The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center

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Research Motivation

- Land use change has been suggested as a possible approach to reducing extent and severity of floods in agricultural landscapes
- How much risk reduction is possible from land use change in Iowa landscapes?
- Evaluate this question for the Raccoon River watershed, with respect to perennial rotations

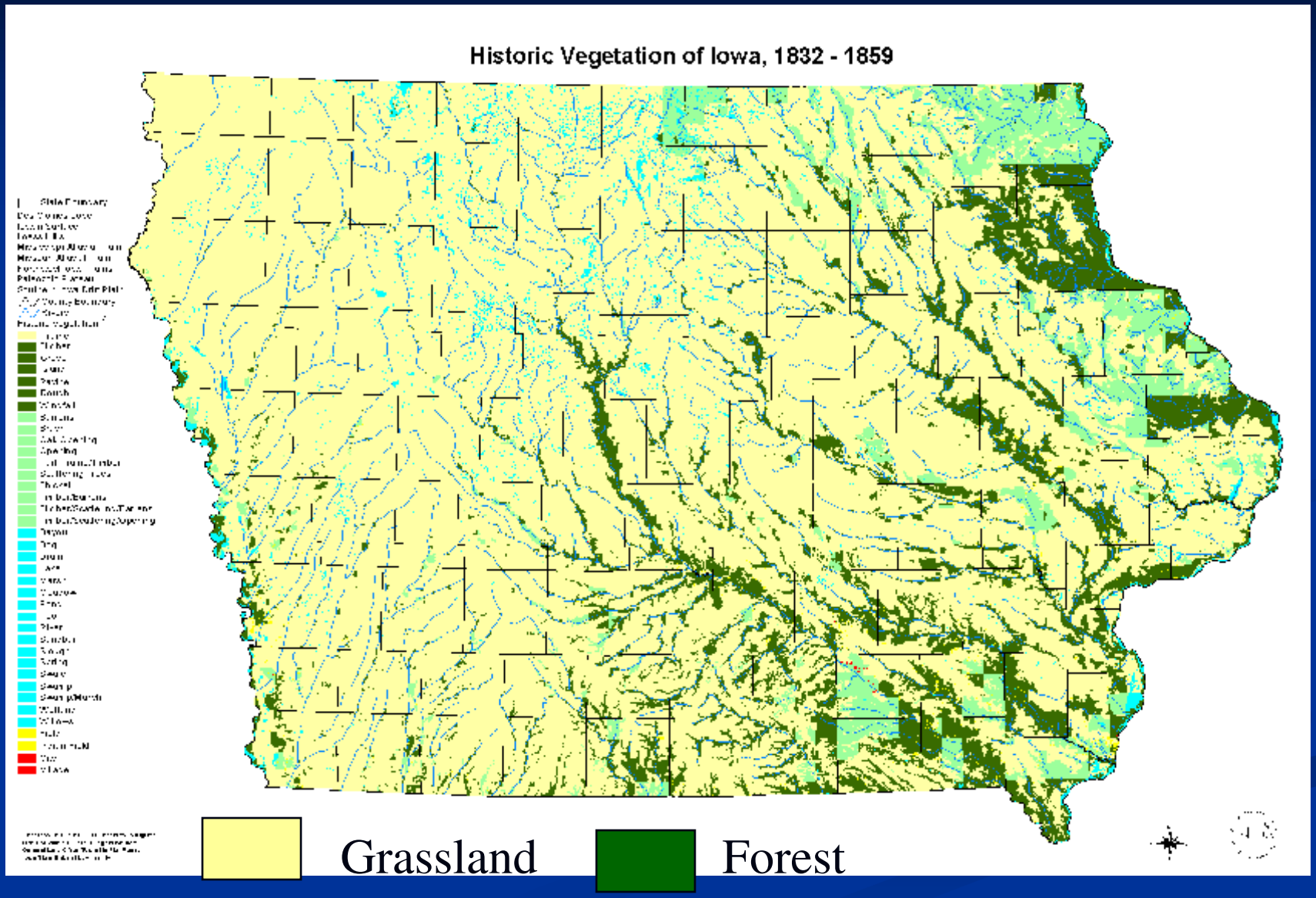
Methods

- Populate watershed based water quality model using detailed land use and hydrologic data for the Raccoon
- Develop a baseline scenario of flood risk based on the current land use typical weather
- Simulate increased use of perennials on the landscape under the same weather patterns and compare the change in flood occurrence with baseline
- Monte Carlo Analysis: repeat above two steps under a large number of random weather scenarios to develop empirical distribution of flood risk

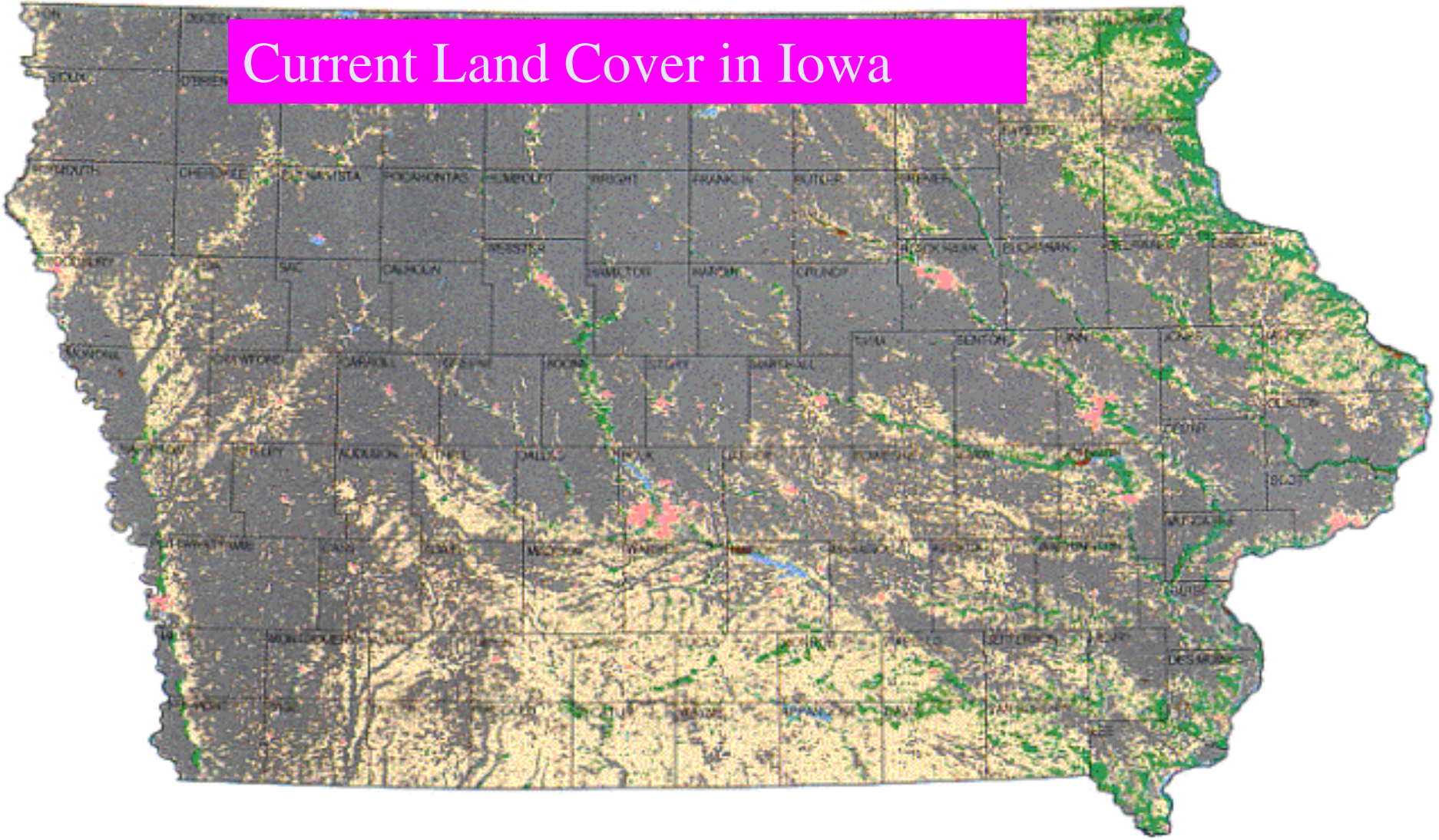
Overview of rest of talk

1. Keith and Calvin, intro to Raccoon, TMDL development, etc.
2. Phil, SWAT model details for Raccoon
3. Cathy, Monte Carlo findings

Land Cover in Iowa around 1850



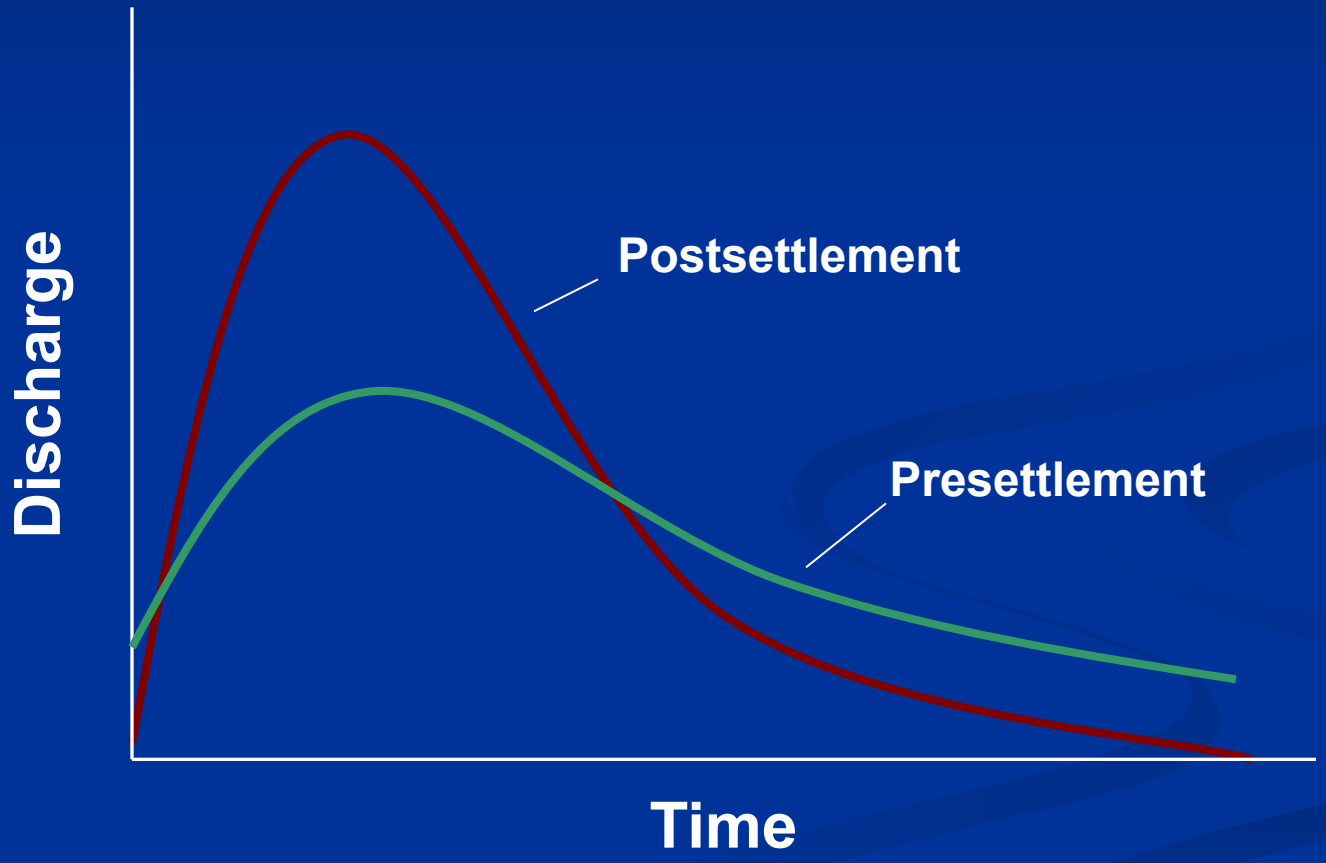
Current Land Cover in Iowa



Land Cover Map of Iowa

Urban / roads	Forest	Barren
Grassland	Row crop	Water

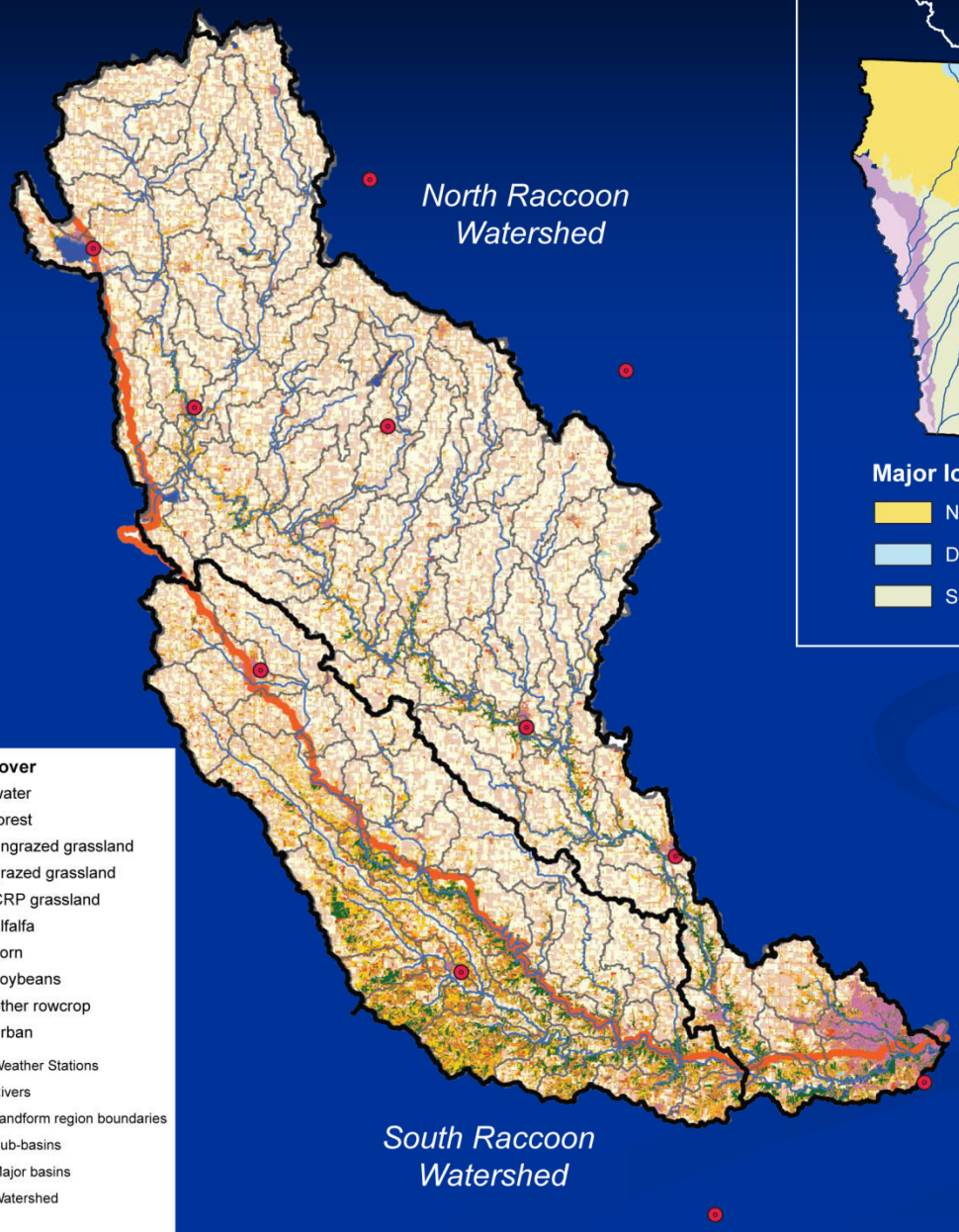
Historical Alterations of Stream Discharge Patterns in Agricultural Ecosystems

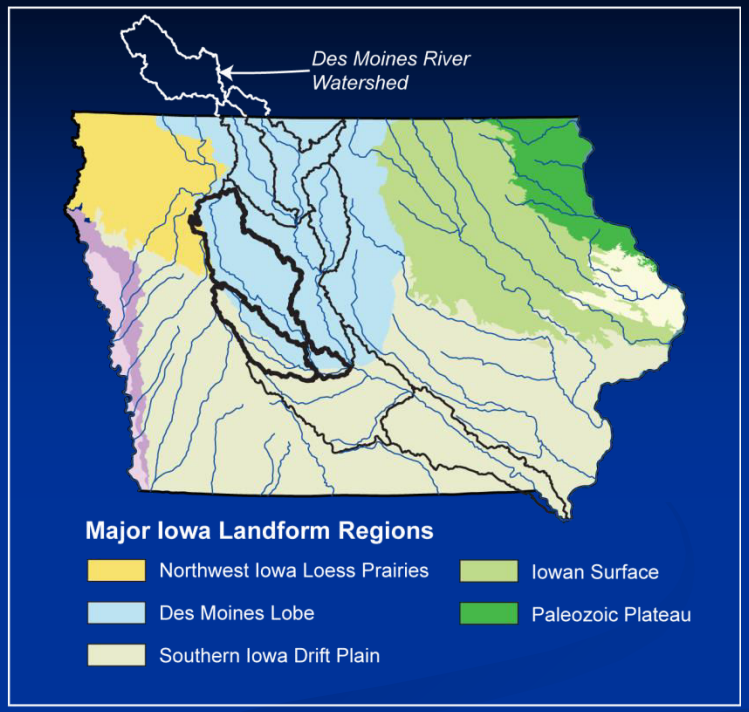


After Menzel, 1983

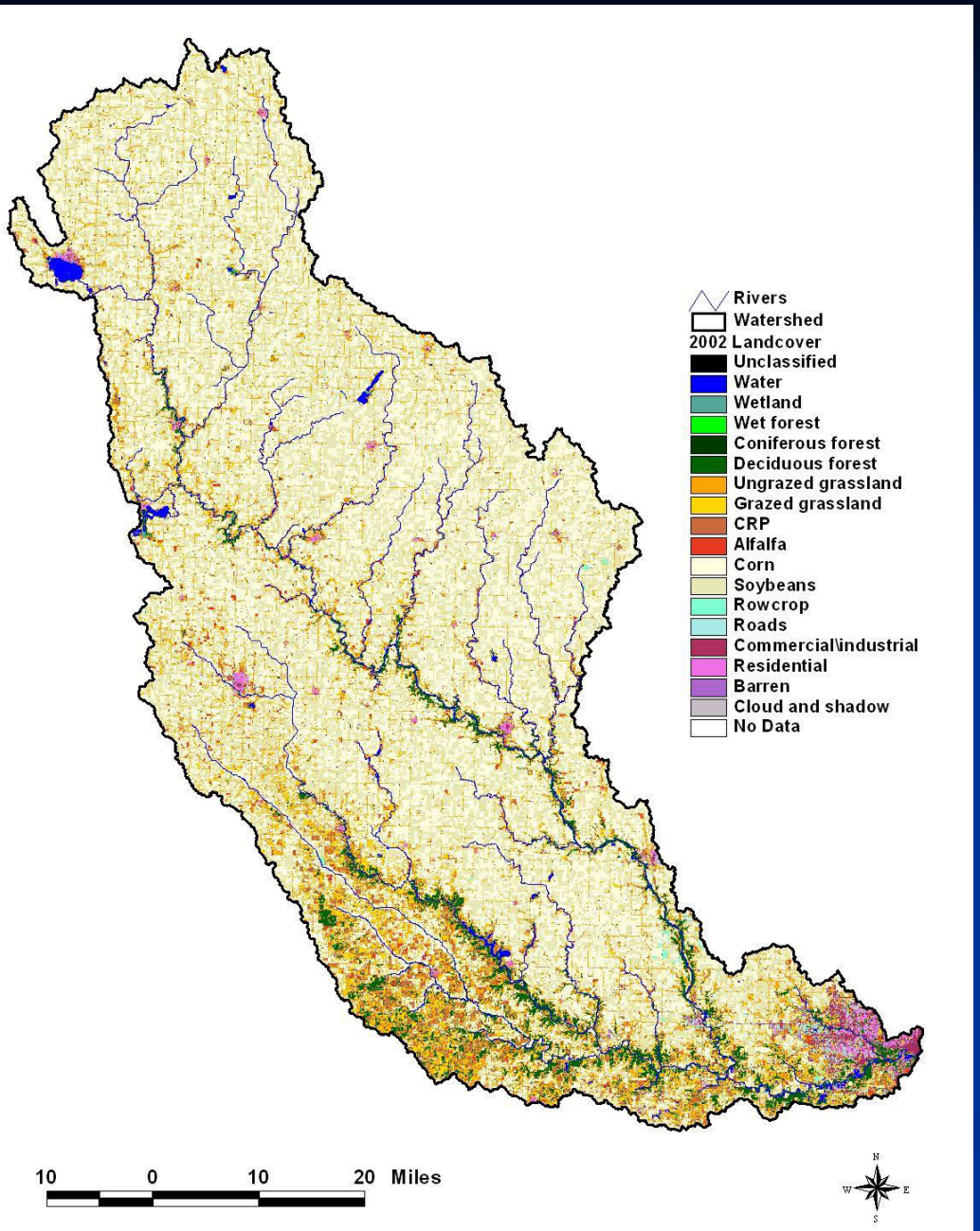
Why the Raccoon River?

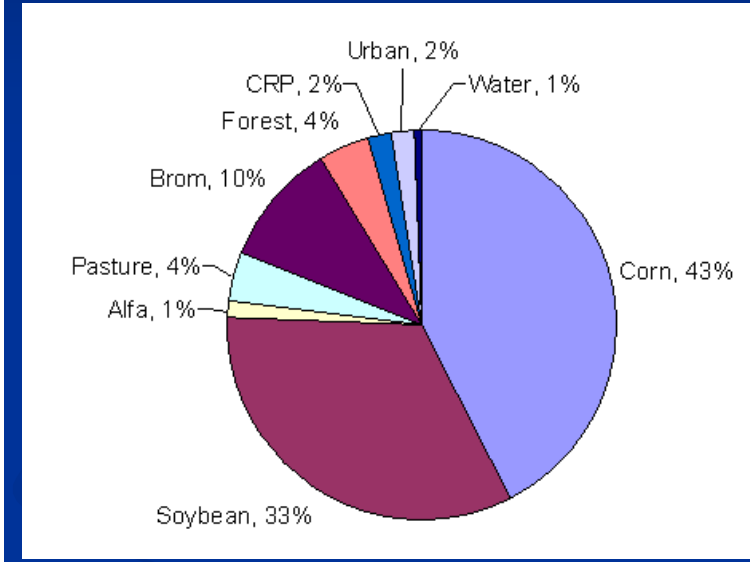
- Impaired water body for nitrate-N and E. coli bacteria
- History of flooding
- SWAT model developed for watershed
- Understanding that land cover changes will affect water yield in the basin

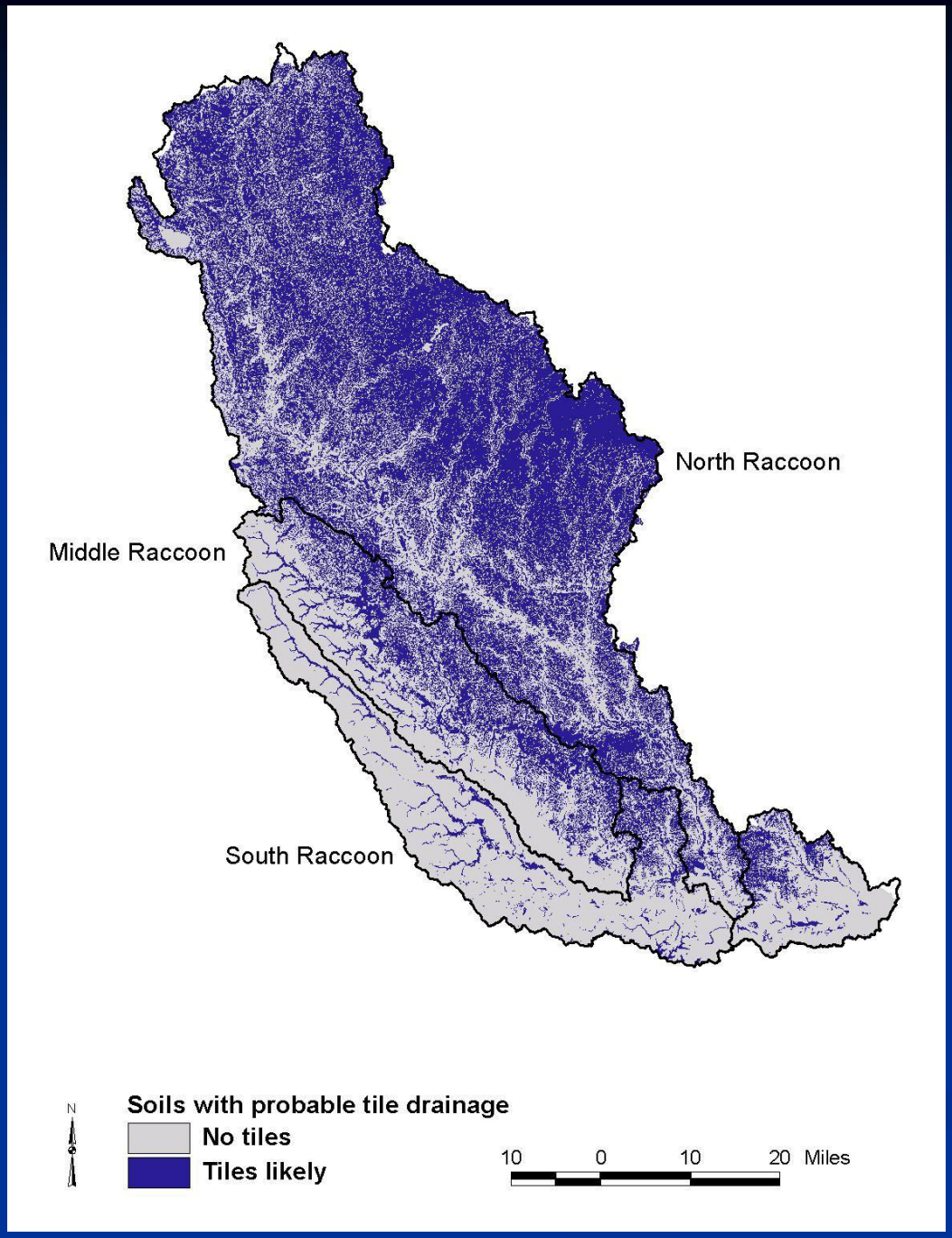

North Raccoon Watershed
South Raccoon Watershed
Landcover
water
forest
ungrazed grassland
grazed grassland
CRP grassland
alfalfa
corn
soybeans
other rowcrop
urban
Weather Stations
Rivers
Landform region boundaries
Sub-basins
Major basins
Watershed


Des Moines River Watershed
Major Iowa Landform Regions
Northwest Iowa Loess Prairies
Des Moines Lobe
Southern Iowa Drift Plain
Iowan Surface
Paleozoic Plateau

Land Cover in Raccoon River Watershed







Soils with Probable Tile Drainage

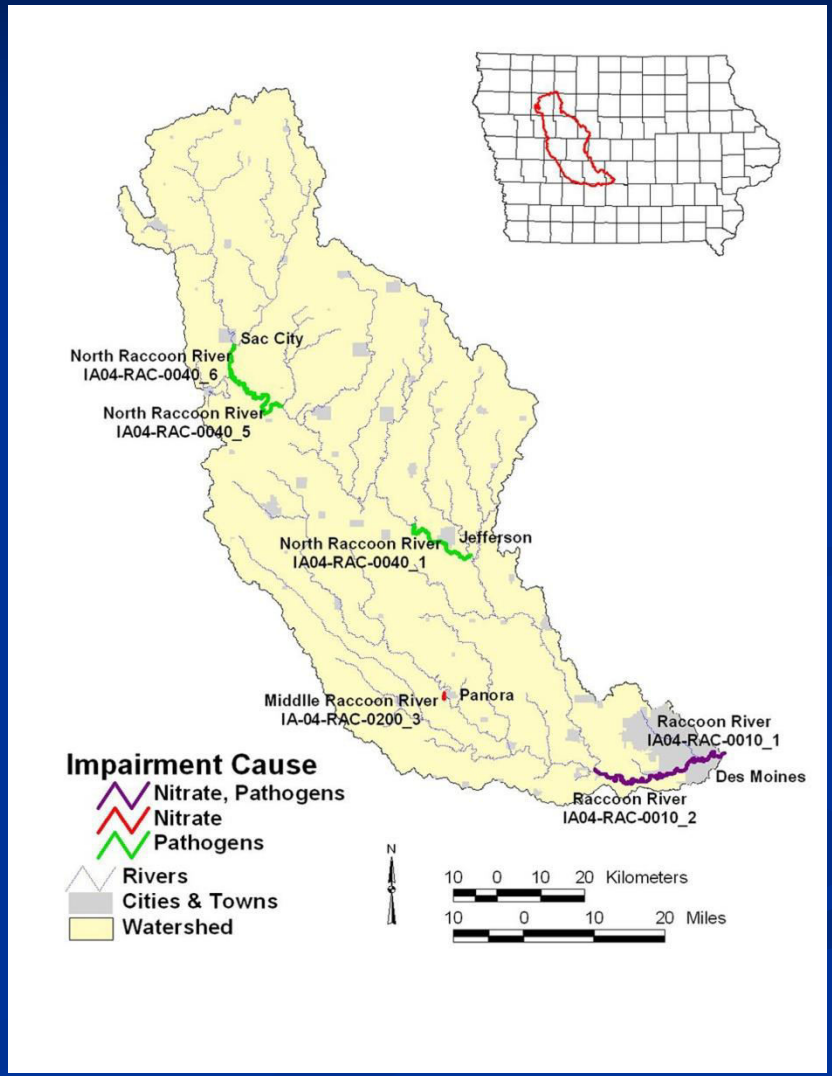
North Raccoon = 77.5 %

South Raccoon = 42.1%

Water quality impairments

Nitrate concentrations in the Raccoon River are above drinking water standards at Des Moines Water Works and City of Panora

Escherichia coli (*E.coli*) concentrations in the Raccoon River are above applicable water quality standards for primary contact recreation



SWAT Model

- Continuous watershed scale hydrology and water quality model
- Developed to predict impacts of land management practices on watershed hydrology and water quality
- Watershed divided into 112 subbasins and 3640 HRUs
- Model developed for Raccoon River TMDL and also used to support development of the Raccoon River Watershed Master Plan

Rivers as a drinking water source are vulnerable to flooding

Des Moines Water Works is a public water supply serving Des Moines metropolitan area of 400,000 people

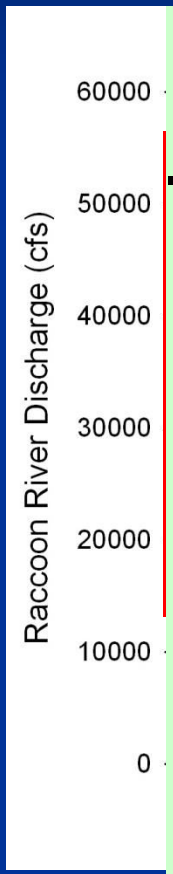
DMWW source water includes surface water collected directly from the Raccoon and Des Moines Rivers

The Raccoon River has flooded on numerous occasion during the last two decades

In 1993, flooding overtopped the levee and left the city without water for more than a week

Levee was raised but flooding still impacts infrastructure

Flooding History in Des Moines

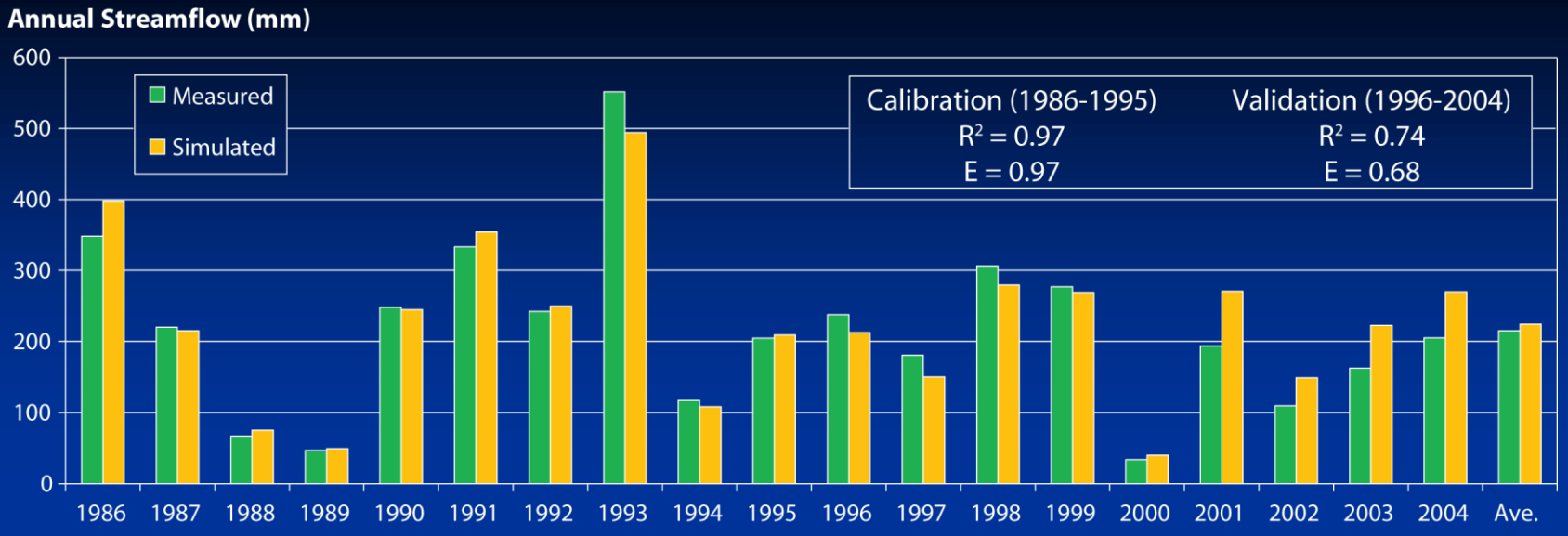


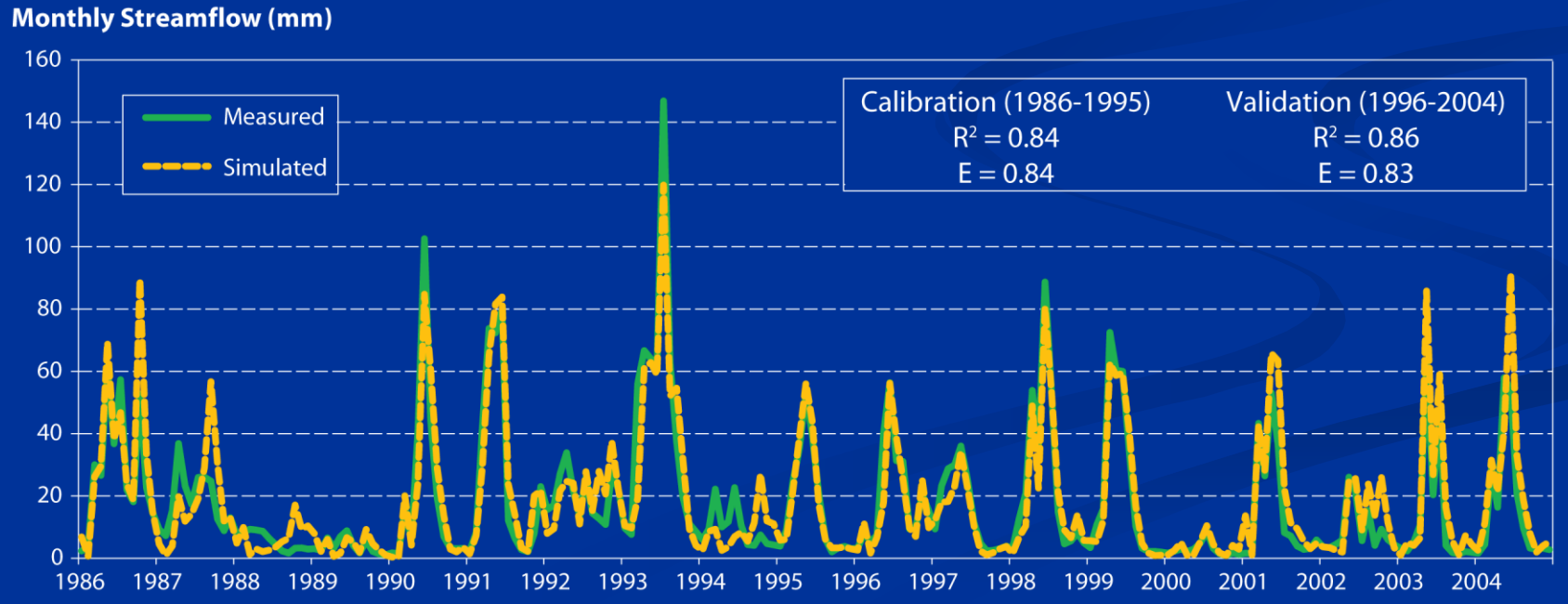
Water Year	Flood Events	Total Flooding Days	Flood Duration (days)
1998	3	14	4.7
1999	4	12	3.0
2000	0	0	
2001	1	1	1.0
2002	0	0	
2003	2	11	5.5
2004	2	7	3.5
2005	1	2	2.0
2006	0	0	
2007	3	22	7.3
2008	2	22	11.0
2009	1	2	2.0
2010	8	56	7.0
Total	27	149	
Average	2.1	11.5	4.7

Flooding at Fleur Drive water treatment plant from 1997 to 2010

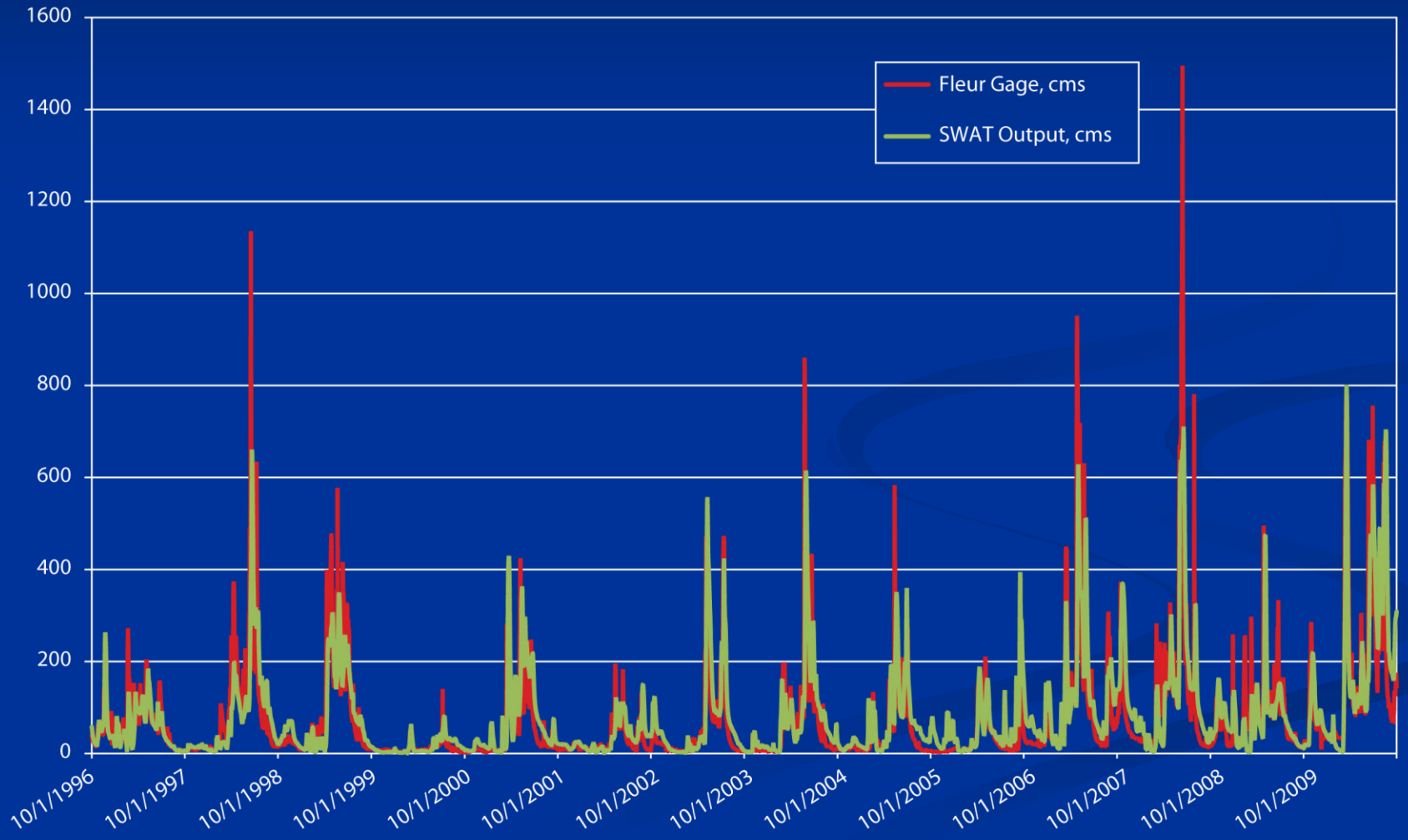
- 27 events
- 149 days
- 4.7 days of flooding per event

SWAT Streamflow Calibration and Validation

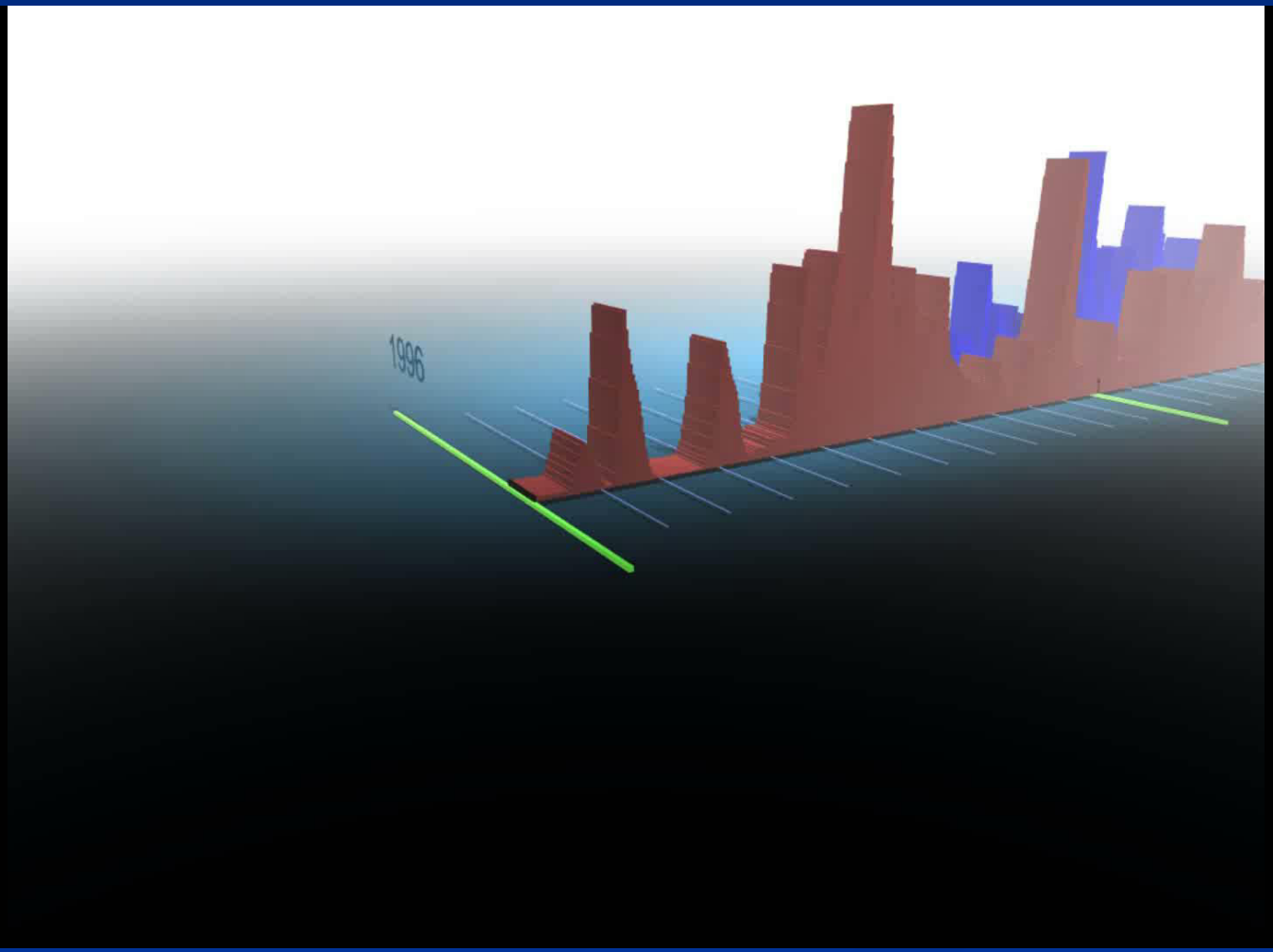




Daily Flow Comparisons: SWAT vs. Measured Streamflows at Raccoon Outlet (Fleur Gage)

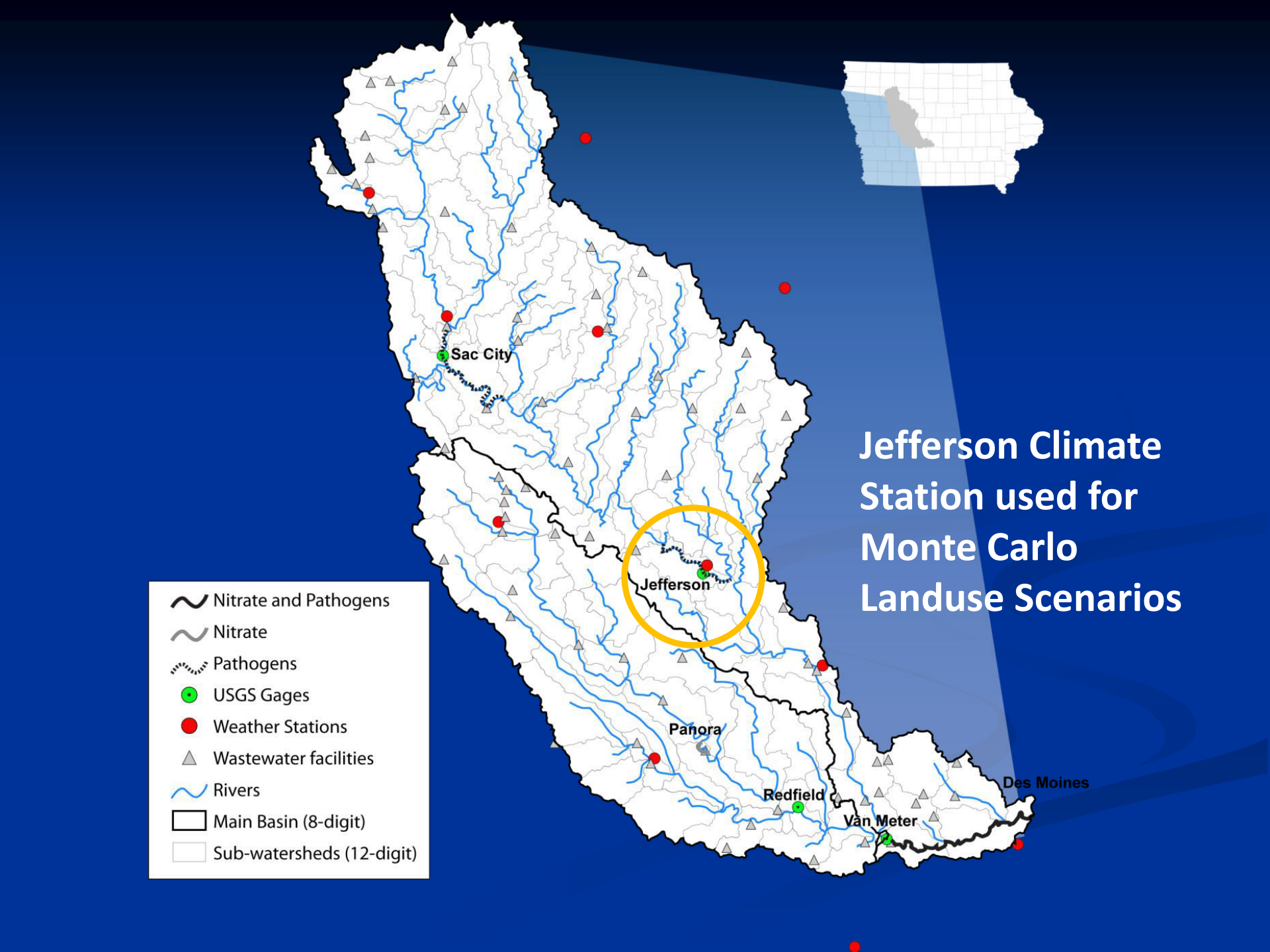


SWAT vs. Fleur Gage (popcorn anyone?)

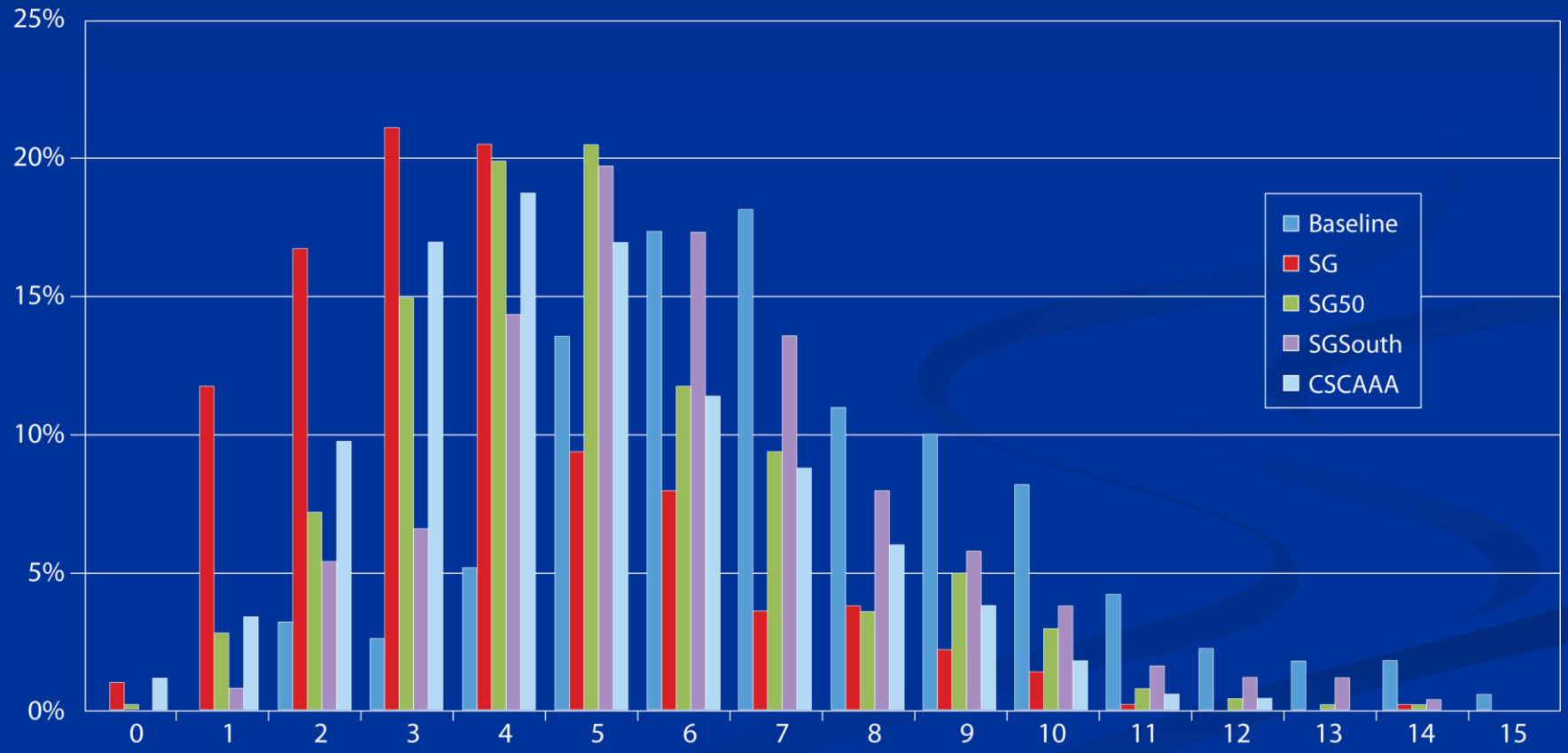


Land Use Scenarios

- Baseline: existing cropland,
- Switchgrass scenario: all of the cropland in the watershed is planted with switchgrass,
- Switchgrass on half the acreage: the highest 50% sloped land is planted with switchgrass ,
- Switchgrass southern portion: all acreage in the South Raccoon is planted with switchgrass,
- Corn/soybean/alfalfa rotation: all cropland in the watershed is placed into a six year rotation, CSCAAA.


Sac City
Jefferson
Panora
Redfield
Van Meter
Des Moines
Nitrate and Pathogens
Nitrate
Pathogens
USGS Gages
Weather Stations
Wastewater facilities
Rivers
Main Basin (8-digit)
Sub-watersheds (12-digit)
Jefferson Climate Station used for Monte Carlo Landuse Scenarios

Probability of Flood Events over 19 years under Five Land Use Scenarios

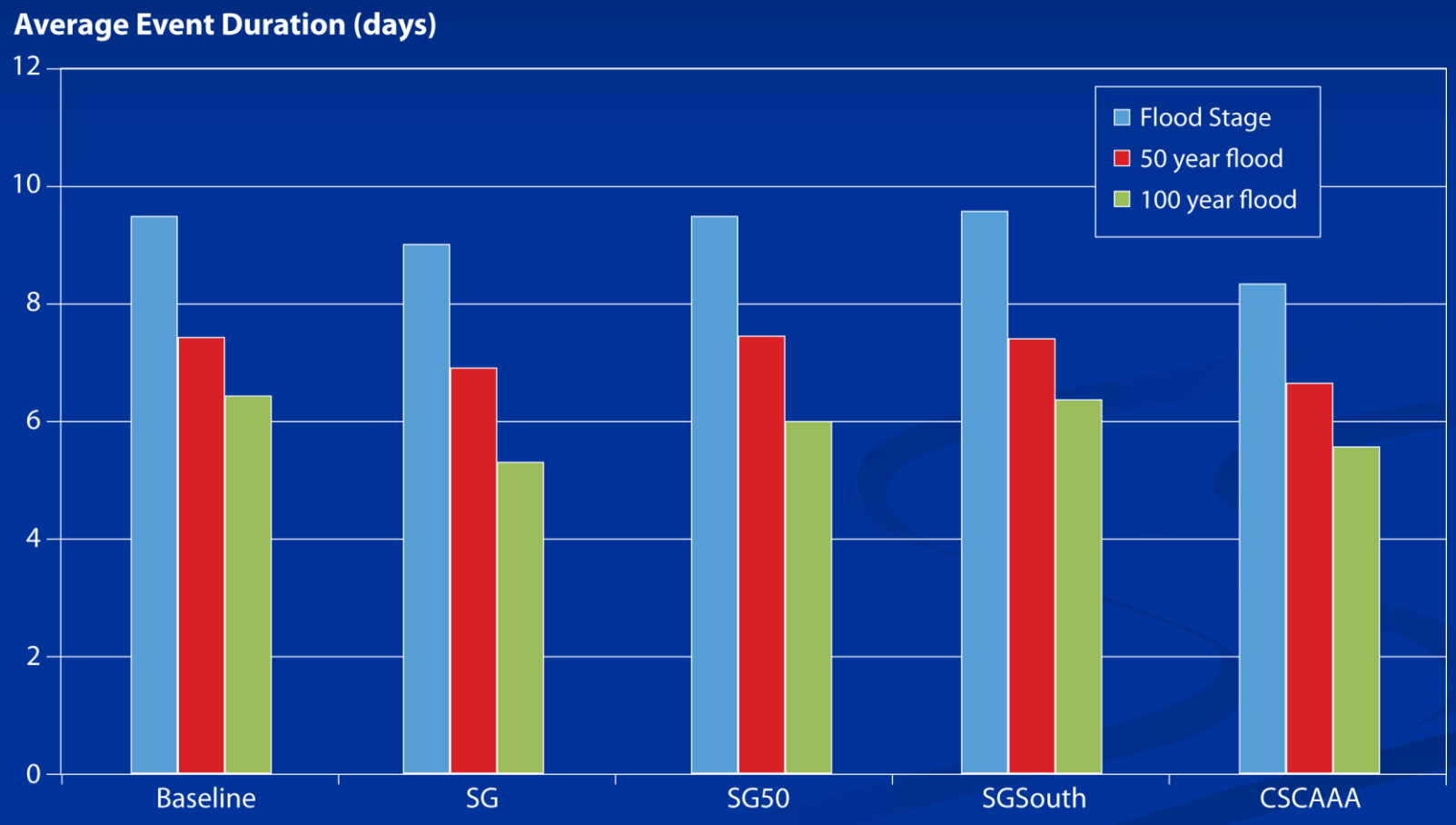


Baseline vs. Four Scenarios

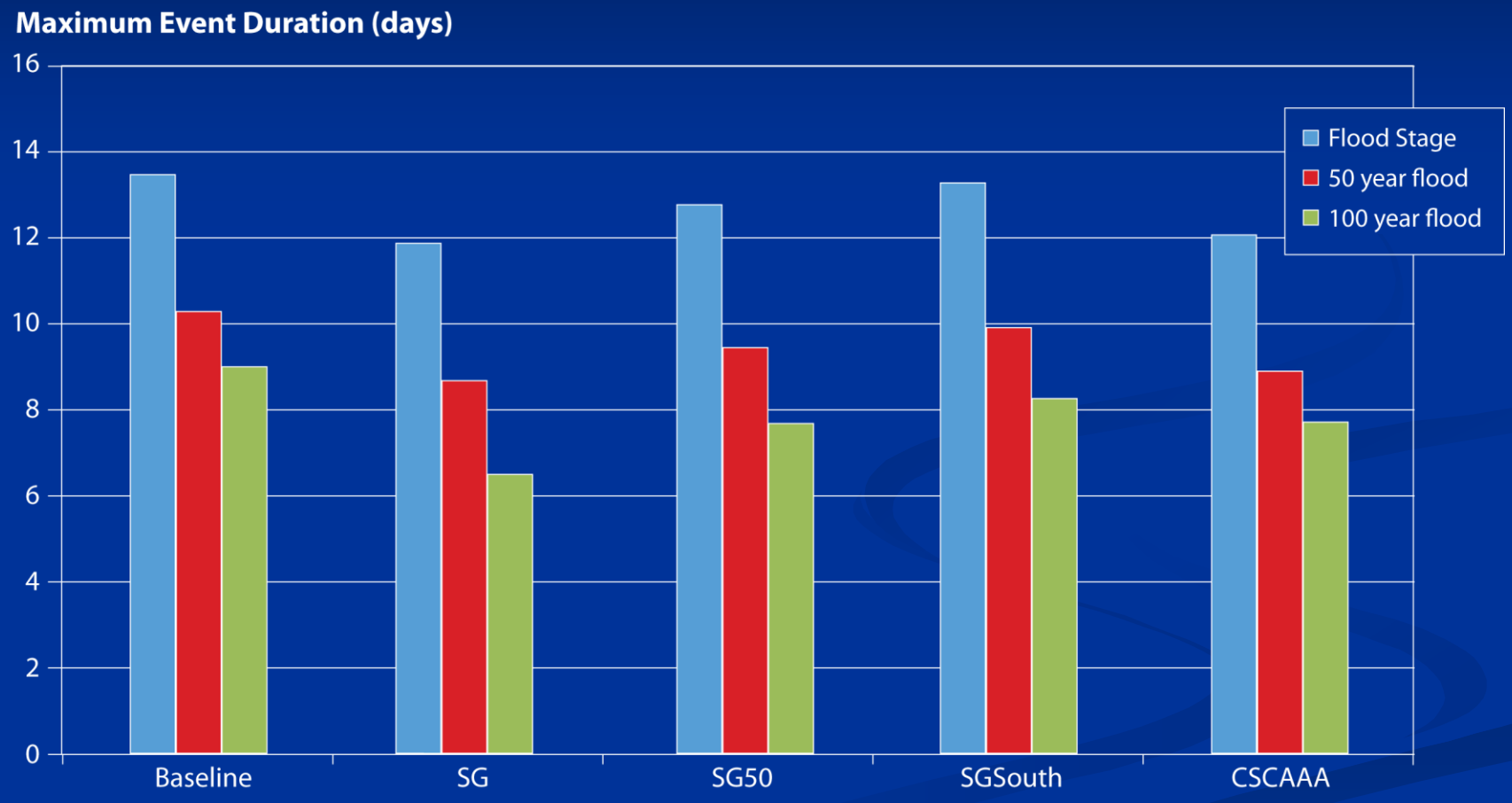
Raccoon River Flood
Simulation

2011-10-26
Seeds 436-438

Average Event Duration



Maximum Event Duration



Findings

- Extensive coverage of switchgrass has potential to reduce the number of flood events
- Targeting switchgrass to the highest sloped land achieved a significant percentage of the gains
- The CSCAAA rotations and switchgrass targeted to the South Raccoon had similar flood reduction benefits