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Cost Comparison of DWM Ecosystem Service Delivery with Conventional Strategies

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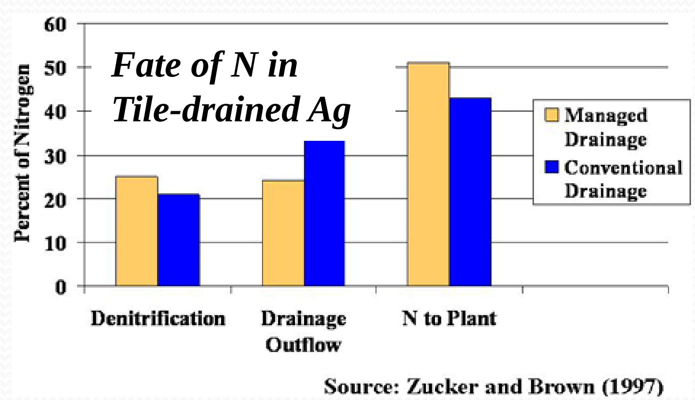
Ag Drainage Systems and WQ

- Drainage systems enabled conversion of millions of acres of marginal land into highly productive, profitable farmland
- Subsurface drainage correlated with increase in nitrate loading to water bodies
- Recognized need to control tile outlet level to decrease drainage water volume
- 88-95% of nitrate loss via tiling occurs during fallow period

Solution?...Drainage Water Management (DWM)

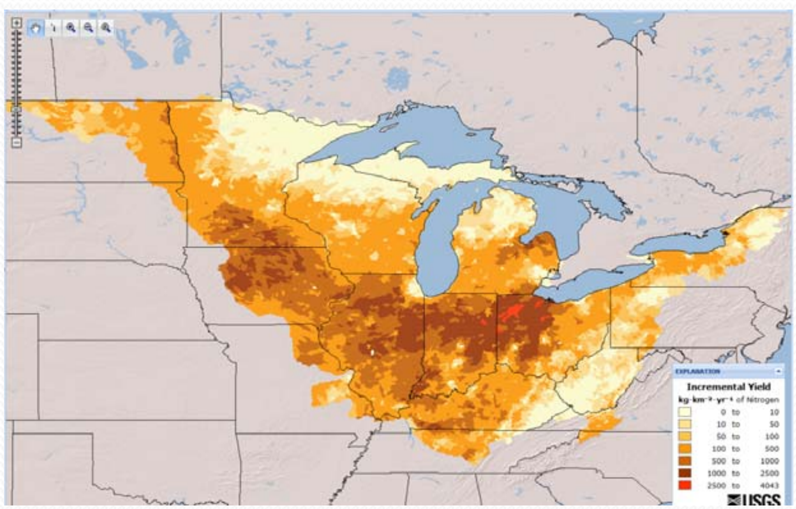
Problems Addressed by DWM

- DWM substantially reduces nitrate losses from farm fields
  - Reductions achieved by reducing drainage volumes
  - Typically no reduction in effluent nitrate concentration
  - Most reductions during non-cropping season
- Following harvest, drainage outlet adjusted to bring water table near surface
  - Additional environmental benefits achieved with water table above the soil surface
  - Ponding can provide wildlife benefits (e.g., seasonal pot-hole wetlands for migratory birds)



Potential for DWM Adoption

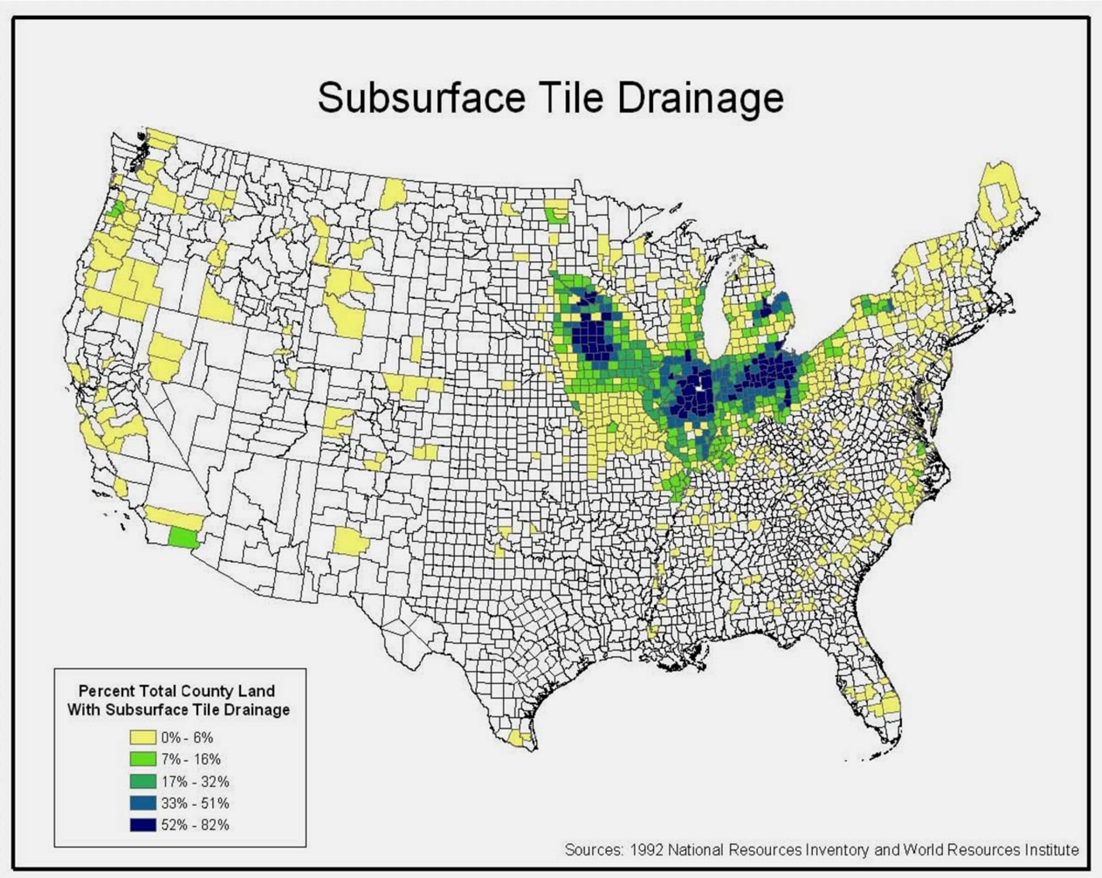
- Optimal sites for DWM
  - Flat, uniform fields
  - Slopes </= 1 percent
  - >1 slope requires additional drainage control structures
- Target areas: high in-stream nitrate concentrations



SPARROW model output depicting the incremental yield of nitrogen (kg/km·yr^{-1}) from agricultural practices.
http://cida.usgs.gov/sparrow/

Seeing is believing

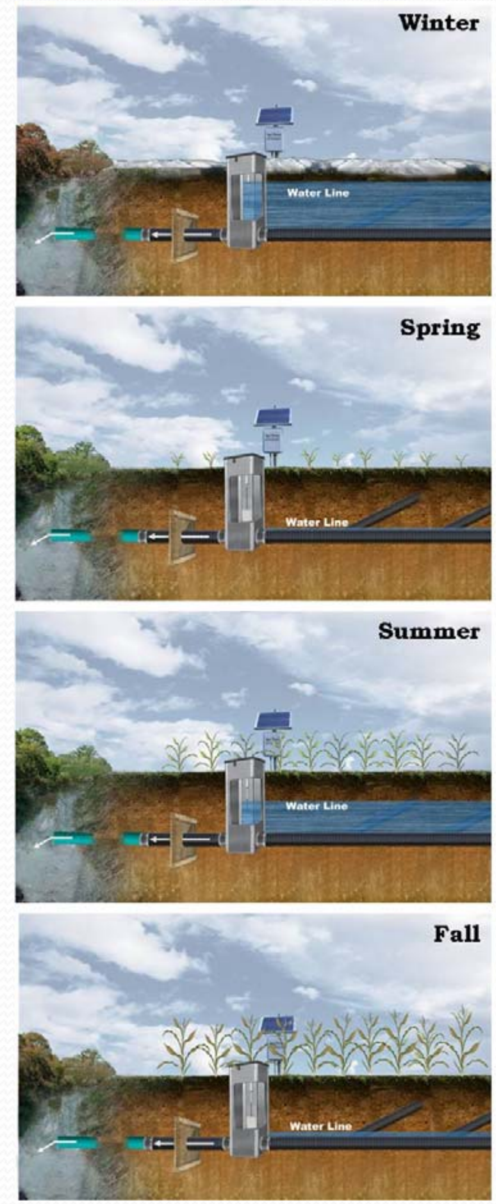
- Nitrogen hot spots coincide with high tiling densities



Extent and location of subsurface drainage, as estimated by Sugg, 2007.

DWM Technology …the premise

- Potential to substantially reduce nitrate losses from farm fields thus improving water quality
- Adoption could expand where the technology has the potential to generate on-farm economic benefits, in addition to off-site environmental benefits
- Increased crop yields associated with DWM could offset implementation costs and increase farm profitability
- During dry periods, DWM technology can be used to retain moisture in the soil profile, reducing crop stress and potentially boosting yields



Approach

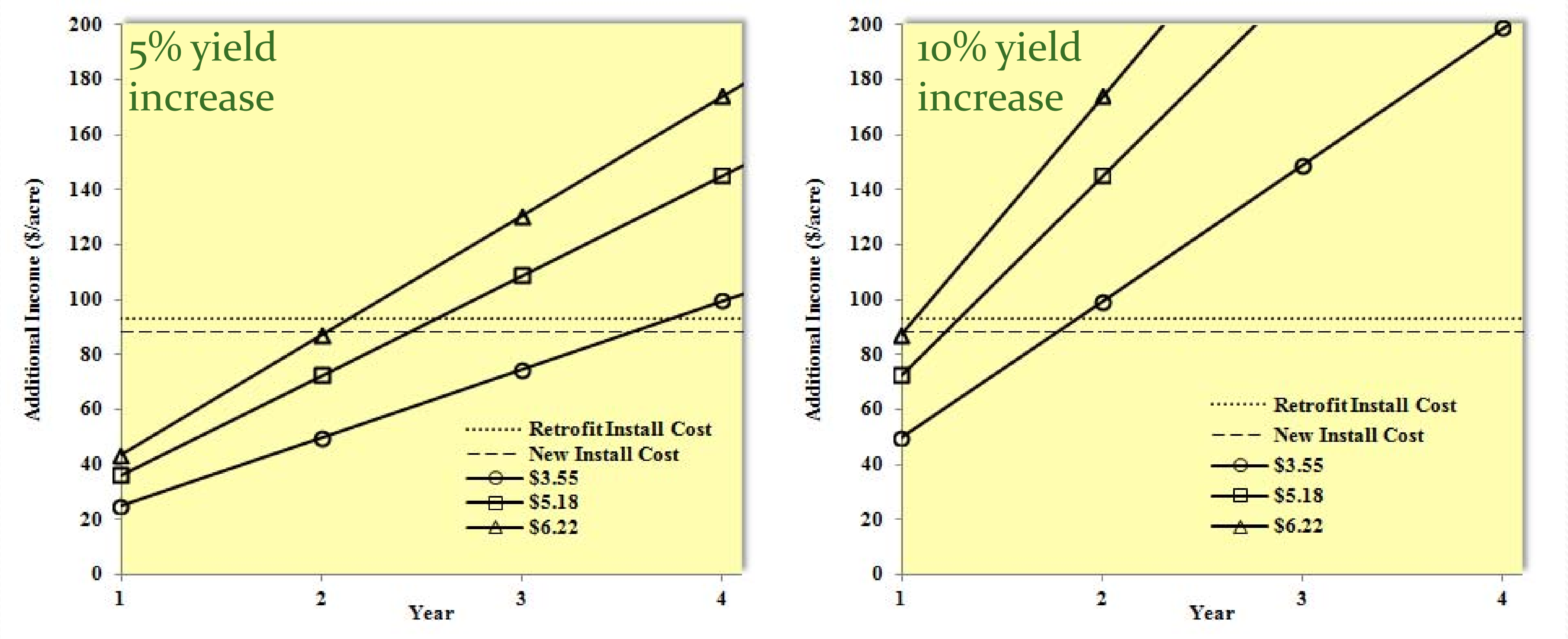
- Preliminary literature evaluation of potential economic benefits of DWM and conditions where cost-effective
- Calculate break-even point when installation costs would be recovered under multiple scenarios in corn and soybean production systems
  - Estimated costs used were $93/acre for DWM retrofits and $88/acre for new installations
- Costs compared to additional profit generated by potential yield increases of 5 and 10 percent at a range of crop prices for corn and soybeans

Observed yields with DWM

Reference	Location	Years Observed	Number of Sites	Crop	DWM Yield Effects
Fausey 2005	Ohio	5	1	Corn	No effect
		5	1	Soybean	No effect
Poole et al., 2011	North Carolina	6	2	Corn	11% increase
		5	2	Wheat	No effect
		6	2	Soybean	10% increase
Delbecq et al., 2012	Indiana	5	2	Corn	5.8% to 9.8% increase
Jaynes 2012	Iowa	2	1	Corn	No effect
		2	1	Soybean	8% increase
Helmers et al., 2012	Iowa	4	1	Corn	Reduced yield
		4	1	Soybean	No effect
Cooke and Verma 2012	Illinois	2	4	Corn	No effect
		2	3	Soybean	No effect
Ghane et al., 2012	Ohio	1 to 2	7	Corn	1% to 19% increase in 6 of 9 observations
		1 to 2	7	Soybean	1% to 7% increase in 7 of 11 observations

(Adapted from Skaggs *et al.*, 2012)

Farm profitability with DWM



- Break-even analysis for corn with base yield of 140 bushels/acre

Cost Findings

- Yield increases with DWM potentially could cover costs of technology installation within the expected lifetime of device
  - 5 percent yield increase meets installation cost of retrofit or new DWM device within 4 years
  - Producer could recover installation costs within 2 years if yields increased by 10 percent
- Years do not need to be consecutive but rather reflect total number of years where necessary factors are present for yield boosts to occur
- Actual on-farm economic benefits of DWM depend on site-specific characteristics, as well as weather conditions in given season
- Yield effects observed through field trials are highly variable and additional research is needed to determine long-term averages

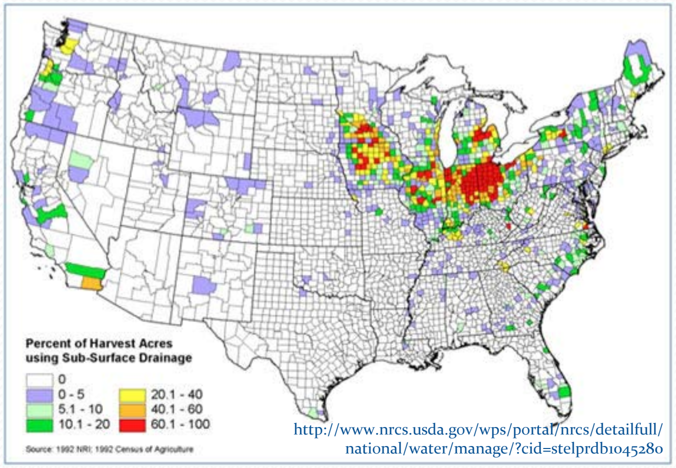
DWM Benefits for Ag

- Yield boosts when DWM optimized in growing season to retain soil moisture reducing crop stress in dry periods
- >10 percent yield increases for corn/soybeans
- Retrofit installations $93/acre; new installations $88/acre
- 5-10% higher yields could offset DWM installation costs
  - 3-5 years for corn
  - 5-9 years for soybeans
- Improved benefits through drainage system design, device placement and management intensity
- Research needed on long-term yields under various conditions
- Greater yields with DWM and sub-irrigation

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/il/newsroom/features/?cid=nrcs141p2_030837

DWM Ecosystem Service Benefits

- DWM effective for reducing nitrate losses from Ag fields
- 7.2M acres of cornland suitable for DWM in Upper Mississippi and Tennessee/Ohio watersheds
  - 1.43M acres in retrofits
  - 5.73M acres by new installations
- DWM on 7.2M acres = $638M
  - $133 million for retrofits
  - $505 million for new installations)
- 114.4M pounds of nitrate-N reductions with DWM



http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/?cid=stelprdb1045280

(From Jaynes, D.B., K.R. Thorp, D.E. James (2010) Potential Water Quality Impact of Drainage Water Management in the Midwest USA. Proceedings of the 9th International Drainage Symposium held jointly with CIGR and CSBE/SCGAB, June 13-16, 2010, Quebec City, Canada.)

DWM realities

- Benefits vary with site-specific conditions/management
- Regional variability in nitrate loss reductions with DWM
- Data gaps exist
  - Updated information on cost-benefits
  - Research on optimizing applications
  - Additional benefits with other practices (subirrigation)
  - Potential for cost-share programs applications such as market-based incentives to increase adoption rates
- Quantifiable profitability with investment in DWM
- Quantifiable WQ benefits with DWM

Additional Documentation

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Adoption & Implementation of Drainage Water Management
Technical Brief

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This technical brief examines producer and environmental benefits of drainage water management (DWM). The anticipated audience for this brief likely will be potential technology investors and policy makers interested in advancing DWM practices to improve water quality.

Drainage Water Management Implementation Costs
Abstract

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Build-up of the current agricultural drainage network began during the 1870s as part of a national land reclamation policy. Since then, drainage has been both criticized and praised. Overall, agricultural drainage enabled previously marginal land to become highly productive and profitable farmland.[i] However, intense drainage also contributed to negative environmental impacts, including substantial losses of wetlands and wildlife habitat.[ii]

Subsurface drainage lines act as conduits of nitrate – the mobile form of nitrogen – to surface waters. Under natural conditions, nitrate-laden water passes through the soil profile and is removed, at least partially, through denitrification. In fields with subsurface drainage, tile lines intercept the water before denitrification can occur. As a result, subsurface drainage effluent contributes to excess nitrate loading to surface waters, which can lead to water quality impairments.[iii] Figure 1 illustrates the estimated extent of subsurface drainage.[iv]

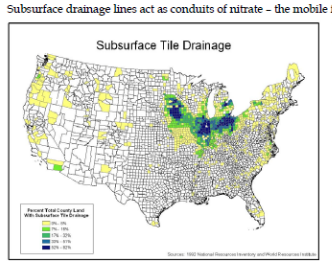

Figure 1. Extent and location of subsurface drainage, as estimated by Sugg, 2007.[iv]

Nitrate export through tile lines can be reduced by implementing drainage water management (DWM). One such practice involves installing a device that controls the volume of water leaving a field. These controlled drainage devices can be adjusted based on the season and drainage needs. The control device can adjusted such that water tables drop prior to planting to allow the fields to become sufficiently dry for equipment access. Subject to producer desires and time constraints, the device can be used to adjust water levels throughout the growing season. Then after harvest, the water level is raised to minimize drainage during the non-cropping season.

DWM reduces nitrate export by reducing the drainage volume from tile drain outlets as opposed to reducing the concentration of nitrate in the effluent. Most of the nitrate reductions

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Drainage Water Management Yield Effects and Farm Profitability

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Drainage water management (DWM) is associated with crop yield increases that, under certain conditions, potentially could offset implementation costs and increase farm profitability. Actual yield effects are highly variable and depend on site-specific characteristics. This technical brief presents a summary of observed DWM yield effects based on published literature, as well as a preliminary analysis of on-farm economic benefits.

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