Ethanol and Water Quality: Avoiding Unintended Consequences

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Major Water Issues with Expanded Ethanol Production

- Water Quality
  - Managing facility wastewater
  - Nutrient impacts from expanded and intensified grain (corn) production
  - Co-location of animal operations near ethanol facilities
  - Impact of distillers grains in feed on manure nutrient content
  - Potential water quality benefits from some cellulosic feedstocks
- Water Quantity
  - Facilities consume substantial amounts
  - Impact will vary by region
  - Will high grain prices increase irrigation in drought prone areas (Southeast, Mid Atlantic)

Water Use and Ethanol Production Facilities

- Consumptive water use
  - About 3.5 to 6 liters of water is consumed for each liter of ethanol produced *
  - Consumption largely comes from evaporation during cooling
  - Plants are achieving greater efficiency over time
  - About 3 liters of water per liter of ethanol is probably low end with current technology
  - Producing 72B l/yr (20B GPY) of ethanol, would consume 216B l/yr (60B GPY) of water

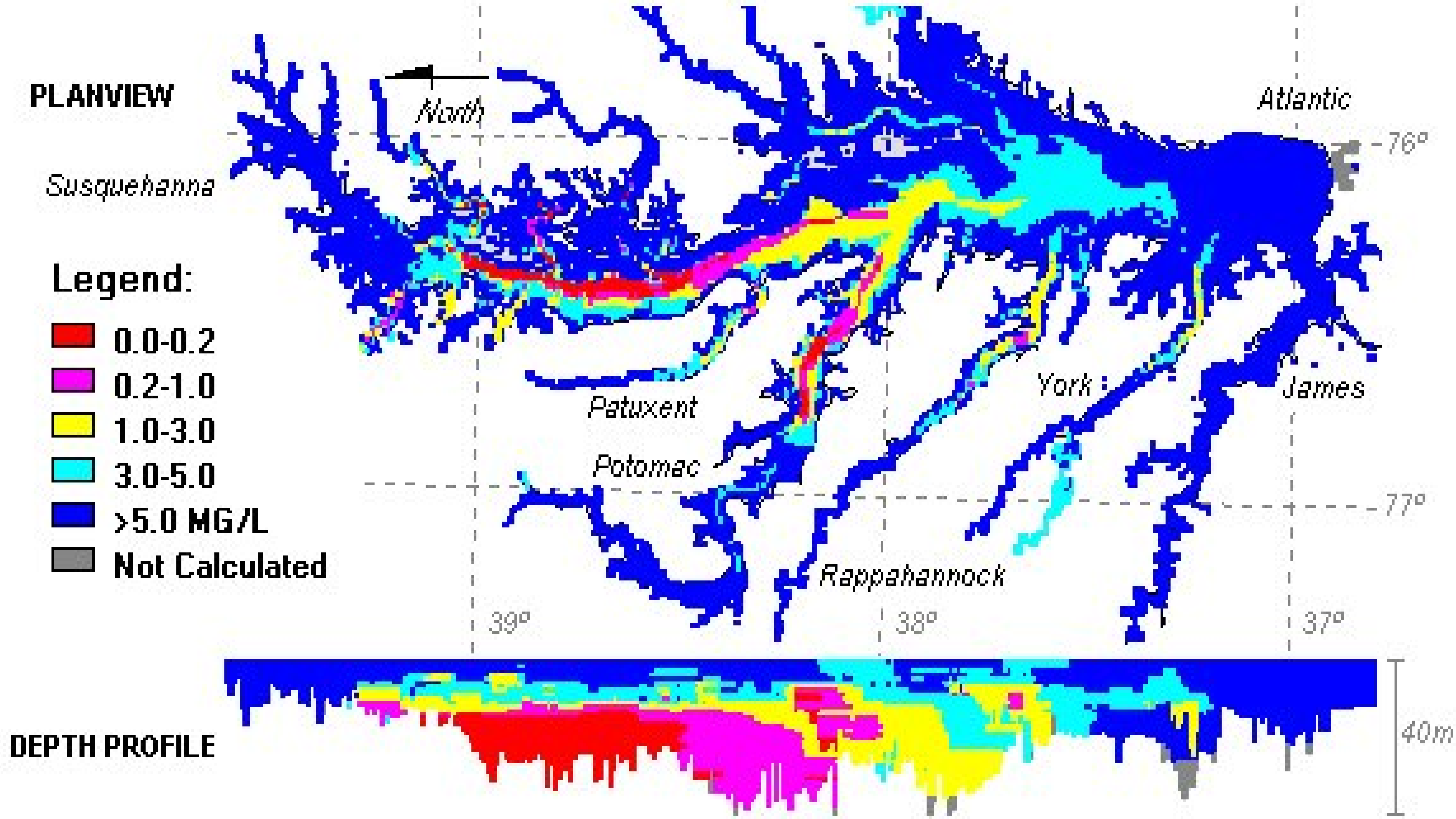
*Institute for Agriculture and Trade Policy
Water use by ethanol plants--potential challenges

Eutrophication: Nitrogen and Phosphorus over enrichment in coastal waters

- Results in excessive algal growth
  - Cause low oxygen
  - Reduce clarity and loss of underwater grasses
  - Change composition of bottom of food chain
- Limiting nutrient for algal growth
  - Phosphorus in freshwater
  - Nitrogen in salt water (>10ppt salinity)
- In estuaries, limiting nutrient changes with location and season

Monitoring Program Shows Continued Low D. O. in Mainstem and Large Tributaries

August, 1997 Cruise



Examples of Nutrient Impacted Coastal Waters

- Chesapeake Bay
- Northern Gulf of Mexico (MRB)
- Tar/Pamlico/Neuse Basins
- Long Island Sound
- Tampa Bay
- Baltic Sea
- Sea of Japan
- Black Sea/Danube

A 100-Million Gallon Ethanol Plant ...

- Uses roughly 940 million kg of corn
  - *Needs corn from about 125,000 ha*
- Produces 285,000 Mt/yr of DGs
  - This could feed about 120,000 dairy cattle
  - Co-location would not require drying DGs
- Manure from 120,000 dairy cattle could produce enough methane to meet 25% of the ethanol plant's natural gas needs
  - Nutrients would remain in manure and be locally concentrated

Adapted from CARD, Iowa State University, 2006

Estimated increase in N and P loss to streams from 6.5 million new hectares of corn .

Acreage shift to support ethanol	Land area	N loss			P loss	
		Mean	Annual increase		Mean	Annual increase
	10^6 ha	kg/ha	10^6 kg		Kg/ha	10^6 kg
New corn acres	6.5	33.6			3.4	
Converted from soybeans	3.3	25.2	27		3.4	
CRP land	1.6	5.6	45		0.6	4.5
Idle, pasture or hay	1.6	5.6	45		0.6	4.5
Estimated increased loss			117			9.0

Ethanol plants create local nutrient imbalances

- Either import large quantities of nutrients in grain or reduce exports
- Market Distiller's Grains (DGs) as close as possible or co-locate animal operations
  - Costly to dry and transport DGs
  - DGs are high in N and P compared to most rations
  - Inclusion at even 10% of ration, overfeeds P, at ~20% , may overfeed N
  - Currently primarily beef and dairy, limited use by swine and poultry
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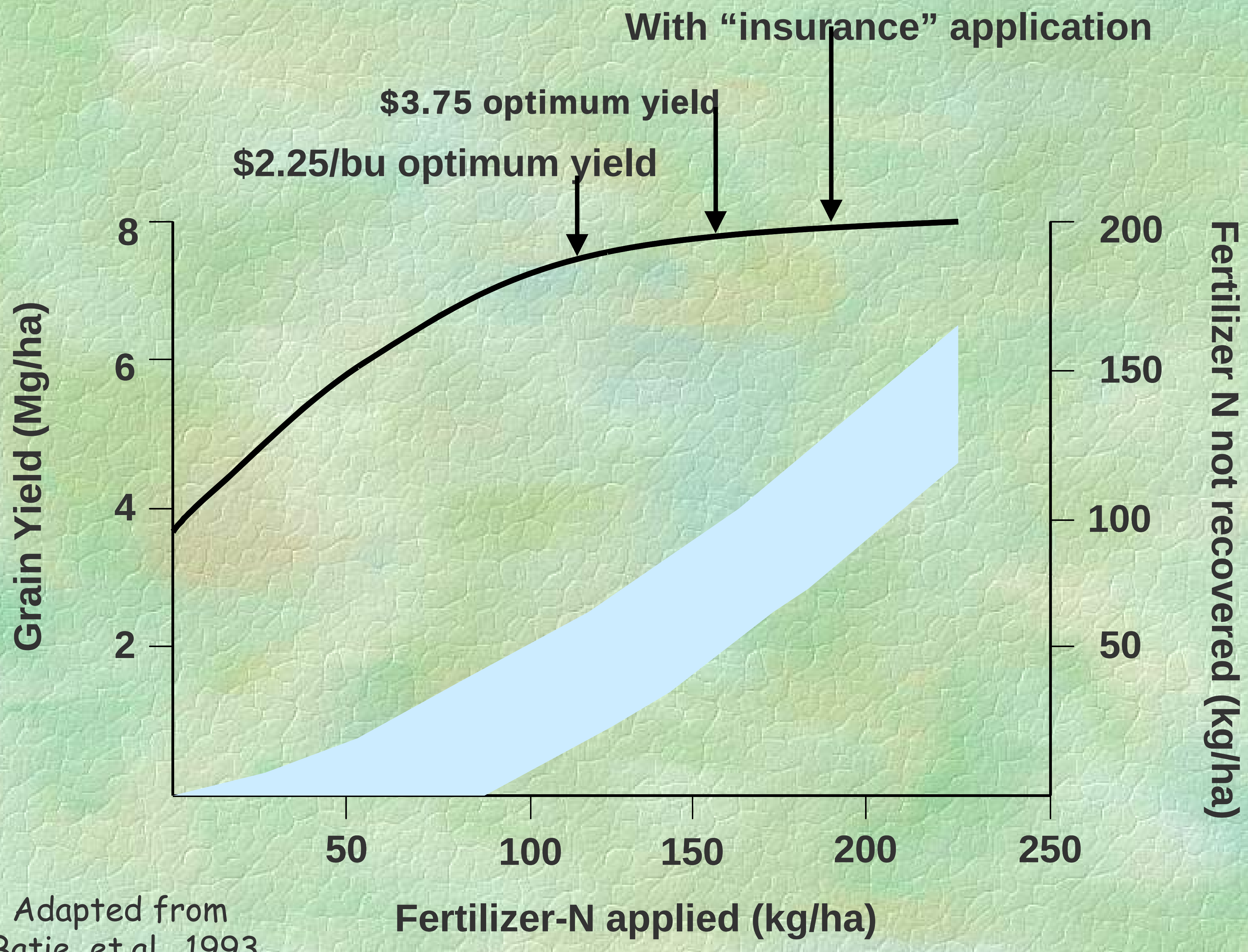
Dried Distillers Grain and feed management

- DDGS are glutting the market and making way into beef and dairy rations
- In Chesapeake watershed, have major feed management initiative for poultry, swine and dairy, with NRCS cost share
- Reducing dairy P from .40-.45% to .33-.35%, but DDGs are .75-.90% P
- May reverse reductions in manure P through feed management
  - Impacting Bay state feed dairy management programs now
  - Major impact if increased use in poultry and swine

Nutrient management and nutrient use incentives

- Economic optimum yield increases w/ price
  - Small yield increases per unit of nutrient
  - Some have estimated 15% increase in N rates
- Farmer more risk averse, “insurance” nutrient prone
- “BMP yield warranty” and other conservation incentive programs will be less attractive and more costly



Adapted from
Batie, et.al., 1993

Land retirement, longer rotations and "perennialization"

- Disincentive for land retirement programs
- Costs of retirement programs will rise
- Loss of CRP and CREP lands
- Creates pressure to bring pasture and marginal lands into corn production
- Increased continuous corn; discourage long rotations w/ hay & other perennials
- Reduces interest in perennial grasses

If so many issues with grain based, why not cellulosic?

- Infrastructure and market constraints
- Cellulosic fermentation technology issues
- Growing, storing, handling switchgrass not a simple option; requires new infrastructure
- Corn stover currently projected to be largest cellulosic feedstock

General agreement: Substantial cellulosic ethanol production is a decade away

Corn stover and cellulosic ethanol

- Plans to harvest corn stover to make cellulosic ethanol
- Concerns:
  - Decrease use of conservation/no till
  - Increased erosion losses (w/i "tolerable" soil loss)
  - Reduced soil organic matter and soil quality
  - Potential long term yield impacts
  - Net soil carbon release, not sequestration

Why might perennial-based cellulosic, specifically switchgrass, succeed?

- Lower cost to produce over time
- Switchgrass is long term perennial
- Greater net energy production
- Ligno-cellulosic co-product can be burned for heat
- Does not *directly* compete with feed
- Environmental benefits rather than consequences
- Potential for multiple revenue streams

Multiple revenue sources from switchgrass

- Topgrowth sold for biofuels
- Burn fermentation residue for heat/energy
- Carbon sequestration in root system
- Tradable nutrient credits (>50% reduction from row crops)
- Soil quality credits (currently in USDA's CSP)
- Improved soil productivity for the future

Summary

- Expansion and intensification of grain production has water quality implications
- Dried Distiller's Grains can increase manure N and P content
- Cellulosic is promising but a decade away
  - Corn stover has soil, water and air implications
- Making ethanol a sustainable transportation fuel
  - Require rigorous conservation for grain/row crops
  - Accelerate development of cellulosic ethanol
  - Evaluate environmental impacts of all feedstocks and technologies as part of development