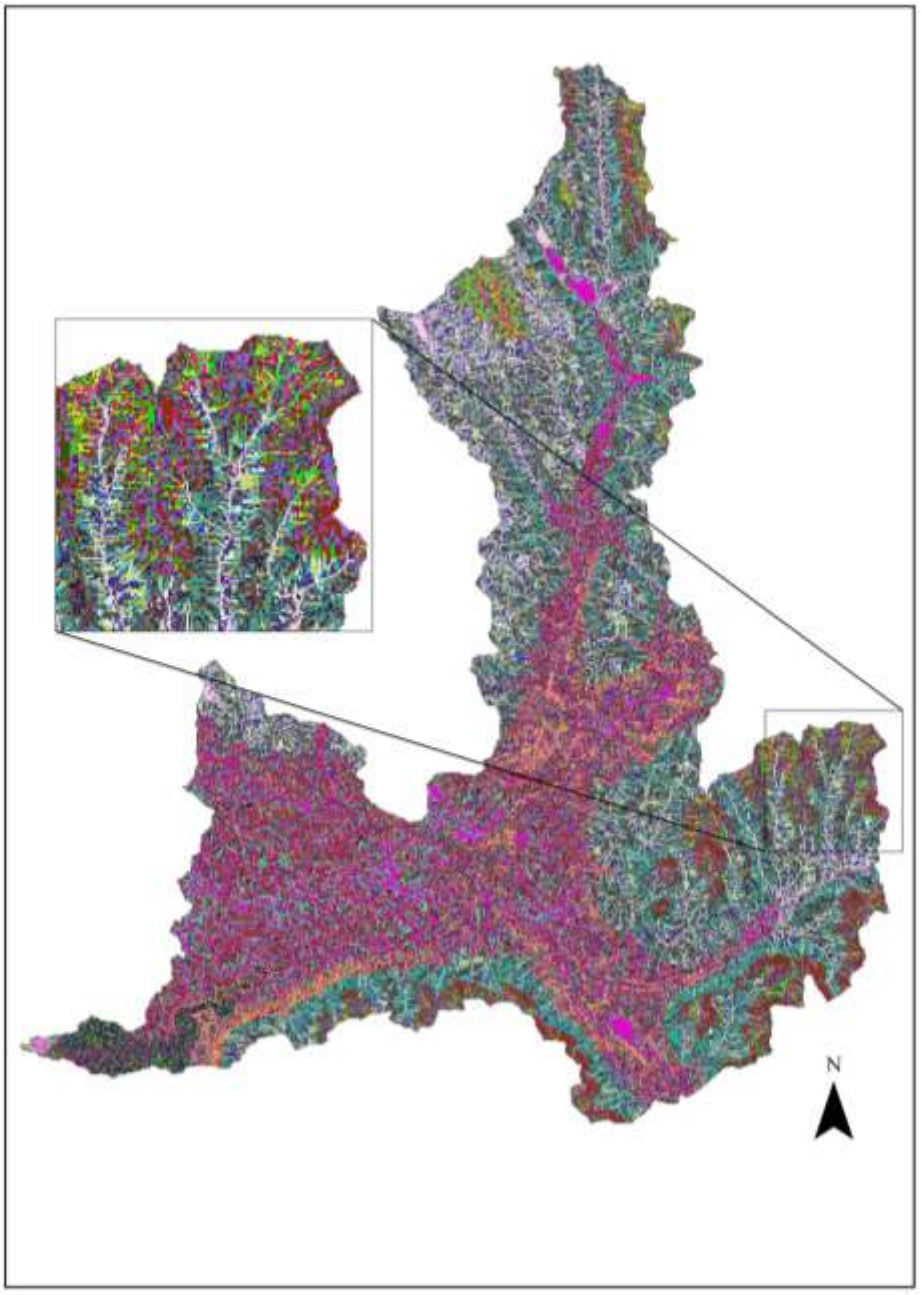
Update Points

- Review hydrological modeling approach
- **Testing the modeling framework**
  - Stream flow
  - Storm runoff
- Incorporating agricultural management (mostly dairy manure)



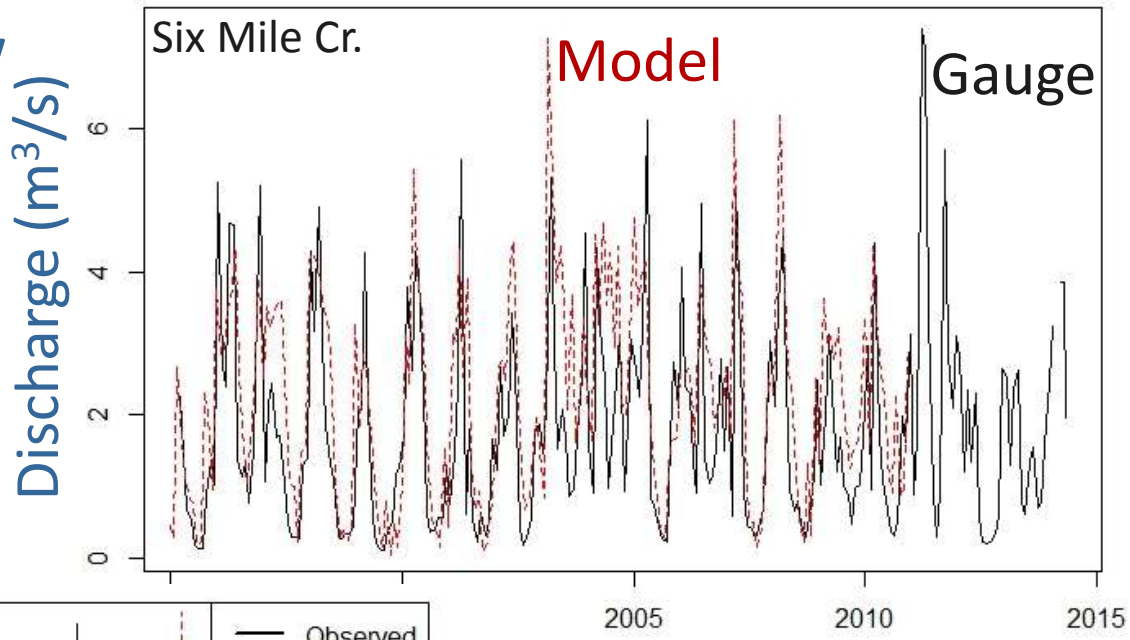

Landuse (NLCD 2011)
Open Water
Developed, Open
Developed, Low
Developed, Medium
Developed, High
Barren
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub
Grassland
Pasture/Hay
Cultivated Crops
Woody Wetlands
Herbaceous Wetlands
N

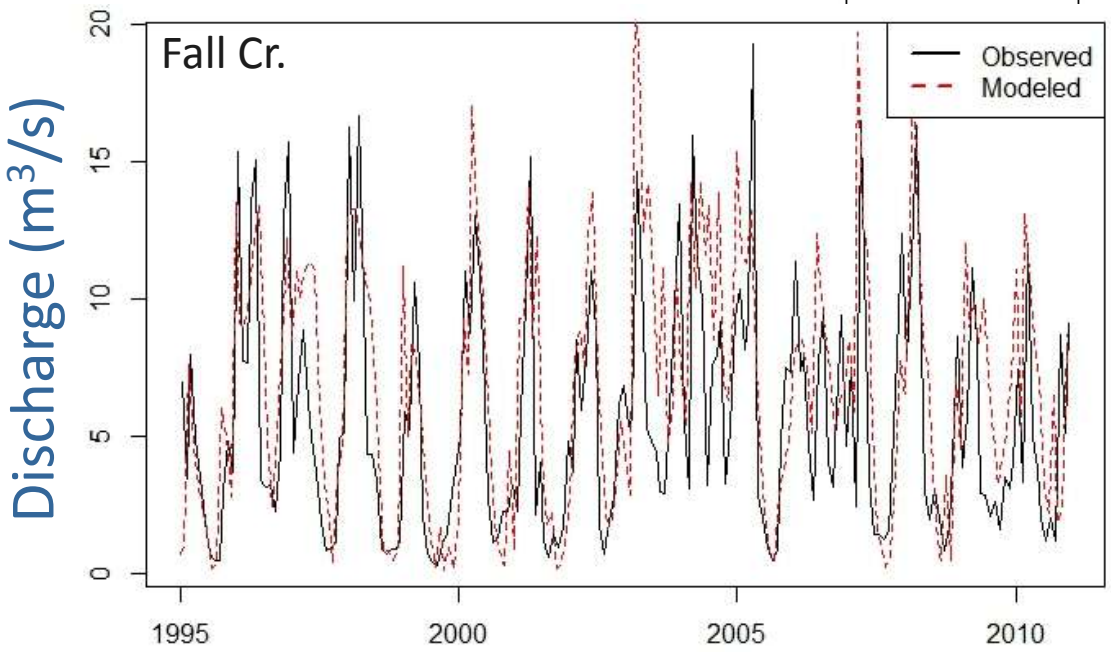



N

Stream Flow

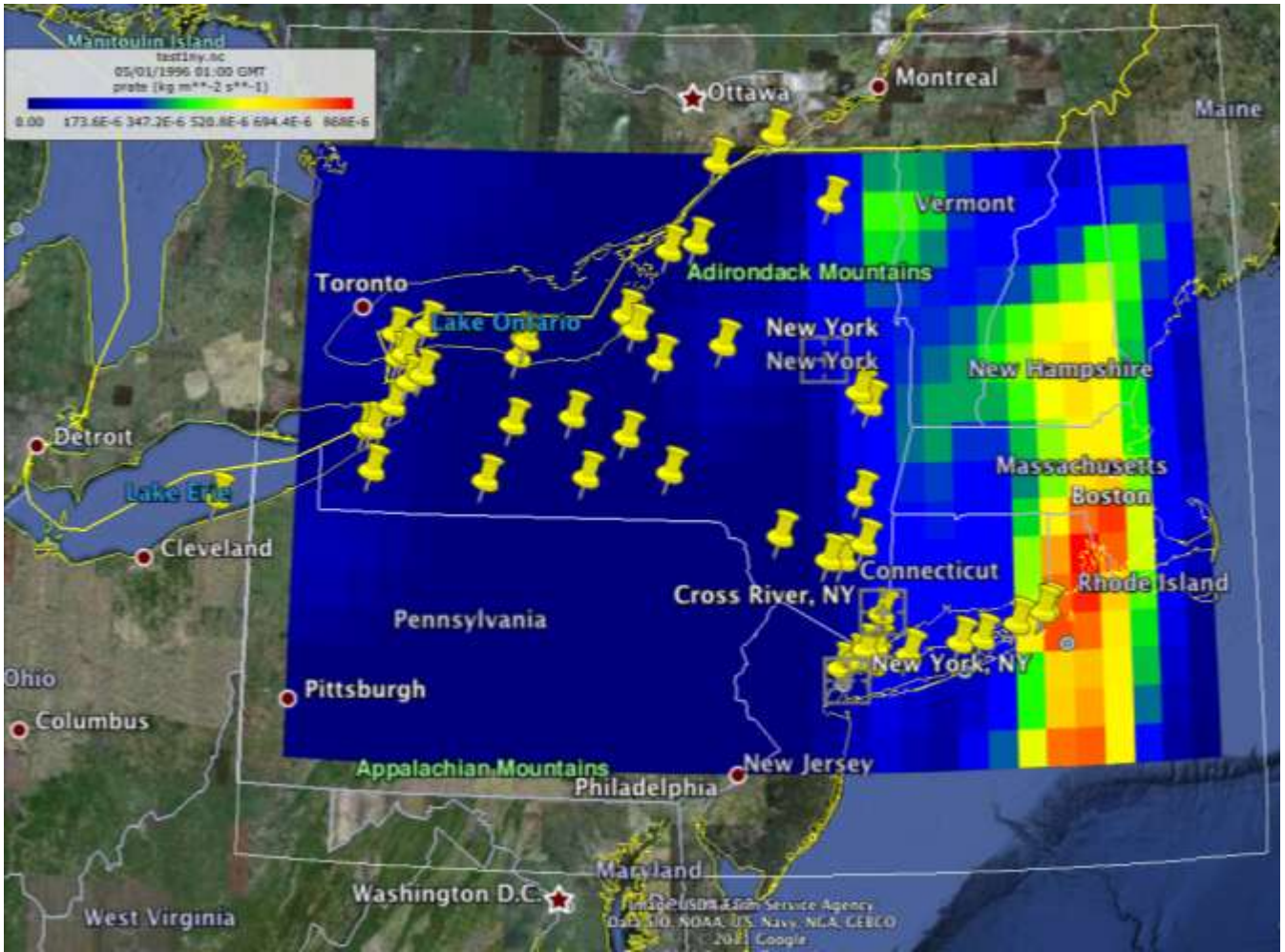
Climate Forecast System Reanalysis (CFSR)





Weather Data

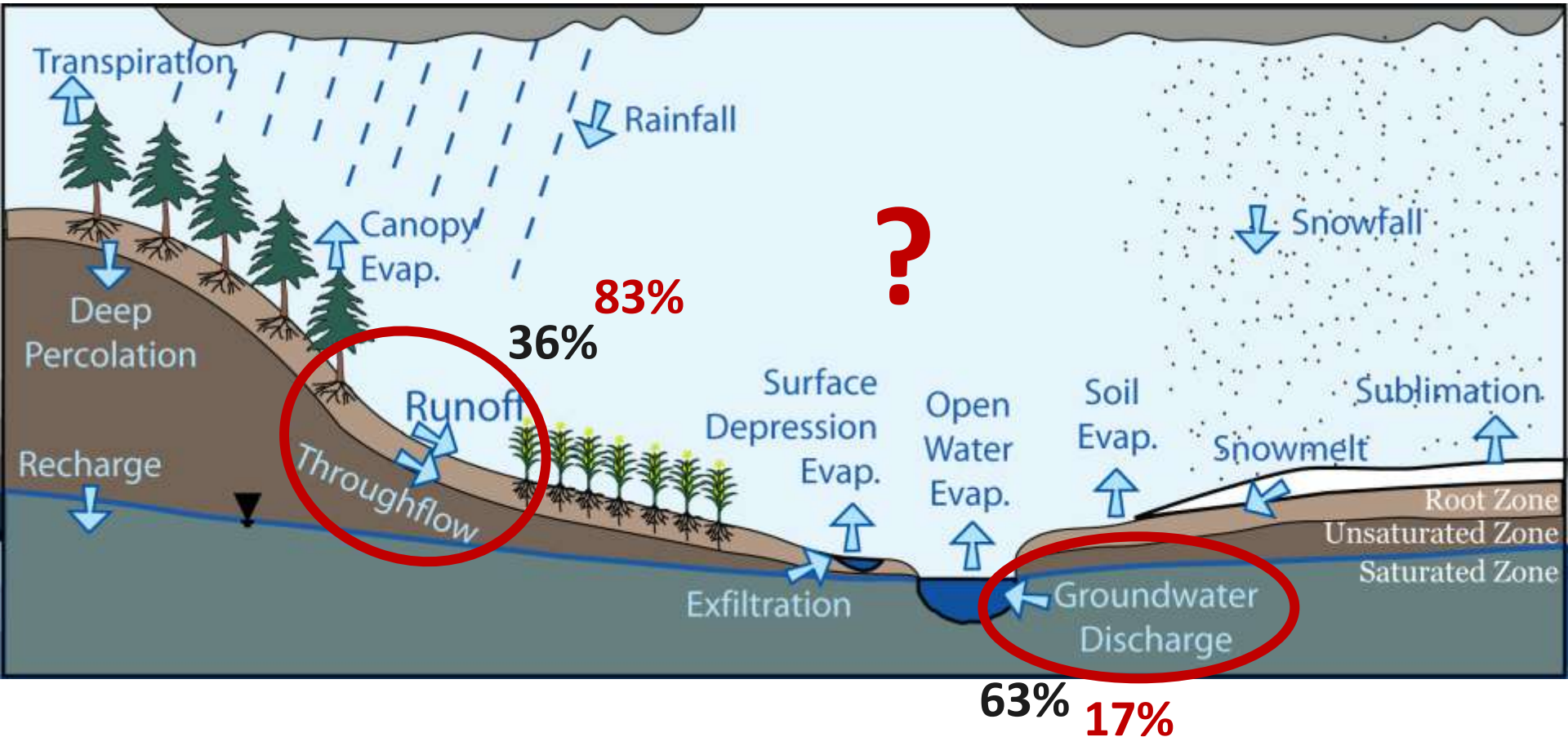
- Climate Forecast System Reanalysis (CFSR)



Still Tweaking Flow Estimates

Discharge : Precipitation

observed = 54% **Model = 50%**

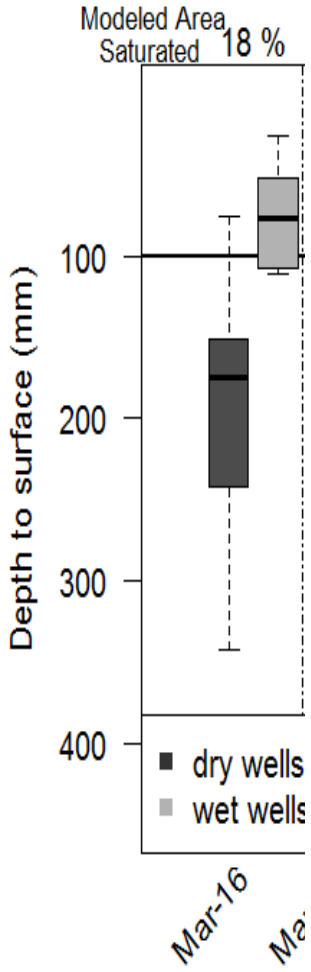


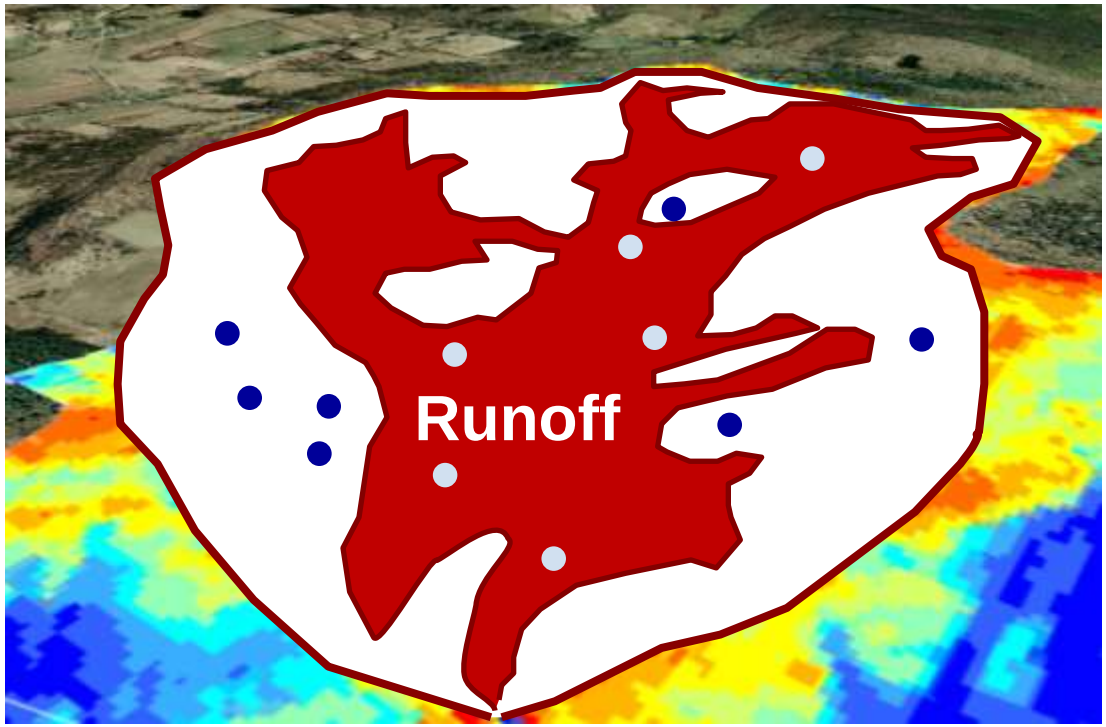
Update Points

- Review hydrological modeling approach
- **Testing the modeling framework**
  - Stream flow
  - Storm runoff
- Incorporating agricultural management (mostly dairy manure)

Are we predicting these correctly?

Storm Runoff Predictions

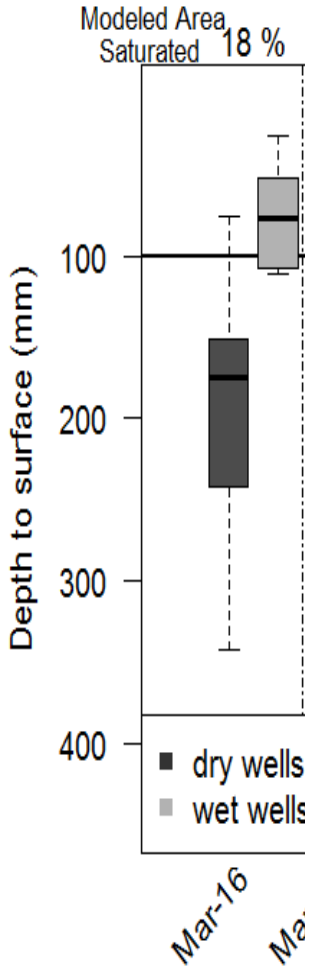


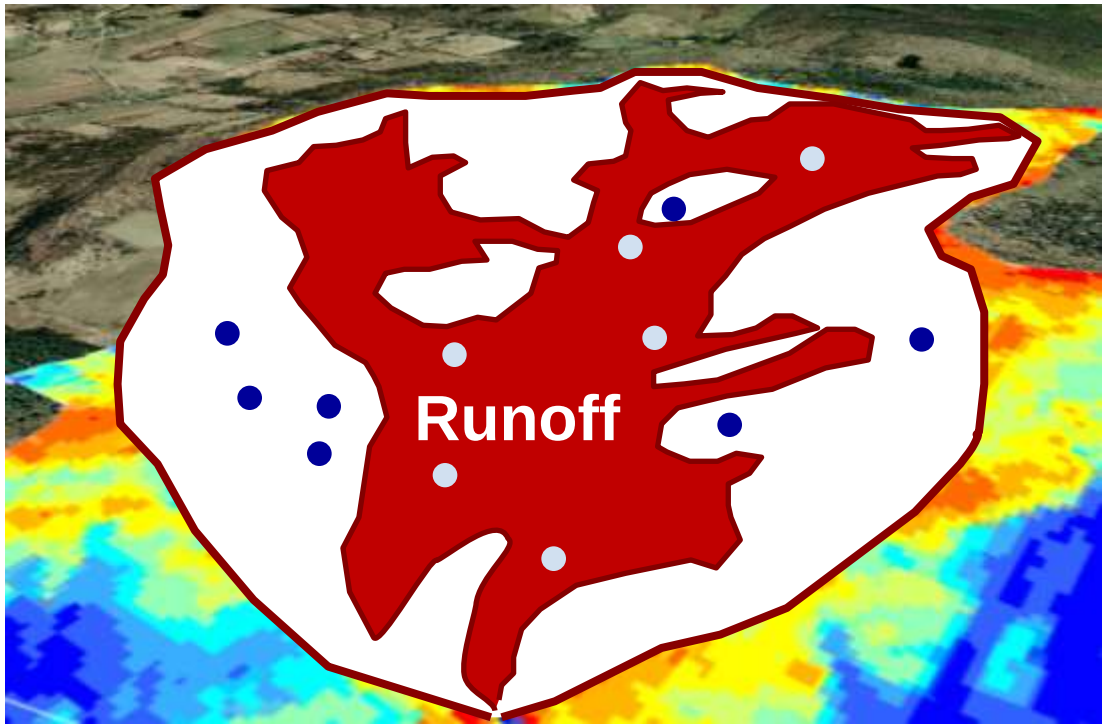


Event Dates

Archibald et al. 2014. *Journal of Hydrology: Regional Studies* 1: 74-91

Storm Runoff Predictions

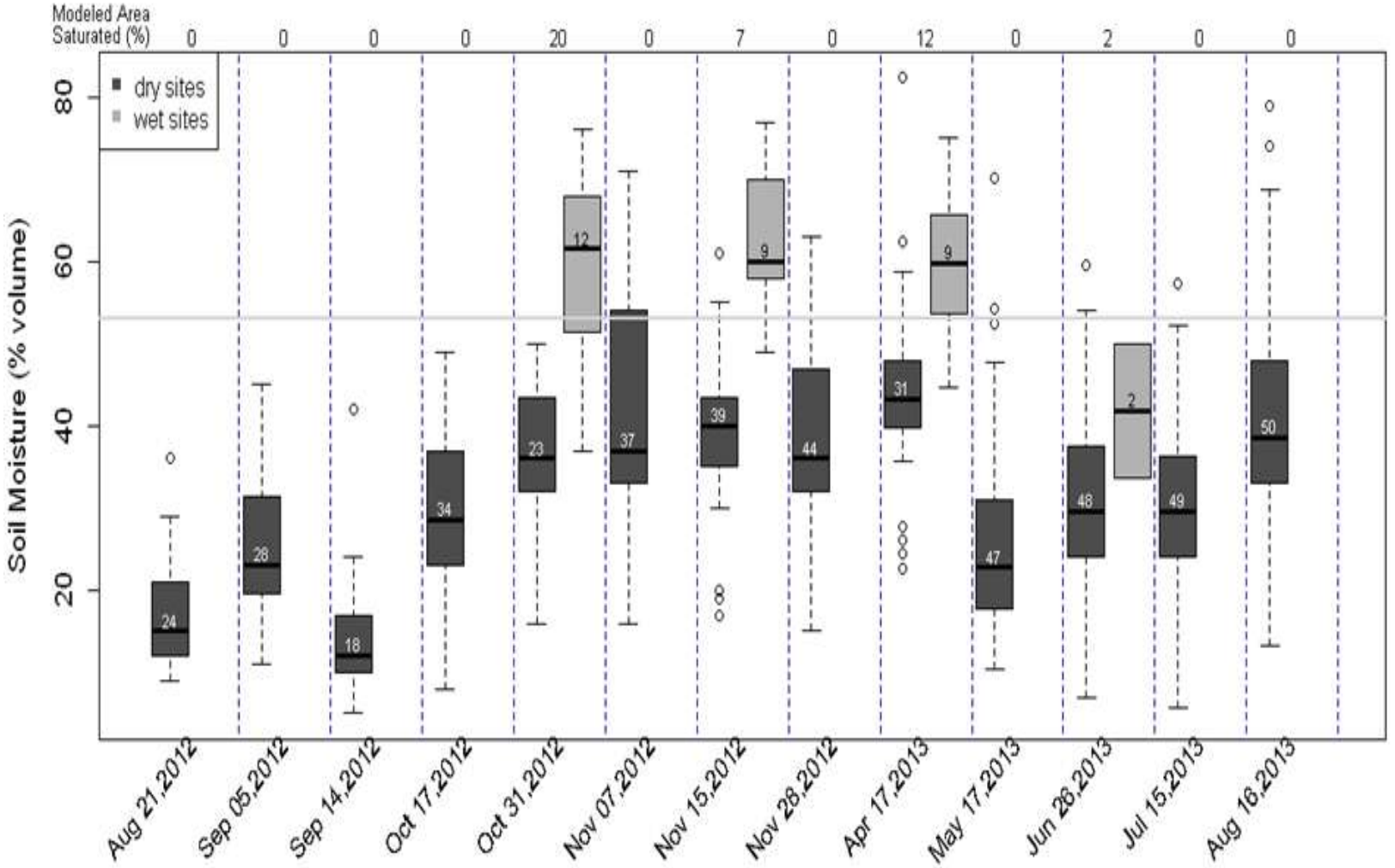




Event Dates

Archibald et al. 2014. *Journal of Hydrology: Regional Studies* 1: 74-91

Storm Runoff Predictions



Fall Creek

Update Points

- Review hydrological modeling approach
- Testing the modeling framework
  - Stream flow
  - Storm runoff
- **Incorporating agricultural management** (mostly dairy manure)

Engaging Experts

- Soil and Water Conservation Districts
  - Cayuga County (Jason Cuddleback)
  - Tompkins County (Aaron Ristow, Jon Nagley)
  - Cortland County (Amanda Barber, Shawn Murphy)
- Pro-Dairy (Karl Czymmek)
- Soil and Water Conservation Committee (Greg Albrect)

How common is this?

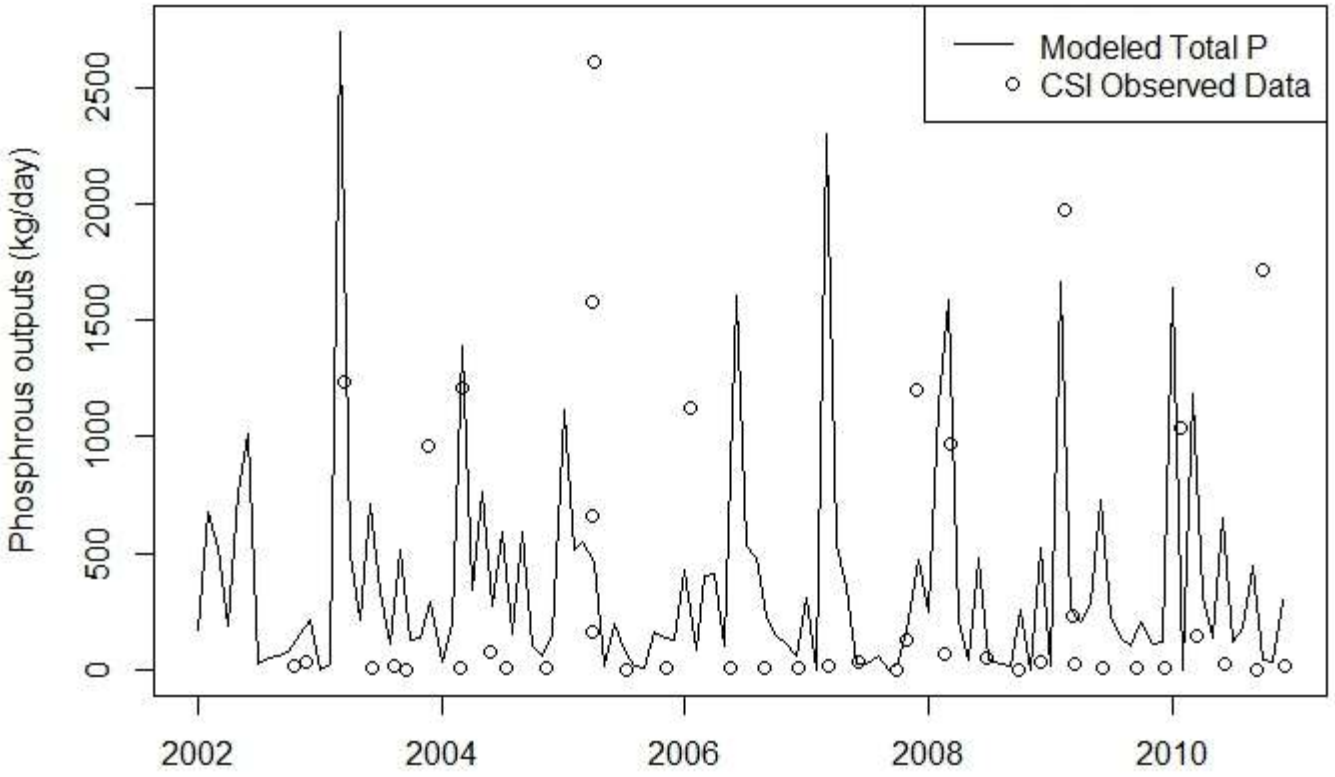
Photograph by L. Geohring, BEE Cornell U.

What do we need to know

- Fraction of land managed by CAFOs vs. AFOs vs. other
- Animal waste rate
- Frequency of disposal per managed unity (field)
- How to extrapolate beyond Fall Cr.?

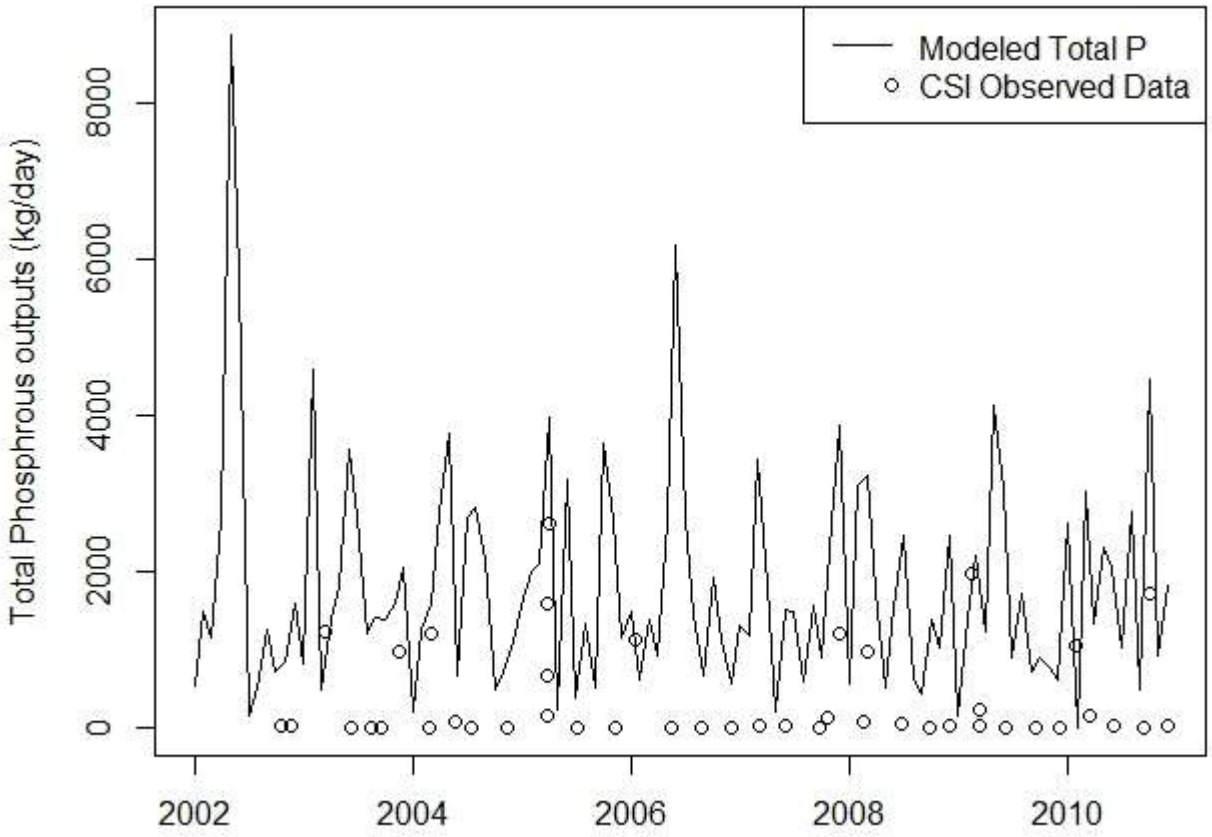
Representing management

- Un-calibrated SWAT output – Fall Cr.



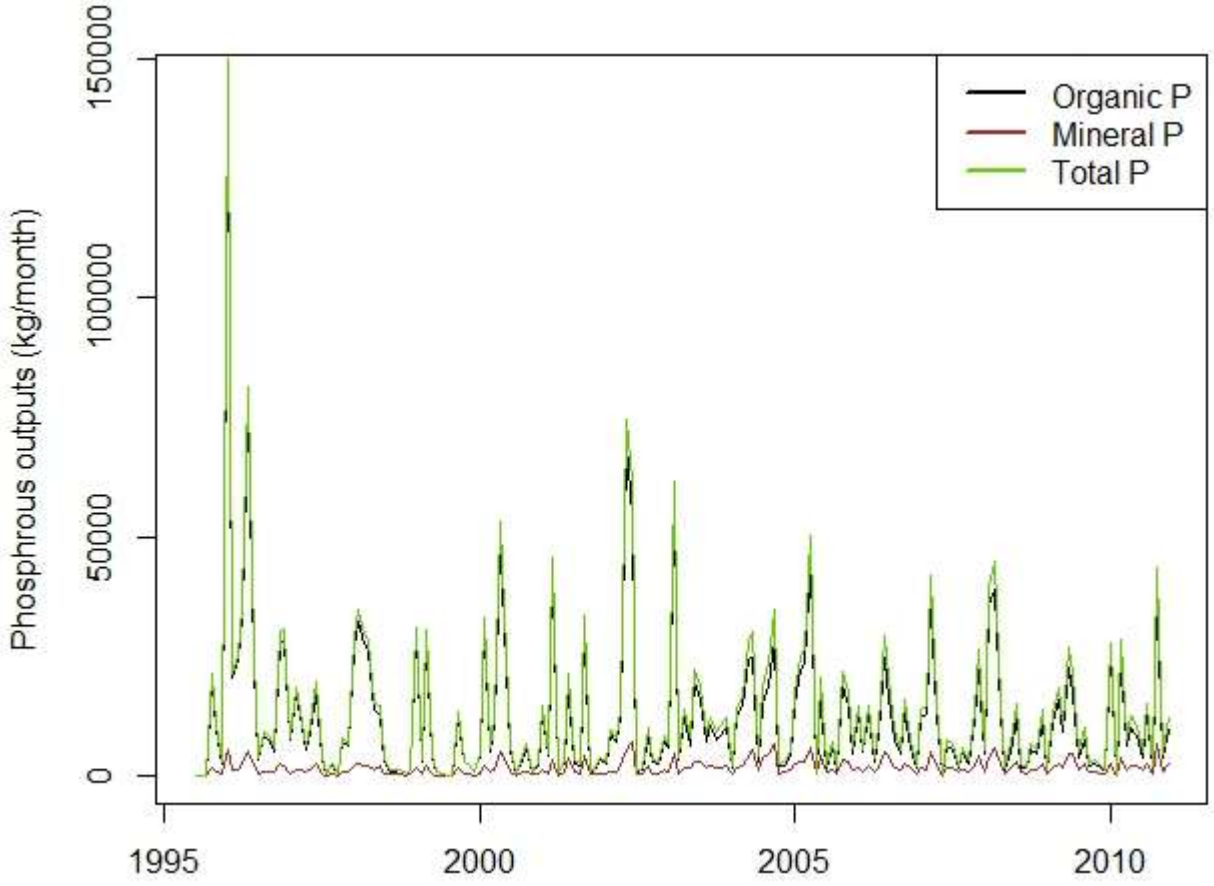
Representing management

- Accounting for manure management – Fall Cr.



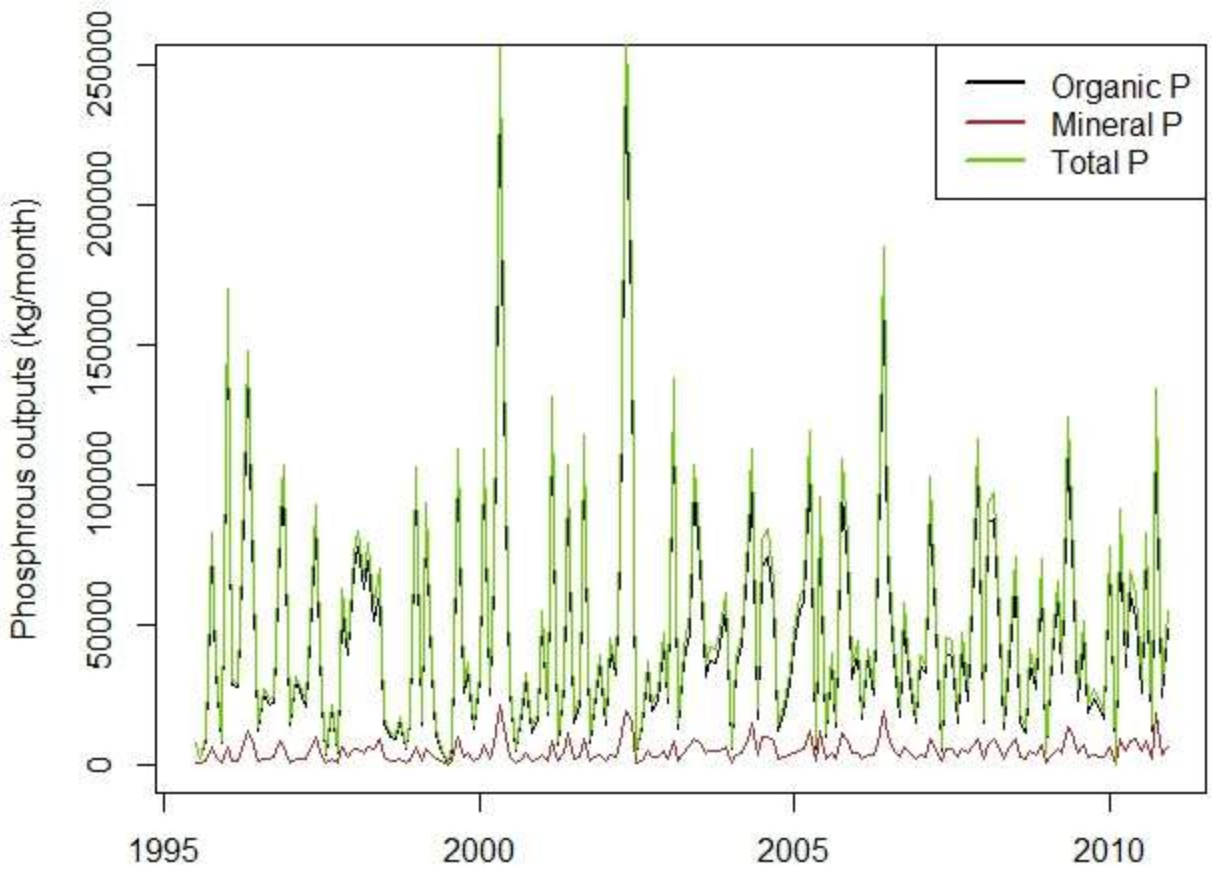
Representing management

- Un-calibrated SWAT output – Fall Cr.



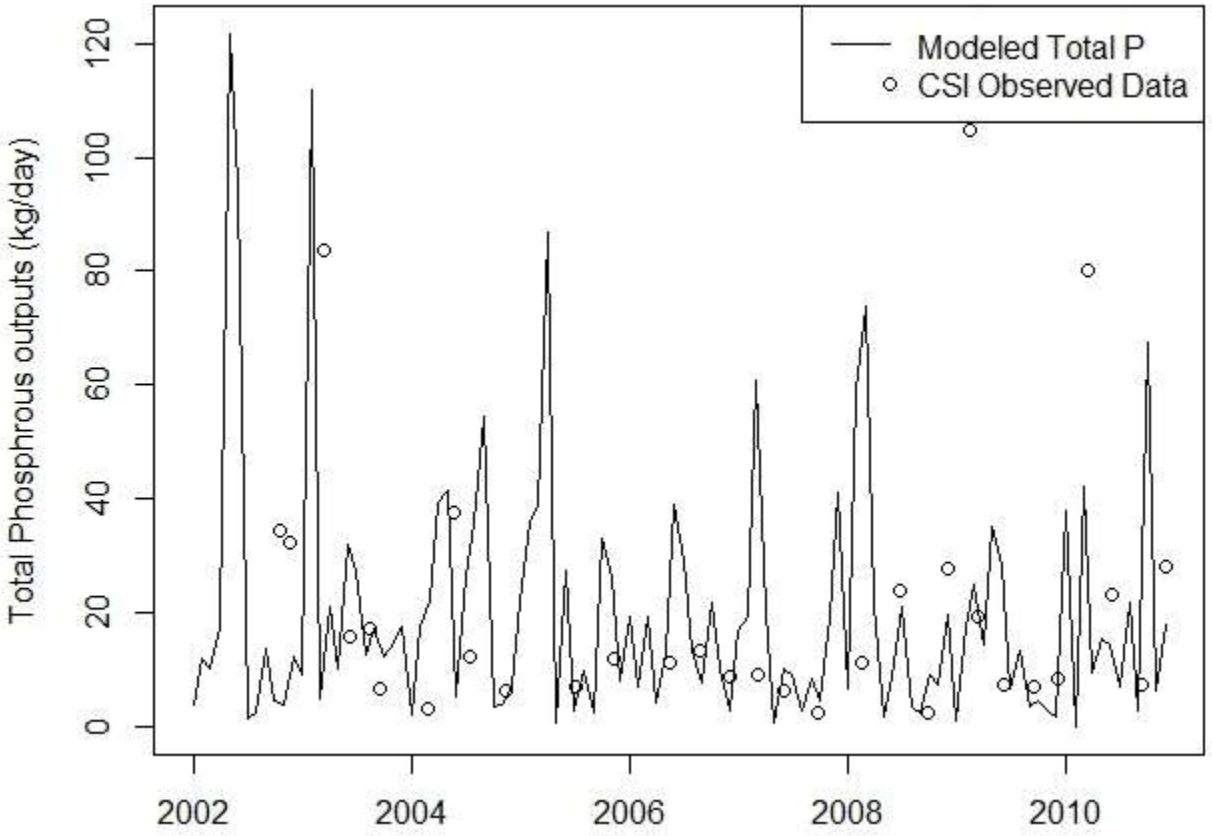
Representing management

- Accounting for manure management – Fall Cr.



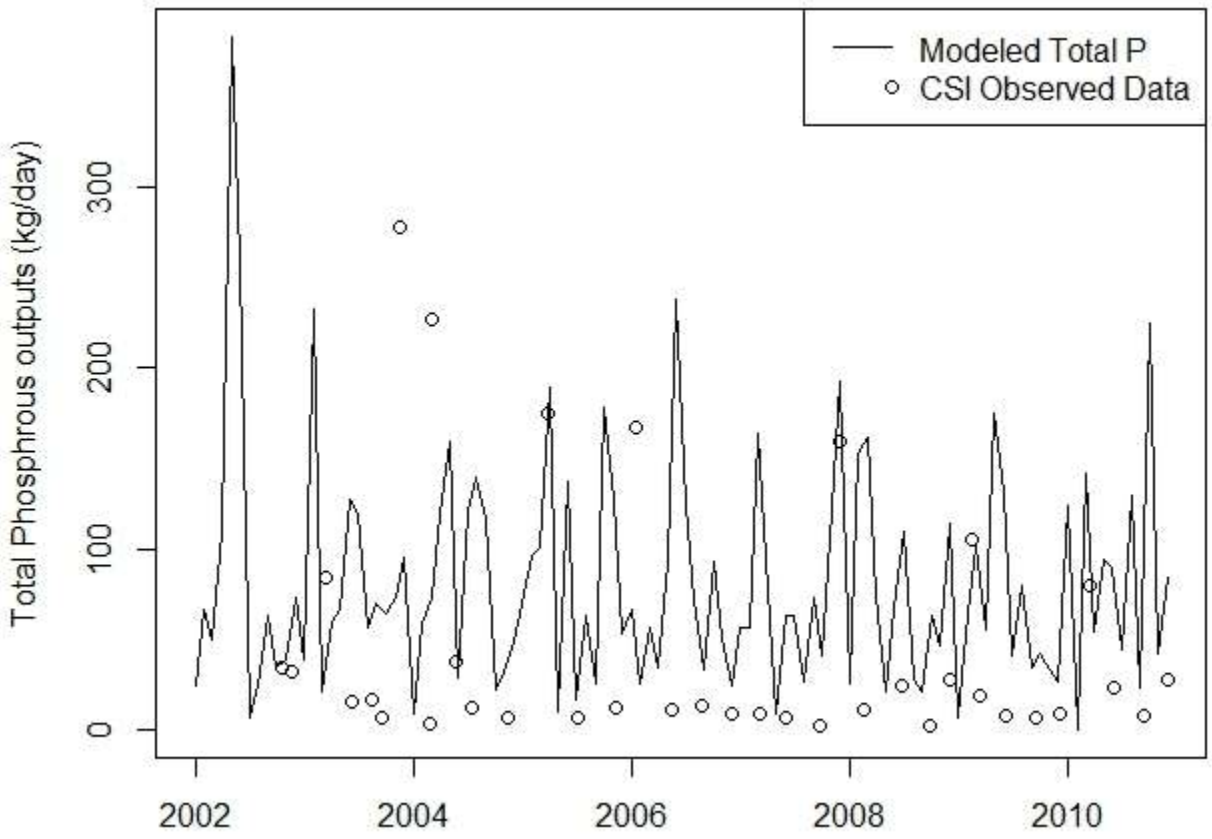
Representing management

- Un-calibrated SWAT output– Fall Cr.



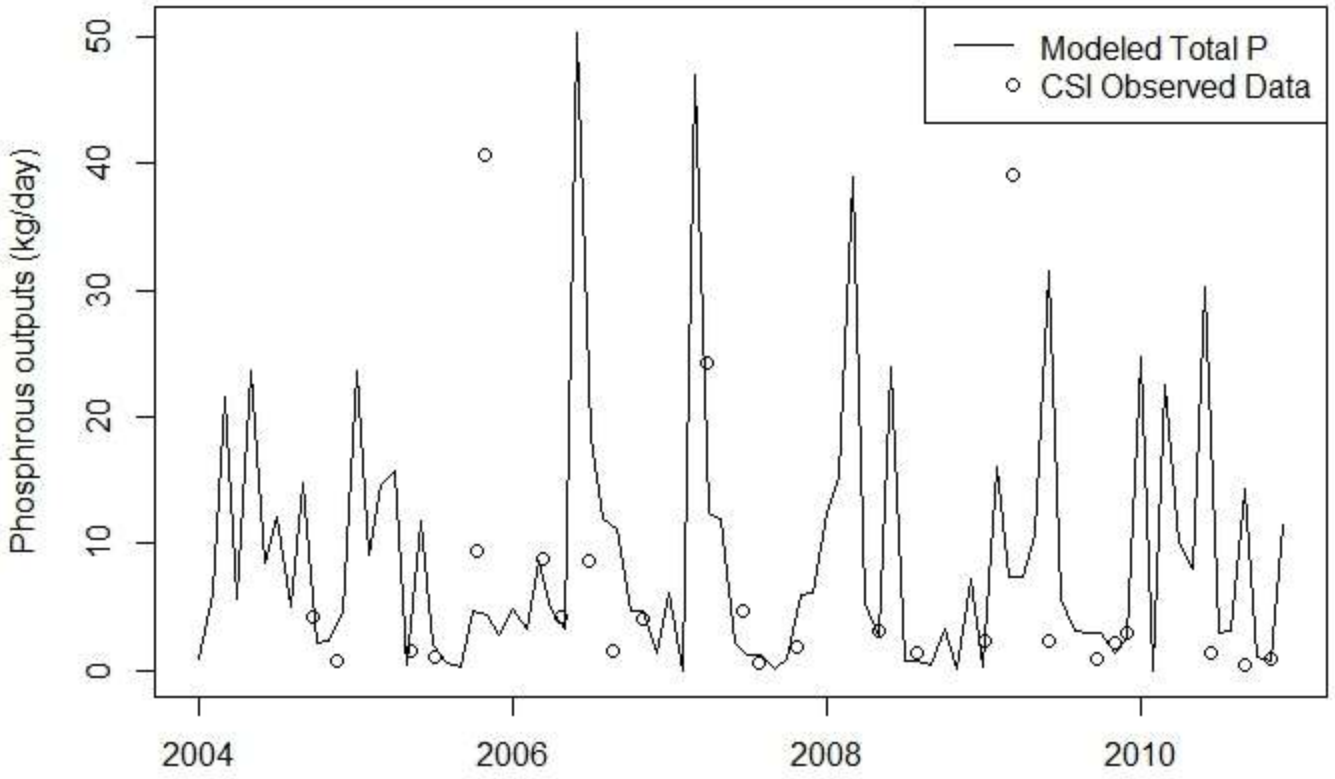
Representing management

- Accounting for manure management – Fall Cr.



Representing management

- Un-calibrated SWAT output – Six Mile Creek



Next Immediate Steps

- Work on getting hydrology more realistic
- Refine management representations
- Work with Peter Vadas (USDA ARS) to refine SWAT manure-P model
- Expand model to entire watershed

- Decide when we the model is as good as it can be
- Identify basic knowledge gaps

Thank You

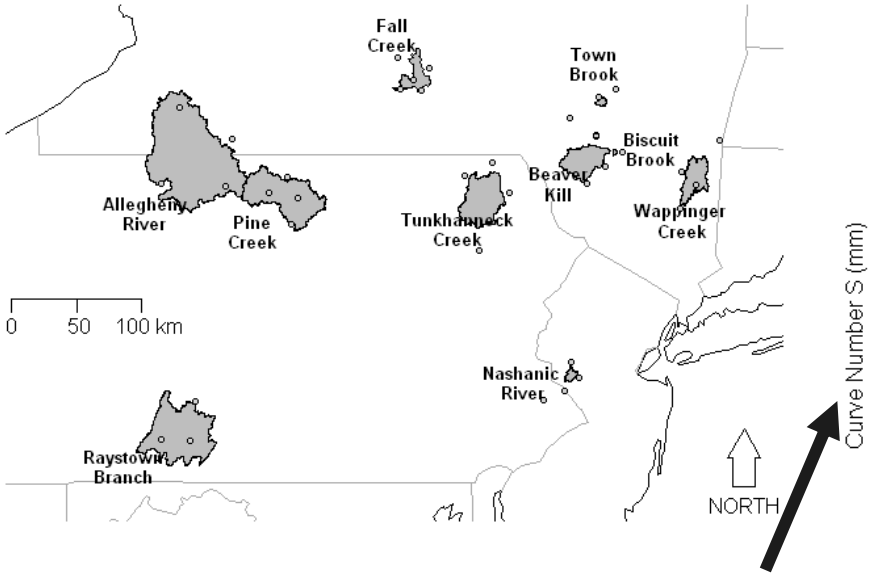
Acknowledgements

Erin Menzies and Dan Fuka

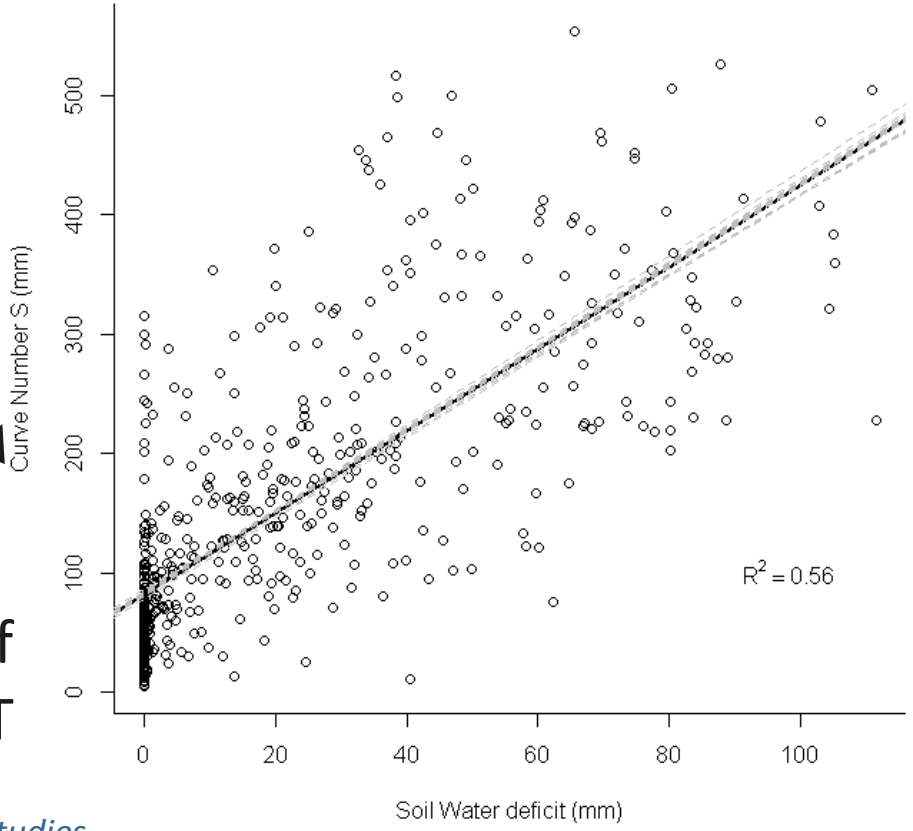
Also thanks to:

Katy Hofmeister, Christine Georgakakos, Brian Buchanan, Josephine Archibald, Margaret Fleming

Regionalizing storm runoff parameters

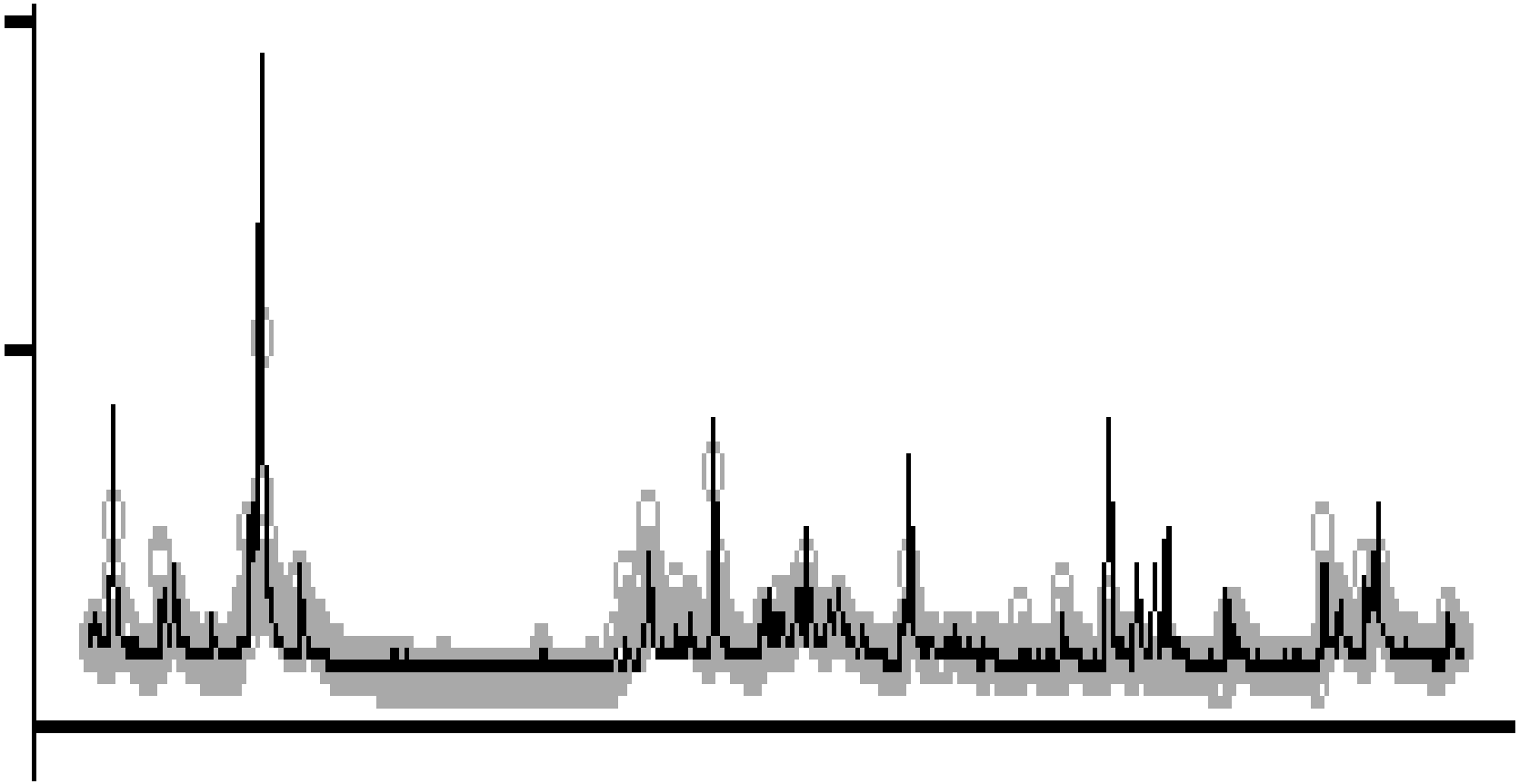


The primary storm runoff parameter in SWAT

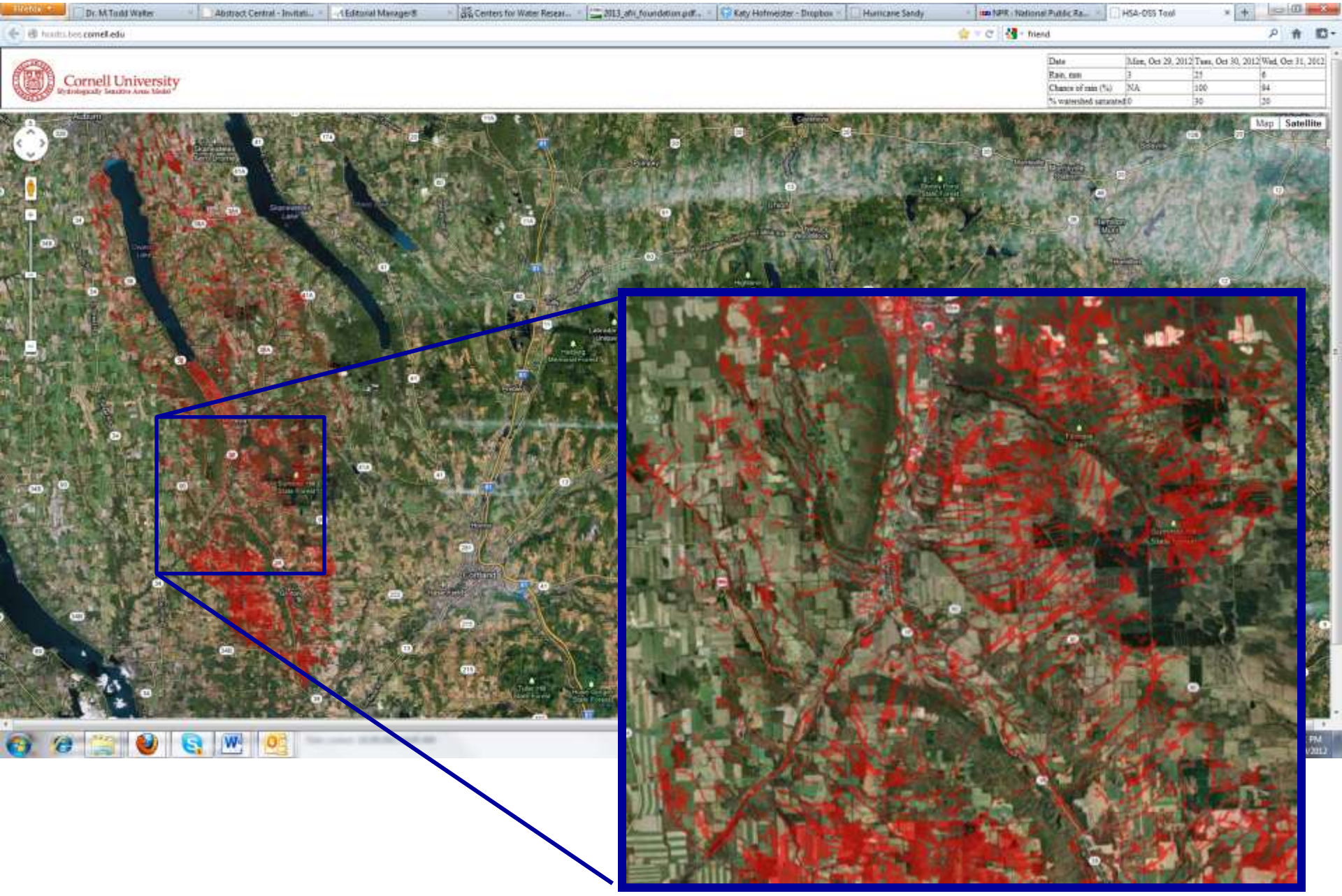


Archibald et al. submitted. *Journal of Hydrology: Regional Studies*

Regionalizing storm runoff parameters – Fall Cr., Daily Flows



Archibald et al. submitted. *Journal of Hydrology: Regional Studies*


Cornell University
Cornell University
Map
Satellite