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Developing GHG Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions in Agricultural Crop Production:

Handout for US EPA Integrated Nitrogen Committee

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Outline

- N_2O offset project background
- N_2O emissions in agriculture and climate change
- N_2O project implementation

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Project Background and Summary

- Nitrous Oxide (N_2O) is a powerful non-CO_2 greenhouse gas (GHG).
  - 100-year Global Warming Potential (GWP) is 296.
  - 1 ton of N_2O emissions = 296 tons CO_2e.

- This EPRI project is focused on demonstrating the potential to achieve large scale, cost-effective GHG emissions offsets by reducing N_2O emissions from agricultural crop production.

- EPRI developed this project in collaboration with one of the world's foremost experts on non-CO_2 GHG emissions from agriculture – Dr. Phil Robertson, Professor of Crop and Soil Sciences at Michigan State University (MSU).

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EPRI N_2O Project Goals

Row crop ecosystems, such as this corn crop in the United States, contribute to ~50% of anthropogenic N_2O emissions.

- Increase breadth of options available to electric companies and others to offset GHG emissions in response to potential carbon constraints.
- Demonstrate an innovative approach to creating cost-effective, widespread and large-scale GHG reductions.
- Develop a way for electric companies to create GHG emissions reductions in collaboration with the agricultural community.

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Key Tasks

1. Evaluate technical potential and economic cost to offset GHG emissions by reducing N_2O emissions from agricultural crop production.

2. Conduct field testing to confirm that N_2O "flux" can be reduced by lowering nitrogen fertilizer (N) input with little concomitant loss in crop yield.

3. Develop quantitative models to predict the relationship between N_2O flux and crop yields in major cropping systems and soil / climate regimes.

4. Conduct socio-economic analysis to identify factors that may promote or inhibit farmer acceptance of this approach.

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Project Supporters & Participants

Electric Companies

- Ameren
- Detroit Edison Co.
- Duke Energy
- FirstEnergy
- Hoosier Energy Rural Electric Coop
- Nebraska Public Power District
- Oglethorpe Power Corporation
- Southern Company

Other Institutions

- EPRI
  - Adam Diamant
- Michigan State University (MSU)
  - G. Philip Robertson, Ph.D.

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N_2O Emissions, Global Climate Change and Agricultural Crop Production

Row crop ecosystems, such as this corn crop in the United States, contribute to ~50% of anthropogenic N_2O emissions.

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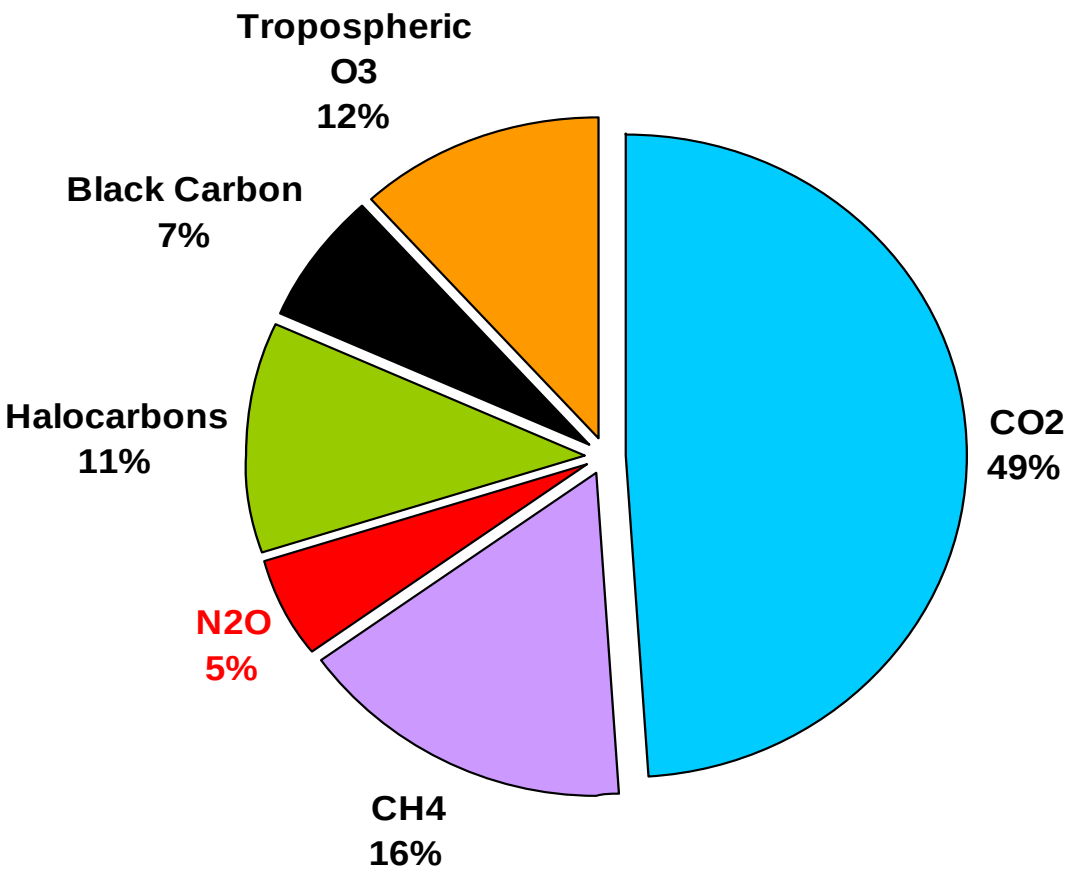
Global Sources of Atmospheric Radiative Forcing 1750 - 1998



Source: IPCC 2001

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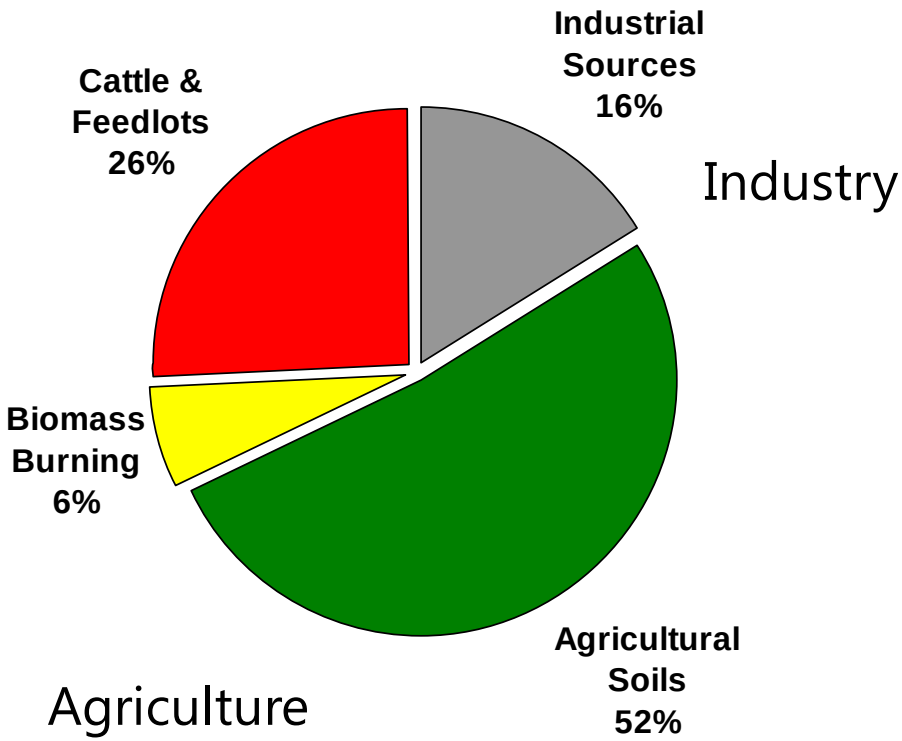
N_2O Emissions In Agriculture



Anthropogenic sources of N_2O globally; the total anthropic flux is 1 Pg C / year (from IPCC 2001, Robertson 2004).

- N_2O emissions from agricultural soils accounts for more than 50% of global anthropogenic N_2O flux.
- N_2O is formed during nitrification and denitrification.
- Recent experiments suggest that reducing fertilizer applications can reduce N_2O emissions with little or no loss in crop production.

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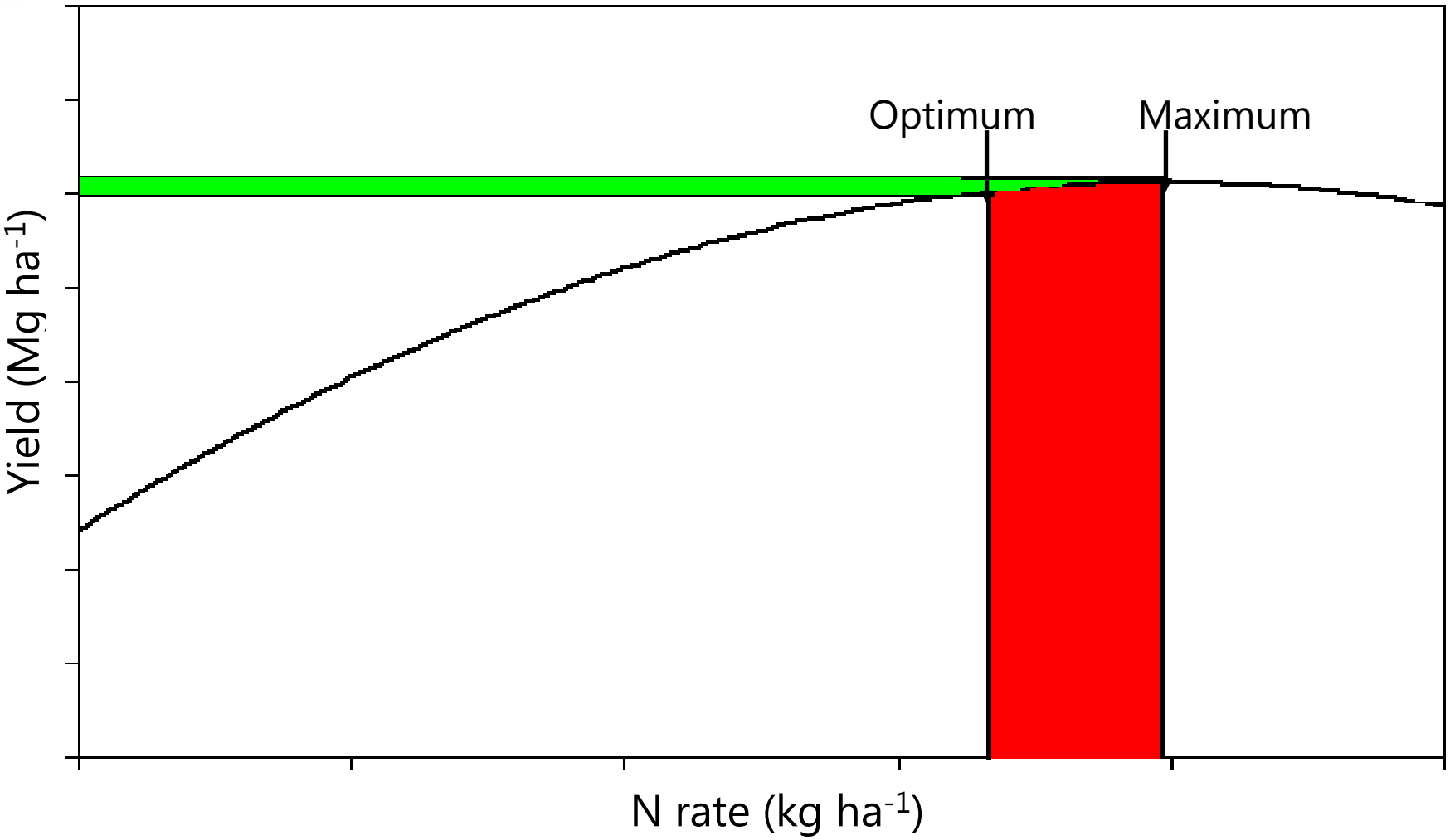
Corn Yield Response to Applied Nitrogen



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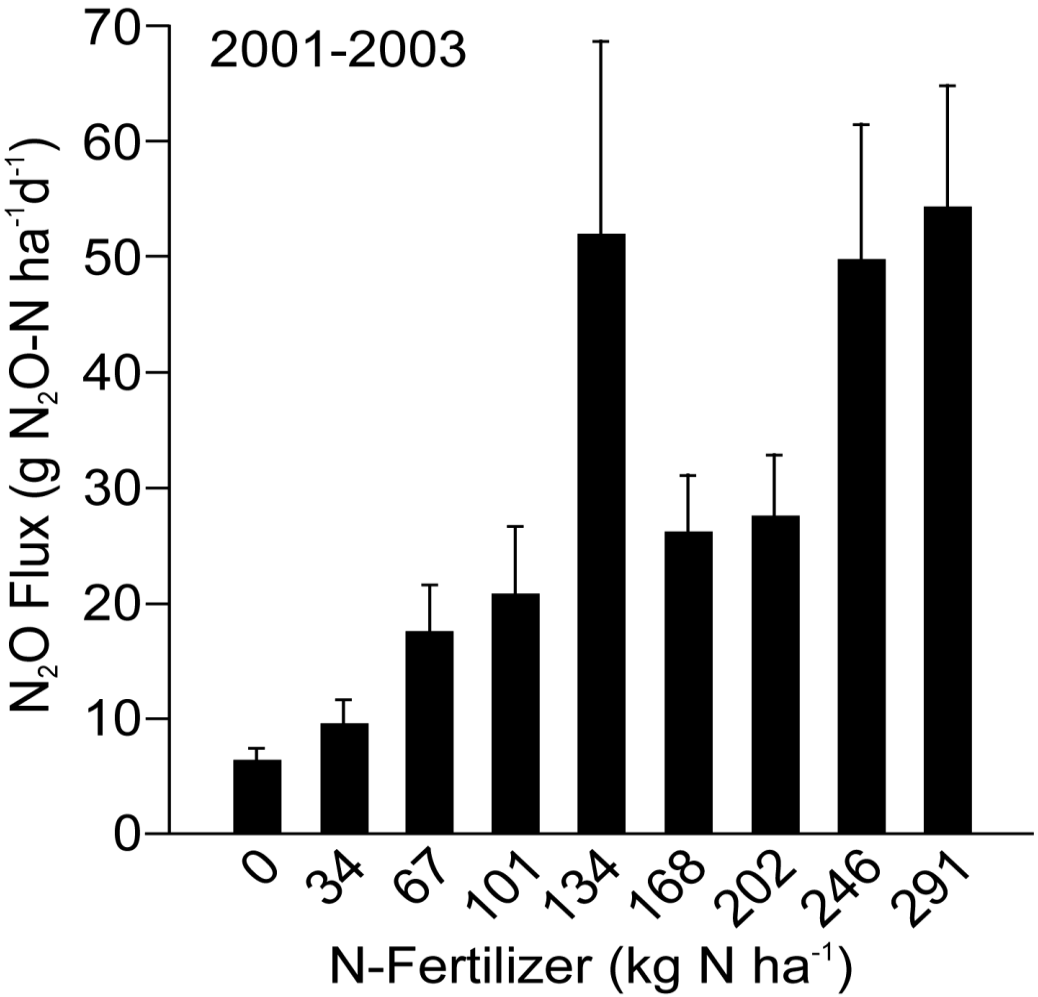
N_2O Flux and N-Fertilizer Use



Nonlinear response of N_2O flux to N-fertilizer levels in continuous corn over a 3-year period.

Implications

- N_2O "flux" increases exponentially as N fertilizer rates increase.
- Reducing N fertilizer application can reduce dramatically N_2O emissions.

Source: McSwiney & Robertson, *Global Change Biology*, 2005.

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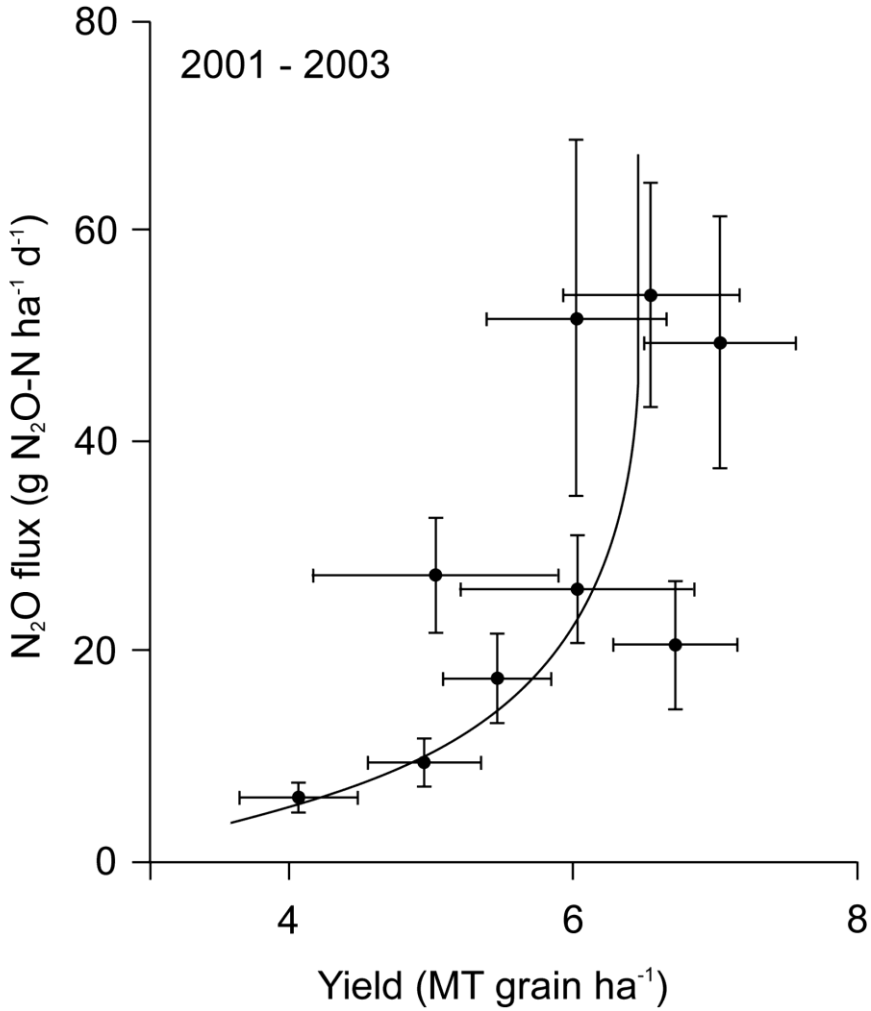
N_2O Flux versus Crop Yields



N_2O flux as a function of crop yield in continuous corn at a site in southwest MI.

Implications

- N_2O "flux" increases exponentially as crop yields increase.
- Implication – N_2O emissions can be reduced dramatically with little or no impact on total crop yield.

Source: McSwiney & Robertson, *Global Change Biology*, 2005.

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Benefits of N_2O Emissions Reductions

- Reducing N fertilizer application in crop production can be expected to reduce ~0.5tCO_2e / acre on annual basis.
  - No-till crop production may achieve ~1.0tCO_2/ac-yr
  - Afforestation / reforestation may achieve ~2-7tCO_2/ac-yr

- Reducing N_2O emissions offers important GHG emissions reduction benefits that cannot be achieved with no till or afforestation, including
  - N_2O reductions are permanent
  - N_2O reductions do not cause leakage
  - N_2O reductions potentially can be implemented across a very wide range of crop lands and geographic areas in the U.S. and abroad.
  - N_2O reductions potentially can be achieved at very low cost.

- Ancillary co-benefit of improved water quality.

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Project Implementation

Row crop ecosystems, such as this corn crop in the United States, contribute to~50% of anthropogenic N_2O emissions.

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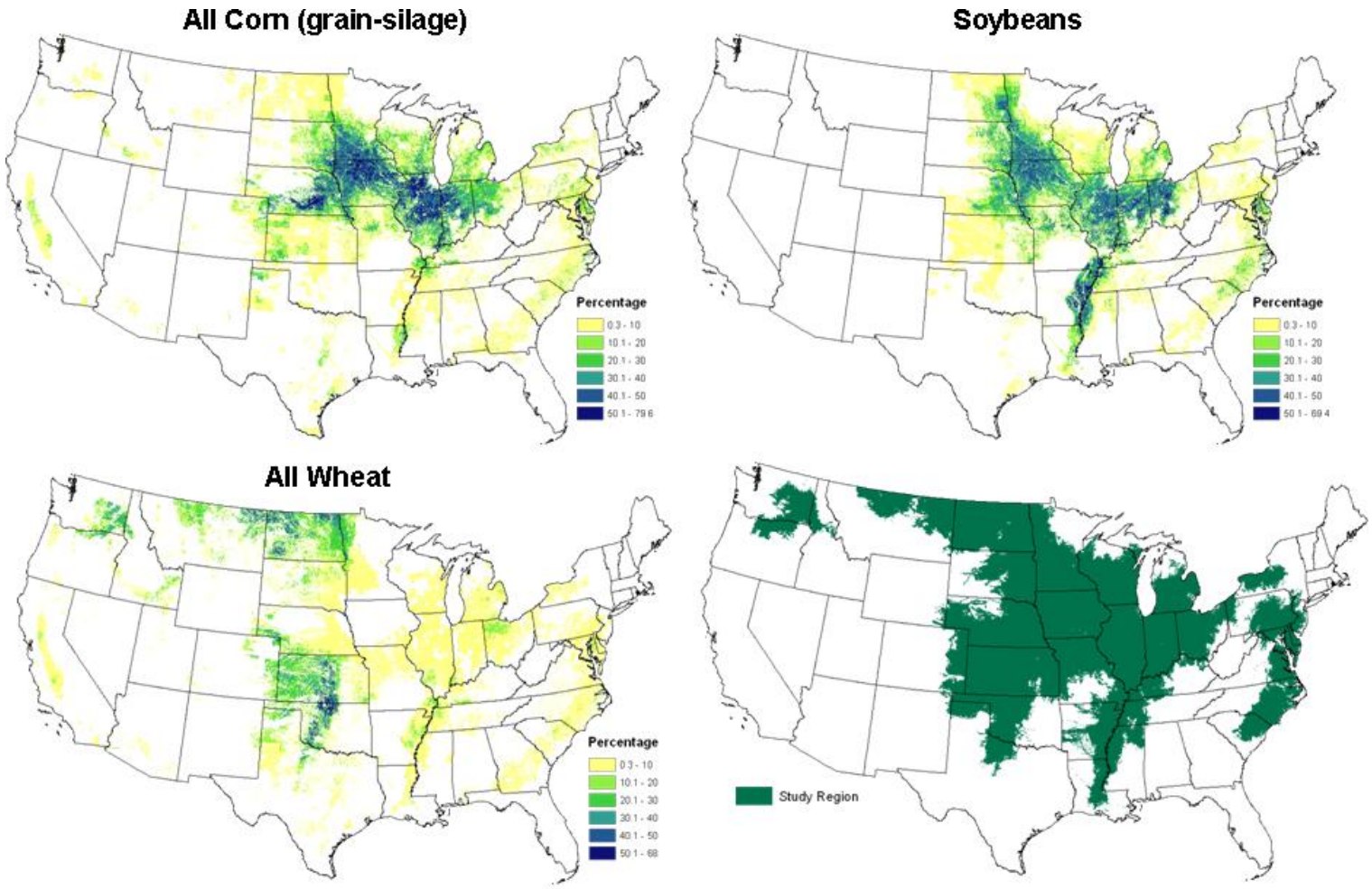
Region for N_2O Assessment Modeling



Data sources: a) National Land Cover Data 2001, b) National Agriculture Statistics Service, c) UDSDA STATSGO polygons.

Prepared by Manuel Colunga, Sep 7, 2007

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Field Study Goals / Benefits

- Confirm preliminary results from small "test plots" on larger farm-scale fields
- Compare N_2O flux versus soil N, fertilizer rate, and crop yield
- Calibrate and verify data for modeling effort
- Confirm that N_2O flux can be reduced by reducing N fertilizer inputs without a significant impact on farm profitability.

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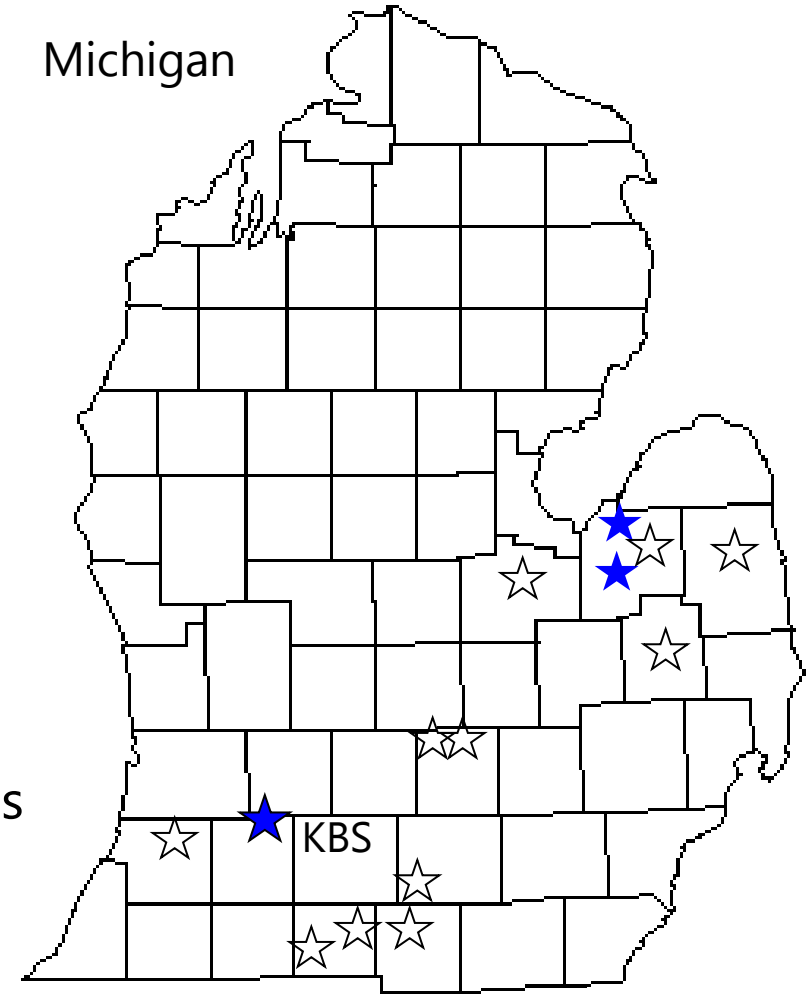
2007 EPRI Corn-Nitrogen Study Locations



★ EPRI corn N rate study locations

☆ Other MSU corn N rate study locations

EPRI may add sites in other regions, such as the Southeast.

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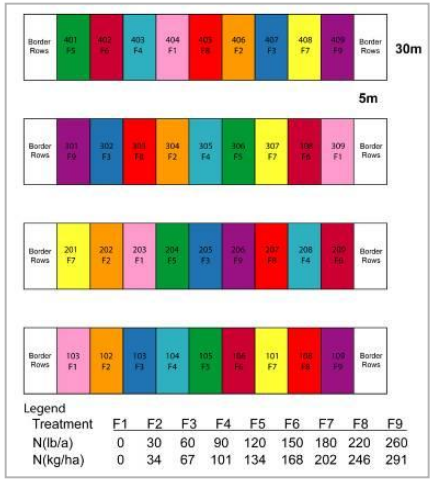
Measuring Field N_2O Production with Automated Chambers



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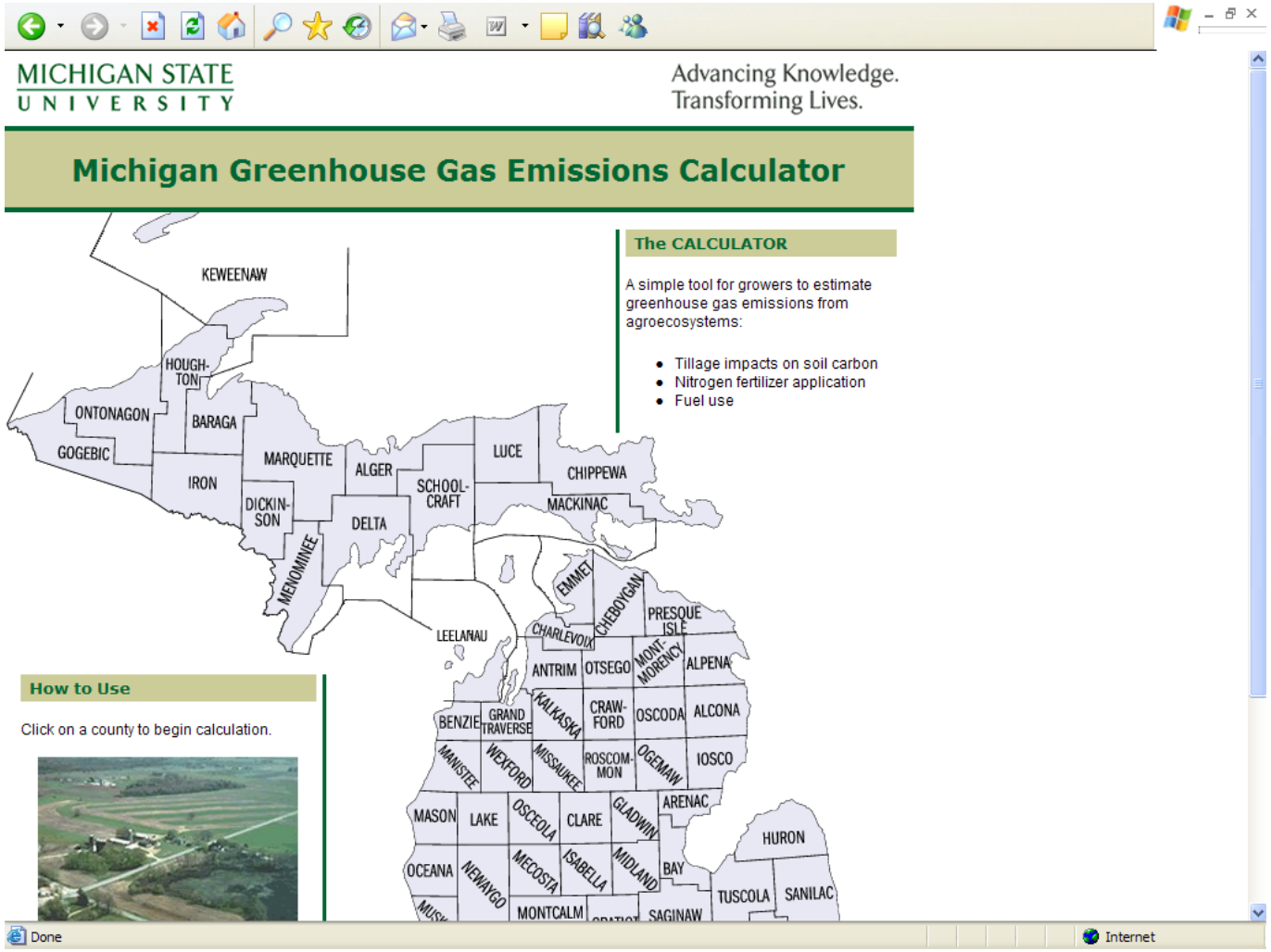
Web-based GHG Emissions Calculator (1 of 3)



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Web-based GHG Emissions Calculator (2 of 3)

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Michigan Greenhouse Gas Emissions Calculator

<< back to map

Saginaw (MI)

Mean annual precipitation	725 mm
Temperature	3.3 - 13.6 °C
Soil Texture	17.5 % clay
Soil bulk density	1.44 g/cm^3

Length of rotation (years) 2 Set

Area (hectares) 5

Initial SOC (%) 1 Use Default

Instructions

1. Input the length of your rotation (e.g. corn-soybean = 2) Press SET
2. Input soil test results (approx 0-10 cm), or Select USE DEFAULT to use a local value
3. Input your normal yield, or Select DEFAULT to use a local value
4. Select your Tillage option
5. Input the typical amount nitrogen fertilizer used (kg/ha)
6. Click on RUN MODEL – the model will run for 10 years

Crop	Avg. Crop Yield (kg/ha)		Tillage	Nitrogen (kg/Ha)
Soybeans	2014	default	No-Till	0
Corn For Grain	7116	default	No-Till	200

Corn For Grain
Corn For Silage
Soybeans
Wheat (winter)
Spring Cereal (e.g. oats, rye)
Alfalfa
Hay (grass)

Internet

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Web-based GHG Emissions Calculator (3 of 3)

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<< back to map << back to form

Saginaw (MI)

Mean annual precipitation	725 mm
Temperature	3.3 - 13.6 °C
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Sources of emissions

1. All greenhouse gas emissions are expressed as tons CO_2 equivalents (CO_2e), and includes the emissions of other greenhouse gases e.g. nitrous oxide (N_2O) and methane (CH_4)
2. Soils will lose C with cultivation and may potentially increase in C when you return crop residues.
3. Nitrogen fertilizers release N_2O, which is 310 times as potent as CO_2 as a greenhouse gas.
4. No-till or reduced tillage systems may have lower N_2O emissions
5. Fuel use is estimated from the NRCS Energy Estimator

RESULTS

TOTAL CO_2e emissions = 60 tonnes = 19t SOIL + 37t FERTILISER + 4t FUEL

Year	Crop	Tillage	Nitrogen	SOC (%)	Soil CO_2e	Fertilizer CO_2e	Annual CO_2e	Annual CO_2e	**Cumulative CO_2e**
1	Soybeans	No-Till	1	0.98	4.84	0.04	0.35	5.22	**5.22**
2	Corn For Grain	No-Till	200	0.97	1.81	7.45	0.35	9.62	**14.84**
3	Soybeans	No-Till	1	0.96	3.28	0.04	0.35	3.67	**18.51**
4	Corn For Grain	No-Till	200	0.96	0.79	7.45	0.35	8.60	**27.11**
5	Soybeans	No-Till	1	0.95	2.67	0.04	0.35	3.06	**30.16**

Done Internet

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