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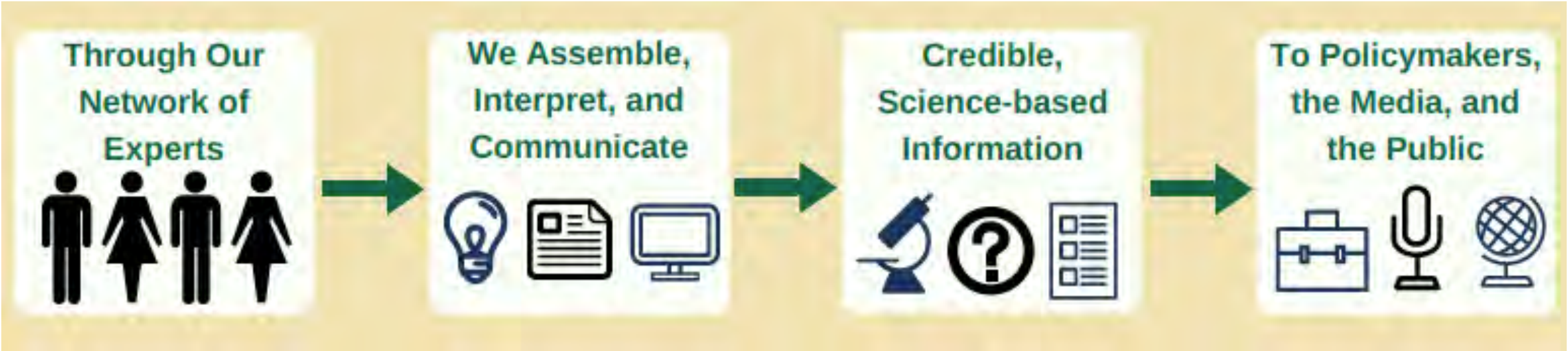

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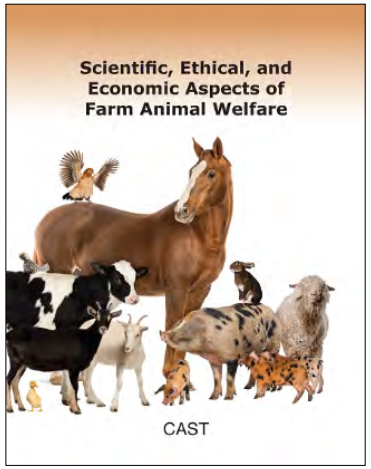

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Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape

CAST Issue Paper 64

Presented by

Heidi Peterson, Ph.D.

VP-Ag Research & Conservation, Sand County Foundation

September 2019

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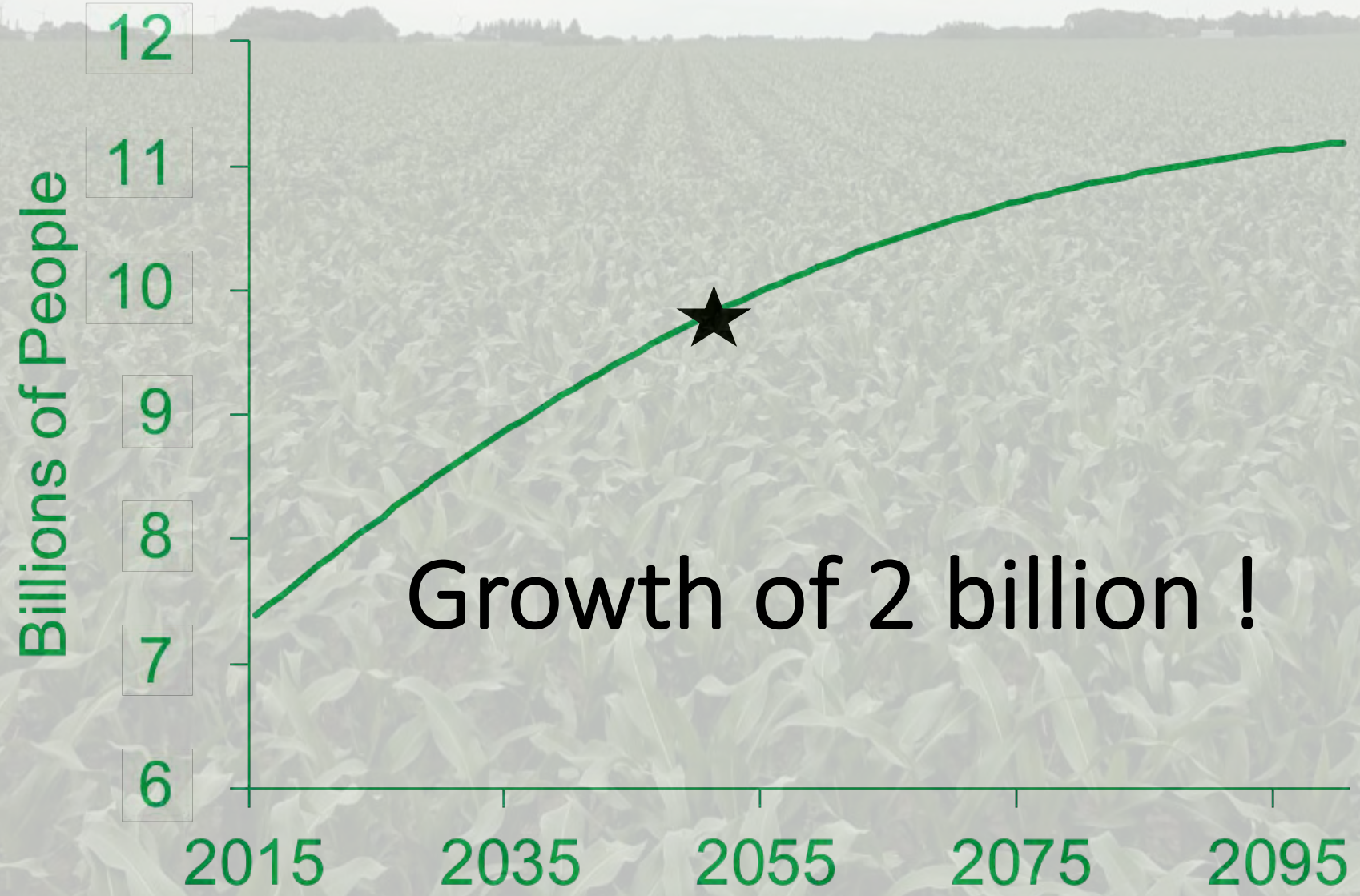
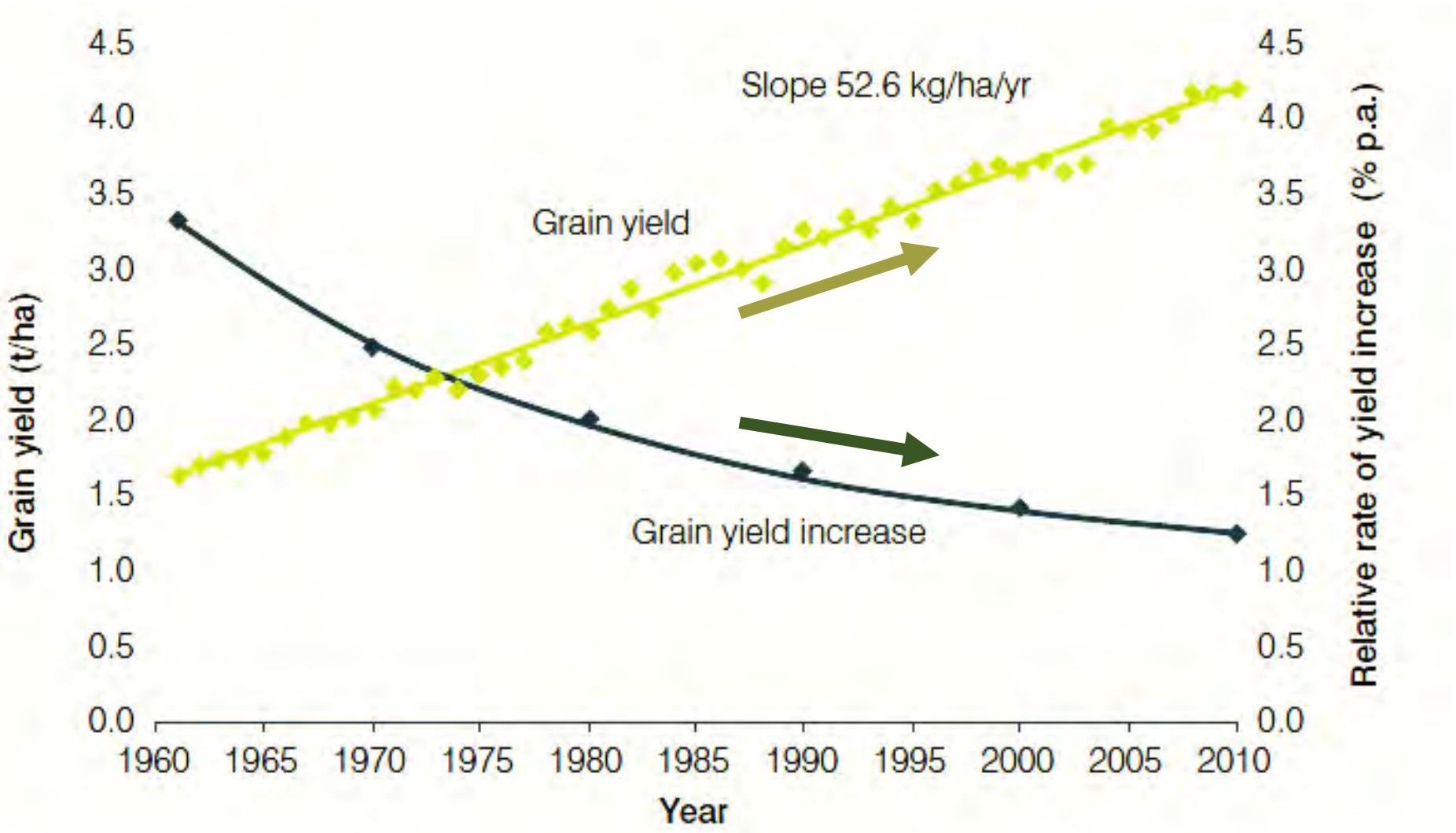
Global population >9 billion by 2050



Data Source: UN, 2017

The world needs to produce more food ….. 25-70% increase by 2050.

Source: Hunter et al. 2017 – *Using 2014 as baseline*



Source: Fischer et al. 2014 (FAOSTAT 2013)

Fertilizers increase grain yield.

Readily available organic nutrient sources alone cannot maintain current crop production levels.

Fertilizer attributes on average 40-60% of yield in the U.S.

Source: Stewart et al., 2005

'Do not drink, do not boil' water: Crisis closes out second day with little information

By **WTOL Staff** | August 4, 2014 at 1:39 AM EST - Updated July 20 at 11:25 PM

TOLEDO, OH (Toledo News
Congresswoman Marcy Kap
evening called upon the U.S
Protection Agency (USEPA

New Jersey-Size 'Dead Zone' Is Largest Ever in Gulf of Mexico

Scientists report the latest data from the Upper Gulf of Mexico, and the results aren't good.

5-year fight removes less than 1% of phosphorus from Lake Winnipeg basin

Targeted action needed against nutrient causing toxic algae blooms, scientists and advocates say

By Cameron MacLean, CBC News Posted: Sep 17, 2017 4:00 AM CT | Last Updated: Sep 17, 2017 11:02 AM CT

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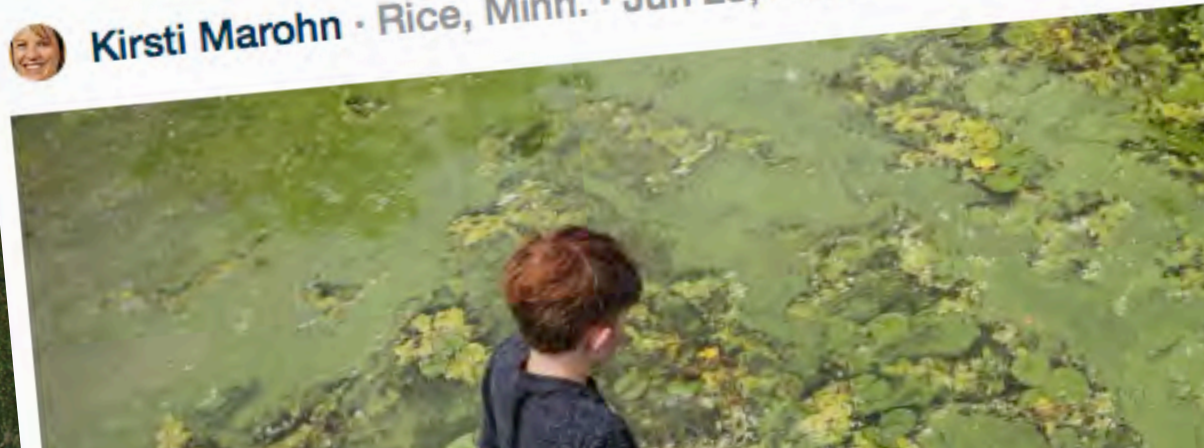
DNR plan to save algae-plagued lake s optimism, opposition

Kirsti Marohn · Rice, Minn. · Jun 28, 2018



WLEB Harmful Algae BloomGoogleEarth Oct 2011

What are the controls on nutrient loss?

Soil nutrient cycling involves four main processes:

Addition — input of nutrients to the soil system;

Translocation — movement of nutrients within the soil without changing form;

Transformation — chemical or biological conversion between chemical assemblages containing the element; and

Loss — movement of nutrients out of the soil system through the harvested grain, with water, or to the atmosphere as a gas.

Nutrient Use Efficiency (NUE)

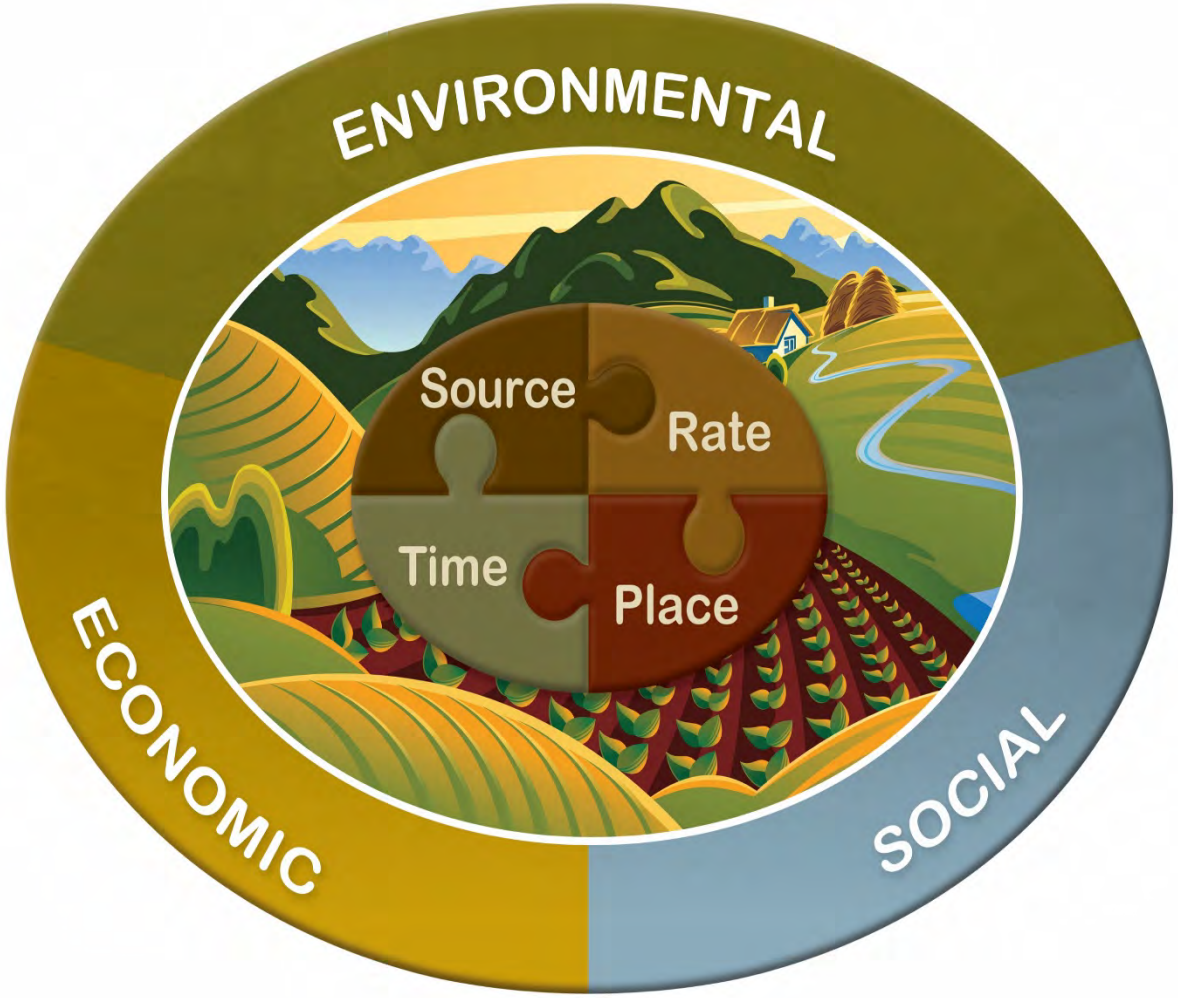
Partial Nutrient Balance

$$\text{Crop Nutrient Use Efficiency} = \frac{\text{crop nutrient removal}}{\text{applied fertilizer + manure nutrients}}$$

NUE > 1: Crops mine nutrients from soil

NUE < 1: Nutrient storage in soil

4R Nutrient Stewardship:



Right **Source** of fertilizer

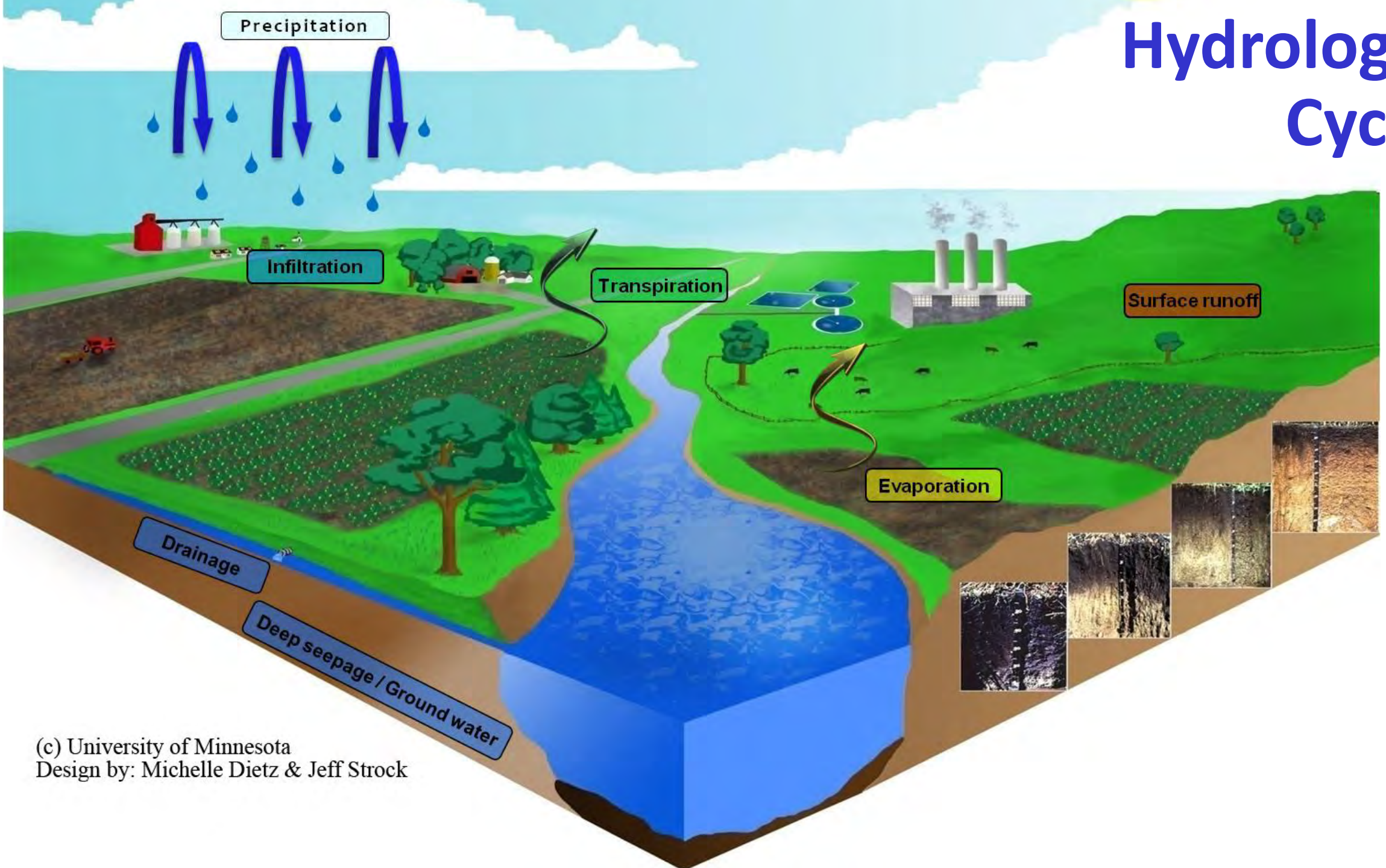
Right **Rate** for crop needs

Right **Time** to match crop uptake

Right **Place** so crops can utilize

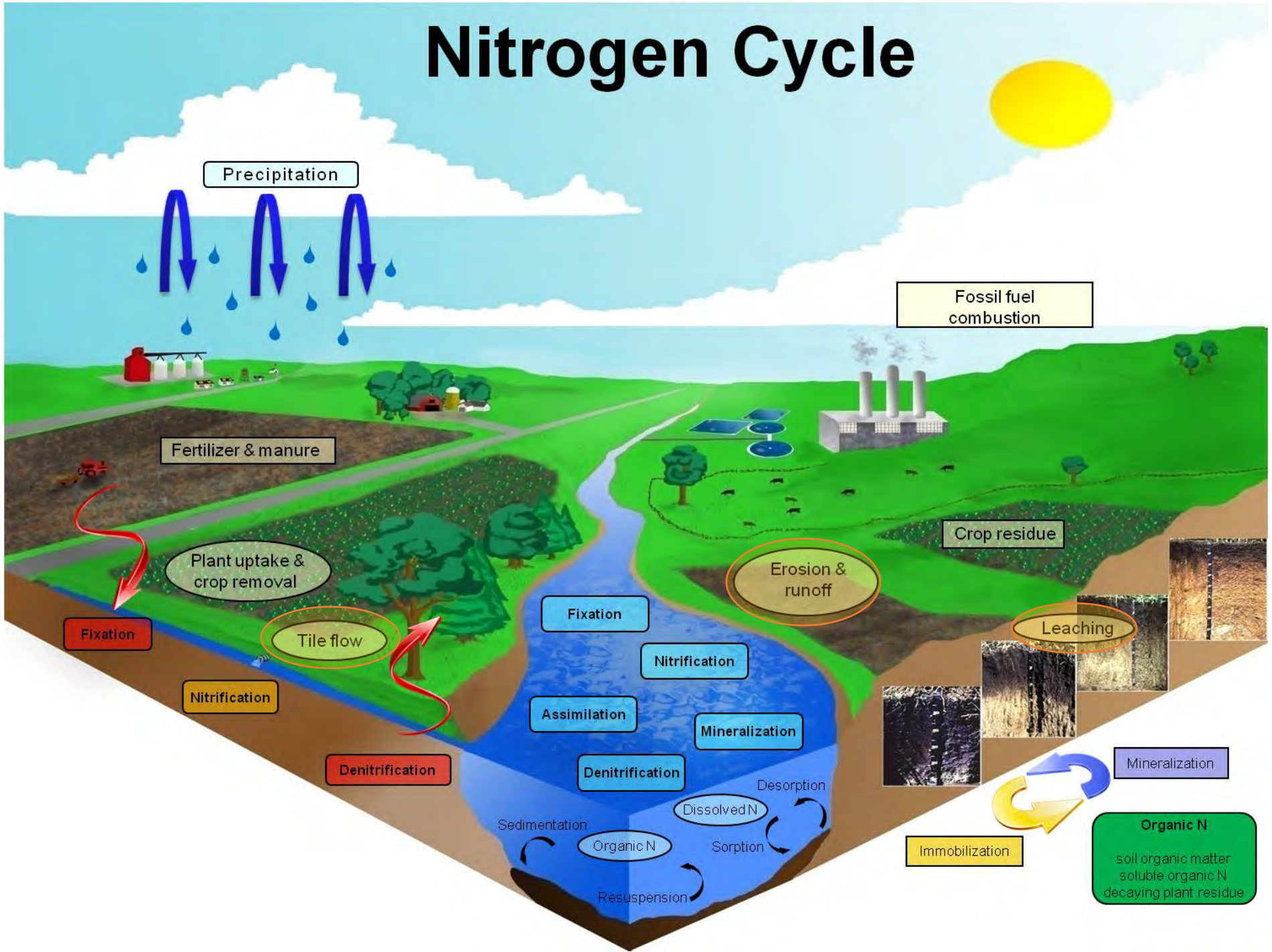
nutrient stewardship

Hydrologic Cycle

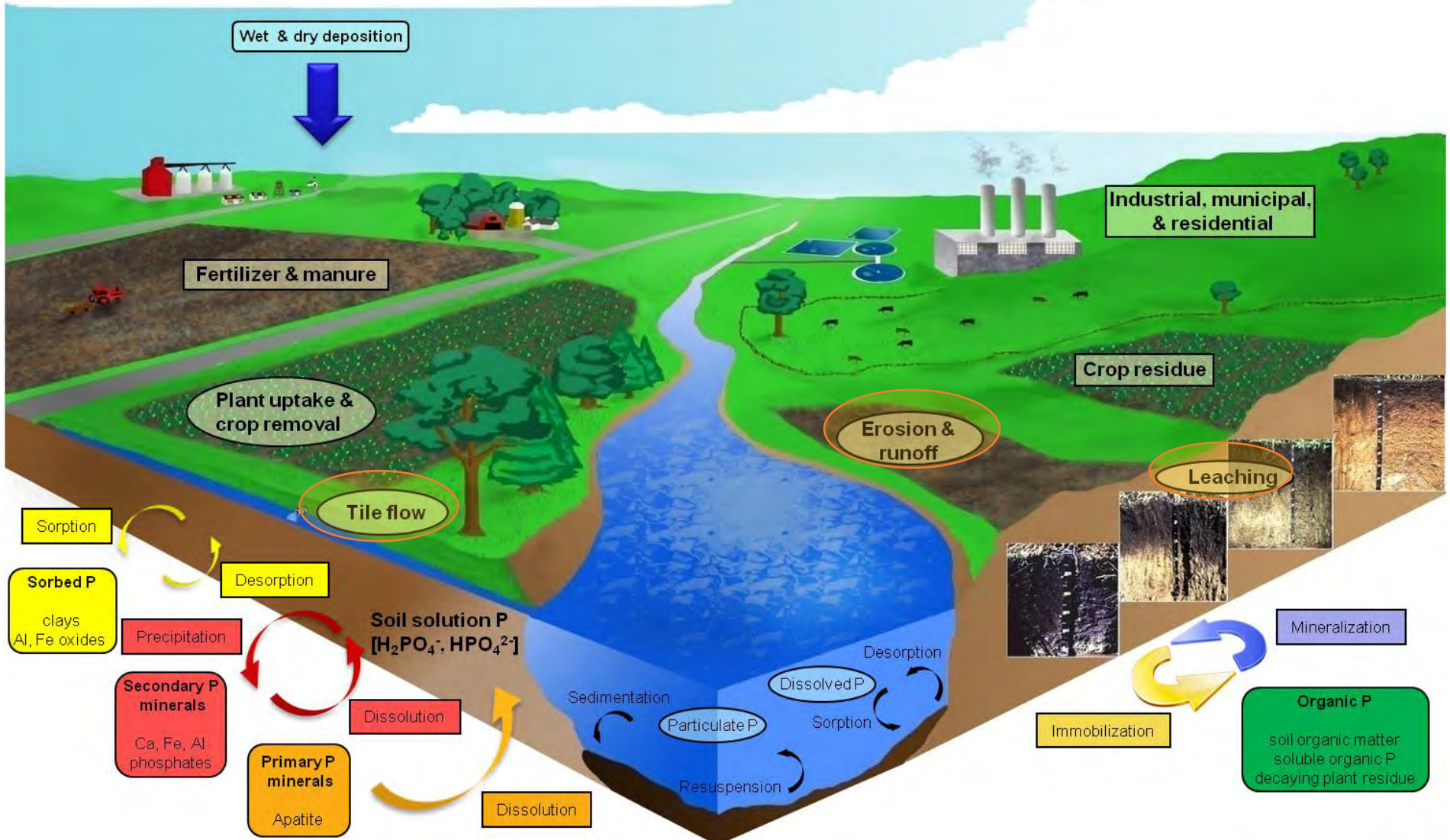


(c) University of Minnesota
Design by: Michelle Dietz & Jeff Strock

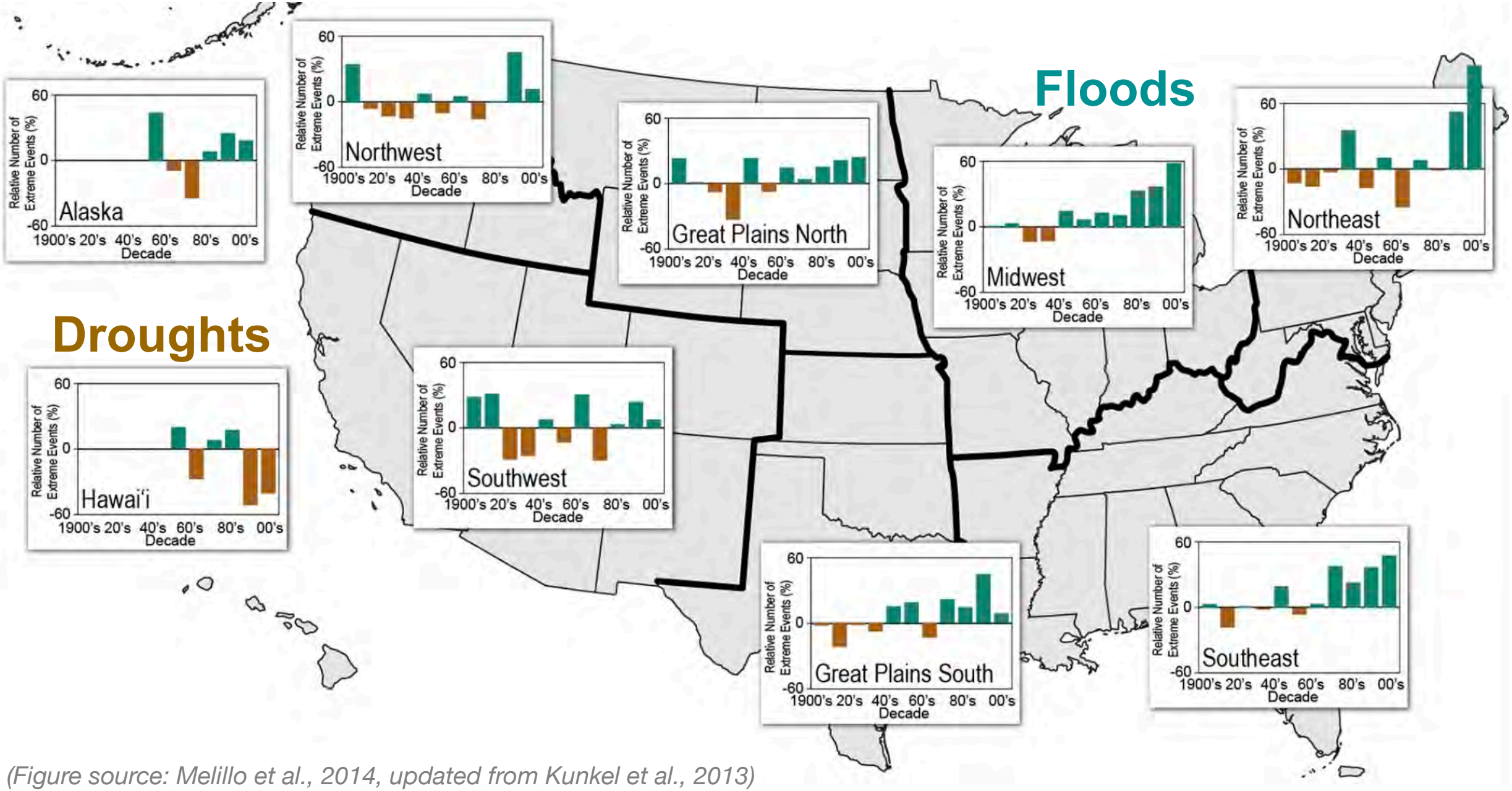
Nitrogen Cycle



Phosphorus Cycle

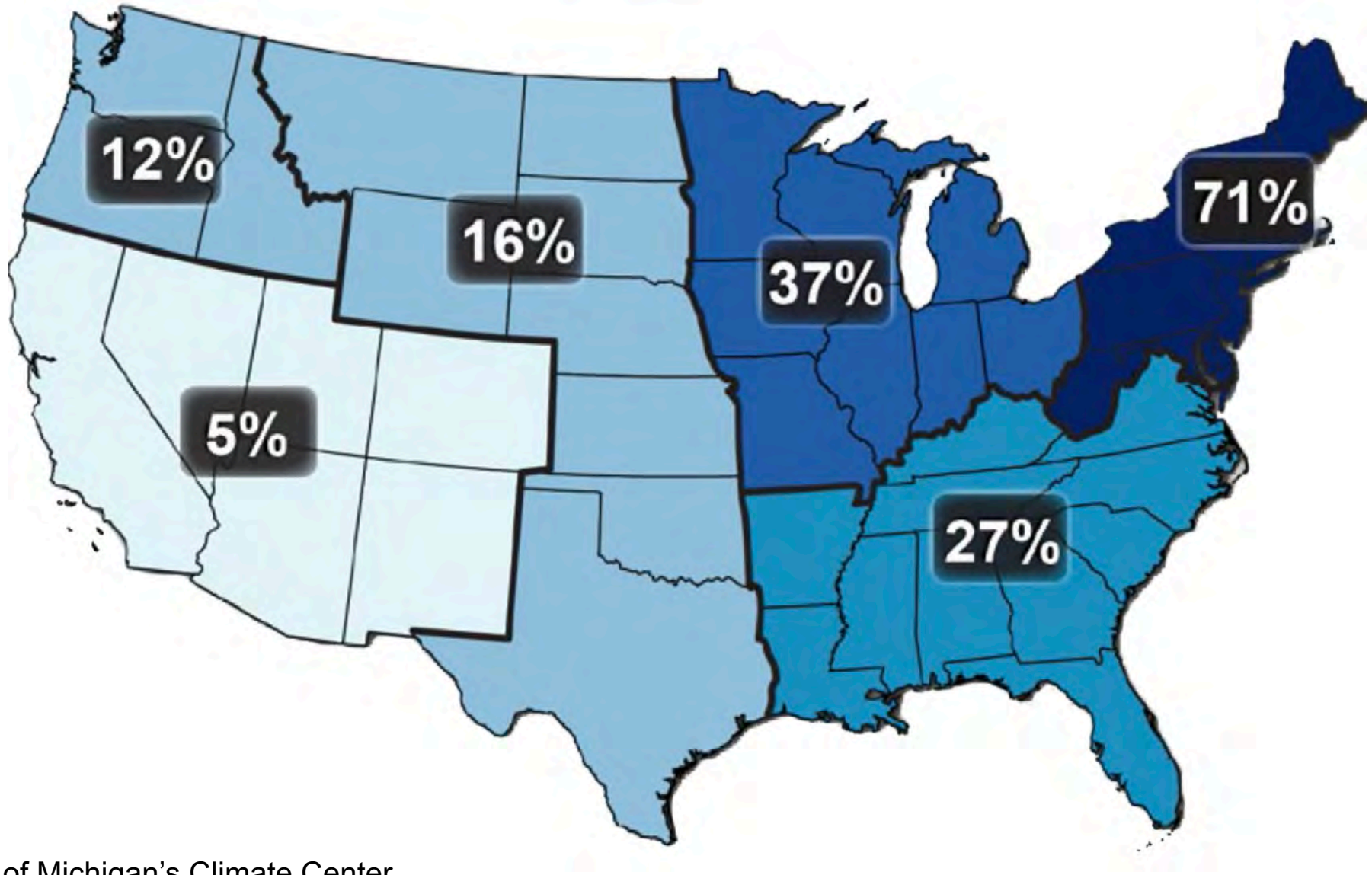


Increase in Extreme Precipitation Events



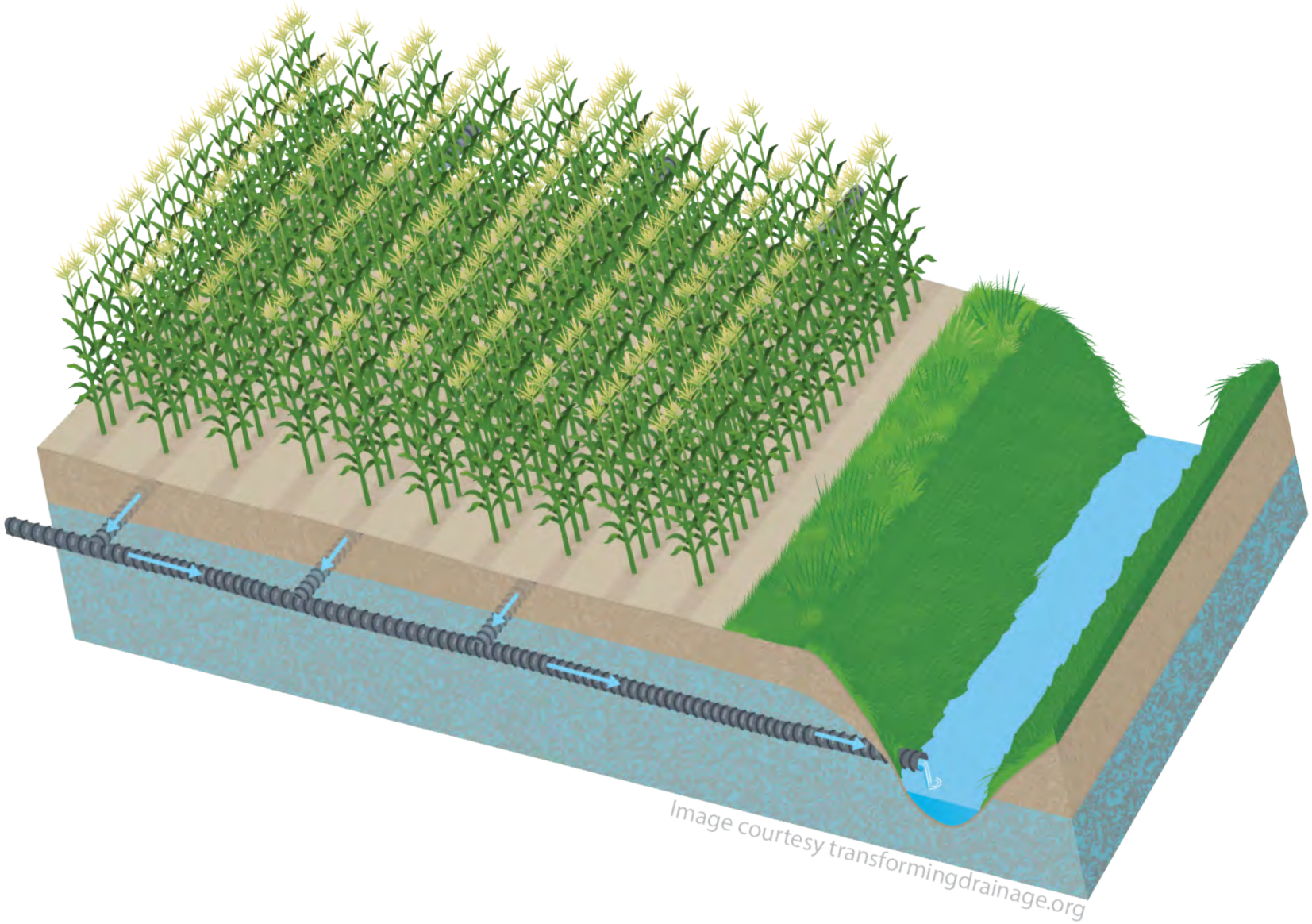
(Figure source: Melillo et al., 2014, updated from Kunkel et al., 2013)

Precipitation falling during the top 1% of severe storms increased across the U.S. between 1958 to 2012.

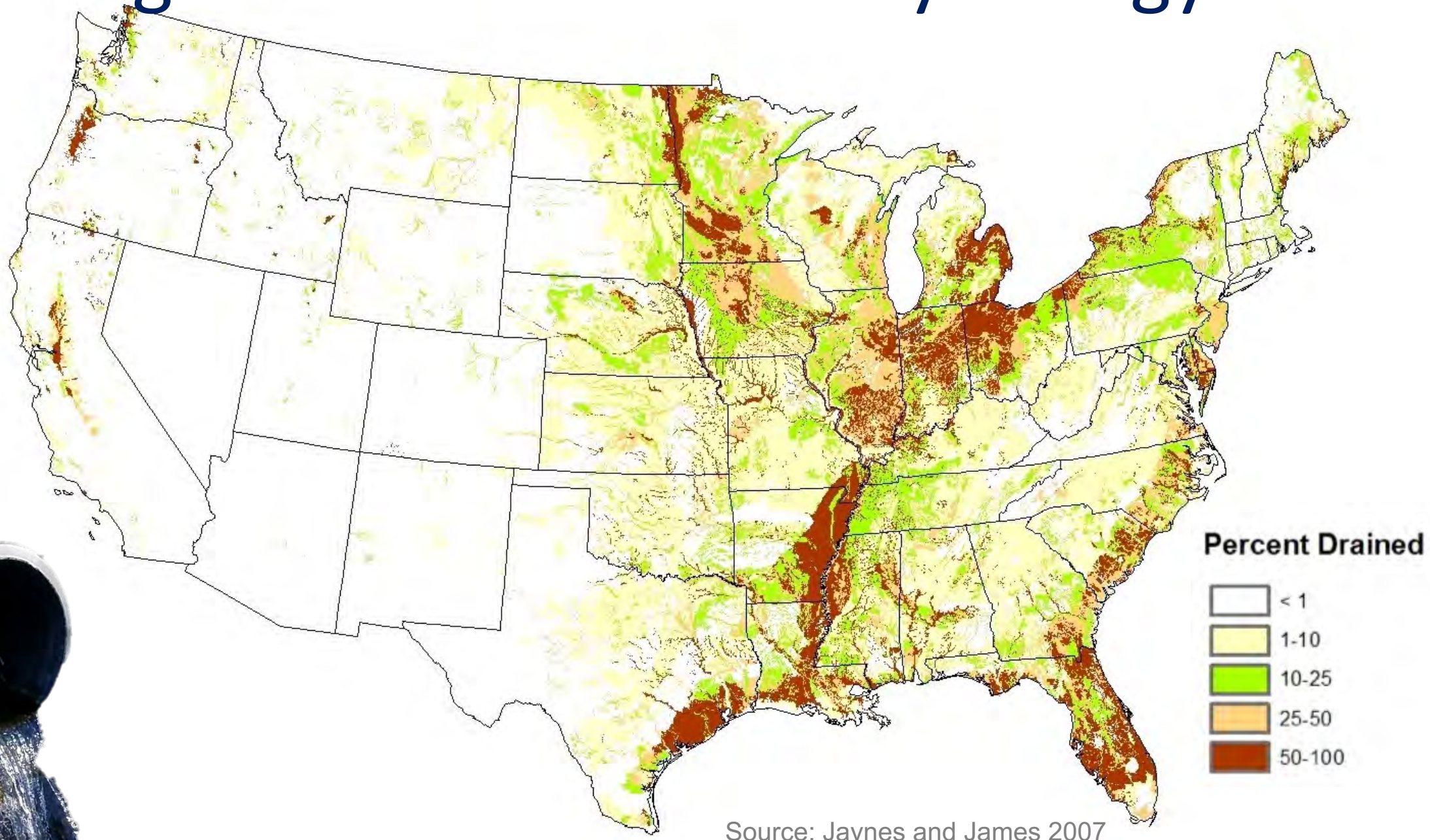


GLISA, University of Michigan's Climate Center

Artificial subsurface (tile) drainage removes excess field water.



Drainage alters the natural hydrology.



Source: Jaynes and James 2007

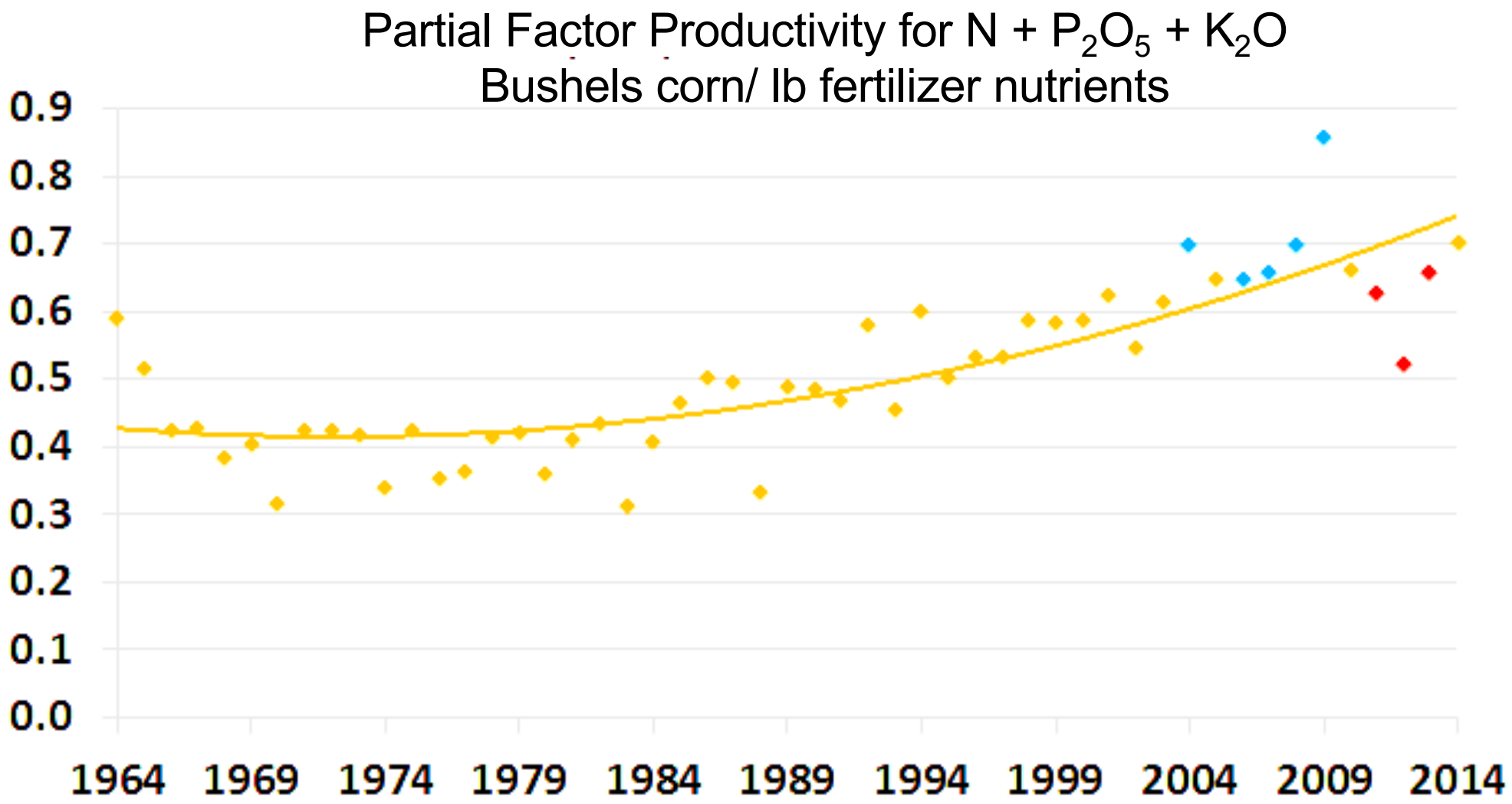
What are the challenges?

Photo courtesy A. Guentzel

Current knowledge of N and P rates is imprecise.

Photos by H.Peterson, A. Guentzel & J. Garms.

U.S. corn fertilizer use efficiency nearly doubled over last 50 years



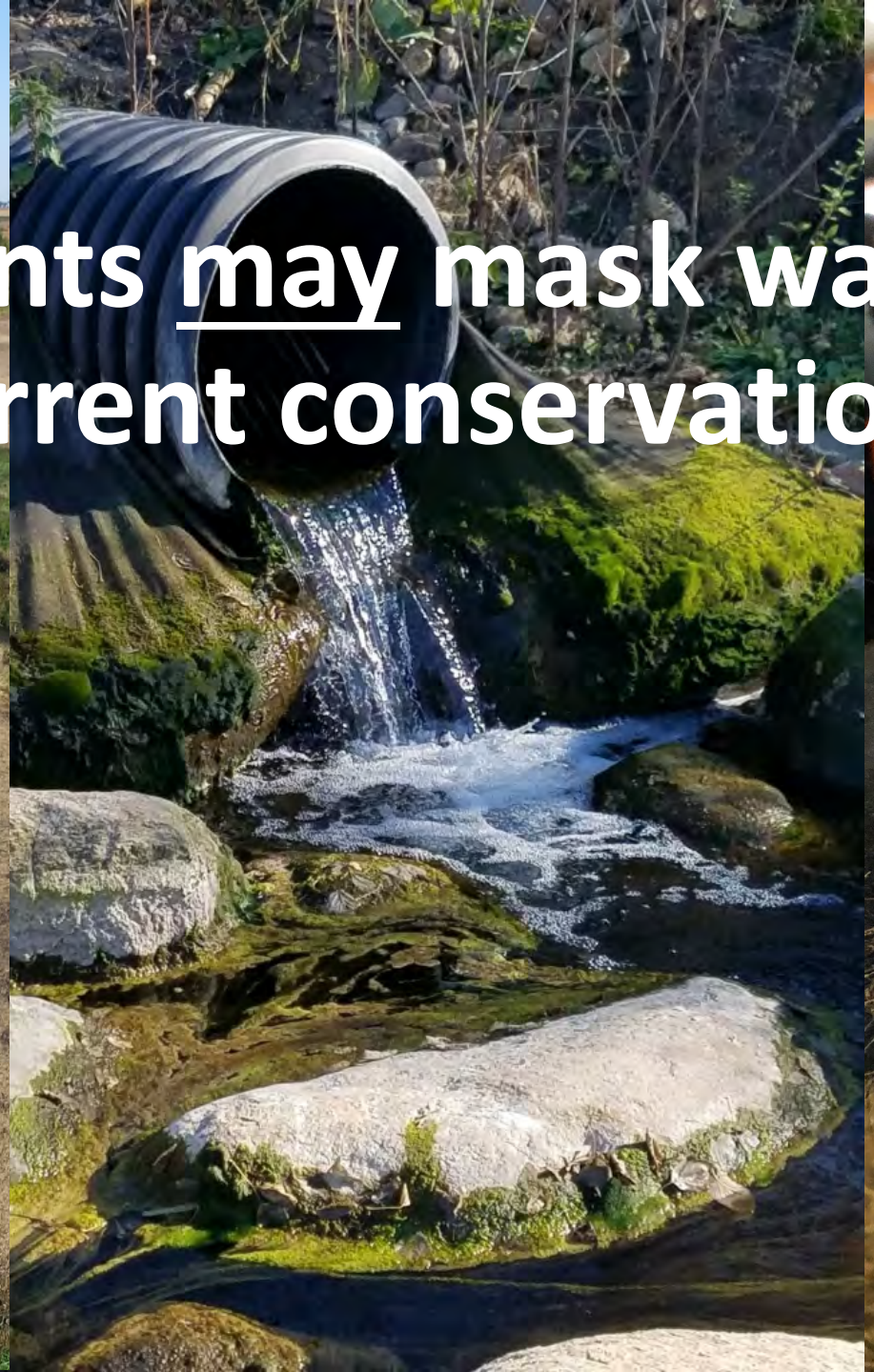
Nutrient reductions for both nutrient management and conservation practices are field specific.

<5% of the applied N and P tends to be lost in runoff

(Daniels et al. 2018; Galloway and Nustad 2017, Smith et al. 1983, Tomer et al. 2016)

NRCS/USDA Photo by L. Betts

Legacy nutrients may mask water quality impacts of current conservation efforts.



Photos by USDA, R. Derickson & H. Peterson

Most implemented conservation practices do not address dissolved nutrients.

Few conservation practices provide in-stream nutrient removal.

Conservation program success requires collaboration and cost-effective implementation.

NRCS/USDA Photo by L. Betts

Achieving agricultural water quality goals requires……

Research to better understand complex processes controlling crop nutrient requirements and losses,

New conservation practices and technologies, and

Sustainable programs engaging industry and other regional stakeholders to prioritize goals and integrate complex attitudes and constraints associated with landowner conservation adoption.

Questions/Discussion

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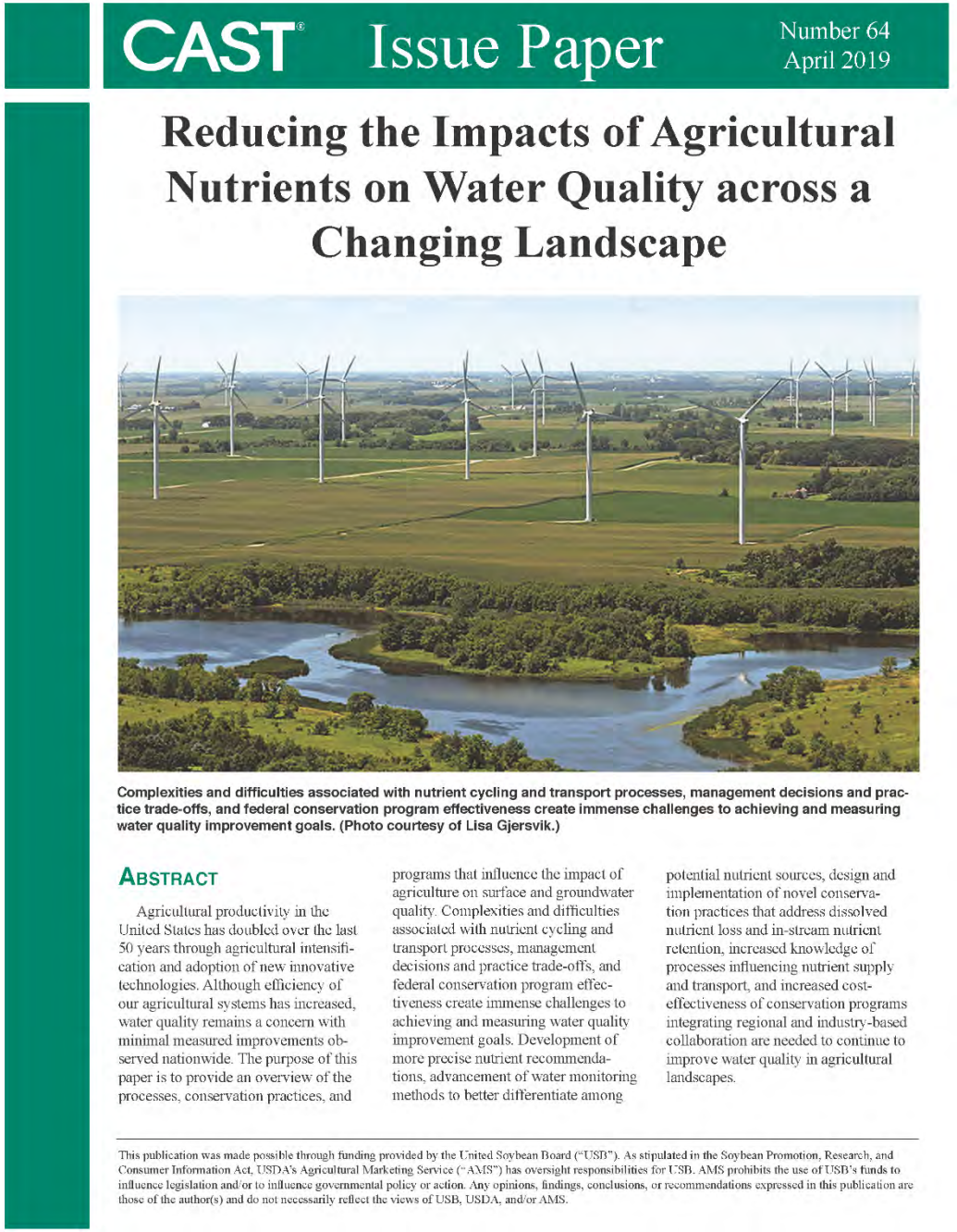

CAST® Issue Paper

Number 64
April 2019

Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape

Complexities and difficulties associated with nutrient cycling and transport processes, management decisions and practice trade-offs, and federal conservation program effectiveness create immense challenges to achieving and measuring water quality improvement goals. (Photo courtesy of Lisa Gjersvik.)

Abstract

Agricultural productivity in the United States has doubled over the last 50 years through agricultural intensification and adoption of new innovative technologies. Although efficiency of our agricultural systems has increased, water quality remains a concern with minimal measured improvements observed nationwide. The purpose of this paper is to provide an overview of the processes, conservation practices, and programs that influence the impact of agriculture on surface and groundwater quality. Complexities and difficulties associated with nutrient cycling and transport processes, management decisions and practice trade-offs, and federal conservation program effectiveness create immense challenges to achieving and measuring water quality improvement goals. Development of more precise nutrient recommendations, advancement of water monitoring methods to better differentiate among potential nutrient sources, design and implementation of novel conservation practices that address dissolved nutrient loss and in-stream nutrient retention, increased knowledge of processes influencing nutrient supply and transport, and increased cost-effectiveness of conservation programs integrating regional and industry-based collaboration are needed to continue to improve water quality in agricultural landscapes.

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