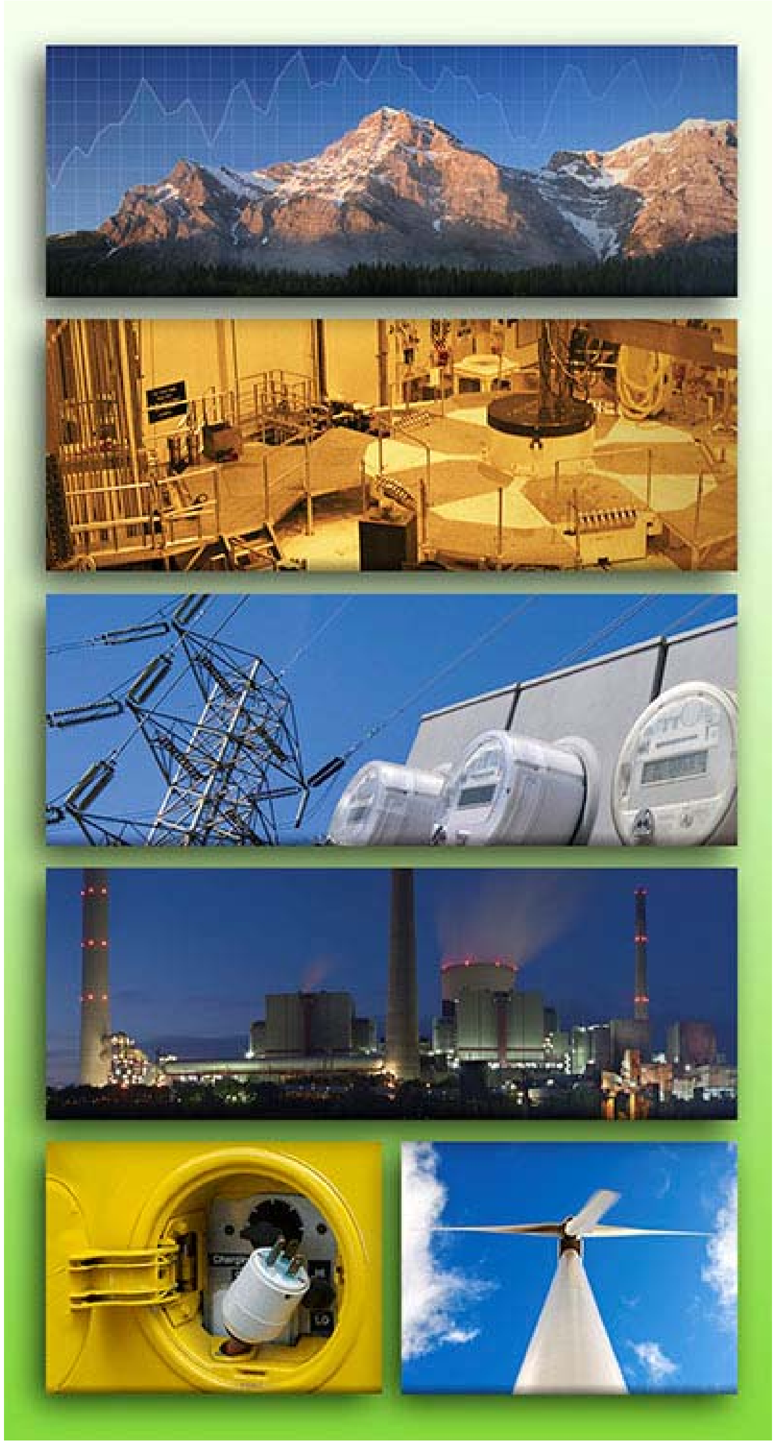

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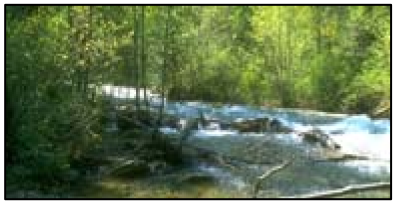
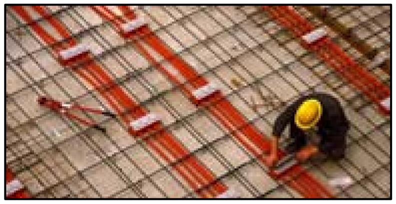
Overview of the EPRI-MSU Nitrous Oxide (N_2O) Greenhouse Gas Emissions Offsets Methodology

Adam Diamant
Senior Project Manager
EPRI Global Climate Program

Joint C-AGG, T-AGG, M-AGG Meeting
Chicago, IL
October 4, 2010

EPRI-MSU N_2O Offsets Project Collaboration

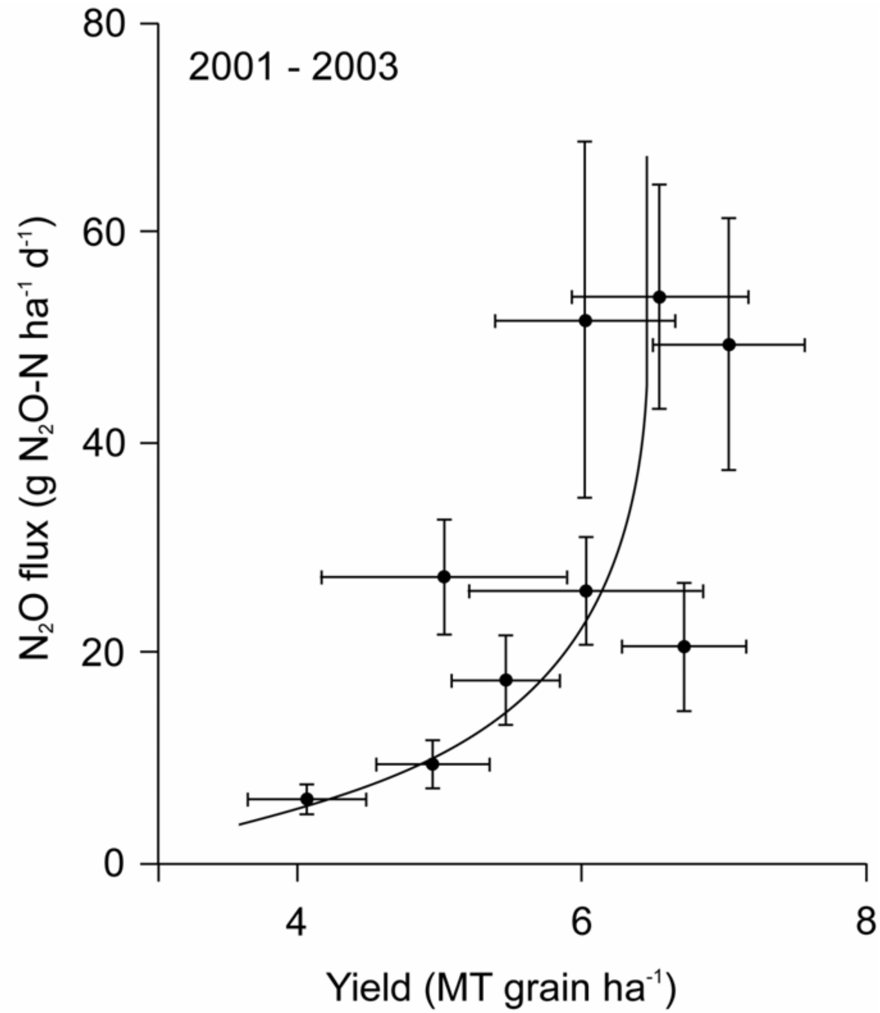





- Electric Power Research Institute (EPRI)
  - U.S. non-profit "501(c)(3)" scientific research consortium founded 1973 to perform objective electricity research for the public benefit
  - Members include companies who generate more than 90% of electricity delivered in the U.S.
  - EPRI has more than 450 participants in more than 40 countries around the world.
- Michigan State University (MSU)
  - Major U.S. "land grant" university
  - Respected for high-quality research in agriculture, agronomy, crop sciences and related fields
  - Principal Investigator is Dr. Phil Robertson – an expert on non-CO_2 GHG emissions from agriculture.

MSU N_2O Offsets Project Research Team

- **Dr. Phil Robertson,** Professor of Ecosystem Science, W. K. Kellogg Biological Station, Michigan State University
- **Dr. Neville Millar,** Research Associate, Michigan State University
- **Dr. Peter Grace,** Professor of Global Change, Queensland University of Technology, Queensland, Australia
- **Dr. Ron Gehl,** Assistant Professor, Department of Soil Sciences, North Carolina State University
- **John Hoben**, Graduate Student, Michigan State University

N_2O "Flux" Versus Crop Yields

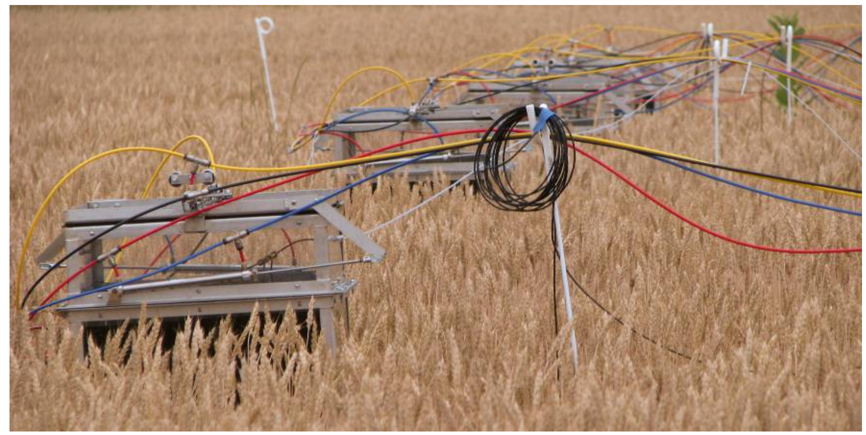


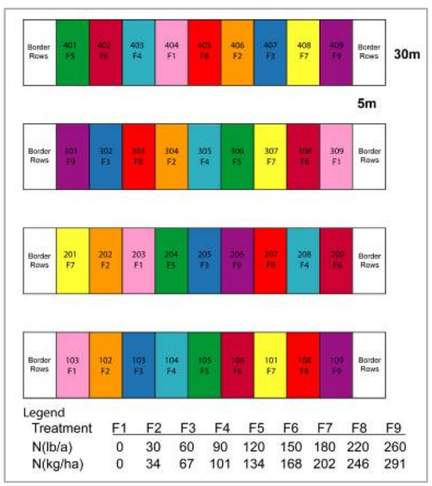
- N_2O flux increases exponentially as N-fertilizer increases beyond crop yield increase.
- Implication – N_2O emissions can be reduced dramatically with little or no impact on total crop yield.

N_2O flux as a function of yield (nitrogen availability) in continuous corn at a site in southwest Michigan. Results suggest that a significant decrease in N_2O flux could be achieved with little yield impact.

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

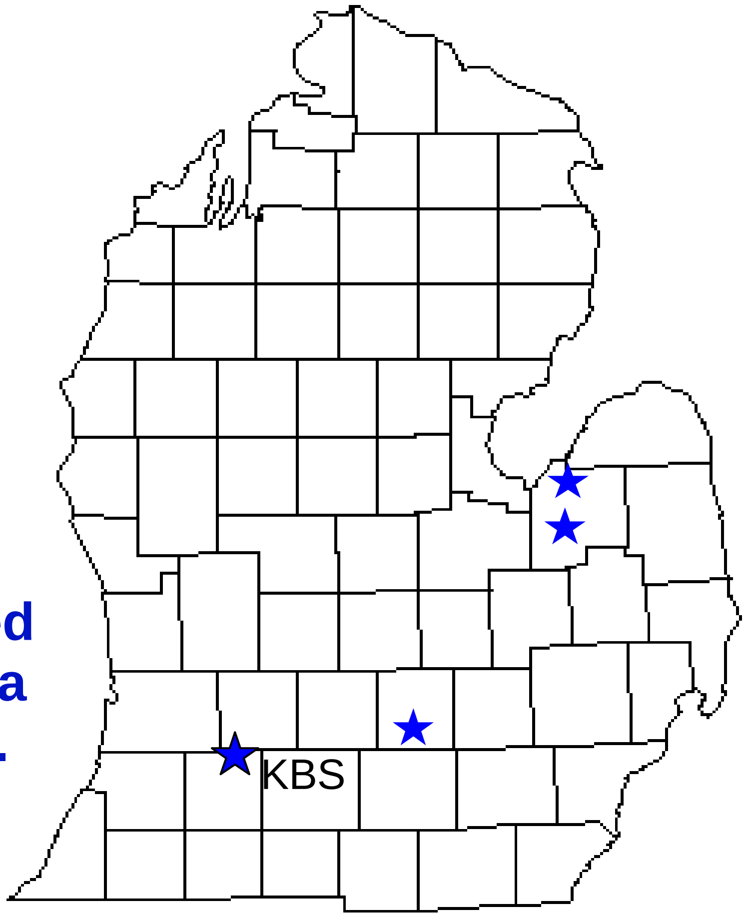
Non-linear N_2O Flux Response Validated on "Test Plots" Using Automated Chambers





N_2O Flux Response Validated on Commercial Farms over a 3-Year Period

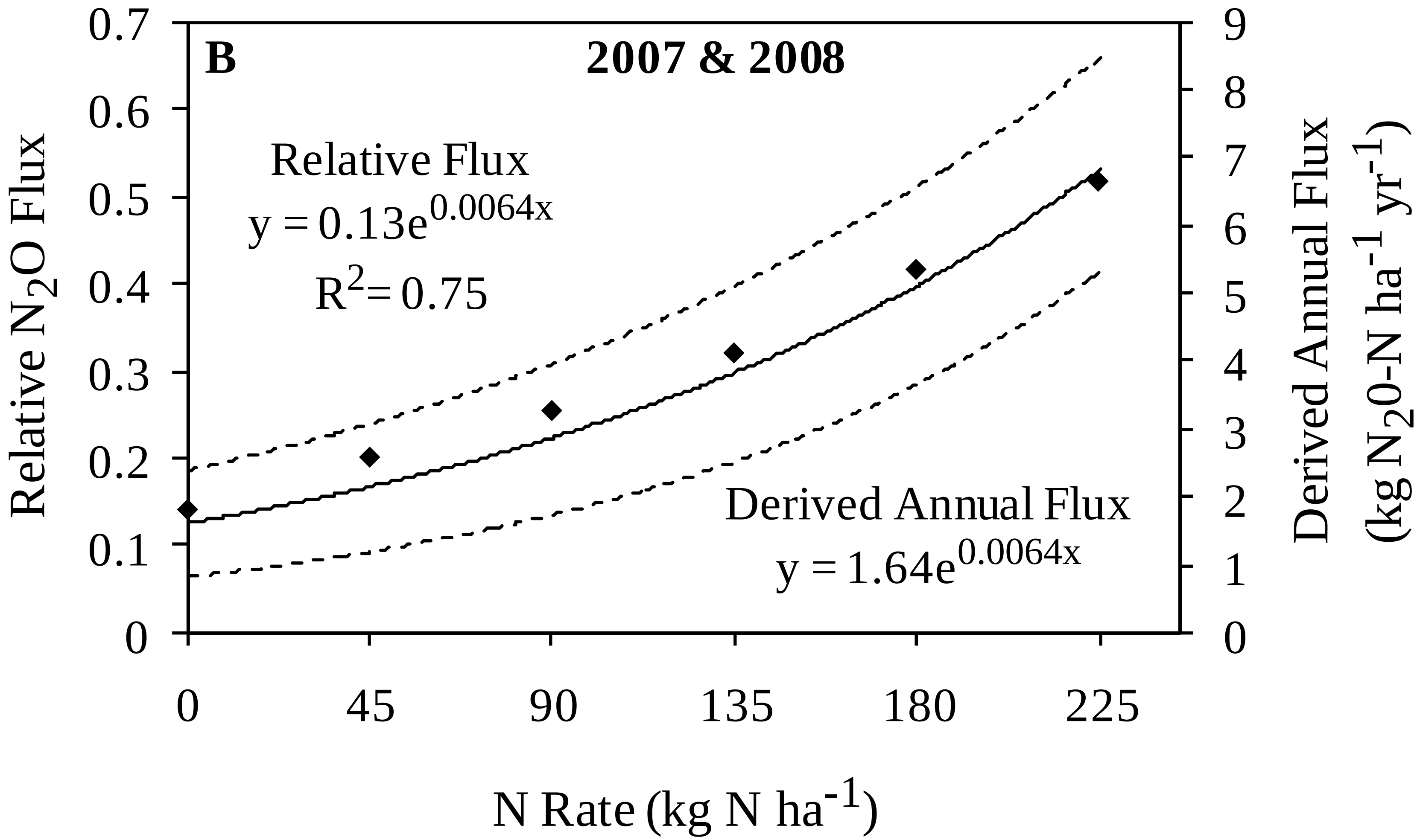
- Confirmed preliminary results from small "test plots" on larger farm-scale fields
- Compared N_2O flux versus soil N, fertilizer rate, and crop yield
- Calibrated & verified data for modeling
- MSU completed field studies in 2007, 2008 and 2009.
- **Confirmed that N_2O flux can be reduced by reducing N fertilizer inputs without a significant impact on farm profitability.**



Michigan

★ EPRI 2008 corn N rate study locations

Empirical Research Provided Basis for Use of Non-linear N_2O Response Equation for the NCR Region



EPRI-MSU N2O GHG Offsets Protocol Published in Peer-Review Science Literature

Mitig Adapt Strateg Glob Change (2010) 15:185–204
DOI 10.1007/s11027-010-9212-7

ORIGINAL ARTICLE

Nitrogen fertilizer management for nitrous oxide (N_2O) mitigation in intensive corn (Maize) production: an emissions reduction protocol for US Midwest agriculture

Neville Millar • G. Philip Robertson • Peter R. Grace •
Ron J. Gehl • John P. Hoben

http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s11027-010-9212-7

Peer-review GHG offsets accounting protocol provides a powerful scientific foundation to develop an offsets protocol that can be validated under existing offsets standards, such as the VCS.

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EPRI-MSU N_2O Offset Protocol
Guiding Principles

- ✓ Simple to understand and to implement
- ✓ Transparent
- ✓ No gaming opportunities
- ✓ Scientifically robust – based on peer-reviewed scientific literature and accepted understanding of N_2O flux
- ✓ Widely applicable to different climates, soils, crops
  - ➢ Tier 1 Approach outside North Central Region
  - ➢ Tier 2 Approach in the NCR

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The MSU–EPRI N_2O Offsets Protocol
VCS Validation Status

Voluntary Carbon Standard (VCS)
VCS Sectoral Scope 14: Agriculture, Forestry and Other Land Use

VCS | VOLUNTARY CARBON STANDARD

Documents submitted : 17th August 2010

VCS website posting : 8th Sept. 2010

(30 day world-wide public consultation now underway)

Double Approval Process

First Validator (contracted by MSU) : ENVIRONMENTAL SERVICES, INC.

Second Validator (to be contracted by VCS) : To be determined

EPRI-MSU N_2O Offset Protocol
Requirements for Eligibility (1 of 3)

Fertilizer Type

- Synthetic N (e.g., readily soluble, single or multi-nutrient).
- Organic N (e.g., animal manure, compost, sewage sludge).

All N inputs are considered equal on a mass basis irrespective of source.

Fertilizer Management

- Deliberately and directly applied to the soil as external source.
- Can be applied throughout entire cropping cycle (year agnostic).
- Project proponent must adhere to Best Management Practices (BMPs) of the region.

EPRI-MSU N_2O Offset Protocol
Requirements for Eligibility (2 of 3)

Nitrous Oxide Emissions

- Direct – produced on–site (i.e., project soil). From farmers field within a defined project boundary.
- Indirect – produced off-site (beyond project boundary). Includes N_2O produced in waters and soils as a result of NO_3 leaching and NH_3 volatilization.
- Increases in emissions of CH_4 and CO_2 and reductions in the soil carbon pool are considered negligible during the project crediting period.

Geographic Location and Calculation Method

- Method 1: Direct N_2O emissions (Tier 1), is applicable to cropland within the contiguous United States and the states of Alaska and Hawaii.
- Method 2: Direct N_2O emissions (Tier 2), is applicable to cropland within the North Central Region (NCR) of the USA.
- Same Method must be applied to both Baseline and Project Emissions.

EPRI-MSU N_2O Offset Protocol
Requirements for Eligibility (3 of 3)

Cropping System

- Method 1: Eligible for all agricultural systems where the product is harvested for food, livestock fodder or for another economic purpose and which typically receive a substantial anthropogenic input of nitrogen.
- Method 2: Eligible for corn row–crop systems including continuous corn, and rotations that include a corn component, in particular corn–soybean.

Cropping Area

- Baseline crop area must encompass the project crop area to ensure that the same land area is used in emission reduction calculations.

Soil Type

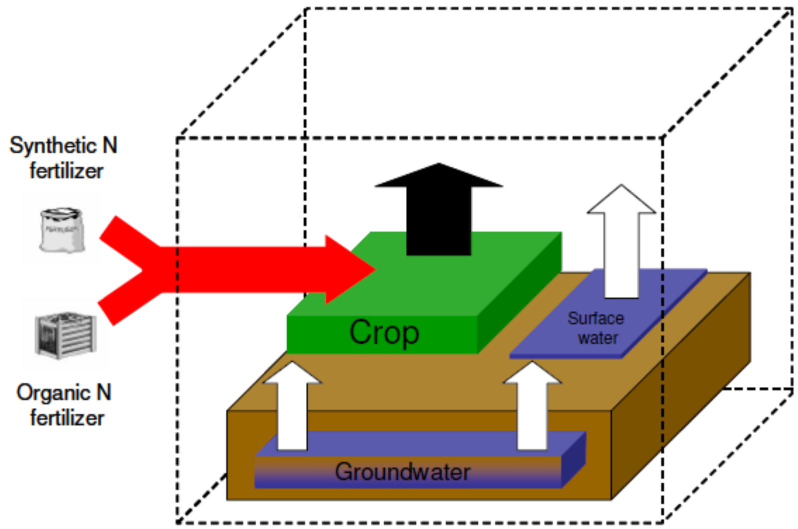
- "Organic" soils, as defined by the World Reference Base for Soil Resources (FAO 1998), are ineligible (e.g., wetlands, peat, etc…)

EPRI-MSU N_2O Offset Protocol
Project Boundaries

Spatial Boundary:

Encompasses both direct and indirect N_2O Emissions

- Spatial boundary (dotted line)
- Direct emissions (black arrow)
- Indirect emissions (white arrows)



Temporal Boundary:

VCS ALM project crediting period

- Not to exceed 10 years
- Can be renewed

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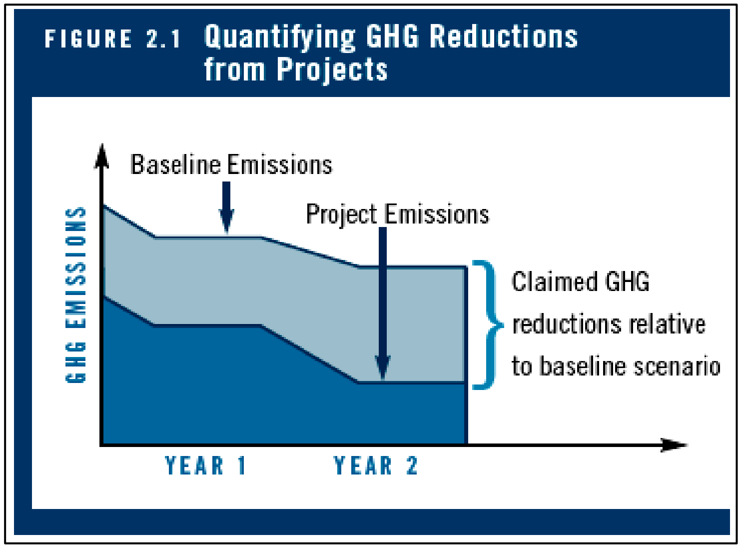
EPRI-MSU N_2O Offset Protocol
Project Baseline

- In the absence of a project, fertilizer N rate is applied in a "Business-as-Usual (BAU) manner, resulting in higher N_2O emissions than when a project is implemented.
- Emissions baseline is amount of N_2O that would have been emitted during the project with the N rate that would have been in place without the project.
- The baseline scenario is equivalent to the "common practice" fertilizer regime for the project developer.



Source: *The Greenhouse Gas Protocol: Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*, World Resources Institute (WRI) and World Business Council for Sustainable Development (WBSCD), 2007.

- Baseline N_2O emissions are carried out using one of two approaches. Both approaches initially generate a baseline fertilizer N application rate, from which emissions of N_2O are calculated.

EPRI-MSU N_2O Offset Protocol
Baseline Selection (1of 2)

Approach 1: **Site Specific**

- Baseline determined from project proponents' management records for previous five years crop rotation prior to project implementation.
  - Management records include N fertilizer purchase and application rate data, as well as manure application rate and manure N content data.
- **Approach 1 is preferred**
  - Finer spatial resolution
  - More potential offsets available compared to Approach 2

EPRI-MSU N_2O Offset Protocol
Baseline Selection (1of 2)

Approach 2: **County Level**

- Baseline fertilizer N rate calculated using crop yield data at the county level (USDA–NASS) and equations for determining fertilizer N rate recommendations based on yield goal estimates.
  - Available from state agriculture departments and university agricultural extension documents.
- Approach 2 is used if records are <u>not</u> available or verifiable for Approach 1.

EPRI-MSU N_2O Offset Protocol
Assessment of Additionality

Additionality assessed using Performance Benchmark. Under the VCS, two tests that must be passed:

1. Regulatory Surplus

- No mandatory law or other regulation is in place at the local, state, or federal level that requires farmers to reduce N fertilizer rate below BAU rates.

2. Performance Standard

- Exceeds a performance threshold that represents BAU rate
- “Common practice” threshold used that is identical to calculated N rate baseline value, irrespective of whether Approach 1 or 2 is used.

EPRI-MSU N_2O Offset Protocol
Emission Factors

Emission Factor used dependent on Method / Project Location

EF_{BDM1} – IPCC Default (Tier 1) : **0.01**

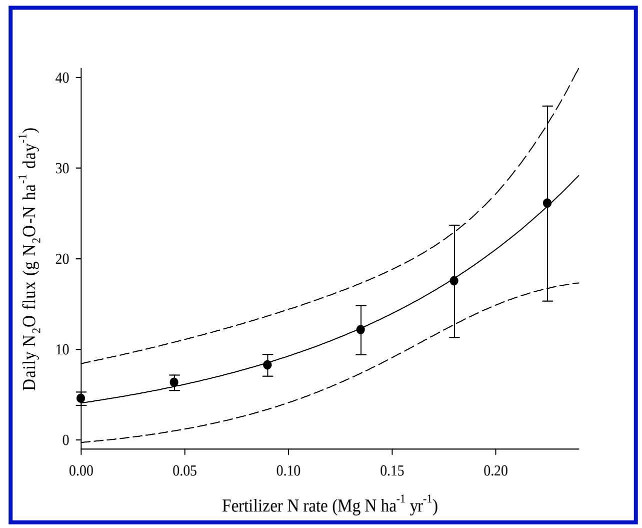
EF_{BDM2} – Empirical Field Data (Tier 2) : **0.0072 *exp [5.2*($F_{B\ SN,\ t}$ + $F_{B\ ON,\ t}$)]**

2006 IPCC Guidelines for
National Greenhouse Gas Inventories

Volume 4 Agriculture, Forestry and Other Land Use

TABLE 11.1
DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM MANAGED SOILS

Emission factor	Default value	Uncertainty range
EF_1 for N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon [kg N_2O–N (kg N)$^{-1}$]	0.01	0.003 - 0.03



Linear relationship

EF_1: Default value - constant EF

Exponential relationship

EF_2: Regional value – variable EF

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EPRI-MSU N_2O Offset Protocol
Permanence and Leakage

Permanence

- Avoided N_2O emissions occur immediately. They are irreversible and permanent.
- **No permanence concerns.**

Leakage

- Land maintained for production prior to implementing project.
- No yield reductions → no yield compensation → no additional N use.
- **Market leakage not applicable** with VCS ALM project type

EPRI-MSU N_2O Offset Protocol
Next Steps

- Continue VCS 1st and 2nd methodology validation
- Prepare N_2O Protocol for submission to Winrock's American Carbon Registry (ACR)
- N_2O Project Design Document for "pilot" N_2O offsets project in MI being developed by MSU for submission to VCS
- Ongoing interaction with Climate Action Reserve (CAR) as they consider developing an N_2O offsets protocol

Thank You

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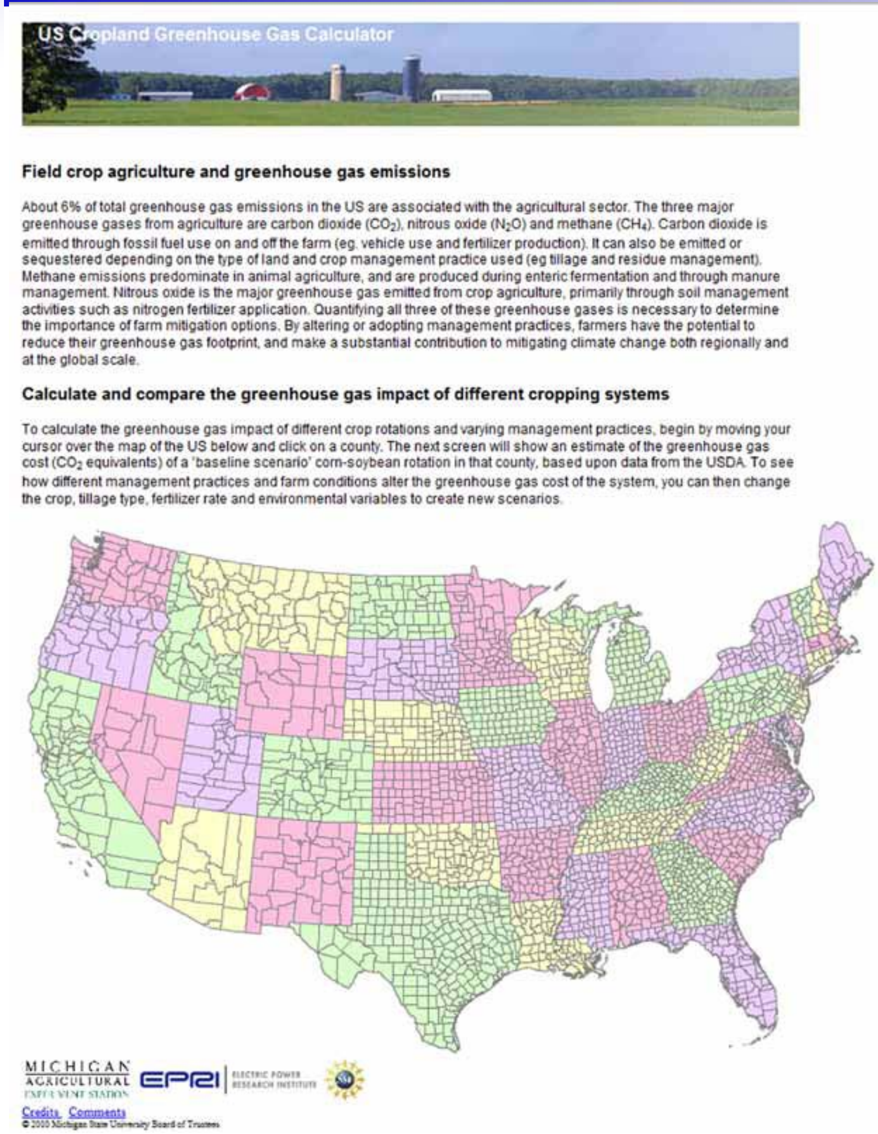
MSU Web-based Decision Support System: N_2O GHG Calculator


US Cropland Greenhouse Gas Calculator

Field crop agriculture and greenhouse gas emissions

About 6% of total greenhouse gas emissions in the US are associated with the agricultural sector. The three major greenhouse gases from agriculture are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Carbon dioxide is emitted through fossil fuel use on and off the farm (eg. vehicle use and fertilizer production). It can also be emitted or sequestered depending on the type of land and crop management practice used (eg tillage and residue management). Methane emissions predominate in animal agriculture, and are produced during enteric fermentation and through manure management. Nitrous oxide is the major greenhouse gas emitted from crop agriculture, primarily through soil management activities such as nitrogen fertilizer application. Quantifying all three of these greenhouse gases is necessary to determine the importance of farm mitigation options. By altering or adopting management practices, farmers have the potential to reduce their greenhouse gas footprint, and make a substantial contribution to mitigating climate change both regionally and at the global scale.

Calculate and compare the greenhouse gas impact of different cropping systems

To calculate the greenhouse gas impact of different crop rotations and varying management practices, begin by moving your cursor over the map of the US below and click on a county. The next screen will show an estimate of the greenhouse gas cost (CO_2 equivalents) of a 'baseline scenario' corn-soybean rotation in that county, based upon data from the USDA. To see how different management practices and farm conditions alter the greenhouse gas cost of the system, you can then change the crop, tillage type, fertilizer rate and environmental variables to create new scenarios.

Credits Comments

- N_2O calculator allows offset project developers, electric companies, and others to quantify potential N_2O offsets and identify the best locations to implement them.
- Calculator makes use of existing USDA and other data.
- Provides comparative CO_2e "costs" of N_2O, soil carbon change, fuel, and fertilizer;
- Allows comparison of different scenarios based on crop, tillage, and fertilizer decisions

www.kbs.msu.edu/ghgcalculator

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EPRI-MSU N_2O Offset Protocol
Emission Calculations

Baseline $_{(B)}$ and Project $_{(P)}$ Emissions (Baseline example)

$$N_2O_{B\ total,\ t} = N_2O_{B\ direct,\ t} + N_2O_{B\ indirect,\ t}$$

- $N_2O_{B\ total,\ t}$: **Total N_2O emissions**
- $N_2O_{B\ direct,\ t}$: **Direct N_2O emissions**
- $N_2O_{B\ indirect,\ t}$: **Indirect N_2O emissions**

$$N_2O_{B\ direct,\ t} = (F_{B\ SN,\ t} + F_{B\ ON,\ t}) * EF_{BDM1} * N_2O_{MW} * N_2O_{GWP}$$

- $(F_{B\ SN,\ t} + F_{B\ ON,\ t})$: **Mass of Synthetic + Organic N fertilizer**
- EF_{BDM1}: **Emission Factor 1 or 2**
- N_2O_{MW}: **Ratio of N_2O to N_2**
- N_2O_{GWP}: **Global Warming Potential for N_2O**

$$N_2O_{B\ indirect,\ t} = N_2O_{B\ volat,\ t} + N_2O_{B\ leach,\ t}$$

- $N_2O_{B\ volat,\ t}$: **Indirect N_2O emissions from atmospheric deposition of volatilized N**
- $N_2O_{B\ leach,\ t}$: **Indirect N_2O emissions from leaching and runoff of N**