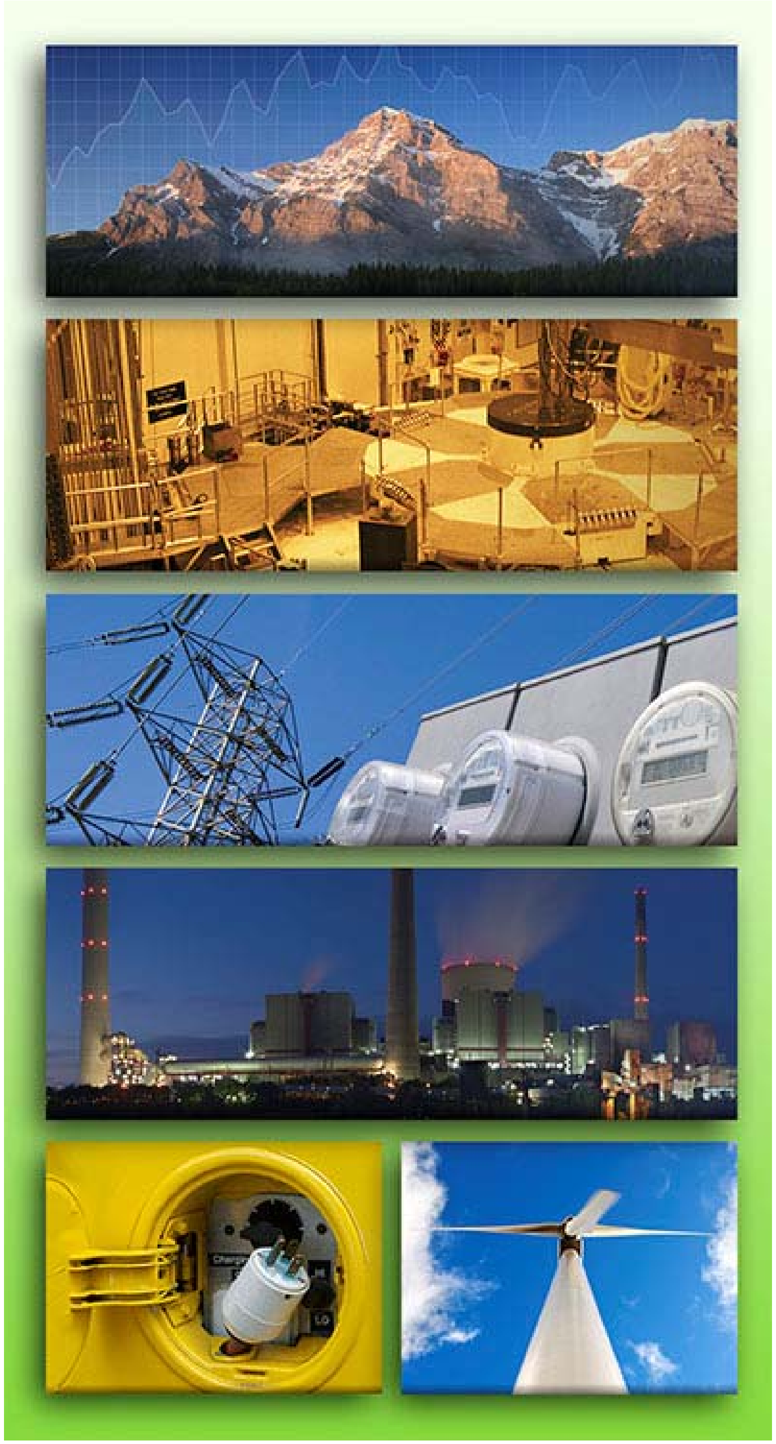


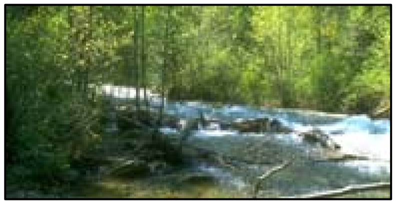
ELECTRIC POWER RESEARCH INSTITUTE

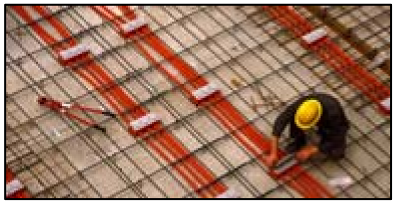
Overview of the EPRI-MSU Nitrous Oxide (N_2O) Greenhouse Gas Emissions Offsets Methodology

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



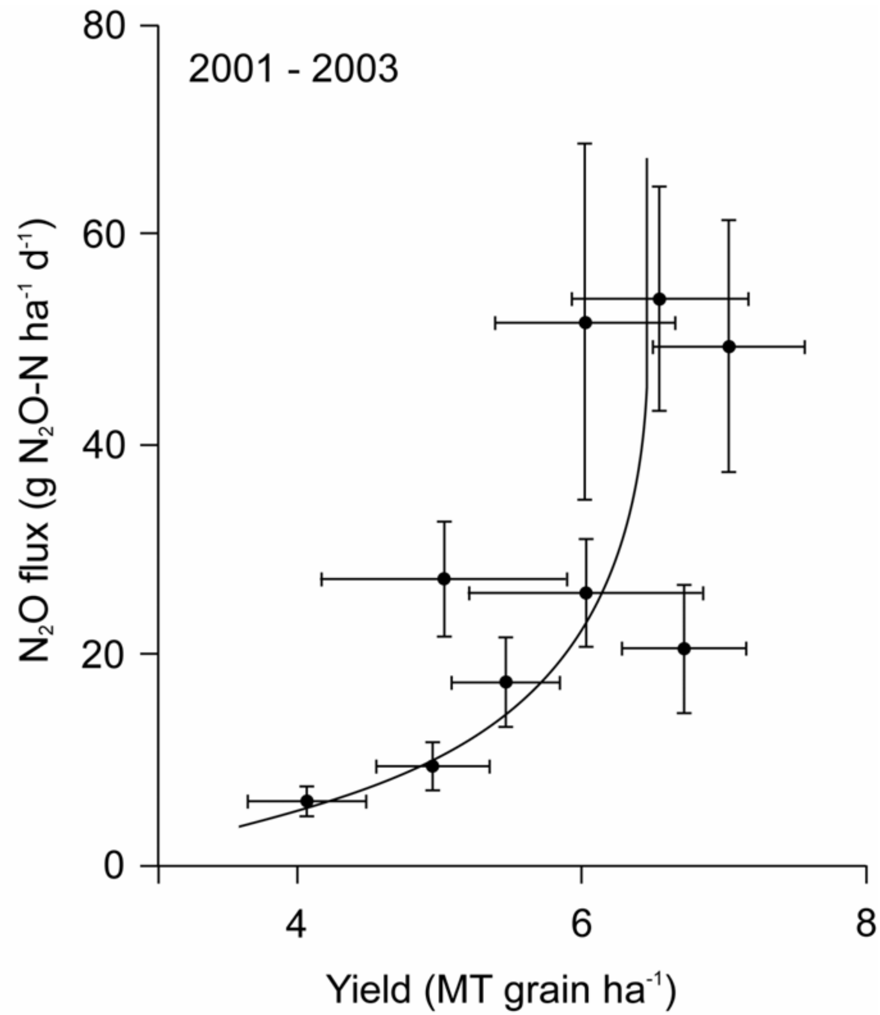


- Electric Power Research Institute (EPRI)
  - U.S. non-profit "501(c)(3)" scientific research consortium founded 1973 to perform objective electricity research for the public benefit
  - Members include companies who generate more than 90% of electricity delivered in the U.S.
  - EPRI has more than 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

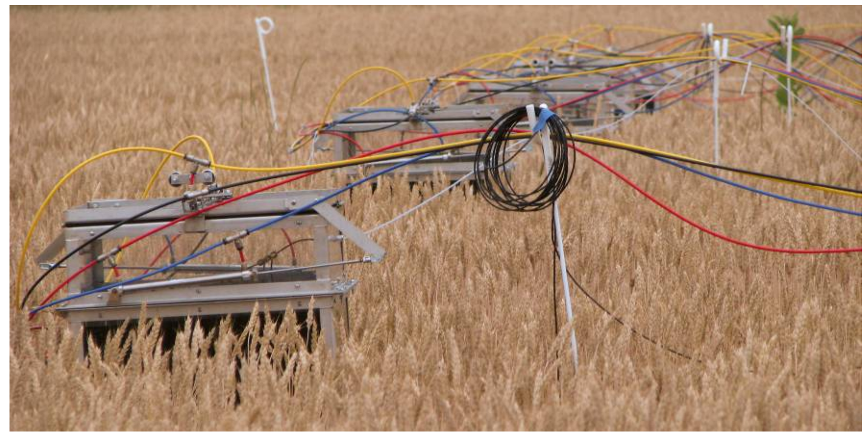


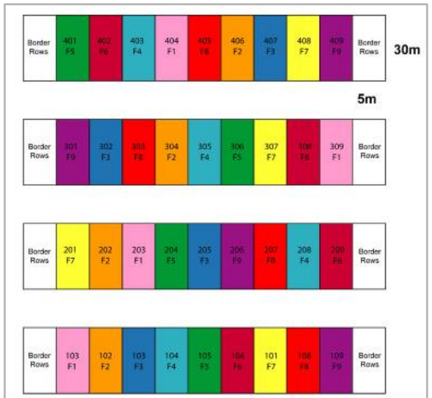
- N_2O flux increases exponentially as N-fertilizer increases beyond crop yield increase.
- Implication – N_2O emissions can be reduced dramatically with little or no impact on total crop yield.

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



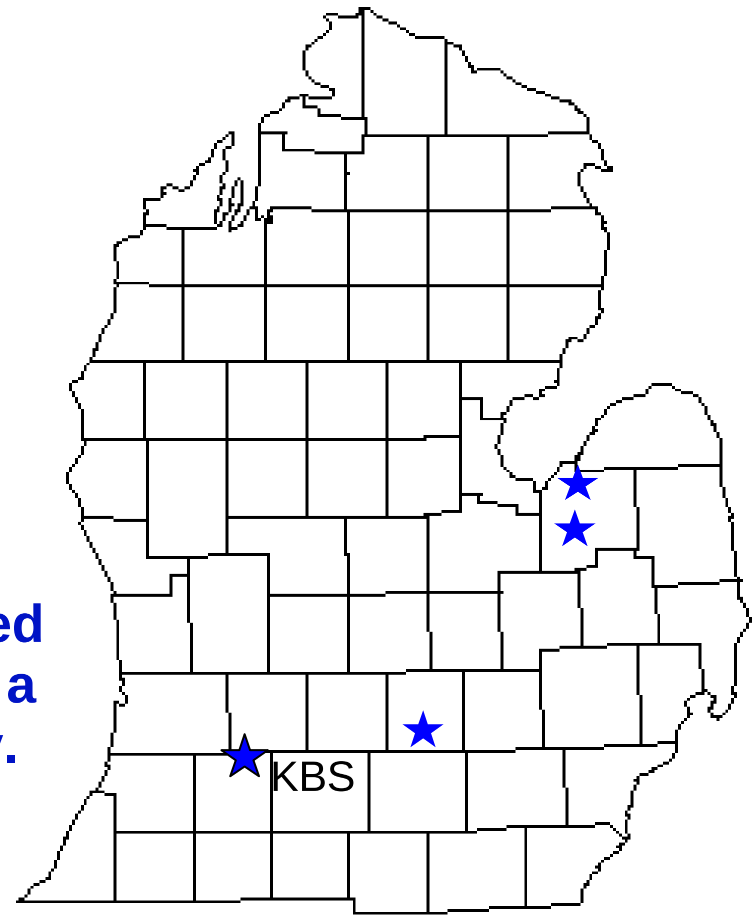


Legend

Treatment	F1	F2	F3	F4	F5	F6	F7	F8	F9
N(lb/a)	0	30	60	90	120	150	180	220	260
N(kg/ha)	0	34	67	101	134	168	202	246	291

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.**

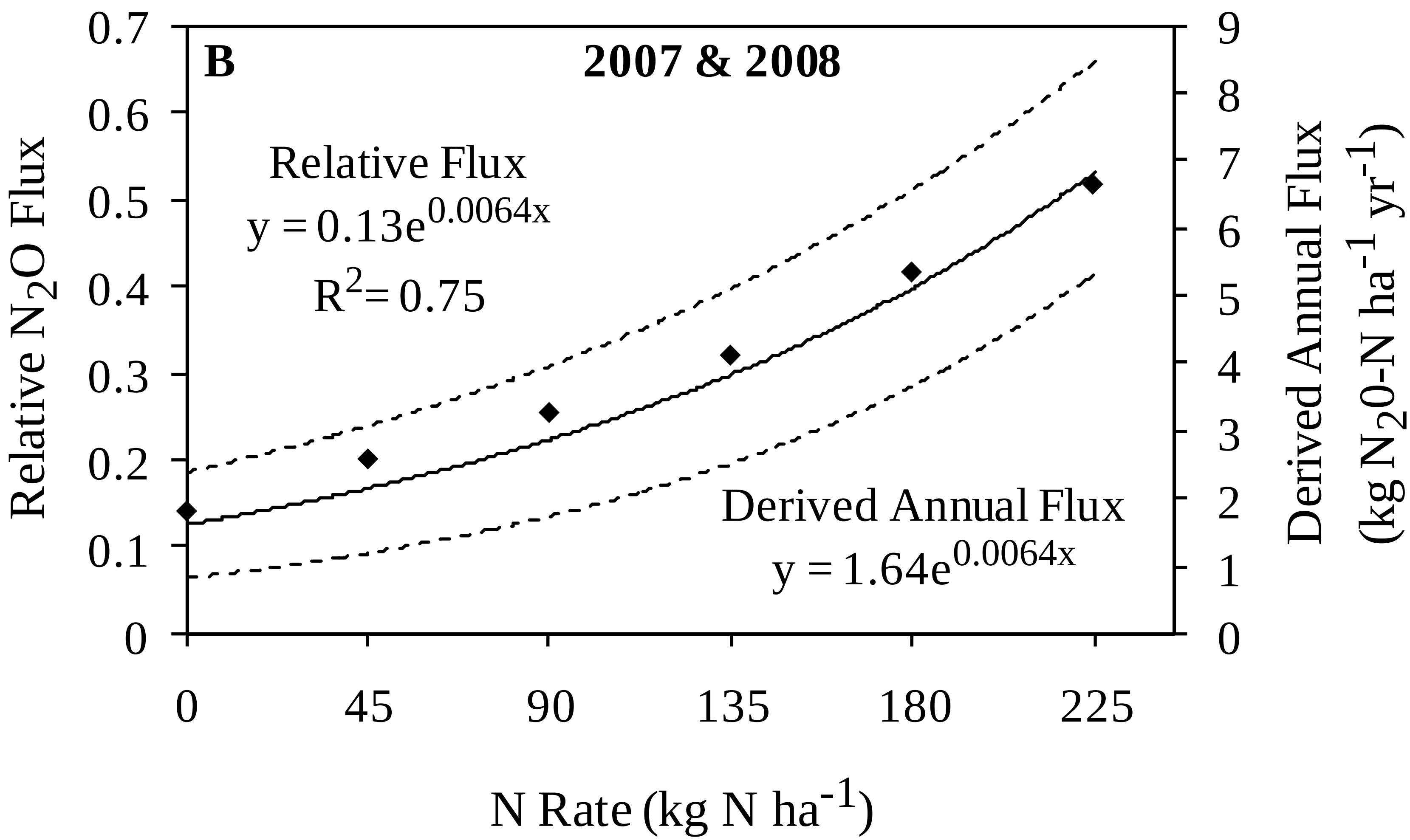


Michigan

★ EPRI 2008 corn N rate study locations

ELECTRIC POWER RESEARCH INSTITUTE

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



ELECTRIC POWER RESEARCH INSTITUTE

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.

ELECTRIC POWER RESEARCH INSTITUTE

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

The MSU–EPRI N_2O Offsets Protocol
VCS Validation Status

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

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 | ELECTRIC POWER RESEARCH INSTITUTE

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

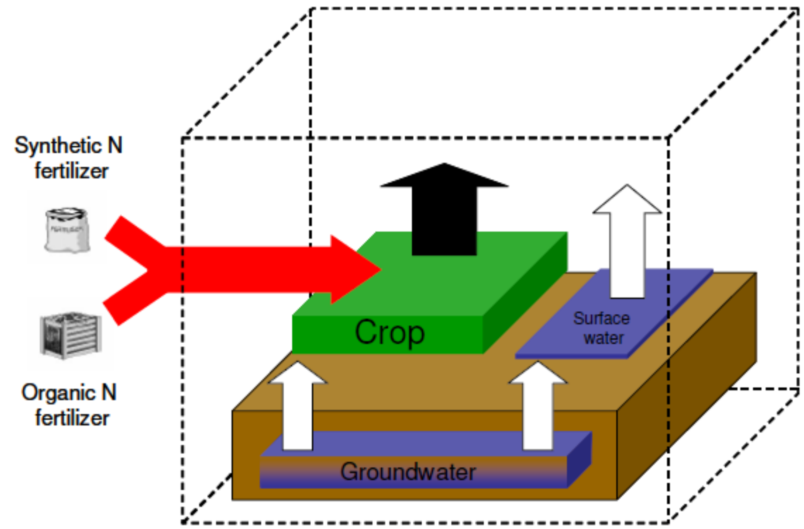
- "Organic" soils, as defined by the World Reference Base for Soil Resources (FAO 1998), are ineligible (e.g., wetlands, peat, etc…)

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)



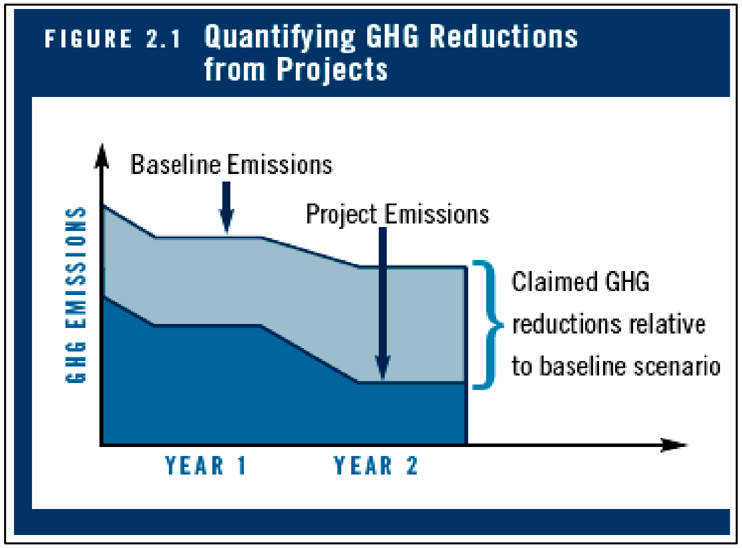
Temporal Boundary:

VCS ALM project crediting period

- Not to exceed 10 years
- Can be renewed

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 not available or verifiable for Approach 1.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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.

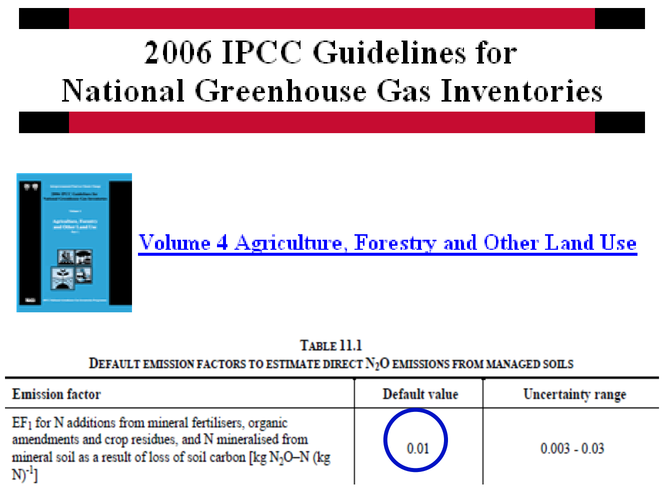
ELECTRIC POWER RESEARCH INSTITUTE

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*($F_{B\ SN,\ t}$ + $F_{B\ ON,\ t}$)]**

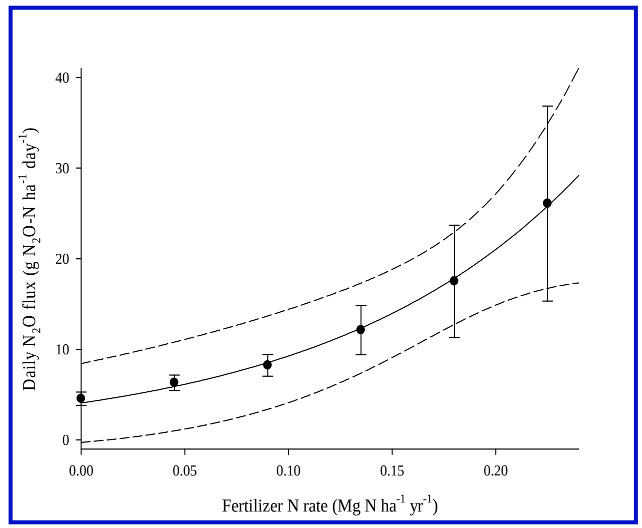


2006 IPCC Guidelines for
National Greenhouse Gas Inventories

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

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Thank You

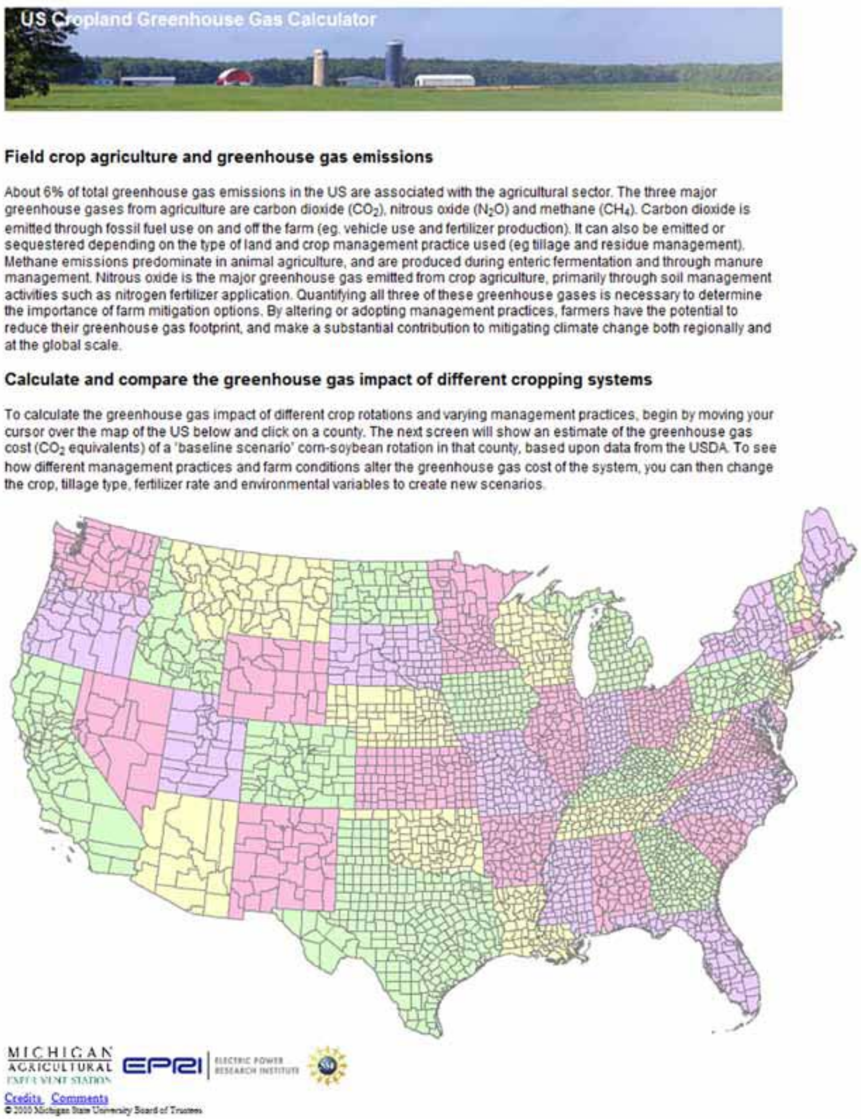
Adam Diamant
Electric Power Research Institute
Senior Project Manager
Phone: 510-260-9105
adiamant@epri.com

Dr. Phil Robertson
Michigan State University
Hickory Corners, MI 49060
Phone: (269) 671-2267
robertson@kbs.msu.edu

Dr. Neville Millar
Michigan State University
Hickory Corners, MI 49060
Phone: (269) 671-2534
millarn@msu.edu

Dr. Peter Grace
Professor of Global Change
Queensland University of Technology
Brisbane, Queensland
pr.grace@qut.edu.au

MSU Web-based Decision Support System: N_2O GHG Calculator



- 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

ELECTRIC POWER RESEARCH INSTITUTE

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**