A Presentation of the

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IOWA STATE UNIVERSITY
University Extension

UNIVERSITY OF MINNESOTA
EXTENSION

Experience from the Cedar River TMDL

"Hypoxia in the Gulf of Mexico:
Implications and Strategies for Iowa"

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Preliminary Draft

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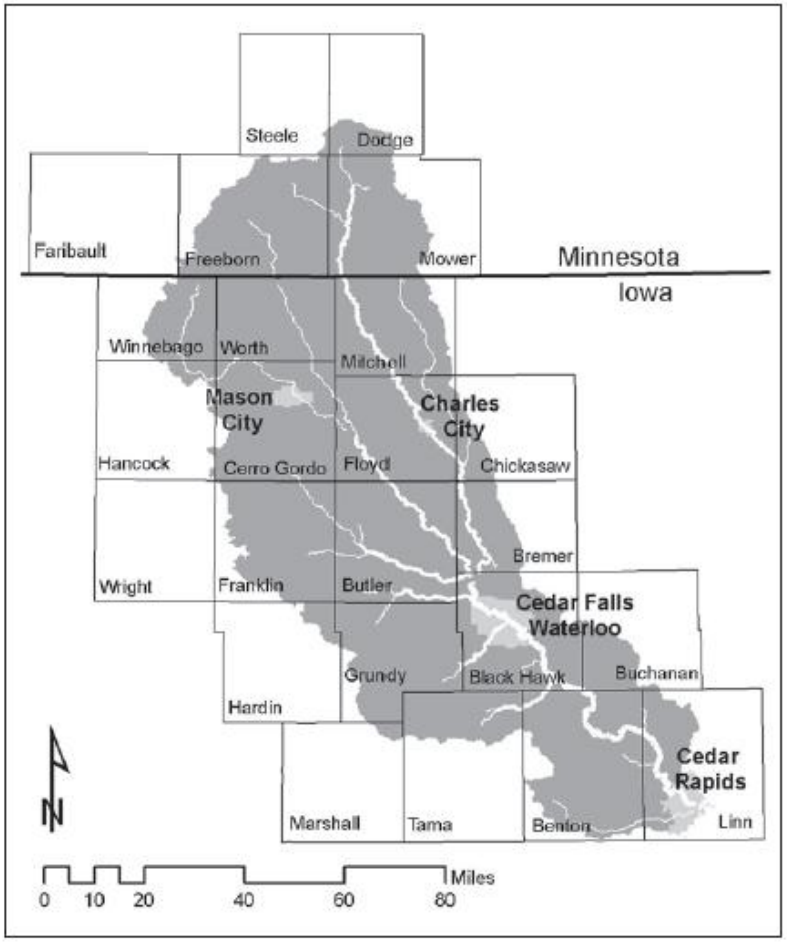
"Case study of the cost and efficiency of practices needed to reduce nutrient loads locally and to the Gulf of Mexico"

- Cedar River Watershed
- ***<u>Preliminary</u>*** results

- Funded
  - 90% State of Iowa (IDALS)
  - 10% UMRSHNC (EPA Grant)



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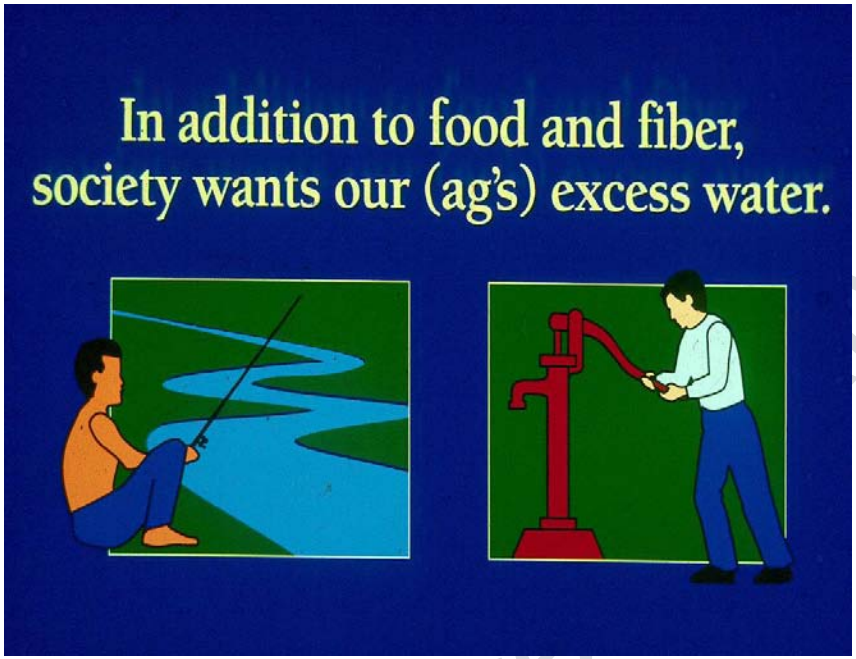
UPPER MISSISSIPPI RIVER SUB-BASIN HYPOXIA NUTRIENT COMMITTEE

UMRSHNC

Agriculture drainage concerns:



- Quality issues of:
  - “fishable”
  - “swimable”
  - “drinkable”
- But also quantity issues:
  - not too “little”
  - not too “much”
  - timed “right”

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An aerial image of downtown Cedar Rapids, Iowa shows flood-affected areas June 13, 2008. (Photo by David Greedy/Getty Images)

Need to educate the public to avoid having “unrealistic expectations”

- Natural variations (in weather) can dominate outcomes.
  - a 10+ inch rain will overwhelm everything
  - any time excess water moves over or through the soil, nutrient losses will occur
- Extreme measures come with extreme costs
  - e.g., converting Corn Belt back to prairies and wetlands
  - yield reductions with severe reductions in nutrient inputs to reduce off-site losses
- Concern for unintended side-effects
  - “mining of the soil” when nutrient removal exceeds inputs
  - displacing needed production to more environmentally sensitive areas

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Background

- Nitrate issues
  - TMDL for drinking water impairment
  - Gulf of Mexico hypoxia area reduction
- Phosphorus issues
  - Pending criteria for local flowing and standing waters
  - Gulf of Mexico hypoxia area reduction

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Loss reduction goals

- TMDL nitrate
  - Maximum concentration 9.5 mg/L
  - Reduce losses 35%
  - Reduce losses 10,000 tons/year (equals 5.5 lb N/acre/year)
  - Load allocation: 92% nonpoint source; 8% point source
- Hypoxia area
  - Reduce N losses 45%
  - Reduce P losses 45%

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Cedar River Watershed

- 3,650,000 acres within Iowa above city of Cedar Rapids
- Nitrate losses (2001 – 2004 period)
  - 28,561 tons/year
  - 15.6 lb/acre/year
- 73% row-crop (2,400,000 acres corn/beans; 150,000 acres continuous corn)
- About 2/3 of the row-crop land has tile drainage
- Annual precipitation: about 34 inches
- Stream flow (2001 - 2004 period)
  - Total 8 inches
  - “Base flow” about 65% of total

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Potential N Management Practices

- In-field
  - N rate/timing
  - Cropping
  - Tillage
  - Cover crops
  - Water management
- Off-site
  - Buffer strips
  - Constructed wetlands

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Practices (nitrate)

- N rate
  - Starting point critical
  - NASS fertilizer data for 2005 for four northeast Iowa sub-regions is 124 lb N/acre/year on corn
  - IDALS state-wide fertilizer sales data for 2001 – 2005 averaged 137 lb N/acre/year on corn
  - Manure applications (?)
- ISU recommendations
  - For corn following soybeans: 100 – 150 lb N/acre
  - For continuous corn: 150 – 200 lb N/acre

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Based on Iowa yield and water quality data; corn at $5.00/bu and N at $0.50/lb

	Corn soybeans	Continuous corn
assumed initial rate (lb N/ac)	140	190
nitrate loss	19.5 lb/ac	23.2 lb/ac
loss reduction with **40 lb/ac** N rate reduction	20.1%	16.2%
nitrate-N loss reduction	3.9 lb/ac	3.8 lb/ac
corn yield reduction	4.8 bu/ac	5.0 bu/ac
cost of N loss reduction	$1.03/lb	$1.32/lb

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Based on Iowa yield and water quality data; corn at $5.00/bu and N at $0.50/lb

	Corn soybeans	Continuous corn
assumed initial rate (lb N/ac)	120	170
nitrate loss	17.3 lb/ac	21.2 lb/ac
loss reduction with **20 lb/ac** N rate reduction	10.0%	8.6%
nitrate-N loss reduction	1.7 lb/ac	1.8 lb/ac
corn yield reduction	3.0 bu/ac	2.9 bu/ac
cost of N loss reduction	$2.94/lb	$2.50/lb

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Based on Iowa yield and water quality data; corn at $5.00/bu and N at $0.50/lb

	Corn soybeans	Continuous corn
assumed initial rate (lb N/ac)	140	190
nitrate loss	19.5 lb/ac	23.2 lb/ac
loss reduction with **80 lb/ac** N rate reduction	32.7%	30.3%
nitrate-N loss reduction	6.4 lb/ac	7.0 lb/ac
corn yield reduction	16.1 bu/ac	15.2 bu/ac
cost of N loss reduction	$6.33/lb	$5.12/lb

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Practices (nitrate)

N timing

- 25 to 33% of N for corn is applied in fall
- Leaching losses with spring-applied N are 0 – 15% less
- Half of total N applied is ammonia-N and half of that is applied in the fall
- Costs of ammonia could go up 5 cents/lb for additional infrastructure needed to apply all of it in the spring (yield effects could be + or -)
- However, this increase would apply to all N sold, not just that currently fall-applied.

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Practices (nitrate)

- Fall cover crops
  - Fall-planted rye or ryegrass can reduce nitrate leaching loss by 50%
  - Fall-planted oats by 25%
- Costs
  - Incentive costs for rye: $30/acre (seed, planting, dealing with the living plants in the spring, possible corn yield reduction)
  - For oats: $20/acre (plants not alive in spring)
- For continuous corn
  - Rye loss reduction: $2.59/lb N
  - Oats loss reduction: $3.44/lb N
- For corn-soybeans
  - Rye loss reduction: $3.07/lb N
  - Oats loss reduction: $4.10/lb N

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Practices (nitrate)

- Drainage water management
  - Modeling predicts a ~50% nitrate loss reduction with installation of drainage water management
- Costs
  - Installation: $1000/acre (20 year life; 4% interest)
  - Operation: $10/acre/year
- Applicable to about 6.7% of the row crops
- Nitrate reduction costs of $1.56/lb

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Practices (nitrate)

- Constructed wetlands
  - At a fraction of 0.5 to 2% of watershed as wetland, removal could average 50%
  - This would equate to about 8 lb/ac/yr for drainage from row-crop land
- Costs
  - Assuming a cost of $250/ac of “treated field” for wetland establishment, this would be about $1.45/lb over 50 years (4% interest).

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Practices (nitrate)

- Tillage
  - There are some indications that reduced tillage, and particularly no-till, could reduce nitrate concentrations in tile drainage, possibly because of reduced mineralization with reduced soil disturbance.
  - Also water flow through more macropores with reduced tillage could allow water to “by-pass” nitrate within soil aggregates.
  - However, usually any reductions in concentrations are off-set by increased flow volumes with reduced tillage.
  - Thus, without more conclusive results, tillage is not currently being considered as a practice to reduce nitrate leaching losses.

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Practices (nitrate)

- Buffer strips
  - Tile drainage “short-circuits” subsurface flow through buffer strips, eliminating any chance they would have in reducing concentrations and/or flow volumes and thus nitrate losses.

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One example scenario to reduce nitrate losses 35% (9,200 tons/non-point source allocation) while retaining row-crop production

Practice	% reduction	Acres* treated	Tons reduced	Cost per lb	Total cost/yr
140 to 100 N rate - CB	20.1% or 3.9 lb/ac	all or 1.70 M ac	3,315	$1.03	$6.83 M
190 to 150 N rate - CC	16.2% or 3.8 lb/ac	all or 0.10 M ac	190	$1.32	$0.50 M
Avoid fall application	15% or 2.5 lb/ac	all or 300,000 ac	375	$6.00	$4.50 M
Rye cover crops	50% or 8 lb/ac	10% or 170,000 ac	680	$3.00	$4.08 M
Water mgt.	50% or 8 lb/ac	10% or 167,000 ac	670	$1.56	$2.09 M
Construct. wetlands	50% or 8 lb/ac	59% or 1.00 M ac	4,000	$1.45	$11.60 M
TOTALS		*[*2/3 of 2.55 M or 1.70 M ac]*	9,230	$1.60	$29.60 M/yr

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Scaling to Iowa Statewide

- About ¼ of Iowa is tile drained: equals 9 million acres
- Cost to Cedar River watershed (1.7 million acres drained) estimated at $29.6 million/year
- Cost to Iowa would be $157 million/yr for 35% nitrate removal
- For the next 10%, to reach a 45% reduction, wetlands, cover crops, and further reductions in N applications are only options left (unless cropping changes) – all with increased lb N/ac costs.

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P loss reduction

- Based on report #3 of the “Integrated Assessment” and also the Iowa state nutrient budget, the average P loss with river flow is about 0.75 lb/ac/yr.
- A 45% reduction of the 1,560 tons of P loss per year would be 702 tons.
- Or the average, total P concentration (that in water plus sediment) would have to be reduced from 0.415 to 0.228 mg/L.

[Note that the draft P criterion for standing waters (i.e. lakes) in Iowa is being proposed at 0.035 mg/L].

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Using the Iowa P Index

- It has three components:
  - erosion/soil loss
  - surface runoff
  - subsurface drainage (if any)
- It considers location and soil and weather characteristics
  - distance to water course
  - soil slope/type
  - annual precipitation
- It considers management
  - current P soil test level
  - amount of P additions
  - method of P additions
  - crop rotation
- It considers sediment transport control practices
  - vegetated buffer stripes
- It considers erosion control practices (using RUSLE2)
  - contouring
  - conservation tillage

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P index calculations in two Cedar River subwatersheds (Chad Ingels and John Rodecap; ISU extension)

Results of P index calculations

- Coldwater-Palmer
  - 207 fields
  - 99 with P index ≥ 1.00 (lb/ac/yr)
  - 9 with P index ≥ 2.00
  - max = 6.12; average = 1.06
  - average soil test P = 34 ppm (max = 401; 54% above the optimum range)
- Lime Creek
  - 209 fields
  - 67 with P index ≥ 1.00 (lb/ac/yr)
  - 3 with P index ≥ 2.00
  - max = 3.01; average = 1.07
  - average soil test P = 36 ppm (max = 120; 57% above the optimum range)

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Practice: reducing soil test levels to the optimum level

- The break between “optimum” and “high” soil test P levels (Bray-1) for row-crops is 20 ppm.
- At 20 ppm soil test P level, soluble P in surface runoff is estimated at 0.150 mg/L.
- At 35 ppm, it is 0.225 mg/L.
- With 35% of river flow estimated to be surface runoff, that would be 2.8.”
- Over time, reduced or no P inputs to fields testing “high” would save money and reduce P levels and losses.
- The reduction in P loss associated with reducing the average soil test level from 35 to 20 ppm would meet about 1/7 of that needed for a 45% reduction.

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Achieving the remaining 6/7 P reduction

- Further conversion to conservation and no tillage (currently 4% no-till).
- Additional contouring (currently 6%).
- Use of vegetated buffer strips.
- Use of water and sediment control basins.
- Use of terraces.

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Summary: Potential and limitations (1)

- For the Cedar River TMDL for nitrate, there is the potential to reach the 35% reduction goal.
- The limitations will be the large direct costs, as well as program costs to achieve producer cooperation to make the major changes needed.

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Summary: Potential and limitations (2)

- For the Gulf Hypoxia reduction goal of 45% for total nitrogen, the potential is much lower.
- One limitation will be that in the tile-drained areas, the unit costs for nitrate reduction over 35% will increase.
- Furthermore, if the reduction in total nitrogen, of which nitrate is about 2/3, has to come through additional nitrate reduction, the costs will be even higher.

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Summary: Potential and limitations (3)

- For the Gulf Hypoxia reduction goal of 45% for total phosphorus, the potential is also much lower.
- In addition to large costs and major production changes needed, there is the concern that reducing field P losses, and more importantly reducing P which is actually transported to streams, will not reduce in-stream P concentrations or the amount exported to the Gulf.
- At issue is how much P can be provided by recycling from the soils and sediment already present in the stream, lake, and marine systems.

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Summary: Concerns

- Despite what some believe, there are few “win-win” situations, and those associated with rate of nutrient inputs will not get us to currently targeted water quality goals.

- Reaching those goals will come at considerable effort and costs, and therefore, it is imperative to be sure that the practices promoted will secure those goals; and furthermore, that reaching those goals will result in the anticipated environmental benefits.

- Producers and the public, once deceived and/or disappointed, will not readily cooperate or be supportive in the future.

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Science of Soil Sustainability and Water Quality Issues

- 170 lb N/ac/yr for continuous corn is about the "tipping point" at which soil organic matter should not decrease
- However, for the corn-soybean rotation, at 120 lb N/ac in the corn year, the N mass balance is at least 80 lb N/ac negative over the two-year period of rotation
- Thus, any reduction in N rates would increase the "mining" of soil organic matter
- Reduced soil organic matter not only reduces soil productivity but also increases water quality problems

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Question:

Will we make decisions based on:

- Emotion, perception, and opinion, or
- Logic, information, and knowledge?

And will they include probability of success and cost/benefit analyses?

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