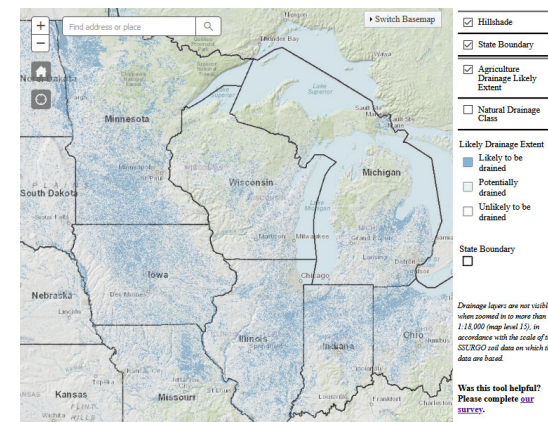


Management of Nitrogen in Tile Drained Systems

Jane Frankenberger

Professor and Extension Agricultural Engineer
Department of Agricultural & Biological Engineering
Purdue University
West Lafayette, Indiana

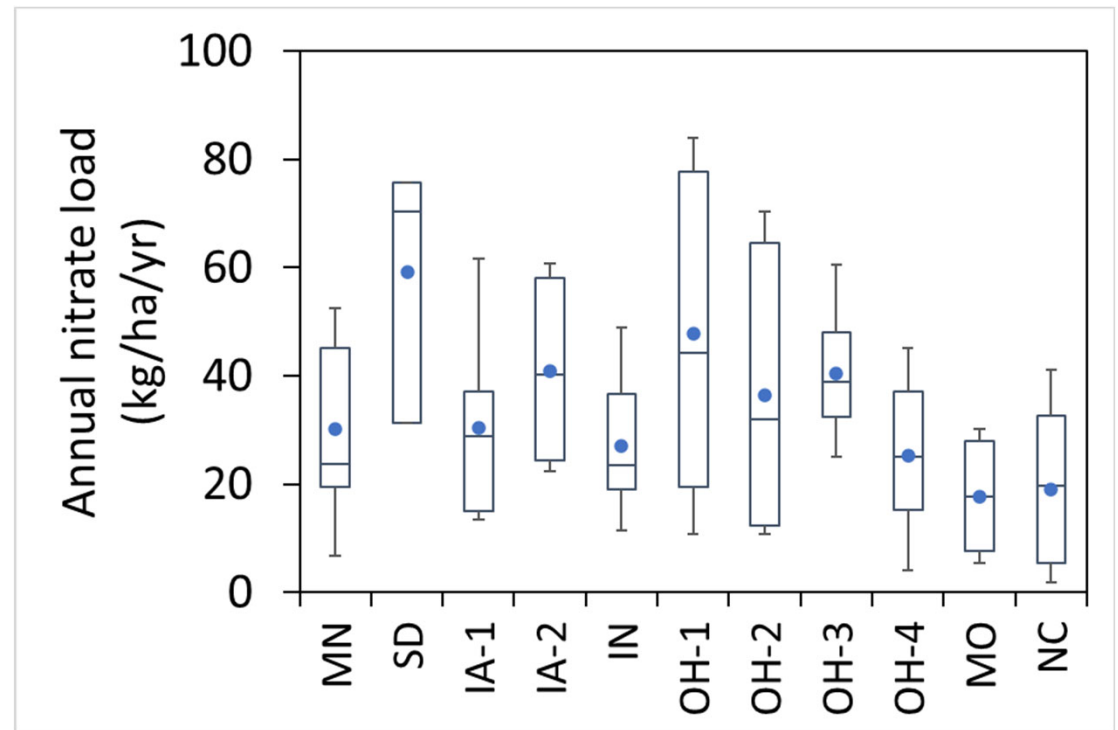
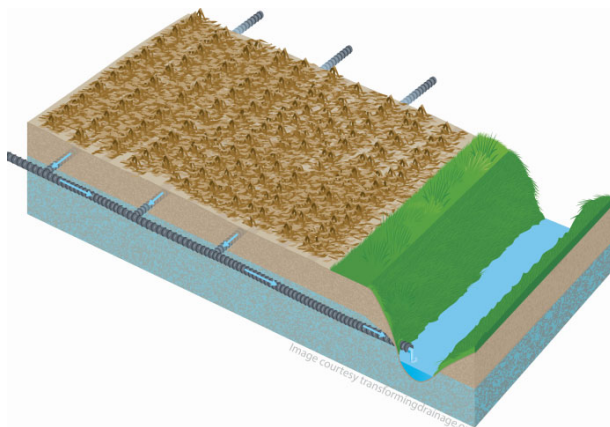


<http://transformingdrainage.org/tools>



Nitrogen losses are usually high from tile-drained systems

- At sites across the Midwest, nitrate-N loads typically 20 to 40 kg/ha/yr.
- The Transforming Drainage project has brought together data from sites across the region where innovative practices are compared.



Unpublished figure by Ben Reinhart, Transforming Drainage project

Transforming Drainage database

Chighladze, G., L.J. Abendroth, D. Herzmann, M. Helmers, L. Ahiablame, B. Allred, L. Bowling, L. Brown, N. Fausey, J. Frankenberger, D. Jaynes, X. Jia, J. Kjaersgaard, K. King, E. Klavivko, K. Nelson, L. Pease, B. Reinhart, J. Strock, M. Youssef, to be published 2021.



Opportunities for reducing nitrogen losses





Ten Ways to Reduce Nitrogen Loads from Drained Cropland in the Midwest



Nitrogen losses from subsurface (tile) drained land can cause water quality problems downstream. Reducing these losses, while maintaining agricultural productivity, is possible. Scientists and engineers have identified the ten most promising ways to reduce nitrogen loads.

The Nitrogen Cycle

There are four processes to reduce nitrogen loads from drained cropland, and various practices employ different combinations to reduce nitrogen losses. The nitrogen cycle is complex because nitrogen exists in many forms and can easily change from one form to another. The nitrogen processes that affect nitrogen loads in subsurface drains are the basis for how the ten strategies work to reduce nitrogen loads.

-  Reducing nitrogen sources: If less nitrogen is available in the soil, less will be lost.
-  Increasing plant uptake: If plants take up more nitrogen, particularly in the non-growing season, nitrate loads will decrease.
-  Increasing denitrification: Denitrification is the process through which microbes naturally convert nitrate in the soil or water to nitrogen gas.
-  Reducing drain flow: Practices that reduce the amount of water leaving the field will reduce nitrogen loads.

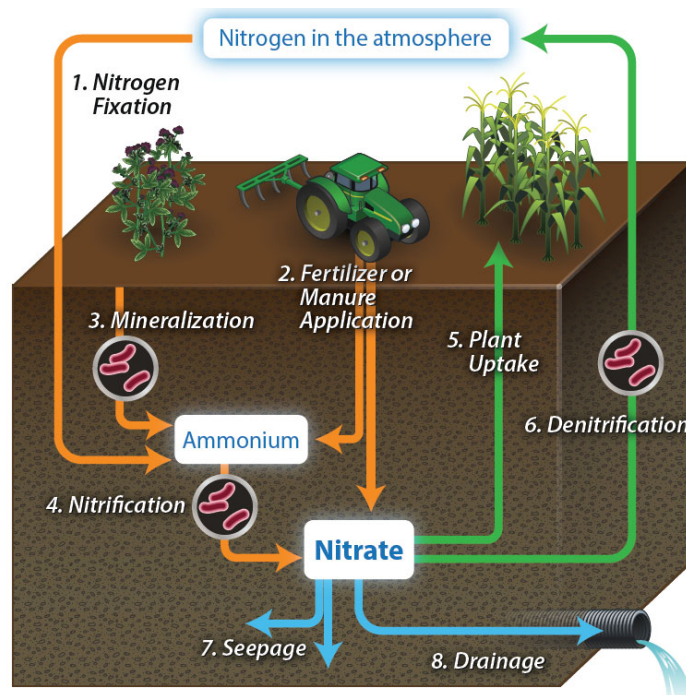
Finding the Solutions that Work for You

There is no universal approach for improving drainage water quality. Each of the *Ten Ways* provides unique features and characteristics that will be appropriate for some but not all field circumstances. Many of these practices can be used in combination, and several such combinations are very complementary (for example, use of an in-field and edge-of-field practice together).




A suite of water quality improvement approaches will be needed across the landscape to meet our water quality goals. No one practice will be suitable on every acre, but every acre needs at least one practice.

More information on reducing nitrate is available through the full *Ten Ways* booklet <http://go.acres.illinois.edu/TenWays>





Co-authors: Laura Christianson, Chris Hay, Matt Helmers, Gary Sands



Simplified nitrogen cycle in drained agricultural systems

-  Orange arrows: Inputs
-  Green arrows: Outputs to plants and air
-  Blue arrows: Outputs to water

Processes that can reduce nitrogen losses

-  Reducing nitrogen sources
-  Reducing drain flow
-  Increasing plant uptake
-  Increasing denitrification

Practices that modify the cropping system

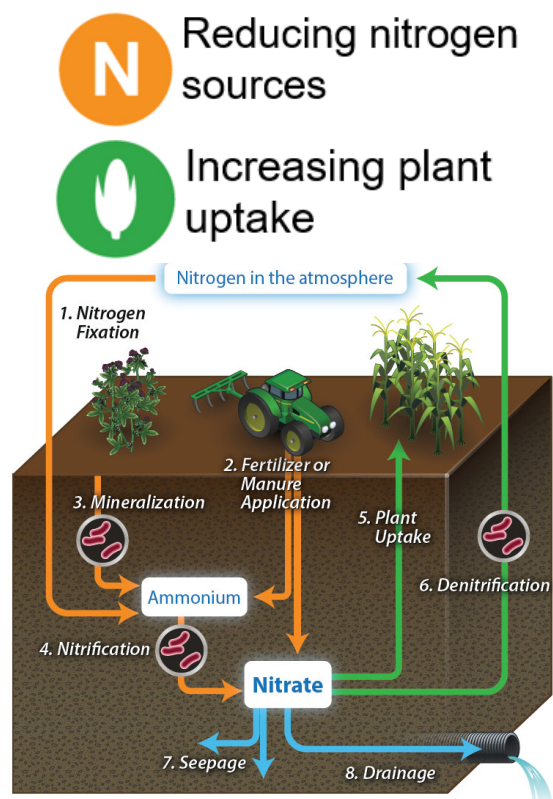
1. Improved nitrogen management

What it is

Nitrogen recommendations often given as 4Rs:

- Right source
- Right place
- Right time
 - When crop needs it (after planting)
- Right rate
 - Economically Optimum Nitrogen Rate (EONR).

How it works to reduce nitrogen loss



Adoption issues

- Economically Optimum Nitrogen Rate is likely not **environmentally** optimum.
- Current incentives maximize yield and profit, not reducing nitrogen loss.

Practices that modify the cropping system

2. Winter cover crops

What it is

Cover crops are grown after the cash crop is harvested. Goals are soil health, erosion reduction, carbon sequestration, and **nitrogen loss reduction**.



Image: NRCS

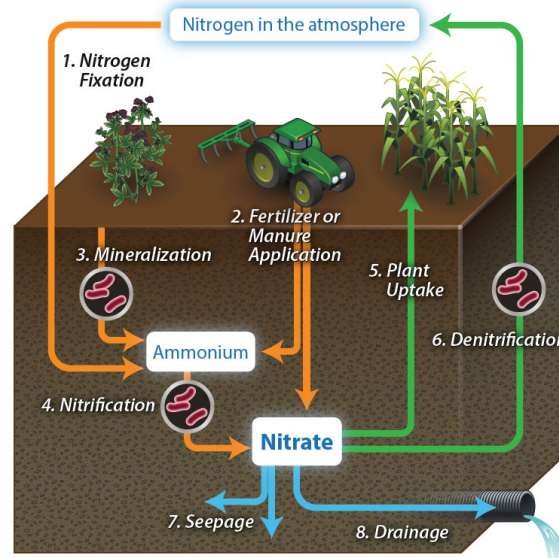
How it works to reduce nitrogen loss



Increasing plant uptake



Reducing drain flow



Adoption issues

- Added cost, effort
 - Costs of seed and planting
 - Difficulty of establishment in many years
 - Difficulty in terminating in the spring
- Strongly supported by multiple conservation programs

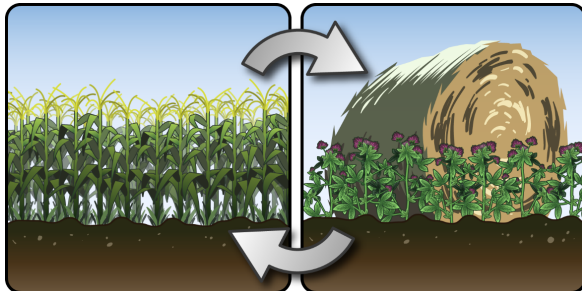
Practices that modify the cropping system

3. Add perennials to cropping systems

What it is

Perennials are plants that can grow for two or more years without re-planting.

- Grass and legumes planted for pasture
- Bioenergy crops
- Perennial grains and oil seed crops.



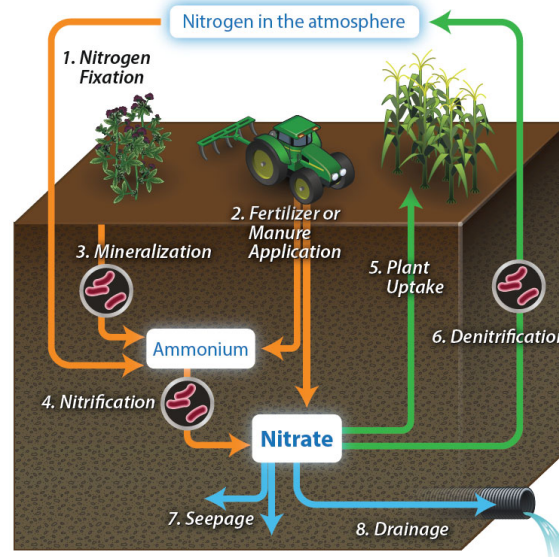
How it works to reduce nitrogen loss



Increasing plant uptake



Reducing drain flow



Adoption issues

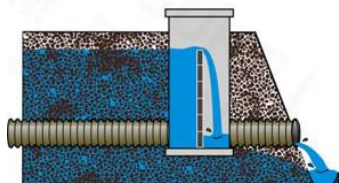
- Adoption is very limited, due to lack of markets, infrastructure, and on-farm utilization opportunities.

Practices that modify the drainage system

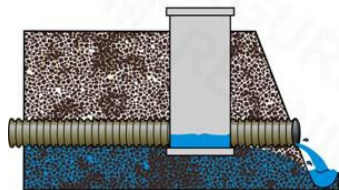
4. Controlled drainage (Drainage water management)

What it is

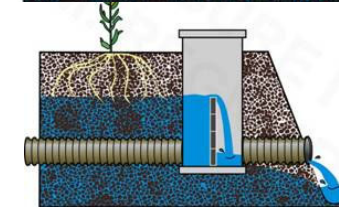
Managing drainage water using adjustable water control structures placed in the drainage system.



After harvest



Before planting or harvest

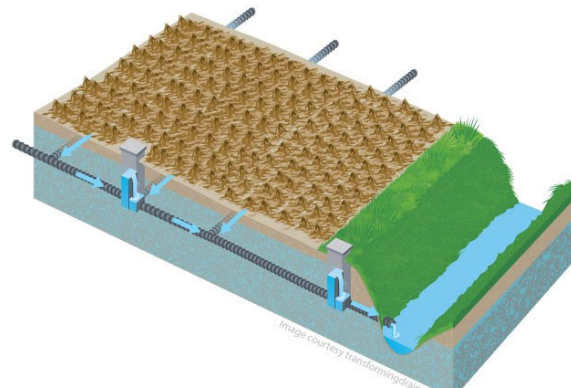


After planting

How it works to reduce nitrogen loss



Reducing drain flow



Raising the outlet level when drainage is less critical reduces drainage and nitrogen that move downstream.

Adoption issues

- Cost of installation
 - Most cost-effective on slopes $< 0.5\%$.
- Manually-operated gates require time
 - Adjustments spring and fall required for water quality benefits
 - Adjustments following wetness will benefit yield
- Automation is being developed but adds cost.

Practices that modify the drainage system

5. Reduced drainage intensity (drains with wider spacing)

What it is

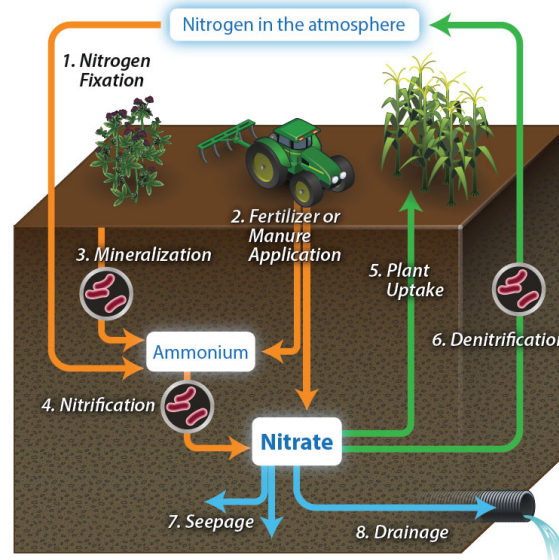
Installing drainage pipes either with wider spacing or closer to the soil surface can reduce the total water drained.



How it works to reduce nitrogen loss



Reducing drain flow



Adoption issues

- Newer drainage systems are moving in the opposite direction: Narrower spacing
- Increases in precipitation in the Midwest make narrower spacing more likely in the future.



Practices that modify the drainage system

6. Drainage water recycling

What it is

Storing drained water in a reservoir and using it as irrigation later in the season.



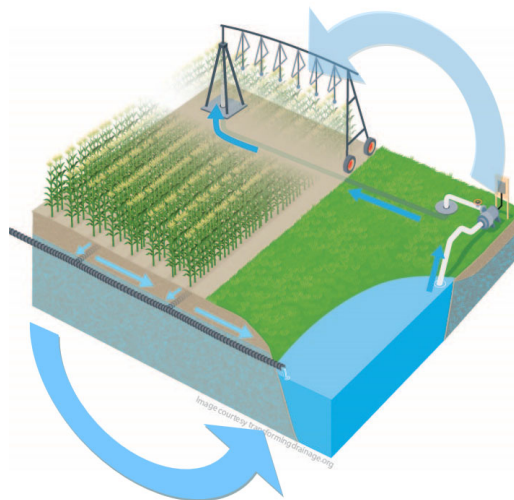
How it works to reduce nitrogen loss



Reducing drain flow



Increasing plant uptake



Adoption issues

- **Expensive** \$
 - Land taken out of production for water storage reservoir
 - Cost of construction
- Irrigation on poorly-drained soils in the Midwest is new and not well researched.
- New NRCS Conservation Practice Standard (CPS 447) may support this once adopted in Midwest states

Practices that work at the edge of the field

7. Denitrifying woodchip bioreactors

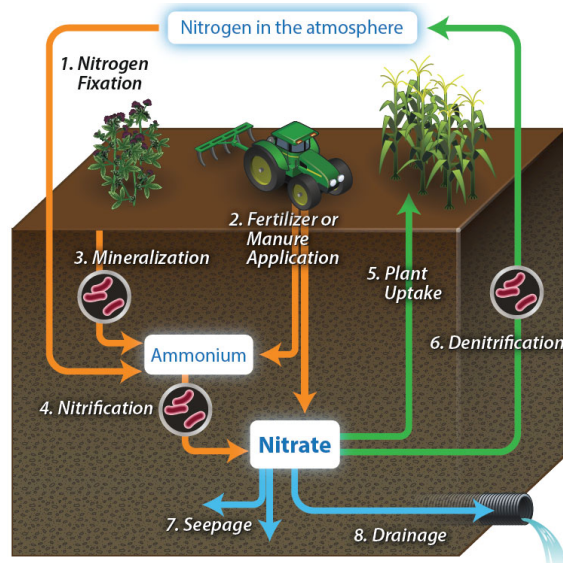
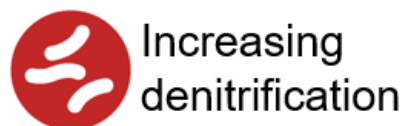
What it is

Bioreactors are trenches filled with woodchips that treat the water by enhancing the natural, biological process of denitrification.



WCS/IDALS Photo by Lynn Betts.
Conservation Media Library

How it works to reduce nitrogen loss



Adoption issues

- No yield benefit
- Require space at the edge of the field.
- Questions still being researched, including longevity.



WCS/IDALS Photo by Lynn Betts. Conservation Media Library

Practices that work at the edge of the field

8. Constructed wetlands

What it is

Wetlands are dynamic ecosystems containing plants, soil, bacteria, and water.



NRCS Photo by Lynn Betts.

How it works to reduce nitrogen loss



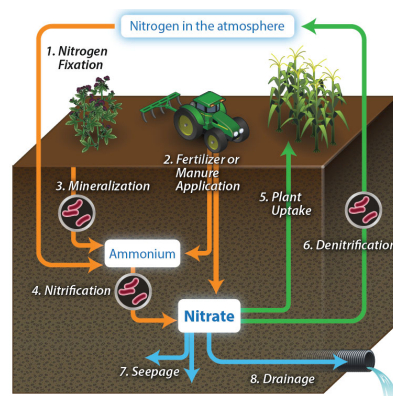
Increasing plant uptake



Increasing denitrification



Reducing drain flow



Adoption issues

- Cost of taking land out of production
- CREP and other programs provide funding



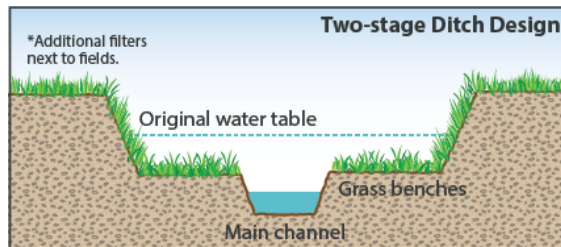
Iowa CREP Program photo

Practices that work at the edge of the field

9. Two-stage Ditches

What it is

Adding a floodplain for high flows within the ditch. This creates a zone of plants and soil for plant uptake and denitrification, and may also reduce flow.



How it works to reduce nitrogen loss



Increasing plant uptake



Increasing denitrification



Reducing drain flow

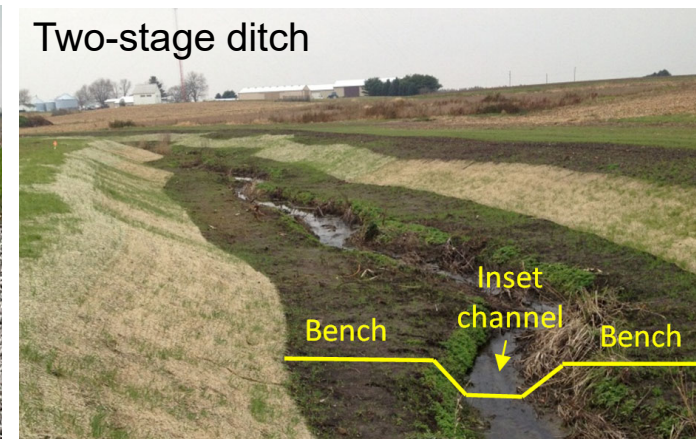
Adoption issues

- Cost of land needed for wider ditch
- Ditches may be more stable, reducing maintenance longterm

Typical trapezoidal ditch



Two-stage ditch

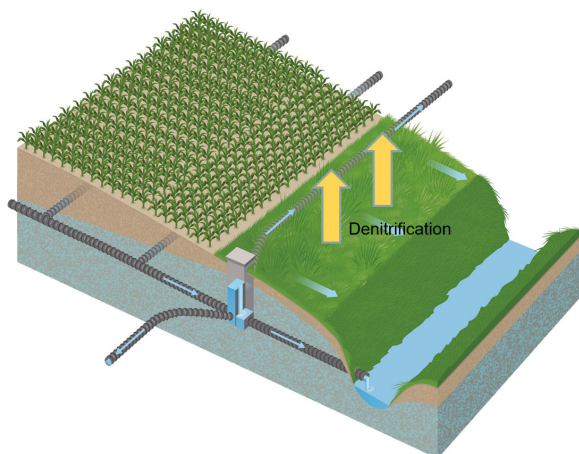


Practices that work at the edge of the field

10. Saturated buffers

What it is

Drain water is distributed through a riparian buffer via a shallow perforated drain pipe that extends laterally along the buffer.



How it works to reduce nitrogen loss



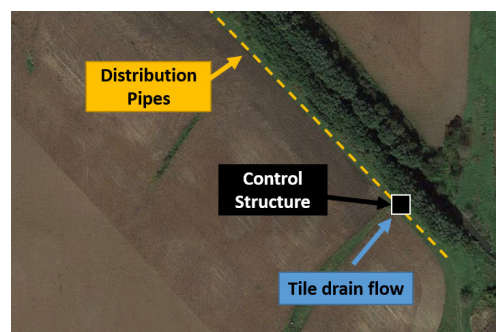
Increasing plant uptake



Increasing denitrification



Reducing drain flow

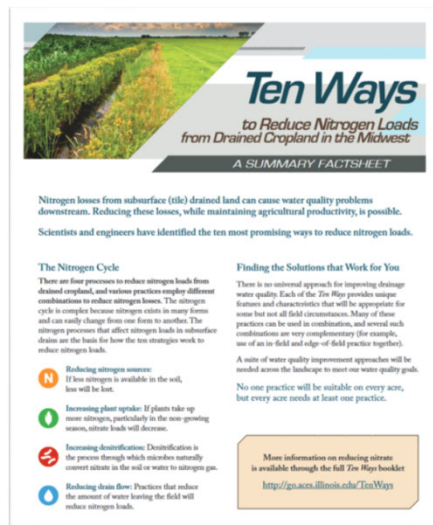


Adoption issues

- No yield benefit
- Not all areas are suitable:
 - Buffer should be at a lower elevation than the field
 - Soil must contain high organic matter content and not have layers of high permeability (sand or gravel layers)

Conclusions

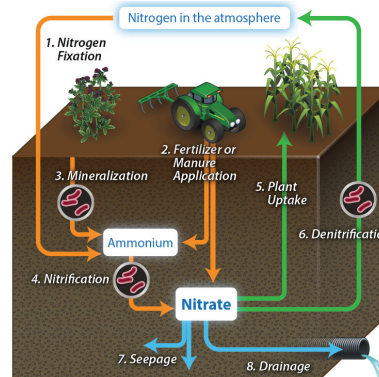
- **Ten Ways** exist to reduce nitrogen loads from drained cropland.
- All can work, but all have costs for individual farmers with today's incentives.



Ten Ways co-authors: Laura Christianson, Chris Hay, Matt Helmers, Gary Sands, Ben Reinhart

Researchers are working on new ways to combine processes, but all options have costs.

- Reducing nitrogen sources
- Reducing drain flow
- Increasing plant uptake
- Increasing denitrification



Adoption Issues

- Today's incentives have resulted in today's nitrogen losses.
- Education and research may help, but reducing the nitrogen problem and its health impacts likely requires shifting the incentives.

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2015-68007-23193, "[Managing Water for Increased Resiliency of Drained Agricultural Landscapes](#)." Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.