Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions in Agricultural Crop Production:
Experience Validating a New GHG Offset Protocol

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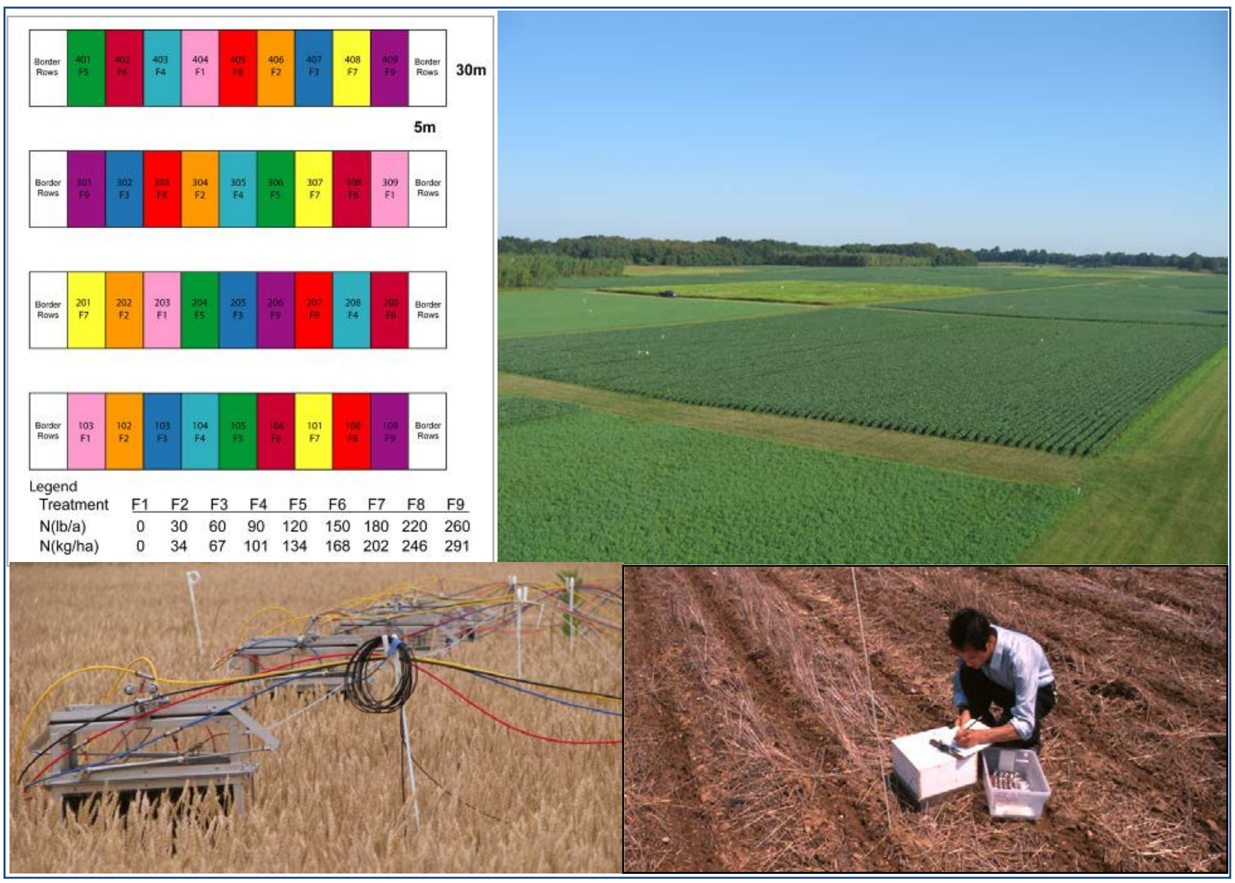

Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions in Agricultural Crop Production: *Experience Validating a New GHG Emissions Offset Protocol*

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Technical Update, May 2013

A. Diamant

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Michigan State University

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PRODUCT DESCRIPTION

This project report describes in part the second phase (years four through six, 2010–2012) of a two-phase, six-year long EPRI-sponsored research project entitled "*Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions*." This project investigated an innovative approach to developing large-scale, cost-effective greenhouse gas (GHG) emissions offsets that potentially can be implemented across broad geographic areas of the United States and internationally.

This report focuses on the process of activating the scientific research completed in Phase 1 (2007–2009) of the project by obtaining approval for use of the MSU–EPRI N_2O Offsets Methodology (MSU–EPRI Methodology) in the programs operated by the three leading GHG offset standards organizations operating in the U.S. and internationally: (i) the American Carbon Registry (ACR); (ii) the Climate Action Reserve (CAR or the Reserve); and, (iii) the Verified Carbon Standard (VCS). The other objectives of Phase 2 also are described briefly below. Phase 1 of this project is described in a previous EPRI report – *Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions in Agricultural Crop Production: Final Project Report. EPRI, Palo Alto, CA: 2009. 1020546.*

Objectives

The principal objective of Phase 2 was to obtain approval for the use of the MSU-EPRI N_2O Offsets Methodology (MSU–EPRI Methodology) to create GHG emissions offsets under one or more well-respected offsets standards operating in the U.S. and globally today, such as the ACR, the CAR, and the VCS. This report highlights the project team's efforts to obtain approval for the use of the MSU-EPRI Methodology in whole or in part under the offset programs operated by these three offset standards.

Additional Phase 2 project objectives included:

- Developing and implementing an on-farm pilot N_2O offsets demonstration project that uses the MSU-EPRI N_2O Methodology, and that can be credited with GHG offsets.
- Conducting a public-outreach workshop to inform and solicit feedback from public agencies, offset project developers, stakeholder groups and others.
- Conducting a technical workshop to explore future development of N_2O offsets protocols under existing and evolving GHG offsets protocols.

Approach

In this project we sought to activate a scientifically robust, straightforward, readily implementable, and widely adoptable N_2O emissions reduction offsets methodology that can be used by farmers to create GHG emissions offsets under multiple existing offsets standards. The team's strategy was to implement versions, or components, of the MSU-EPRI Methodology that were consistent across the various offset standard organizations, but which had sufficient flexibility to be readily adaptable to the varying and shifting requirements of the individual validation and approval processes of these organizations. In doing so, the team developed a number of innovative approaches to address key issues associated with the development of GHG offsets.

Results and Findings

During Phase 2 of the project, the project research team completed the following:

- Validation of the MSU-EPRI Methodology under the American Carbon Registry (ACR) for use in their voluntary GHG emissions offsets program (July 2012).
- Validation of the MSU-EPRI Methodology under the Verified Carbon Standard for use in their voluntary GHG emissions offsets program (March 2013).
- Acceptance of the quantification component of the MSU-EPRI Methodology (in particular the emissions reductions calculations and uncertainty in emissions reductions calculations) under the Climate Action Reserve (CAR or the Reserve) Nitrogen Management Project Protocol (NMPP) for use in their voluntary GHG emissions offsets program (July 2012).
- Submission of the MSU-EPRI Methodology to the now moribund Chicago Climate Exchange (CCX) (April 2010).
- Active participation in the Reserve multi-stakeholder workgroup (MSU – Millar) to develop the CAR NMPP. The work-group members included academic researchers and industry representatives, federal agency personnel, environmental organizations, project developers and aggregators, verifiers and expert consultants.
- Active participation in the CAR Scientific Advisory Committee (SAC, MSU - Robertson) to help the Reserve to interpret and apply the best available science into the CAR NMPP. The Reserve and the Nicholas Institute for Environmental Policy Solutions at Duke University selected the members of the SAC based on scientific expertise, knowledge of GHG offset protocol development issues, and explicit interest in translating research into GHG mitigation policy applications for agriculture.
- The approval of the MSU-EPRI Methodology by these three primary voluntary offset standards organizations is expected to provide impetus for the California Air Resources Board (ARB), United States Department of Agriculture (USDA), and other organizations to adopt a similar approach for developing future compliance offset methodologies and programs to reduce N_2O emissions in agricultural crop production.

Applications, Values and Use

The analysis, quantitative modeling, tools, and information developed in this project will help to broaden the GHG emissions offset options available to electric companies and others, and can serve as a mechanism to develop and strengthen partnerships between electric companies and agricultural communities they serve.

EPRI Perspective

Nitrous oxide emissions reductions from crop production offers an approach that can generate large-scale and cost-effective GHG emissions offsets which can be implemented across broad geographic areas of the United States and internationally. This may:

- Increase the breadth of GHG offset options available to electric companies; and
- Enable development of offset projects on agricultural lands owned by electric companies or located within an electric company's service territory.

Keywords

Nitrous oxide, GHG offsets, crop-based agriculture, nitrogen fertilizers, greenhouse gas mitigation, climate change

GLOSSARY OF TERMS

ACR	Winrock International's American Carbon Registry.
BAU	Business As Usual
CAR	The Climate Action Reserve carbon offset registry. Previously the California Climate Action Registry (CCAR). Also known as the Reserve.
BMP	Best management practices.
Clean Development Mechanism (CDM)	A provision described in Article 12 of the Kyoto Protocol that allows tradable credits, called CERs, to be generated by emissions reduction projects in developing countries that can be used by industrialized countries for compliance with their Kyoto commitments.
CH_4	Methane. A powerful GHG with a 100-year GWP of 25.
CO_2	Carbon Dioxide. A GHG with a 100-year GWP of 1.
CO_2eq / CO_2e	Carbon dioxide equivalent. Unit of measure that allows all greenhouse gases to be compared relative to CO_2 based on Global Warming Potentials.
CRT	Climate Reserve Tonnes. Equal to one metric ton of CO_2e. Offset credits for the voluntary market issued by the Climate Action Reserve.
Denitrification	The microbial reduction of NO_3^- to N_2O, which can then escape to the atmosphere or be further reduced to the gas N_2.
EF	Emission Factor. The proportion of nitrogen fertilizer emitted from soil as N_2O.
GHG	Greenhouse gas. This term usually is used to refer to the collection of all six types of GHGs regulated by the Kyoto Protocol (CO_2, CH_4, N_2O, SF_6, PFCs and HFCs).
Global Warming Potential (GWP)	The radiative warming caused by a molecule of gas relative to that of CO_2 for a defined period, usually 100 years. By convention CO_2 has a GWP of 1; N_2O has a GWP of 310.
Gt	Gigatonnes. Equal to one billion tonnes, or alternatively one petagram (1015). For example, one 1 $GtCO_2$ is one billion tonnes of CO_2.
Hectare (ha)	A unit of surface area equal to 10,000 square meters or 2.47 acres.
IPCC	The United Nations Intergovernmental Panel on Climate Change.
KBS	W.K. Kellogg Biological Station. KBS is an MSU AgBioResearch Center, a National Science Foundation Long-term Ecological Research (LTER) site, and hosts the DOE Great Lakes Bioenergy Field Research Center.
Mg	Megagram. Equal to 1,000 kilograms, and 1 metric ton or 1 tonne.

MSU	Michigan State University.
MT	Metric ton. Equal to 1,000 kilograms. Also referred to as a tonne.
MMT	One million metric tons. Equivalent to Tg.
N	Nitrogen.
N_2O	Nitrous oxide. A greenhouse gas with a 100-year GWP of 310.
N_2O Flux	The movement of N_2O between soil and the atmosphere.
N_2O-N	The atomic mass of the nitrogen contained in the N_2O molecule.
NH_4^+	Ammonium ion.
Nitrification	The microbial oxidation of NH_4^+ to NO_3^- during which N_2O can be produced as a byproduct.
NO_3^-	Nitrate ion.
NO_x	Nitrogen oxides (the gases NO + NO_2).
NCR	North Central Region of the United States.
NRCS	Natural Resource Conservation Service of the USDA.
NUE	Nitrogen use efficiency.
Offset	A GHG emission reduction, sequestration, or avoidance that typically is achieved outside of an organization's internal operations and outside the regulatory and geographic boundaries of any associated GHG cap-and-trade program. Typically, offsets are required to be real, additional, permanent and verified to qualify for use as a compliance instrument.
OPR	An Offset Project Registry approved by the California Air Resources Board to operate as part of the California GHG Cap-and-Trade Program.
Pg	Petagram. Equal to 10^{15} grams or 10^9 metric tons. Equal to gigatonne (Gt) and 1,000 million metric tons (MMt).
RTA	Ratio of removed to applied nitrogen.
SSR	Source, sink, and reservoir.
Tg	Teragram. Equal to 10^{12} grams or 10^6 metric tons. Equal to 1 million metric tons (MMT).
USDA	United States Department of Agriculture.
VCS / VCSA	Verified Carbon Standard. Verified Carbon Standard Association. The VCSA operates the VCS program.

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EXECUTIVE SUMMARY

For the past six years, the Electric Power Research Institute (EPRI) has been collaborating with Michigan State University (MSU) on a research project to explore the potential to reduce nitrous oxide (N_2O) emissions by improving nitrogen (N) management practices on croplands in the United States. During the first three years (Phase 1) of our collaboration, MSU conducted fundamental research to improve the scientific understanding of N_2O emissions based on the amount of N fertilizer applied to corn. This work resulted in the publication of a number of peer-review scientific research articles describing key findings and implications of crediting N_2O emissions reductions associated with reduced use of N fertilizer on croplands.

During Phase 2, the MSU team developed an N_2O Offsets Methodology that now has been approved by the American Carbon Registry (ACR) and the Verified Carbon Standard (VCS) for use in their voluntary GHG emissions offsets programs. Major components of the MSU-EPRI Methodology also underpin the Nitrogen Management Project Protocol adopted by the Climate Action Reserve (CAR-NMPP). These include quantitative tools used to calculate N_2O emissions reductions and uncertainty in N_2O emissions reductions.

A small pilot project that uses the MSU-EPRI Methodology also has been completed, and is expected to be submitted to the ACR for verification and issuance of offset credits. Carbon offset credits generated by this Michigan-based, small-scale project are expected to be issued, sold and retired during 2013, and will to our knowledge represent the world's first trade of offsets derived from agricultural N_2O emissions reductions.

Nitrous oxide is a significant GHG that contributes to global climate change. Each ton of N_2O emitted to the atmosphere is equivalent to emitting approximately 300 metric tons of CO_2 because of N_2O's high Global Warming Potential (GWP). Consequently, GHG emission offset projects that reduce emissions of even small amounts of N_2O can have a disproportionately large effect on climate change. This sensitivity to small changes provides a strong impetus for including N_2O and the other non-CO_2 GHGs in the development of effective GHG mitigation strategies.

Nitrous oxide emissions reductions from crop production offers an approach that can generate large-scale, cost-effective GHG emissions offsets that could be implemented across broad geographic areas of the U.S. and internationally. Economic analysis of "economy-wide" legislative proposals have concluded that GHG emissions offsets are likely to play a key role in reducing the economic cost ($/ton CO_2e) of achieving GHG emissions reductions, and have identified the agricultural sector to provide a key source of potential domestic GHG offsets.

The quantitative analysis, tools, and information developed in this project will broaden the GHG emissions offset options available to electric companies and other sectors of the U.S. and international economies, and can serve as a mechanism to develop and strengthen partnerships between electric companies and the agricultural communities they serve.

The project has resulted in versions of the MSU-EPRI N2O offsets methodology being approved for use by two of the three major carbon offset programs operating in the U.S. and internationally (ACR and VCS), and key portions of the MSU-EPRI methodology being adopted as part of a nutrient management protocol adopted by CAR. The process of obtaining approval of the MSU-EPRI Methodology by these offset programs led to a number of changes to the generalized protocol that members of the project team first published in the peer-reviewed scientific literature in 2010. Changes came about as a result of each registry's approval process, which included institutional review, expert review, and public comment. Consequently, the three protocols have significant differences related to the eligible geographic area, and their acceptance of the so-called "Tier 1" default emission factor developed by the U.N. Intergovernmental Panel on Climate Change (IPCC), and minor differences related to eligible crops, fertilizer types (synthetic vs. organic), and uncertainty discounts.

Completing the methodology validation process also uncovered two important issues associated with the development of methodologies by public institutions. First, is a set of issues related to legal indemnification and legal jurisdictions. Typically, public institutions, such as MSU, are not at liberty to take on the same financial risks that may be assumed by private sector or non-governmental organizations, and thus require a level of legal indemnification that is new to these offset programs. Likewise, public institutions may not be willing or allowed to settle potential future disputes through an arbitration process overseen by foreign courts. Indemnification issues jeopardized approval of the MSU-EPRI Methodology with one of the offset programs, and came close to jeopardizing it with a second offset program.

The second issue is related to the cost, and therefore likelihood, of completing future revisions to the MSU-EPRI Methodology. Only one registry (VCS) directly compensates an offset methodology developer with a financial royalty based on the volume of offsets created using the associated methodology. Over time, this royalty may help to underwrite the costs of completing future methodology updates. Most methodology developers also are offset project developers who derive financial benefits from developing offset projects and selling and trading offset credits. Public institutions like MSU are not likely to be involved directly in offset project development or trading, so they typically will not receive any financial compensation that can provide a direct and sustainable means (nor perhaps incentive) to pay for future revisions to the methodology.

2
INTRODUCTION

Background on EPRI Project

Below is a brief overview of the EPRI project "*Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions.*"

Phase 1

In fall of 2006, EPRI launched Phase 1 of the project – a three-year long initiative to investigate the potential to reduce N_2O emissions in agricultural crop production.

The key challenges and objectives of Phase 1 were:

- To determine the technical potential and economic cost to offset GHG emissions by reducing N_2O emissions in crop production across representative soil and crop types in the U.S.
- To confirm through field testing that the N_2O flux (the movement of N_2O from soil to the atmosphere) can be reduced substantially by decreasing the amount of N fertilizer applied to cropland with little or no loss in crop productivity.
- To further refine existing computer simulation models so they can be used to predict N_2O fluxes in cropping systems.
- To identify, describe, and analyze socioeconomic factors that may encourage or inhibit farmers from participating in N_2O emissions reduction projects, and identify approaches to overcome potential farmer reluctance to participate.
- To identify incentives that may be needed to encourage farmers to change cropping practices to achieve N_2O reductions.

The main accomplishments of Phase 1 were:

- Validation at the farm scale that N_2O emissions in crop production can be reduced substantially by reducing N-fertilizer application with no reduction in crop yield.
- New predictions of N_2O emissions based on quantitative models scaled to the North Central Region (NCR) of the United States that show N_2O was responsible for ~57% of row crop agriculture's GHG footprint from 1964-2009.
- Development of a nation-wide web-based farmland GHG calculator that demonstrates the importance of N_2O vs. other sources of global warming potential in row-crop agriculture.[1]
- Development of a draft N_2O offset methodology in the peer-reviewed literature, ready to be submitted to carbon offsets standards.[2]

[1] See http://surf.kbs.msu.edu/ .
[2] See Millar, N., G. P. Robertson, P. R. Grace, R. J. Gehl, and J. P. Hoben. 2010. Nitrogen fertilizer management for nitrous oxide (N2O) mitigation in intensive corn (Maize) production: an emissions reduction protocol for US Midwest agriculture. Mitigation and Adaptation Strategies for Global Change 15:185-204.

Phase 2

In October 2009, EPRI launched phase 2 of the project. Phase 2, which built directly upon Phase 1 research, aimed to help electric companies and others develop and access large-scale, cost-effective GHG offsets by reducing N_2O emissions from agricultural crop production across broad domestic and international geographic areas.

The key objectives of Phase 2 were to:

1. Validate a consistent version of an MSU-EPRI N_2O Offsets Methodology under one or more offsets standards in the U.S. and globally, including the American Carbon Registry (ACR), the Climate Action Reserve (CAR), the Verified Carbon Standard (VCS), or other similar credible existing or evolving offsets standards.
2. Develop and implement an on-farm pilot N_2O offsets demonstration project that uses the MSU-EPRI N_2O Offsets Methodology and which can be credited with GHG offsets.
3. Conduct a public-outreach workshop to inform and solicit feedback from public agencies, offset project developers, stakeholder groups and others.
4. Conduct a technical workshop to explore future development of N_2O offsets protocols under existing and evolving GHG offsets protocols.

This document focuses on the first objective.

Role of Michigan State University (MSU)

The science that underlies the MSU-EPRI Methodology is a result of two decades of research conducted by MSU at the Kellogg Biological Station Long-Term Ecological Research (KBS LTER) site, and on scientific data developed by MSU through on-farm field testing conducted from 2007 to 2009 with EPRI support. At KBS, and on commercial farm fields across Michigan, KBS scientists measured N_2O emissions from fields that received varying amounts of N-fertilizer.

By closely tracking N_2O emissions, crop yields, and other ecosystem responses to fertilizers, MSU researchers discovered that N_2O emissions increase exponentially with increasing N-fertilizer use. MSU researchers also demonstrated successfully that N_2O emissions in row-crop production can be reduced substantially by using less N-fertilizer with no related reduction in crop yield. In other words, adding fertilizer above the precise amount needed for optimal crop growth creates much more N_2O than otherwise would have been produced. The more excess N that is available, the greater the additional rate of N_2O production. Quantifying this exponential relationship provided a novel and powerful way for farmers to quantify and generate GHG emissions offsets by reducing fertilizer use while maintaining crop productivity.

To spur this development, MSU developed an N_2O offset accounting methodology. It is the only offsets methodology today published in a peer-reviewed scientific journal (Millar et al., 2010), and is based on the empirical relationship between fertilizer nitrogen rate and N_2O emissions documented above (Hoben et al., 2011). This relationship provides the basis for development of a transparent, scientifically robust offsets protocol that can be used by developers of agricultural offset projects to create exchangeable GHG emission offset credits for use in existing and emerging U.S. carbon cap-and-trade markets.

Nitrogen in Agriculture

Agriculture cycles large quantities of N to produce food, fuel, and fiber and is a major source of excess reactive nitrogen (Nr) in the environment. Nitrogen lost from cropping systems and animal operations moves to waterways, groundwater, and the atmosphere. Changes in climate and climate variability may further affect the ability of agricultural systems to conserve N. The N that escapes affects the climate both directly and indirectly: directly through the emissions of N_2O from cropped soils; and, and indirectly through the loss of nitrate (NO_3^-), nitrogen oxides (NO_x) and ammonia (NH_3) to downstream and downwind ecosystems that subsequently emit some of the N received as N_2O (Robertson et al., 2012).

There are many opportunities to mitigate the impact of agricultural N on the climate, and the impact of climate on agricultural N (Robertson et al., 2012). Some are available today; many need further research; and, all await effective incentives to become adopted.

Nitrous Oxide (N_2O) Emissions

Nitrous oxide is not reactive in the troposphere, but is a powerful GHG – approximately 300 times more potent than CO_2 on a mass basis, and atmospheric concentrations have increased consistently from 270 parts per billion (ppb) during pre-industrial times to today's concentrations of approximately 320 ppb. This increase in N_2O has contributed about 6 % of the total GHG forcing that drives climate change (Forster et al., 2007). While this is not a large percentage, the anthropogenic N_2O flux is equivalent to 1.0 Pg C $year^{-1}$ when converted to C equivalents using 100-year global warming potentials (Robertson, 2004; Prinn, 2004), which is of the same magnitude as the contemporary net atmospheric CO_2 increase of 4.1 Pg C $year^{-1}$ (Canadell et al., 2007). About 80 % of the N_2O added to the atmosphere annually by human activities is associated with agriculture. About 60 % of this is emitted from agricultural soils, 30 % from animal waste treatment, and 10 % from burning crop residues and vegetation cleared for new agricultural activities (IPCC, 2001; Robertson, 2004). Row crop agriculture is thus responsible for about 50 % of the global anthropogenic N_2O flux (Robertson, 2004) which is increasing by around 150 Tg N annually (Mosier, 2001).

Agricultural N_2O Emissions

Nitrous oxide is produced in the soil predominantly by the microbial processes of nitrification and denitrification. Factors that control these two processes – available carbon, inorganic nitrogen, and oxygen as affected by soil moisture, porosity, and aggregate structure – regulate production of N_2O (Robertson and Groffman, 2007). Practices other than N fertilizer management that most influence emissions of N_2O from cropped soils include crop type, tillage, residue management, and irrigation (Parkin and Kaspar, 2006).

Soil management activities, primarily N fertilizer application, account for about 68% of total N_2O emissions in the U.S.; annual emissions of N_2O from U.S. cropland summed to 151 Tg CO_2 in 2010 (EPA, 2012). Nitrous oxide emissions represent the single largest contributor to the global warming impact of annual cropping systems (e.g., Robertson et al., 2000; Robertson and Grace, 2004; Mosier et al., 2005; Gelfand et al., 2013), due primarily to its atmospheric longevity and its associated radiative forcing.

As N_2O in soil is produced predominantly through microbial transformations of inorganic N, the potential to produce and emit N_2O increases with increasing N availability across a wide variety of ecosystems (e.g., Matson and Vitousek, 1987) including agricultural (e.g., Bouwman et al., 1993). Although some N_2O emissions are an unavoidable consequence of maintaining highly productive cropland (Mosier et al., 2001), in general activities that lower the input of N into cropland agriculture or reduce N availability should significantly reduce emissions of N_2O.

Altering N fertilizer management practices other than N rate, such as timing, placement, and fertilizer formulation also can alter N_2O emissions. However, to date there have been far fewer studies investigating their impact on N_2O responses as compared to the impact of *N fertilizer rate*. Nevertheless, the MSU-EPRI Methodology allows these practices to earn GHG emissions offsets by crediting the degree to which they allow less fertilizer to be used – i.e., the degree to which they improve system-wide fertilizer use efficiency, which often is a key goal of their use.

Fertilizer N Rate and N_2O Emissions

In successive meta-analyses of available field data, simple ratios have been developed to relate the rate of N fertilizer applied to crop land to subsequent direct emissions of N_2O. These global fertilizer-induced emissions factors (EF) have been determined by a variety of researchers, including Bouwman (1990), Eichner (1990), Bouwman (1996), Bouwman et al. (2002), and Stehfest and Bouwman (2006). The current global mean value for fertilizer-induced emissions, derived from over 1000 agricultural field studies, is ~0.9% or 0.009 (Bouwman et al., 2002; Stehfest and Bouwman, 2006). In short, for every 100 kg of N fertilizer applied, 0.9 kg of N in the form of N_2O–N is assumed to be directly emitted. This EF (rounded to 1% or 0.01) has been adopted by the IPCC as their "Tier 1" default EF for use by countries when estimating their direct emissions of N_2O from managed soils (IPCC 2006). About 75% of reporting countries use this default factor (Lokupitiya and Paustian, 2006).

Under IPCC (2003) guidelines, there are two additional methodologies that can be used to calculate emissions from agricultural soils: "Tier 2" uses EFs tailored to *regional and country-specific parameters*, and "Tier 3" uses more complex models and inventory systems.

The use of a single constant EF value irrespective of N rate intrinsically establishes a linear relationship between N fertilizer rate and N_2O emissions. This link is indifferent to biological thresholds, which might occur, for example, when the availability of inorganic N exceeds the requirements of competing biota such as crops.

Developing state or regional EFs (Tier 2) in representative agricultural management systems will better account for local climate, soil, management, and other conditions. Continuous corn and corn-based rotations, particularly corn-soybean, are representative agricultural ecosystems that dominate farmland in the U.S. Midwest, and in eastern and central North America. Corn is an N intensive crop, typically receiving large N additions to the soil. Alterations to the N management of this crop therefore have a major impact on U.S. agricultural N_2O emissions. The MSU-EPRI Methodology focused on developing a regional Tier 2 EF for corn derived from empirical field-based studies conducted at multiple sites over a number of years in the U.S. Midwest (North Central region or NCR).

A number of studies in U.S. grain corn cropping systems previously have investigated the response of N_2O emissions to N fertilizer management (e.g., Bremner et al., 1981; Venterea et al., 2005, 2010; Liu et al., 2006; Mosier et al., 2006; Parkin and Kaspar, 2006; Halvorson et al., 2008, 2010; Tan et al., 2009; Parkin and Hatfield, 2010). These studies have been important for documenting EFs for fertilized U.S. grain systems, but because most of them examined only a single fertilizer rate (and some without a zero fertilizer rate comparison), there is no power to detect N rate thresholds – e.g., changes in EF as the availability of N exceeds crop N demand.

Response curves for N_2O flux as a function of N rate are not common, but can help to predict better region- and site-specific N_2O emissions in response to N additions. For the few N_2O response experiments in which more than two levels of N were applied, N_2O flux in response to increasing N rates has been described by both linear and nonlinear functions. The vast majority of these kinds of studies, however, have shown that a nonlinear (exponential) relationship best describes the N_2O response to increasing input of N fertilizer (Kim et al, 2012). Studies in MI best exemplify this response, and have been both the impetus for (McSwiney and Robertson, 2005, and the result (Hoben et al., 2011) of this project.

If N fertilizer rate is the <u>most robust</u>, single-factor proxy for estimating N_2O emissions from U.S. corn cropping systems as scientific literature and resulting IPCC methodology suggests, then the form of the relationship between N fertilizer rate and N_2O emissions has significant consequences for predicted N_2O emissions reductions associated with a reduction in the N fertilizer rate (Millar et al., 2010). The difference between a linear and a nonlinear relationship has both environmental and economic implications that will affect both inventory estimates as well as market-based incentives for reducing N fertilizer rates to generate GHG emission reduction credits from agricultural offset projects.

Compliance markets

The MSU-EPRI project team's strategy was to implement a version or components of the MSU-EPRI Methodology that were consistent across the major voluntary offset standard organizations operating in the U.S. and internationally. Approval of the MSU-EPRI Methodology by one or more of these voluntary GHG offset programs may help to provide the foundation upon which the ARB may develop a "nutrient management" compliance protocol as part of California's new GHG emissions cap-and-trade program. Recently, the ARB has announced plans to explore development of a nutrient management offset protocol in late 2013 or early 2014.

To date, ARB has approved four compliance offset protocols (U.S. Forest, Livestock, Ozone Depleting Substances, and Urban Forest), all of which are modified versions of similar protocols originally developed by the Reserve for use in the voluntary offset market. At this time, ARB has now approved two Offset Project Registries, CAR and ACR, and likely will look to both of these organizations as well as others sources to develop future ARB offset protocols.

Alternative modeling approaches to estimate N_2O emissions reductions

Numerous simulation models have been developed to predict N_2O production, ranging from those that attempt to comprehensively simulate all soil processes to more empirical approaches requiring minimal input data (e.g., the calculations that underpin the MSU-EPRI Methodology). Models of varying complexity have been constructed to predict N_2O production. Process-based field-scale N_2O simulation models that simulate whole agroecosystems are widely used in the scientific literature.

Process-based field scale models (IPCC Tier 3 equivalent) for N_2O include NLOSS, ECOSYS, Expert-N, WNMM, FASSET, EPIC/APEX, CERES-NOE, DNDC and CENTURY/DAYCENT. They vary somewhat in their approaches to modeling soil processes, and in their calibration for different regions, management activities, and crops. Three of these models are widely used in the U.S. for quantifying agricultural GHGs: CENTURY/DAYCENT, DNDC, and EPIC/APEX.[3]

Given the complexity of most process-based models and the amount of data they require, running them accurately and consistently requires a high level of sophistication and expertise. Setting up the full process models and running them for individual projects is complex, requires substantial expertise, can be prone to error or bias, and may be cost prohibitive for a project. One of the primary challenges for using process models for determining baseline and quantifying GHG impacts at farm- or regional-scales is to standardize how the technology can be made available to non-expert users such as project developers, consultants, and verifiers in quantification protocols or program guidelines. Given different model types, complex input variables, different scales of application, and range of sensitivities, the model selected and how it is used may have a profound impact on estimates of GHG changes (Dumanski et al., 1998).

Irrespective, the use of DNDC (DeNitrification-DeComposition) predominates in the small number of offset methodologies currently active that involve the calculation of N_2O emissions from agricultural soil. For example, DNDC is the primary N_2O quantification tool used in the ACR (Methodology for N_2O emission reductions through changes in fertilizer management, Nov 2010), VCS (Estimation of emissions of non-CO_2 GHGs from soils - Module VMD0029, Nov. 2012), and CDM (Reduction of N_2O emissions from use of nitrogen use efficient (NUE) seeds that require less fertilizer application, Dec. 2012). The core of DNDC is a soil biogeochemistry model simulating thermodynamic and reaction kinetic processes of C, N, and water driven by the plant and microbial activities in the ecosystems.[4]

[3] Descriptions of these models and a comparison table can be found in the Technical Working Group on Agricultural Greenhouse Gases (T-AGG) Supplemental Report: Using Biogeochemical Process Models to Quantify Greenhouse Gas Mitigation from Agricultural Management Projects at http://nicholasinstitute.duke.edu/ecosystem/t-agg/using-biogeochemical-process .

[4] More information on the model can be found at: http://www.dndc.sr.unh.edu/ .

3
MSU-EPRI N_2O OFFSETS METHODOLOGY

Overview

The MSU-EPRI Methodology is GHG emissions offsets protocol that provides a way for farmers to obtain GHG emission offset credits by reducing the amount of N used to fertilize crops.

Below is a brief summary of the MSU-EPRI Methodology, including requirements for project eligibility, an overview of quantification tools used to calculate the number of offset credits, and information on how the issues of baseline determination, additionality, permanence, leakage, and uncertainty are handled. These methodological components are common to the MSU-EPRI Methodology approved by the ACR, the VCS, and underpin the CAR NMPP. Further details of the MSU-EPRI Methodology as adopted by these organizations, and how they differ are discussed in Section 4, 5, and 6 of this report, and at the organizations' respective websites.[5]

Project Eligibility

Nitrogen fertilizer management

The MSU-EPRI Methodology is geared towards farmers who currently use external sources of N to fertilize their crops. Synthetic and organic sources of fertilizer are eligible, with all N inputs considered equal on a mass basis irrespective of source. The fertilizer can be applied at any time during the cropping cycle (e.g., before, at, or after planting), and N management must adhere to the appropriate Best Management Practices (BMPs) of the region with respect to fertilizer timing, placement and formulation.

Nitrous oxide emissions

Direct and indirect emission reductions of N_2O are eligible for crediting, and are quantified for the baseline and project period. Direct emissions are those emitted from a project site where the fertilizer is applied. Indirect emissions are those emitted beyond the project site, but as a result of fertilizer application at the project site. These include N_2O produced in waters and soils as a result of nitrate (NO_3^-) leaching and ammonia (NH_3) volatilization.

Geographic location

The quantification tools embedded in the MSU-EPRI Methodology (ACR, CAR, and VCS) to calculate offsets credits can be used for N_2O emissions reduction projects implemented on corn-based crops in the U.S. NCR, including mono-cropping of corn, and corn grown in rotation with wheat or soy. The NCR encompasses the 12 Midwestern states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin, and is the major producer of U.S. corn—in 2012, of the 96 million acres of corn grain planted in all the U.S.; 80 million acres (~83%) were planted in the NCR. Due to the expanse of corn and the large amounts of external N fertilizer applied, this ecosystem represents a “hot-spot” for N_2O emissions, and therefore potentially emissions reductions. A conservative estimate of the

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[5] See www.americancarbonregistry.org; www.v-c-s.org; and, www.climateactionreserve.org .

technical potential for reducing emissions of N_2O by reducing N fertilizer rate in NCR corn crops eligible for use in offset projects utilizing the MSU-EPRI protocol is approximately six million metric tons CO_2e per year.

The VCS version of the MSU-EPRI Methodology also includes provision for *non-corn* based N_2O offset projects to be developed throughout the 48 conterminous U.S. states, including in CA, and for *corn-based* projects to be developed *outside* the NCR, including in CA. Offset projects that either are non corn-based within the U.S., or corn-based outside of the NCR, can use the current IPCC Tier 1 EF for N_2O emissions (IPCC 2006) to calculate N_2O emissions reductions under the VCS approved version of the MSU-EPRI Methodology.

The ACR version of the MSU-EPRI Methodology provides approaches for project developers who wish to develop N_2O offset projects opportunity for projects outside the NCR or the U.S. to submit data to demonstrate to the ACR that the use of the Tier 1 EF (Category 2), or a new project-specific EFs (Category 3; equivalent to IPCC Tier 2), are conservative for calculating N_2O emissions reductions in N-receiving agricultural crops. The CAR NMPP also incorporates ways to expand project eligibility in a modular fashion to include new crops, geographic regions, and N-management practices.

Protocol Accounting

The MSU-EPRI Methodology uses the nonlinear N_2O emissions response to increasing inputs of N to a cropping system as the basis for quantifying project N_2O emissions reductions. This inherent relationship, and the common occurrence for N inputs to be applied at levels greater than an agricultural crop requires, is a driver and incentive for N management practice change.

Figure 3-1 shows the N_2O emissions reductions achievable by using the MSU-EPRI Methodology's variable EF in comparison to those achievable by a non-variable EF (e.g., IPCC Tier 1) following an identical N fertilizer rate reduction. The starting (higher) and finishing (lower) N rate can be considered to represent a baseline and project scenario, respectively. The N_2O emissions reductions calculated using the MSU-EPRI Methodology nonlinear approach more closely approximate actual N_2O emissions to the atmosphere, and can be substantially larger than calculated using the linear approach. These additional N_2O emissions reductions result in larger numbers of offset credits and greater financial and environmental payback, and add to the incentive for farmers to participate in GHG reduction projects.

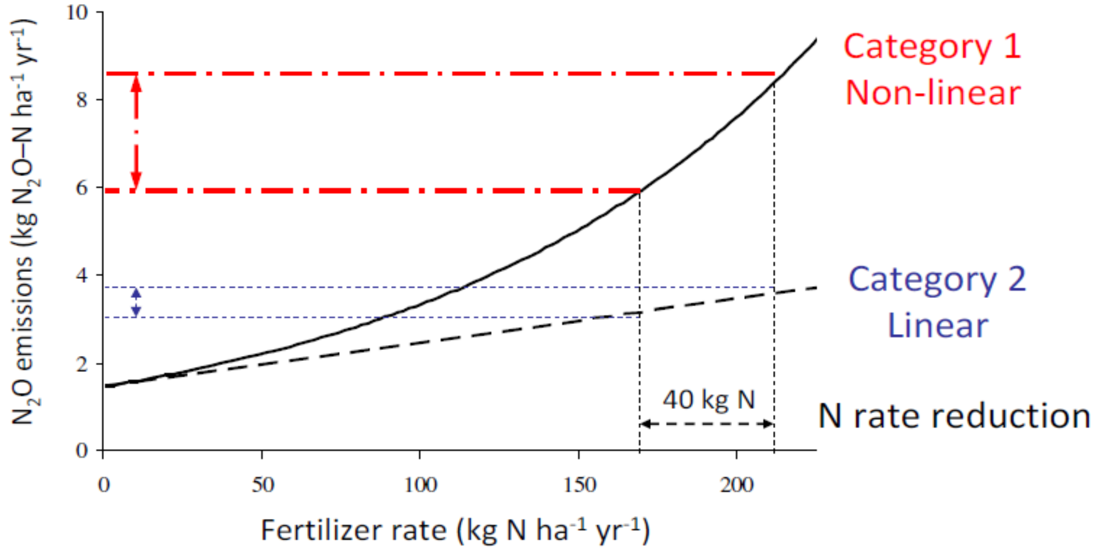

Figure 3-1
Comparison between the Category 1 and the Category 2 quantification methods used to calculate N_2O emissions reductions in the MSU-EPRI Methodology (ACR version).[6]

Protocol Flexibility

The MSU-EPRI Methodology is non-prescriptive and flexible with respect to the eligible management practices a farmer can adopt or change to reduce N fertilizer rate.

Examples of approaches a farmer can use to reduce N fertilizer rate are shown below. Changes to, and/or adoption of these and other management practices, may be required by a project to adhere to regional fertilizer BMPs, but in most cases will represent actions beyond these practices.

- Increased accuracy of the estimates of crop N requirement. For example, by using economic optimization calculators, such as the Maximum Return to N (MRTN) approach.[7]
- Better timing of N application. For example, a shift to spring from fall application of fertilizer, or a split application with N fertilizer applied at planting and after.
- More appropriate N fertilizer source. This can also include fertilizer formulation for slow N release, or in fertilizer combined with N inhibitors.

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[6] The x axis shows N fertilizer rate (kg N ha^{-1} yr^{-1}) and the y axis 'direct' N_2O emissions (kg N_2O-N ha^{-1} yr^{-1}). The solid and dashed black lines represent the separate N_2O emissions response to increasing N fertilizer rate for the MSU-EPRI nonlinear relationship (Tier 2; U.S. NCR) found as a result of empirical field work conducted in MI, and the IPCC global linear relationship (1% of applied N is emitted as N_2O–N, EF = 0.01), respectively. The vertical dotted black lines represent a reduction in N rate (e.g., from a hypothetical baseline scenario to a hypothetical project scenario) of about 40 kg N ha^{-1}. The horizontal dotted blue lines and arrow represent the accompanying N_2O emissions reductions if the linear Category 2 IPCC quantification method is used, and the horizontal dot-dash red lines and arrow represent the accompanying N_2O emissions reductions if the nonlinear Category 1 MSU-EPRI quantification method is used.

[7] See http://extension.agron.iastate.edu/soilfertility/nrate.aspx for more information about the MRTN calculator.

- Improved placement of N fertilizer. For example, by using precision agriculture technology to better represent the requirement of the crop at a finer spatial scale.

These four management practices have been termed the 4Rs – right rate, right time, right source, and right placement.

Another approach is the planting of a cover crop into an annual crop rotation. For example, a winter cover crop can take up residual N from, or excess N applied to, the previous summer crop. This N, available to the next summer crop through mineralization can reduce the amount of external N fertilizer needed to grow the summer crop.

Ultimately, the aim is to give the farmer flexibility in their choices to manage the field, and to give greater confidence and lower risk to the decision making process for reducing N fertilizer rate. Irrespective of the choice of N management practice or practices adopted and/or altered, the integrated result is a lower N rate, and a reduction in N_2O emissions.

Baseline Determination

The determination of baseline N rate is the <u>only</u> criterion required to estimate baseline N_2O emissions. The baseline N rate can be determined using one of two approaches. Both approaches require at least five years of management records (the length of the historical record required depends on the project crop and the rotation history of the project site) prior to the project start.

- *Approach 1* uses site specific management records, including N fertilizer purchase and application rate data, and manure application rate and manure N content data. This is currently the only eligible approach that can be used in the CAR NMPP.
- *Approach 2* (USA only) uses county-level records and calculates baseline N rate from crop yield data, and relevant regional/state equations based on yield goal estimates.

Demonstrating Additionality

Additionality is determined using tests adopted by each offset program that are intended to ensure that project –based emissions reductions are in addition to reductions and removals that would have occurred under current laws and regulations, current industry practices, and without carbon market incentives.

Additionality for a project using the MSU-EPRI Methodology is assessed using a combined *Performance Standard* and a *Regulatory Surplus test* (ACR [U.S. only], VCS, CAR), or a "*Three-Prong Test*" (ACR [worldwide outside U.S.]). Although the descriptions of the requirements to meet the Regulatory Surplus Test (termed Legal Requirement Test in the CAR NMPP) differ slightly between the ACR, VCS, and CAR – e.g., the CAR NMPP includes details related to allowing or preventing credit or payment "stacking " with other programs – the test is essentially identical. The requirements to meet the Performance Standard Test are identical in the ACR and VCS methodologies, but differ in the Reserve's methodology. Further details are provided in sections 4, 5, and 6, and at the organizations respective websites. A brief overview is provided below.

Regulatory surplus / Legal requirement test

The regulatory surplus test is passed if there are no laws, regulations, statutes, or other regulatory frameworks that affect GHG emissions associated with a project action or baseline. For example, the adoption, or continued use, of approved N management project activities at the project site.

Performance standard test

In the MSU-EPRI Methodology (ACR and VCS versions), the performance test is passed at a project site if the N fertilizer rate is *below* a threshold that represents the business-as-usual (BAU) rate. This BAU rate is based on the ***yield-goal approach*** (historical and current common practice), and is identical to the calculated baseline N rate of the project, using either Approach 1 or 2.

In the CAR NMPP, the performance standard for a project activity is based on a N use efficiency (NUE) metric termed the ratio of Removed to Applied Nitrogen (RTA) calculated as a ratio of the amount of N removed by crop biomass to the amount of N available to the crop as a function of how much total N was applied to the crop.

Permanence

Permanence relates to the potential for a reversal of GHG reductions accrued during a project. Emission reductions that occur at the time a technology or activity is put in place are irreversible. This is the case with projects that are based on the MSU-EPRI Methodology. Avoided N_2O emissions, due to a reduction in N fertilizer rate, occur immediately and are irreversible and permanent. Consequently, there are no permanence or reversal concerns associated with the use of the MSU-EPRI protocol, and no risk mitigation mechanism for offsets are required. This is an important benefit of this protocol, as many other activities that can reduce GHG emissions in the agricultural and forestry sectors may be subject to permanence concerns, such as the potential for wildfire to release carbon stored as part of forest carbon sequestration projects.

Proving No Project Leakage

Project leakage can be defined as an increase in GHG emissions outside an offset project's boundary that occurs because of a project action.

There is no incentive for market leakage or activity shifting due to the implementation of a project that uses the MSU-EPRI Methodology because:

- For a project to be eligible, land must have been maintained in crop production for five or more years prior to implementation.
- In the absence of a project, continuation of crop production using BAU management practices is the most realistic and credible baseline scenario.
- No crop yield reductions are expected due to project implementation.

With regard to yield, crop producers are highly risk averse and will not intentionally suffer reduced crop yields in exchange for the limited revenue associated with offset credits from reducing N fertilization rates in a manner that affects expected crop yields.

For example, reducing N rates by adopting N rates based on economic optimization (e.g., Maximum Return to Nitrogen [MRTN], Figure 2) will not result in a significant reduction in average crop yield. Consequently, with no or negligible reduction in productivity within the project boundary, there will be no associated incentive or requirement for a shift of activity or increased production outside of the project boundary, which might result in increased N fertilizer use and N_2O emissions.

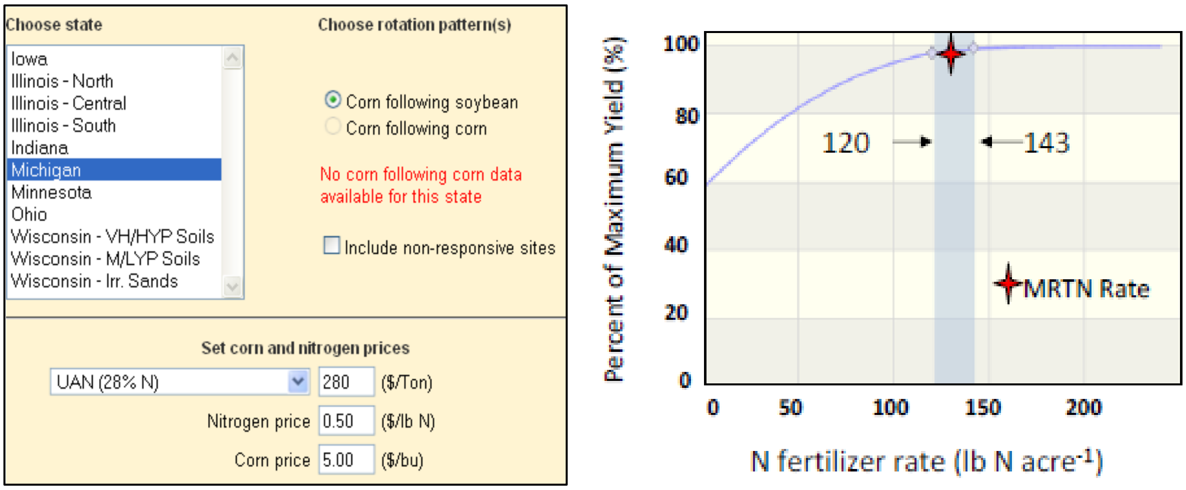

Figure 3-2. Screen shots from a web-based application from Iowa State University extension that calculates the economic optimum N rate application to corn in seven U.S. Midwestern states (Iowa, Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.[8]

As shown in Figure 3-2, a farmer fertilizing at 175 lbs N using a yield goal approach can expect to achieve yield equal to nearly 100% of the agronomic potential. The MRTN economic analysis can provide a farmer with confidence that a reduction of N rate to 143 lbs N will not reduce yield, and that a larger N rate reduction to 120 lbs may have only a negligible impact on expected yield. Therefore, alteration from the typical yield goal approach to an economic optimization approach for estimating the required N rate provides farmers with the opportunity to reduce N rate and save on fertilizer costs without reducing crop yield.

This and similar N rate calculators can be a useful tool for farmers who may want to participate in N_2O reduction projects by providing a quantitative estimate of the yield impact a particular N rate reduction may have, and along with other considerations may provide a greater degree of confidence for changing N rate practice.

This economic approach is only one of the many options a farmer has to lower N_2O emissions using the MSU-EPRI Methodology without impacting their crop yield.

In the VCS and ACR versions of the MSU-EPRI Methodology, offset credit deduction factors for leakage are considered zero. In the CAR NMPP, calculations are included to quantify increases in GHG emissions outside of the project area if yields decline significantly in the project area.

[8] The left screen shows the state or region that can be chosen, and where the N fertilizer price and corn price are entered. The right screen shows an example of a "yield response to N rate" graph generated from Michigan data for a corn-soybean rotation at a N to corn price ratio of 0.10 (a typically representative ratio). The grey vertical band on the graph shows the profitable N rate range for corn (in this case 120 to 143 lbs N per acre, or ~ 135 to 160 kg N ha^{-1}). The red star shows the MRTN rate, in this case ~130 lbs N per acre or ~145 kg N ha^{-1}.

Addressing Uncertainty

The MSU-EPRI Methodology quantifies the uncertainty associated with direct N_2O emissions (Tier 2), and N_2O emissions reductions at a project site and incorporates this as an uncertainty deduction factor into calculations to discount the number of offset credits awarded to a project. The greater the uncertainty of the emissions reductions at the project site, the greater the deduction of credits. The VCS and ACR versions of the MSU-EPRI Methodology use identical uncertainty calculations and deduction factors. The CAR NMPP includes modified, but similar uncertainty equations based on a project's geographic location.

Determining Common Practice for N Fertilizer Rate Application

When using the ACR and VCS versions of the MSU-EPRI Methodology, project proponents must pass a Practice-Based Performance Standard Test. This standard equates the BAU baseline scenario for N fertilizer application with the common practice of producers to apply N fertilizer rates based upon recommendations derived from yield goal estimates. Project developers pass the Performance Standard Test by reducing their N fertilizer rate below the BAU rate, which is also the baseline value for N fertilizer rate for the proposed project. Reducing the N fertilizer rate (and therefore N_2O emissions) below the BAU rate (Approach 1 or 2) results in project additionality.

Brief evidence for the wide-scale historic and continued use of the yield-goal approach in U.S. crop agriculture, and therefore its legitimacy as a Performance Standard for testing additionality is provided below. More information can be found in Annex E of the VCS version of the MSU-EPRI Methodology.

For four decades it has been common practice throughout the NCR and U.S. in general for agricultural producers to apply rates of N fertilizer based on recommendations derived from so-called "yield-goal" estimates. The yield-goal approach provides an N fertilizer rate recommendation for a particular field on the basis of an expected maximum yield for the field's soil type multiplied by an N yield factor that can be adjusted for N contributions from other sources, such as prior leguminous crops or manure. A recent USDA definition for improving NUE in the context of N rate (Ribaudo et al., 2011) requires the use of yield-goal calculations, and shows their ongoing and important function in N management at the national scale. Despite concerns that yield goal-based recommendations result in excess N fertilizer being used, the practice is still followed widely, and recommended, leading to application of N fertilizer in excess of crop requirements, principally as a result of unrealistic yield estimates. Furthermore, producers are risk averse and have a tendency to hedge against a perceived insufficient supply of N from the soil or previous N inputs by applying N fertilizer in excess of the recommendations as compensation.

An alternative approach now being adopted by farmers in much of the U.S. Corn Belt is based on the site-specific N rate at which the value from increased grain yield just matches the cost of added N. This approach utilizes historical and current N fertilizer rate research data from field trials to determine economically profitable N inputs, expressed as a range of N rates around a Maximum Return to Nitrogen (MRTN) at different N fertilizer and crop prices (Iowa State University Agronomy Extension, 2004). Any additional N cannot be economically justified in the absence of higher grain prices or cheaper fertilizer. This methodology involves constructing N response curves for various cropping systems on different soils. By definition, the economically optimum N rate will be lower than the fertilizer rate at which yields are maximized. How much lower is determined by the ratio of N price to grain price; as N becomes more expensive or grain price declines (increasing the ratio), producers will reap the same profit with less fertilizer N. Calculating separate economic optima for different rotations, e.g. one for corn following corn and another for corn following soybean, removes the need to estimate a residual N credit for the preceding crop.

The MRTN is now the official university-based recommendation in seven of the 12 NCR states, but in most states has only been in effect for a few years. Evidence suggests that few farmers in NCR states use this approach to determine the optimal amount of N to apply to their crops, and still rely predominantly on yield goal or more informal approaches. At this time, we are not aware of any research or other information that suggests the yield-goal approach has been supplanted by the MRTN or other approaches to determine the recommended application rate of N fertilizer.

Very few studies have quantified the impact that the many factors and their interactions have on farmer decision-making regarding N rate. The few studies available imply that the majority of farmers rely heavily on their own experience. For example in Ribaudo et al. (2011, Table A4), results show that "over 70 percent of growers base N rates on their routine practice." However, this data does not inform us of the rationale used, and the decisions made by a farmer to arrive at this routine practice. A recent MSU survey sent to 1000 Michigan farmers (Stuart et al., 2012) shows that more than 70% of commercial corn farmers use simple yield-goal calculations to derive their N rate. The agricultural departments of land grant universities and state and federal agricultural organizations typically have endorsed yield-goal N fertilizer rate recommendations. These organizations are the most common source of external information and advice for producers, and this network serves as the foundation for producer BAU practice in the NCR and beyond, constituting a sector-wide approach for calculating baseline N fertilizer rates, and by extension, emissions of N_2O.

4
AMERICAN CARBON REGISTRY (ACR)

Overview

The American Carbon Registry (ACR) is a non-profit voluntary registry founded in 1996 as the "GHG Registry" by two non-profit environmental organizations, the Environmental Resources Trust (ERT) and the Environmental Defense Fund (EDF). At its founding, it was the first private voluntary GHG registry in the U.S. In 2007, ERT became part of Winrock International, another non-profit organization, and in 2008 its registry was renamed the American Carbon Registry. The ACR develops carbon offset standards and methodologies, and has operational experience in carbon offset project registration, offset issuance, serialization and on-line transaction and retirement reporting. ACR generally accepts methodologies and tools approved for use by the United Nations' Clean Development Mechanism (CDM) and ACR-reviewed and approved methodologies from other programs to the extent they comply with ACR's Standards. ACR has also accepted one U.S. EPA Climate Leaders methodology. In December 2012, ACR was approved by the ARP as an OPR for the California Cap-and-Trade Program.

As of February 2013, the ACR had issued nearly 39 million tradable offsets, called Emission Reduction Tons (ERTs) from 68 offset projects. Of these, approximately eight million offsets have been generated by one Industrial Gas Substitution (IGS) project, 22 million by five Carbon Capture and Storage (CCS) projects, and four million by three Forest Carbon projects. At this time, nearly nine million credits have been traded, and almost three million credits retired.

Methodology Approval Process

The ACR process for approval of methodologies includes a public comment period and a scientific peer review process.[9] Further details of this process as experienced by the MSU-EPRI project team are described briefly below.

- A proposed methodology undergoes an internal review by ACR staff. Changes needed to comply with ACR standards, and issues anticipated being barriers to a successful public comment and peer review process, are communicated to the methodology developers via a written report.
- The revised methodology is posted online with a formal announcement. Any and all public comments are then accepted by ACR over a four week period. The public comments received are compiled internally by ACR into a "public comment and response" document and forwarded to the methodology developers following closure of the public comment period.
- Following the methodology developer's submission of responses to the public comments, ACR conducts an internal appraisal of these responses to evaluate whether methodology revisions or rebuttals to the public comments are adequate and appropriate. At this time, the methodology developer can communicate directly with ACR staff for clarifications and to discuss revisions to the methodology. There is no opportunity for further public comment

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[9] Additional information online at: http://americancarbonregistry.org/carbon-accounting/carbon-accounting .

(either new comments, or additional comments in response to the methodology developer's formal written responses) prior to methodology being approved.

- The revised methodology along with the public comments and responses from the methodology developer are then typically forwarded to three peer reviewers (one lead and two secondary). Peer reviewers are not required to address the public comments, or how the methodology developer responded to them. The secondary reviewers forward comments to the lead reviewer who conducts their own review, and compiles the other two sets of comments into a document that is sent to ACR.
- The peer review comments received by ACR are compiled internally into a "peer review comment and response" document that is forwarded to the methodology developer.
- The methodology developer enters into a back-and-forth discussion with the peer reviewers that is facilitated by ACR until all issues are resolved. At this time, the methodology developer is permitted to engage in direct communication with ACR staff for further clarifications and to discuss potential revisions to the methodology (see Key Issues below).
- Following approval of the methodology by ACR, both sets of public and peer review comments and responses from the methodology developer are posted online along with the methodology and other relevant documentation.

Key Issues

The key issues (technical, programmatic, and others) encountered during each stage of the MSU-EPRI Methodology approval process are detailed below. These are followed by a summary of these issues, and the key revisions made to the methodology to address these issues, and a time line of the methodology approval process experienced by the MSU-EPRI team.

Public comments

During the public comment period, ACR received comments on the proposed MSU-EPRI Methodology from the National Wildlife Federation (NWF), and CDC Climate Research (CDC).

ACR allocated these comments to relevant sections of the methodology, and reformatted them into an ACR "comment-and-response document." The comments covered a variety of methodological issues, including applicability and scope, project eligibility, project boundary, emission measurements, and leakage and permanence. The main issues are discussed below.[10]

- Geographic applicability of a Tier 2 (nonlinear N_2O response curve) to the NCR;
- The exclusion of N management practices (other than N rate reduction) that could impact N_2O emissions, including N fertilizer formulation, timing, and placement;
- The exclusion of other management practices that could impact N_2O emissions, including tillage and cover crop use practices;
- Exclusion of GHG emissions associated with synthetic N fertilizer manufacture;

[10] The MSU-EPRI team responses to the public comments can be found online at: http://www.americancarbonregistry.org/carbon-accounting/msu-epri-methodology-public-comments-and-responses.

- Use of emission factors to estimate N_2O emissions;
- Potential for double counting of indirect N_2O emissions and resulting lowered emissions reductions; and,
- Lack of a minimum yield threshold during the project period.

Peer review

The first peer review period generated many comments from the peer reviewers, allocated to relevant sections of the methodology in a comment-and-response document. The comments covered a number of methodological issues including sources, definitions and applicability, project eligibility, project boundary, emissions measurements, uncertainty assessment, and data and parameters. The main concerns included:

- Geographic applicability of a Tier 2 (nonlinear N_2O response curve) to the NCR;
- Suitability (i.e., potential for non-conservativeness, uncertainty, and systematic bias) of using the IPCC Tier 1 emissions factor to estimate N_2O emissions from multiple crops in different regions;
- Use of a semi-quantitative "conservativeness" approach rather than a more complex statistical model to evaluate emissions uncertainty;
- Credibility of the assessment of N fertilizer Best Management Practices (BMPs).
- Potential for increased GHG emissions associated with fossil fuel usage during the project period when compared to the baseline period;
- Inclusion of GHG emissions associated with N fertilizer production, specifically emissions factors relating to urea use;
- Inability of [average precipitation / PET] relationships to reliably describe event-driven leaching events; and,
- The identical treatment of fall versus spring applied N fertilizer.

The second peer review period provided the peer reviewers the opportunity to respond to the MSU-EPRI project team's initial responses, and raise new issues. Many of the MSU-EPRI team's responses to the peer-reviewers' comments were accepted. The key concern that remained to be addressed was the geographic applicability of a Tier 2 (nonlinear N_2O response curve) to the entire NCR.[11]

During the third and final peer review period all outstanding methodological issues were resolved by the peer reviewers and ACR was officially notified of this in late February, 2012.

ACR process

Once the peer reviewers are satisfied with a methodology, and officially have notified ACR staff, the ACR typically approves the methodology quickly. This process was not strictly adhered to

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[11] The peer review comments and responses document (following the two rounds of our responses) can be found online at: http://www.americancarbonregistry.org/carbon-accounting/msu-epri-methodology-peer-review.

with regard to the approval of the MSU-EPRI Methodology. During the final internal ACR review process, further technical questions were brought to the MSU-EPRI team's attention. This was unexpected, as these issues had been addressed previously during the public and peer review processes, and the MSU-EPRI team had received email communications from ACR to this affect.

As a result, until early July, 2012, there was a period of consultation and discussion between the MSU-EPRI project team, the ACR, and the peer reviewers via email, conference calls, and direct meetings. No direct communications took place between the MSU-EPRI team and the peer reviewers, since it is the ACR's policy to conduct blind peer review.

The main science-based issue that remained to be addressed included ACR's concern that use of the IPCC Tier 1 emissions factor to estimate N_2O emissions from crops and regions *outside* of corn crops grown in the U.S. NCR might not be conservative enough, have a high enough degree of certainty, and might be biased in some way. More specifically, there was a concern that insufficient information was available within the global data set of agricultural N_2O emissions studies for ACR to be assured that use of the Tier 1 approach might not result in the over-crediting of emissions reductions in some regions and cropping systems where project developers might propose to use this approach.

A possible approach to resolve this concern was agreed upon that required the MSU-EPRI team to draw up a "positive list" of regions and crops within the U.S. for which the Tier 1 emissions factor of one percent could be shown to be a conservative estimate of N_2O emissions. A map and list of eligible project categories reflecting crop type, region, and data integrity was established, and is shown in Appendix A. Ultimately, this positive list approach was abandoned, in part, due to the lack of scientific justification for breaking up eligibility into crop by region specificity, and the large degree of stochasticity introduced by doing so.

There was agreement that an IPCC Tier 1 emissions factor of one percent was conservative across large regions, over many crops, and over an extended period of time. However, its use for project-based offset crediting was seen as untenable by ACR due to the strict burden of proof that is required for project crediting, and the goal of conservative crediting for each and every offset ton and project. ACR believed it could face a reputational risk if it adopted such a Tier 1 approach and could not absolutely defend each ton of CO_2e emissions reduction generated using the MSU-EPRI Methodology. This concern in part was the consequence of the intense scrutiny of agricultural protocols being considered for use in the emerging CA carbon market, and the potential for litigation and unwanted media exposure that could be brought by critics of the offset mechanism itself.

This issue was finally resolved by creating two new categories of projects within the ACR version of the MSU-EPRI Methodology. For one of these new categories, an offset project developer can use the IPCC Tier 1 emissions factor if they are able to demonstrated using project-specific "… empirical data published (or accepted to be published) in peer-reviewed scientific journals that the use of the Tier 1 emission factor (EF1 = 1.0% [0.01]; IPCC 2006) is conservative for calculating N_2O emissions at the project site(s)."

On July 6, 2012, the MSU-EPRI Methodology was approved by ACR, with an official announcement made though press release on July 18, 2012.[12, 13, 14]

A webinar to introduce stakeholders to the methodology was hosted by ACR, MSU, and EPRI on November 15, 2012.[15]

Summary of key issues

Below is a list of the substantive technical issues raised during validation (public comment and peer-review) of the MSU-EPRI Methodology. Their presence in the list is based upon their potential to strongly impact the applicability, adoptability, and accuracy of the methodology.

- The applicability of the Tier 2 (nonlinear N_2O response curve) derived from empirical field studies in Michigan to the entire 12 state NCR;
- The potential for non-conservativeness, uncertainty, and systematic bias of the IPCC global Tier 1 emissions factor for estimating N_2O emissions reductions from crops other than corn and regions outside the NCR; and
- The use of a semi-quantitative conservativeness approach as opposed to a more complex statistical model to evaluate N_2O emissions reductions uncertainty.

Key Revisions to MSU-EPRI Methodology

Major revisions to the MSU-EPRI Methodology brought about by the ACR validation process were:

- The inclusion of an uncertainty reduction equation developed from a detailed uncertainty analysis using empirical field data to more accurately calculate the uncertainty associated with N_2O emissions reductions in corn-based projects in the U.S. NCR;
- The use of deduction factors linked to the uncertainty equation outputs (% uncertainty) to discount the number of N_2O emissions reduction offsets credits awarded - the greater the uncertainty in emissions reductions, the greater the deduction factor;
- The removal of the IPCC global emissions factor (1%) to calculate emissions reductions for projects outside corn cropping systems in the U.S. NCR;
- The inclusion of a project category allowing project developers to submit data based on existing research to show that use of the IPCC global emissions factor (Tier 1, 1%) is conservative for calculating N_2O emissions reductions;
- The inclusion of a project category allowing project developers to submit data based on new research to show that use of a new project-specific emissions factor (Tier 1 or Tier 2) is conservative for calculating N_2O emissions reductions; and

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[12] The MSU-EPRI Methodology (v1) can be found at: http://www.americancarbonregistry.org/carbon-accounting/msu-epri-methodology-v1 .

[13] Accompanying publications, an overview of the MSU-EPRI Methodology, and links to the public and peer review comments and responses can be found at: http://www.americancarbonregistry.org/carbon-accounting/carbon-accounting/methodology-for-n2o-emission-reductions-through-fertilizer-rate-reduction .

[14] The ACR press release can be found at: http://americancarbonregistry.org/acr-approves-msu-epri-methodology-for-emissions-reductions-from-agricultural-n2o.

[15] The webinar can be found at: http://www.youtube.com/watch?v=oDVsRDD66FA&feature=youtu.be

- The inclusion of retroactive crediting for projects initially credited under the two new project categories to incentivize the collection of N_2O emissions data and the development of emissions factors compatible with IPCC Tier 2 methodologies.

Timeline

The time elapsed between submission of the MSU-EPRI Methodology (v1.0) to ACR, and approval of the methodology (v1.8) by ACR was approximately 16 months. A brief time line of major events is shown in Table 4-1. A more detailed time line is presented in Appendix B.

Table 4-1. Abbreviated Time Line of Major Events Related to ACR Methodology Validation.

Event	Date (Month/Day/Year)
Methodology (v1.0) submitted	03/10/11
ACR internal review returned to MSU	03/16/11
Public comment period	05/23–06/17/11
Public comment responses submitted	08/17/11
Peer review response 1 submitted	12/06/11
Peer review response 2 submitted	02/10/12
Peer reviewers initially approve methodology	02/27/12
ACR approves methodology	07/06/12
ACR formally announce approval (press release)	07/18/12

Methodology Revision

Details of the process for revising existing ACR methodologies can be found in the ACR Standard (v2.1, October 2010, Ch. 7).[16] The text below is taken from the document.

"*ACR will permit modifications where they do not negatively impact the conservativeness of an approved methodology's approach to determining additionality and quantification of GHG emissions reductions and removals. Project Proponents should submit any proposed methodology modification to ACR for review by the relevant ACR Technical Committee. If the Technical Committee deems that the proposed modification is a minor deviation, the modification will be approved internally by the committee. If the Technical Committee deems the proposed modification is significant enough to constitute a revision, approval will require public consultation and peer review.*"

Validation Costs

For the MSU-EPRI Methodology, the direct costs of the validation process are shown in Table 4-2 below. These costs do not include the substantial cost of EPRI and MSU staff time and related administrative costs required to complete the ACR methodology validation process.

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[16] Online at: http://www.americancarbonregistry.org/carbon-accounting/american-carbon-registry-standard-v2.0/ACR%20Standard%20v2.1%20Oct%202010.pdf .

Table 4-2. Direct Costs of ACR Methodology Validation

Action	**Cost ($)**
ACR methodology screening fee	5,000
ACR public comment process	7,500
ACR peer review process	7,500
TOTAL	**20,000**

Table 7-1 compares the validation processes of the ACR, CAR, and VCS.

5
VERIFIED CARBON STANDARD

Overview

The Verified Carbon Standard (VCS) is a private, non-profit, GHG accounting program used by offset projects to verify and issue carbon credits in voluntary and pre-compliance markets. The VCS was launched in November 2007[17] by the VCS Association (VCSA), a non-profit organization responsible for developing and maintaining the VCS Program. The launch followed a public review and approval of the standard by a Steering Committee that included three organizations[18] that created the VCSA, NGOs, auditors, industry associations, project developers and large offset buyers. The VCSA was incorporated as a non-profit organization in 2009, the first VCS methodologies were approved in 2010, and in March 2011 VCS Version 3 documentation was released along with the name change to the Verified Carbon Standard.

The VCS Program provides the standards and framework for independent third-party validation and verification of GHG emission reductions and removals based on ISO standards 14064-2:2006 and 14064-3. To date, the VCS Program has recognized CDM, Joint Implementation (JI), and CAR methodologies, with the exception of the Reserve's Forest and Urban Forest protocols.

VCS uses a multiple-registry system built on the central VCS Project Database. The VCS Registry System was launched in March 2009, and currently consists of two independent, approved registry operators (APX Inc. and Markit) that interact directly with the database to upload project documents, obtain unique serial numbers and issue, hold, transfer and retire VCS issued offset credits call Verified Carbon Units (VCUs).

As of February, 2013, VCS had issued more than 116 million VCUs, and had registered more than 950 projects. At this time, nearly 31 million VCUs have been retired.

Methodology Approval Process

The VCS process for approving proposed methodologies includes assessment and validation by two separate and independent validation/verification bodies (VVBs). This process previously was referred to as the Double Approval process (the term was dropped with the launch of VCS Version 3). The first VVB is contracted by the methodology developer, and the second is contracted directly by the VCSA. With the launch of Version 3, the VCSA is now more intimately involved in various steps of the methodology approval process, as discussed below.

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[17] Originally, the Verified Carbon Standards was called the Voluntary Carbon Standard (VCS).
[18] The Climate Group, the World Business Council for Sustainable Development (WBCSD), and the International Emissions Trading Association (IETA).

The basic steps of the VCS methodology approval process (MAP)[19] are:

- Methodology developer prepares and submits documentation;
- VCS conducts 30-day public consultation;
- Methodology developer contracts first VVB to review the methodology and produce an assessment report;
- VCS contracts second VVB to review the methodology and produce an assessment report;
- VCS reviews documentation and assessment reports; and,
- VCS approves methodology for use.

Key Issues

The key technical, programmatic, and other issues encountered during individual stages of the VCS methodology approval process as experienced by the MSU-EPRI project team are detailed below. These are followed by a summary of these issues, and the key revisions to the methodology resulting from the validation process, and a time line for the methodology approval.

Prior to public posting of methodology

Following submission of the draft MSU-EPRI Methodology and prior to its public posting, VCS conducted an internal screening process, and as a result requested minor amendments to the draft methodology (mostly relating to formatting), including the addition of a sentence to clarify that the additionality test proposed in the methodology included a performance benchmark approach.

Discussions also took place relating to the appropriateness of using the BAU scenario as the performance benchmark, and potential values for this benchmark.

The project team subsequently submitted an amended version of the methodology to the VCS.

Public comments

During the public comment period, VCS received comments from the National Wildlife Federation (NWF), Terra Global Capital (TGC), and The Fertilizer Institute (TFI).[20]

During fall 2010, general information explaining how public comments should be addressed by methodology developers was presented in the VCS Normative Document Double Approval Process v1.1. Currently (as of January 2013), the Methodology Approval Process document (v3.4; October 12, 2012) provides this information (Steps 2 and 3):

> Section 3.3.6. of this documents states: “At the end of the public comment period, the VCSA shall provide all and any comments received to the developer. The developer shall take due account of such comments, which means it will need to either update the methodology or

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[19] Described online on the VCS website at http://v-c-s.org/methodologies/develop-methodology. VCS Methodology frequently asked questions can be found at: http://v-c-s.org/faq/methodology, and,
The Methodology Approval Process document (v3.4; October 12, 2012) is available at: http://v-c-s.org/sites/v-c-s.org/files/Methodology%20Approval%20Process.%20v3.4.pdf.
[20] These public comments can be found at: http://v-c-s.org/methodologies/quantifying-n2o-emissions-reductions-us-agricultural-crops-through-n-fertilizer-rate-0.

demonstrate the insignificance of the comment. It shall demonstrate to each of the validation/verification bodies what action it has taken, as set out in Section 3.4.2."

Section 3.4.2. "All and any of the first validation/verification body's findings shall be responded to. As a result of any such findings, the developer may need to amend the methodology element documentation."

Section 3.4.3. "The first validation/verification body shall produce an assessment report in accordance with the VCS rules and best practice."

"In addition, the assessment report shall contain the following:

- An explanation of whether and how the developer has taken due account of all comments received during the public stakeholder consultation."

Comments received from the VCS in December, 2010, also addressed the procedure for methodology developers to address public comments. They can be summarized as:

- There is no requirement for the methodology developer to submit responses to public comments to VCSA.
- The methodology should be revised in accordance with the comments, or the methodology developer should demonstrate that the comment was considered, but does not require action.
- In their assessment reports, both the first and second validator will identify the public comments, and review how the methodology developer considered and addressed them.

The MSU-EPRI team submitted responses to the public comments to the first validator (Environmental Services Incorporated, ESI) in December, 2010. ESI reviewed our responses along with our responses to questions raised by ESI's validators.[21] ESI concluded that the EPRI-MSU team "provided adequate and sufficient responses addressing each comment received."

The public comments and responses also were assessed by the second validator (Det Norske Veritas, DNV). They were "of the opinion that the methodology developer has taken due account of all comments submitted and that all of the responses from the project developer are adequate."

First validation (Environmental Services Incorporated [ESI])

The first round of requests for clarifications and corrections (CACRs) from ESI (35 in total: 20 technical; 15 programmatic) were submitted to us in October, 2010.

The technical questions included queries related to:

- The reasoning for selecting the NCR for the Tier 2 emission factor;
- Whether methane (CH_4) emissions could be considered negligible;

[21] The MSU-EPRI responses to public comments are presented in Appendix C. They are not available on the VCS website. Confirmation that the public comments were addressed is found in the ESI First Assessment Report (pg. 11; Global Stakeholder Consultation) at: http://www.v-c-s.org/sites/v-c s.org/files/Draft%20First%20Assessment%20Report%20ESI_0.pdf.

- Inconsistencies relating to use of the terms “business as usual” and “common practice;”
- The omission of soil N test data to determine baseline N rate;
- How crop residue and legume N is considered;
- The effects of tillage on N_2O emissions;
- The effects of irregular rainfall on nitrate leaching; and,
- Diurnal variation in N_2O emissions.

The programmatic questions included queries related to:

- Potential negative environmental and socioeconomic impacts of the methodology;
- The inclusion of information on implementation barriers for project developers;
- The creation of a new performance standard, and its allowance by the VCS;
- The inclusion of discussions on reversal and permanence;
- The approach for identifying organic soils;
- Assumptions related to negligible project leakage;
- The frequency and duration of monitoring; and,
- Definitions of the “growing season.”

Following submission of our response document in November, 2010, the vast majority of the CACRs were considered sufficiently addressed and closed by ESI. The remaining issues to be addressed included:

- The legitimacy of extrapolating the MSU-EPRI Methodology to the entire NCR; and
- Whether and how the VCS would address the innovative performance-standard approach proposed by the MSU-EPRI team.

A follow-up conference call addressed these issues. A second round of ESI comments required only minor corrections and amendments to the methodology (four technical and six programmatic queries). Following the submission of the revised methodology, ESI submitted a draft validation report to us in mid-January, 2011, and the final First Assessment Report was submitted to us and VCSA in early February, 2011.

Transition from first to second validation

Although the contract for the second assessment is between the VCSA and the assessor, VCS allows the methodology developer to select this assessor. However, as stipulated in the VCS Normative Document Double Approval Process v1.1 (in force at the time), and the Methodology Approval Process document (v3.4) currently in operation, “The VCSA retains the right to choose another validator if it is not satisfied with the option(s) provided.”

Typically, the methodology developer will gather a small number of work proposals and make a decision based on these. The methodology developer can submit the work proposals to the VCS along with their preferred choice of second validator. As with all assessors, the second assessor chosen by the methodology developer must meet all VCS eligibility requirements. At this time during the process (December 2010), the eligibility requirements for the assessors (VVBs) were set out in the VCS Normative Document Double Approval Process. Currently (December 2012), the Methodology Approval Process document (v3.4; October 12, 2012) provides this information (Section 4):

The MSU-EPRI team previously had received a proposal for conducting the first validation from DNV.[22] At this time, the team provisionally selected DNV as the second validator, pending their submission of an acceptable revised proposal to us and the VCSA. A revised proposal for the second validation was sent by DNV to us, and forwarded by us to VCS.

VCS requested further clarification from DNV on a number of issues in the proposal, including:

- The number of rounds of CARs (Corrective Action Requests) included in the proposal;
- The daily per person rate for additional work outside of the proposal scope; and,
- The timeline with regard to specific validation milestones.

DNV submitted a revised statement of work (SOW) to VCS and us that satisfied these VCS requirements.

Document transfer

During the transition time between the first and second validation, the responsibility for the delivery of documentation was unclear. Specifically, it was not clear who had responsibility to submit the current version of the methodology and the first assessment report to the VCS and the second validator (DNV). ESI believed they were responsible only for submitting their assessment report to the MSU-EPRI team and the VCS. We contacted the VCS to clarify the situation, and were advised that the methodology developer was allowed to submit the current methodology to the VCS. Subsequently, we submitted the methodology (v1.3) to the VCS.

At the time (February 2011), the VCS Normative Document Double Approval Process (v1.1) was in force. Section 4.5.3 of this document states:

> "*The methodology element developer shall provide the VCSA with the most recent methodology element documentation and the assessment report produced by the first validator. The VCSA shall then provide such documentation and report to the second validator*."

So it became clear to us that the MSU-EPRI team was responsible for submitting both documents to the VCSA. This requirement currently still is in place. From the methodology approval process (v3.4; section 3.4.4):

> "*The developer shall provide the VCSA with the most recent methodology element documentation and the assessment report produced by the first validation/verification body.*"

Notice that the second sentence "*The VCSA shall then provide such documentation and report to the second validator*." has been removed. The Methodology Approval process (v3.4; section 3.4.5) now stipulates:

> "*The VCSA shall review the most recent methodology element documentation, using the procedure set out in Section 3.3.2. Where it deems it necessary, the VCSA shall require the*

[22] Request for Quotation [RFQ]) from DNV in June 2010.

developer to revise the methodology element documentation, and shall involve the first and second validation/verification bodies, as required."

This language was not present in the VCS Normative Document Double Approval Process (v1.1).

VCS involvement

The VCS responded to the submission of the MSU-EPRI methodology (v1.3), with written comments expressing concerns about the additionality component of the methodology and a request for suitable alteration.

At that time (February, 2011), we were unaware of any written guidance in VCS documentation that allowed for any substantive intervention in the methodology approval process (technical or programmatic) directly by the VCS staff.[23] Currently, there is written guidance to this effect found in the Methodology Approval Process document (v3.4; October 12, 2012).[24]

From section 3.3.2 and 3.3.3 (pg. 6) of this document:

> 3.3.2. "The VCSA shall review the methodology element documentation to ensure compliance of the methodology element with the VCS rules, including, inter alia, the integrity of the approach to additionality, the appropriateness of the applicability conditions and the correctness of reference to and use of VCS requirements and defined terms. Where it deems it necessary, the VCSA shall require the developer to revise the methodology element documentation before accepting it into the methodology approval process. The purpose of the VCSA review is to assist the developer in identifying areas of non-compliance with the VCS rules early in the process and therefore to streamline the overall assessment process.
>
> Note - Where preliminary appraisal of the methodology element shows that it is not yet of the requisite standard, the VCSA shall not undertake a review, and the VCSA shall require the methodology developer to work further on the methodology before undertaking a review and proceeding with the methodology approval process."
>
> 3.3.3. "Where the VCSA deems that the methodology element is still not in compliance with the VCS rules or would sanction politically or ethically contentious project activities, or may otherwise impact the integrity of the VCS Program or the functioning of the broader carbon market, it reserves the right not to accept the methodology element into the methodology approval process."

The VCS comments regarding the proposed additionality approach in the MSU-EPRI methodology can be summarized as follows:

- The process for demonstrating additionality is not clear, and may not meet VCS requirements.
- The methodology does not set a specific performance standard threshold.

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[23] For example, no such guidance was presented in the VCS Normative Document Double Approval Process v1.1 (now) found at: http://v-c-s.org/sites/v-c-s.org/files/VCS-Program-Normative-Document_Double-Approval-Process_v1.1.pdf.

[24] http://v-c-s.org/sites/v-c-s.org/files/Methodology%20Approval%20Process.%20v3.4.pdf.

- The methodology should consider using a *project test* rather than a *performance test*.
- The developers should remove a section on implementation barriers (this section was previously inserted into the document at the recommendation of the first validator, in accordance with VCS requirements).

Following a conference call between the VCS and the MSU-EPRI team to discuss these issues, a revised version of the methodology (v1.4 draft) was sent to VCS. This revision removed the section on implementation barriers as requested, but did not alter the additionality approach. VCS then carried out further internal discussions regarding our proposed additionality approach, and requested a further conversation. At this time, VCS requested greater clarification on the process for establishing the performance benchmark so it could inform a VCS Steering Committee on Standardized Methods for Baselines and Additionality. The VCS also commented that the MSU-EPRI Methodology was "innovating in this space."

Following the second conference call, the VCS followed up with requests for additional clarifications and additions to the additionality and other sections. We submitted the revised methodology (v1.4) to VCS. VCS then forwarded the revised methodology to DNV along with an explanation of the changes in the version number brought about by their requirements.

The changes incorporated into the draft methodology (v1.3 to 1.4) that came about as a result of the VCS staff's involvement following the first validation period can be summarized as follows:

- Inclusion of a statement that projects can be implemented in the U.S. only;
- Relocation of the instructions on using Method 1 or Method 2 to calculate direct N_2O emissions from the Requirements for Eligibility section into a section that discusses the quantification of GHG emission reduction and removals;
- Rephrasing of the rules for project crediting period to avoid repetition, and to reference the rules and requirements as set out in the VCS Standard; and
- Relocation of the "Implementation barriers" section from a subsection in the Additionality section, to the beginning of the same section, to provide justification and explanation of the performance benchmark threshold.

VCS also communicated with DNV to express their interest in the outcome of DNV's assessment of the approach to additionality, considering the novel approach used by the MSU-EPRI team to establish the Performance Benchmark threshold in the methodology.

Second validation (Det Norske Veritas, DNV)

Following delays due to problems with validation team coordination and the unavailability of a suitable AFOLU expert, the first round of DNV comments were submitted to us in June, 2011. The comments comprised of 18 Corrective Action and Clarification Requests (CACRs), both technical and programmatic, and covered a wide range of issues, including:

- Type and frequency of monitoring for ensuring N Best Management Practices;
- Leakage due to potential project yield reduction;
- Eligibility (crop, geographic, and N management);
- Exclusion of soil C pool, and CO_2 and CH_4 emissions;

- Uncertainty in activity data and N_2O emissions reductions;
- Potential use of nitrification inhibitors;
- Exclusion of N_2O emissions from crop residues;
- Suitability of input based performance standard test for additionality; and,
- Rationale for N_2O emissions accounting (Tier 1 vs. Tier 3).

VCS version 2007.1 versus VCS version 3

Due to the form and phrasing of the CACRs, we requested confirmation from DNV regarding the VCS standard DNV was validating the MSU-EPRI Methodology against (v2007.1 or v3). Version 3 documentation recently had been released (March 2011), however there were "grace periods" in place for methodologies that had started the validation process under v2007.1, as was the case with the MSU-EPRI Methodology.

At this time, we understood DNV was validating the MSU-EPRI methodology under v2007.1 as stipulated in the VCS–DNV contract. We submitted responses to the first round of DNV comments with this understanding. Initial confirmation from DNV indicated their team were validating against v2007.1. However, after checking further, DNV reported that members of its validation team actually had been validating the methodology against two different VCS versions of the applicable VCS standard (i.e., one was using v2007.1, and one was using v3).

Due to the protracted nature of the DNV validation process, we proposed that validation by DNV and reconciliation with ESI (who had validated under v2007.1) under v3 was more appropriate. Validation under v3 ended our concern over the deadline for the grace period, due to expire in September, 2011, beyond which methodologies and projects that had been completed or were still undergoing validation or verification potentially could be put "on hold" pending revisions for compliance with v3.

Both DNV reviewers were advised to re-validate the proposed methodology against VCS v3. The second round of CACRs was sent to the MSU-EPRI team in early July, 2011. The reviewer who previously had validated the methodology against v2007.1 generated no new CACRs requiring clarifications. The reviewer who previously had validated the methodology against v3 generated new CACRs, and requested further information related to previously closed CACRs.

We submitted responses to the second round of comments, and a revised version of the methodology (v 1.4.2) in late August 2011. Revised comments and major amendments to the methodology included:

- Clarification on the criteria and procedures for identifying and assessing GHG sources, sinks and reservoirs (SSRs) that are affected by the project (i.e. leakage). This included amendments to reflect the *de minimis* exclusion of CH_4 and CO_2 from the calculations, and assertion that peer-reviewed literature comprised the criterion by which soil C can be considered *de minimis* for all projects.
- A major re-analysis of the empirical field data to further evaluate the uncertainty associated with direct N_2O emissions reductions from a baseline (higher N rate) to a project (lower N rate) scenario in the NCR. This resulted in the development of a revised emissions factor for

the NCR, and an equation that calculated the percentage uncertainty in N_2O emissions reductions associated with a reduction in N rate.

- Clarification on the rationale, development, and use of the Performance Benchmark test for project additionality. At that time (and currently), the VCS had no approved performance benchmark for crop-based agriculture in relation to N fertilizer rate management. The MSU-EPRI Methodology created this benchmark from which future projects could determine their additionality. See Performance Benchmark tool section below for further discussion.

Following further discussions, the EPRI-MSU project team submitted a third round of comments and a revised methodology (v 1.4.3) to DNV in late September, 2011. Confirmation that all CACRs had been closed was received and the documents were forwarded for a DNV Technical Review (see section below).

Uncertainty analysis

Comments and clarifications during the VCS Double Approval process that related to uncertainty in the MSU-EPRI Methodology predominantly were directed towards the quantification of the uncertainty associated with emissions and the emissions factor for direct N_2O emissions in the NCR (Tier 2). Prior to the derivation of the N_2O emissions reduction uncertainty equation that is active in current versions of the MSU-EPRI Methodology (VCS and ACR), the MSU-EPRI team suggested a greater reliance on the ISO principle of *conservativeness*, as incorporated into the VCS Standard, and a less formally quantitative approach to uncertainty. As noted in VCS documentation:

> *"Accuracy should be pursued as far as possible, but the hypothetical nature of baselines, the high cost of monitoring of some types of GHG emissions and removals, and other limitations make accuracy difficult to attain in many cases. In these cases,* ***conservativeness*** *[emphasis added] may serve as a moderator to accuracy in order to maintain the credibility of project GHG quantification."*

The main points we suggested for consideration in this context are presented below:

- To counter the increased and expected inherent heterogeneity (i.e., uncertainty around the mean) of N_2O emissions at higher N rates, a best-fit exponential model response curve (Hoben et al., 2011) was presented that calculated substantially lower N_2O fluxes compared to the raw average N_2O fluxes at each N rate. At the highest N rate investigated (225 kg N ha^{-1} yr^{-1}), the model data used to determine the emissions factor used an average N_2O flux that was ~30% lower than the calculated raw field data.
- The annual N_2O emissions calculations from the field data used the lowest daily N_2O flux measured over all sites and years from the relevant period, as the daily flux from which the cumulative emissions for early spring (March–April) and late fall (October–November) were calculated. The use of this lowest flux to calculate cumulative emissions during these periods underestimates actual emissions over these times.
- The annual N_2O emissions calculation from the field data assumed that the fluxes of N_2O from frozen soils to the atmosphere are nil, including during soil freeze–thaw cycles during the winter period (December–February). This assumption underestimated the actual fluxes that likely will have occurred during this time, and constitutes a very conservative approach to calculating overall N_2O fluxes.

- We believed the systematic underestimation of N_2O emissions using model data and conservative principles constituted a “conservative approach” to estimate N_2O fluxes, emissions factors, and emissions reductions. Further, we believed this approach provided a fully compensatory mechanism to account for the increasing variability of N_2O emissions at higher N rates, and the decreasing confidence in N_2O emissions at these rates.

Irrespective of these points, the proposed MSU-EPRI approach to address uncertainty was not accepted, and an extensive, revised uncertainty analysis was conducted. New methodology text was developed that reflected this new analysis, including assumptions, criteria and equations incorporated into a revised methodology document.

Performance Benchmark tool

One major reason the EPRI-MSU team proposed a Performance Benchmark was to create a site specific (project-scale) test for additionality that could act as a sectoral baseline for agricultural crop N management projects in the U.S. We expect this approach to reduce the current need to conduct costly and time consuming site-specific evaluations of additionality for each proposed emissions reduction project. Project developers pass the Performance Benchmark by being below a threshold value that represents a BAU application of N fertilizer – identical to the baseline N application rate at a project field. Reductions in rate, and therefore N_2O emissions, below the BAU value result in project additionality. In other words, the additionality benchmark is identical in value to the crediting benchmark.

Currently, the VCS Performance Benchmark metric can be *output based* (e.g., tCO_2e per cubic meter of timber harvested), *input based* (e.g., tCO_2e per tonne of fertilizer per hectare) or *sequestration based* (e.g., tC stored per hectare). At the time of DNV validation of the MSU-EPRI Methodology, VCS documentation indicated that only an output based metric was valid. Later, a VCS Steering Committee on Standardized Methods for Baselines and Additionality helped revise and expand options relating to the Performance Benchmark. Irrespective, the distinction between an *input* and *output* based metric for the MSU-EPRI Methodology Performance Benchmark can be considered moot as described below.

To calculate baseline N_2O emissions, a baseline N fertilizer rates is required. This N rate is determined from producer management records, and is an average value calculated from historical N rates applied to the same crop type in the same field as the proposed project. In this sense the Performance Benchmark, which is identical in value to the baseline N rate, can be considered an input based metric and can be measured in tCO_2e per tonne of fertilizer per hectare. However, the N rate applied during the baseline period, and therefore the baseline N_2O emissions, is derived from previous known crop yields (i.e., the yield-goal approach). These yields are derived either from site specific management records or county level records. Therefore, the baseline emissions also can be considered to be based upon output, and the performance benchmark can be defined as N_2O emissions per unit of previous yield (i.e., tCO_2e per tonne of corn harvested). Nitrogen rates during the baseline period serve as a proxy for output (yield), and reduced N rates during the project period constitute a reduction in emissions intensity and are *de facto* additional.

DNV Technical Review

The Technical Review (TR) is an independent assessment conducted by a senior technical reviewer on staff at DNV. The purpose of the TR is to review the assessment of the DNV project validation team. The TR can identify new issues, or can disagree with how previous issues were resolved, and does not need to accept the justification provided during the initial validation by DNV, or indeed the first validation organization (ESI). In effect, this TR acts as a third validation of a proposed methodology.

Typically, DNV conducts internal discussions to resolve any issues at this stage. If no new concerns are raised by the TR, then the validation process is complete. If agreement cannot be reached, then DNV would submit a formal document detailing the remaining concerns and require further comment from the EPRI-MSU team.

In the case of the MSU-EPRI Methodology this procedure was not followed. Rather, to expedite the validation process (there were availability issues between members of the original DNV project validation team and the technical reviewer), the ”draft” CACR document was submitted to us by DNV before DNV internal discussions had been completed. Although well intentioned, this action led to misunderstandings and further delay.

Following further extensive discussions between the EPRI-MSU team and DNV, one issue remained unresolved:

- The need (or lack thereof) for a project developer to demonstrate that project yields would be expected to be comparable to baseline yields.

Although agreement was reached that this demonstration would not be required *ex-po*st (i.e., there was no need to directly compare project yields with baseline yields), there was disagreement about how, and indeed whether it was necessary at all, and that this could be demonstrated *ex-ante*.

To resolve this issue, the MSU-EPRI team proposed the inclusion in the methodology of an attestation from the farmer/project proponent with the following language:

I/We certify that it is our intent: (i) to continue to utilize the project area for the purpose of commercial crop production during the crediting period; and, (ii) to apply an amount of external nitrogen fertilizer (synthetic plus organic) during each cropping season in the crediting period that is sufficient to generate expected annual yields similar to annual yields of the same crop grown during the baseline period.”

This language and approach was rejected by the senior technical reviewer at DNV. The issues cited can be summarized as follows:

- The belief that certified crop advisers (who also frequently are fertilizer dealers) would be willing to sign written confirmation of their N fertilizer advice to farmers. (i.e., a lowering of N rate). Our view was most advisers have an inherent bias towards *over-fertilizing* rather than under-fertilizing as their income benefits from it. They would also likely want to protect their professional credibility, and would be highly unlikely to state that a lower N rate is sufficient.

- Concerns that the “self-declaration” by farmers/project proponents amounted to “printing his own credits” and that “there is an inherit incentive to state that the fertilization levels are kept low.” We argued that a simple statement from the farmer should be sufficient – only if and when offset credits become more valuable than actual crop yield would there be a conflict of interest. The opportunity cost of under-fertilizing is very large – a bushel of corn at typical recent prices of ~$5-7 contains less than $0.50 of fertilizer. Irrespective of this, deliberately supplying misinformation also would constitute fraud, and project verifiers also would be expected to flag and investigate suspiciously low levels of self-declared N inputs.
- A lack of concern that the MRTN calculator was the only tool available for generating N rate recommendations. We previously had argued that while this was a useful tool for potentially helping to lower N rates, its use as the only means to generate N rate recommendations was too prescriptive, and its coverage too restrictive – only workable for corn in seven U.S. Midwestern states. DNV’s suggested rationale was that the current MRTN tool would stimulate further development of this approach in other geographic areas and crops – notwithstanding the fact that it had taken decades to reach its current limited impact.
- Following further discussions, the mutually agreed upon text shown below was incorporated into the MSU-EPRI Methodology (v1.4.6), and the methodology was resubmitted to DNV:

  “To demonstrate the total amount of N to be applied to the project area during a cropping season is sufficient to generate expected annual yield similar to the average annual yield of the same crop(s) during the baseline period as required in Section 4 (Fertilizer Nitrogen Management), the project proponent is required to provide one of the following two forms of evidence (1 or 2 below).

  1. Demonstrate consistency with the most recent state or regional N rate recommendations provided by the University Agriculture Extension Service, state department of agriculture, or a federal agency such as the USDA Natural Resources Conservation Service (NRCS) or Farm Service Agency (FSA). In this context, “consistency” means that the total amount of N to be applied to the project area during a cropping season must be equal to or greater than 80% of the lowest estimate of N rate range recommended for the relevant crop(s) in the region in which they are grown. This can be demonstrated using one of the two approaches below (a or b below):

    a. Consistent with the total N rate recommended in official publications from these organizations, such as extension bulletins or soil test lab reports.

    b. Consistent with data output from approved N rate calculators. Examples of approved N rate calculators include the Iowa State University corn nitrogen rate calculator (http://extension.agron.iastate.edu/soilfertility/nrate.aspx) for multiple Midwest states, and the University of Wisconsin corn N rate calculator (http://ipcm.wisc.edu/iPhone/tabid/120/Default.aspx) for Wisconsin, both of which calculate the profitable N rate range for corn around the maximum return to nitrogen (MRTN) rate. Other N rate calculators can be used provided they have been made available to the public by a University Agriculture Extension Service, state department of agriculture, or a federal agency, such as the USDA NRCS or FSA. A worked example demonstrating the use of the Iowa State University corn nitrogen calculator is shown in Annex H.

2. Written certification provided by a professional crop advisor stating that total amount of N to be applied to the project area during a cropping season is sufficient to generate expected annual yield similar to the average annual yield of the same crop(s) grown during the baseline period.

The professional crop advisor must be: (a) a Certified Crop Advisor (CCA) certified by the American Society of Agronomy (ASA); (b) a Certified Professional Crop Consultant (CPCC) certified by the Soil and Water Conservation Society (SWCS); (c) a professional staff member of a University Agricultural Extension Service; (c) a professional staff member of the USDA NRCS or FSA; (d) a professional staff member of a state agriculture agency in the state in which the project is located; or (e) an equivalent professional crop advisor as demonstrated by similar professional qualifications."

The MSU-EPRI team argued successfully that the minimum of "80% of the lowest estimate of N rate range recommended for the relevant crop(s) in the region in which they are grown" was appropriate and would allow leeway for local geography and potential use of novel fertilizer technologies.

Following submission of the MSU-EPRI Methodology (v1.4.6) to DNV, all CACRs were considered closed by DNV. During the latter stages of the TR, consultation between the technical experts at DNV and ESI took place to reconcile the issues raised during the second validation.

Validator reconciliation

Any changes to a methodology that occur as a consequence of the second validation must be reviewed and re-assessed by the first validator as part of the reconciliation process. Coordination and consultation between the two validators is essential to resolve any discrepancies, and ensure the validation teams are validating the same final version of the methodology.

During the latter stages of the second validation, DNV directly contacted ESI's technical expert involved in the first validation to try to help resolve the issues raised during their TR. ESI's technical expert then contacted the rest of the ESI validation team to ensure both validation groups were fully informed.

Despite ESI's technical expert's support for the views of the MSU-EPRI team regarding the lack of need for the project developer to demonstrate that project yields would be expected to be comparable to baseline yields, the DNV Technical Reviewer remained unmoved. Consequently, new text (detailed in the DNV Technical Review section above) was added to the MSU-EPRI Methodology to clarify how this requirement could be addressed by project developers.

Final review and approval

Following validator reconciliation, the methodology developer is charged with providing VCSA with the final reconciled methodology and the assessment reports from the first and second validator. We provided VCSA with these documents by early February, 2012.

Following submission of these assessment reports, the final approval by the VCSA of the MSU-EPRI Methodology was delayed significantly by the need to resolve several legal issues related to the VCSA's potential final approval of the methodology. During the rest of 2012 and into early 2013, protracted legal discussions were held between MSU, VCS and eventually EPRI related to MSU's concerns related to potential legal liabilities and indemnification associated with the use of the MSU-EPRI Methodology, as well as other legal issues, such as the appropriate jurisdiction where potential disputes would be arbitrated. These issues officially were resolved in late February, 2013.

During the latter part of these legal discussions, when it became apparent that a resolution was in sight, VCSA initiated their final review of the MSU-EPRI Methodology (v1.4.6), and the assessment reports from ESI and DNV.

In those situations like this one, in which the first and second assessment reports both approve of a new methodology element, the VCSA then reviews the methodology and the two assessment reports. Where necessary, the VCSA can require the methodology developer to revise the methodology documentation, involving the first and second validation/verification bodies, as required. The VCSA also can make minor revisions to the methodology (e.g., to correct typos or clarify language), and will consult the methodology developer and validation/verification bodies, as required.

Following their review, VCSA requested further clarification and elaboration on the performance benchmark method used in the methodology. Specifically, they requested more information and transparency to justify the equivalency of the performance benchmark and the BAU scenario as they related to baseline N rate. It was suggested that this should include:

- An analysis of sector performance to show that yield goal is the predominant quantitative approach used by farmers to determine their recommended N rate; and,
- Justification for why Approach 2 (county level determination of baseline N rate) was "conservative" through a discussion of the trade-offs between false positives (the crediting of activities that are not additional) and false negatives (the exclusion of activities that are additional).

VCSA indicated that these requirements could be met using qualitative information, but should include data if available to illustrate the qualitative rationale.

As a result of the legal discussions between the organizations, the revised methodology also needed to be revised to include a legal liability disclaimer.

Further minor editing – mostly related to language used to ensure the methodology was clear and consistent with VCS rules and terminology – also were requested.

Versions 1.4.7 and 1.4.8 sequentially were submitted to the VCSA following these revisions and additions.

On March 5, 2013 the MSU-EPRI Methodology was approved by VCS[25], with an official Program announcement made on March 6, 2013.[26]

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[25] Links to the MSU-EPRI Methodology (v1.0), Public Comments, Assessment Reports, and Draft Methodology Versions can be found at: http://v-c-s.org/methodologies/VM0022 .

[26] The Program announcement and information on the webinar can be found at: http://v-c-s.org/news-events/news/new-methodology-approved-limiting-nitrogen-fertilizer .

A webinar to introduce stakeholders to the new VCS methodology was hosted by VCS, MSU, EPRI and ESI on March 21, 2013.

Summary of key issues

Below is a list of the substantive technical and programmatic issues raised during the validation of the MSU-EPRI Methodology.

- The applicability of the Tier 2 (nonlinear N_2O response curve) derived from empirical field studies in Michigan to the entire 12 state NCR;
- The use of a semi-quantitative "conservativeness" approach to address N_2O emissions reductions uncertainty rather than a more complex statistical model;
- The validity of the Performance Benchmark tool to determine baseline N rate and project additionality;
- The conservativeness of Approach 2 to determine baseline N rate;
- The confusion and inconsistency surrounding the transition from VCS standard versions 2007.1 to 3.0, particularly as related to the "grace periods" for methodology and project development and validity, and the validation of the methodology by DNV; and,
- Legal issues associated with intellectual property, financial liability, insurance, and jurisdiction for arbitration of conflicts.

Key Revisions to MSU-EPRI Methodology

As a result of the MSU-EPRI Methodology going through the VCS's Double Approval process, the MSU-EPRI Methodology was revised in a variety of important ways, including:

- The inclusion of an uncertainty reduction equation developed from a detailed statistical uncertainty analysis using empirical field data to calculate more accurately the uncertainty associated with N_2O emissions reductions in corn-based projects in the NCR;
- The use of deduction factors linked to the uncertainty equation outputs (% uncertainty) to discount the number of N_2O emissions reduction offsets credits awarded – the greater the uncertainty in emissions reductions, the greater the deduction factor;
- The inclusion of text stipulating the need for the project developer to supply a sufficient amount of N during the project period to generate similar yield to the baseline period; and
- The inclusion of a detailed and in-depth justification of the choice of threshold for the Performance Benchmark, including a qualitative analysis of the trade-offs between false positives and false negatives with regards to credits awarded using Approach 2, and a qualitative/semi-quantitative analysis of the distribution of N fertilizer input in the sector based on yield-goal.

Timeline

The time elapsed between submitting the MSU-EPRI Methodology (v1.0) to the VCS and final approval in March, 2013, was approximately 31 months. The time elapsed between submitting the MSU-EPRI Methodology (v1.0) to VCS, and submitting the MSU-EPRI Methodology (v1.4.6) approved by both validators was approximately 18 months. A time line of major events during the latter period is shown below. A more detailed time line of the entire VCS methodology validation process as experienced by the MSU-EPRI team is presented in Appendix D.

Table 5-1. Timeline of VCS Validation of the MSU-EPRI Methodology

Event	Date (Month/Day/Year)
Methodology (v1.0) submitted to VCS	08/17/10
ESI validation (1st round) comments sent to MSU	10/04/10
Validation (1st round) responses sent to ESI	11/03/10
ESI validation (2nd round) comments sent to MSU	11/18/10
Public comment responses sent to ESI	12/27/10
ESI validation report (v1.0) sent to MSU	01/19/11
Methodology (v1.3) submitted to ESI	01/29/11
ESI submit validation report to VCS	02/02/11
Methodology (v1.3) submitted to VCS	02/15/11
Methodology (v1.4) submitted to VCS	02/23/11
MSU confirms VCS-DNV contract	02/24/11
VCS converts from version 2007.1 to version 3	03/08/11
DNV validation (1st round) comments	06/10/11
Responses (1st round) submitted to DNV	06/22/11
DNV validation (2nd round) comments	06/28/11
DNV validation comments (VCS v3.0) sent to MSU	07/07/11
MSU submits responses (2nd round) to DNV	08/24/11
DNV validation (3rd round) comments	09/06/11
MSU submits responses (3rd round) to DNV	09/20/11
DNV confirm all CARs/CLs are closed	09/30/11
DNV submit methodology for TR (internal auditor)	10/09/11
DNV send TR report (v1) to MSU	10/19/11
DNV send TR report (v2) to MSU	10/31/11
MSU submits TR responses to DNV	12/13/11

Event	Date (Month/Day/Year)
DNV (TR reviewer) confirm all comments are closed	01/05/12
MSU submits methodology (v1.4.6) to DNV and ESI	01/09/12
DNV submit validation report to MSU	01/19/12
MSU submits DNV validation report to ESI	01/23/12
ESI submit reconciliation report (draft) to MSU	01/30/12
DNV submit final validation report to MSU	02/03/12
ESI submit final validation report to MSU	02/03/12
MSU submits DNV and ESI validation reports to VCS	02/08/12
MSU/EPRI/VCS legal discussions	March 2012 – February 2013
MSU submits methodology (v1.4.7) to VCS	02/19/13
MSU submits methodology (v1.4.8) to VCS	02/27/13
VCS approves methodology	03/05/13
VCS, MSU, EPRI, and ESI host methodology webinar	03/21/13

Methodology Revision

An overview of how a VCS methodology is revised can be found in the VCS document *Methodology Approval Process* currently v3.4 (4 October, 2012, section 6). The text below is excerpted from section 6.2 of this document.

"A revision to a VCS methodology is handled as an update to the prevailing version of the methodology and the following applies:

- *The methodology revision shall not narrow the methodology's applicability or in any other way exclude project activities that are eligible under the prevailing version of the methodology, unless such narrowing or exclusion is authorized by the VCSA.*
- *The methodology document of the prevailing version of the methodology shall be edited to incorporate the methodology revision. The Word version of the prevailing methodology document may be requested from the VCSA. Where the prevailing version of the methodology does not use the VCS Methodology Template, the methodology shall be transferred into the template.*
- *Where the methodology revision is approved by the VCSA, the prevailing version of the methodology shall be withdrawn and the methodology revision shall replace it."*

Validation Costs

The costs of conducting both methodology validation assessments in the VCS methodology approval process are borne by the methodology developer. Costs are largely dependent on the validation organizations contracted by the methodology developer, the initial quality of the methodology, and the length of time taken by each validation/verification body to complete its assessment. The methodology approval process administration fee currently is $2,000.[27]

For the MSU-EPRI Methodology, the costs of completing the Double Approval process are shown in Table 5-2. The validation costs shown in Table 5-2 exclude the substantial cost of EPRI and MSU staff time to support the VCS Double Approval process for a new methodology.

Table 5-2. Direct cost to Validate EPRI-MSU Methodology at the VCS.

Action	Cost ($)
VCS approval process fee	2,000
First validation (ESI)	22,000
Second validation (DNV)	18,870
TOTAL	**42,870**

Table 7-1 compares the validation processes under the ACR, VCS, and CAR in detail.

[27] The costs of methodology validation with the VCS are outlined in the document "Program Fee Schedule" currently v 3.3 (1 February, 2012) are found under the "Requirements" section at: http://v-c-s.org/program-documents.

6
CLIMATE ACTION RESERVE (CAR)

Overview

The Climate Action Reserve is a not-for-profit offset program and registry that establishes protocols for GHG offset projects eligible in the U.S. and its territories, and Mexico. The Reserve oversees independent third-party verification bodies, issues carbon offset credits known as Climate Reserve Tonnes (CRTs), and tracks issuances and transactions of offset credits in a publicly accessible offsets registry. The Reserve does not adopt protocols from other programs, but rather develops its own protocols through a multi-stakeholder workgroup process.

Previously the Reserve was known as the California Climate Action Registry (CCAR), which was chartered by California state legislation in 2001 to encourage voluntary reporting of GHG emissions inventories. The CCAR also produced offset project protocols, starting with a forestry protocol in 2005. Since 2001, CCAR has worked with other states and countries to expand use of its GHG reporting methodologies. In 2007, The Climate Registry was founded as a separate non-profit organization to carry on the emissions inventory reporting work of CCAR. The Climate Registry is a collaboration among North American states, provinces, territories and Native Sovereign Nations that establishes GHG accounting standards. In 2010, The Climate Registry took over voluntary emissions inventory reporting for CCAR members.

The four ARB approved offset protocols that can be used for compliance with the California Cap-and-Trade Program (i.e., U.S. Forest, Livestock, Ozone Depleting Substances, and Urban Forest) all started as Reserve offset protocols for use in the voluntary market. These Reserve protocols subsequently were subjected to additional regulatory development and public scrutiny, and ultimately approved by the ARB for use in the compliance market in 2011. Since December, 2012, the Reserve also has been serving as an OPR in the California Cap-and-Trade Program.

As of mid-February, 2013, the Reserve had issued more than 32 million CRTs and retired 5.7 million from future use. The largest sources of existing CRT's are projects associated with Landfill gas (12.0 million) and Ozone depleting substances (9.8 million).

On June 27, 2012, the Reserve's Board of Directors adopted Version 1.0 of its "*Nitrogen Management Project Protocol: Reducing Nitrous Oxide Emissions through Improved Nitrogen Management in Crop Production (NMPP v1.0)*." Many of the key provisions incorporated in the quantification methodology of this offsets protocol are derived directly from the MSU-EPRI N_2O offsets protocol. For example, the only approach that can be used to quantify N_2O emissions and emissions reductions explicitly approved in NMPP v1.0 is that developed by the MSU-EPRI team. In addition, the only approved N management practice allowed to be used by farmers to generate N_2O offsets is the reduction in the rate of N fertilizer used to grow corn in the NCR, based on the scientific literature developed as part of the MSU-EPRI project.

The Reserve's Program Manual summarizes their overarching principles, its general project accounting guidelines, and its rules and procedures for registering projects and creating offset credits. It also describes the process used by the Reserve to develop protocols for carbon offset projects.[28]

Methodology Approval Process

The Reserve is a "top-down" offsets program. New project types are selected for protocol development by Reserve staff with input from the CAR Board of Directors and other stakeholders. Key issues considered by CAR in scoping potential new protocols include GHG mitigation potential, existing science and methodologies, and potential challenges for new project types. The Reserve also accepts suggestions for project protocol concepts from interested stakeholders. [29, 30]

The process used by the Reserve to develop offset protocols is summarized in their Program Manual. The Reserve Protocol development typically follows the process listed below:

- Internal research and scoping;
- Kick-off/scoping meetings;
- Multi-stakeholder workgroup formation;
- Draft protocol produced by Reserve staff;
- Draft protocol considered by workgroup;
- Revised draft released for public comment;
- Public workshop;
- Reserve staff responds in writing to all comments received, updating the protocol as necessary; and,
- Final version of protocol adopted by Reserve Board in public session.

During the NMPP approval process, the Reserve convened a multi-stakeholder workgroup (that included MSU's Dr. Millar), and a Scientific Advisory Committee (SAC; that included MSU's Dr. Robertson) to help interpret and apply the best available science into the NMPP.[31]

Key Issues

During the NMPP approval process, the Reserve made available a number of supporting documents to the multi-stakeholder workgroup and SAC for comment. The Reserve contracted with Terra Global Capital (TGC) to assist with preparation of these documents, and to provide advice throughout the protocol development process. During this time, the MSU-EPRI team submitted four documents to the Reserve in response to the preparation of the following supporting documents prepared for Reserve:

- Draft Reserve Project Protocol – August 10, 2011

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[28] The manual can be found at: http://www.climateactionreserve.org/how/program/program-manual/.
[29] Details of this submission process can be found at: http://www.climateactionreserve.org/how/future-protocol-development/ .
[30] The criteria for Reserve protocol development can be found at: http://www.climateactionreserve.org/how/future-protocol-development/criteria/.
[31] The list of organizations represented in the workgroup, and a summary of the SAC report are available online at: http://www.climateactionreserve.org/how/protocols/nitrogen-management/dev/#ver.

- Scientific Background Paper – September 29, 2011
- Quantification Approach Comparison – January 18, 2012
- Guidelines for New N_2O Quantification Approaches – March 9, 2012

None of these draft documents have been made public, and all were significantly revised following review by the MSU-EPRI team and others, including Reserve staff.

The key issues identified by the MSU-EPRI project team with respect to these draft documents included:

- An initial focus on a Tier 3 DNDC modeling approach to quantify N2O emissions and emissions reductions, and the exclusion of all other quantification approaches despite the availability of other approaches and well-known problems with Tier 3 modeling approaches in general, and DNDC in particular. These problems include high uncertainty, incomplete validation, potential gaming opportunities, high verification costs, uncertain data sources, and lack of transparency.
- Overly-restrictive stipulations related to the number of N fertilizer practices, number of fields, types of cover crops, field ownership, organic fertilizers, project start times, prescriptive thresholds, field N tests, contract periods, and the set of soils, sinks and reservoirs used to set GHG assessment boundaries.
- Incomplete and uneven assessments of opportunities to reduce N_2O emissions through N fertilizer management, including changes in N fertilizer rates, and poorly justified dismissals of published methodologies based on N fertilizer rates;
- Misinterpretation of the MSU-EPRI Methodology in particular, including inappropriate comparisons with DNDC results, the use of selected and unpublished data to test model results, and inappropriate focus on the prediction of *absolute* N_2O fluxes rather than *changes* in N_2O fluxes as a result of N management changes.

The draft documents reviewed underwent major revisions during the protocol development process as a result of feedback from the MSU-EPRI team, the NMPP workgroup and SAC members, and additional research by the Reserve and TGC staff. Some of the revised documents are publicly available.[32]

Key Revisions to the CAR NMPP

Two key revisions to the draft protocol Version 1.0 (July 27, 2011) included: (i) altering the quantification approach to calculate N_2O emissions reductions from the Tier 3 process-based modeling approach using the DNDC model to use of the Tier 2 empirical modeling approach embodied in the MSU-EPRI Protocol; and, (ii) restricting the potential practices that could be adopted to lower N_2O emissions to N rate reduction as in the MSU-EPRI Protocol.

Additional significant revisions included (i) restricting the crop and geographic scope of the protocol to corn grown on untiled fields in the NCR where annual precipitation is between 600-1200 mm yr^{-1}, (ii) removing the requirement that more than one management practice be adopted

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[32] Documents supporting development of the Nitrogen Management Project Protocol are available at: http://www.climateactionreserve.org/how/protocols/nitrogen-management/dev/#ver_1.

for project eligibility, and (iii) lowering the RTA performance benchmark value to make it possible for more farmers to participate in NMPP offset projects.

A second NMPP workgroup meeting was convened on April 10, 2012, to consider these changes in a second draft protocol Version 1.0 (April 4, 2012). The final Version 1.0 protocol was adopted by the Reserve Board in June 2012.

Technical revisions to the protocol were included in NMPP Version 1.1 adopted by the Reserve in January 2013. The MSU-EPRI team provided a background report suggesting the inclusion of tile-drained lands as eligible project lands. The efforts from the MSU-EPRI team and others as well as further consultation of IPCC documents were important for helping to justify the inclusion of these lands in NMPP v1.1.

Timeline

The Reserve began scoping potential agriculture protocols in October 2010, and began actively developing the NMPP in April, 2011. The technical workgroup met from May 2011 to April 2012 to refine the draft protocol. A public workshop was held in May 2012 to discuss the draft protocol, which was available for public comment through April and May 2012. Reserve staff responded to the public comments received, and revised the protocol accordingly. Version 1.0 of the protocol was approved by the Reserve Board on June 27, 2012. The time elapsed between the initial scoping and approval of version 1.0 was approximately 21 months, as shown in the timeline in Table 6-1.

The Reserve undertook a technical update to Version 1.0 of the protocol beginning in August 2012. Version 1.1 was released for public comment in October 2012, and was adopted for use on January 17, 2013. A timeline of major events during this period is shown below.

Methodology Revision

After the Reserve Board adopts a new protocol, new protocols periodically are revised in light of ongoing stakeholder feedback, on-the-ground experience, and technological, scientific, and regulatory developments. In addition, the Reserve continues to review and update performance standards and standardized baselines as new data becomes available. There are two types of revisions to that may be made to the Reserve's project protocols: (i) policy revisions and (ii) program revisions. Policy revisions reflect changes to project definitions and other eligibility criteria, and program revisions can be considered technical updates as typically they address issues relating to, for example, quantification (e.g., the update of NMPP v1.0 to v1.1).[33]

Validation Costs

The Reserve is a top down offset program, with protocols selected for development by Reserve staff with input from the CAR Board and other stakeholders. As protocols may not be submitted to the Reserve for validation and adoption by third parties, there are no official validation costs associated with the protocol development and validation process, and therefore no direct costs

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[33] Further details of these can be found in the CAR Program Manual (section 4.3) found at: http://www.climateactionreserve.org/how/program/program-manual/.

associated with the inclusion of key components of the MSU-EPRI Methodology in the NMPP. Costs incurred during the NMPP development process were primarily project team salary expenses associated with reviewing documents and participating in the NMPP workgroup and SAC activities.

Table 6-1. Timeline for Development of CAR NMPP

Event	Date (Month/Day/Year)
Methodology Synthesis Paper	05/06/11
Workgroup Meeting 1 (conference call)	05/18/11
Workgroup Meeting 2 (conference call)	06/27/11
1st Draft Background Paper Completed	07/18/11
1st Draft protocol for workgroup review	07/27/11
Workgroup Meeting 3 (Los Angeles)	08/01/11
Science Advisory Committee Meeting (Los Angeles)	09/07/11
Workgroup Meetings 4 (conference call)	10/25/11
Workgroup Meetings 5 (conference call), *continuation of meeting 4*	11/10/11
Publication of final Background Paper	12/22/12
Science Advisory Committee (conference call)	01/17/12
Workgroup Meeting 6 (conference call)	01/25/12
2nd Draft Protocol for workgroup/SAC review	04/03/12
Workgroup Meeting 7 (San Francisco)	04/10/12
Protocol (v1.0) released for 30-day public comment period	04/20/12
Public workshop (Sacramento)	05/09/12
Protocol v1.0 adopted by Reserve Board	06/27/12
Technical protocol revisions	Aug – Oct 2012
Protocol (v1.1) released for 30-day public comment period	10/10/12
Protocol v1.1 adopted	1/17/2013

Table 7-1 in section 7 compares the validation processes under the ACR, VCS, and CAR.

7
KEY INSIGHTS AND LESSONS LEARNED

In this section briefly describes some key insights gained and lessons learned by the MSU-EPRI team based on our efforts to obtain approval for the use of the MSU-EPRI Methodology in the offset programs operated by the ACR, CAR and VCS.

A summary of the key issues, and the key revisions made to the MSU-EPRI Methodology during the methodology review processes operated by these organizations, are provided in the relevant sections elsewhere in this report. Tables comparing the three methodology approval processes, and the criteria and components of the adopted MSU-EPRI Methodology or a similar methodology at these organizations are presented in this section.

Key Insights

The MSU-EPRI team's experience working with these three offset standards to validate our offsets methodology were broadly positive. All three of these organizations have adopted robust and comprehensive processes for validating / approving proposed offset methodologies, and the staff members of all three organizations are professional, well-prepared, and dedicated to creating GHG emissions offsets that have a very high degree of environmental integrity.

The methodology validation process contributed significantly to a more robust MSU-EPRI N_2O offsets methodology. Nevertheless, the validation processes could be improved; we encountered a number of issues that lengthened the duration of the processes and increased its financial costs. Some of these may have broader implications for the validation of agricultural methodologies in the future. These included:

- **Unexpected Interventions**
  - Involvement by staff at the standard organizations beyond the scope of the validation process as originally documented, contracted, and understood by the MSU-EPRI team.
  - The potential for a single individual's opinion to weaken the methodology's impact and reduce project participation.
- **Uneven Valuation of Conservativeness**
  - A limited (or missing) role for the principle of "conservativeness" to act as a moderator to accuracy to maintain an offset projects' GHG emissions credibility.
  - Broader organizational fears relating to reputational risk and potential litigation stemming from scrutiny of new offset methodologies.
- **Unclear Communications**
  - Lack of clarity related to the role of each participant (whether validator, methodology developer, or standard) in the transfer of documents such as methodology revisions, assessment reports, and public comment responses.
- **Uneven Reviewer Qualifications**
  - Uneven depth of professional knowledge and expertise among third-party verification staff as related to AFOLU offset project types, and specifically agricultural land management projects.

- The difficulty of finding methodology verifiers who are both accredited under a particular offset standard and who have important relevant scientific expertise in the specific area of N_2O emissions abatement in agriculture.

- **Inconsistencies During the Validation Process and among Methodologies**
  - Changing organizational staff involved in the methodology validation during the validation process that contributes to the need for extra time and increased costs.
  - Changing offset project and program eligibility requirements for a proposed methodology during validation confuses the validation process and requires additional staff time and expenses associated with validation.
  - Lack of coordination between methodologies related to reducing N_2O emissions in agricultural production across the standard organizations that may allow offset developers to cherry-pick specific offset protocols to obtain the biggest potential payback on project investments;
- **High Cost of Validation**
  - The very high financial cost to validate a new offset methodology, which may lead to many interested and qualified parties, particularly public sector and non-profit organizations, being excluded from methodology development.
  - The direct costs to validate the MSU-EPRI N_2O offsets protocol varied across the offsets standards from $20,000 (ACR) to more than $40,000 (VCS). These substantial direct costs do not include more than $250,000 in MSU and EPRI staff time dedicated to supporting validation of the methodology in these programs.
  - Lack of a mechanism to financially compensate methodology developers post-adoption that will make it difficult for existing and future methodologies to be revised in response to changing program requirements; among these three programs only the VCS has a modest mechanism in place to compensate methodology developers in a way that might help defray the costs of future methodology revisions.
- **Time for Validation**
  - The length of time it takes to validate a new offset methodology. It took ~12 months for CAR to develop v.1.0 of the NMPP, 13 months for us to complete the ACR validation, and 18 months for us to complete VCS validation (excluding legal deliberations that took more than one year). The length of time and complexity of the methodology validation process may inhibit many interested and qualified parties from helping to develop new protocols;
- **Legal concerns**
  - Liability, indemnification, insurance, and legal jurisdiction for arbitration that were particular issues for MSU as a public sector developer; these issues had not before been encountered by the standards.

Methodology Comparison

Table 7-1 below list key common components included in the validation / approval of a proposed new offsets methodology, and briefly describes how these components are addressed by each of the three voluntary offset programs (ACR, VCS, and CAR). Further details are provided in the “methodology approval process” for each of these programs in sections four, five and six of this report. Detailed time-lines for the validation process for the ACR and VCS programs are presented in Appendices B and D.

Table 7-1. Comparison of the key components included in the offset methodology validation and approval processes of the ACR, VCS, and CAR.

Component	Standard		
	ACR	VCS	Reserve
Pre-screen of methodology following submission?	Yes	Yes	Not applicable
Public comments accepted?	Yes	Yes	Yes
Public comment period	~30 days	~30 days	~30 days
Timing of public comment period	After pre-screen & prior to peer review	After pre-screen & prior to Double Approval process	After methodology development & prior to Board adoption
Peer-review?	Yes	Yes	Yes
Peer-review approach	Small team of sectoral experts hand-picked by ACR	VCS approved sectoral expert on each validation team	• Scientific Advisory Committee convened[1] • Technical experts in multi- stakeholder work-group
Work-groups?	No	No	• Multi-stakeholder workgroup • Credit stacking sub-committee • Aggregation sub-committee • Scientific Advisory Committee[1]
Screening post validation?	Yes	Yes	Not applicable
Methodology adoption	Approval by ACR staff	Approval by VCS Association	Adoption by CAR Board in public session
Documents publicly available	• Approved methodology • Public comments and responses • Peer-review comment and response • Relevant peer-reviewed scientific literature	• Methodology posted for public comment • Methodology following first assessment • Public comments • First assessment report (ESI)[2] • Second assessment report (DNV)[2]	• Approved methodology and summary • Previous methodology versions (including early drafts) • Public comments • CAR responses to public comments • Work-group affiliations • Work-group meeting details (agenda, presentations, audio/video) • Public workshop details (agenda, presentations, audio/video) • Scientific Advisory Committee meeting summary • Background documents

Component	Standard		
	ACR	**VCS**	**Reserve**
Documents not publicly available		• Response to public comments[3, 4] • Relevant peer-reviewed scientific literature	• Multi-stakeholder workgroup comments to earlier versions of background papers and methodology[5]
Financial compensation available to developers	No	Yes US$ 0.02 per VCU	No

[1]Not common practice – specific to NMPP.
[2]Document contains section detailing the comments and clarification requests (CACRs) from each validator and our response.
[3]A statement in each of the validator assessment reports attests that the public comments have been addressed adequately by the methodology developer.
[4] See section 5 and Appendix C.
[5]To ensure "freedom of speech" for stakeholders. See section 6.

Table 7-2 below provides a concise comparison of the MSU-EPRI Methodology as adopted by the three voluntary programs (ACR, VCS, and CAR) using major common criteria. Further details on these and other criteria are available in the methodologies posted at the respective program websites.

Table 7- 2. Comparison of MSU-EPRI Methodology at the ACR, VCS, and CAR.

Criteria	Standard		
	ACR	**VCS**	**CAR**
N management	Adhere to BMPs	Adhere to BMPs	BMPs encouraged
N fertilizer	Synthetic and Organic (reductions in both credited)	Synthetic and Organic (reductions in both credited)	Synthetic and Organic (only reduction in synthetic credited)
Organic soils (Histsols)	Excluded	Excluded	Excluded
Irrigation	Allowed if previously used	Allowed if previously used	Excluded
GHG assessment boundary	N_2O direct and indirect	N_2O direct and indirect	N_2O direct and indirect[1] Increased CO_2 from changes in cultivation equipment CO_2, CH_4, N_2O leakage
Geographic location	Global	U.S.	U.S. North Central Region with annual precipitation 600-1200 mm
Crops	Corn – U.S. NCR (Tier 2) All crops – Global (Tier 1 or 2)	Corn – U.S. NCR (Tier 2) All crops – U.S. (Tier 1)	Corn – U.S. NCR (Tier 2) only
Quantification approach	Category 1 – NCR Tier 2 Category 2 – IPCC Tier 1 Category 3 – IPCC Tier 2	Method 1 – IPCC Tier 1 Method 2 – NCR Tier 2	N rate reduction (NCR Tier 2) (only reductions in synthetic N fertilizer rates are credited)
Baseline N rate determination	Site management records (Category 1,2,3) County yield records (Category 1,2,3 – US only)	Site management records (Method 1,2) County yield records (Method 1,2)	Site management records
Baseline period	5 years or 3 project crop years	5 years or 3 project crop years	5 years or 3 project crop years
Leakage	No mechanism (not applicable)	No mechanism (not applicable)	CO_2, CH_4, N_2O quantification, only if yields decline significantly
Uncertainty calculations	Yes	Yes	Yes
Uncertainty deductions	Category 1 (NCR equation) Category 2 (no deduction) Category 3 (project specific)	Method 1 (no deduction) Method 2 (NCR equation)	Modified NCR equation
Conservative factor	Category 1 (0.836 – 1.000) Category 2 (no deduction) Category 3 (project specific)	Method 1 (no deduction) Method 2 (0.836 – 1.000)	According to modified NCR equation
Additionality	Regulatory surplus Performance standard	Regulatory surplus Performance standard	Regulatory surplus Payment stacking assessment Performance standard
Performance benchmark	BAU – baseline N rate based on yield goal	BAU – baseline N rate based on yield goal	Nitrogen use efficiency metric (RTA) based on USDA data
Project parameters monitored	• Amount of fertilizer • N content of fertilizer • Crop area	• Amount of fertilizer • N content of fertilizer • Crop area • Evidence for similar expected yield as baseline	• Amount of fertilizer • N content of fertilizer • Crop area • Planting and harvest dates[2] • Crop yield[2] • Application method[2] • Placement method[2] • Application equipment[2] • Corn stalk nitrate test[2]

[1] Referred to as SSR 1 (direct) and SSR 2 (indirect).
[2] All field monitoring parameters are listed in table 6.1 (section 6.3) of CAR NMPP v1.1.

8
CURRENT STATUS OF MSU-EPRI METHODOLOGY

American Carbon Registry

The MSU-EPRI Methodology (*Methodology for Quantifying Nitrous Oxide (N_2O) Emissions Reductions from Reduced Use of Nitrogen Fertilizer on Agricultural Crop, v1.0*) was approved formally by the ACR on July 18, 2012.[34]

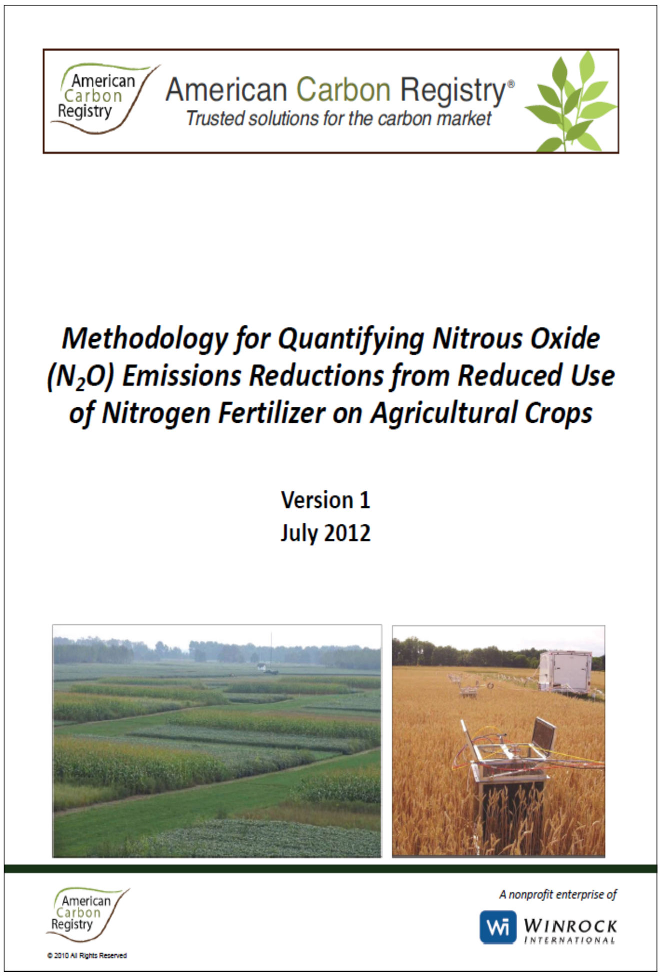

Figure 8-1. Published ACR N_2O Offset Methodology

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[34] http://www.americancarbonregistry.org/carbon-accounting/msu-epri-methodology-v1.

Verified Carbon Standard

The MSU-EPRI Methodology (*Quantifying N_2O Emissions Reductions in US Agricultural Crops through N Fertilizer Rate*) was approved formally by the VCS on March 5, 2013.[35]

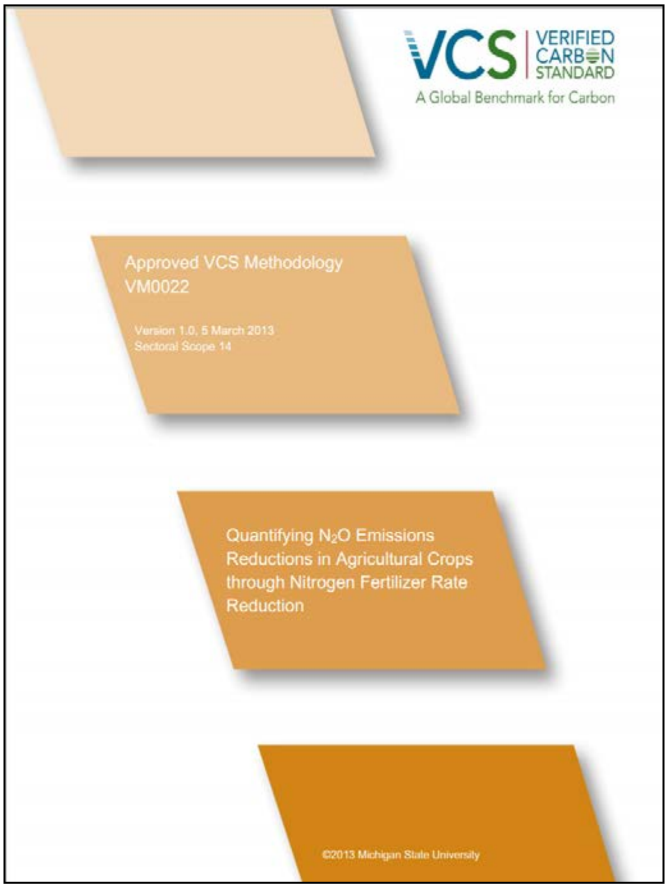

Figure 8-2 Published VCS N_2O Offset Methodology

[35] http://v-c-s.org/methodologies/VM0022.

Climate Action Reserve

Version 1.0 of the *Nitrogen Management Project Protocol: Reducing Nitrous Oxide Emissions through Improved Nitrogen Management in Crop Production*) that incorporates key features of the MSU-EPRI Methodology (e.g., Tier 2 quantification method) was approved Jun 27, 2012. The current version of the NMPP (v1.1) was approved January 17, 2013.[36]

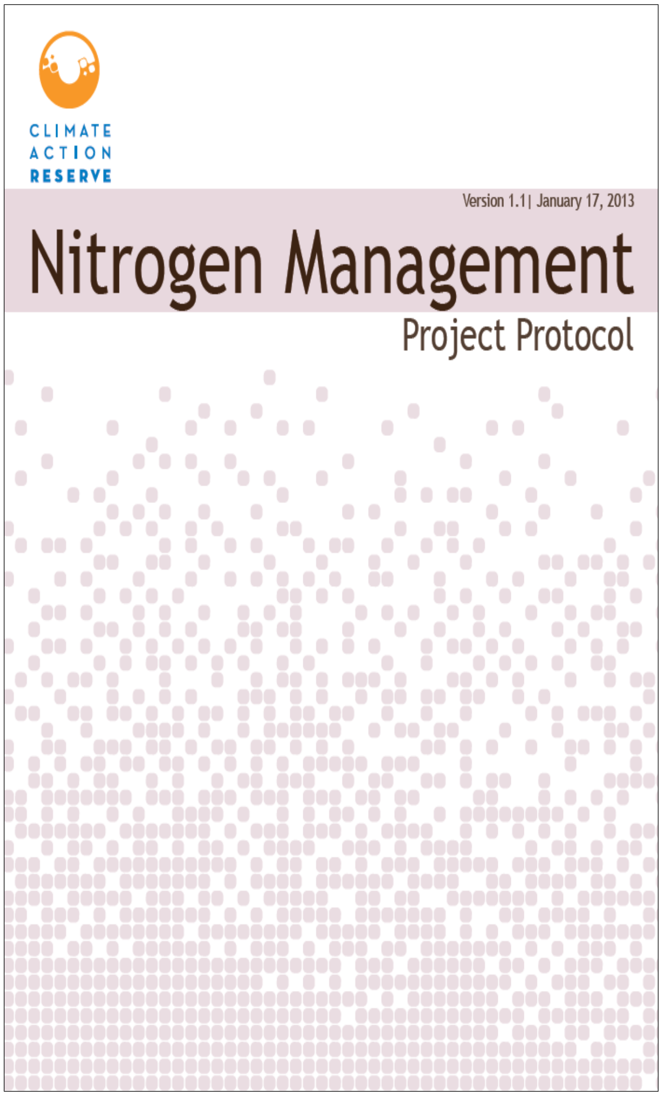

Figure 8-3. Published CAR NMPP v.1.1.

[36] See http://www.climateactionreserve.org/how/protocols/nitrogen-management/.

9
NEXT STEPS & REMAINING CHALLENGES

In addition to validating the MSU-EPRI Methodology in one of more of the leading offsets programs active in the U.S., the MSU-EPRI project team also developed a small pilot project that uses the MSU-EPRI Methodology as part of Phase 2 of this research project. This pilot N2O emissions reduction project has been completed, and is expected to be submitted to the ACR for verification and issuance of offset credits in the near future. Carbon offset credits generated by this Michigan-based, small-scale project are expected to be issued, sold and retired during 2013. When this has been completed, we believe it will be the world's first GHG offset project based on reducing N_2O emissions in agricultural crop production.

Details about this pilot project including its development, implementation, validation, and verification will be presented in a forthcoming EPRI report expected to be published later this year.[37]

Future near-term challenges for the successful implementation of the MSU-EPRI Methodology in the evolving carbon markets include:

- Offset project developers' and aggregators' interest in building large-scale N_2O offsets projects;
- The potential for N_2O offset projects to be *stacked*, in particular with evolving ecosystem service markets for water quality credits / reduced nitrate loading;
- Potential adoption by the California ARB of a nitrogen management compliance offset protocol, combined with recognition by the ARB of one or more of the registries' N management protocols as eligible for early action offset credits;
- Site-specific research within other regions in the U.S. and internationally to enlarge the range of geographies and crops that can use Tier 2 approaches to quantify N_2O emissions reductions and receive offset credits. .

Longer term success will depend on the market price of GHG offset credits, the penetration of new and existing cost-effective agricultural technologies that will enable farmers to further reduce N fertilizer rates; and, the willingness of farmers to participate in agricultural GHG offset programs.

[37] This forthcoming report is expected to be entitled *Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions in Agricultural Crop Production: Development and Implementation of a Farm-Based Offsets Project..*

10
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A
LIST OF ELIGIBLE PROJECT CATEGORIES PRESENTED DURING THE ACR VALIDATION PROCESS

During the ACR validation process, a "positive list" of regions and crops within the US for which the Tier 1 emissions factor of 1% could be shown to be conservative was requested to allay fears of non-conservativeness in a number of the regions and cropping systems where the MSU-EPRI Methodology (Tier 1) potentially could be used by project developers.

A map and list of eligible project categories in table form reflecting crop type, region, and data integrity was developed by MSU based upon this requirement. This took the form of Annex H in versions 1.4 (April 17, 2012) and 1.5 (May 17, 2012) of the MSU-EPRI Methodology.

Ultimately, this approach was abandoned, in part due to the lack of scientific justification for breaking up eligibility into crop by region specificity, and the large degree of stochasticity introduced by doing so.

The text, map, and tables from the MSU-EPRI Methodology (v 1.5 – not otherwise publicly available) are presented below.

ANNEX H: ELIGIBLE LAND RESOURCE REGIONS IN THE US

Proposed projects are eligible for validation under Category 1 (section 2.5) if they are located in Land Resource Regions (LRRs) highlighted in Figure H1. Projects that include agricultural crops will use Method 1 to calculate N_2O emissions reductions. The list of eligible LRRs will be expanded on an on-going basis with the acceptance of published, peer-reviewed empirical data from projects in Categories 3 and 4.

Projects located within the NCR boundary and in eligible LRRs that involve crops other than corn (eligible under Category 2) including crops in rotation with corn, are eligible under Categories 1, 3, and 4.

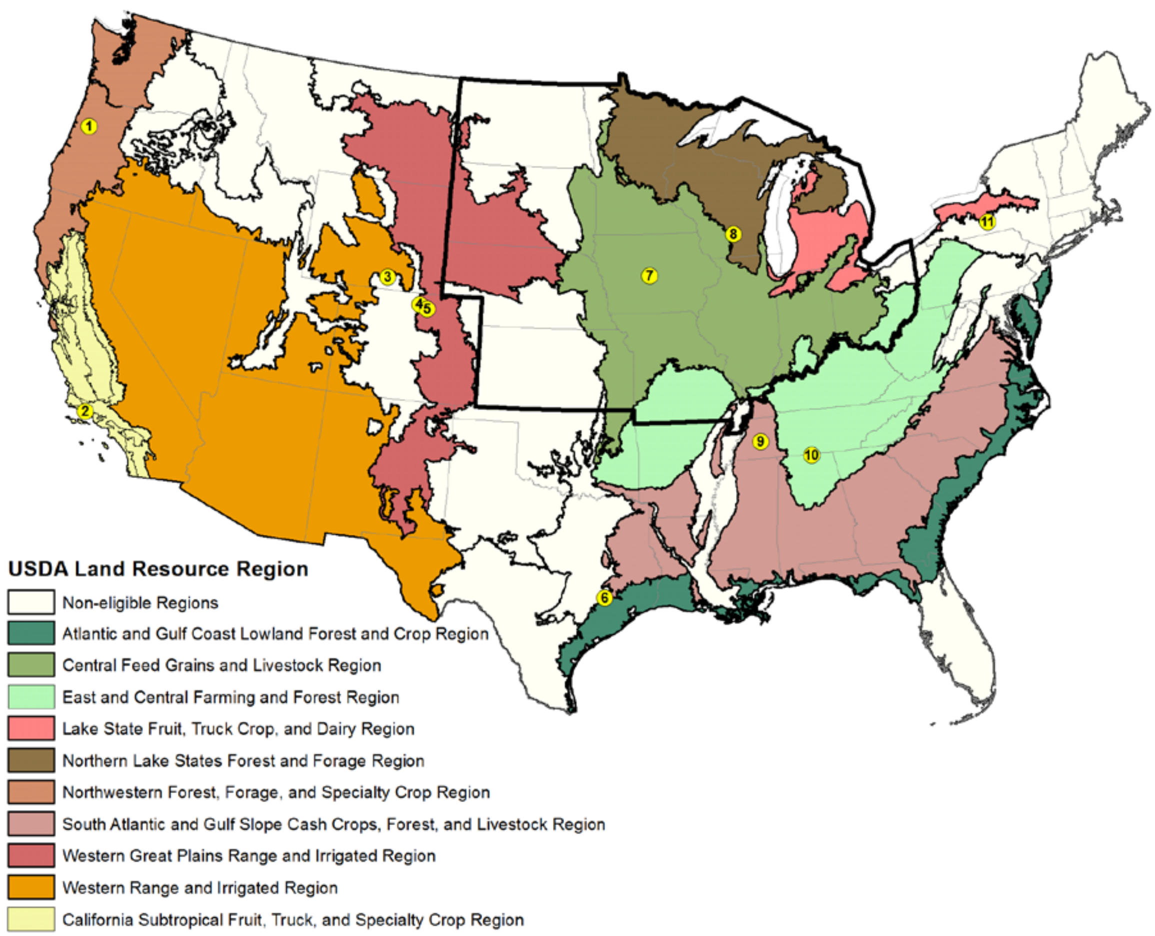

Figure H1. Eligible Land Resource Regions (LRRs) in the US (USDA-NRCS, 2006). The bold black line represents the boundary of the North Central Region (NCR; Section 1.2). The yellow circles show representative sites in eligible LRRs for which field studies have shown that the Tier 1 emission factor (1.0% [0.01]; IPCC 2006) is conservative for calculating direct N_2O emissions from agricultural crops.

Twenty three studies at 11 sites represented by yellow circles on the map (Figure H1; Table H1) were identified through analysis of a global dataset of N_2O emissions from agricultural fields (Stehfest and Bouwman, 2006). The full data set can be obtained from http://www.mnp.nl/en/publications/2006. In 20 studies (9 of 11 sites) there was a zero-N control plot. For 3 studies (2 sites) for which there was not a zero-N control but for which there were at least 2 N-rates tested, the slope of the relationship between N rate and N_2O emissions was > 0.01. For studies that were shorter than 365 days (the average length was 151 days) fluxes were extrapolated to an annual estimate based on the average daily flux for the period measured. There is no subdivision by crop because crop type matters little when defining a minimum 1% emission factor (Table H2).

Table H1. Field studies at the representative sites shown in Figure H1.

Site No(s).	Land Resource Region	References
1	Northwestern Forest, Forage, and Specialty Crop Region	Horwath et al. (1998)
2	California Subtropical Fruit, Truck, and Specialty Crop Region	Ryden et al (1979), Ryden and Lund (1980)
3	Western Range and Irrigated Region	Delgado et al. (1996)
4, 5	Western Great Plains Range and Irrigated Region	Bronson and Mosier (1993), Bronson et al. (1992), Mosier et al. (1981; 1982; 1986), Delgado and Mosier 1996, Parton et al. (1988).
6	Atlantic and Gulf Coast Lowland Forest and Crop Region	Hutchinson and Brams (1992)
7	Central Feed Grains and Livestock Region	Bremner et al. (1981a;b), Breitenbeck et al. 1980, Breitenbeck and Bremner (1986a;b).
8	Northern Lake States Forest and Forage Region	Goodroad and Keeney (1984)
9	South Atlantic and Gulf Slope Cash Crops, Forest and Livestock Region	Thornton et al. (1996), Thornton and Valente (1996).
10	East and Central Farming and Forest Region	Thornton et al. (1998)
11	Lake State Fruit, Truck Crop, and Dairy Region	Duxbury and McConnaughey (1986)

Table H2. Emission factors for different crop types in studies compiled by Stehfest and Bouwmann (2006).

Crop type	EF mean	SD	n
Cereal (small grains)	0.01	0.01	149
Vegetables	0.02	0.03	40
Brassicas	0.01	0.01	38
Legumes	0.02	0.03	9
Corn	0.01	0.02	85
Grass	0.02	0.03	237
Fruit	0.01		1
Fallow	0.01	0.01	85

B
TIMELINE FOR ACR APPROVAL OF THE MSU-EPRI METHODOLOGY

Table B-1. Detailed timeline for Approval of the MSU-EPRI Methodology at the ACR

Event	Date (Month/Day/Year)
Methodology (v1.0) submitted	03/10/11
ACR internal methodology screening	03/10–16/11
Methodology (v1.1) submitted	05/16/11
Public comment period	05/23–06/17/11
Public comment report received	06/20/11
Public comment responses submitted	08/17/11
Methodology (v1.2) submitted	08/23/11
Peer review 1 initiated	08/30/11
Peer review report 1 received	10/26/11
Peer review response 1 submitted	12/06/11
Methodology (v1.3) submitted	12/06/11
Peer review 1 report 2 received	01/12/12
Peer review 1 responses 2 submitted	02/10/12
Peer reviewers approve methodology[1]	02/27/12
Methodology revisions (consultations between MSU, ACR, and peer reviewers)[2]	02/27-07/06/12
Methodology (v1.4) submitted	05/01/12
Peer review 2 report 1 received	05/08/12
Peer review 2 response 1 submitted	05/17/12
Methodology (v1.5) submitted	05/17/12
ACR / peer reviewer notes received	06/02/12
Methodology (v1.7) submitted[3]	06/27/12
Internal revisions of Methodology conducted	06/27-07/05/12
Methodology (v1.8) submitted	07/06/12
ACR approves methodology	07/06/12
ACR formally announce approval (press release)	07/18/12
ACR, MSU, and EPRI host methodology webinar	11/15/12

[1]Typically ACR quickly approves methodologies following peer reviewers approval; however, see Chapter 4 (ACR process).
[2]Consultations took the form of email communications, conference calls and direct meetings.
[3]Methodology (v1.6) was created as an internal MSU document and not submitted to ACR.

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RESPONSES TO PUBLIC COMMENTS DURING THE VCS DOUBLE APPROVAL PROCESS

During the public comment period the VCS received comments from the National Wildlife Federation (NWF), Terra Global Capital (TGC), and The Fertilizer Institute (TFI).[38]

The MSU-EPRI team submitted responses to these public comments to the first validator (ESI) on December 27, 2010. These comments, presented below, are not otherwise publicly available.

MSU – EPRI Response to Public Comments

1. National Wildlife Federation (NWF) Comments

We appreciate the comments and concerns voiced by the National Wildlife Federation.

General Comment

From our reading of the comments posted by the NWF, we understand that their primary concern relates to the exclusion from the protocol of management factors other than N rate (i.e., N fertilizer type, N fertilizer timing, N fertilizer placement, and tillage practice) that can potentially affect N_2O emissions. The inclusion or disaggregation, of these factors is proposed as being better able to fully account for variation in emissions, and lead to more accurate estimates of N_2O emissions.

Response

Emissions of N_2O from agricultural land are spatially and temporally heterogeneous. We are aware that a host of management and environmental factors can affect emissions of N_2O. We are also aware that evidence to support variation in agricultural N_2O emissions brought about by variation in each of these factors exists in the peer-reviewed literature, as evidenced by specific examples of studies, reviews, and meta-analyses cited by the NWF. Evidence that confounds or contradicts the assertions made in these publications can also be found in the peer-reviewed literature. Notwithstanding the fact that few if any of these practices are sufficiently consistent in their N_2O response to merit consideration for a general N_2O credit protocol, none are directly applicable to our methodology.

For example, there is no special consideration for tillage in our protocol. While there are many studies in the literature documenting how tillage practices affect N_2O emissions, there is no clear evidence that a particular practice affects fluxes in a consistent and quantifiable manner.

To date the vast majority of evidence supports nitrogen input (annual N rate) as the most robust and reliable default proxy for calculating N_2O emissions. It is consistent and straightforward to

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[38] These public comments can be found at: http://v-c-s.org/methodologies/quantifying-n2o-emissions-reductions-us-agricultural-crops-through-n-fertilizer-rate-0

quantify as a metric for determining N_2O emissions. Its use is substantiated by the IPCC (IPCC 2007), which uses annual N input as the default factor for calculating annual N_2O emissions from managed land in national greenhouse gas inventories. In our protocol, we have taken a conservative approach that is consistent with the IPCC default (Tier 1) approach. We have additionally proposed a Tier 2 approach in geographic areas where we are confident of its applicability. The Tier 2 approach was derived from empirical field emissions measurements taken on commercial farms (Hoben et al. 2010).

Variation in emissions observed in the Hoben et al. (2010) study does indeed indicate that factors other than N application rate have an effect on N_2O emissions. However, we are unaware of any evidence that our proposed methodology will produce biased estimates of N_2O emissions because of factors left out of the estimation calculations.

With regard to the 'exclusion' of other N management practices (i.e., N fertilizer type, timing, and placement), our protocol specifically requires the adoption (or continuance), during the project crediting period on the project site, of "Best Management Practices" (BMPs) for the management of N fertilizer. This stipulation inherently includes mandatory adherence to the aforementioned practices for the crop(s) and site specific environmental conditions under consideration within the project boundary. Therefore, a project developer may under certain circumstances need to alter one or more of the four N management criteria to qualify for project acceptance. However, in accordance with conservative principles demanded by carbon standard organizations like the VCSA, only the reduction in N rate below the baseline N rate estimate is proposed to be rewarded with carbon equivalent offset credits.

For example, fall applied N fertilizer typically is assumed to result in higher emissions of N_2O when compared to spring applied N fertilizer (although there is a dearth of peer reviewed literature from studies in the US investigating this assertion). Our approach in the protocol is to treat this potential conservatively, i.e. effectively ignore the additional savings that might accrue from reducing fall fertilizer vs. spring fertilizer, and instead treat both similarly. This is conservative because our empirical work and consequent equations are based on spring fertilizer application; such that if anything our method will underestimate the additional savings that would presumably occur were fertilizer instead applied in the fall.

Specific comments

1. NWF: "A recent meta-analysis of 35 studies found that nitrification inhibitors reduced nitrous oxide emissions by an average of 38%. Polymer coated fertilizers (controlled release fertilizers) reduced nitrous oxide emissions by an average of 58%."

Response: We thank the NWF for directing us to this recent publication (Akiyama et al. 2010) on enhanced efficiency fertilizers (EEFs). We were aware of the majority of the studies that constituted this analysis and also further recent studies on inhibitors, and polymer coated urea products in, for example, Halvorson et al. 2010.

From Akiyama et al. (2010):

"*It should be noted that the number of datasets for Nis [nitrification inhibitors] was limited, except studies of the effect of DCD on N_2O emissions. Therefore, more field studies are needed to evaluate the effectiveness of each NI;*"….. "*However, the effect of PCFs [polymer coated* *fertilizers] on N_2O mitigation showed contrasting results among land uses and soil types. PCFs were very effective on imperfectly drained Gleysol grassland, but they were not effective for well-drained Andosol upland fields.*"

Previous and ongoing work on evaluating long-term effects of EEFs could offer exciting opportunities for reducing agricultural N_2O emissions and other N pollutants. However, we believe at this time predictions of their quantitative efficacy across a wide range of environmental conditions for reducing N_2O emissions and generating agricultural offset credits are premature.

NWF and other interested parties are certainly welcome to develop and submit proposed new AFOLU offset methodologies that could be used to provide offset credit for activities that are designed to reduce N_2O emissions through utilization of EEFs. The MSU-EPRI protocol does not in any way preclude use of EEFs by project proponents or the development of additional protocols designed to credit alternative methods of reducing N_2O and generating offset credits. In fact, were EEFs (or other technology, such as site-specific fertilizer application) used to reduce N fertilizer use from baseline levels, that reduction is creditable under the MSU-EPRI protocol.

2. NWF: "Projects seeking to use these range of technologies (enhanced efficiency fertilizers) will be unfairly excluded."

Response: As noted, our protocol does not exclude the use or deployment of enhanced efficiency fertilizers - their use is allowed in projects, as with all other N sources outlined in the protocol. Any N_2O reduction will be credited if their use leads to a reduction in the total N rate applied during the credited project period, when compared to the baseline (pre-project) period. However, the use of EEFs during a project period compared to, for example, the use of a traditional readily soluble N fertilizer during the pre-project period, with both being applied at the same rate, is not sufficient by itself to qualify for N_2O reduction credits under the MSU-EPRI protocol.

3. NWF: "There are clear and obvious chemical differences between manure, compost and sewage sludge". "Compost and manure are both amendments with a diverse, complex mix of nutrients including nitrogen, carbon and micronutrients."

Response: This is true, but carbon and nutrient inputs other than nitrogen are not considered in this protocol. All eligible N inputs on a mass basis are considered equal irrespective of their source - N from an organic source is treated identically to N from a synthetic fertilizer. Of course specific organic amendments may confer additional co-benefits to the soil, crop or environment as a whole, following their addition, but this has no bearing on the method of calculation of baseline and project N_2O emissions used in this protocol.

4. NWF: "Sewage sludge often includes toxic heavy metals and various biologically active wastes such as hormones or medicines."

Response: As stated in Annex D, project developers must conduct a complete evaluation of federal, state and local regulations applicable to fertilizer (and other N containing organic amendments) use in the selected project location as part of the additionality assessment. This includes regulations relating to the application of toxic heavy metals or other possible harmful constituents in organic amendments, that if applied to cropland exceed (any) legal thresholds.

In response to questions raised by Environmental Strategies Incorporated (ESI), as part of the VCS program's First Validation of the EPRI-MSU protocol, we have revised the protocol to incorporate the following statement:

"To the best of our knowledge, implementation of project activities associated with this protocol, with or without being registered as an AFOLU project, shall not lead to violation of any applicable law even if the law is not enforced."

5. NWF: "The proposed exclusion of fertilizer N from crop residues and cover crops fails to include a significant source of nitrous oxide affected by the project and within the project boundaries."

Response: Nitrogen from crop residues and cover crops will not be excluded from the protocol. Our protocol requirement is in effect 'rotation agnostic'. The protocol stipulates a requirement for records stretching back at least five years (i.e., a monoculture of corn) or more (e.g., six years for three rotations of corn-soybean, or two rotations of corn-soybean-winter wheat). During this pre-project period the producer will have taken account of any 'N credits' provided by leguminous crops or cover crops in the rotation, and reduced his N application to, for example corn, accordingly. In using the yield goal approach for determining N fertilizer rate recommendations, factors for legume N credits will have been included, and management records during the baseline period will reflect this. The records detailing N rate in effect 'integrate' any N credit from leguminous and / or cover crops within the baseline N rate estimation for the farmer, from which subsequent project N rates must be reduced. The N credit is therefore included. Also, any N from crops grown outside the project site, but applied to the crop at the project site will be included in the protocol as an external source of N and calculated along with other synthetic and organic N applications.

6. NWF: "The protocol proposes one leaching factor "$Frac_{LEACH-(H)}$" for all fertilizers, dependent solely on precipitation and evapotranspiration. This ignores what can be significant losses of nitrogen to ecosystems, depending on fertilizer types."

Response: The factors used for leaching and run-off (0.3 and zero) are identical to the default (Tier 1) values recommended by the 2007 IPCC Guidelines for National Greenhouse Gas Inventories, and therefore consistent with the approach of our protocol. We acknowledge that future research may provide an effective refinement of this approach.

2. Terra Global Capital (TGC) Comments

We appreciate the in-depth comments posted by TGC.

General Comment

From our understanding of the comments submitted, we have divided our response into two sections below: 1) Confidence intervals for N_2O emissions and conservative approach for reduction estimations; and 2) Omitted factors (e.g., texture, drainage class, pH) and representative conditions for extrapolation to NCR.

1) First, we want to provide an important clarification regarding the graphics displayed in our protocol and the associated appendices. Figure G4 in the protocol was redrawn from an earlier Figure 6a in Hoben et al. (2010; http://onlinelibrary.wiley.com/doi/10.1111/j.1365-

2486.2010.02349.x/abstract and attached. Figure G4 shows the model curve for the average daily flux, with 95% confidence intervals. Figure 6a shows the model curve for the average daily flux, with 95% confidence intervals, and also the observed “raw averages” for each N rate.

As pointed out by TGC, there is variation in N_2O emissions at each of the investigated N rates. Greater variation and therefore increasing confidence intervals (decreased confidence) around the model curve occur at increasing N rates (Figure 6a). This variation is to be expected and is a result of the inherent heterogeneity of N_2O emissions, both temporally and spatially, as discussed throughout the literature. It is also common for environmental properties everywhere for variance to increase with the mean.

Notwithstanding, our approach for calculating N_2O emissions and emissions factors is conservative and unbiased:

a) The best-fit exponential model response curve (observed flux, equation G3), from which the emissions factor relationship (equation G5) is derived calculates lower values for N_2O fluxes, as compared to the “raw average” N_2O fluxes at each N rate (diamonds in Figure 6a). For example the raw average flux from all site years for the highest N rate investigated (225 kg N ha^{-1} yr^{-1}) is ~ 26 g N_2O-N ha^{-1} day^{-1}, whereas the actual model data used to help determine the emissions factor (EF_{BDM2} and EF_{PDM2} in the protocol) is ~ 18 N_2O-N ha^{-1} day^{-1}, a “reduction” of ~ 30%. The higher the N rate, the larger this reduction in N_2O emissions calculated using the model when compared to the raw field data. This systematic “underestimation” in using the model data constitutes a conservative approach.

b) The calculation for estimating annual N_2O emissions at each N rate from which the emission factor (EF_D) is calculated is conservative for the following reasons:

i) The calculation uses the lowest daily N_2O flux measured over all sites and years from the relevant period, as the daily flux from which the cumulative emissions for early spring (March-April) and late fall (October – November) are calculated. The use of this lowest flux to calculate cumulative emissions during these periods very likely underestimates the actual emissions over these times; and,
The calculation also assumes that there are no (zero) fluxes of N_2O from frozen soils, and during soil freeze–thaw cycles during the winter period (December – February). Again, this assumption almost certainly underestimates the actual fluxes that will have occurred during this time, and constitutes a very conservative approach. Please see page 11 of Hoben et al. (2010) for further discussion.

We believe that our conservative underestimation of daily and annual N_2O fluxes, and by extension the emission factors used in our protocol is cautious and justified with regard to the requirements of new methodologies in the AFOLU sector that are under intense scrutiny. We also view this approach as a fully compensatory emissions reduction mechanism for the increasing variability of N_2O emissions at higher N rates and the decreasing confidence in N_2O emissions at these rates.

Furthermore, at the highest investigated N rate (225 kg N ha^{-1} yr^{-1}) the lowest and highest N_2O emissions represented by the 95% confidence interval, are ~6 and ~30 g N_2O-N ha^{-1} day^{-1}, respectively, i.e., a five-fold variation. This variation is relatively low, when for example compared to the upper and lower N_2O emissions (~1.8 and ~18 g N_2O-N ha^{-1} day^{-1}, respectively

– a 10-fold variation) calculated from the same N rate using the uncertainty range for the IPCC default emission factor of 0.3 – 3.0 %.

TGC suggests that our protocol should adhere to the draft VCS guidance documents' specific criteria for acceptable confidence interval values. As far as we are aware, the VCS 2011 draft guidance documentation currently posted on the VCS website (http://www.v-c-s.org/vcs2011.html) was not in effect at the time of our protocol submission, and currently remains in draft form pending future implementation by the VCS sometime next year. While we appreciate the need for VCS to continue to refine and clarify VCS protocol standards and requirements for projects in the AFOLU arena, the proposed criteria associated with confidence levels contained in these documents are draft criteria that have not yet been adopted formally by the VCS. Since the criteria were not in place at the time we submitted our protocol we did not address them explicitly.

2) Emissions of N_2O from agricultural land are inherently spatially and temporally heterogeneous, and we are aware that a host of management, soil, and environmental factors can affect emissions of N_2O. Evidence for and against the relative merits of soil properties such as texture, drainage class and pH and their effect on N_2O emissions can be cited from the peer-reviewed literature.

Our protocol is consistent with IPCC Tier 1 and Tier 2 methods, and is based upon empirical data derived from representative commercial farm land experiencing a wide range of environmental conditions throughout the growing season. It is not an attempt to fully quantify all (or even a large number) of the factors that can contribute to altering N_2O emissions, or an effort to impose a complex biogeochemical model on project developers that has not been fully tested on appropriate systems. There is no evidence to show that the introduction of a larger number of parameters will improve the accuracy of estimates of N_2O emissions from these systems. Our approach is conservative in that the overall relationship determined between N rate and N_2O emissions (Hoben et al. 2010) is an "integrator" of the variability of soil and environmental conditions encountered at the study sites. Moreover, we would not expect parameters such as soil texture, drainage class and pH in the project period to differ from those during the baseline period as a result of the reduction of N fertilizer rate.

The soil properties and environmental conditions at each of the study sites are shown in Table 1 and the supporting information of Hoben et al. (2010). The sites detailed in this study were specifically chosen to ensure a wide range of soil type, texture, and grain yield that is comparable to that found across the NCR. The sites used in the development of the nonlinear N_2O flux model for Michigan are broadly representative of crop rotations and conditions throughout the Midwest; during years with normal precipitation, crop yields at these sites are typical of the region as a whole (Smith et al. 2007). The N rates employed in Hoben et al. (2010) also are within the range commonly required for optimum corn grain production and recommended for the US Midwest (Sawyer et al., 2006; Vitosh et al., 1995). For these reasons, we consider our empirical results from Michigan to be representative of the NCR, as did reviewers of Millar et al. (2010), and Hoben et al. (2010).

External, third-party review of similar N_2O studies suggest that at recommended fertilizer application rates, there is no evidence to show that soil and climate variations of typical crop fields across the NCR results in greater variation of N_2O emission rates than weather variations and the site specifics of, for example, fertilizer N type or timing. Furthermore, there is no evidence that the soil and climate variations across the NCR region are different from the study sites in any way that is likely to lead to the methodology's resulting in biased estimates of N_2O emissions or emissions reductions. We are not aware of any evidence that the proposed methodology will produce biased estimates of N_2O emissions because of any factors not included in the N_2O emissions estimation calculations included in the protocol.

3. The Fertilizer Institute (TFI) Comments

We thank the TFI for posting their concerns.

For clarity our responses chronologically follow (exclusive of TFI pre-amble) the section titles as posted by the TFI:

1) Development process; 2) Conformance to ISO 14064-2; 3) Completeness of posted methodology scope; 4) Implementation of Method I — Tier I Approach; 5) Derivation and implementation of Method 2 — Tier II Approach; 6) Justification for equations to determine if leaching and runoff occur; and 7) Guidance for implementation of methodology.

1) Development process

We agree with TFI that "*publication of components of the protocol does not constitute the use of a consensus-based, structured, and transparent process of development.*" and that *"publication of the N_2O method used does not necessarily mean that the method represents a consensus of scientific opinion."*

Our protocol was developed to be in conformance with the VCSA's requirements for the development of a new AFOLU offset methodology. Please also refer to our comments under response 2 below.

We do not make the explicit claims described above in the protocol or in our publications. While we believe publication of peer-reviewed research in the scientific literature is preferable as a component of the validation of a particular approach, we understand that it is independent of the protocol validation process. The integrity of our protocol does not rest solely on the fact that research related to the protocol has undergone peer-review.

Under the aegis of the VCS, there is no requirement to develop a protocol using extensive stakeholder engagement to arrive at a 'scientific and political consensus.' The merits of this approach for achieving 'validity' or 'equity' for a protocol that aims to reduce agricultural greenhouse gas emissions can be debated in any case.

Irrespective of this, we certainly appreciate the value of involving expertise from multiple disciplines in developing our methodology. As such, during the development process, we have collaborated and continue to work with various and numerous researchers and stakeholder groups, including social scientists, economists, aggregators, and producers.

Please also note that alongside our protocol we will be submitting associated project documents that will bring practical implementation of our protocol to farmer fields in the Midwest. Our submitted protocol therefore does not represent an *ad hoc* attempt to promote our methodology via the carbon market, but is rather a component of ongoing research that aims to mitigate reactive nitrogen in the environment, while fairly rewarding good land stewardship that contributes to this goal.

TFI further note, that "…*the protocol for comment differs substantively from the published version (Millar et al. 2010…), but no description is given of the process of decision-making which led to these changes.*

As noted above, while Millar et al. (2010) validates our approach, it is not sufficiently detailed or specific to constitute a protocol. The submitted protocol is a stand-alone document that must be evaluated on its own merits, underwritten by studies such as Millar et al. (2010) and others, but ultimately different in ways that put the approach into practical terms.

Notwithstanding, it may be worth noting that the fundamental accounting methodology in both the published manuscript (Millar et al. 2010) and the submitted protocol is entirely consistent – in both cases N fertilizer rate is used as a proxy for N_2O emissions during the baseline and project periods, with the same formulas used to generate credits, and in both cases there is a requirement that Best Management Practices for N management be adhered to prior to project acceptance.

2) Conformance to ISO 14064-2

Our understanding, recently verified with VCS and consultants, is that the VCS program, standards, and methodology validation process (including public consultation, as participated in by TFI), are all consistent with applicable ISO standards. Since our protocol is being developed in a manner consistent with the VCS program and offset methodology development standards, it is in fact compliant with all relevant ISO 14064-2 standards.

3) Completeness of posted methodology scope

Aside from the issue relating to ISO 14064-2 conformance addressed in response 2), the TFI statement that "*quantification and monitoring of the nitrogen derived from crop residue*.." are excluded is false, and rests on a misunderstanding of the methodology from which the baseline and project emissions are calculated. Subsequent TFI comments and justification for inclusion of crop residues as a nitrogen input are thereby moot.

Our protocol is in effect 'rotation agnostic.' It stipulates a requirement for baseline estimation of N_2O emissions, for management records stretching back at least five years for monocultures or six years for 2- or 3-crop rotations (e.g. three rotations of corn-soybean or two rotations of corn-soybean-winter wheat). During this pre-project period the producer will have taken account of any N credits provided by crop residues (i.e., from leguminous and non-leguminous crops, including cover crops) in the rotation, and reduced his N application to the fertilized crop accordingly. In using the yield goal approach for determining N fertilizer rate recommendations, factors for crop residue N credits will have been included, and management records during the baseline period will reflect this. These records detailing N rate in effect integrate any N credit from leguminous and / or cover crops within the baseline N rate estimation for the farmer, from which subsequent project N rates must be reduced. The N credit from crop residues is therefore included.

Please also note that any N from crops grown outside the project site, but that are applied to the crop at the project site (e.g. as compost) will be included in the protocol as an external source of N and calculated along with other synthetic and organic N applications.

4) Implementation of Method I — Tier I Approach

TFI states that:

Tier 1 approach is designed for use in developing nations, or in regions where no better data is available;

It seems inappropriate that a Tier 1 approach would be considered a science-based approach for a sophisticated region within a developed country;

The protocol is designed for use in a region with more data than most developed nations. USA National Inventory Report method is Tier 3;

The developers propose the Tier 1 and derived "Tier 2" approach is more transparent than a Tier 3 approach.

Response

We are unaware of a requirement that protocols developed for projects use the same accounting methods used for their country's greenhouse gas inventory. There are good scientific reasons for the absence of such a requirement – first among them a scaling issue, second among them a field-scale validation issue. Notwithstanding, in fact the US uses a combination of Tier 1 and 3 approaches (US EPA 2010, Annex 3.11, A-224 – A 242), and most of the other Annex 1 countries (56%) use a Tier 1 approach with the remainder using either Tier 2 (26%) or not reporting N_2O emissions from agricultural soils (18%; Lokupitiya and Paustian 2006). All of these approaches are science-based.

5) Derivation and implementation of Method 2 — Tier II Approach

If we understand their comments correctly, TFI are unfavorably comparing our approach, in developing an N_2O emission factor from empirical field work in Michigan, to the development of a country-specific (Canada) methodology to calculate the inventory of N_2O emissions from all agricultural soils, as detailed in Rochette et al. (2008).

We believe comparison (negative or positive) between our derivation of a regionally appropriate fertilizer induced emission factor for the USA and methods used to calculate the country-wide inventory of N_2O emissions from agricultural soils in Canada may be useful from a research and discussion perspective but has little bearing on the process of protocol validation for the NCR. Our protocol does not preclude the adoption and use of a TFI-preferred protocol in Canada or elsewhere, and we welcome any verifiable approach that reduces N_2O emissions. Moreover, as we note in response to earlier comments, our protocol allows for credits generated by N-fertilizer reductions using the Canadian 4R framework or any other methods for doing so.

More specifically, TFI comments express concerns with:

a) the nonlinear relationship between N rate and N_2O emissions;

b) the exclusion of modifying factors for N_2O emission e.g., climate and soil texture; and

c) the geographical scope of our work and its extrapolation to the North Central Region.

a) Nonlinear N_2O response. The publication by Hoben et al. (2010) includes a detailed statistical analysis of the data collected from our field sites, showing the derivation of the best-fit nonlinear N_2O response function to increasing N fertilizer rate. Nonlinearity is not common in the literature because there have been few studies of N_2O-response against more than two fertilizer rates at individual research sites. Meta-analyses, such as those used to determine fertilizer induced emissions factors in Canadian regions, by their very nature confound numerous factors along with N rate in their goal to generate a simple relationship with N_2O emissions. A number of more recent site studies have reported nonlinear response curves and these include a number of row-crop sites in Canada (e.g., Grant et al. 2006; Zebarth et al. 2008; Ma et al. 2009).

The reality that a nonlinear relationship between N rate and N_2O emissions can in effect ‘generate’ more carbon offsets when N rates are reduced, when compared to a linear relationship using the same N rate reduction, is not a serendipitous artifact of our methodology, but rather is predicted by biogeochemical theory. The greater incentive that this scenario affords, with respect to potential financial remuneration for a producer, is a major driver of our desire to implement the protocol.

b) Exclusion of modifying factors. Emissions of N_2O from agricultural land are inherently spatially and temporally heterogeneous, and we are aware that a host of management, soil, and environmental factors can affect emissions. In line with the stringent requirements of carbon standards, our approach is conservative: we can view the overall relationship determined between N rate and N_2O emissions (Hoben et al. 2010) as an “integrator” of the variability of soil and environmental conditions encountered at the study sites. There is also no evidence to show that the introduction of a larger number of ‘modifying parameters’ will improve the accuracy of estimates of N_2O emissions from cropping systems. Moreover, we would not expect parameters such as soil texture and topography in the project period to differ from those during the baseline period as a result of the reduction of N fertilizer rate.

Finally, we are not aware of any evidence that the proposed methodology will produce biased estimates of N_2O emissions because of any factors not included in the N_2O emissions estimation calculations included in the protocol.

c) Geographical scope. Our protocol is consistent with IPCC Tier 1 and Tier 2 methods, and is based upon empirical data derived from representative commercial farmland experiencing a wide range of environmental conditions throughout the growing season.

The soil properties and environmental conditions at each of the study sites are shown in Hoben et al. (2010; Table 1 and the supporting information). The sites detailed in this study were specifically chosen to ensure a wide range of soil type, texture, and grain yield that is comparable to that found across the NCR. The sites used in the development of the nonlinear N_2O flux model for Michigan are broadly representative of crop rotations and conditions throughout the North Central Region; during years with normal precipitation, crop yields at these sites are typical of the region as a whole (Smith et al. 2007). The N rates employed in Hoben et al. (2010) are also within the range commonly required for optimum corn grain production and recommended for the US Midwest (Sawyer et al., 2006; Vitosh et al., 1995). For these reasons, we consider our empirical results from Michigan (in particular the N_2O response curves) to be representative of the North Central Region. This view was supported by reviewers of Millar et al. (2010) and Hoben et al. (2010).

6) Justification for equations to determine if leaching and runoff occur

TFI state that:

"It is not clear how the $Frac_{LEACH}$ derivation is consistent with IPCC (2006) and Rochette et al. (2008)."

"As the methods used in the references provided do not align exactly with the EPRI method, it would be helpful for the developers to describe fully the derivation of their approach to calculation of $Frac_{LEACH}$."

We agree that the text is unsuitable when referring to equations A1 and A2 in Annex A, and their relationship with equations used in IPCC 2006 and Rochette et al. (2008). We propose to alter the text to read:

"The approach presented here uses default (Tier 1) values for leaching and run-off from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and the ratio of growing season values of precipitation to potential evapotranspiration."

Potential evapotranspiration is a measure of the climatic demand for water from a saturated soil volume. Available energy (often expressed in terms of potential evaporation) and precipitation, largely determine evapotranspiration and runoff rates at a site.

We also propose to alter the term '$Frac_{LEACH-(H)}$' as used in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, to '$Frac_{LEACH}$'. This reflects the fact that the term as now used is consistent with the 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 3, Chapter 4) and that it does not only apply to regions where soil water-holding capacity is exceeded, as a result of rainfall and / or irrigation.

For sites where the ratio of growing season values of precipitation to potential evapotranspiration is greater than or equal to 1.0, the maximum $Frac_{LEACH}$ value recommended by the IPCC (2006) of 0.30 was assigned. For other regions, the default $Frac_{LEACH}$ value is set to zero, as recommended by IPCC (2006). The use of IPCC default (Tier 1) factors is consistent with the approach of the protocol.

7) Guidance for implementation of methodology

From our understanding of the comments posted, we assume that TFI have interpreted that in order for projects that use the protocol to be accepted, project proponents need only reduce the project N rate when compared to the baseline N rate, and need not adhere to other N best management practices. As noted on page 3 of the protocol, project proponents are required to follow Best Management Practices" (BMPs) for the management of N fertilizer. This stipulation inherently includes mandatory adherence to these practices for the crop(s) and site-specific environmental conditions under consideration within the project boundary. Therefore, a project developer, under certain circumstances may need to alter all four of the N management criteria to qualify for project acceptance.

The TFI's list of 4R endorsements has no direct bearing on the validity of our approach, and whether our protocol '*needs to more closely conform to 4R*'. Growers are free to more finely tune any part of the 4R equation (source, rate, time, place) to achieve better nitrogen use efficiency and provide creditable fertilizer savings.

However, unlike the 4R approach, in accordance with conservative principles demanded by carbon standard organizations like the VCSA, only the verifiable reduction in N rate below the baseline N rate estimate is proposed to be rewarded with carbon equivalent offset credits in our approach.

For example, fall applied N fertilizer typically is assumed to result in higher emissions of N_2O when compared to spring applied N fertilizer (although there is a dearth of peer reviewed literature from studies in the USA documenting this assertion). Our approach in the protocol is to treat this potential conservatively, i.e. effectively ignore the additional savings that might accrue from reducing fall fertilizer vs. spring fertilizer, and instead treat both similarly. This is conservative because our empirical work and consequent equations are based on spring fertilizer application; such that if anything our method will underestimate the additional savings that would presumably occur were fertilizer instead applied in the fall.

As well as being a VCSA requirement, the major reason for this 'conservative' approach, is the lack of consistent, non-confounded, and reliable evidence, across a wide range of environmental conditions in the USA, that alteration of any of the N management practices discussed above, other than N rate, will have a predictable directional bias on N_2O emissions. Moreover, quantification of the effect of these N management practices on N_2O emissions, based upon literature, peer-reviewed or otherwise, is we believe premature.

To date the vast majority of evidence supports nitrogen input (annual N rate) as the most robust and reliable default proxy for calculating N_2O emissions. It is consistent and straightforward to quantify as a metric for determining N_2O emissions. Its use is substantiated by the IPCC (IPCC 2007), which uses annual N input as the default factor for calculating annual N_2O emissions from managed land.

The claim by TFI that "*the protocol does not provide detailed guidance*" in regard to conformance with 4R principles is correct, insofar as the protocol documentation does not provide an exhaustive, and prohibitively extensive, list of publications and documentation from each state and / or region in the USA. We believe that this is unnecessary, and credit the project developers with the ability to retrieve this readily available documentation (from the NRCS, Farm Service Agency, and state departments of agriculture) to ascertain which BMPs are in place for their project site. From the protocol (slightly amended at the suggestion of the validators: "Details of fertilizer BMPs are readily available for each US state via State Departments of Agriculture and from federal agencies such as the Natural Resources Conservation Service. More generally these BMPs are described in the Global 4R Nutrient (Fertilizer) Stewardship Framework (Right Source–Rate–Time–Place), published by the International Plant Nutrition Institute (IPNI)."

We are uncertain why TFI think that, "*Without this detailed guidance, it is expected it will be difficult to ensure projects are implemented to simultaneously minimize* N_2O *emissions while maintaining crop yield, soil quality, and environmental integrity.*"

As mentioned above this guidance is readily available, and indirectly referenced in the protocol.

TFI: "*there is essentially no guidance given concerning the documentation needed to provide verifiable evidence that projects have been implemented according to the posted Methodology.*"

By design our protocol does not mandate a specific list of documents required to determine the baseline. Rather the protocol language is in accordance with VCS guidelines as detailed in their Tool for AFOLU Methodological Issues, i.e., "the baseline fertilizer N rate is determined from the project proponents' management records for at least the previous five years…."

In Annex C we provide a description of the types of management records that are deemed suitable: "Examples of these include synthetic fertilizer purchase and application rate records, as well as manure application rate and manure N content history." We also specify that "management records from which baseline fertilizer N rate can be directly determined are required." The protocol thus provides guidance that we believe sufficient about information with which a project developer can determine a baseline N rate. The protocol also describes a 'contingency' if site-specific records are considered insufficient or inappropriate, in the form of our Approach 2. A detailed worked example of this approach is available (Annex C) that provides guidance on the mechanism and documentation required to determine baseline N rate. Also, again, as mentioned above, the expectation is that expert project validators will be in place to determine whether a project conforms to the protocol or not.

We are very aware of the concept of 'gaming' and understand some project developers may attempt to 'unfairly' optimize their financial and business opportunities. With this in mind, one of the major aims of the language included in the protocol is to minimize the potential for gaming. We believe the protocol as written accomplishes this important goal. However, we also believe that neither this nor any other offsets protocol can be written in such a way as to predict each, and every possible scenario that may result from the protocol entering the public domain.

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D

TIMELINE FOR VCS APPROVAL OF THE MSU-EPRI METHODOLOGY

Table D-1. Detailed Timeline of the approval of the MSU-EPRI Methodology at the VCS.

Event	Date (Month/Day/Year)
Request for Quote (RFQ) sent to potential validators	05/07/10
Received RFQ (ESI)	06/07/10
Received RFQ (DNV)	06/27/10
Validator bids reviewed (ESI chosen as 1st validator)	06/27/10-07/01/10
Received VCS submission form signed by MSU	08/04/10
Signed COI document sent to ESI	08/17/10
Methodology (v1) submitted to VCS[1]	08/17/10
VCS internal methodology screening	08/17/10-09/08/10
ESI completes COI process (no issues)	08/27/10
Methodology submitted to VCS[2]	09/03/10
VCS public comment period	09/08/10-10/08/10
ESI internal project initiation meeting	09/13/10
ESI validation plan (v1) submitted to MSU	09/14/10
MSU-ESI Conference call (Meeting 1)	09/15/10
ESI validation plan (v2) submitted to MSU	09/16/10
ESI contract PO number sent by MSU	09/16/10
ESI validation plan (v2) returned signed by MSU	09/20/10
MSU submits reference materials to ESI	09/26/10
ESI validation (1st round) comments sent to MSU	10/04/10
Validation (1st round) responses sent to ESI	11/03/10
MSU/ESI Conference call (Meeting 2)	11/15/10
ESI validation (2nd round) comments sent to MSU	11/18/10
Methodology (v2) submitted to ESI	12/02/10
MSU public comment responses sent to ESI	12/27/10
Methodology (v2.1) submitted to ESI	01/10/11
Methodology (v3) submitted to ESI	01/14/11
MSU submits validation RFQ to DNV	01/16/11
ESI validation report (v1) sent to MSU	01/19/11
ESI revised validation report (v1) sent to MSU	01/19/11
MSU/ESI Conference call (Meeting 3)	01/21/11

Event	Date (Month/Day/Year)
DNV submits validation proposal to MSU	01/28/11
Methodology (v1.3) submitted to ESI[3]	01/29/11
ESI submits validation report to VCS/MSU	02/02/11
MSU submits DNV work proposal to VCS	02/05/11
VCS requests more detail on DNV work proposal	02/08/11
VCS and DNV communications on proposal/SOW	02/01-22/11
Methodology (v1.3) submitted to VCS by MSU	02/15/11
VCS provides email comments on methodology (v1.3)	02/17/11
VCS requests conference call for methodology discussion	02/17/11
Conference call (MSU/VCS) to discuss methodology	02/22/11
DNV submits revised SOW to VCS and MSU	02/22/11
Methodology (v1.4) submitted to VCS by MSU	02/23/11
VCS submits VCS-DNV contract to DNV and MSU	02/23/11
DNV submits signed contract to VCS	02/23/11
MSU confirms VCS-DNV contract	02/24/11
VCS requests conference call for methodology discussion	03/02/11
Conference call (MSU/VCS) to discuss methodology	03/07/11
VCS provides email comments on methodology (v1.4)	03/08/11
VCS converts from version 2007.1 to version 3	03/08/11
MSU submits methodology (v1.4 rev.) to VCS	03/09/11
VCS sends methodology and ESI val. report to DNV	03/10/11
DNV voice concerns regarding timeline / validation team	03/23/11
DNV confirms validation team and submit timeline	04/10/11
MSU/DNV Conference call (Meeting 1)	05/19/11
MSU submits reference materials to DNV	05/19/11
DNV notifies MSU of delay on validation report	06/06/11
DNV validation (1st round) comments	06/10/11
VCS email regarding VCS 2007.1 validation timeline	06/15/11
DNV clarifies validation was relative to VCS 2007.1	06/21/11
MSU submits responses (1st round) to DNV	06/22/11
Methodology (v1.4.1) submitted to DNV	06/23/11
DNV validation (2nd round) comments	06/28/11
DNV and VCS conference call (performance standards)	06/30/11
DNV confirms VCS validator “mix-up” (v2007.1 vs. v3.0)	06/30/11
DNV confirms “new” validation relative to VCS v3.0	07/05/11
DNV validation comments (VCS v3.0) sent to MSU	07/07/11
MSU/VCS conference call	07/26/11

Event	Date (Month/Day/Year)
MSU submits responses (2nd round) to DNV	08/24/11
Methodology (v1.4.2 [3.0]) submitted to DNV	08/30/11
DNV validation (3rd round) comments	09/06/11
DNV validation (3rd round revised) comments	09/11/11
MSU/DNV Conference call	09/16/11
Methodology (v1.4.3 [3.0]) submitted to DNV	09/20/11
MSU submits responses (3rd round) to DNV	09/20/11
DNV confirms (email) all CARs/CLs are closed	09/30/11
DNV notifies MSU of Technical Review (TR) delay	10/04/11
Methodology (v1.4.3 [3.0]) submitted to VCS	10/07/11
Methodology (v1.4.3A [3.0]) submitted to DNV	10/09/11
DNV submit methodology for TR (internal auditor)	10/09/11
DNV send informal TR report to MSU	10/13/11
DNV send TR report (v1) to MSU	10/19/11
MSU/DNV Conference call	10/25/11
DNV send TR (v2) to MSU	10/31/11
MSU/DNV Conference call	10/31/11
MSU/DNV Conference call	11/14/11
MSU submits methodology (v1.4.4 DRAFT 3) to DNV	12/13/11
MSU submits TR responses to DNV	12/13/11
DNV (TR reviewer) confirm all comments are closed	01/05/12
MSU submits methodology (v1.4.6) to DNV	01/09/12
MSU submits methodology (v1.4.6) to ESI	01/09/12
DNV submits validation report to MSU	01/19/12
DNV/ESI official reconciliation phase	01/20-30/12
MSU submits DNV validation report to ESI	01/23/12
ESI confirms no further technical issues with methodology	01/24/12
MSU submits methodology (v1.4.6A) to ESI[4]	01/25/12
ESI/DNV revises validation reports (VCS v3.0 template)	01/26-30/12
ESI submits reconciliation report (draft) to MSU	01/30/12
DNV submits final validation report to MSU	02/03/12
ESI submits final validation report to MSU	02/03/12
MSU submits DNV/ESI validation reports to VCS[5]	02/08/12
Methodology assigned MSU ‘Invention Disclosure’ ref	03/12/12
MSU forwards methodology (1.4.6B) to CAR[6]	05/30/12
MSU/EPRI/VCS legal discussions	March 2012 – February 2013
VCS requests conference call to review methodology	01/08/13

Event	Date (Month/Day/Year)
MSU/VCS Conference call	01/15/13
MSU receives VCS request for methodology revisions	01/17/13
MSU submits methodology (v1.4.7) to VCS	02/19/13
MSU/VCS Conference call	02/21/13
MSU submits methodology (v1.4.8) to VCS	02/27/13
VCS approves methodology	03/05/13
VCS Program announcement confirming approval	03/06/13
VCS, MSU, EPRI, and ESI host methodology webinar	03/21/13

[1] Separate methodology and annexes documents were submitted along with a double approval submission form and covering letter (document titles: VCS N_2O Reduction Methodology v2, VCS N2O Reduction Methodology Annexes v2, VCS Submission Form Signed, and VCS Covering letter signed).
[2] A combined methodology and annexes document was submitted following advice from VCS (VCS N_2O Reduction Methodology and Annexes v1).
[3] Methodology v1.3 is Methodology v3, renamed in response to concern about potential confusion in ESI validation report.
[4] Methodology v1.4.6A (25 January, 2012) modified from v1.4.6 (9 January, 2012) by correction of typos.
[5] Submission did not include signed VCS "element approval form" necessary to officially start final VCS internal validation
[6] Document submitted to Climate Action Registry (CAR) following request from Duke University via CAR and confirmation from VCS. Methodology v1.4.6B (25 January, 2012) identical to v1.4.6A apart from minor revision to Tier 2 emission factor equations.

Meeting times and Validation milestones during the first validation process (ESI) also can be found in the ESI First Assessment Report (pgs. 8-9).[39]

[39] http://www.v-c-s.org/sites/v-c-s.org/files/Draft%20First%20Assessment%20Report%20ESI_0.pdf.

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