Nitrogen Fertilizer Rate Management as a Nitrous Oxide Mitigation Strategy:
Development of a Nitrous Oxide Emission Reduction Protocol

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Justification

- Nitrous oxide (N_2O) is a potent agricultural greenhouse gas (GHG) with a global warming potential (GWP) of ~ 300.
- Over half the global anthropogenic N_2O flux is attributable to soil emissions, primarily due to nitrogen (N) fertilizer applications.
- Emissions of N_2O represent the single largest contributor to the global warming impact of annual cropping systems.
- Quantification of trade–offs between N_2O emissions, N fertilizer rate, and crop yield is essential to inform management strategies.
- Nitrous oxide, is a major target for protocols and offset projects due to the high payback associated with its emission prevention.

Field and Laboratory

Static chamber deployment and sampling in field and automated sample analysis in laboratory.

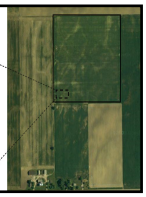
Layout and Geography

- Five sites (8 site years)
- Corn – soybean rotations
- Conventional tillage
- Six N fertilizer (urea) rates
- Static chamber methodology

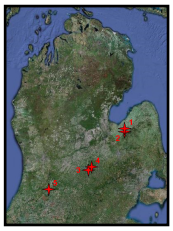
Rep 1	Rep 2	Rep 3	Rep 4
Nitrogen Rate (kg N ha^{-1})			
0	135	180	45
90	225	225	0
180	180	90	90
225	0	45	135
135	45	0	225
45	90	135	180

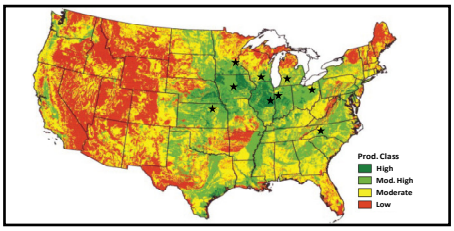
35 m

60 m



Landscape, site agronomy, and example of experimental RCB design.

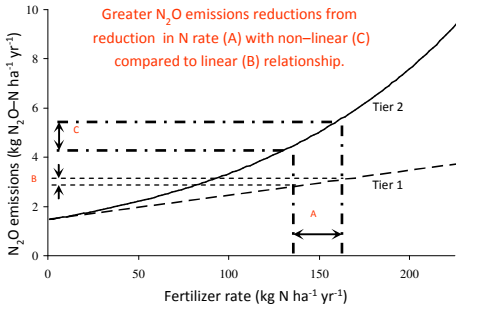




Study site locations in Michigan, and potential US Midwest site locations.

Protocol Rationale and Accounting

- N fertilizer rate proxy for N_2O emissions.
- GHG credits from reduction in N rate.
- Regionally derived (Tier 2) and default IPCC (Tier 1) emission factors.
- Form of relationship affects:
  - *GHG inventory estimates.*
  - *Market–based incentives for adoption of reduced N fertilizer rate.*
  - *Emission reduction credits generated for carbon offset projects.*



Market Players and Media

American Carbon Registry® Trusted solutions for the carbon market

CarbonFix Standard

Australian Carbon Trader ACT

enveX Australian Carbon Markets

Greenhouse Gas Reduction Scheme

Regional Greenhouse Gas Initiative

Western Climate Initiative

Chicago Climate Exchange

VCS VOLUNTARY CARBON STANDARD

BBC Australia shelves key emissions trading scheme

ABC News Renewed calls for emissions trading scheme

Protocol Evaluation, Implementation Barriers, and Potential Impact

Issues of Compliance

Baseline
- Conservative approach – verifiable management records.

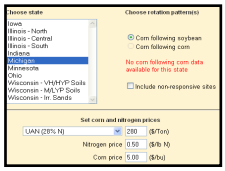
Additionality
- Barriers (e.g., Regulatory, Common Practice, Social).

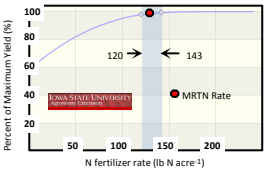
Permanence and Reversal
- Avoided N_2O emissions immediate, irreversible and permanent.
- Producer aggregation – collective persistence of credits.

Project Leakage
- No yield reductions, no yield compensation, no additional N use.

Co–benefits
- Reduced reactive N in environment (e.g., nitrate leaching).

Trade–offs with Crop Yield Optimization





Price Ratio:	0.05	0.10	0.15	0.20
MRTN Rate (lb N/acre):	149	130	119	115
Profitable N Rate Range (lb N/acre):	135 - 164	120 - 143	113 - 129	107 - 121

- Maximum Return To Nitrogen (MRTN) approach.
- Economic optimum N rate at varying crop: fertilizer price ratios.

Emission Reduction Potential

- Tier 1: Reduction (139 → 118 lb N a^{-1}) 0.05 tons CO_2e a^{-1} yr^{-1}
- Tier 2: Reduction (225 → 190 lb N a^{-1}) 0.6 tons CO_2e a^{-1} yr^{-1}
- 88 million acres corn planted in USA (2010).
- Potential (Tier 2) N_2O emissions reduction: ~ 53 million tons CO_2e a^{-1} yr^{-1}
- US short–term (10 years) offset deficit: ~ 1300 million tons CO_2e

Cap and Trade and Carbon Offsets

Cap and Trade – the basics

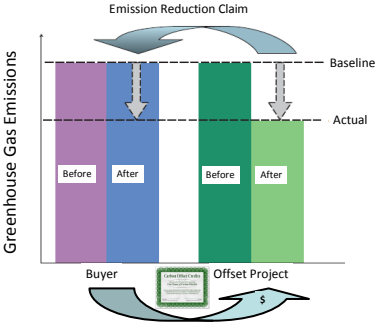
Tally greenhouse-gas emissions
- Track fossil fuels at points they enter economy.

Set a cap
- Require permits.
- Number of permits match the cap.

Distribute permits
- Auctioning.
- Give them away free (grandfathering).
- Holders buy and sell allowances among themselves.

Enforce the cap
- File periodic reports.
- Audit reports to curb speculation and gaming.

Step it down
- Distribute fewer permits on a predictable schedule.



- Offsets are credits for GHG emissions *reductions*, *avoidance* or *sequestration* that occur in sectors or geographic regions outside an emissions cap.

Protocol Provisions and Attributes

Provisions

- Negates / Minimizes productivity loss.
- Economic incentive (MRTN rate).
- Environmental incentive (N_2O reduction).

Attributes

- Scientifically robust.
- Environmental integrity.
- Transparent to all stakeholders.
- Cost-effective.

- ***High Technical Potential for Generating Large Numbers of Offset Credits.***
- ***Potential for 'Credit Stacking'.***

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