Council for Agricultural Science and Technology
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The Science Source for Food, Agricultural, and Environmental Issues
Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape

CAST Issue Paper 64

Presented by

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Global population >9 billion by 2050

Data Source: UN, 2017

Growth of 2 billion!
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
Largest Ever in Gulf of Mexico

New Jersey-size "dead zone" is

optmism, opposition

DNR plan to save algae-plagued Lake St.

5-year right removes less than 1% of phosphorus from Lake
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

Crop Nutrient = \( \frac{\text{crop nutrient removal}}{\text{applied fertilizer} + \text{manure nutrients}} \)

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
Hydrologic Cycle

(c) University of Minnesota
Design by: Michelle Dietz & Jeff Strock
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.
Artificial subsurface (tile) drainage removes excess field water.
Drainage alters the natural hydrology.
What are the challenges?
Current knowledge of N and P rates is imprecise.
U.S. corn fertilizer use efficiency nearly doubled over last 50 years

Partial Factor Productivity for $N + P_2O_5 + K_2O$
Bushels corn/ lb fertilizer nutrients
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)
Legacy nutrients may mask water quality impacts of current conservation efforts.
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.
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.
Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape

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 improved 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. Complements 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 both nutrient loss and in-stream nutrient retention, increased knowledge of processes influencing nutrient supply and transport, and increased cost-effectiveness of conservation programs integrate regional and industry-based collaborations are needed to continue to improve water quality in agricultural landscapes.

This CAST Issue Paper is available at www.cast-science.org/publications.

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