Overview of the EPRI-MSU Nitrous Oxide (N₂O) Greenhouse Gas Emissions Offsets Methodology

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EPRI-MSU N₂O 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-CO₂ GHG emissions from agriculture.
MSU N₂O 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
N₂O “Flux” Versus Crop Yields

• N₂O flux increases exponentially as N-fertilizer increases beyond crop yield increase.

• Implication – N₂O emissions can be reduced dramatically with little or no impact on total crop yield.

N₂O flux as a function of yield (nitrogen availability) in continuous corn at a site in southwest Michigan. Results suggest that a significant decrease in N₂O flux could be achieved with little yield impact.

Non-linear N$_2$O Flux Response Validated on “Test Plots” Using Automated Chambers
N₂O Flux Response Validated on Commercial Farms over a 3-Year Period

- Confirmed preliminary results from small “test plots” on larger farm-scale fields
- Compared N₂O flux versus soil N, fertilizer rate, and crop yield
- Calibrated & verified data for modeling
- Confirmed that N₂O flux can be reduced by reducing N fertilizer inputs without a significant impact on farm profitability.

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Empirical Research Provided Basis for Use of Nonlinear N$_2$O Response Equation for the NCR Region

Relative Flux
\[ y = 0.13e^{0.0064x} \]
\[ R^2 = 0.75 \]

Derived Annual Flux
\[ y = 1.64e^{0.0064x} \]
Nitrogen fertilizer management for nitrous oxide (N$_2$O) 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


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.
EPRI-MSU N₂O 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 N₂O flux
✓ Widely applicable to different climates, soils, crops
  ➢ Tier 1 Approach outside North Central Region
  ➢ Tier 2 Approach in the NCR
The MSU–EPRI N₂O 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)

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.
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$_2$O 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$_2$O emissions (Tier 1), is applicable to cropland within the contiguous United States and the states of Alaska and Hawaii.
- **Method 2:** Direct N$_2$O 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 N₂O 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...).
Spatial Boundary:

Encompasses both direct and indirect N\(_2\)O 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 \( \text{N}_2\text{O} \) 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 \( \text{N}_2\text{O} \) emissions than when a project is implemented.

- Emissions baseline is amount of \( \text{N}_2\text{O} \) 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.

- Baseline \( \text{N}_2\text{O} \) emissions are carried out using one of two approaches. Both approaches initially generate a baseline fertilizer N application rate, from which emissions of \( \text{N}_2\text{O} \) are calculated.

EPRI-MSU N₂O Offset Protocol
Baseline Selection (1 of 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
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.
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.
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Emission Factors

Emission Factor used dependent on Method / Project Location

\[ \text{EF}_{\text{BDM1}} = \text{IPCC Default (Tier 1)} : 0.01 \]

\[ \text{EF}_{\text{BDM2}} = \text{Empirical Field Data (Tier 2)} : 0.0072 \times \exp \left[ 5.2 \times (F_{\text{B SN, t}} + F_{\text{B ON, t}}) \right] \]

2006 IPCC Guidelines for National Greenhouse Gas Inventories

Volume 4 Agriculture, Forestry and Other Land Use

<table>
<thead>
<tr>
<th>Default emission factors to estimate direct N₂O emissions from managed soils</th>
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<tbody>
<tr>
<td>Emission factor</td>
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<td>----------------</td>
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<td>( \text{EF} )</td>
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Linear relationship

\( \text{EF}_1: \) Default value - constant EF

Exponential relationship

\( \text{EF}_2: \) Regional value – variable EF
Permanence

- Avoided N₂O 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$_2$O Offset Protocol

Next Steps

• Continue VCS 1$^{st}$ and 2$^{nd}$ methodology validation
• Prepare N$_2$O Protocol for submission to Winrock’s American Carbon Registry (ACR)
• N$_2$O Project Design Document for “pilot” N$_2$O 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$_2$O offsets protocol
Thank You

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MSU Web-based Decision Support System: N$_2$O GHG Calculator

- N$_2$O calculator allows offset project developers, electric companies, and others to quantify potential N$_2$O offsets and identify the best locations to implement them.
- Calculator makes use of existing USDA and other data.
- Provides comparative CO$_2$e “costs” of N$_2$O, soil carbon change, fuel, and fertilizer;
- Allows comparison of different scenarios based on crop, tillage, and fertilizer decisions

www.kbs.msu.edu/ghgcCalculator
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Emission Calculations

Baseline (B) and Project (P) Emissions (Baseline example)

\[ N_{2O_B}^{\text{total}, t} = N_{2O_B}^{\text{direct}, t} + N_{2O_B}^{\text{indirect}, t} \]

- Total N₂O emissions

\[ N_{2O_B}^{\text{direct}, t} = (F_{B SN, t} + F_{B ON, t}) \times EF_{BDM1} \times N_{2O_MW} \times N_{2O_GWP} \]

- Mass of Synthetic + Organic N fertilizer
- Emission Factor 1 or 2
- Ratio of N₂O to N₂
- Global Warming Potential for N₂O

\[ N_{2O_B}^{\text{indirect}, t} = N_{2O_B}^{\text{volut}, t} + N_{2O_B}^{\text{leach}, t} \]

- Indirect N₂O emissions from atmospheric deposition of volatilized N
- Indirect N₂O emissions from leaching and runoff of N

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