Overview of the EPRI-MSU Nitrous Oxide ($N_2O$) 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 N₂O Flux Response Validated on “Test Plots” Using Automated Chambers
N$_2$O 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$_2$O flux versus soil N, fertilizer rate, and crop yield
- Calibrated & verified data for modeling
- Confirmed that N$_2$O flux can be reduced by reducing N fertilizer inputs without a significant impact on farm profitability.

EPRI 2008 corn N rate study locations

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Empirical Research Provided Basis for Use of Non-linear \( \text{N}_2\text{O} \) Response Equation for the NCR Region

\[
y = 0.13e^{0.0064x}
\]

\[
R^2 = 0.75
\]

\[
y = 1.64e^{0.0064x}
\]
Mitig Adapt Strateg Glob Change (2010) 15:185–204
DOI 10.1007/s11027-010-9212-7

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


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 N$_2$O 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$_2$O 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 : ENVIRONMENTAL SERVICES, INC.
(contracting by MSU)

Second Validator : To be determined
(to be contracted by VCS)
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 N₂O produced in waters and soils as a result of NO₃ leaching and NH₃ volatilization.

• Increases in emissions of CH₄ and CO₂ and reductions in the soil carbon pool are considered negligible during the project crediting period.

Geographic Location and Calculation Method

• **Method 1**: Direct N₂O emissions (Tier 1), is applicable to cropland within the contiguous United States and the states of Alaska and Hawaii.

• **Method 2**: Direct N₂O 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.
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 N₂O Offset Protocol**

**Project Boundaries**

**Spatial Boundary:**

Encompasses both direct and indirect N₂O 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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Project Baseline

- In the absence of a project, fertilizer N rate is applied in a “Business-as-Usual (BAU) manner, resulting in higher N$_2$O emissions than when a project is implemented.

- Emissions baseline is amount of N$_2$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 N$_2$O emissions are carried out using one of two approaches. Both approaches initially generate a baseline fertilizer N application rate, from which emissions of N$_2$O are calculated.
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

\[ EF_{BDM1} \text{ – IPCC Default (Tier 1)} \]

\[ EF_{BDM2} \text{ – Empirical Field Data (Tier 2)} \]

- **EF\textsubscript{BDM1} – IPCC Default (Tier 1)**
  - \( 0.01 \)
- **EF\textsubscript{BDM2} – Empirical Field Data (Tier 2)**
  - \( 0.0072 \times \exp [5.2(F_{B_{SN,t}} + F_{B_{ON,t}})] \)

### 2006 IPCC Guidelines for National Greenhouse Gas Inventories

*Volume 4 Agriculture, Forestry and Other Land Use*

#### Linear relationship

**EF\textsubscript{1}:** Default value - constant EF

#### Exponential relationship

**EF\textsubscript{2}:** Regional value – variable EF
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Permanence and Leakage

**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 $\rightarrow$ no yield compensation $\rightarrow$ no additional N use.
- **Market leakage not applicable** with VCS ALM project type
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Next Steps

• Continue VCS 1\textsuperscript{st} and 2\textsuperscript{nd} methodology validation
• Prepare N₂O Protocol for submission to Winrock’s American Carbon Registry (ACR)
• N₂O Project Design Document for “pilot” N₂O offsets project in MI being developed by MSU for submission to VCS
• Ongoing interaction with Climate Action Reserve (CAR) as they consider developing an N₂O 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/ghgcculator
EPRI-MSU N$_2$O Offset Protocol
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 N$_2$O emissions**
- **Direct N$_2$O emissions**
- **Indirect N$_2$O emissions**

\[ N_{2O_B \text{ direct, } t} = (F_{B \text{ SN, } t} + F_{B \text{ ON, } t}) \times E_{FBDM1} \times N_{2O\text{MW}} \times N_{2OGWP} \]

- **Mass of Synthetic + Organic N fertilizer**
- **Emission Factor 1 or 2**
- **Ratio of N$_2$O to N$_2$**
- **Global Warming Potential for N$_2$O**

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

- **Indirect N$_2$O emissions from atmospheric deposition of volatilized N**
- **Indirect N$_2$O emissions from leaching and runoff of N**