

Evaluating Water Quality in the Yahara Watershed under Changes in Land Cover, Nutrient Management, and Climate

Tracy Campbell

Eric Booth, Melissa Motew, Chris Kucharik

AWRA Annual Meeting

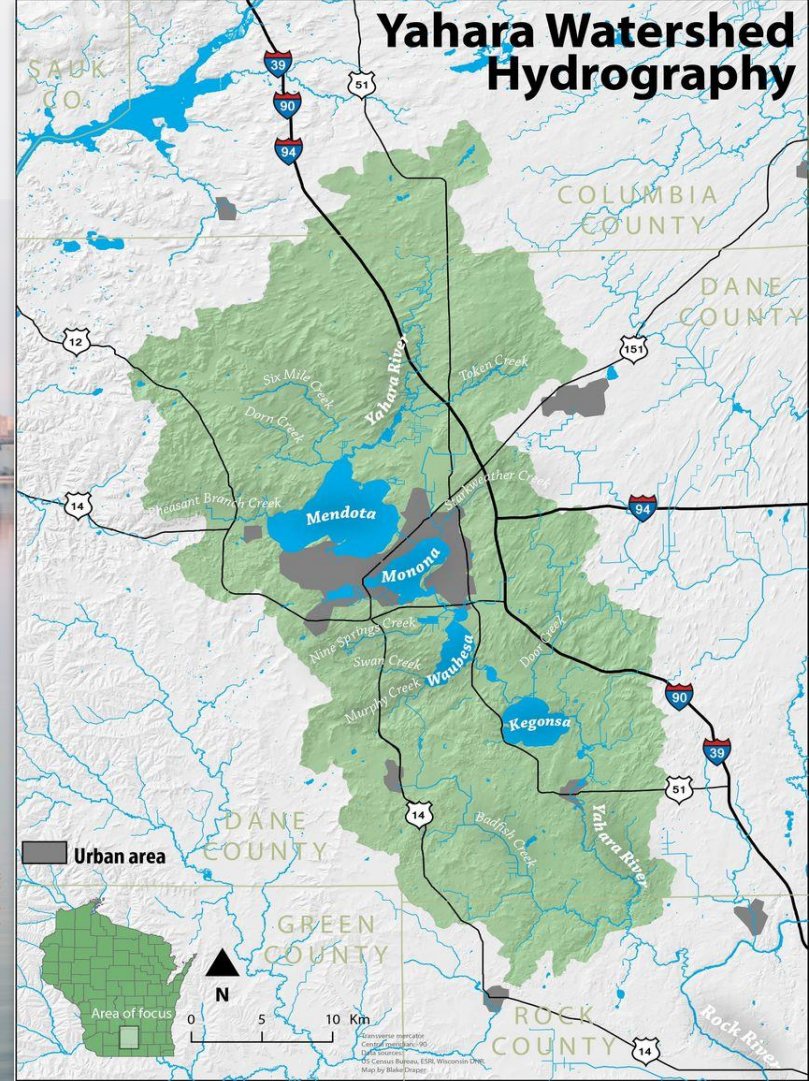
9 March 2018



College of
Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

Yahara Watershed

- Size: 1345 km²
- Chain of lakes: Mendota, Monona, Waubesa, Kegonsa
- Rock river → Mississippi River → Gulf of Mexico
- Urbanizing and agriculturally dominated



Urbanizing

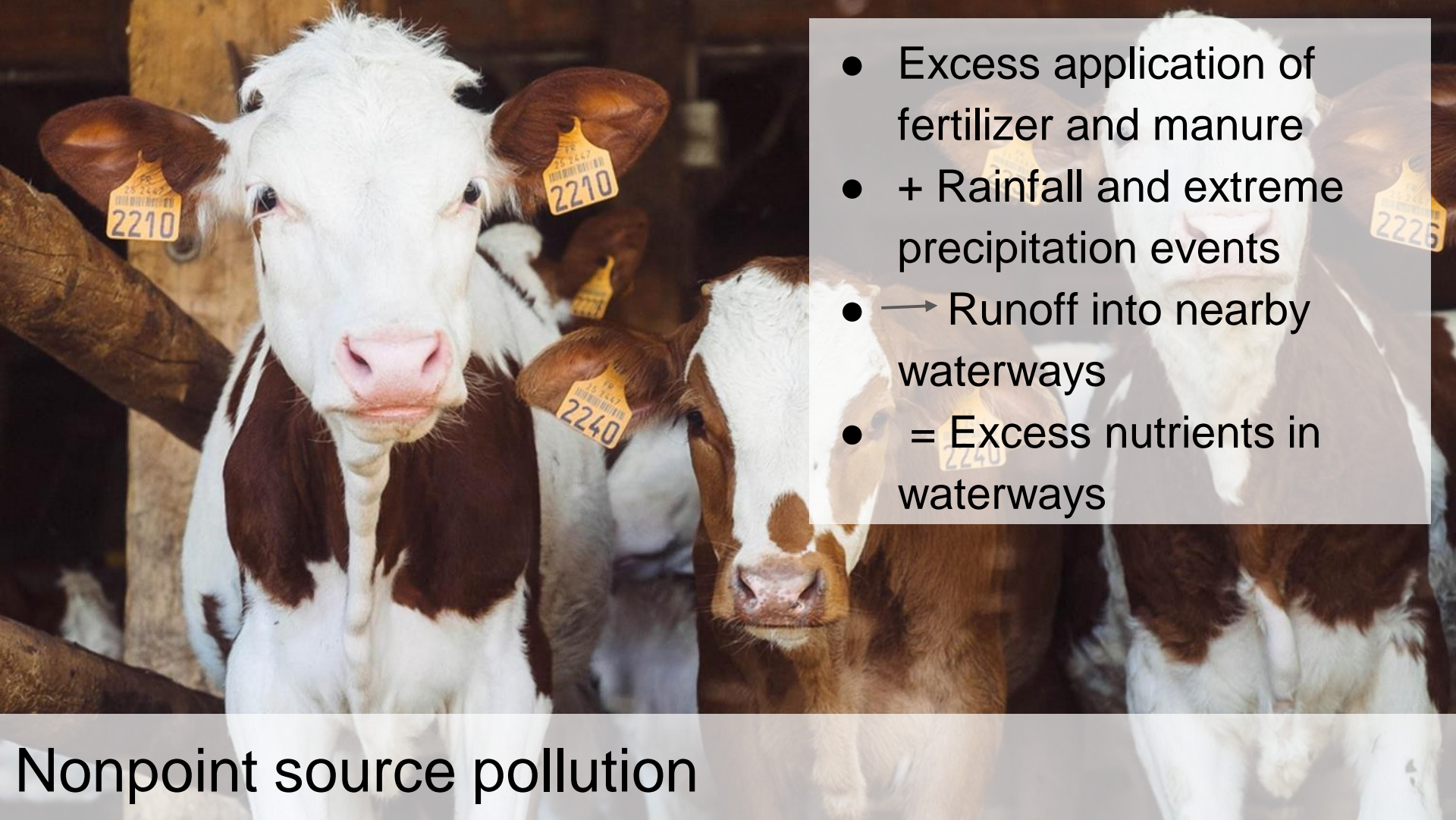
- Population: 372,000
- With growth expected



- ~ 50% of watershed is dedicated to agriculture
- Dairy, Corn, Soybeans dominate



Agriculturally Dominated



- Excess application of fertilizer and manure
- + Rainfall and extreme precipitation events
- → Runoff into nearby waterways
- = Excess nutrients in waterways

Nonpoint source pollution

A red sign on a wooden post is positioned in the foreground. The sign has black text that reads: "BEACH CLOSED No Swimming", "BECAUSE of ELEVATED BACTERIA LEVELS IN THE SWIMMING AREA", and "IF YOU HAVE ANY QUESTIONS, PLEASE CALL: MADISON & DANE COUNTY DEPT. OF PUBLIC HEALTH 266-4821". The background shows a swimming area with green, algae-covered water and a rope with red and white buoys. Large rocks are visible in the distance.

**BEACH
CLOSED**
No Swimming

BECAUSE of ELEVATED
BACTERIA LEVELS
IN THE SWIMMING AREA

IF YOU HAVE ANY QUESTIONS, PLEASE
CALL: MADISON & DANE COUNTY DEPT. OF
PUBLIC HEALTH 266-4821

Eutrophication



BEACH
CLOSED
No Swimming

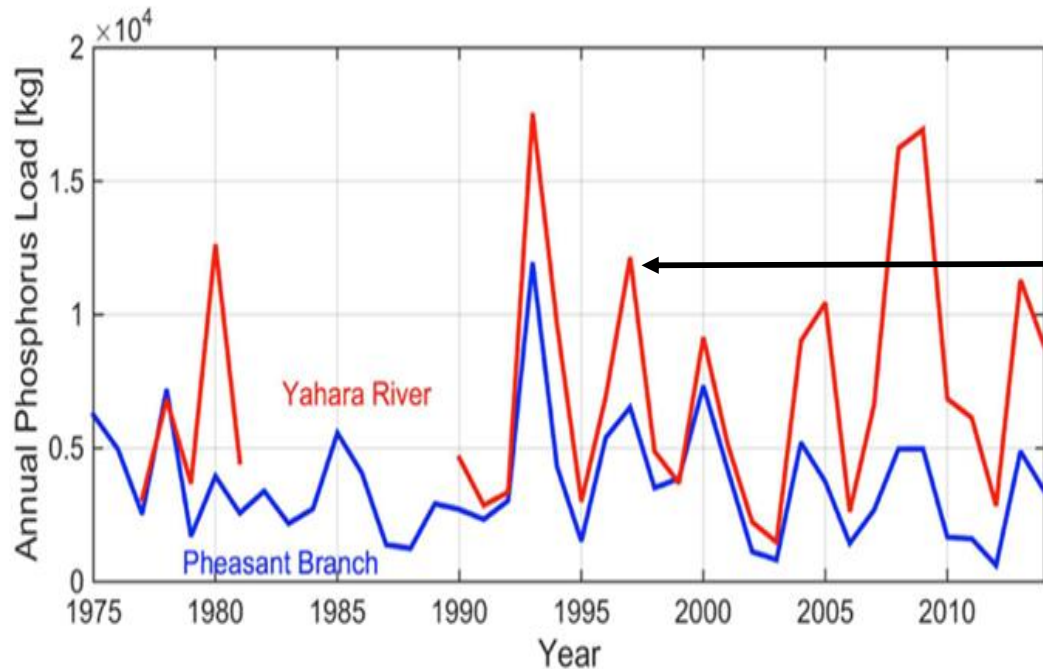
BECAUSE of ELEVATED
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IF YOU HAVE ANY QUESTIONS, PLEASE
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PUBLIC HEALTH 266-4821

- Development of better management practices (BMPs)
- Goal of **50% reduction** in P Yield

Water Quality Initiatives

Phosphorus Loading from the Landscape



Yet, no improvement over 40+ years.

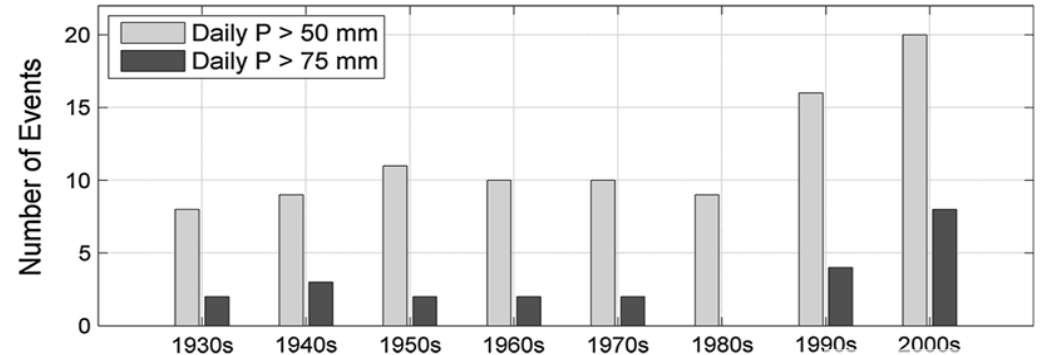
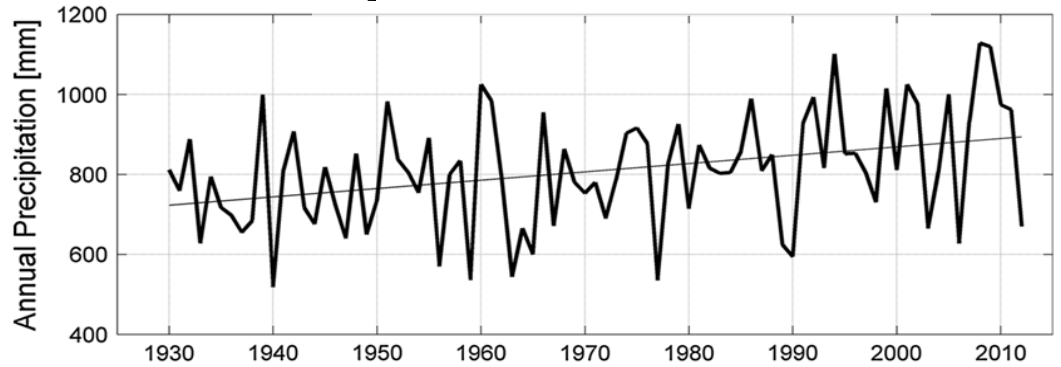
Why?

↑ Precipitation

Legacy P

+

P still stored
in soil



Considering current challenges & drivers of change...

....how do we plan for the future?



Growing Population



Food Production
& Consumption



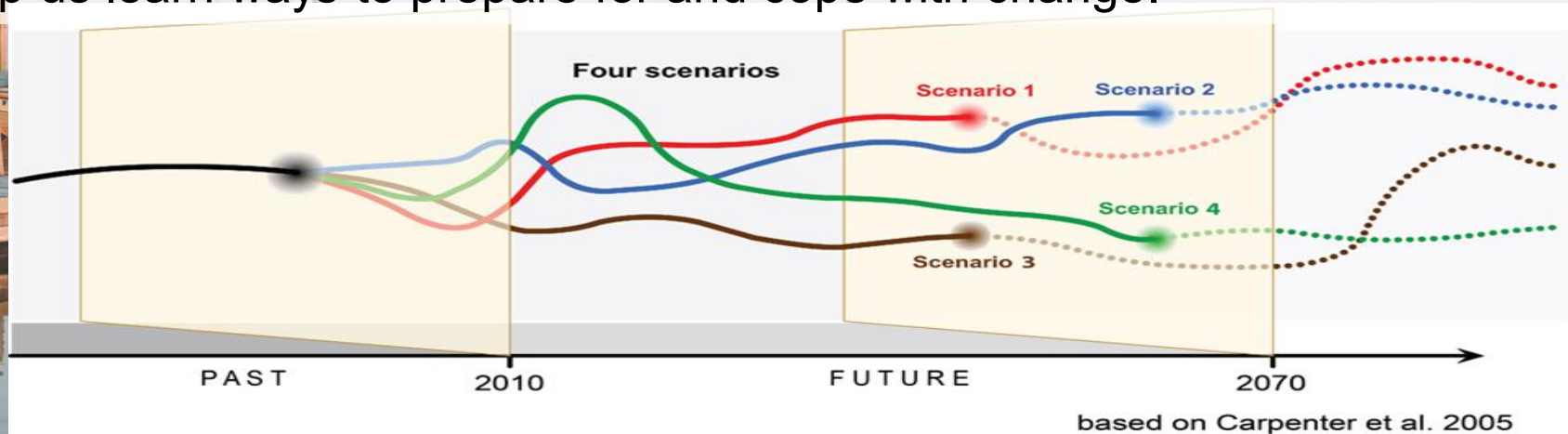
Environmental
Degradation

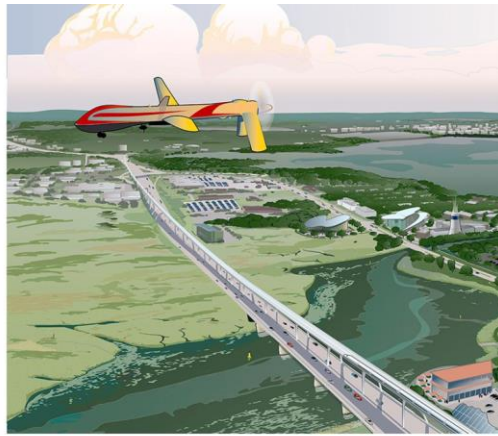


Climate Change

Creation of Scenarios

- Provocative, plausible stories about the future with contrasting social and environmental conditions.
- Explore questions of “What if?”
- Facilitate long-term thinking.
- Help us learn ways to prepare for and cope with change.





YAHARA2070



Plausible & Provocative Scenarios

Based on stakeholder interviews

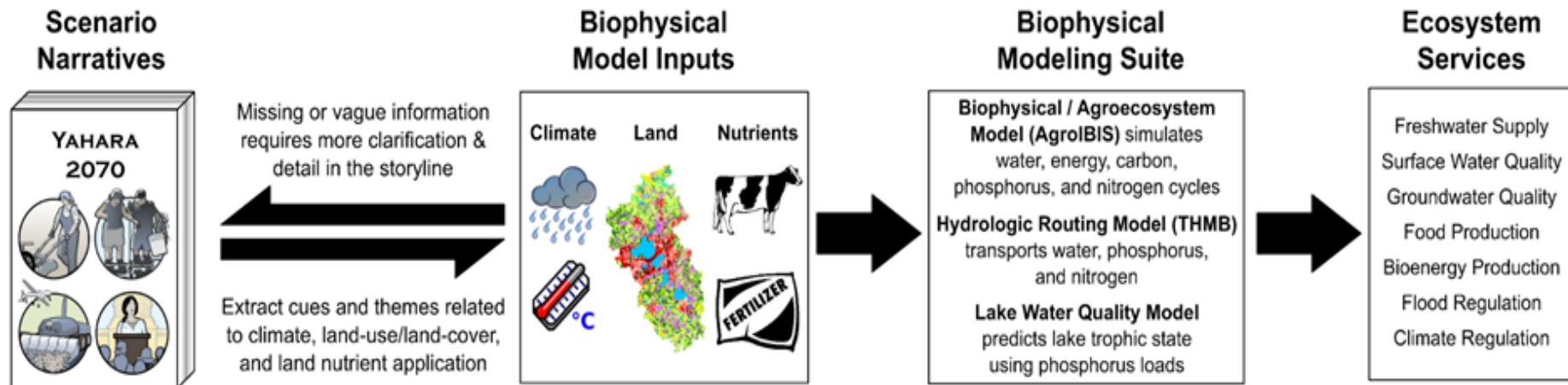
Reflect shift in values, governance, technology, diet, etc.

Includes either adaptation or transformation

Reflects concern over extreme weather events

Water Sustainability and Climate Project

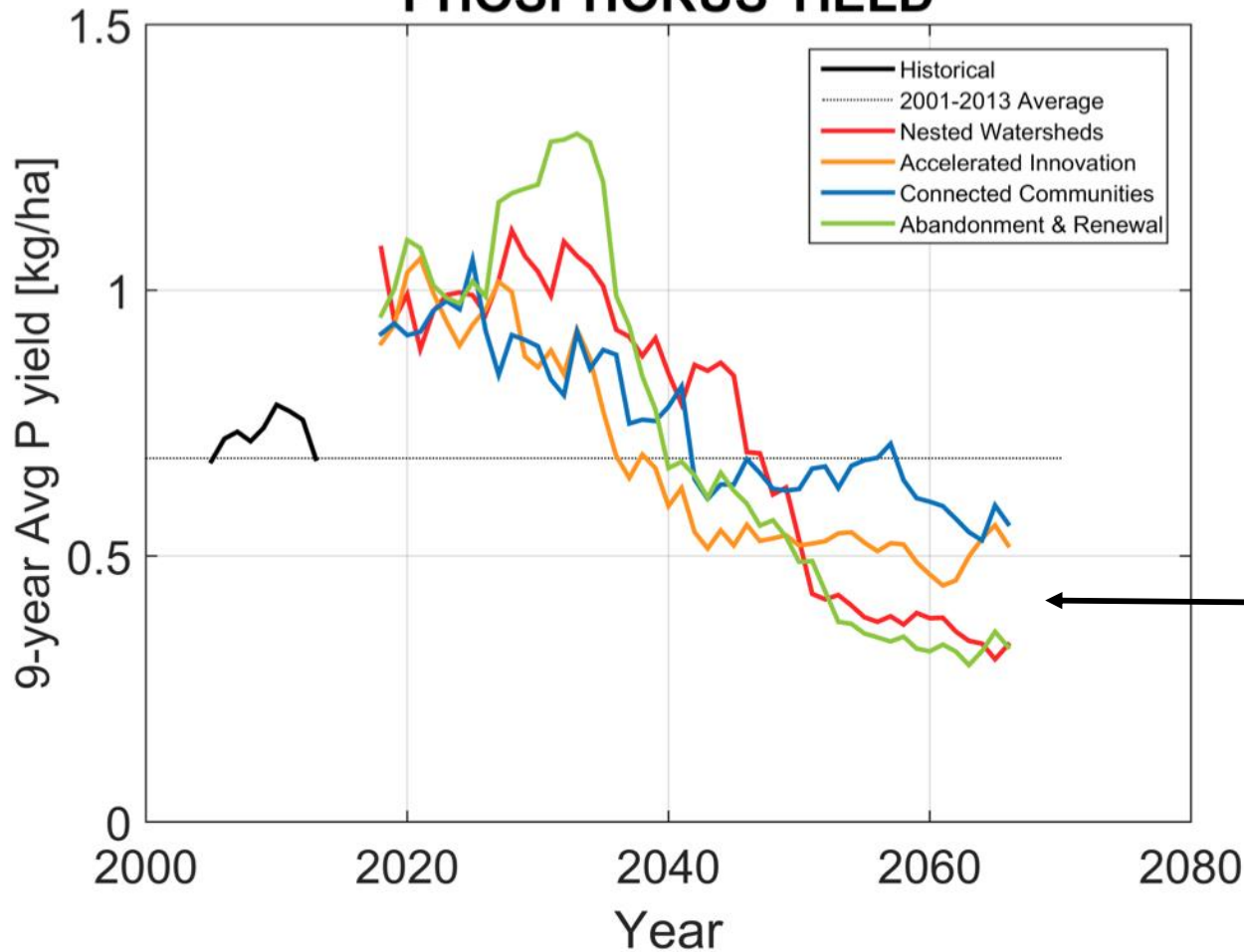
Yahara 2070 scenarios



- Iterative process between modeling team and narrative writers
- Scenarios that are internally consistent, plausible, and contrasting

PHOSPHORUS YIELD

Watershed Average



But takes 50+ years, and reduction ranges from 20 - 50%

← P Yield Reduction by 2070

Focus on Water Quality & Large Scale Incremental Changes

What transformations to **land cover** and **nutrient management** are required to improve water quality under a **changing climate**?

If we change our actions today, what **timeline** is required for improvements to occur?

What are the **tradeoffs**?

Cropland: alfalfa,
corn, soybeans,
small grains

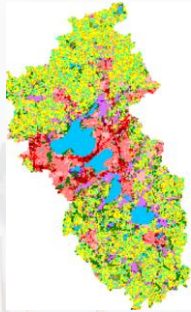
% of Cropland
Dedicated to
Perennial Grasses

Replacement
based on LCC
(Land Capability
Classification)

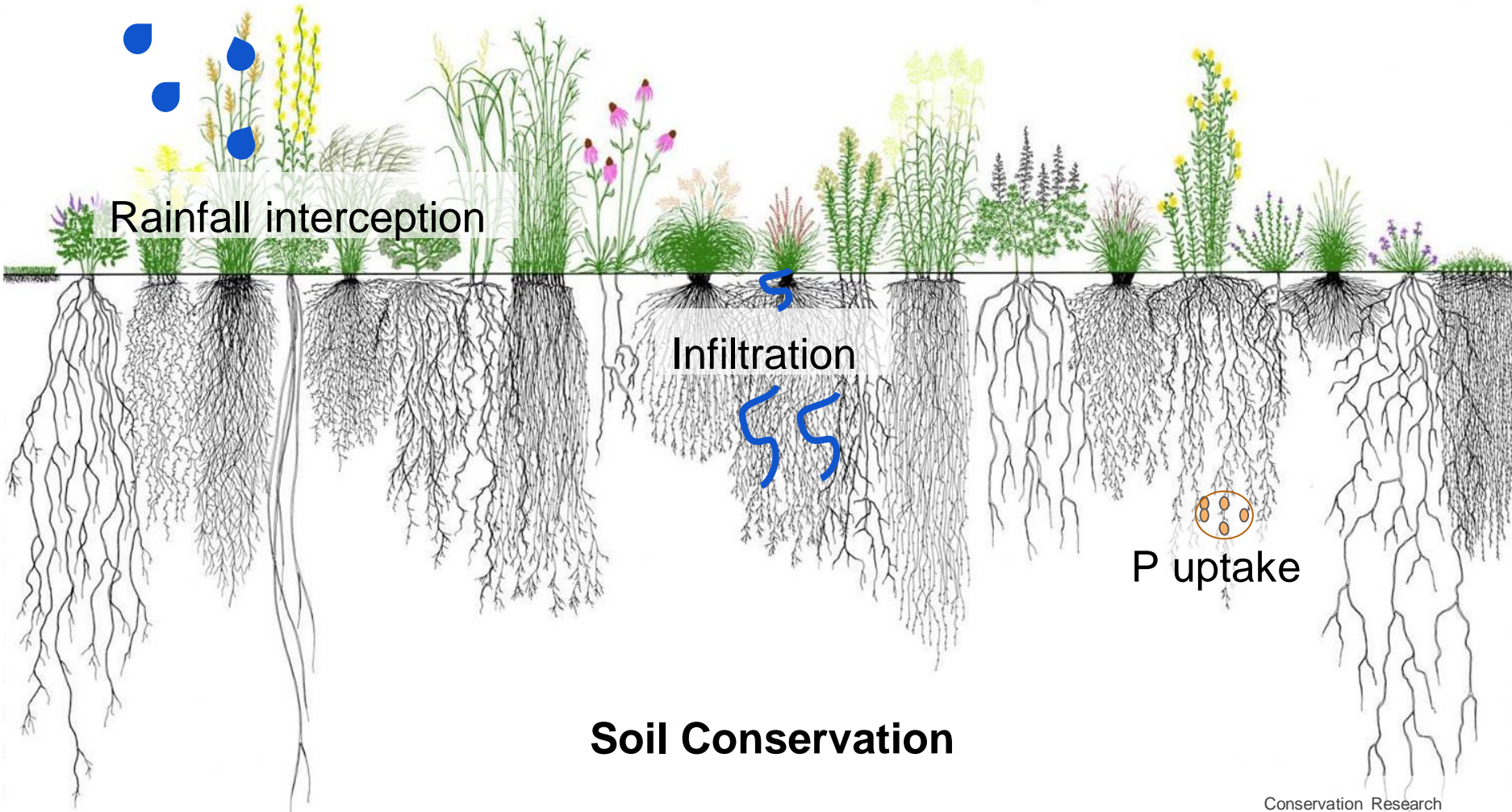
- Baseline
- 10%
- 25%
- 50%

3 tier approach

- Marginal land (4-8)
- 5% of cropland
Incorporate level 3
 - 27% of cropland
Incorporate level 2
 - 92.5% of
cropland



Land cover



Rainfall interception

Infiltration

P uptake

Soil Conservation



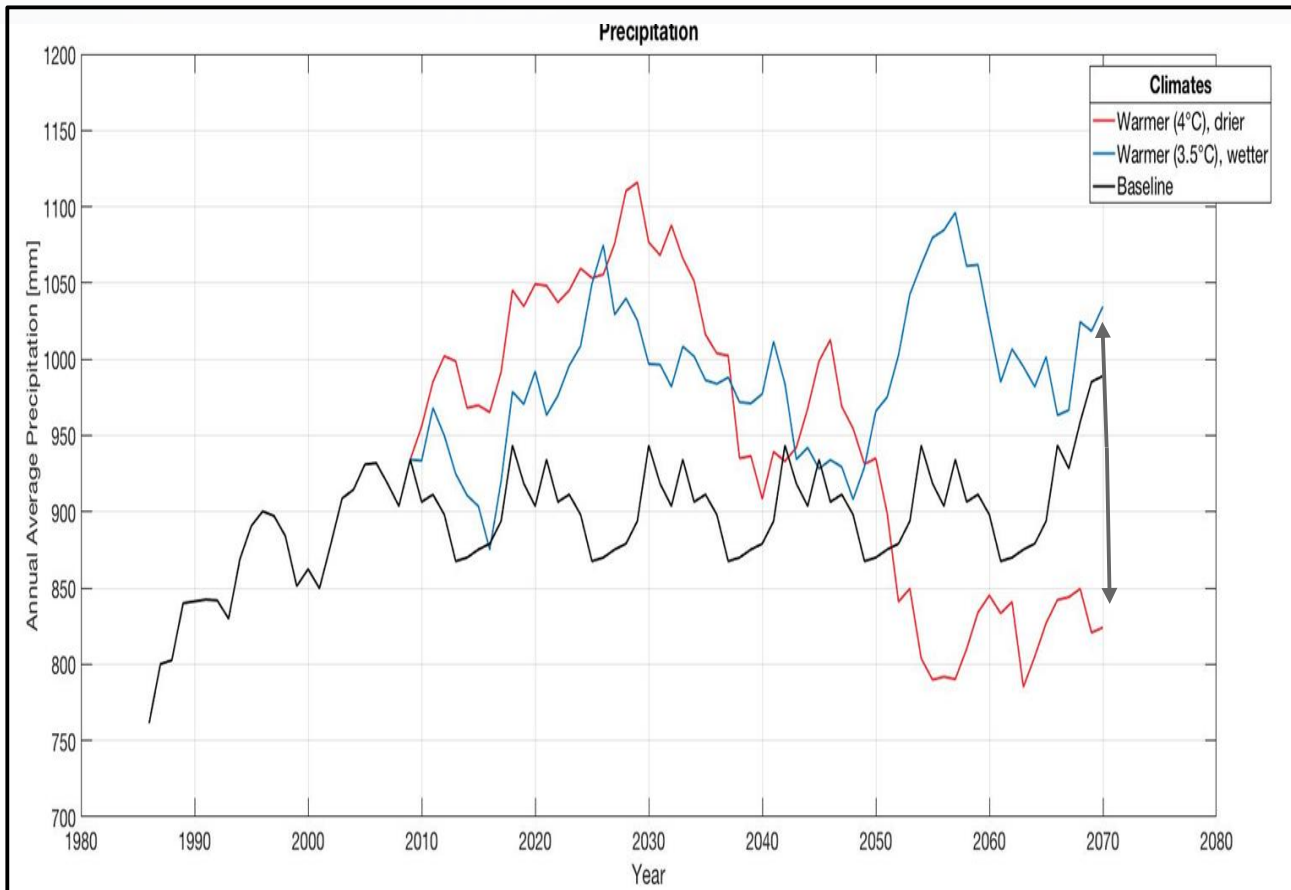
Reducing Manure &
Fertilizer Application
(N and P)

- 0%
- 10%
- 25%
- 50%

**Nutrient
Management**



Climate



Baseline:
Climate of
2004-2013
repeated



Baseline

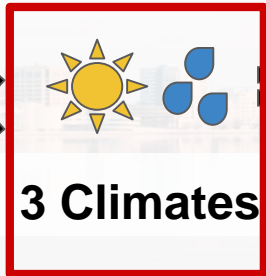
10%
25%
50%

% Perennial Cover



% N and P Reduced

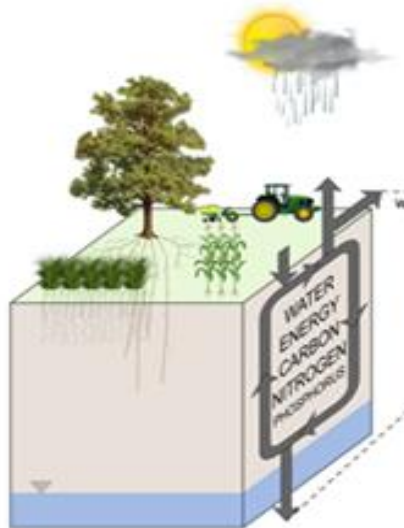
0%
10%
25%
50%
10%
0%
25%
0%
50%
0%



30 Scenarios

**30
Scenarios**

AgroIBIS
Biophysical /
Agroecosystem Model



Models drivers of change
Process based
Spatially explicit
220m by 220 m resolution

**Ecosystem
Services**

Freshwater Supply
Surface Water Quality
Groundwater Quality
Food Production
Bioenergy Production
Flood Regulation
Climate Regulation

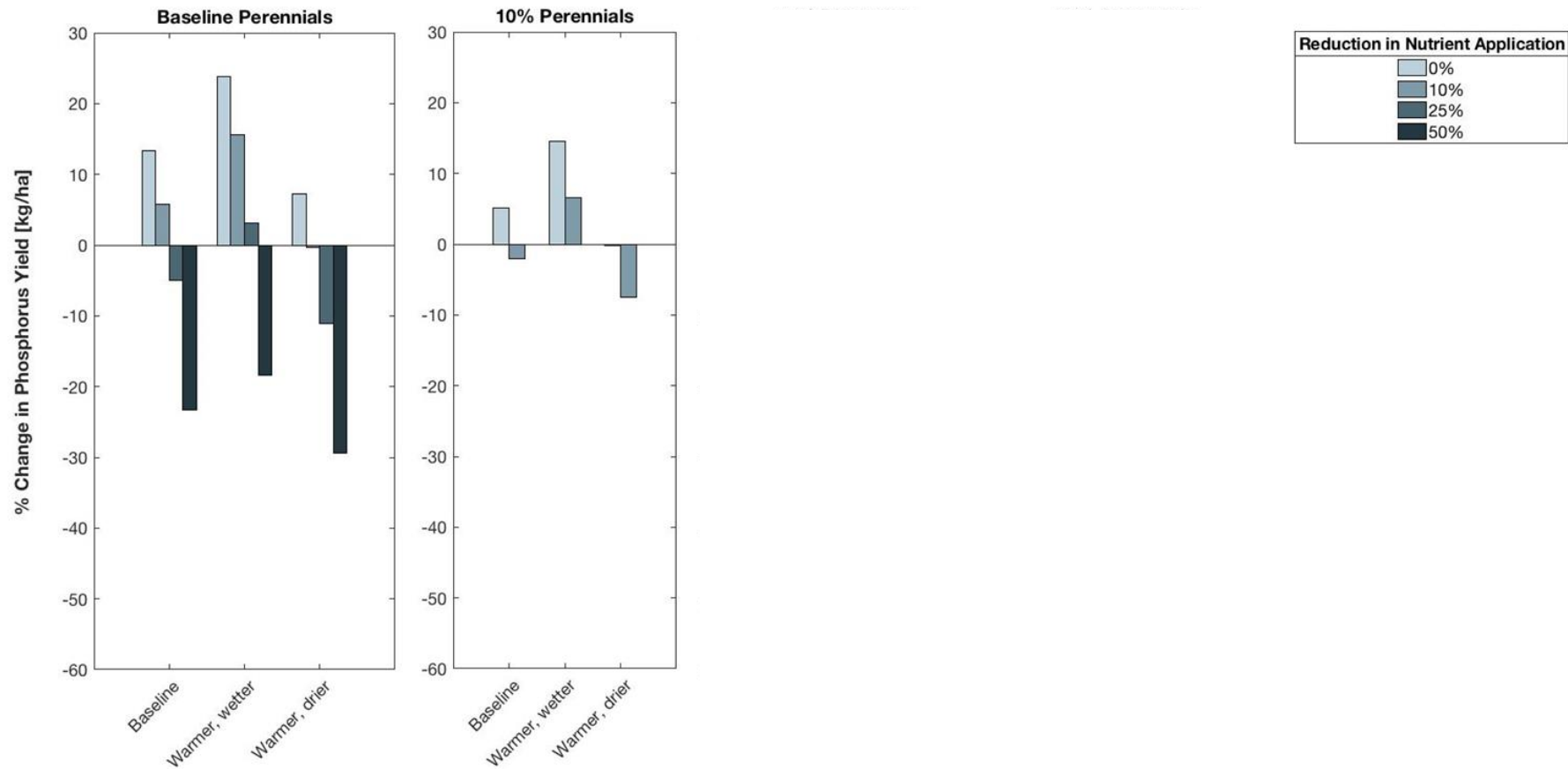
Projected to
2070

Land use / land cover
Climate and weather events
Nutrient (P and N) management

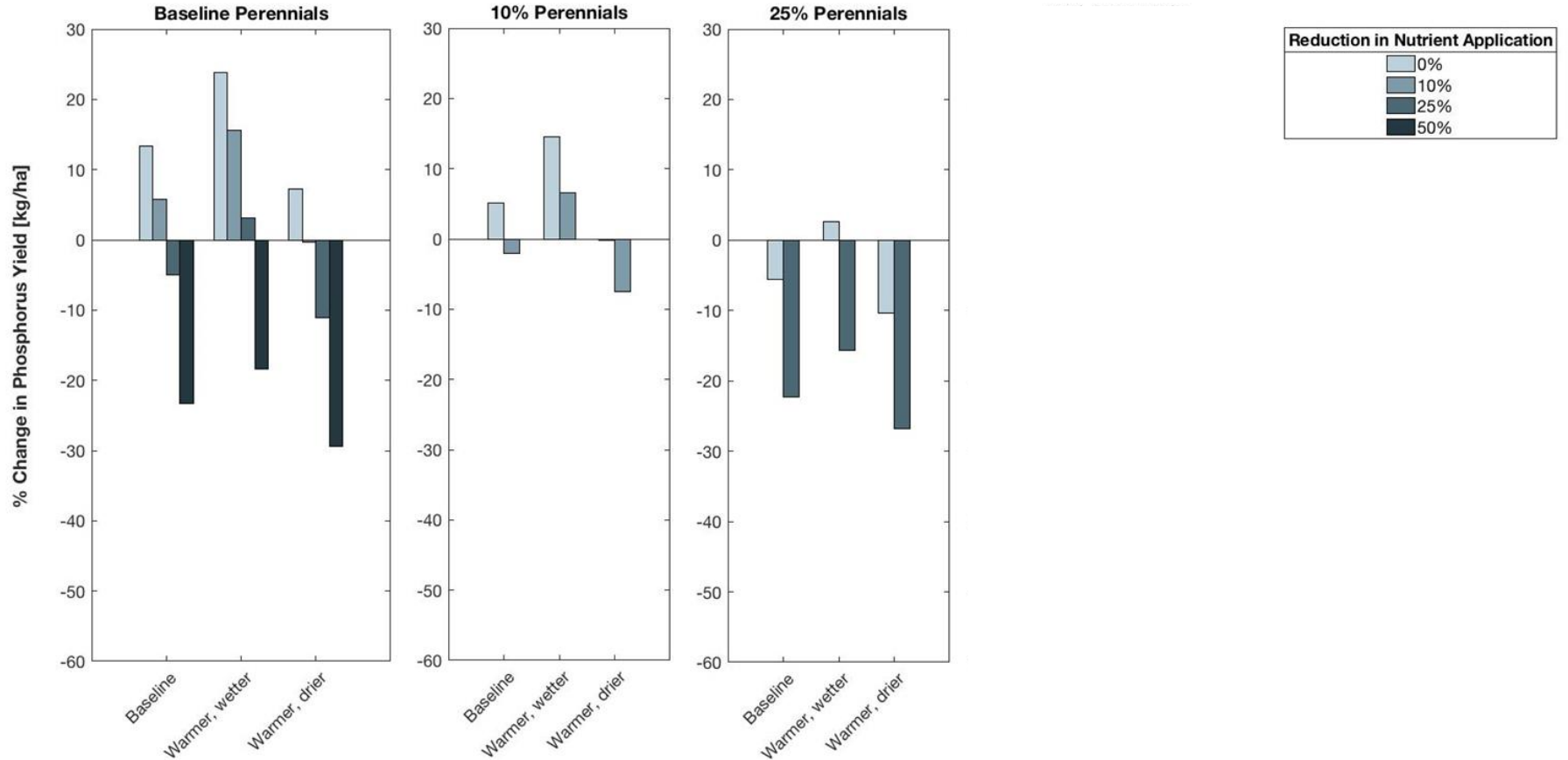
Projected Change in Watershed Average Phosphorus Yield



Projected Change in Watershed Average Phosphorus Yield

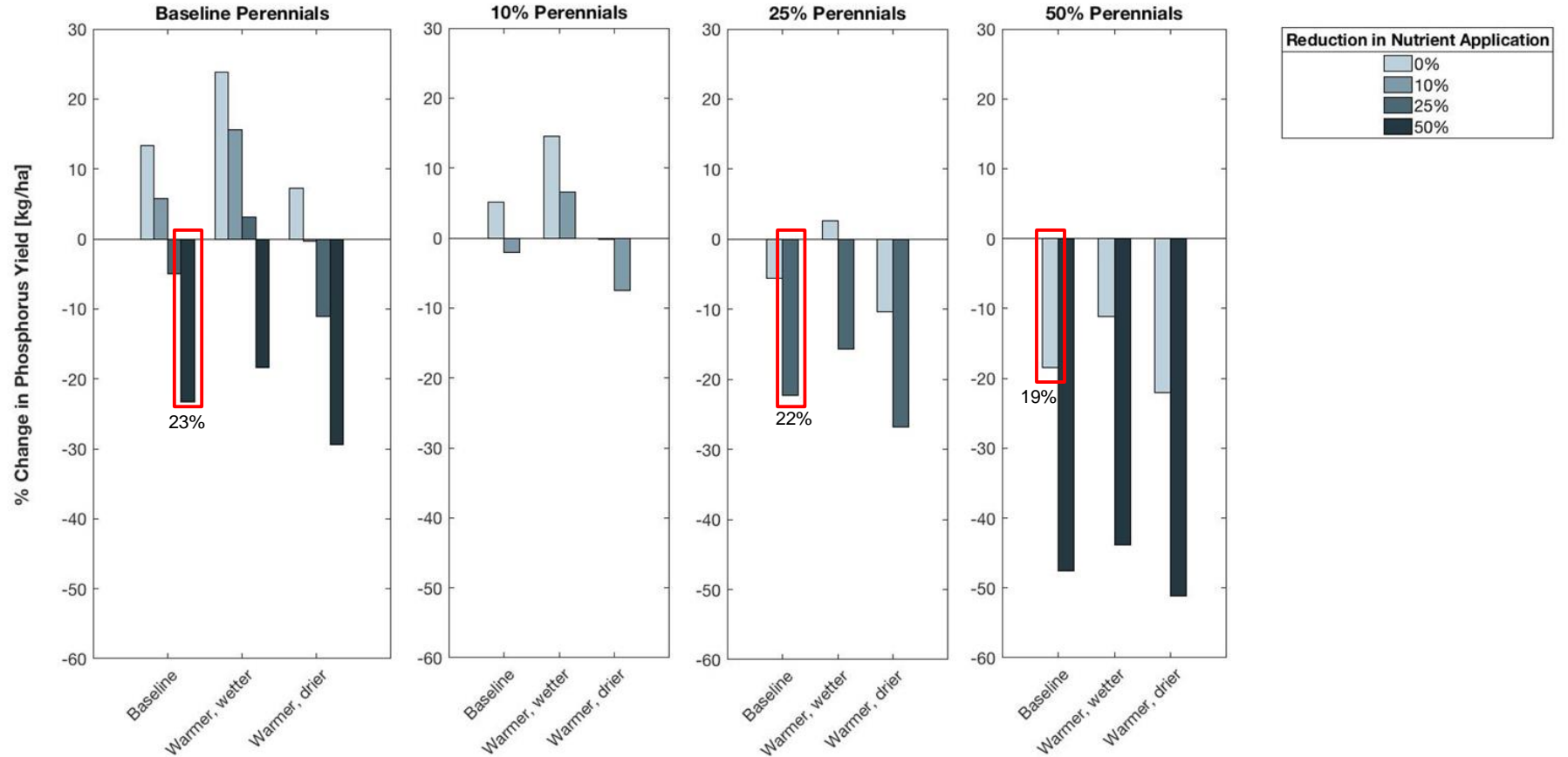


Projected Change in Watershed Average Phosphorus Yield



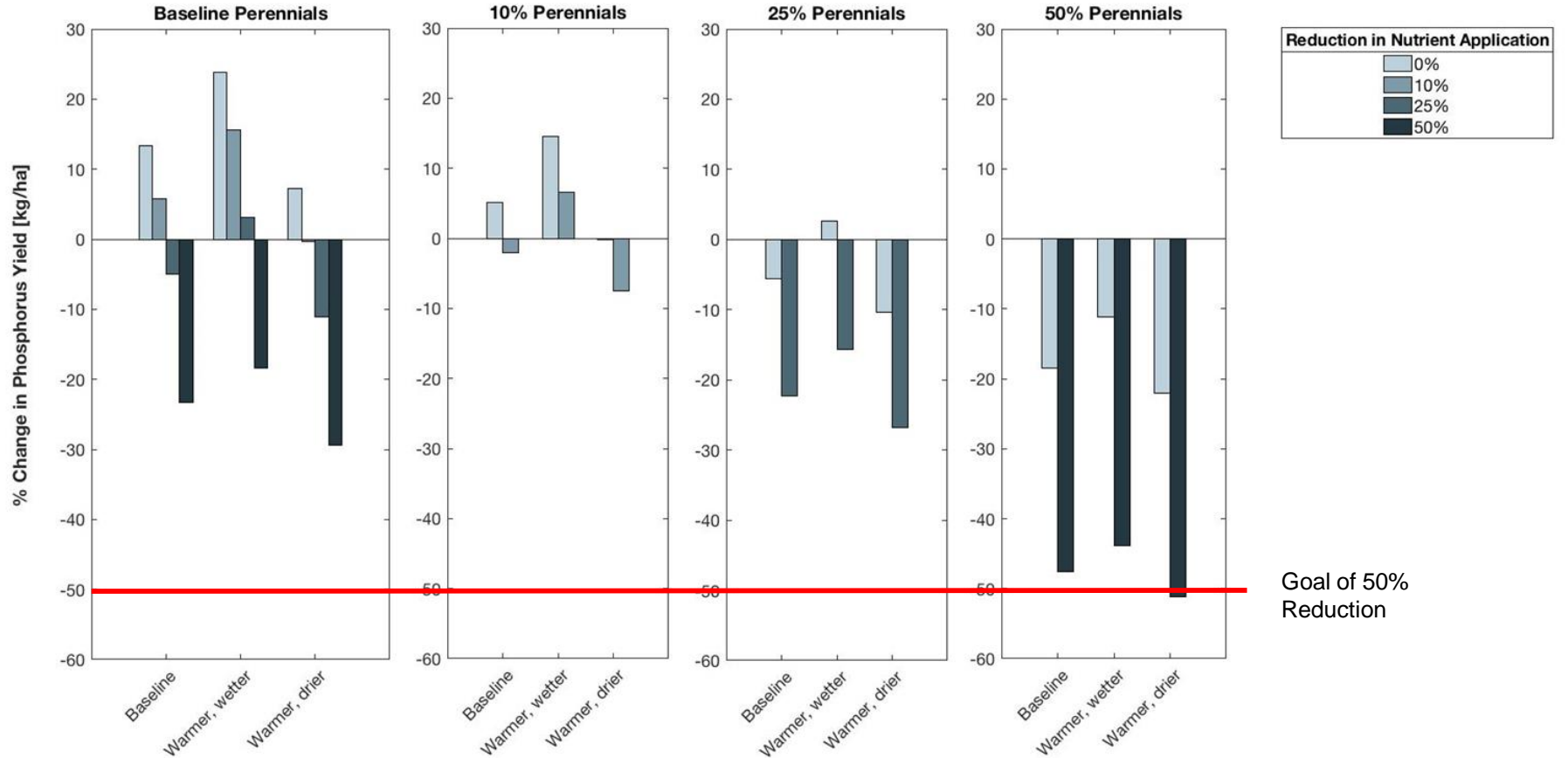
Climate

Projected Change in Watershed Average Phosphorus Yield



Climate

Projected Change in Watershed Average Phosphorus Yield



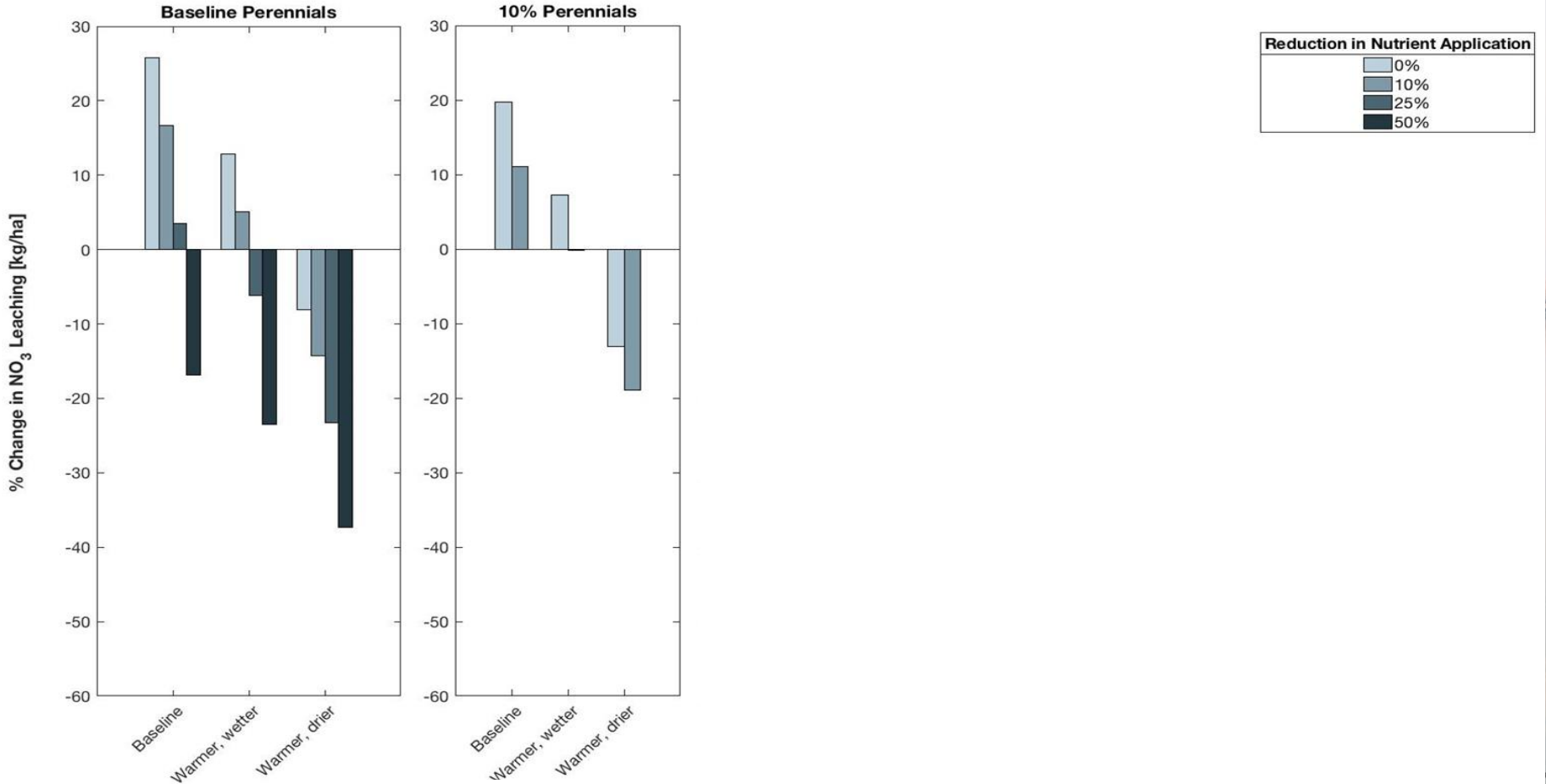
Climate

Projected Change in Watershed Average NO₃ Leaching



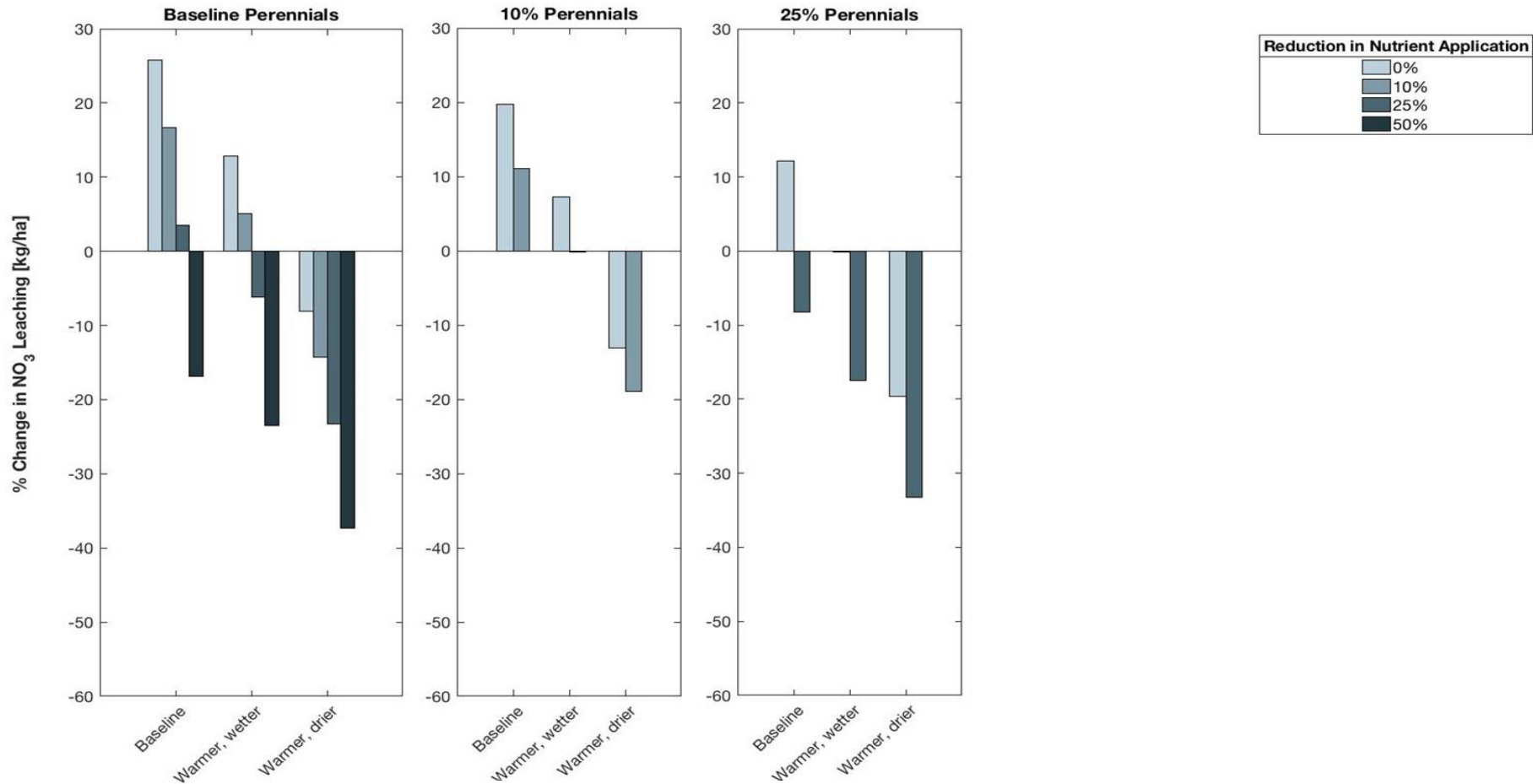
Climate

Projected Change in Watershed Average NO₃ Leaching



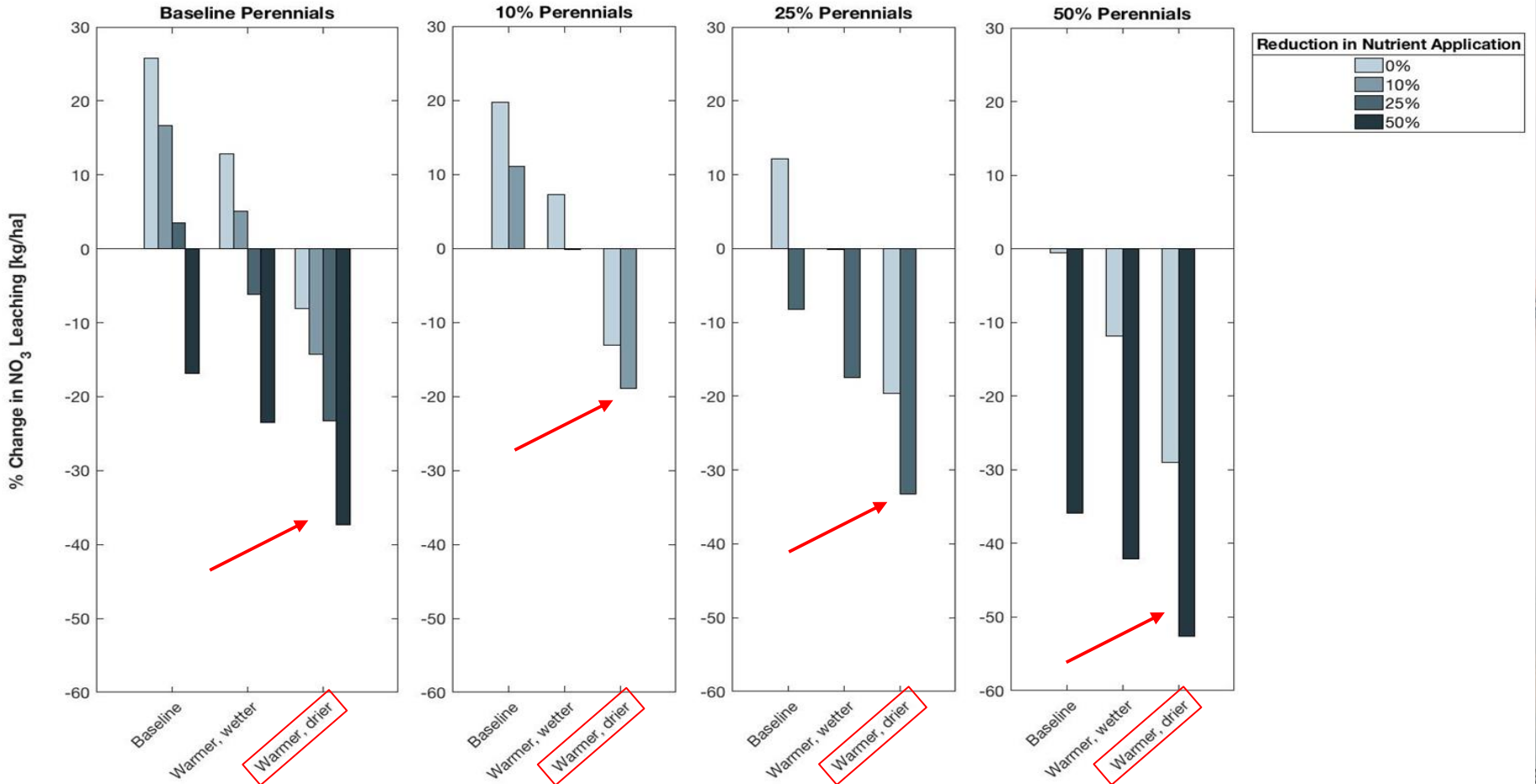
Climate

Projected Change in Watershed Average NO₃ Leaching



Climate

Projected Change in Watershed Average NO₃ Leaching

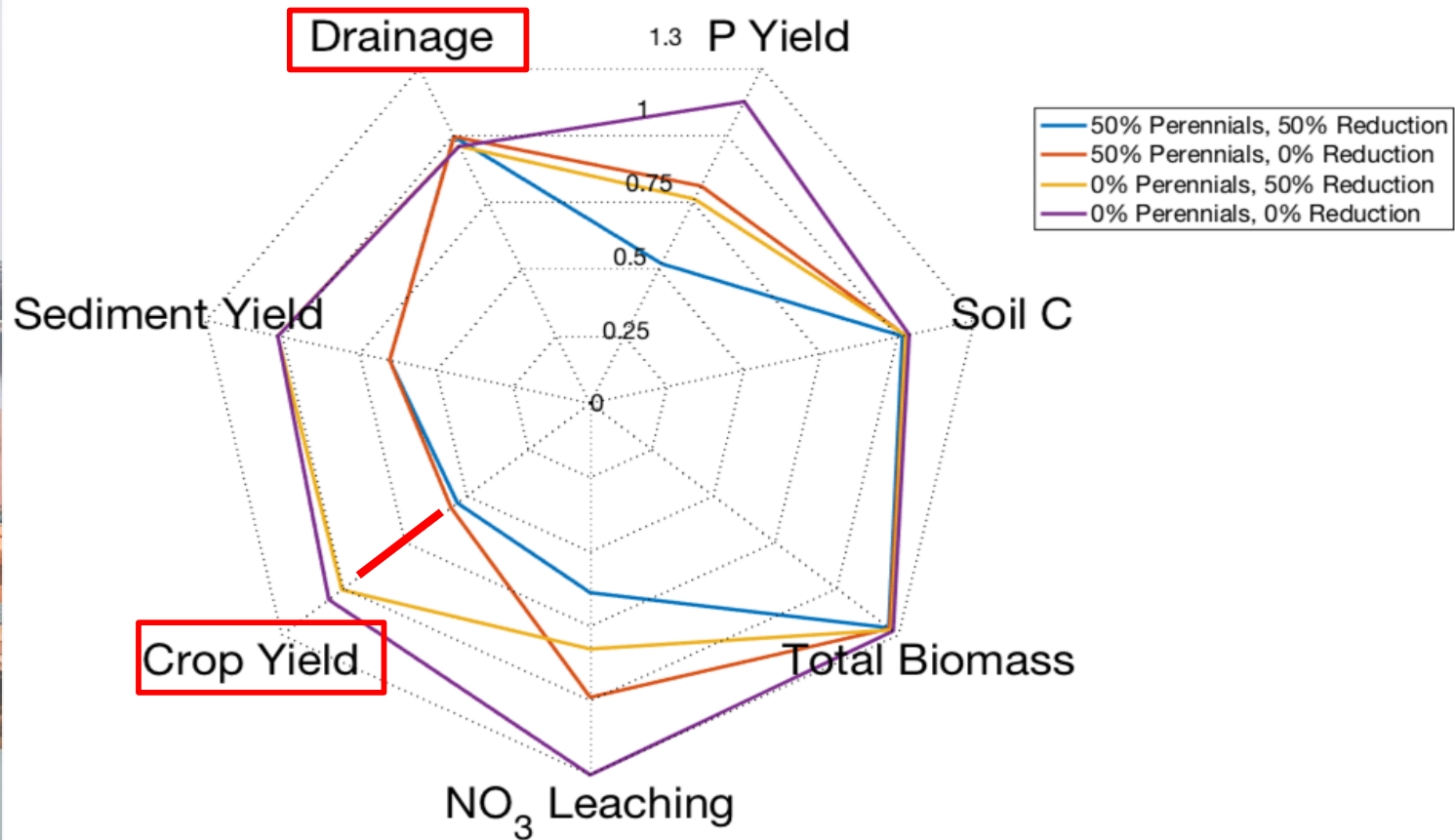


Climate

Take Home Messages

- Increasing perennial cover on the landscape results in **improvement of water quality** metrics compared to baseline scenarios
- **Coupling** increases in perennial land cover **with** reductions in manure and fertilizer application shows the most potential for mitigation
- Climate has the potential to either mitigate or exacerbate nutrient loading

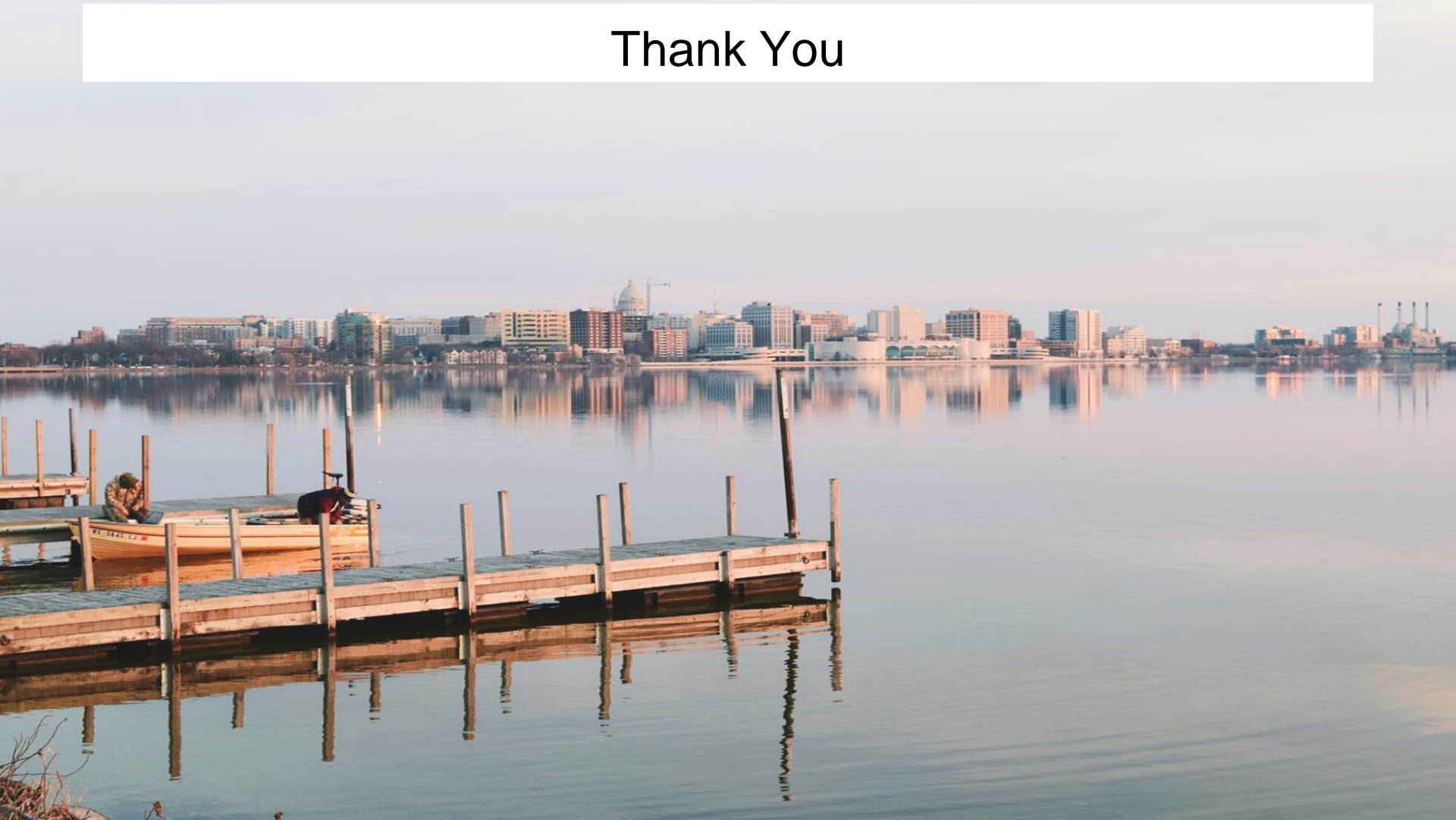
Systems Approach - Tradeoffs



Take Home Messages

- Increasing perennial cover on the landscape results in **improvement of water quality** metrics compared to baseline scenarios
- Coupling increases in perennial land cover **with** reductions in manure and fertilizer application shows the most potential for mitigation
- Improvements in water quality are possible in the next 50 years, but require **large scale management changes** - and come with tradeoffs
- Finer scale, targeted approaches + cross sector efforts may provide additional potential improvement

Thank You



Agriculturally Dominated

- ~ 50% of watershed is dedicated to agriculture
- Dairy, Corn, Soybeans dominate



Yahara River Watershed
2013 Land-Use/Land-Cover



0 2 4 8 12 16 Kilometers

