PROMOTING INCREASED NUTRIENT USE EFFICIENCY THROUGH CARBON MARKETS

Report submitted on behalf of The Climate Trust in cooperation with The Fertilizer Institute

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THE CLIMATE TRUST

About The Climate Trust

For 18 years, The Trust has played an integral role in climate finance. Under the mandate of the Oregon Carbon Dioxide Standard, The Trust has been responsible for acquiring carbon offsets, and selecting and managing pollution reduction projects on behalf of regulated utilities. Since its inception, The Trust has invested more than $5.8 million in upfront payments and retired 2.3 million tons of carbon dioxide with sectoral expertise in agriculture, biogas and forestry. We currently manage $11.6 million that will be committed to additional greenhouse gas-reducing projects. With our years of experience investing in projects, The Trust is well positioned as an investor and carbon manager. Our success is based on our technical proficiency with offset protocols and emerging carbon market policies, as well as our track record commercializing carbon credits in both the voluntary and compliance markets.

CARBONCREDIT SOLUTIONS INC

About Carbon Credit Solutions Inc.

Carbon Credit Solutions is a Canadian company that provides commendable aggregation services in the Canadian carbon offset market and internationally. We act as an agent for our customers by gathering information, preparing the required documentation and engaging with appropriate governments on their behalf. We monitor and manage each carbon credit transaction from beginning to end with minimal effort required from our clients. We use proprietary OAS software to collect, track and manage the data required to aggregate, quantify and verify emission offsets generated by companies and individuals. We work with agriculture, hog ranchers, cattle ranching, energy generation and alternate fuels.

About Jarecki Enviro Consulting

Dr. Marek Jarecki is an independent research scientist working in the field of GHG emissions from agricultural land including CO_2 and N_2O, carbon sequestration, and reduction in N_2O emissions by changing crop management practices. Dr. Jarecki has worked as a postdoctoral soil scientist in Carbon Management and Sequestration Center at the Ohio State University in Columbus and as a research scientist for the National Laboratory for Agriculture and Environment in Ames Iowa. Since 2011 he has been involved in this project, working on quantification of the GHG emissions from agricultural land in dependence on soil and crop management, using the biogeochemical DNDC computer model.

About The Fertilizer Institute (TFI)

TFI is the leading voice in the fertilizer industry, representing the public policy, communication and statistical needs of over 200 producer, manufacturer, retailer and transporter members in the fertilizer sector. TFI has been at the forefront of improving environmental performance in agriculture through improved nitrogen management. It is a leading advocate of the 4Rs (i.e. the right source, at the right rate, at the right time and in the right place). TFI works closely with producers, agronomic service providers, the fertilizer industry, and federal, state and local authorities to promote improved agricultural land stewardship.

Acknowledgements:

The commercialization portion of our report is informed by extensive primary research with carbon market actors, agricultural experts, sustainability professionals, academics, and many others. The Project Team wishes to thank those who have been gracious enough to share their knowledge, experience and ideas with us over the course of this project.

We also wish to thank the following individuals, who have worked extensively on efforts to develop carbon crediting programs in agriculture and other sectors and provided invaluable feedback as reviewers of this report:

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Executive summary

The world's population is growing, necessitating a robust and sustainable agricultural system. At the same time, a changing climate threatens agricultural production in the form of increased drought, flooding and other impacts. This report examines one way in which agriculture itself may become a change agent capable of reducing global greenhouse gas emissions: the production of offset credits from changes in nitrogen fertilizer practices on cropland. This report has two components: Part 1, the Protocol Road Test Report, and Part 2, the Credit Generation and Commercialization Report.

The Protocol Road Test presents results of credit calculations performed using both biogeochemical modeling and simplified rate-based methodologies on real-world data, and compares them to the project team's earlier effort, referred to here as Nitrace. While the project team intended to capture data from multiple practice changes for this new effort, the only data volunteered for the project was from a farm implementing a change in nitrogen application rate. The results from this road test are shared in an academic manner to add to the existing body of knowledge. Key learnings from the Project Team's protocol road test are:

- Enrollment efforts would be helped by partnerships with agrologists who can help implement practice changes allowing farmers to capture the value offered by carbon crediting.
- Average credits per acre from fields tested varied between .11 and .16. These values are lower than those resulting from the Nitrace field test, as that test captured data from multiple practice changes.
- All four methodologies tested resulted in similar credits per acre and total credit potential estimates; this is due to the fact that fields tested had implemented nitrogen rate reductions.
- Biogeochemical modeling results in the highest estimates of credit potential across all practices, but simpler methodologies may lead to cost savings within the offset credit process during data collection and verification.

Drawing upon the experiences of this project team, others within the carbon markets, and other agricultural stakeholders such as data service providers, academics and sustainability professionals, the Credit Generation and Commercialization report is an analysis of known barriers to the successful and scalable carbon crediting of nutrient management practices. According to our analysis the key barriers to successful crediting are:

- Confusion about division of labor among carbon market stakeholders;
- A fragmented information management landscape which complicates easy access to information relevant for carbon credit calculations;
- Lack of real-world experience with credit generation under the existing calculation protocols leading to uncertainty about potential credits per acre; and
- Uncertainty about who will purchase the resulting credits.

In addition to identification of barriers, the Credit Generation and Commercialization report proposes possible solutions- some straightforward and others inventive- to address the barriers discussed.

Introduction

The Project

In 2011, a coalition of partners including Camco Clean Energy, The International Plant Nutrition Institute, Climate Check and The Climate Trust and led by The Fertilizer Institute (TFI) undertook work on a Conservation Innovation Grant provided by USDA's Natural Resource Conservation Service (NRCS). The goal of this project was to incentivize corn and soy growers in the Midwest to adopt Best Management Practices (BMPs) for the application of nitrogen fertilizers. An approach to account for account for all fertilizer application practices, 4R Stewardship—right fertilizer source, right rate, right time, right place—was tested next to an alternate, rate-only-based methodology developed by Michigan State University and the Electric Power Research Institute to determine how the methodologies compared in terms of credit generation potential and ease of use.

The lessons learned by this work were the subject of a report submitted to NRCS in early 2015 entitled, *The Nitrace Demonstration Program: A 4R Framework for Delivering Nitrogen Management Credits*, hereafter referred to simply as Nitrace. During this same time, a no-cost extension was granted for the continuing pursuit of research which could ultimately lead to the creation of a scalable nutrient management program. The Climate Trust (The Trust), one of the original project partners, was subcontracted by TFI to do additional road-testing of the protocols and develop expertise and tools to aid the commercialization of the resulting credits; this report is the result of that extension.

This report is broken into two major components. Part 1 is the Protocol Road Test Report, which will add to what is known about the existing protocols by running additional tests with a new set of data from corn fields in the Midwest. Part 2 is the Credit Generation and Commercialization Report, which will offer a broad, contextualized discussion of currently known barriers to the successful implementation of a nationwide nutrient management offset market by drawing on the experience of the Nitrace project and other actors in the agricultural market and recommend targeted solutions to some of these barriers in the interest of market advancement.

Context

The United Nations has named 2015 the International Year of Soils, with good reason. Producing enough food to feed a worldwide population over seven billion strong requires massive resources for agriculture—a system which is estimated to contribute roughly 14% of GHG emissions worldwide[1], recently surpassed deforestation as the world's largest land-based source of climate pollutants[2], and from which emissions are still increasing[3]. Furthermore, international climate negotiations are

[1] EPA's Global Emissions by source, accessible online at: http://www.epa.gov/climatechange/ghgemissions/global.html#two

[2] Upton, John. "Farming now worse for climate than deforestation", Climate Central Online 2/3/15. Accessible online at: http://www.climatecentral.org/news/farming-now-worse-for-climate-than-deforestation-18629

[3] Food and Agriculture Organization of the United States, "Agriculture's greenhouse gas emissions on the rise", 4/11/14. Accessible online at:

approaching at the end of 2015 and countries are submitting emission reduction plans called Intended Nationally Determined Contributions (INDCs). The INDC for the US does not propose specific actions to be taken toward emission reductions from land uses such as agriculture and forestry[4]; however the federal government has in recent years been increasing its efforts to support these types of reductions in order to lend credibility to US negotiators at the upcoming talks.

The vast majority of agriculture's emissions can be traced to two greenhouse gases with global warming potentials 56 and 280 times[5] that of carbon dioxide over a 20 year time horizon, respectively: methane (CH4), which is released by cows during their digestion process, and nitrous oxide (N20), which is created during the application of nitrogen fertilizers. This report focuses on the latter of the two, nitrous oxide, and the ways in which carbon markets may help to incentivize practice changes in the fertilization of crops that can optimize productivity while reducing nitrous oxide emissions.

Importance of 4R Nutrient Stewardship

Nitrogen fertilizers have led to an unprecedented increase in crop productivity, but have also been attributed to negative environmental outcomes. While nitrogen itself is not inherently harmful, bacterial processes within soil can convert it to other forms, which can have adverse environmental impacts if lost from soils.

Of chief concern for water quality is nitrate (NO_3^-) a naturally occurring anion salt which is soluble in water and can travel off-farm to surface and ground waters if the soil's water storage capacity is exceeded, as in heavy rainfalls; this process is known as leaching[6]. The Environmental Protection Agency has set a maximum contaminant level goal (MCLG) of 10 parts per million for nitrate; this is the recommended level at which the agency expects there are no likely negative health impacts[7]. This threshold has been exceeded in some areas of the country[8], leading multiple state and federal agencies to offer recommendations for the testing and treatment of water from private wells. In addition, twelve states within the Mississippi river basin have agreed to plan voluntary nutrient reduction strategies, primarily due to concerns that nitrate is contributing to hypoxia in the Gulf of Mexico[9].

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http://www.fao.org/news/story/en/item/216137/icode/
Food and Agriculture Organization of the United States Statistics Division, "Emissions-Agriculture". Accessible online at:
http://faostat3.fao.org/browse/G1/*/E

[4] United States Intended Nationally Determined Contribution, March 2015. Accessible online at http://www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf

[5] "Global Warming Potentials", United Nations Framework Convention on Climate Change website, accessible online at http://unfccc.int/ghg_data/items/3825.php

[6] "Soil Nitrate and Leaching", International Plant Nutrition Institute Stewardship Specifics series No. 17, available online at www.ipni.net/publication/stewardship.nsf/0/9B970014A1DE1EA685257BE500554B0E/$FILE/StewSpec-EN-17.pdf

[7] "Basic Information About Nitrate in Drinking Water", US Environmental Protection Agency, available online at http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm

[8] "A National Look at Nitrate Contamination of Ground Water", US Geological Survey, available online at http://water.usgs.gov/nawqa/nutrients/pubs/wcp_v39_no12/

[9] "State and Federal Nutrient Reduction Strategies", Mississippi River Gulf of Mexico Watershed Nutrient Task Force. http://water.epa.gov/type/watersheds/named/msbasin/nutrient_strategies.cfm

Nitrous oxide gas (N_2O) is of significant concern to those monitoring changes in atmospheric conditions, including climate change. N_2O can be formed under specific soil conditions by bacteria when nitrogen is applied to soils, and like nitrate, it is also capable of leaving the field- in this case into the atmosphere. In addition to being a known greenhouse gas, N_2O can also be harmful to the ozone layer, which- when damaged- allows more ultraviolet light to reach Earth's surface, leading to negative health consequences including an increased risk of skin cancer[10].

Fortunately, avoiding the loss of nitrogen as nitrate or as nitrous oxide has the same solution: matching the use of nutrients to the needs of crops- in other words, using science-based methodologies to plan applications for optimal nitrogen use efficiency and production. It is for this reason that The Fertilizer Institute advocates 4R stewardship. The four R's are:

- Right source: The type of fertilizer applied can impact the amount of nitrogen that leaves the field. For example, ammonium (NH_4^+) fertilizers are more stable than some other forms and can minimize leaching[11].
- Right rate: Using field measurements of nitrogen in soils and knowledge of the crop's needs, farmers can better estimate the amount of fertilizer to apply.
- Right time: Timing the application to coincide with when the crop needs the nutrient most can help reduce losses.
- Right place: Applying nutrients closer to where the crops will be able to make the best use of them can also help to reduce nutrient loss.

Project developers of nutrient management projects are awarded carbon credit on the basis of *avoided emissions*; that is, their project represents a shift in practices, and carbon credits come from proving that less nitrous oxide entered the atmosphere as a result of the change. Carbon markets have been attempting to encourage these practice changes through offset crediting, but to date, it has been difficult for the carbon markets to capture the full potential of 4R stewardship. As the ability to credit these changes depends upon being able to validly translate the complexity of soil dynamics into easy-to-use calculation methodologies that can help keep costs lower for project developers, only two credits have been successfully generated and retired under a methodology related to rate reduction.

Why carbon markets?

One tool in the toolkit for slowing or reversing the acceleration of climate change is to promote the development of projects which have a greenhouse gas benefit, and carbon markets exist to facilitate this development. A carbon market is, at its core, an economic mechanism which places a monetary value on the reduction of greenhouse gas emissions. Two basic types of carbon markets exist globally:

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[10] "Nitrous Oxide: Reducing Emissions from Fertilizer and Manure Nitrogen", International Plant Nutrition Institute Stewardship Specifics series No. 19, available online at www.ipni.net/publication/stewardship.nsf/0/B77659016F88E9A885257D1500656A87/$FILE/StewSpec-EN-19.pdf

[11] "Managing Nitrogen to Meet Crop Demands while Protecting Water", International Plant Nutrition Institute Stewardship Specifics series No. 9, available online at www.ipni.net/publication/stewardship.nsf/0/E856D0B18949B44D85257BE500552FCC/$FILE/StewSpec-EN-09.pdf

Compliance markets, which are created by regulation. The EU emissions trading system and California cap and trade system are two notable examples. A governing body will place a cap over some percentage of emissions sources, and carbon reduction projects from sectors not underneath the cap may sell carbon credits (offsets) into the system, as a low-cost way for capped sectors to meet a portion of their compliance obligation.

Voluntary markets, which are driven by self-imposed emissions targets set by organizations, companies and municipalities. As in compliance markets, projects with a carbon reduction benefit generate credit, but this credit is then sold and retired so that the voluntary buyer may claim to have offset a portion of its emissions.

Despite these names, nutrient management is likely to remain a discretionary action under either type of market for the near future. Agricultural nutrients are difficult to regulate, both from a political and practical standpoint, and in order to prove that a project is "additional" for the carbon market—that it marks a distinct deviation from business-as-usual—it must prove that it is NOT required by regulation; this is known as the "regulatory surplus" additionality test. By definition, offsets under a compliance market are not covered by the regulation's cap; they represent emission reductions which happen outside the cap. Therefore, even under a compliance market, the action of reducing emissions from agriculture is voluntary so long as agriculture is not a capped sector.

Farmers who wish to take advantage of financing to implement upgrades to their conservation practices may apply for funding under programs run by USDA's Natural Resource Conservation Service (NRCS), such as the Conservation Stewardship Program (CSP) or Environmental Quality Incentives Program (EQIP). These programs, having always made up a small portion of total potential conservation funding, have lost funding through revisions to the Farm Bill in recent years.

Carbon markets offer access to an alternative revenue stream from the sale of credits. At present, nutrient management activities occur only within the voluntary carbon market, and this presents both opportunity and challenges. Voluntary markets are often the testing ground for credit calculation methodologies which are later adopted by compliance mechanisms, so piloting projects in nascent voluntary sectors such as nutrient management can offer an important proof-of-concept for these methodologies. However, willing voluntary buyers of credits from nutrient management have been slow to emerge, leading to challenges in articulating the market's value proposition to farmers.

Potential credit supply from nutrient management

Credit calculation protocols, as currently written, are best suited to calculating credits from continuous corn or corn/soybean rotations in corn-heavy growing regions of the United States, in particular the Midwest and Great Plains states. According to USDA's National Agricultural Statistics Service (NASS) these states planted nearly 69 million acres of corn in 2014, over two thirds of total corn planted in the US that year. Narrowing this acreage down to only that which is accessible to the carbon market requires the consideration of a number of factors beyond the market's control; these factors are also some of the biggest barriers to project implementation from the developer's perspective:

- **Number of acres already employing optimized nutrient management.** Farms which have already changed practices to optimize the application of fertilizers are usually not eligible for credit, unless they made the shift recently and have kept their records of applications prior to the change.

- **Eligibility for participation under credit calculation protocols.** Histosols, for example, are typically omitted from the calculations which allow credit to be awarded, as these wetter soils are more difficult to cultivate than mineral soils and are natural carbon sinks.
- **Willingness of farmers to participate in crediting programs.** Farmers may reject the use of carbon revenue for multiple reasons: a belief that fertilizer conservation may negatively impact their yield, disbelief that the resulting revenue is enough to offset the cost or effort of implementation, unfamiliarity with carbon markets, or personal beliefs about climate change.
- **Accessibility of nutrient management data.** A farmer who is willing to make a practice change but does not keep records of or have access to relevant fertilizer data will still not be able to generate credit.

In addition to factors the carbon market cannot control, there are also factors within the market's control which can impact the addressable market for crediting services:

- **Outreach strategies that incent farmer participation.** This includes strong and consistent messaging from all actors in the carbon markets, focused on bringing value directly back to the farmer.
- **Level of incentive provided by carbon revenue.** An attractive and consistent incentive level is required, to allow farmers to include carbon revenue in their plans for the future.

It is likely that due to the mitigating factors listed here, the potential to generate carbon revenue from corn in the short term is much lower than the total acreage planted. As a conservative estimate, if 10-15% of planted acres were captured, this would still represent 7-10 million acres, a fairly ambitious target for a nascent offset sector.

Table 1 explores how many offsets 7-10 million acres could represent under various estimates of credits per acre, as well as how many credits are represented by the total corn acreage of the North Central region of the US. As a frame of reference for these estimates, note that the entire worldwide voluntary market transacted 87 million credits in 2014.[12]

Table 1: Potential nutrient credit supply from the North Central Region

Crediting rate	Description	Offsets from 7-10 million acres of corn	Offsets from 69 million acres of corn
.27	Average credits per acre derived from 28 test fields in Nitrace project (2014), including calculation outliers[13]	1,890,000-2,700,000	18,630,000

[12] Ecosystem Marketplace, "Ahead of the Curve: State of the Voluntary Carbon Markets 2015", June 2015.
[13] Actual credits per acre from the Nitrace fields varied between 0 (under the VCS-MSU-EPRI method for fields switching source and placement of fertilizer) to 1.97 (under the VCS-MSU-EPRI method for a field drastically reducing N rate).

.13	Average credits per acre derived from 12 test fields in Protocol Road Test report (averaged across all tests for all methodologies)	910,000-1,300,000	8,970,000
.11	Coefficient used by NRCS COMET-Planner to calculate emission reductions from changes in nutrient management	770,000-1,100,000	7,590,000

There is also potential for the nutrient management carbon market to begin to address additional acreage, by adapting to include additional crops and additional regions, which could increase the estimates listed here. Adaptation of protocols can be time-intensive, because the scientific rigor demanded by the carbon markets demands the creation of regional-specific factors for the calculation of emissions. That's not to say this should not be attempted; to the contrary, if other extremely ambitious goals can be paralleled by the carbon markets, this could lead to widespread adoption of carbon crediting from agriculture. For example, Field to Market, a membership-based web tool for increasing sustainability on farms, has set itself a new target of 50 million enrolled in its supply chain sustainability program, equivalent to 20% of the total commodity crop acreage planted in the US, by 2020.

Part 1: Protocol road test report

Project Summary

Nitrace was able to run basic field tests of two of the four major emissions reduction quantification methodologies. The project team generated an estimated credit calculation for all four using data collected and processed under a sub grant with Carbon Credit Solutions, an aggregator in Alberta, Canada. The four methodologies are listed below, along with acronyms we have created to simplify our report:

Table 2: Existing nutrient management crediting methodologies

Methodology Name	Standard	Acronym
VM0022: Quantifying N2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction	Verified Carbon Standard	VCS-MSU-EPRI
Methodology for Quantifying Nitrous Oxide (N2O) Emissions Reductions from Reduced Use of Nitrogen Fertilizer on Agricultural Crops	American Carbon Registry	ACR-MSU-EPRI
Nitrogen Management Project Protocol Version 1.1	Climate Action Reserve	CAR-MSU-EPRI
N2O Emission Reductions through Changes in Fertilizer Management	American Carbon Registry	ACR-DNDC

As the acronyms suggest, the first three methodologies listed here are variations on a calculation technique derived by a joint research project of Michigan State University and the Electric Power Research Institute, referred to as the MSU-EPRI methodology. While both VCS and ACR have adopted this calculation methodology with few modifications, the CAR Nitrogen Protocol uses the calculations from MSU-EPRI as one component in a calculation methodology that includes an expanded scope of emission reductions from farm equipment and leakage.

The fourth methodology, approved under ACR, is based on the DeNitrification DeComposition (DNDC) model. Unlike the MSU-EPRI model, which accounts for emission reductions only from changes in rate of application, the DNDC model is adjustable to account for differences in type, timing and placement of nitrogen fertilizers, offering a wider range of potential practice changes to farmers who wish to realize the emissions reduction potential of nitrogen fertilizers.

Though literature exists on all four methodologies and their potential for cost-effective emissions reductions, to date there has been no field test that compares the four simultaneously. We believe this can be helpful to the market at large, as it works to determine how methodologies can be scaled. First, we examine the findings of the project team's previous effort, the Nitrace field test.

Nitrace Project Quantitative Findings

Field Baselines

The 28 Nitrace fields tested were the result of a data collection effort among conservation-minded farmers represented by the Iowa Soybean Association. Seven farmers provided Nitrace with information about their current fertilizer practices as well as an expression of interest in understanding how specific 4R practice changes could impact their field emissions. The Nitrace team used this feedback to put together "marker scenarios": plausible scenarios for practice changes for each field which they could use to determine an estimate of available credits from each protocol tested. Tables 3 and 4 describe the baseline scenarios on each field, as well as the marker scenarios which were selected for testing on each field.

Table 3: Nitrace field baseline scenarios

Farm ID	Field ID	Field Size (acres)	Cropping System	N Baseline Fall	N Baseline Spring
1	1	38	Continuous Corn	Bedded Cattle Manure	Ammonia Phosphate (AP) sidedress AA
1	2	39	Continuous Corn	Liquid Swine Manure	Sidedress AA
1	3	37	Soy-Corn	Bedded Cattle Manure	Sidedress AA
2	4	95	Soy-Corn	AA	-
3	5	38	Soy-Corn	AP + AA	-
3	6	75	Soy-Corn	AP + AA	-
3	7	55	Soy-Corn	AP + AA	-
3	8	160	Soy-Corn	AP + UAN	-
4	9	39.6	Soy-Corn	AA	UAN, after harvest AP
4	10	63	Soy-Corn	AA	UAN, after harvest AP
4	11	79	Soy-Corn	Liquid Swine Manure	UAN
5	12	65	Soy-Corn	AA	-
5	13	76	Continuous Corn	AA	-
6	14	53.5	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	15	78	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	16	64.9	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	17	77.8	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	18	74.1	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	19	87	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	20	114.9	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	21	109	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	22	77	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	23	39.8	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	24	194.1	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
7	25	107.5	Soy-Corn	-	1/2 UAN in spring, 1/2UAN in sidedress
7	26	122	Soy-Corn	-	1/7 AP in spring, 6/7 UAN in preplant
7	27	76.3	Soy-Corn	-	1/7 AP in spring, 6/7 UAN in preplant
7	28	157	Soy-Corn	Liquid Swine Manure	preplant UAN
total acres:		2,293			

Notes: AP=ammonia phosphate, AA = anhydrous ammonia, UAN=urea ammonium nitrate

Table 4: Marker scenarios on Nitrace fields

Farm ID	Field ID	Marker Scenario	Practice Change Summary Based on 4Rs Changes to N Management Rate	Source	Time	Place	Total N Rate (organic + synthetic) Baseline (lbN/acre)	Scenario (lbN/acre)	Scenario Nitrogen Percent Reduction	Fertilizer Reduction (lbN/acre)
1	1	Switch to synthetic fertilizer (AP, AA) only	☑	☑			393	210	47%	183
1	2	AP in fall + BCM in spring + sidedress AA	☑	☑	☑	☑	384	373	3%	11
1	3	Switch to synthetic fertilizer (AA, AP) only	☑	☑		☑	352	183	48%	169
2	4	Switch to Urea in Spring , 15% N reduction	☑	☑	☑	☑	150	128	15%	22
3	5	AP in fall, UAN sidedress	☑	☑	☑	☑	158	153	3%	5
3	6	AP in fall, UAN sidedress	☑	☑	☑	☑	176	171	3%	5
3	7	AP in fall, UAN sidedress	☑	☑	☑	☑	158	153	3%	5
3	8	AP in fall, UAN sidedress + nitrification inhibitor		☑			163	153	6%	10
4	9	Switch to LSM in fall, reduce N input and UAN in spring (EQIP)	☑	☑	☑		215	200	7%	15
4	10	Switch to LSM in fall, reduce N input and UAN in spring (EQIP)	☑	☑	☑		215	200	7%	15
4	11	Reduced LSM in fall (EQIP contract)	☑	☑	☑		227	150	34%	77
5	12	Spring slow release urea		☑	☑	☑	150	150	0%	0
5	13	Switch to Urea, 30% reduction	☑	☑	☑	☑	200	140	30%	60
6	14	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	15	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	16	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	17	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	18	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	19	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	20	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	21	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	22	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	23	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	24	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
7	25	1/2 UAN in spring, 1/2 UAN in sidedress reduce N input by 15%	☑				155	132	15%	23
7	26	1/7 AP in spring, 6/7 urea in sidedress reduce N input by 15%	☑	☑	☑	☑	164	139	15%	25
7	27	1/7 AP in spring, 6/7 urea in sidedress reduce N input by 15%	☑	☑	☑	☑	164	139	15%	25
7	28	Switch to synthetic fertilizer: preplant AP, sidedress UAN	☑	☑	☑	☑	232	164	29%	68

Notes: BCM=bedded cattle manure, LSM=liquid swine manure, CL=chicken litter, AP=ammonia phosphate, AA = anhydrous ammonia

Calculation results

Nitrace revealed some key differences between ACR-DNDC and VCS-MSU-EPRI. Because the ACR-DNDC model is able to account for changes to not only rate but timing, source and placement, the credit generation potential from this methodology is generally higher than that of the VCS-EMU-EPRI method. This is due to several key differences in calculations.

First, the baseline direct emissions results from ACR-DNDC were, in aggregate, 55% higher than those of VCS-MSU-EPRI, and project direct emissions similarly 28% higher. Perhaps due to the increased accuracy of the model relative to VCS-MSU-EPRI and resultant higher direct emissions, emission reductions were also higher- about twice as high- as VCS-MSU-EPRI. This means that in some cases across the 28 fields studied, ACR-DNDC would have produced around 2.4 times as many credits as VCS-MSU-EPRI.

The following chart illustrates total emission reductions across the 28 fields tested, with each field assigned a “marker scenario” based on the Nitrace team’s best estimation of practice changes which would be chosen in reality:

Table 5: Emission reduction calculations for Nitrace fields under ACR-DNDC and VCS-MSU-EPRI

Farm #	Field #	Total N_2O (tCO_2e/field) Baseline Scenario Total Emissions ACR	Baseline Scenario Total Emissions VCS	Marker Scenario Total Emissions ACR	Marker Scenario Total Emissions VCS	Total Emission Reductions ACR	Total Emission Reductions VCS
1	1	92	96	52	21	**41**	**75**
1	2	82	92	61	84	**22**	**8**
1	3	75	68	32	16	**43**	**52**
2	4	49	29	27	23	**22**	**6**
3	5	42	13	15	12	**27**	**1**
3	6	94	30	51	29	**44**	**2**
3	7	57	18	42	17	**15**	**1**
3	8	98	57	91	57	**7**	**0**
4	9	65	23	37	21	**28**	**2**
4	10	88	36	46	34	**42**	**2**
4	11	120	54	89	27	**31**	**27**
5	12	54	20	20	20	**34**	**0**
5	13	149	38	81	21	**68**	**17**
6	14	15	15	8	15	**7**	**0**
6	15	23	22	12	22	**10**	**0**
6	16	19	18	10	18	**9**	**0**
6	17	22	22	12	22	**10**	**0**
6	18	22	21	12	21	**10**	**0**
6	19	26	24	14	24	**12**	**0**
6	20	35	32	19	32	**16**	**0**
6	21	33	31	18	31	**15**	**0**
6	22	22	22	12	22	**10**	**0**
6	23	11	11	6	11	**5**	**0**
6	24	57	55	31	55	**26**	**0**
7	25	70	35	57	27	**13**	**8**
7	26	71	44	44	33	**27**	**10**
7	27	55	27	39	21	**16**	**6**
7	28	130	112	66	56	**63**	**56**
	TOTALS	1676	1065	1004	793	672	272
	DIFFERENCE		**-611**		**-211**		**-399**

Though ACR-DNDC performed better in the Nitrace test with regard to credit generation, in reality no credits would have been produced by either methodology in this case, as each require at least 5 years of historical data to be collected before the baseline emissions can be calculated. The project collected one, in some cases two, years of historical data, voiding the eligibility of all fields to generate real credits from this project. Nitrace's challenge in data collection illuminates an important barrier to credit production: because many farmers are simply new to the methodologies and their inputs, they do not necessarily know to collect and store this information.

ACR-DNDC requires more effort in terms of the quantity and types of data needed, model runs required, and the fact that verification of the calculations requires verification of the correct calibration of the model using regionally-appropriate factors. The VCS-MSU-EPRI methodology, though less accurate, has fewer inputs and, with the exception of an option to use a regionally-derived emission factor in one method of credit calculation, does not need to be calibrated on a per-project basis. However, if farmers do not know to collect the required inputs, as with the ACR-DNDC model, the baseline condition cannot be established for this methodology.

It is important to note that for the fields tested by Nitrace, there were important differences in crediting rates between fields focusing primarily on reduction of N rates and those focusing on improving nitrogen management through the use of other practices. For example, switching fall N anhydrous ammonia (AA) application to side dress urea ammonium nitrate (UAN) application, as was the case for Field #5, leads to a greater emission reduction under the ACR-DNDC method than under VCS-MSU-EPRI, as the latter is not designed to handle this type of change.

Nitrace Project Qualitative Findings

Nitrace resulted in a number of lessons learned on the supply end of the nutrient management market, including barriers to enrollment and the potential for improvement of existing credit calculation methodologies. Nitrace encountered barriers at many stages in the process of trying to successfully launch a nutrient management crediting program.

Enrollment

The value proposition of nutrient management carbon credits remains largely hypothetical. To date, only 2 credits from a nitrogen application change have been successfully retired, as the result of a partnership between The Climate Trust and the Delta Institute. Further work is needed to establish the kind of proven market demand for credits that would convince growers of the benefit of enrollment.

In addition, with no market there is also no established market price. Interested growers, therefore, have no way to compare the financial incentive to the cost on a per acre basis, significantly reducing their likelihood of enrollment.

Finally, enrollment outreach under Nitrace and similar programs to date has been largely trial-and-error. Issues of audience type, messaging and communication channels are still being road-tested, with best practices for outreach still very much emergent. In general, there is a lack of understanding among growers about environmental credit markets; this leads to a significant upfront investment in terms of outreach, as the program manager will need to provide an introduction to these markets before a conversation can begin about the benefits of enrollment.

While many growers are open to learning about credits, the collapse of the Chicago Climate Exchange in 2010 has convinced some that these markets are not worth pursuing; this represents another challenge among a certain subset of potential enrollees.

Data

Nitrace encountered significant roadblocks with respect to the collection of grower data. The biggest hurdle in data collection stems from the sheer amount required to accurately calculate emission reductions under the current methodologies. Inputs are numerous, and historical records going back five to six years are required to establish a baseline for calculations. With such a daunting data requirement, growers naturally have questions about the confidentiality and security of their information, including concerns that it will be shared with government agencies as a precursor to regulation.

Protocols

As discussed earlier, the existing protocols for calculation of emission reductions from fertilizer management are so complex as to hinder the process of scalable credit generation. Nitrace performed an analysis of credit generation potential for 28 fields in Iowa using two of the most commonly cited protocol examples: ACR-DNDC and VCS-MSU-EPRI. Both protocols proved to be difficult to collect the appropriate amount of data for, and as a result of a lack of historical data provided by the project's 7 growers, Nitrace was only able to model a potential set of emission reductions rather than commercialize credits as was originally intended.

Policy

Currently, policy incentives regarding agricultural gases are limited, and the strong price signal needed to incentivize practice changes for farmers does not exist. California's Air Resources Board has been the first mover in this regard, with the adoption of a compliance offset protocol for rice projects under the state's cap and trade system in the summer of 2015.

It is fairly likely that ARB will, in the future, adopt an offset protocol for nutrient management and thereby provide nutrient management projects with a more certain buyer for their credits. However, it may only be after several years of testing under the rice protocol that aggregation might be allowed, and therefore costs to nutrient programs may prove prohibitive to enrollment for the foreseeable future.

Below is a summary table of barriers to the nutrient management market illuminated by Nitrace:

Table 6: Summary of market barriers encountered by Nitrace

Barriers:
Enrollment: • No established market for credits • No widely acknowledged market price • No standard enrollment strategies
Data collection: • Too many variables to collect data for • Need historical data for five years for baseline calculation • Privacy and confidentiality concerns
Protocols: • Cumbersome to use
Policy: • No compliance offset market for nutrient management • Aggregation not guaranteed

Continued needs

The Nitrace project proved to be extremely informative in terms of credit generation potential and user friendliness of two potential methodologies. With these results in mind, the project team's second protocol road test sought answers to the following questions:

1) Would a second field test produce similar results to the first?
2) How do the MSU-EPRI methodologies compare, not only to ACR-DNDC, but to each other?
3) Under what circumstances are certain protocols more advantageous than others for farmers and project developers?

The Protocols

To provide a holistic analysis of the performance of existing protocols, this project attempts to road test all four of the existing protocols side-by-side for credit generation potential and ease-of-use. To begin, we provide comparisons of some more general aspects of the protocols for ease-of-use context.

The ACR-DNDC model was originally proposed by Winrock International under a grant from the David and Lucille Packard Foundation, and was intended as a more accurate way to quantify emissions from cultivated lands than had at that point been achieved through application of the Tier 1 emissions factor from IPCC. In a separate effort, Michigan State University researchers paired with the Electric Power Research Institute (EPRI) to write a methodology based on best available research on the emissions associated with applying fertilizer to corn crops. EPRI then submitted this methodology for adoption by ACR, CAR and VCS and shared this experience in an issue paper[14] which details how each standard body built this methodology into a resulting protocol.

Each protocol's particular intent, development process, and adoption procedure under a standard have led to important distinctions, even among the MSU-EPRI methodologies which share a common credit calculation framework. The most important distinctions are outside of the credit calculations themselves and deal with project boundaries, eligibility, additionality assessments, record collection and storage requirements, and specifics around the monitoring and verification of projects.

Qualitative Methodology Comparisons

Eligibility and Applicability

Common to all methodologies is applicability to US croplands and primarily continuous corn or corn-soy rotations, as well as a requirement that project activities do not negatively impact crop yield. Histosols- organic soils with poor drainage which are natural carbon sinks- are excluded from eligibility in all cases.

VCS-MSU-EPRI and ACR-MSU-EPRI are nearly identical in terms of eligibility, with the exception being that ACR-MSU-EPRI can be used on cropland outside of the United States. ACR-DNDC projects must be

[14] Diamant, A. "Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N2O) Emissions in Agricultural Crop Production: Experience Validating a New GHG Offset Protocol", Electric Power Research Institute, May 2013.

comprised of multiple fields with similar soil and climatic conditions, and the model must be calibrated appropriately to the crop and specific location. CAR-MSU-EPRI projects are subject to a variety of stipulations regarding the crops and practices that are eligible for credit, project ownership, etc. This methodology also has an expanded scope compared to the other three, calculating not only direct and indirect emissions from soils but emissions from cultivation equipment as well.

Table 7: Protocol comparison- Eligibility and applicability

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• Corn-row systems including continuous corn and rotations that include a corn component. • Crops must have been cultivated on the project site for at least 10 years prior to implementation. • Fertilizers applied according to BMP • Project must demonstrate N application is sufficient to maintain yield. • Project must use BMPs as described by state agricultural agencies, federal agencies or the global 4R Framework during crediting period • The project must take place in the United States. • Histosols are excluded • Soil C losses < 5% change	• Corn-row systems including continuous corn and rotations that include a corn component. • Crops must have been cultivated on the project site for at least 5 years prior to implementation. • Fertilizers applied according to BMP • Projects outside of the United States are eligible • Project must demonstrate N application is sufficient to maintain yield. • Project must use BMPs as described by state agricultural agencies, federal agencies or the global 4R Framework during crediting period • Histosols are excluded • Both the baseline and project condition take place on the same parcel of land and use the same crops	• Corn-row systems including continuous corn and rotations that include a corn component; in rotations only the corn component is credited • Only applicable to nitrogen fertilizer rate reduction, and only in the Northcentral region of the US • Project may start no more than 6 months prior to submission • Project must demonstrate N application is sufficient to maintain yield • Clear ownership of resulting credits must be established • Additional requirements for highly erodible land • GHG assessment boundary includes emissions from equipment and shifted production (leakage) • Histosols are excluded • Project activities must take place on land with annual precipitation between 600 and 1200mm • Irrigation is not permitted • Tile drainage is permitted if present in the baseline condition • Organic and synthetic fertilizers may be	• Project activities must be in valid reference regions, or geographic areas in which broad climatic and soil conditions are relatively homogenous. • Projects that involve a change in fertilizer rate, type, placement, timing and use of fertilizers. • Project must incorporate a minimum of 5 fields and must not lead to a decrease in crop yield (>5%) • These changes must be implemented for one year or longer. • This methodology is only applicable to crops, management systems, and regions where the DNDC model has been sufficiently validated to statistically quantify model structural uncertainty. • Histosols are excluded

		applied but only reductions in synthetic fertilizer are eligible for credit	

Determining Additionality

Additionality is a term which refers to the project's ability to prove that the project activity goes above and beyond the business as usual (BAU) practices of the farm; in other words, that this activity is not something the farmer would have done in the absence of a carbon project. All methodologies are fairly similar with regard to additionality screening. The typical requirements that must be met to prove the project's additionality are:

- The project exceeds what is required by local, state or federal laws or regulations
- The project exceeds common practice for the region (common practice is defined as the practices being adhered to by the majority of growers in a common area)
- The project complies with all applicable laws and regulations
- The project faces some barrier to implementation (financial, technical or otherwise)

Table 8: Protocol comparison- Additionality screening

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• VCS uses the performance method to calculate additionality: ○ Projects must meet requirements on regulatory surplus (i.e. the project activity is above and beyond what regulations or laws require); and. ○ Projects exceed performance benchmarks (i.e. a measure of "common practice" • Regulatory surplus: ○ No law requiring N reductions below BAU. • Performance benchmark ○ Site-specific BAU (Approach 1). ○ Countywide BAU (Approach 2).	• To be additional projects must: • Exceed approved performance standard and pass test for regulatory surplus or, • Pass 3-pronged additionality test of ACR. This requires demonstration that the project exceeds: ○ current laws and regulations; ○ common practice in the agricultural sector; and, ○ Face either financial, technological, or institutional barriers to implementation.	• Projects must meet the following standards for additionality: • Performance standard- requires completing the nitrogen use efficiency calculation in the protocol. • Legal requirement standard, which attests that the project is not required by any regulation. • Regulatory compliance standard, which attests that the project will comply with all applicable laws	• Projects using approach 1 or 3 must test for additionality using ACR's three-pronged additional test. This requires demonstration that the project exceeds: ○ current laws and regulations; ○ common practice in the agricultural sector; and, ○ Face either financial, technological, or institutional barriers to implementation. If a project is excluded through a financial analysis or demonstration of a barrier, then it is considered non-additional and non-eligible for crediting under the ACR meth.

Project Boundaries and Crediting Periods

Every protocol defines a set of project boundaries, which define the physical, temporal, activity and emissions-related limitations under which a project operates.

Crediting Periods: A crediting period is a project's primary temporal boundary, and is defined as the length of time under which a project remains eligible to generate credit. Each methodology defines this length of time slightly differently; for some, the definition spans the project year, while for others it spans the length of time a farm may be enrolled in a project. Crediting periods are generally dependent on both the crop and the length of the crop cycle (one full rotation if crops are in rotation).

Physical boundaries: Each of the protocols allows the calculation of credits for US farms; most narrow this scope even further to include added calculation specificity for states in the North Central Region, including most Midwestern and Great Plains states. The other physical boundary typically defined by protocols is the field itself- a continuous area with relatively homogeneous characteristics and management practices.

Emissions boundary: All protocols also define the scope of emissions to which they can be applied. Every protocol is designed to specifically calculate N2O emissions and other greenhouse gases are typically excluded. Each protocol calculates both direct emissions from the application of fertilizers and indirect emissions from leaching, volatilization and runoff. In one case, the CAR-EMU-EPRI method, the scope is expanded beyond the dynamics of the farm's soils to include carbon emissions from cultivation equipment.

Table 9: Protocol comparison- Crediting period and project boundaries

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
Crediting Period			
One full crop cycle (post-harvest to harvest)	Seven years (programmatic); no limit on crediting period renewals	Five eligible crop years, which may occur over a period of ten calendar years; may be renewed once	• 5 Years (Programmatic) • 1 full crop cycle (or longer)
Project Activities/Boundary			
• Projects within the United States (Method 1) • Projects involving corn within North Central Region of the US, including Iowa & Illinois (Method 2) • Projects involving crops other than corn (including rotations with corn) in NCR (Method 1).	• Spatial boundary: Results of actions under project's control, including direct and indirect emissions • Temporal boundary: Projects may verify multiple project years at once; verification required every five years • Emissions boundary: Direct and indirect emissions of N2O from	• Projects can be either a single field or an aggregate of many fields • "Field" means: • Under control of a single entity • Continuous • Management practice is homogenous • Cultivation cycle is defined as 365 days • Eligible crop years do not need to be	• Projects within Iowa & Illinois • Projects that change fertilizer management by adjusting application rate and other practices. • Project activities must take place in valid reference regions or geographic areas in which broad climatic and soil conditions are

• The project activity is applying fertilizer at economically optimum N rates that do not harm productivity and requires the use of verifiable BMPs for N.	both the baseline and project conditions No change to soil carbon stocks	continuous but records must be kept for ineligible crop years between eligible years to maintain credit eligibility	relatively homogenous.

Establishment of the Baseline Condition

The baseline establishment process forms the "control" condition against which the project condition is measured. In the case of row crops, this requires several years of historical information to calculate. For each of the MSU-EPRI methodologies, establishing a baseline requires at least 5 to 6 years of historical data, depending on the nature of the crop rotation. CAR-MSU-EPRI requires field-specific records, while the other two MSU-EPRI methodologies allow for a baseline to be established using county-specific data if field-specific data is unavailable.

ACR-DNDC has three baseline calculation methods which correspond to the practice type(s) being included in the project's emissions: rate reduction, other practices, and some combination of rate reduction and other practices.

Table 10: Protocol comparison- Establishment of the baseline condition

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• The baseline condition allows for 2 approaches: ○ #1 (site specific) must be used if site-specific data are available ○ #2 (county scale data) may be used in cases of limited data availability and relies on USDA county-level data ○ The baseline scenario requires 5 years monoculture or 6 years for a two-crop rotation	• The baseline condition allows for 2 approaches: ○ #1 (site specific) must be used if site-specific data are available ○ #2 (county scale data) may be used in cases of limited data availability and relies on USDA county-level data ○ Only approach 1 may be used outside the US	• Baseline is defined as five years prior to project implementation • If fewer than three eligible crop years occur in the five year period, this period will be extended until 3 eligible crop years are included • Baseline is calculated using equations in the protocol for all baseline years • Baseline years are averaged together to form a basis of comparison to the project condition	• There are 3 approaches for determining the baseline scenario: ○ #1: Projects that reduce application rate, without changing any other aspect of fertilizer management, must use a field historic baseline ○ #2: Projects that change fertilizer management by adjusting more than application rate, and for which the current adoption rate for the Project Activity is ≥5% within the reference region must a Common Practice Baseline.

			○ #3: Projects that change fertilizer management by adjusting more than application rate, and for which the current adoption rate of the Project Activity is <5% must use a Field Specific Historical Baseline.

Baseline Record Requirements

In addition to the methods used to calculate the baseline condition, each protocol also has a list of required data inputs in order to make this calculation; these data requirements mark the biggest distinctions between the four protocols and greatly impact their ease of use, because fewer data inputs are typically much easier for project developers to collect and simplify the calculation process.

Both the VCS-MSU-EPRI and ACR-MSU-EPRI methods rely heavily on default values and publicly available weather information, and requires limited inputs to be gathered by the farmer: mass and nitrogen content of both synthetic and organic fertilizers. CAR-MSU-EPRI, due to the expansion of its scope to include cultivation equipment emissions, also gathers data on the specific machinery being used, and adds a nuance to the collection of fertilizer data by requiring that this be reported not only along the parameters of synthetic/organic but also of liquid/solid.

ACR-DNDC, as a complex biogeochemical model, requires more inputs to be gathered from both the farmer and publicly available databases, including much more information about the soil and any practices being used by the farmer aside from simple rate reduction, such as reduced tillage, use of controlled-release fertilizers, use of nitrification inhibitors, and more.

Table 11: Protocol comparison- Baseline records required

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• Baseline establishment requires management records of fertilizer application rates by crop going back: ○ 5 yrs. for a monoculture; or ○ 6 yrs. for rotating crops • The management records must include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or	• Baseline establishment requires management records of fertilizer application rates by crop going back: ○ 5 yrs. for a monoculture; or ○ 6 yrs. for rotating crops • The management records must include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or	• Baseline establishment requires management records of fertilizer application rates by crop going back: ○ 5 yrs.; or ○ More than 5 years if fewer than 3 eligible crop years are included • The management records must include: ○ Mass and N content of fertilizer, by fertilizer type	• Management records must include the following data in order to quantify baseline conditions: ○ Location of each field; ○ Daily meteorology; ○ Soil characteristics, including clay content, bulk density, soil pH, soil organic carbon, soil texture, slope, depth of water

organic) in lbs. N acre^{-1} yr^{-1}; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur ○ Planting and harvest dates	organic) in lbs. N acre^{-1} yr^{-1}; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur ○ Planting and harvest dates	(synthetic or organic) in kg N/ha for solid and liquid fertilizers and gallons/acre for liquid fertilizers only ○ Application rate data ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur. ○ Width of area covered by application equipment ○ Equipment speed and horsepower ○ Planting and harvest dates	retention layer, high groundwater table; ○ Crop type; ○ Planting date; ○ Harvest date; ○ Fraction of leaves and stem left in field after harvest; ○ Yield; ○ Season, depth and Type of tillage; ○ Source, rate time and placement of Fertilizer; ○ Source, rate time and placement of inorganic fertilizer and C:N ○ Number, type and amount of irrigation events per season.

Project Record Requirements

Because the calculation of emission reductions relies on the ability to subtract project emissions from baseline emissions, the inputs collected during the baseline years, listed above, are also collected during the project years to form a rigorous basis for comparison. All of this information is then kept by the farmer for a particular length of time listed in the protocol, to be sure that records are available to refer to should questions arise after credits have been issued.

In addition to these recordkeeping requirements, the CAR-MSU-EPRI protocol also requires laboratory testing of corn stalks to be able to verify reported reductions in nitrogen application for each project year, the records of which must also be kept.

Table 12: Protocol comparison- Project recordkeeping requirements

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• Annual management records are required of the following: ○ Mass and N content of fertilizer by fertilizer type	• Annual management records are required of the following: ○ Mass and N content of fertilizer by fertilizer type	• Recordkeeping requirements include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or	• Project management records must include the following data: ○ Location of each field; ○ Daily meteorology;

(synthetic or organic) in lbs. N $acre^{-1} yr^{-1}$; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield; and, ○ Yes/no response on whether leaching and runoff occur	(synthetic or organic) in lbs. N $acre^{-1} yr^{-1}$; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur	organic) in kg N/ha for solid and liquid fertilizers and gallons/acre for liquid fertilizers only ○ Application rate data ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur. ○ Width of area covered by application equipment ○ Equipment speed and horsepower ○ Planting and harvest dates ○ Results of a corn stalk nitrogen test	○ Soil characteristics including clay content, bulk density, soil pH, soil organic carbon, soil texture, slope, depth of water retention layer, high groundwater table; ○ Crop type; ○ Planting date; ○ Harvest date; ○ Fraction of leaves and stem left in field after harvest; ○ Yield; ○ Season, depth and type of tillage; ○ Source, rate time and placement of Fertilizer; ○ Source, rate time and placement of inorganic fertilizer and C:N; and, ○ Number, type and amount of irrigation events per season.

Calculation Method

Differences also exist among the protocols with respect to how emissions are actually calculated. All three MSU-EPRI methodologies calculate emissions using a series of equations. While both ACR-MSU-EPRI and VCS-MSU-EPRI use the exact same equations, CAR-MSU-EPRI expands the equation approach and uses more equations due to its expanded emissions scope. It also provides, at many junctures, different options for calculation of particular outputs, based upon what kinds of information has been collected from the farmer.

ACR-DNDC is a much different approach, in that it is based on computer modeling of the most likely emissions scenarios depending on the inputs provided to it. It relies both on Tier 1 methodologies developed by IPCC and field-specific modeling.

Table 13: Protocol comparison- Quantification approach

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• A series of equations are used to calculate direct and indirect emission reductions	• A series of equations are used to calculate direct and indirect emission reductions	• A series of equations are used to calculate direct and indirect emission reductions	• The DNDC model must be used to quantify direct and indirect emission reductions

• Depending on the approach used the methodology uses an IPCC Tier 1 methodology or a Tier 2 regional emission factor (applicable in the 12 states in the USDA's North Central Region)	• Depending on the approach used the methodology uses either producer-specific records (Approach 1) or regionally-derived factors (Approach 2). Only Approach 1 may be used outside the US.	• Calculations require field-specific records • Protocol calculates emissions from multiple SSRs (sources, sinks and reserves) • Many places in the protocol provide multiple ways to calculate an SSR depending on records available	according to the methodology. • The methodology uses a combination of Tier 1 methodologies (IPCC) and Tier 3 (the DNDC model).

Monitoring and Verification

All credit calculation protocols list their "monitored parameters"- the inputs for which information needs to be collected by the farmer. Some protocols also specify when and how often verification is required for compliance with their standards. Monitoring requirements are essentially the same for VCS-MSU-EPRI and ACR-MSU-EPRI, as these use the same inputs for calculations. CAR-MSU-EPRI requires that the project submit a monitoring plan to the standard before commencement of the project, and monitored parameters vary depending on whether the project is comprised of a single or of multiple fields. ACR-DNDC simply requires that all of its monitored parameters be retained for two years after the production of credits.

For verification, CAR-MSU-EPRI has by far the most stringent requirements, with an annual verification and site visit required. Verifiers are also required to bring either a certified crop advisor or agronomist with them for the site visit.

Table 14: Protocol comparison- Monitoring and verification

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• All data points mentioned under the baseline and project condition must be monitored and recorded according to the methodology. • Data for monitored parameters are derived from farmer's records that are used for compliance with any mandated (regulated) farm-related programs, including state and federal BMPs.	• All data points mentioned under the baseline and project condition must be monitored and recorded according to the methodology. • Data for monitored parameters are derived from farmer's records that are used for compliance with any mandated (regulated) farm-related programs, including state and federal BMPs.	• CAR requires the creation of monitoring plans for both single fields and aggregates with participating fields; specifics appear in the protocol • Different recordkeeping is required for single fields and multi-field aggregates • Projects will be verified on an annual basis • Single fields can choose a verification period between 12 and 24 months	• All data collected as part of the methodology must be archived electronically and retained for at least 2 years. • Information shall be provided & recorded to establish that: ○ The geographic position of the project boundary is recorded for all areas of land; and,

		• Aggregates chose their verification period based on timing of individual projects • Verifiers must be accompanied by a Certified Crop Advisor (CCA) or agronomist	○ Commonly-accepted principles of agricultural land management are implemented.

Project results

Enrollment

As in the original Nitrace project, outreach to farmers proved to be difficult, but resulted in lessons learned that are useful to share with others who may attempt enrollment in the future. Carbon Credit Solutions, Inc., which undertook this work on behalf of the project, is a project developer in Alberta, Canada, which has significant experience generating credits under the province's carbon reduction legislation. This regulation, called the Specified Gas Emitters Regulation (SGER), caps emissions from industrial facilities in the province. Facilities can reduce emissions onsite, pay a fee of $15/ton for each ton of emissions they produce above the cap, or purchase offsets from qualified projects within Alberta, such as the nutrient management projects offered by Carbon Credit Solutions.

CCSI's enrollment strategy centered primarily around finding famers in Midwestern states who had adopted variable rate technology (VRT) for application of nitrogen fertilizer, and using the information collected by this instrumentation to generate and verify credits. It was assumed by the project team that farmers who had already implemented VRT on their fields were likelier than others to be willing participants in multiple 4R practices and therefore more effective targets for participation. In essence, this strategy attempted to reach "early adopter" farms, with the intent to gather data on any 4R practice changes they had implemented. However, upon further research the company discovered that while VRT is standard practice throughout many Midwestern states, it is done primarily for seed and phosphorus application and not for nitrogen.

CCSI hired a full time sales agent in early 2015 to focus attention on enrolling farmers in the United States. As the company had established a successful enrollment relationship with Hutterite colonies in Alberta, it began its US enrollment effort by making calls to Hutterite farms throughout the Midwest, many of which were using VRT for seed application. Upon discovering that VRT was not commonly used for nitrogen fertilizer application, this agent continued making calls to Certified Crop Advisors, agronomists, precision ag managers and farmers- over 300 calls in total spanning over 6 weeks of full time work and representing over 2 million acres of cropland. Of these 300 calls, two farmers offered to share their data for the project; only one of them followed through with this offer.

Information was eventually collected from a single farmer in Indiana with multiple corn fields on which an N rate reduction had been implemented. **Please note that unlike the results presented by Nitrace, the results that follow cannot describe credit generation potential for changes in fertilizer source, timing or placement and are not intended to be used in this way.** Though the intent of the project team was to collect information about all 4R practices, only information regarding reduction of N rate was volunteered. Therefore results from this rate-based data are presented here academically, only to add to the current body of knowledge regarding credit generation from N rate reductions. Our key learnings also assume that for the foreseeable future, the use of particular calculation protocols will continue to be driven by data collected, rather than the promotion of protocols driving the collection of data. For greater detail on CCSI's enrollment effort, refer to Appendix A.

Data collection

Data collection for this project relied on field data collected from the farmer's application equipment; this method was chosen both because data collected from equipment may have less potential for human error than data input manually, and because this method is less time intensive for the farmer than manual entry.

Requested data: The following is a list of parameters CCSI requested from farmers, including acceptable sources and formats for the data coming in to CCSI:

- Crop Planted
- Planting dates
- Harvest dates
- GPS Field boundary

  Data sources: Tractor, 3rd party GPS boundary work, physical map
  Data Formats: ESRI Shape file, KML file, KMZ file. In the event that digital data is not available, a physical field map is also acceptable.
- Fertilizer Application data

  Type: Nitrogen fertilizer type, application date and application method
  Data sources: Tractor monitor, VRT records, Personal records
- Tillage Events

  Type: Number, date and depth of all tillage events
  Data sources: Tractor monitor or personal records
- Yield

  Type: Bushels per acre
  Data sources: Personal records or yield monitor results
- Irrigation Events

  Type: Irrigation dates, rate, and type of irrigation events
  Data sources: Operator records
- Soil type

  Data sources: SURGO database, pH, texture, clay content, and bulk density and SOC at surface

The data tested by the project team was received in 3 different formats from the farmer: an excel spreadsheet with field specific historical data, polygonal shape files containing fertilizer prescription data by field zone, and point specific shape files containing planting and yield data. It is worth noting here that this farmer was very organized with respect to data management; this significantly streamlined both the enrollment and data collection processes. The project team expects that as agricultural data management becomes more digital and more precise over time, this will greatly enhance the ability of carbon markets to make use of farmers' information for the purpose of crediting.

Data processing

Because the farmer was using variable rate technology for nitrogen application, fields were subdivided into fertilizer application "zones", based on the soil type on different areas of the fields. In order to prepare this data for ACR-DNDC a series of spatial overlay operations needed to be completed. These operations combined fertilizer prescription data, planting data, yield data and soils data into resultant spatially referenced polygons and an associated data file containing the spatial data. This resultant data file contained the bulk of the data required to run the DNDC model.

Project Fields and Baseline Condition

Data was collected from a single farmer in Whitley County, Indiana. This farmer was able to provide baseline fertilizer prescriptions and two years of project data; each project year contained data from 11 fields. The 11 fields tested for the 2013 project year represented slightly over 200 acres while those tested for the 2014 project year represented over 300 acres.

Through the use of variable rate technology (VRT), the farmer had been able to reduce the rate of nitrogen fertilizer applied. No other nutrient stewardship practices were reported for these fields and therefore these were not tested.

Figure 1: Project field locations

The MSU-EPRI methods consider only one practice in the establishment of a baseline: a project that reduces fertilizer application rate without considering other aspects of fertilizer management and specific soil properties. The ACR-DNDC method has the option of baseline determination via three approaches, one each for different fertilizer management strategies: 1) a project that reduces fertilizer application rate without changing any other aspect of fertilizer management such as the implementation of 4R practices (similar to how baseline is calculated in the MSU-EPRI methodologies), 2) a project that proposes changes in fertilizer management through application of proper 4R practices (as was the case for most of the fields tested by Nitrace) and 3) a project that proposes adjusting application rate in combination with implementation of proper 4R practices (some of the Nitrace fields).

Table 15 describes the baseline nitrogen loading of the 11 fields tested and the reduction rates applied to each field. In the 2013 project year, average reduction in rate across all fields was 39%, while in 2014 this average reduction was 27%:

Table 15: Baseline and project N loading data

No.	Field name	Field Acreage (acres)	Fertilizer N input Baseline (lb/ac)	Fertilizer N input Project (lb/ac)	Nitrogen Percent Reduction
Year 2013					
1	Briggs E	6.4	163	87	47
2	Briggs W	20	209	74	64
3	Carter E	14	57	43	25
4	Carter W	3.9	94	46	51
5	Geese S	34	138	106	23
6	Harrold E	22	175	97	44
7	Harrold W	55	175	93	47
8	Porky E	3.9	200	181	10
9	Porky W	3.9	220	165	25
10	Shearer W	8.3	80	42	48
11	Taulbee A	37	175	98	44
Total*		208	153	94	39
Year 2014					
1	Carter N	25.2	169	99	41
2	Carter S	34.1	169	84	50
3	Geese NW	45.7	169	130	23
4	Home S	28.9	162	100	38
5	Nicodemus A	112.3	144	129	11
6	Porky E	3.9	200	191	5
7	Porky W	3.9	220	165	25
8	Schrader E	11.7	140	118	16
9	Schrader W	34.0	140	108	23
10	Shearer E	4.3	80	54	33
11	Shearer W	8.3	81	41	49
Total*		312	152	111	27

*Sum for Acreage and Average for fertilizer N input

Results of Emissions Calculation

Table 16 describes the results gathered from the project team's road test on the Indiana fields. In reading this chart, it is important to note that the specific circumstances of this particular project allowed the project team to significantly simplify the reporting of these results. VCS-MSU-EPRI, ACR-MSU-EPRI and CAR-MSU-EPRI all share a common series of equations for the calculation of baseline and project emissions; CAR-MSU-EPRI differs slightly in that it includes a distinction between solid and liquid fertilizers (the other two methodologies simply ask for one combined number each for synthetic and organic fertilizers). Since this farm applied only liquid fertilizer, these inputs are the same for all three MSU-EPRI methodologies. CAR-MSU-EPRI also includes a calculation for emissions caused by cultivation equipment, however this calculation is only required if a change of equipment occurs to implement the project activity. As stated on page 26 of the CAR-MSU-EPRI protocol (emphasis is the project teams):

"Emissions may be significant if management requires an increase in the use of cultivation equipment or a change in the type of equipment required (e.g. increased number of fertilizer applications). Increase emissions due to project activity must be accounted for. ***Decreased emissions due to project activity are not accounted for****, to be conservative and to avoid double counting under a cap (e.g. in regions such as California where emissions from transportation fuels will be capped)."*

As this project included no change to cultivation equipment, this calculation may be omitted and therefore the calculation under CAR-MSU-EPRI is the same as that under ACR-MSU-EPRI and VCS-MSU-EPRI. Therefore, Table 16 lists a single column, marked "MSU-EPRI", which represents the calculations from all three of these methodologies.

Table 16: Emission reductions from project fields

		Total N_2O Emissions Reduction					
	Protocol	ACR-DNDC		MSU-EPRI		ACR-DNDC	MSU-EPRI
		per acre	per ha	per acre	per ha	per field	
No.	Field name	(tCO_2e)					
Year 2013							
1	Briggs E	0.24	0.59	0.18	0.44	1.5	1.1
2	Briggs W	0.29	0.71	0.36	0.89	5.7	7.2
3	Carter E	0.02	0.04	0.02	0.05	0.2	0.3
4	Carter W	0.15	0.37	0.08	0.20	0.6	0.3
5	Geese S	0.10	0.26	0.07	0.18	3.5	2.5
6	Harrold E	0.20	0.49	0.20	0.48	4.4	4.3
7	Harrold W	0.23	0.56	0.20	0.51	12.5	11.2
8	Porky E	0.03	0.07	0.07	0.17	0.1	0.3
9	Porky W	0.17	0.41	0.20	0.50	0.7	0.8

10	Shearer W	0.12	0.29	0.06	0.15	1.0	0.5
11	Taulbee A	0.19	0.48	0.19	0.48	7.1	7.2
All Fields 2013*		0.16	0.39	0.15	0.37	**37.4**	**35.7**
Year 2014							
1	Carter N	0.13	0.33	0.24	0.59	3.4	4.3
2	Carter S	0.16	0.39	0.13	0.31	5.4	6.8
3	Geese NW	0.13	0.33	0.18	0.44	6.1	4.8
4	Home S	0.16	0.40	0.05	0.12	4.7	4.3
5	Nicodemus A	0.04	0.10	0.06	0.15	4.7	4.4
6	Porky E	0.05	0.11	0.25	0.61	0.2	0.1
7	Porky W	0.15	0.37	0.05	0.12	0.6	0.8
8	Schrader E	0.09	0.21	0.09	0.22	1.0	0.6
9	Schrader W	0.09	0.23	0.14	0.33	3.2	2.5
10	Shearer E	0.07	0.17	0.07	0.17	0.3	0.2
11	Shearer W	0.09	0.22	0.10	0.25	0.7	0.5
All Fields 2014*		0.11	0.26	0.12	0.30	**30.2**	**29.4**
All Fields 2013 and 2014*		0.13	0.33	0.14	0.34	**67.6**	**65.1**
*Average per unit area and sum for fields				Difference VCS - ACR -DNDC:			**-2.4**

Under the ACR-DNDC methodology, credits per acre under the farmer's implemented rate reduction ranged between .02 and .24, with averages of .16 and .11 in 2013 and 2014 respectively. Under the MSU-EPRI methodologies, credits per acre ranged from .02 to .36, with respective averages in 2013 and 2014 of .15 and .12. Per field under ACR-DNDC, credits ranged from .1 to 12.5, which led to total farm reductions from both project years of 67.6 metric tons. Similarly, for MSU-EPRI, per-field reductions were in the range of .1 to 11.2, with total tons reduced in both project years at 65.1.

Overall, results of each methodology's calculations were relatively well-matched. This suggests that for nutrient management projects employing simple N rate reductions, we can expect to see similar results regardless of the protocol used. At an overall average of .13 credits per acre, the results of this field test were also largely consistent with what the project team expected following the Nitrace tests.

Key Lessons Learned

Enrollment: Working with agrologists and crop advisors is a best practice for carbon project developers.

The project team's effort to enroll farmers relied upon a salesperson with experience in carbon markets reaching out to those attempting to implement technologies to plan their fertilizer applications. It is clear from this experience that collecting information from farmers implementing 4R practices requires a different approach than was used here. Going forward it is apparent that groups wanting to calculate emission reductions from nutrient management should partner with agrologists that can help implement the 4Rs. Agrologists understand record keeping requirements, their role in the process and, are actively working with progressive farmers that are working to reduce nitrogen loss.

Ultimately, farmers are more likely to participate in carbon crediting programs if they are receiving fertilizer advice from someone who is familiar with these markets. Rather than this information coming from project developers themselves, project developers can work with these trusted advisors to communicate the benefits of 4R stewardship and carbon crediting, and allow them to draw in the farmers they work with.

Protocols: MSU-EPRI methodologies create similar credit estimates to the ACR-DNDC model for N rate reductions; however, greater reductions can be accounted for using ACR-DNDC to address changes to source, placement or timing.

Preparation of baseline data for the MSU-EPRI protocols depends on the condition of the farmer's records. The most desired situation is when the requested data is available directly from farm records. In other cases the baseline nitrogen (N) input should be calculated from The National Agricultural Statistics Service (NASS) records. Calculation of the baseline N input based on county corn yield data from NASS can take several hours. More time-consuming is the preparation of weather data for the estimation of the leaching fraction. Requested temperature precipitation and wind-speed data can be obtained from the weather network (http://www.wunderground.com). After a recalculation of the growing season, the data will be used for the calculation of potential evapotranspiration (PET). The template for calculating monthly PET, based on maximum/minimum temperature, sum of precipitation, and wind-speed data is available online (http://extension.uidaho.edu/kimberly/2013/04/spreadsheets-supporting-fao-56-example-calculations). Calculated monthly PET is summarized for the growing season and compared with the precipitation for this period. Then the sums of the precipitation for the growing season and PET for the same period are ready as input data for VCS calculation. N input (baseline and project) precipitation and PET data can be inserted into a previously prepared template where the final results are Verified Carbon Units expressed in tCO_2eq/field. Preparing a template can take a few hours. Since the project team's calculation for the Indiana fields had been prepared during the initial Nitrace project, the time to calculate these reductions was limited to input of proper data and the result was obtained immediately.

The ACR-DNDC protocol, beside the farm's N application and N management data, requires daily meteorological data (available on line (at http://www.wunderground.com). The soil data is available online (USDA Web Soil Survey). To obtain proper functioning of the DNDC model all data should be revised before implementation. Meteorological data is sometimes incomplete or inadequate because of temporary failure of the registering system, so it is necessary to use data from other stations located nearby. Soil data for the whole field usually consists of 4 to 9 soil units. Some of the fields are a mosaic of mineral and organic soils; because the protocols are not built to handle them, poorly drained organic soils like histosols are excluded. In some cases bulk density has an inadequately high value. It can be corrected to a proper value based on soil organic matter, clay, and sand data by Saxton calculator[15]. The DNDC model requires calibration for every batch run whenever changes in crop yield occur. These circumstances can cause the preparation of the batch for DNDC simulation to take a few days.

The availability of multiple calculation protocols should ideally encourage farmers to adopt any number of emissions-reducing practices because they can be certain that these practices can generate credit; the application of particular protocols can be said to depend largely on the type of data collected from

[15] The Saxton calculator is available online at http://hydrolab.arsusda.gov/soilwater/Index.htm

the field. DNDC requires a greater number of inputs, therefore, if only rate reduction data can be collected, the MSU-EPRI method may create fewer credits but save time for both the developer and the verifier. The DNDC method should be functional in projects where there are applied changes in N management (alterations in application of rate, type of synthetic fertilizer, organic amendment, placement, timing, use of time released fertilizers, use of nitrification inhibitors, and other technologies and/or practices). The results of Nitrace's testing bear out this conclusion; reductions were higher for 4R Stewardship projects under ACR-DNDC, but in cases where the practice change was a reduction in N rate, MSU-EPRI often delivered higher reduction estimates.

Data collection: Variable rate technology can help to streamline the data collection process for future projects.

The process of completing the overlay analysis to prepare the data for model runs used standard GIS overlay algorithms that are available in any commercial GIS software package. Unfortunately, these overlays had to be processed field by field. Scaling up emission reduction calculations to a commercially viable size would benefit from a more efficient data processing procedure.

The project team believes that increased adoption of variable rate technology (VRT) for nitrogen application- defined as technology which allows for the precise control of field-specific application practices- would be beneficial both to the farmer, who can use this technology to better decide upon and track their fertilizer applications over time, and to carbon project developers, who would gain access to high quality fertilizer data which tracks applications in real time.

As this technology is more widely adopted, the project team believes that carbon project developers will adapt to the process of overlaying data to create a better fit with the inputs of the nutrient management credit calculation protocols, and that overall the process of generating credits for farmers using nitrogen VRT will be cheaper than the process of generating these same credits for farmers not using VRT, as the collection of nutrient data will be vastly simplified.

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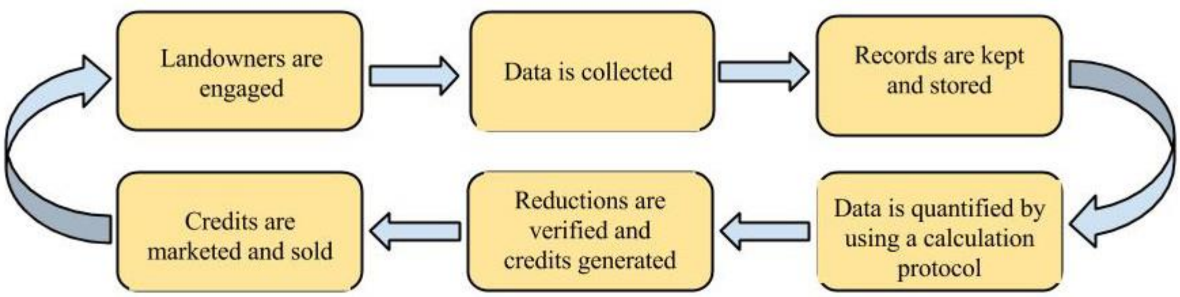
Part 2: Credit Generation and Commercialization Report

Introduction

The mechanics of taking nutrient management offset crediting to scale have been discussed for years in carbon market circles, but to date the sector has seen little success in actually generating credits. This report attempts to synthesize what is known about the barriers to this nascent sector and how these barriers might be overcome, from the very first step in credit generation to the final sale of the credit.

To contextualize market barriers, we present the following visual representation of how greenhouse gas credits are typically generated. As market experience has proven and this paper will reiterate, the process is highly cyclical; that is, the successful completion of one cycle of credit generation tends to seed others by incentivizing additional landowner enrollment.

Figure 2: Credit generation cycle



Viewed a different way, this chart describes the key points across the lifecycle of a nutrient management carbon credit, assuming that the farmer is willing and able to change their nutrient management practices:

Step 1: Landowner enrollment
Step 2: Data collection
Step 3: Data storage
Step 4: Quantification of emission reductions
Step 5: Verification
Step 6: Marketing
Step 7: Purchase

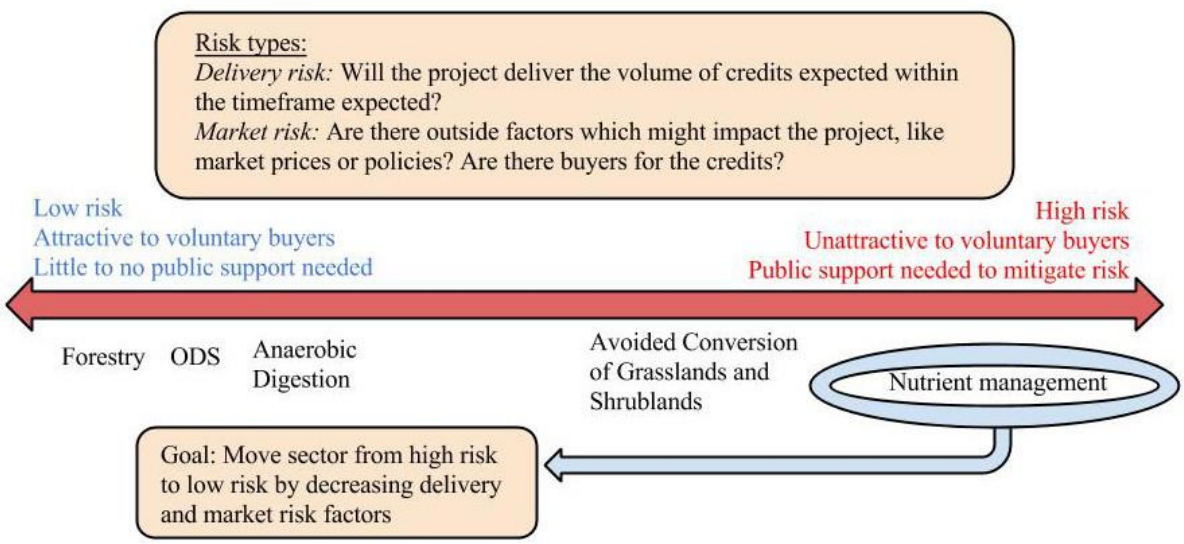
Each of these potential steps in the generation of a credit carries different kinds of risks. Many of the current failures within the market are attributable to unclear boundaries between these steps and which market actors are able and willing to handle the risks associated with them. This report attempts to clarify the source of failures to date and recommend alternative scenarios, which help to mitigate existing risks and act as a catalyst for a successful nutrient management carbon crediting sector.

Risk management for offset sectors

Offset project sectors are characterized by two major categories of risk—delivery risk and market risk—which carry with them implications for the attractiveness of investments in the sector. *Delivery risks* may be framed as any risk which decreases the chance a project will produce the estimated number of credits within a required timeframe; examples may include, but are not limited to, project development costs, credit calculation methods, and project developer expertise with carbon markets. *Market risks* may be framed as any risk which decreases the ability of a developer to sell credits from a project once generated; examples of these include sudden shifts in carbon prices or climate policies, and whether there are organizations willing to buy. While delivery risks are more easily mitigated by working with established project types and experienced developers, market risks are somewhat harder to control.

As shown in the diagram below, nutrient management is viewed as a high risk to potential investors when compared with more mature offset sectors like forestry and anaerobic digestion. Mature sectors benefit from well-established and road tested protocols, which are often the first to be adapted to compliance markets; if compliance-eligible, mature sectors also benefit from a built-in market for credits. The nutrient sector has yet to experience successful generation of credits at scale and does not qualify as a compliance option, increasing market risk and reliance on public support. It also suffers from significant barriers, discussed in this report, which increase delivery risk. As the below illustration describes, it is possible to decrease the risks associated with nutrient management crediting. This will help to make the sector more attractive to a wider range of investors and buyers and help to ensure the commercial market, rather than public investment, can sustain the sector over time.

Figure 3: Risk profile of nutrient management



One case in point which proves the ability of nascent sectors to lower risks is the example provided by a different, agriculturally-related project type: Avoided Conversion of Grasslands and Shrublands, otherwise known as ACoGS. ACoGS projects incent owners of grasslands to enter into conservation easements which prevent their land from being tilled for agriculture, thus preserving crucial habitat for migratory birds and maintaining the ability of the soil to sequester carbon. As with nutrient management, the protocol for calculating carbon credit from ACoGS is still relatively new, and the costs to develop the project (contracting, verification, etc.) were largely paid by the developer, Ducks Unlimited.

In the case of this project, Ducks Unlimited was willing to see the project through to delivery of credits despite the fact of an untested protocol. In addition, a buyer with an established relationship to Ducks

Unlimited, Chevrolet, agreed to purchase the credits. With these two factors in place, this pilot project was largely able to avoid the pitfalls of delivery and market risk that currently characterize nutrient management projects. A nutrient management project with an identified buyer may still fail at this point, because unlike ACoGS, where the credit is contingent on a simple binary action (land conserved vs. land not conserved), there are many more factors which can impact the delivery of credits from nutrient management and which are largely out of the control of the developer, such as weather patterns.

While admittedly more difficult than in the Ducks Unlimited example, it is still possible to correct for both delivery and market risks in nutrient management. Some of the key barriers which are creating needless complexity for the nutrient management offset market and increasing the risks attached to investment in nutrient projects are:

- Confusion about division of labor among carbon market stakeholders,
- A fragmented information management landscape which complicates easy access to information relevant for carbon credit calculations,
- Lack of real-world experience with credit generation under the existing calculation protocols leading to uncertainty about potential credits per acre, and
- Uncertainty about who will purchase the resulting credits.

Mitigation of risk in nutrient management crediting: Problems and Recommendations

Revisiting the credit lifecycle in Figure 2, in this section we describe each step in detail, focusing in particular on the risks associated with each step and the entity or entities best suited to mitigate these risks.

Delivery Risks:

1. Farmer engagement and enrollment

Key questions in this section:
Who is capable of enrolling farmers?
Does enrollment as we know it even need to happen?
How can changes in marketing of credit programs incent participation?

Market role	Risks	Who could do it?
Enroll farmers	• Unclear value proposition • Reluctance to change • Imbalance between value and effort • Contracting issues	• Aggregators • Supply chain initiatives • Agribusinesses • Equipment providers • Extension, CCAs and others

The first step in creation of any nutrient management offset program is the ability to involve individual farms, because as of now, no credit calculation protocol has been written that does not rely, at least in part, on field-specific management records. As Nitrace articulated, this process is often more complicated than it sounds. For this project, The Trust interviewed practitioners of existing efforts to launch nutrient management crediting programs, none of whom have had enough success enrolling farms to generate credits at scale.

According to these interviewees, several factors need to come together for enrollment to be successful, many that are dependent on the success of other pieces of the credit generation process, discussed later in this report.

1) Specific numerical values for tons per acre and dollars per ton should be used with farmers to help them understand the potential value of their practice changes,

2) The farmer must believe, and be shown, that changes to their nutrient management practices will not negatively impact crop yield,

3) The process of generating credit must be as off-farm as possible; that is, the more time a farmer needs to spend inputting data or dealing with a verifier, the less likely they will want to be involved,

4) Any paperwork (contracts, data requirements or other) must be as streamlined as possible and clearly understood by the farmer, and

5) The price of carbon needs to be high enough to consistently attract farmer participation.

Efforts to enroll farmers to date have been hampered by a failure to address one or more of these factors[16]. The value offered by the carbon market has never been clearly defined; it is difficult to quote the value of a credit to a farmer when no stable market exists for the credit.

Similarly, the amount of effort currently needed to generate credits is greatly increased by the fact that information infrastructure remains largely fragmented across the agricultural sector; this is discussed in more detail in the Data Collection section. As a result, the time investment on the part of the farmer begins to look unattractive compared to the value of a credit, even if this value is quite high.

The perfect balance of value vs. effort has yet to be identified or achieved, and this makes nutrient crediting a chicken-and-egg problem; farmers need to see value in order to want to enroll, but the value cannot be created until they do.

Problem: Incentive level

In the voluntary carbon markets, prices for credits are highly variable and depend on a variety of different factors that include delivery risks, project type and location, credit vintages, project charisma and co-benefits, and buyer preferences. It is currently very difficult to quote farmers a specific price per acre for their credits or an accurate number of credits from their fields as successful verification is the only way to be certain of these numbers, and this vastly complicates the process of communicating the value of carbon markets.

[16] For more on enrollment barriers, see the Nitrace report.

A farmer's desire for carbon revenue is directly tied to the number of acres being farmed, fertilizer cost, volatile commodity crop prices, additional incentives the farmer receives, and the perceived cost-benefit analysis of credit generation; the interactions between these factors are not well understood at this time. Further complicating matters, the existing credit calculation protocols allow for credit generation in nonconsecutive years to accommodate farmers choosing not to plant a credit-eligible crop in a particular year. In this case, the value proposition of carbon revenue in subsequent years may also change.

Recommendation: Further study of revenue impacts

Further research is needed specifically on the interactions between different revenue sources for farms. This could take the form of a survey which asks respondents to clarify, on a per-acre basis, their expected revenues from various sources for the upcoming crop year, and then asking their willingness to participate in the carbon market at various levels of per-acre revenue. This would help the market to determine how the level of incentive from carbon interacts with other revenue streams, and subsequently determine the range of values at which carbon revenue begins to attract widespread participation.

Recommendation: Better price discovery

In the compliance markets such as California's, prices for offsets are much easier to predict, because they tend to be loosely tied to the price of allowances, which are auctioned off using a predetermined price floor as a starting bid; this price also rises at the rate of 5% plus inflation each year, guaranteeing a price increase for both allowances and offsets over time. The voluntary market is also capable of price discovery via auction. The World Bank's Pilot Auction Facility (PAF)[17] provides one such model. The model works as follows:

The originator of the credit buys "put options" from PAF; these options provide a guarantee that the credit can be sold for a minimum price at auction if demand for credits is low, but also leaves the option open that they may sell for a higher price elsewhere if demand is high. This concept arises directly from agriculture, as "put options" are also used by the sector to guarantee minimum prices for commodity crops in bumper crop years. The put options from PAF are backed by a bond that is made up of donor funds, and this bond is zero-coupon; meaning, it generates no return.

This model provides some price certainty in the form of a minimum price for which credits can be known to be sold, and the prices garnered at auction can provide the market with some clarity into demand. This type of certainty can go a long way in assuring farmers of what their credits could be worth; however PAF is targeted only toward methane emission reduction projects at this time.

Problem: Unclear boundaries between market actors with respect to enrollment

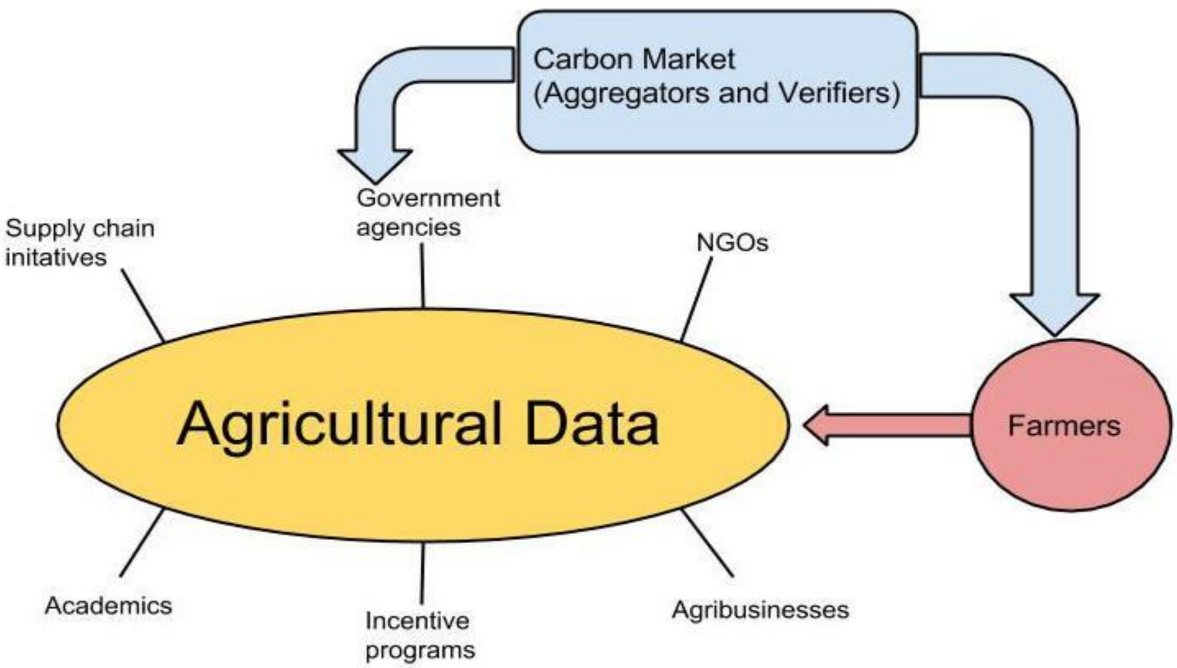
Current practice is that farmers are approached directly by project developers, also called aggregators—representatives of the carbon market who specialize in the aggregation of multiple farms into a single project. These aggregators enter into contracts with farmers to collect and process data on their

[17] More information about the World Bank Pilot Auction Facility can be found online at: http://www.pilotauctionfacility.org/

nutrient management practices, hire a verifier to corroborate this information, and work with the relevant registries to make the credits official before marketing them to buyers.

However, the aggregator does not necessarily need to manage the enrollment process. In fact, this may be more efficiently accomplished elsewhere in the agricultural supply chain; the factor most determinate of who should enroll farmers may be who needs to collect data from them. As shown in the illustration below, the carbon and agricultural markets are two separate systems to farmers. To date, the carbon markets have interacted directly with farmers (the arrow on the right), but the potential exists to interact with farmers' previously-collected data through other market actors (the arrow on the left) given properly constructed privacy and ownership protections:

Figure 4: Interaction between farmers, the agricultural market, and the carbon markets



Recommendation: Partner with other organizations to streamline enrollment

If the latter were the case, presumably farmers would not need to be "enrolled" by the carbon markets at all, but simply be able to "opt-in" to having their information shared with aggregators by others who collect it. In this case, the need to write a contract between the aggregator and farmer would be avoided altogether, thereby decreasing one expense of project development.

One possible example of this model are the various supply chain initiatives underway at major food and beverage companies. These companies are attempting to influence particular aspects of the sustainability of their raw inputs and presumably need to collect some type of evidence (data) that practice changes made to these aspects are having the desired impacts. If nutrient management is an area of focus for one of these initiatives, potential for partnership with carbon markets could exist. However, as data collection initiatives within large supply chains are currently at various stages of development, this potential is contingent on the ability of carbon market representatives to develop trusted relationships with these companies to help them realize the potential of any nutrient data they collect.

Another example is partnerships with fertilizer retailers. The most recent Iowa Farm Poll[18] indicated that farmers are generally supportive of the state's nutrient loss reduction strategy. All states with watersheds flowing to the Gulf of Mexico have been encouraged by the federal government to write such strategies to reduce their impact. Of farmers polled, 72% indicated that they would be willing to improve their nutrient use efficiency, and that 60% would prefer their fertilizer provider to provide recommendations on how to achieve this. Fertilizer retailers, then, have a unique opportunity to promote nutrient crediting programs to farmers as a way to contribute to reduced nutrient pollution from states.

The table below summarizes some additional partnership opportunities, in which "enrollment" could be as simple as an opt-in by the farmer. All scenarios require this opt-in and maintain the famer's ownership over their own data, but in some circumstances different revenue-sharing models for the resulting carbon revenue may arise:

Table 17: Possible partnership scenarios for farmer enrollment

Potential partner for the carbon markets	How it might work
Supply chain initiatives	Supply chain buyer collects relevant fertilizer inputs, allows farmer to opt-in to data sharing through this data capture initiative.
Fertilizer retailers	Retailers promote practice changes to optimize N use and carbon credits as a potential revenue source. Farmers opt-in through the retailer, which partners with an aggregator to produce credits, and revenue is shared with the farmer.
Data service providers (data-supported decision software)	With farmer opt-in, information is fed to an aggregator directly from on-farm application equipment, is stored by the decision-support software, and is accessed by carbon markets.
Agribusinesses	Farmers pay agribusinesses to process their data to support planting and fertilizer decisions; with opt-in from farmer this information is shared to the carbon market and revenue is shared between the agribusiness and the farmer.
Government agencies	Relevant information is collected by existing government statistics servers (NASS, SSURGO and others); with farmer opt-in this information is accessible to carbon markets.
Academic institutions	Fertilizer data is collected for the purposes of scientific research; with farmer opt-in this information is accessible to carbon markets
Incentive programs	Information about fertilizer practices is collected to prove eligibility for conservation incentives or crop insurance; with farmer opt-in this information is accessible to carbon markets.

[18] "Farmer Perspectives on Iowa's Nutrient Management Strategy", Iowa Farm and Rural Life Poll, Iowa State University, June 2015.

Of course, each of these partnership opportunities will need to address three important considerations before they can be successful. First, the carbon market will need to ensure that its verification process can inexpensively handle distributed data storage, because the records needed to prove practice change adherence during a crediting period will still be owned by the farmer. Secondly, any potential partner will need to collect field-specific records in order to be eligible for credit calculation under the existing protocols. And finally, an appropriate revenue-sharing model would need to be designed, to ensure all parties' costs are covered while providing a fair share to the farmer.

Problem: Ineffective marketing of programs

Carbon markets are a complex topic, even for the people who work within them daily, and it is often difficult to communicate their value without verging on information overload. Efforts to date have focused on building simple systems for enrollment and data collection which presume to remove some of this extemporaneous explanation, but even this strategy has seen little success.

With voluntary programs as they are currently framed, questions often arise from farmers who are suspicious that the data being collected is a precursor to costly regulations on fertilizer application. One simple change in framing the conversation may solve both issues.

Recommendation: Frame carbon revenue as the voluntary solution

Carbon markets are, by their nature, a part of a free market economy. Far from trying to force regulation on farmers, nutrient crediting depends on practices for which there is NO regulation; otherwise, projects would fail to pass the "regulatory surplus" portion of testing for additionality. Carbon markets thus far have not done much to emphasize this point, but it is an important one: the goal is to incentivize conservation practices through economic means, not regulatory ones. In fact, if enough farmers utilized carbon revenue to take conservation practices to scale for a wide variety of crops, regulatory interference might even become unnecessary.

Problem: Carbon markets are in direct competition with others in the agricultural market

It is well known by business scholars that any upstart company which shares a value proposition with many large, successful competitors will have a difficult time differentiating itself enough to capture significant market share. In the case of nutrient management project developers, it has always been assumed that the primary value proposition offered by carbon markets was a new revenue stream, which could be used by farmers as a source of project finance. However, the promise of a new revenue stream has not yet catalyzed a successful nutrient management carbon crediting market. Among the reasons for this failure may be the fact that there are other very well-known providers of financing for conservation practices; the largest of these is USDA itself. Here, we illustrate how two very common value propositions for agricultural providers have created crowded competitive landscapes for service providers:

Table 18: Competition in agricultural value propositions

Value	Provider(s)
Financing for conservation practices	• NRCS subsidies • Other incentive programs • Grant funding from NGOs and others

	• Aggregators (in the form of carbon revenue)
Data-supported decision making	• Software developers • Equipment providers • Retailers • Extension services • Certified Crop Advisors

Recommendation: Recognize competition and course-correct

This leaves the carbon market in the position of needing to find a more unique value proposition—a shift away from a simple binary of carbon revenue vs. no carbon revenue, at least until the price of carbon is much higher. Carbon project developers would be well advised to also explore other ways of leveraging their strengths in carbon modeling, data management and climate mitigation to provide additional value to farmers and other market stakeholders.

Problem: No established best practices for messaging or mechanics of enrollment

Due to the various barriers discussed throughout this report, very few organizations have made any attempt to enroll farmers under aggregated nutrient management crediting programs in the US. Though organizations such as the Coalition on Agricultural Greenhouse Gases (C-AGG) exist to help these few producers share lessons together, more can be done to engage outside the carbon market community, begin to synthesize these lessons into actionable best practices, and thereby incentivize others to attempt large-scale carbon crediting for nutrient practice changes.

Recommendation: Share knowledge and compile best practices for enrollment

Much on-the-ground knowledge already exists about how to enroll individuals into other crediting program types and other kinds of cooperative programs. Furthermore, attempts such as those made by Nitrace and Carbon Credit Solutions to do this for nutrient management have generated useful feedback and key lessons learned about incentives, messaging and the mechanics of transferring data from farmers to aggregators. This knowledge needs to be compiled from the experiences of carbon credit developers, crop advisors, agronomists and others, and shared for the benefit of current and future carbon project developers.

2. Collection of data

Key questions in this section:
Who is best suited to collect information?
Who might have relevant data today?
Who is willing to accommodate the external audit required by the carbon market?
Is the actor collecting the data the same as the actor storing it, or are these separate?
Who owns the data when a transfer occurs?

Market role	Risks	Who could do it?
Collect data	• Privacy and legal issues	• Aggregators • Supply Chain initiatives

		• Agribusinesses • Equipment providers • Extension, CCAs and others

The process of generating credit from multiple aggregated farms necessitates the collection of data from those farms. As mentioned above, farmers often have multiple stakeholders requesting different information about a variety of inputs and practices. Data they collect also helps them to make educated decisions about timing of inputs, resource conservation, and much more. In a perfect world, information would be organized to provide value to everyone who interacts with it; this is currently not the case.

The Trust brought in a data analyst intern for this project, to help us understand the complexity of this issue and how it relates to the ability to generate nutrient management credits. From this analysis we are able to conclude two things. First, the agriculture sector is due for a standard set of data capture procedures; properly harnessing this new information system as it is built is key to being able to scale nutrient crediting. Secondly, until a sector-wide system is developed, the carbon market must continue to work around this constraint by pursuing stop-gap measures, like partnerships with existing web tools.

Agricultural data is everywhere. It comes from onboard sensors/computers from product spreading equipment, crop advisors, fertilizer and seed companies, and the mind of the farmer. It is kept in spatial data files, invoices, software programs, and notebooks. Unlike other industries that have worked for decades to standardize the collection and processing of data—we use healthcare as an example—agriculture is only now at the beginning of a “big data” revolution. Both established companies and startups have begun to see the potential in a streamlined information system, which allows for the easy capture, storage and access of data by multiple stakeholders throughout the agricultural system.

Current State of Data Collection in the Agricultural Segment

Government

Producers participating in various USDA farm programs are required to self-report all cropland on their farm(s) to the Farm Service Agency (FSA) each year. For each crop, farmers report acres planted, failed, and prevented. Within the USDA, the FSA, NASS, NRI, SSURGO, and EQIP all accept data from farmers for respective programs. The NASS uses the FSA data to supplement the vast array of detailed survey data it collects from producers to make reliable crop acreage estimates. The FSA data are incorporated into the estimating process along with other variables. The method of data collection ranges from manual form and fillable .pdf to electronic filing, not unlike how we can now file our federal and state taxes.

Crop Insurance

The Common Crop Insurance Policy requires a farmer to provide information and documentation supporting his or her losses while cooperating in the investigation of the claim. As with many requests of this nature, the documentation requested by the insurance provider can be expansive and time consuming to compile. To help ensure a prompt resolution of the claim, it is recommended that a qualified party such as a crop consultant or agronomic specialist visit the farm and make notes as to any conditions that resulted in crop losses or prevented a timely planting of the crop. Moreover, additional proof of loss or adverse farming conditions, including photographs, farm records, crop samples, weather data, or scale tickets, may also help facilitate a more efficient handling of the loss claim.

Problem: Agricultural data is fragmented

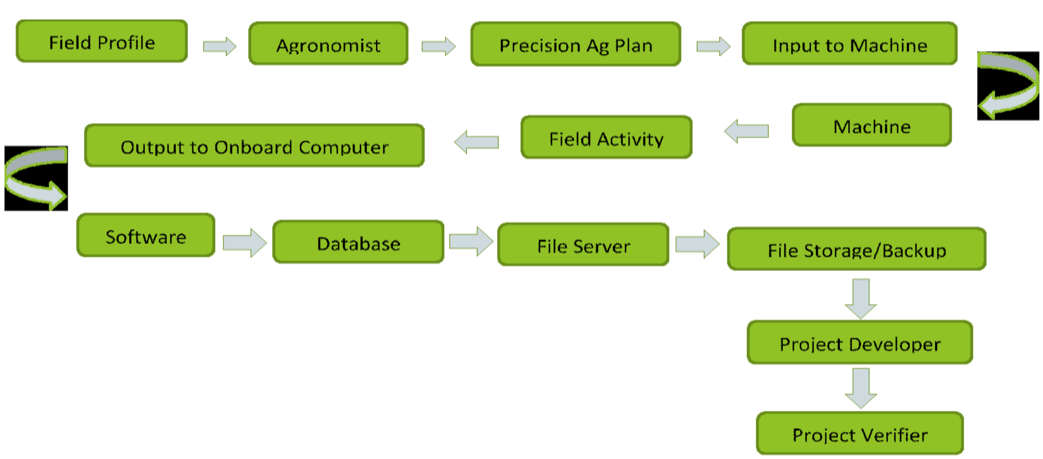
In a statement from the White House's Press Secretary on July 29th, 2014, the Obama administration announced an intention to streamline how data is used to increase the climate resiliency of food production:

"To continue momentum under the Climate Data Initiative, the Obama Administration is today renewing the President's call to America's private-sector innovators to leverage open government data and other resources to build tools that will make the U.S. and global food systems more resilient against the impacts of climate change. In response to this call, today's launch includes a number of commitments by Federal agencies and private-sector collaborators to combat climate change and support food resilience through data-driven innovation."

The listed participants in the statement are mostly those offering the use of datasets, infrastructural components for the movement of data and those proposing data standards. This illustrates the gathering momentum for how the fragmented data space of agriculture is slated for a more organized approach. In a parallel effort, organizations in the private sector have also begun to pull together a common set of data collection principles for agricultural technology providers.[19] In the interim, however, fragmentation continues to pose problems not only for the agricultural market (farmers, agribusinesses, crop advisors and others) but for the carbon markets, which require access to significant datasets for credit production.

Farmers who wish to enroll in crediting programs must provide a variety of inputs to project developers and project verifiers in order to establish a baseline, track eligibility, and verify adherence to established regulatory-quality standards. Currently there are many steps to the data flow. They reflect the physical and logistical nature of agri-business. In Figure 5 we present one possible idea flow of data from the source (farmers) to the carbon markets (aggregators and verifiers):

Figure 5: Data flow map for nutrient crediting



[19] Privacy and Security Principles for Farm Data, May 5, 2015, American Farm Bureau Federation and other signatories. Available online at http://www.fb.org/tmp/uploads/PrivacyAndSecurityPrinciplesForFarmData.pdf

Due to a lack of standardization with respect to data capture in agriculture, many different approaches to collection are used at each step along the path outlined in this diagram. Smaller operations will use log books to manually record data. In most cases, some or all of the information is transferred and kept on local computers. Equipment and software continues to improve the process, but for now farmers often use different machines for different datasets. It should also be noted that there are large areas in rural counties that have no broad-band high speed internet access; this may impact the gathering of data.

Recommendation: Learn from HIPAA's example to reform the agricultural data management system

Parallels in data capture, storage and access between agriculture and healthcare may not seem immediately obvious. However, the common need for accuracy, privacy, and cross platform compatibility makes a compelling case for considering similar approaches to solving problems and challenges in agri-data management scenarios. The medical profession has made significant strides to standardize and digitize records. They have benefited from the adoption of electronic medical records (EMR) and the associated HIPAA compliance standards that were established and are now required. Here, we give some background on how healthcare managed this information update, and how a similar structure might be employed in agriculture.

HIPAA Timeline

The design, adoption and implementation of standardized electronic medical records (EMR) started in 1996 after congress passed HIPAA in order to modernize health information exchange. Over the next seven years, The White House and congress made adjustments to much of the original law making it less cumbersome and more effective. The final version came in 2003 along with phased in aspects of compliance. The intent was to create a secure privately accessible system without causing undue hardship on hospitals, doctors or their patients. During the next 10 years, incentives and voluntary window of compliance (explained below) resulted in a positive trend in acceptance and implementation nation-wide. The resulting system allows more efficiency and security in the ever increasing movement of patient records.

Stakeholder Motivations and Access

The preamble to the HIPAA privacy rule states:

According to the American Health Information Management Association (AHIMA), an average of 150 people "from nursing staff to X-ray technicians, to billing clerks" have access to a patient's medical records during the course of a typical hospitalization. While many of these individuals have a legitimate need to see all or part of a patient's records, no laws govern who those people are, what information they are able to see, and what they are and are not allowed to do with that information once they have access to it.

Electronic, standardized, and sharable data means that there are many other uses that might be considered for the data contained within an EMR. For instance:

- Patient safety reporting
- Clinical research, including patient-centered outcomes research, and to identify patients who could benefit from participating in a research study

- To provide referrals to their patients for community services, like smoking cessation or weight management programs
- Providers working with disease surveillance case report forms may use data for modeling
- Leverage clinical information collected to review and pre-authorize certain medical devices EMRs to support additional review of expensive medical equipment

Voluntary Window of Compliance

The term "voluntary window of compliance" refers to a tiered incentive program combined with a period of lenient penalty enforcement, the purpose of which is to help participants to "phase in" compliance with the new data structure over a period of years.

In the HIPAA market, **Stage 1** started in 2011 and opened a period that meaningful use could begin to be implemented and recorded (meaningful use is discussed below). Stage 1 was primarily focused on the effective generation of data, that is, the transition from paper record-keeping to using a computer terminal, pad or other device to enter information. **Stage 2** began in 2014 and is slated to run through 2016 with opportunity for incentives that are aimed at the standardization of data for access across multiple platforms. **Stage 3,** scheduled to start in 2017, will have fewer incentives and will focus on tracking improved outcomes, correcting breaches in the system, and applying penalties to those out of compliance.

Meaningful Use Incentives

Providers must attest to demonstrating Meaningful Use (MU) every year to receive an incentive and avoid a Medicare payment adjustment as a penalty. To be considered a meaningful EHR user during an EHR reporting period in a payment year, certified EHR technology must be used to capture, exchange and report specific information and quality measures. The purpose of the incentive is to develop process improvements over time, and implies that technology developers will be able to be certified by Centers for Medicare & Medicaid Services (CMS.gov).

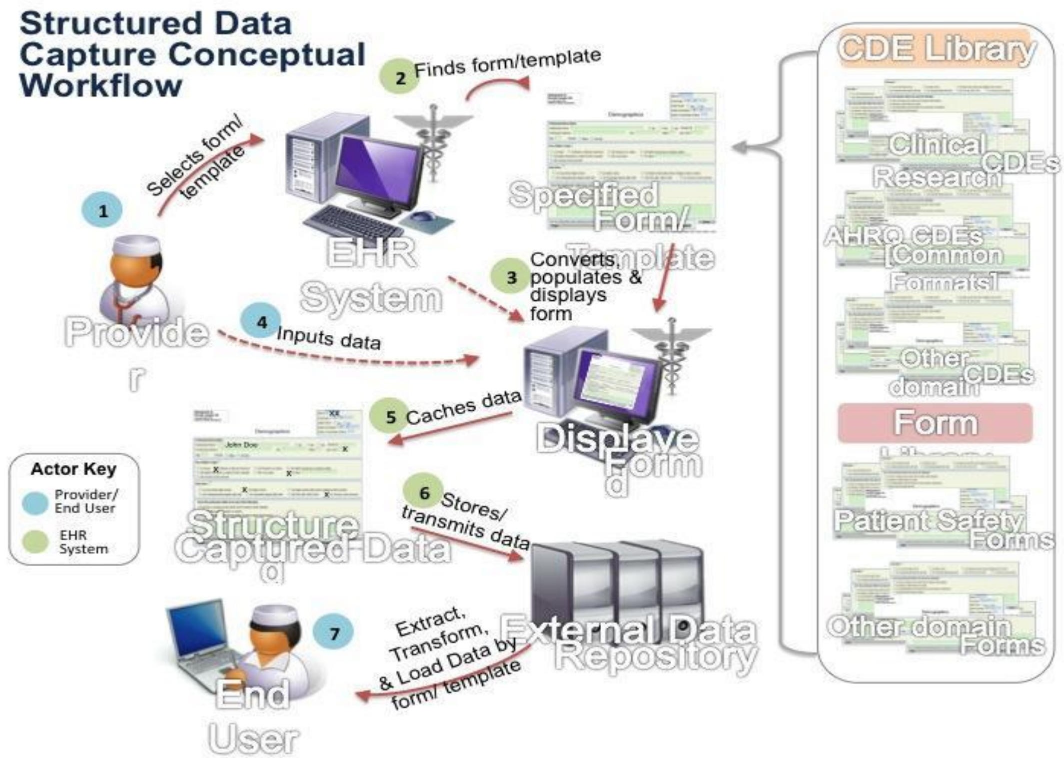
Structured Data Capture

It would be challenging to include every possible data element (as important as it may be) in the core MU data elements. This would create a risk of overwhelming providers, vendors, or others with the complexity and scope of the standardized data that EHRs would be required to collect. A solution to this problem is being explored in the latest new initiative in the Standards and Interoperability (S&I) Framework—the structured data capture (SDC) initiative.

The goal of the initiative is to identify how EHR interoperability technology can be used to:

1. Access a template that contains structured data, sometimes called common data elements (CDEs)
2. Automatically populate the template with the correct CDEs from existing EHR data
3. Store or transmit the completed template to the appropriate organization or researcher

Figure 6: Workflow for structured data capture



Significant work has been done on CDEs in healthcare already, so like other S&I framework initiatives, the expectation is that the SDC Initiative will leverage existing EHR interoperability standards, harmonize them, and agree on a common approach to support structured data capture.

Connection to Agriculture

It is important to understand that though the needs being fulfilled are similar for EHRs and Electronic Agricultural Records (EARs), the complexity in agriculture is significantly lower. With fewer records, fewer users accessing the data and consistent inputs, the need for an extended timeline is reduced. As with healthcare, agriculture can begin to take the guess work out of operational decisions while increasing research opportunities in nutrient management and other conservation practices. Advancement will likely come sooner and at a lower cost if the farmer allows technology to do the heavy lifting.

The process of streamlining data collection in agriculture has already begun. Much of the work has been done in creating template “workbooks” that accept common agricultural data requirements (CDEs). These include inputs on everything from soil and weather conditions to rate and content of fertilizer spread. Currently the barriers to mapping cleanly and easily to form templates come in the form of proprietary software formats that add cost to conversion. This is slowly being addressed by equipment manufacturers. Again, the idea of agreed upon electronic agriculture data standards would settle concerns and speed the auto-collection methods this report recommends. Implementing a structured data capture model for agriculture could be a bridge for inputs that are currently not able to conform to standards.

The United States' 2.2 million farms are generating important information about their primary asset—their land. The industry as a whole is rapidly adopting new technologies to help manage operations and to access their information. Various government entities collect and process data on planting, yield, soil quality and other attributes. The government's future role, as with the healthcare industry, might evolve into helping establish data standards and rules to make reporting less costly and time consuming.

It is important to reiterate that most farmers are already navigating significant paperwork for submitting data to a host of government agencies (NRI, SSURGO, FSA, EQIP, NASS, etc.). The purpose of creating data standards is to reduce confusion and offer an acceptable path to leveraging their data to greater benefits. These include not only meeting governmental requirements, but also increased efficiencies in all areas of operation and labor costs.

Meaningful Use Incentives paired with Voluntary Window of Compliance and Structured Data Capture (SDC), create the potential that exponential data utilization for the agricultural sectors could be realized in less than 10 years of implementation. Much of the current unnecessary duplication of data capture and storage could be phased out. While privacy would be of utmost priority, the reduced paper workload on the farmer and the improved verification and payment timeline for the carbon market is an ideal value proposition. All of this will gain farmers time to invest elsewhere in the operation of the farm. In essence, farmers will be compensated for becoming more effective at both the business and the stewardship sides of farming.

As agriculture moves toward greater use of data to track inputs and inform decisions, the key to unlocking large quantities of data for nutrient crediting is to ensure that the carbon markets are a part of this ongoing conversation. For this report, The Trust spoke with many organizations that seem poised to take on key roles in this transition—government agencies, farm bureaus, software developers, equipment specialists—few if any we spoke to knew what kinds of information the carbon market would need access to, but all seemed interested in learning this. Simply making it known that credit is available with the provision of certain data inputs (see Figure 8 for details) seems to be the first step in unlocking the potential for crediting at scale. *The carbon market needs to ensure that from this point forward, it is viewed as a stakeholder in these ongoing conversations about data usage and, more importantly, a source of value for other stakeholders.*

Problem: The carbon market needs a stopgap

As this larger effort to streamline data management for agriculture takes shape in the coming years, the potential still exists today to be generating credit from data collected. Therefore, the carbon market needs some kind of stopgap—a way to generate credits from data in the absence of a streamlined data collection system that will increase interest in participation from farmers.

Recommendation: Partnerships with existing data collectors

Many such efforts are already underway, utilizing the types of partnerships discussed under Enrollment. Moreover, there are many data collection services which, if provided with lists of required inputs from the carbon markets, could be crucial partners in the years ahead.

In order to satisfy the needs of the carbon markets, any potential partner will need to prove that:

1) Their tool collects, or would be willing to collect, inputs required by the carbon protocols and,
2) Data will be stored, managed, and accessible at a location to allow for an audit trail

Existing data collection tools

COMET-farm: A tool developed by USDA's Natural Resource Conservation Service in partnership with Colorado State University, COMET-farm allows farmers and ranchers to calculate potential emission reductions from practice changes. Its scope encompasses field crops, livestock and on-farm energy usage. Intended as an educational tool for farmers, COMET-farm doesn't store data, but it does collect the majority of inputs needed to run a credit calculation under one of the MSU-EPRI methodologies.

Field to Market: A membership-based nonprofit organization, Field to Market originally developed its Fieldprint Calculator as a way for farmers to compare themselves to others in their region with respect to resource use. Fieldprint Calculator shows farmers their operations versus the regional average across seven "sustainability indicators": greenhouse gas emissions, water use, energy use, water quality, soil carbon, conservation and land use. The tool has enabled some input about fertilizer application. Should its members wish to know how fertilizers impact the greenhouse gas emissions in their supply chains the website offers a comparison to state averages. At this time it remains unclear whether there is an opportunity to link the calculator to environmental markets.

Nutrient Tracking Tool (NTT): An initiative of Tarleton State University under funding from NRCS, NTT is designed to be used in evaluations of water quality in agricultural areas. As such, it does collect inputs that are relevant for carbon calculations, like information on nutrient applications and qualities of the soil. Adaptation for carbon markets is theoretically possible; the added benefit of this tool would be the ability to calculate not only carbon credits but water quality credits, which in theory may be stacked to increase potential revenue for nutrient projects.

The Sustainability Consortium Toolkit: The Sustainability Consortium is a private sector initiative developed to help product developers in a variety of industries improve the sustainability of their products across the product life cycle. It has developed a variety of toolkits which collect data for use by its members; one of these is a module for sustainability in agriculture.

Proprietary Tools: In addition to those funded by academia, government agencies and private sector partnerships, many companies have developed their own proprietary tools, which provide farmers information to help them plan fertilizer applications for a fee. Some eventually plan to offer information regarding nitrous oxide emissions as well; therefore, carbon project developers may see future partnership opportunities in the exchange of data for carbon revenue.

As noted in the Enrollment section, partnership with data collection services could result in a situation where farmers simply opt-in to having their information shared with an aggregator for the generation of carbon revenue. However, the existing tools currently occupy various stages of relevance to the carbon markets. Some may need to shift inputs to collect relevant data, and most would need to shift their marketing strategies to include the possibility of a carbon component to their value proposition.

One suggestion for an effective stop-gap for carbon markets is to partner with a tool that can offer not only collection of relevant inputs, but a streamlined method of doing so, such as mobile capabilities. This way, any farmer "opting in" to such a service would have a simple, mobile way to input the needed data, and this would be collected in a standardized way that was easy for the carbon markets to decipher and generate credit from. Actors within carbon markets should continue to explore these possibilities with existing data collectors, so that credits are easier to generate in the short term as well as the long term.

Problem: Unclear data ownership

One of the most interesting problems illuminated by the original Nitrace project was that of data ownership; in fact, most enrollment efforts to date are hampered by this. The carbon market believes (perhaps rightly) that at least some of the data it requires for nutrient crediting exists elsewhere in the agricultural market in some form. Farmers, their crop advisors, and fertilizer producers all need good information about the delicate balances between fertilizer usage and yield in order to do their jobs.

Because agricultural retailers make recommendations to farmers about the optimal use of fertilizers, these companies often do capture some data which would be relevant to carbon markets. However, this results in somewhat of a catch-22; with companies collecting this data, farmers do not need to keep in on hand—they can access it anytime—but the companies themselves cannot release this data to third parties (including carbon project developers) without express permission of the farmer.

This has led to a somewhat unique situation, wherein the proliferation of precision agriculture (the ability to make data-informed choices about particular farm inputs) is also raising questions about the ethics of data collection and who should ultimately own the data. While some believe it is acceptable for service providers to own it, most market experts we spoke to for this report believe that farmers are the ideal owners.

Recommendation: Clear ownership by the farmer under data collector/carbon market partnerships

While there is no inherent flaw with such a system—farmers should ultimately own and be able to use any data they generate—the challenge is to build systems which allow for farmer opt-in from existing tools, as suggested above, but still allow for an audit trail to be developed for the carbon market. In other words, though the carbon market is able to generate credit from "scrubbed" —or anonymized—data, it still needs to be able to trace credits to individual farms.

In theory, collection of data for the carbon markets should be a matter of increasing communication with those who already collect data (the private sector, government, academia and others) to inform these actors of what data is needed for credit calculation. A great deal of work will need to be done to achieve this, but collection of data is still less complicated than the step which comes after—storage.

3. Storage of data

Key Questions in this section:
How was this handled in other types of markets?
How would data be accessed by multiple stakeholders?
Where is data being stored right now?
Can we create intentional redundancies in data storage to defend against threats?

Market role	Risks	Who could do it?
Store data	• Liability if data reveals noncompliance with laws	• Aggregators • Supply Chain initiatives • Agribusinesses

	• Data security	• Equipment providers • Extension, CCAs and others • Government entities • Independent third party

It is storage—rather than collection—of data which poses the biggest unknowns to the agricultural offset market, because unlike some of the other stakeholders in agriculture, carbon markets rely on a traceable auditing system and demand that their data is stored for this reason. This is particularly important in compliance markets; for example, most California ARB protocols require projects meet stringent requirements for recordkeeping to ensure an audit trail in the case of an accidental reversal or incorrect calculation.

Problem: Very little storage currently happening for nutrient data

Until recently, the farmer's involvement in the management of their own data has been minimal. Most have only saved what they have regularly reported on. According to equipment manufacturers like Case, John Deere, Raven and others, precision agricultural equipment has only been capable of automatically storing data from field activity since approximately 2013. The rate of adoption has coincided with new equipment purchases and a portion of that information has gone unused and likely discarded for lack of interest. This is a problem for carbon markets, because credit calculation protocols demand the storage of at least 5-6 years of historical field data to establish a baseline condition for a project. If no one currently stores this data, this means the generation of credit from data beginning to be stored today could be 6-7 years away.

Recommendation: Advocate for inclusion of nutrient data in storage solution

The many and competing voices requesting access to individual farm data has led to the development of an array of options for farmers to capture, organize and utilize their own data themselves. Instead of relying on agri-business suppliers, they can with the help of internal third party applications, make planting, irrigation, and fertilizer application decisions in-house. Some of these tools are simple mobile apps that can be run from a pad or even a mobile phone. Other software applications integrate field data into operations and accounting at the enterprise level. It cannot be over-stated that farmers will continue to have greater control of both their data and how it is organized and put to use. This bodes well for increased precision in nutrient application because reliable datasets are becoming the norm. It is incumbent upon the carbon markets to ensure that the data being collected and stored are relevant for carbon credit calculations, and this requires consistent communication with companies developing storage solutions for agricultural data.

Problem: Storing data increases risk exposure

Storage of data could be done by a variety of different market entities, but is not a simple action. For example, in researching the potential for supply chain initiatives to generate their own credits from data collected from their suppliers, one large company pointed out that if they were to store data, it could expose them to liability should any of their suppliers be found to be out of compliance with a regulation or employing questionable practices. Large companies, therefore, generally do not keep this data but simply use it for their own purposes before disposing of it.

In addition, any organization charged with storing large quantities of data needs to deal with issues of data security and will be exposed to risk from data breaches. Therefore, it is critical that the entity charged with storage be familiar and comfortable with such risks, and that the system built for storage provides multiple levels of data security.

The nature of agricultural data is largely proprietary, but not necessarily as sensitive as data in other industries which have already begun to shift to sophisticated information management systems such as health care. Farmers need to know that their "proprietary formula" for high yields cannot be copied by other growers of the same commodity, and that none of the records generated are as personal as a physical exam. Also unlike health care, in which up to 150 users (practitioners, insurance agents, health programs and others) may need access to a single record, agricultural data would need to be accessed by fewer distinct users.

Recommendation: Find a storage provider that de-risks the storing of data for the whole market

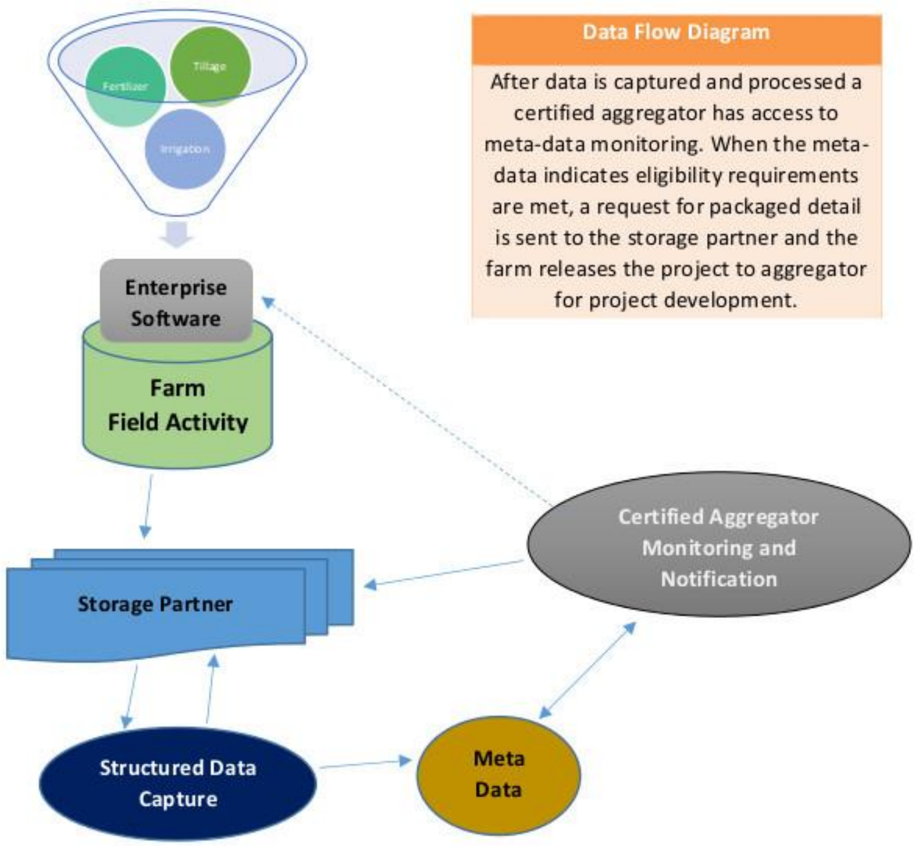
In the business world, data is a company's most valuable asset. There is rudimentary cloud storage available from many different vendors. Virtualization, extraction and analytics are available for infrastructure and shared resource situations. Once again, the healthcare industry is an example of a model of continuous improvement. Storage and all that entails has become a priority for the largest providers in the country. Providence, Partners in Boston and Kaiser Permanente are just a few who are investing millions of dollars outside their organizations to utilize industry specific data management resources such as Health Catalyst. The added security and range of specialized services are indicative of an industry that is leveraging data to large gains in accuracy, innovation, and cost savings.

Moving into the future with modern agricultural business practices, there is great opportunity for data storage companies. With the growing need for cloud storage and agricultural specific services that allow data management, ag-specific software companies are flourishing. At first, large-acre operations supported development of precision agriculture hardware and software tools. Gradually over the last few years, the increased awareness has spurred all manner of application software to appear on the market. These range from single purpose mobile solutions (for nutrient management and seed rate) to robust enterprise level systems that integrate field operations and field activity and accounting. The need for data storage will likely follow close behind.

Design elements of storage solutions in agriculture

For carbon markets to be able to properly interact with stored nutrient data, we propose the following flow diagram of an ideal storage solution. Data from farms is collected through enterprise software and is used to support on-farm decision making. A storage partner is selected to manage the structured data capture requirement, and the aggregator works both with this partner (to gain access to metadata) and with the farmer (to gain access to field-specific records which will aid in verification).

Figure 7: Data flow for nutrient management data storage



The project team spoke with many service providers currently collecting agricultural data, and compiled the following table to describe the types of actors best suited to each role within the data management value chain. Additional detail regarding software service providers and storage solutions appears below the chart.

Table 19: Managing data storage in agriculture, by market actor

Step	Value Chain Actor	Value Chain Activity	Specific Actors
1	Field	Field ID, Soil Type, Acre Size, Weather	Farmer, Landowner
2	Machine	Nutrient Application, Tillage, Irrigation	Equipment manufacturers
3	Local Network	Collect and store raw data	Local Area Network, Local cloud
4	Software	Establish eligibility, user alerts	Agricultural software service providers
5	Database	Save to local storage and cloud back-up	Local cloud, other web-based storage system
6	Data Manager	ETL, Mapping	Independent third party
7	Data Warehouse	Storage and backup	Independent third party, government database
8	Data Mart	Access to Data	Certified aggregator

Software

Multiple companies offer enterprise level farm management software to help track and manage field activities, manage inventories and analyze yields. These platforms connect the management of daily progress and the prediction of future opportunities. Utilizing cloud computing services, these companies are helping farmers benefit from accumulated data, pulling data from across platforms with less paperwork and fewer manual calculations to manage logistics and accounting. For many of these software providers, goals include helping producers with an eye on growth, and getting the most value from the data by applying a continuous improvement model to farm management. This includes building predictive models that turn the data into decisions.

These types of software providers are an important part of the agricultural data value chain and have the potential to be extremely helpful in the collection of data which can be turned into carbon credits; the combined value propositions of data-supported decision making from the software provider and revenue from carbon markets may be very attractive for farmers.

Storage

Perhaps the best recommendation for a storage solution for data relevant to carbon markets would be an independent and unbiased repository of farm data- an organization using existing data to help farmers benchmark themselves against others. Aggregating a farm's data with many others to create large sample indexed averages while removing anything that identifies specific farms would help assure farmers of the privacy of their proprietary information. By having the ability to network, aggregate and analyze multiple layers of data from all different formats, this storage solution could offer both input and practice analysis for comparative benchmarking.

It is possible that existing datasets could potentially be repurposed by the farmer to support access to carbon revenues. Based on interviews with software developers and industry analysts, the technology to collect this data is mostly in place. Such a proposition would require that carbon market actors and potential storage providers be aware of one another and keep an open dialog to best serve the farmer's needs.

The next step of reporting is largely dependent on the desires of the farmer. That is, the decision to offer the specific variables needed for project development in the carbon market relies on the farmer following through with reporting. Software developers must stay attuned to the needs of their users. As farmers have begun to indirectly leverage the data coming from the machines in their operation, they will see value in gained efficiencies in material and labor. The other data-value option is to directly monetize the information through automated reporting for engagement with the carbon markets. This trend will likely increase the demand from users and drive the development of the necessary reporting tools by software services.

Security

One of the key concerns which often arises for farmers, equipment providers and others who work with agricultural data is, if the data is to be stored somewhere, how can its security be assured? An ideal model of data storage includes a "storage partner"—an entity entrusted with the security and usefulness of data collected. To manage this effectively, this partner should have experience with security; here, we list some of the ways to ensure security of data in a storage system:

- Two–step authentication
- Redundancy; multiple copies of data
- Distributed storage; multiple copies stored in different geographic locations
- Employee screening and background check
- Data encryption at transfer points upstream and downstream
- Encryption keys kept on a central server
- History of any data loss or breach of the system and fault improvements to prevent same failure

Problem: Disparate motivations leading to complex management solutions

As mentioned in the Data Collection section, agriculture's stakeholders each have very different reasons for collecting data. Likewise, they have very different reasons to access the data of others—this leads to a situation under which it is crucial to define which stakeholders can access which kinds of data from any integrated management system. In other industries, this has largely been resolved through a system of unique access codes, which allow different stakeholders to see only the information relevant to them (and not to edit data so as to render it unusable to others).

Recommendation: Limited access for various stakeholders to limit the potential for security breach

The most common way to prevent the breach of data from large-scale storage systems is to create a system where individual stakeholders have only the level of access they require. For some in agriculture, this might be granular, field level data (farmers and crop advisors), while for others it may mean metadata on particular aspects of farm management (supply chain initiatives or government agencies).

One example of this type of system in action is CITSS, the Compliance Instrument Tracking System Service, administered by the California Air Resources Board to track transactions between compliance entities who may sell and purchase allowances from each other for compliance with the state's cap and trade program. Each entity wishing to transact in CITSS must apply for an account, and accounts are tied to specific individuals within firms to add a level of accountability in the case of fraudulent activities.

While there are no transactions per se in an agricultural data storage system, the same principles of data security could apply: individual accounts, with particular access codes, which allow access to particular pieces of data within the system. To further explain what this type of system might look like for agricultural data management, we have created a chart, available in Appendix B.

4. Protocol risk

<u>Key questions in this section:</u>
How can we get the protocols to meet the rest of the agricultural sector halfway?
How much expertise does it really take to process carbon data?
Should this be handled centrally (by an aggregator) or distributed (by individuals in companies who own data)?

Market role	Risks	Who could do it?
Process data (use protocols to calculate estimated credits)	• Understanding of protocol inputs • Data processing system consistency	• Aggregators • Individual Carbon Market Experts

To be able to generate offset credits from nutrient management, project developers need to be familiar with and able to use credit calculation protocols. This is no easy task. Because they are developed by teams of scientists, market specialists and others to ensure the validity of their calculation methods, protocols can be dense reading—anywhere from 45 pages in length (for ACR-MSU-EPRI) to 138 pages (for CAR-MSU-EPRI).

In many ways, protocols lie at the heart of the market's current difficulties in getting agricultural offsets to scale, because there are two primary philosophical approaches to protocols which require a delicate balance:

1) *Rigorous protocols are needed to be able to prove the validity of emission reductions from nutrient management practice changes.* Advocated by carbon market experts, this viewpoint maintains that farmers must provide certain information in order to calculate the amount of credits they can receive, and that this information is driven primarily by the protocol writer's knowledge of the best available science.

2) *Carbon markets should make protocols as easy as possible to use.* Typically advocated by those outside of carbon markets, this perspective asserts that it is the responsibility of protocol developers to prioritize ease of use when developing protocols for emission reductions from nutrient practice changes.

Truly, both philosophies are correct, and this has led to a situation under which protocols developed for ease of use see faster rates of adoption, even if the more scientifically rigorous method is capable of producing higher credit volumes. Ultimately, greater cooperation is needed between the carbon markets and other agricultural stakeholders, to decide on an appropriate balance between scientific rigor and usability, and to ensure that farmers are able to capture value easily from a variety of practice changes.

Anatomy of a protocol:

Typically, there are six "building blocks" common to credit calculation protocols; depending on the standard with which the protocol conforms, each of these can get quite detailed.

- Applicability: To which areas/crops/greenhouse gases/practices the protocol is intended to apply
- Eligibility: A list of requirements to which a project must conform to be eligible for credit
- Baseline procedures: Methods for calculating the baseline by which the project will be measured; there are typically more than one, as projects may be missing some records for their baseline inputs
- Credit calculation methodology: A series of equations which, when completed, give an estimate of possible credits from the project; this is where lists of inputs are derived.

- Monitoring requirements: The standard's requirements for recordkeeping, which usually appears as a list of "monitored parameters"
- Verification requirements: Any requirements for verification that are specific to the protocol

Working with protocols often requires a high level of technical ability, as well as a good working relationship with the standards which develop them in case questions arise. While it is possible to develop calculators which can accept inputs from projects and provide credit estimates, few have been built to date, and the need to ensure qualitative aspects of projects such as eligibility means that project developers have work to do beyond the calculation itself.

Within the context of this complexity, what follows is a discussion of some of the major flaws with project protocols, and recommended next steps to resolve these.

Problem: Lack of real-world information about credits/acre

As only two nutrient credits have been successfully retired, and those two were produced under one of four possible calculation protocols, very little real-world information exists about whether the credits/acre estimates that have been compiled by experts hold up under the circumstances of real-world projects. In the Ducks Unlimited ACoGS project example discussed earlier, the credits per acre generated by the project fell short of projections, causing much consternation among the organizations involved. These types of events are common among nascent sector pilot projects, but are valuable and sometimes necessary to provide better estimates in the future. The challenge is that they also increase perception of project type risk for investors.

Recommendation: Government backing for pilot programs

To get nutrient crediting to scale, at least a few successful pilots will have to be completed to offer proof-of-concept with respect to the generation of credits. USDA conservation funding through the Farm Bill already incentivizes the creation of nutrient management plans. Additional efforts are needed to provide funds for the creation of nutrient credits in the form of grants, low interest loans, or by making carbon project activities eligible for conservation funding opportunities through EQIP or other programs. Possible targets for this funding include pilot projects which can confirm crediting rate estimates, testing of aggregate projects, and development of data systems that are easily accessible by carbon markets. In return for these funds, project developers should agree to provide feedback on the improvement of nutrient crediting protocols that can aid in the development of systems for scalable nutrient crediting.

Problem: Protocols may be too prescriptive

While rigor is a definitive advantage to the carbon offset market, there is an inherent mismatch between the level of rigor in this market and in the rest of the agricultural commodity sphere. To illustrate this point, Figure 8 lists all the inputs needed to calculate credits from the four existing calculation methodologies. While some weather and soil data may be available by accessing government databases, most inputs require field-specific knowledge.

Figure 8: Inputs required for carbon calculation protocols

Crop type	GPS Location
Acres	Land use type
Baseline practice	Clay content
New practice	Bulk density
Organic fertilizer type(s)	Soil pH
Synthetic fertilizer type(s)	SOC at surface soil
Fertilizer application dates	Soil texture
Planting dates	Slope
Harvest dates	Depth of water retention layer
Mass Organic N fertilizer applied, Solid	High groundwater table
Mass synth N fertilizer applied, Solid	C/N ratio of the grain
N content organic, Solid	C/N ratio of the leaf & stem tissue
N content synthetic, Solid	C/N ratio of the root tissue
Annual potential evapotranspiration	Fraction of leaves, stem in field post-harvest
Annual precipitation	Number of tillage events
Mass Organic N fertilizer applied, Liquid	Date of tillage events
Mass synth N fertilizer applied, Liquid	Depth of tillage events
N content organic, Liquid	N fertilizer application method
N content synthetic, Liquid	Time release fertilizer
Mass organic per gallon fertilizer, Liquid	Nitrification inhibitors
Mass synthetic per gallon fertilizer, Liquid	Organic amendment C/N ratio
Width of area covered by operation equipment	Number of irrigation events
Average speed of equipment	Date of irrigation
Horsepower of equipment	Irrigation type
Yield	Irrigation application rate

Key:

Required by all protocols

Required by CAR-MSU-EPRI only

Required by ACR-DNDC only

Due to its need to collect field-specific inputs to generate credits, the carbon market's ability to track practice implementation at the field level currently outpaces that in the rest of the agricultural market. For example corn, which is processed in aggregate and sold wholesale, cannot currently be traced back to its farm or field of origin. For partnerships like those in Table 17 to be effective, both the carbon market and agricultural sector at large need to agree on a level of sustainability rigor within the supply chain that is both acceptable and usable to all. This means striking an appropriate balance between data that is collected at field level and data which can be gathered elsewhere.

Recommendation: More fully develop credit calculation approaches based on regional inputs

Both ACR-MSU-EPRI and VCS-MSU-EPRI allow for the use of "common practice" baselining; that is, regionally-specific, rather than field-specific, data may be used to prove the baseline condition when field-specific data does not exist. This information comes from the National Agricultural Statistics Service (NASS). Similarly, ACR-DNDC uses common practice baselining for some project circumstances. The use of common-practice baselining serves as an important stepping stone for the carbon market; most methodologies require 5-6 years of historical data to establish the baseline condition prior to project implementation, and many farmers may not have records reaching back that far. Until it is proven that farmers can produce this much field-specific information on demand, further development of the protocols is needed to ensure that common-practice baselining is appropriate and easy to use.

Common practice baselining may also be greatly aided in the future by establishing regional-specific emission rate tables. Existing protocols for forestry include regional emission factors based on ecoregions or "super sections", larger portions of land assumed to share similar characteristics with respect to soil type, weather patterns and more. These lookup tables can be used to make very conservative estimates of available credits per acre, which are typically then modified if the land undergoes a full inventory.

Agriculture could use a similar approach. USDA already gathers information on soils, weather and a host of other inputs valuable to carbon calculations; if these could be used to distill basic conservative emission factors for certain regions, much of the work to estimate the baseline condition of any one field would already be done. Conservative emission factors would, of course, lead to conservative numbers of credits, so any farmer or project developer who wanted to capture the full carbon value of their project could opt to model the carbon reductions themselves using a model like DNDC.

Problem: Carbon market experts need manageable operating budgets

Nutrient management project developers, or aggregators, as we know them today, have risen in response to a unique challenge—bridging the gap between owners of agricultural data and the value that the carbon market can provide. This is an extremely potent value proposition, but also unfortunately all-inclusive—aggregators have accepted responsibility for everything from landowner engagement to commercialization of credits, stretching already tight budgets thin and increasing their own exposure to both delivery and market risk.

The lynchpin in the process of connecting carbon revenue to the agricultural landscape at-large is understanding of carbon market protocols. Owners of data may have a variety of motivations for collection—compliance with state and federal regulation, data-supported decision making, or to back up sustainability claims. Rarely are owners motivated to collect data solely for carbon revenue. Therefore, an expert who can explain the value of carbon credits and process the data accordingly is an asset to the market; making aggregators the ideal entity for this task.

Recommendation: Narrow the project developer's focus

Working in concert with other recommendations contained in this report—automatic enrollment, streamlined data collection, and subsidized verification—this section attempts to describe the most appropriate role for the project developer/aggregator. As stated, this role can become nearly unmanageable given the nascent nature of the nutrient crediting market, and must be clarified within the context of the credit generation process to ensure the best results for the market.

Table 20 describes one such scenario. On the left, we revisit the credit generation process and note that the aggregator is capable of all but one step: purchasing credits. On the right, we narrow the focus of the aggregator to only three actionable items: receiving data, processing data, and working with partners to generate the credit. The process on the right describes distributed risk—a key ingredient missing from current discussions about roles within the nutrient crediting market.

Table 20: Narrowing the focus of aggregators

Market role	Who could do it?		Market role	Who does it
Enroll farmers	Aggregators Supply chain initiatives Agribusinesses Equipment providers Extension, CCAs and others		**Enroll farmers**	Farmers automatically enrolled by selecting "opt-in" with a commodity buyer or equipment software developer
Collect data	Aggregators Supply Chain initiatives Agribusinesses Equipment providers Extension, CCAs and others		**Collect data**	Data is collected directly from onboard software on spreading equipment and uploaded to a storage system
Store data	Aggregators Supply Chain initiatives Agribusinesses Equipment providers Extension, CCAs and others Government entities Independent third party		**Store data**	Data is stored by a trusted organization; stakeholders have access via secret code
Process data (protocols)	Aggregators Individual Carbon Market Experts		**Process data (protocols)**	Aggregators are allowed access to data and manage the process of calculating credits. They work with verifiers and registries to ensure all steps are completed to the market's standards, and use their status as "preferred provider" to sell credits to a broker
Pay for verification	Aggregators Supply Chain initiatives Agribusinesses Equipment providers Government entities		**Pay for verification**	Verification is subsidized by government, or the private sector in the form of a corporate grant
Market credits	Aggregators Supply Chain initiatives Agribusinesses Equipment providers		**Market credits**	Credits are marketed by a broker
Buy credits	Corporate Social Responsibility programs Government entities Compliance buyers		**Buy credits**	Credits are purchased by compliance or voluntary buyers

By narrowing focus in this way, the aggregator is able to perform within a larger market context, and no other market actor finds itself taking on excess risk.

5. Verification expenses

<u>Key questions in this section:</u>
What can be done to data to make verification easier and less expensive?
Are there technology solutions to simplify the verification process?
How do we find the proper balance between rigor and expense with the registries?

Market role	Risks	Who could do it?
Pay for verification	• Expense	• Aggregators • Supply Chain initiatives • Agribusinesses • Equipment providers • Government entities

The carbon markets are characterized by a much higher degree of scrutiny than other environmental markets. Due to a few bad actors who have claimed reductions for questionable practices, many policymakers and others of influence have derided offsets as being a pay-to-pollute system. In reality, the very scrutiny placed upon offsets has the consequence of acting as a barrier to entry to new project developers in the nutrient management sector. The cost to verify emission reductions from any single field is simply too high to be cost effective, but still makes up a significant portion of the project development costs.

In turn, companies attempting to aggregate fields together to reduce this expense are finding that the barriers discussed earlier regarding enrollment and data fragmentation prevent the easy collection and processing of data from multiple fields. Verification, while absolutely crucial to proving emission reductions have occurred, is complicating the process of attempting to scale projects.

Problem: Verification is complicated, and this increases its expense

To better understand the expense associated with verification, the project team spoke with verifiers for this report. Verification expenses can vary drastically from project-to-project; understanding the factors which impact these costs can help the market to identify ways to make verifications less expensive. Some of these factors include:

> **Size of the project:** The more credits a project will produce, the greater the cost to verify these reductions. This is because larger volumes of credits are typically associated with multiple fields, and many of the existing protocols demand verification of all fields rather than random sampling.
>
> **Locations:** If a project consists of multiple fields across many geographic areas, traveling to each for a site visit can increase the cost paid to a verifier.
>
> **Experience of the developer:** Developers who have worked with carbon projects before are typically better prepared for verification than those who are new to the market; they are familiar with the process and can streamline the collection and storage of data to make it easy to verify.

Data formatting: Collection can be done in multiple ways, from handwritten notebooks to complicated software systems. The more standardized the data is when collected and stored, the less time the verifier will need to spend tracking down missing pieces.

Protocol complexity: The more inputs a protocol requires, the more time it takes to verify that calculations have been done correctly.

Experience of the verifier: Some projects use the same verifier for each crediting period; once the first verification has been finished, the verifier becomes more familiar with the project and its developer, and is able to complete subsequent verifications in less time.

Only one verifier has ever worked with a nutrient project, making it difficult to pinpoint an exact price range for this development expense. However, verifiers we spoke to claim the price of verification on a moderately sized project (20,000 acres) may vary anywhere from the low tens of thousands of dollars to upward of thirty thousand, depending on the factors above. The most important factor appears to be the number of individual farms enrolled in a project, as the current fragmented state of data collection ensures added complexity for a verifier the more farms are enrolled.

Currently, verification expense is typically paid by the project developer/aggregator and makes up one of the most significant portions of the budget for a project. If the project developer is also engaged in farmer enrollment, data processing and credit commercialization, its budget may easily cross into unsustainable territory. There are two possible routes around this barrier, both of which may be, and should be, pursued at once.

Recommendation: Decrease verification expenses through economies of scale

The first route is to make verification itself less expensive. This can be done through development of protocols which are scientifically sound yet easy to verify, and by using new ways of collecting and processing data which assure compliance with these standards. The project team recommends that standardized data collection be employed for nutrient management data, that records be collected directly from the onboard software of application equipment, and that farmers retain ownership of their data by "opting in" to sharing with carbon project developers. More research is also needed on verification expenses for a variety of different project size scenarios. Our conversations with verifiers suggest the cost differential for a project enrolling a few farms and a project enrolling many farms may be over $10,000, but the market would be greatly aided in understanding the nuances of these expenses in more detail.

Recommendation: Technological solutions

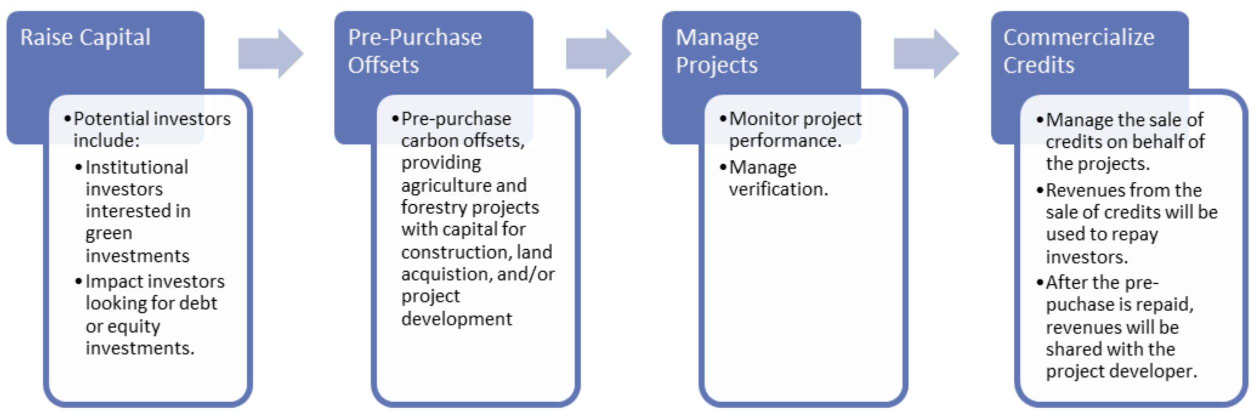
Conversations are already underway within the carbon market about ways that technology could speed up the process of verification. Remote sensing, for example, has been brought up as a way to verify reported irrigation of rice paddies under the new ARB Rice Protocol. While it is too early to say how useful these technologies could be for nutrient management, potential exists for further study of the topic.

Recommendation: Carbon Investment Management Organization model

The second tactic for mitigating verification expense is for someone other than the farmer or aggregator to pay for verifications, and this is where an innovative new model may be able to provide an alternative. As The Climate Trust has proposed for its new business model, the concept of a Carbon Investment Management Organization helps to overcome this barrier. Under the model, some portion of the eventual credit value is collected from investors and paid to the developer upfront to be used for project development expenses (for nutrient management, these would include verification, validation, and registry fees). The CIMO would help ensure the credits are generated and find a market, and revenue would be used to repay investors and provide revenue share to developers.

This model removes delivery and market risk from farmers and aggregators, and shifts the burden to an independent third party with experience evaluating, supporting, and transacting with projects. Figure 10 illustrates the model in action.

Figure 9: The CIMO concept



There is, however, a large challenge in making the CIMO concept work for nascent sectors such as nutrient management. In order to repay investors, the model needs to be sure that credits will reach the commercialization stage. Lacking the proof of concept provided by successful pilot projects, there is still too much delivery risk in the form of uncertainty around protocols and credit calculations to be sure that this sector can repay its investors. Therefore, there would seem to be a sequence of events which must occur before the CIMO becomes a useful model for this market:

- Step 1: More small-scale pilot projects need to be done to prove the credit calculation methodologies
- Step 2: Verification for these pilots is subsidized by government or the private sector in the short term, to ease the burden on project developers and prove credits/acres from projects
- Step 3: Project developers create systems capable of capturing and processing data from larger-scale projects
- Step 4: Farmers are enrolled by touting benefits received by pilot farmers
- Step 5: CIMO offers pre-purchase of credits from scalable projects and subsidized verification is no longer needed.

Recommendation: Carbon Markets and Sustainability Certifications may be a natural fit

The short-term subsidy of verification may be best handled through government programs like EQIP or CSP. However, one other option remains: large corporations which are trying to make supply chain sustainability improvements. As discussed in the Enrollment section, these companies could potentially serve as a source of data for the carbon markets. Likewise, they could provide demand for carbon emission reductions from agriculture by way of third-party sustainability certifications. The structure of such certifications provides clues as to how this could be achieved.

In Europe, the International Sustainability and Carbon Certification (ISCC)[20] is a body which provides certification to a variety of product types. ISCC publishes a library of checklists which can be used to validate sustainability claims made at various points along a product's supply chain, from raw inputs to final sale. Companies who wish to pursue certification pay a membership fee to ISCC and hire an approved third-party certifier to audit their inputs. Once certified, the certification travels with the product to all subsequent stops along the supply chain.

ISCC does have a carbon emissions component in addition to the other things it measures such as social sustainability, but the inputs required for certification are far less strict than those required by the US voluntary carbon markets. Though several sustainability certifications exist in the US for raw inputs such as sugarcane and cotton, the US has no market-wide equivalent to the ISCC.

One of the key questions for any company that is considering setting, or has set, sustainability goals for its operations or supply chain is: how can we be sure that the claims we make are valid and therefore decrease our exposure to reputational risks? This question is especially complex for food and beverage companies that want to ensure sustainability of certain inputs, because these inputs are almost always purchased in bulk. An opportunity exists, therefore, to begin conversations between carbon markets and sustainability certification services and develop compromises that benefit both. Field by field sustainability certification is impractical for agricultural commodities, but there may be a way to adapt carbon protocols for use in this type of supply chain while keeping the credibility of third party certification intact. Carbon is rarely the primary motivation for seeking a sustainability certification in the US, but if it can be proven that operations within the supply chains of large corporations have a carbon benefit, the cost to verify emission reductions may be bundled within the costs of larger sustainability certifications. This has a twofold benefit of setting up a system for the short-term subsidization of verification expenses while remaining an option in the long term as well.

It is important to note here that only 10% of corn produced in the US is used for human consumption[21]; animal feed operations and the ethanol industry use over 30% each. Therefore, it is not only the food and beverage industry which could benefit from proving their corn is produced in a low-carbon way. These industries have been largely overlooked by the carbon markets to date, but should be engaged with equal intensity to ensure low-carbon corn production throughout the US market.

Market Risks:

Market risks can be described as factors which are largely outside the control of a project developer which can impact the success of their project, such as sudden economic and political shifts. However, there is one major market risk which could be alleviated for nutrient management—the risk that there is no market (buyer) for credits. This depends on the near-term ability to market credits to voluntary

[20] More information about this certification is available online at: www.iscc-system.org
[21] "Water and Climate Risks Facing US Corn Production", Ceres 2014.

buyers, and the long-term ability to create demand from compliance buyers for nutrient credits. We discuss these topics in more detail below.

6. Marketing

<u>Key questions in this section:</u>
How do we successfully market nutrient credits to buyers?

Market role	Risks	Who could do it?
Market credits	Understanding of carbon markets	• Aggregators • Supply Chain initiatives • Agribusinesses • Equipment providers • Brokers/speculators

There are currently three potential types of buyers for offset credits in the North American market, each with a very different set of circumstances which would cause them to purchase credits:

Compliance Buyers: Compliance buyers are companies with operations that are covered by a regulation (usually a carbon cap), that purchase offsets for a portion of their obligation to the regulatory agency which implements the regulation. These buyers are motivated by a need to meet their compliance obligation at the lowest cost. They may or may not have preferences regarding the project types they purchase credits from, but in most compliance systems only a few project types are allowed.

Public Sector Buyers: Government agencies may purchase offsets to meet internal carbon reduction goals or simply to provide certainty to emerging markets. However, while many federal agencies have made investments in Renewable Energy Credits (RECs), none have yet made the jump to carbon credits due to the added complexity of the credit generation process for offsets.

Voluntary Buyers: Voluntary buyers are typically large organizations—companies, schools, etc. —which have internal goals for emission reductions. They use offsets to meet some portion of these goals; typically for an emissions source over which they have less control, such as emissions from supply chain operations or corporate travel. These buyers are motivated by a variety of factors, from simple cost, to carbon project co-benefits, and therefore their buying habits are more difficult to predict than those of public sector or compliance buyers.

The Climate Trust has considerable experience in marketing to voluntary credit buyers; combined with the CIMO model, this is where The Climate Trust believes it can provide the most value to the nutrient crediting market. Voluntary buyers look for providers who can supply:

- Sufficient volume to meet the credit demand of the buyer
- Preferential credit vintages—most buyers prefer to buy credits from the future years of projects
- Favorable project types and locations which fit the strategic objectives of the buyer; often, buyers will look for projects in the areas where they have operations
- Standardized contracts which protect the buyer from risks associated with under-delivery of credits and ensure that no credits are double-counted
- Transparency into the credit generation and delivery process

- An accounting of any benefits beyond carbon mitigation of interest to the buyer
- The carbon market experience and savvy to navigate unexpected shifts which can increase delivery or market risks, and a credit buying relationship that can be maintained over time

As was the case with the Ducks Unlimited Avoided Conversion of Grasslands project, voluntary buyers are often attracted to project types that are less established. This provides the buyer the communications advantage of being able to claim to be one of the first to invest in something new. Of course, buyers are also very uncomfortable with risk, so these “first-mover” purchases are contingent on the ability of the seller to prove that a sufficient percentage of these risks have been mitigated.

Problem: Insufficient focus on offsets as a more cost-effective option

From voluntary buyers, sellers hear time and again the importance of cost; more specifically, buyers often claim they don’t have “the budget” to buy offsets. It’s likely that this claim is a valid one. For one thing, offset sellers most often approach a company’s sustainability team to make a sale. This person or people often have a very small budget with which to make significant positive changes, and often this budget comes from a philanthropic wing of the company. Furthermore, the types of projects typically associated with reductions in carbon emissions are often engineering solutions: installing solar capacity, putting in a carbon capture and storage system, or switching to high-efficiency fixtures or equipment. This means that decisions about purchasing carbon offsets are not made in a vacuum; rather, each offset project is weighed against each engineering solution in terms of price and environmental impact. A bundle of offsets from a nutrient management project may be in direct competition with a solar installation.

Recommendation: Standard offerings which place offsets in a broader price context

The best way around this barrier is to have a standard price offering for credits. In forestry, anaerobic digestion and other compliance-eligible sectors, this has been mostly achieved; the market has a reasonable expectation of the price range these projects can expect to fetch. The typical price of nutrient management credits has yet to be established. However, once it is, nutrient management can take advantage of a benefit already available to mature sectors: the ability to place this price in context with other possible carbon reduction solutions. Offsets can cost less per ton reduced than other options in many cases, and this represents a major selling point to companies wishing to achieve low-cost reductions.

Problem: Unclear boundaries between market actors with respect to marketing

Much like enrollment, marketing credits can in theory be handled by any number of market actors, and this all depends on who generates the credit. There are aggregators, who specialize in protocols and interaction with the carbon markets. There are also supply chain initiatives, agribusinesses, and equipment providers who, if they had the desire and proper information, could generate credits from information produced by their suppliers or customers and market them—if the intent were to retire these directly.

Recommendation: Offset brokers

The sale of credits works best when managed by an organization which understands both the complexities of the markets and the needs of buyers. This is why, with a further division of labor that continues to spread the risk, there may still be a role in the market for offset brokers. The addition of brokers carries one additional benefit: depending on the broker, the target market could be anyone from Fortune 500 companies to individuals wishing to offset small events and travel. This opens up possibilities for additional markets for offsets, particularly in nascent sectors such as nutrient management.

7. Purchase

Key questions in this section:
What risks does purchasing offsets pose to the buyer?
How can these risks be mitigated?

Market role	Risks	Who could do it?
Buy credits	Underperformance Contracting	• Supply Chain initiatives • Government entities • Compliance buyers • Other voluntary buyers

Problem: Market risks need to be mitigated to ensure successful purchases

Once a buyer has been identified, risks may still remain for both buyer and seller—particularly if the credits have not yet been verified. Many buyers are hesitant to take on delivery risks, so these must usually be managed by the seller. There are typically two ways for buyers to handle this situation. The first way is to structure a buyer contract which allows for the delivery of replacement credits from a different project if credits from the intended project do not materialize in the volumes expected. While this places added risk on the seller to find these replacement credits-particularly when the buyer demands that these replacement credits are similar to the original credits—this risk can be more manageable if the seller has experience in managing portfolios of projects.

The second option is to structure the purchase and delivery of credits as “unit contingent.” Most deliveries tend to be “firm” —meaning, the buyer requires a certain volume of credits to be delivered at a particular time. In contrast, a unit contingent delivery means that the buyer will accept delivery of credits with no minimum volume requirement. Unit contingent deliveries remove some pressure from the seller, but buyers who accept this type of delivery typically request lower prices per credit as there is no guarantee of a significant volume.

Beyond delivery risk, it is at or directly after the point of sale when concern for market risks needs to be addressed. Market risks vary in scope and severity, and are typically less predictable than delivery risks, making them more difficult to mitigate. A partial list of these risks may include:

- *Unexpected impacts to credit prices in the carbon markets.* Most market actors, whether voluntary or compliance, tend to use compliance prices as a yardstick by which to measure credit purchase offerings. In some markets these prices are high (as in California) while in others they are much lower (as in the European Union). Many things can impact these prices, including sudden changes in demand for transportation fuels, events which invalidate previously generated credits, and supply/demand balances.

- *Changes in policies which impact a project's ability to generate credit.* Such changes may include the adoption of policies or incentive programs which mandate a particular project type; in these cases the project would no longer be eligible for carbon revenue. Because the carbon market for nutrient management credits relies on voluntary practice adoption, if these changes in nitrogen application practices become mandatory, their value on the carbon market will be lost.
- *Interplay with other revenue sources for the project.* As mentioned earlier, a farmer's desire to participate in an aggregated nutrient management crediting program tends to be influenced by the price of the crop in any given year. In years where corn prices are high, farmers may not feel the additional revenue from carbon is necessary to them, but in years where corn prices are low this additional revenue stream can mean the difference between profitability and barely scraping by. Therefore, the price of corn itself may be seen as a market risk to carbon projects, as it will be a determining factor in the success of enrollment.
- *Timing of credit delivery.* In nascent credit markets like nutrient management, the sheer novelty of the credit generation process impacts the length of the project timeline; the sector simply hasn't developed many of the programs and processes that cut down on the credit generation timeline in more mature sectors. Therefore, another important market risk is that while the sector is still new, projects will not meet their contracted delivery due dates.

Recommendation: Buyer due diligence

A myriad of considerations await buyers who wish to purchase offset credits. For companies with established offset purchase programs, the following questions are typical to ask of sellers of credits. These same considerations are also a best practice recommendation for companies only beginning the process of establishing an offset purchasing program:

☐ Is there sufficient volume for our needs?
☐ Is the price commensurate with the volume and the risk?
☐ Is the project additional (is it beyond BAU and not required by law)?
☐ Is a credible protocol being used?
☐ Has the project been verified or are there plans for verification?
☐ Is the project description clear, including a clear change in practice?
☐ Is the carbon revenue considered in a broader context of project financing?
☐ Is a delivery schedule provided?
☐ Is the counterparty reliable and/or experienced in project development?
☐ Is the project a good fit for internal company goals?
☐ Does the project demonstrate benefits beyond a carbon reduction?
☐ Are there any reputational risks which would arise from funding the project?
☐ Are the credit calculations provided, and are they sound?
☐ Is the counterparty financially stable?
☐ Are the contracts between the landowners and counterparty appropriate?
☐ Is there a clear accounting of ownership of the land?

In addition, buyers commonly request additional records from sellers, to validate the answers to many of these due diligence questions:

☐ Company financial information including credit scores
☐ Information on company structure
☐ Example landowner contract
☐ Locations and sizes of fields
☐ Any credit calculation estimates
☐ Project design document(s)
☐ Project financing information

Recommendation: Follow best practices for contracting

For buyers, the primary goal is to ensure that the project is a good investment, and that if risks exist, mechanisms are in place to act as a failsafe. Emission reduction purchase agreements (ERPAs) fill this need for both buyers and sellers. These contracts outline specifically which party will accept which risks, and provide assurance of a working relationship which will be based on mutual risk reduction for the life of the project. Nutrient crediting, as a nascent sector, will likely require lengthier contracts until a certain scale is achieved, and will likely need to meet certain market regulations if it eventually becomes a compliance sector for the California Air Resources Board.

Every ERPA contains the terms of offset delivery which are agreed upon by both buyer and seller on the date of execution. There are two primary delivery structures found in most ERPAs, firm and unit contingent delivery.

Firm delivery: The seller is expected to provide a certain volume of credits at a certain point in time for a certain price. Firm delivery contracts generally include underperformance provisions, a set of requirements the seller is expected to meet should the project not deliver the anticipated number of credits. These may include:

> Replacement credits: Credits from another project managed by the same developer, or purchased by that developer to fill the delivery shortfall. Most buyers look for replacement credits that are of similar type and quality of the original offsets purchased, and replacement credits are delivered for the same price as the original credits.
>
> Claw back provisions: Before a project is even contracted with a buyer, that buyer must perform some due diligence to confirm that the offer is valid and to negotiate a potential purchase contract—an expense commonly referred to as transaction costs. In the case that the project produces fewer than expected or no credits, a provision is sometimes included which allows the buyer to recuperate their transaction costs from the project developer. Claw back provisions can also be used in instances where credits are prepaid by the buyer. If the project fails to produce these credits, the buyer may request the full purchase price back, or some percentage in the form of a per-credit penalty charge.

Unit contingent delivery: The buyer agrees to purchase credits from a project but the consequences associated with under-delivery are removed; instead, the buyer will purchase the credits from the project even if there are fewer than expected. Most unit contingent delivery contracts are also pay on delivery contracts (more on this below) to protect the buyer from the risk of upfront payment on an uncertain number of credits.

In addition to there being two kinds of delivery structures, there are also two kinds of payment structures, milestone and pay on delivery:

Milestone: The buyer purchases credits from the project at predetermined "milestone" points in the project's life cycle. For nutrient management, these milestones may describe the process of ramping up the number of acres enrolled in the project over time. Each new milestone reached triggers a new payment from the buyer.

Pay on Delivery: This type of purchase structure is common for nascent sectors, or projects which carry heavy delivery risk. It means that the buyer will only pay for credits that have been successfully delivered, so the onus is on the developer to produce credits at the expected volume if they wish to capture the full value of the contract.

To develop pilot projects for nutrient management in the voluntary markets, the most likely combination of contracting provisions is a unit contingent delivery structure paired with a payment on delivery. This combination works best in scenarios like the Ducks Unlimited ACoGS example, where a voluntary buyer wishes to purchase credits but the protocol is untested.

Recommendation: Understand invalidation risk if operating in the California compliance market

For California Compliance Offsets (CCOs), a group to which nutrient credits may eventually belong, an additional market risk to buyers comes in the form of invalidation. ARB reserves the right to invalidate credits which have already been generated and verified for three reasons:

1. If there was a material (greater than 5%) overstatement of credits
2. If credits are double-counted or,
3. If the project violates a local, state or federal law or regulation.

The market is generally very good at ensuring that credits are properly calculated and accounted for, which makes these risks fairly minimal. The violation of laws and regulations is of particular concern to projects in the agricultural sector. As the market learned in 2014 during the investigation of ozone depleting substances (ODS) credits produced at a facility in Arkansas, even regulations which do not directly impact the generation of credits can be cause for the invalidation of a project, and farms are subject to a myriad of local, state and federal laws. For this reason, it is important for those developing projects under any eventual agricultural ARB methodologies to understand ARB's offset issuance systems.

Projects come with an 8-year window during which issued credits may be invalidated by ARB. Projects which undergo a second verification by a different verifier for the same credits can reduce this window to 3 years, and credits that make it through either their 8 or their 3 year window may no longer be invalidated. Credits from projects under the 8-year invalidation window are known as CCO8s, while credits from projects under a 3-year invalidation window are known as CCO3s.

Pursuing CCO3 status through a second verification is a recommended way for projects to reduce their invalidation risks, but the cost of undergoing a second verification may be prohibitive. For buyers, the question of whether to purchase CCO8s or CCO3s largely depends on the perceived balance of risk versus cost; while CCO3s are safer from a risk management perspective, they also trade at a premium. Companies who are comfortable with the idea of procuring replacement offsets at some point in the event of an invalidation may prefer to purchase CCO8s at the lower price.

Modeling market risks

Aggregated nutrient management pro forma: Scenario analysis

To better understand the interactions among the factors that contribute expenses and revenues to aggregated nutrient management programs, the project team built an interactive excel spreadsheet[22] which provides revenue estimates based on changes to several key inputs. Here, we outline these inputs—and some key assumptions used within this model—and use them to provide revenue projections for a variety of project size and development cost scenarios. We have used extremely simplified and conservative assumptions for our analysis; the model is meant to be adjustable based on real-world estimates of the input values.

Seven inputs to the model can be adjusted:

1. *Project size, in acres*

2. *Crediting rate*[23]

3. *Carbon price scenario*[24]

This cell is a dropdown menu, from which any of four pricing scenarios may be selected:

Voluntary average price: The average price for which voluntary credits sold in 2014—according to Ecosystem Marketplace's annual State of the Voluntary Carbon Markets report—growing at a 2.5% inflation rate. Begins at $5.90/ton in 2015 and grows to $7.55 in 2025.

Voluntary high price: An estimated price paid by a motivated US voluntary buyer for high-quality, charismatic credits, unchanged with inflation. Begins and ends at $11.00/ton.

Compliance floor price: This scenario calculates the California Carbon Offset (CCO) price by taking the floor price of the California Allowance (CCA) and discounting it by 28%, which has been the historical discount rate between allowances and offsets. It assumes the allowance floor price continues to rise at 5% per year plus inflation. Begins at $8.71 in 2015 and climbs to $17.71 in 2025.

Compliance market expansion price: This scenario is calculated in the same way as the compliance floor price scenario, but assumes the California market expands and the allowance price grows faster than anticipated. Begins at $9.00 in 2015 and climbs to $24.38 in 2025.

[22] Available online at https://climatetrust.box.com/s/5hz8u4rflp8f6tv2k7xc7d38iyd8754i
[23] For our analysis, we used a crediting rate of .27 credits/acre/year. This rate is an average derived from the calculation of potential credits from 28 real-world fields under the Nitrace project
[24] Our analysis uses the voluntary average price, as it seems the most likely scenario for nutrient management in the near term is reliance on the existing voluntary markets- the sector is not yet compliance-eligible.

4. *Registry fees*[25]

5. *Validation Cost*[26]

6. *Verification Cost*

7. *Monitoring Cost in $/year*[27]

Results of Scenario analysis

To better show the relative impact of key variables like project size and verification expenses, we present the following chart, which demonstrates what happens to the carbon margin (carbon revenue minus expenses) for a ten-year project as these inputs change, holding all other inputs constant. The analysis reveals a wide range of possible revenue projections, with revenue increasing in proportion to project size. At all project sizes, each $5,000 in added verification expense corresponds to a $50,000 decrease to carbon margin. This makes sense because our model assumes yearly verification: $5,000 X 10 years= $50,000.

In addition, this model begins to elaborate on the minimum number of acres required for aggregated nutrient management programs to recover the expenses associated with project development. In Figure 11, negative numbers denote projects unable to break even with their expenses.

Figure 10: Acres vs. verification- Carbon margin over 10 years with voluntary average prices

Acres					
Verification	$10,000	$15,000	$20,000	$25,000	$30,000
10,000	$32,260.00	-$17,740.00	-$67,740.00	-$117,740.00	-$167,740.00
20,000	$204,520.00	$154,520.00	$104,520.00	$54,520.00	$4,520.00
30,000	$376,780.00	$326,780.00	$276,780.00	$226,780.00	$176,780.00
40,000	$549,039.00	$499,039.00	$449,039.00	$399,039.00	$349,039.00
50,000	$721,299.00	$671,299.00	$621,299.00	$571,299.00	$521,299.00

Next Steps

This pro forma for estimating carbon margin from crediting programs can easily be improved upon, if the tool is built-out to include a more accurate understanding of the percentage of total revenue a project might expect from carbon credit. Our scenario analysis illustrates that for nutrient management programs in particular, drastic changes in margin occur from slight changes in project development costs.

Additionally, as mentioned in this report's introduction, there are other environmental credit types that may also be available as potential revenue streams to farmers. It is likely that the revenue from these

[25] For our analysis we have assumed registry fees of $.23/credit. This figure is an average and represents what it typically costs to issue and transact credits on the three major US registries (ACR, CAR and VCS).
[26] Validation cost is an added expense for ACR and VCS only, and alludes to the cost of having a third party sign off on the project's development plan. We have used an average value of $5000.
[27] Monitoring cost is the expense associated with day-to-day management of the nutrient crediting program. We have estimated this at $3500 per year.

other types of environmental credits—most notably water quality—could make up a much bigger overall percentage of revenue from a nutrient management project because the credits themselves are worth more. In addition, creation of projects that have both a nutrient and a water quality benefit can enhance the "charisma", or appeal, of a project as multiple benefits can often be more effectively communicated. This holds particularly true for project developers attempting to aggregate farmers for projects, as farmers may be unfamiliar with carbon markets but intimately familiar with water quality issues.

Further research on water quality credit value is needed to build this revenue stream into the tool; however the best way to fully articulate the potential value of a practice change to a farmer is to include all potential environmental credits in the value proposition of the project, a process known as credit stacking.

Credit Stacking

To date, discussions of credit stacking have been mired in a variety of issues ranging from basic definitions of the term "stacking," to additionality concerns, to the interplay of regulatory and other interests. For the purposes of our discussion, we will use the definition of stacking determined by the Electric Power Research Institute (EPRI) 2011 market survey[28]; "stacking" is "establishing more than one credit on spatially overlapping areas, i.e., in the same acre." Therefore, a parcel of wetland which provides breeding ground for an endangered species, under a stacking model, may be able to earn credit both for the benefits of the wetland ecosystem and for the protection of that species.

On paper, stacking has seemed a commonsense proposal, however in practice, complexities tend to arise. There are several types of environmental credits being traded, each of which represent a set of environmental benefits. A few examples of these are:

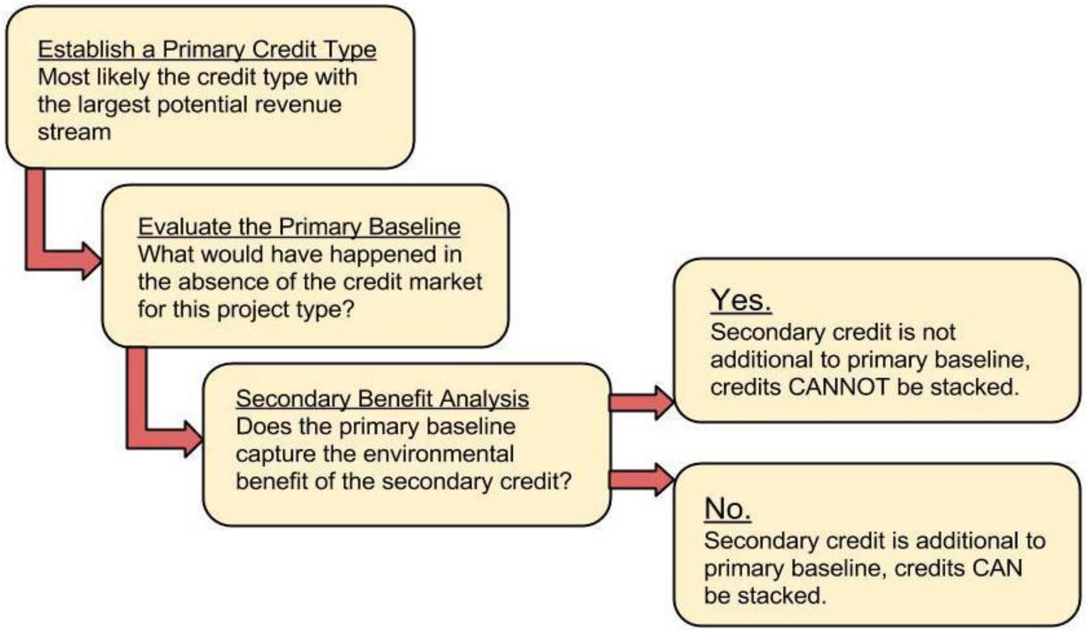
- Wetland mitigation banking
- Conservation banking (endangered species)
- Water Quality credits
- Carbon credits

The complexity of stacking multiple credits is twofold. First, it is easy to see how the same environmental attribute might be covered by more than one type of credit. For example, wetland ecosystems have the capacity to filter toxins from water; therefore, one may wonder whether the cleanliness of the water counts as part of a wetland credit or a water quality credit.

Theories about credit stacking are many; here is just one potential framework to consider, developed by The Climate Trust:

[28] Fox, Jessica et al, "Stacking Opportunities and Risks in Environmental Credit Markets", Environmental Law Institute, 2011.

Figure 11: Potential credit stacking framework



We can use the example of water temperature credits and carbon offsets to illustrate the use of this framework, with water temperature as the primary and carbon as the secondary credit. Water temperature is a concern for biodiversity protection. Facilities which pump water from rivers to use in their operations cannot return heated water to the river; they first need to cool it. A common engineering solution for the problem is to build large water cooling towers, and these cooling towers would represent the primary baseline in The Trust's model.

The cooling tower does not have any greenhouse gas benefit, which is the benefit of the secondary (carbon) credit. In this case, water and carbon credits should be able to be stacked.

Though this example may seem simplistic, credit stacking in practice takes a great deal more work. Each potential credit type likely falls under the jurisdiction of a different regulatory framework. Local water quality is controlled under the federal Clean Water Act but may also need to meet the requirements of a state or local regulation (the Irrigated Lands Regulatory Program in California is one such example). Therefore, the same parcel of land may require multiple agencies' buy-in in order to generate overlapping credits. As it happens, buy-in seems to be key in making stacking work.

EPRI itself launched the first multi-state water quality trading program in the Ohio River Basin. The program works on the basis of heavy engagement with stakeholders across the entire spectrum of water quality for the region; these include power utilities, farmers, wastewater treatment facilities, state and federal agencies and many more. The program has made some initial sales of water quality credits and has stated a desire to reach more buyers in the future. EPRI has been collecting nutrient management data from farmers within the watershed, and plans to begin generating carbon credits to add to its auctions in the near future—a sort of "proof of concept" for credit stacking in agriculture.

Key Takeaways

Nutrient management carbon crediting is certainly possible and plausible, with enormous potential to incentivize changes in nitrogen fertilizer application practices. Three key barriers currently stand in the way of scaling this highly attractive sector:

> 1) *Agriculture will only reach its full potential for nutrient management crediting if a more comprehensive data collection and management system is implemented.* If agriculture were to build on lessons learned in other economic sectors to streamline the collection of data, the process would result in a much more data-supported food system, but this process could take a number of years. The carbon markets would be well-served to formulate partnerships with existing data collection initiatives for the time being, to help bring nutrient crediting pilots online and prove the sector's potential.
>
> 2) *Protocols are still unproven.* A reasonable estimate of potential credits per acre of land is a necessary step in being able to attach a value to each credit produced, which itself is an essential step in enrolling farmers. Small-scale projects which run real-world nutrient data through these protocols is an important proof-of-concept, but credits per acre cannot be proven until verification of credits is achieved from a multi-field project.
>
> 3) *No clear buyer of credits has yet emerged*. The carbon market should continue to hone its value proposition for likely buyers in the voluntary carbon markets. Companies within the supply chain for corn, which include food and beverage companies, ethanol producers and animal feed manufacturers, are the most logical targets for voluntary credit purchases.

It is the conclusion of our research that due to the increased risks associated with these three barriers, a fully-scaled nutrient crediting sector is more likely a longer term proposition (within the next 5-10 years rather than the next 2-3). The timeline on implementation to full-scale can be significantly shortened if ways can be found to prove low risk to potential buyers, such as with the successful implementation and verification of several pilot projects.

The information contained here is intended to provide the beginning of a roadmap to minimize the risk of carbon credit investment in nutrient management and the successful large-scale adoption of nutrient stewardship, because the project team believes that agriculture can play a large and important role in curbing emissions worldwide.

Appendix A: Carbon Credit Solutions Enrollment Report

US Producer Engagement Report

Prepared for: Elizabeth Hardee, Contract Manager
Prepared by: Alastair Handley, President Carbon Credit Solutions

March 14, 2015

Objective

The object of this work is to identify, and collect relevant data from, corn producers in the North Central Region of the USA that had implemented or were in the process of implementing nitrogen management plans that would result in a reduction of greenhouse gas emissions. Carbon Credit Solutions (CCSI) would then determine that the ideal producer would have implemented a 4R Nutrient Stewardship Plan developed with the assistance of a professional agronomist.

Data to be collected includes all data related to the Nitrogen Management Plan and yield information that is required to determine potential emission reductions as determined by either the DNDC model or the reduction calculations defined in the MSU-EPRI Nitrogen Reduction Protocol.

Results to date

CCSI hired an experienced sale's agent in the late fall of 2014 who was tasked with identifying and contacting producers to participate in this project. This agent spent 6 weeks calling farmers and agronomists in the North Central States. Despite best efforts this agent had a difficult time locating producers that were using Variable Rate Technology to manage the application of Nitrogen on their corn crops. The sales agent report on their efforts is as follows.

As CCSI has a very strong working relationship with the Hutterite colonies in Alberta, so my initial outreach was to Hutterite Colonies in North and South Dakota as well as Minnesota. I made contact with 80 colonies explained the program, going in to detail about how we qualify emission reduction based on nitrogen applications through the use of VRT. When asked if they used VRT for seed and fertilizer applications many said that they did and expected that they would qualify for the program. When possible, I took contact information for their agronomist to gather further data.

Once I contacted the colonies agronomists, I discovered that most of them would not qualify because VRT was being used for seed application, not fertilizer. As a result of these findings I changed my focus and started to call certified crop advisors in the NCR to gather more information on VRT through these states. I decided to focus my efforts in Iowa, as it is the largest corn producing state.

I made well over 100 calls to CCA's in Iowa. The data that I started collecting was very positive as most farmers are using VRT for seed and fertilizer application throughout the state. Some CCA's began putting me in touch with "precision Ag managers" who deal with VRT specifically for many of the co-ops. I then began to seek out addition VRT managers online.

My conversations ended up being much the same; explaining the program and how we qualify based on nitrogen reductions through the use of VRT fertilizer applications. After making contact with a number of "precision Ag managers" I came across one gentleman who manages over 700,000 acres of VRT land for a major co-op. He informed me that VRT is standard throughout Iowa and Illinois, but only for potassium and phosphorus, ***not nitrogen****. This was* *unexpected. As a result I began calling back some of the CCA's that I had conversations with earlier and discovered this to be true upon further clarification.*

After some time I did find one Precision Ag Manager who has 10,000 acres of farmland that uses VRT nitrogen application. We are in the process of following up with this individual in an effort to get his growers engaged so that we can access their data for the project.

In total, these efforts took 6 weeks of full time attention with over 300 phone calls made to producers, CCA's, Agronomists and precision Ag Managers that touch roughly 2.5-3 million acres of farmland. While I did have some success it was not what I had hoped for.

My findings indicate that many producers know about carbon credit programs and are interested in learning more about them. This implies that there is an opportunity to educate producers on carbon credit programs and the benefits of managing nitrogen more efficiently.

Though we are still working on getting the 10,000 acres of VRT land we now know about in the program we are am pleased to say that we have located another grower who manages 1000 acres of land and have already received an initial data set from him. We will be inspecting this data set in the next day or two.

Next Steps

CCSI will continue to work on accessing historical farm records on the 10,000 acres of VRT land that we know about. In addition we are working with the EDF to identify farms in their network that may also be able to provide data.

Appendix B: Data Storage and Access

As agriculture works to streamline its processes for data collection, storage and reporting, The Trust created the following chart to articulate one possible scenario for the accessibility of data relevant to carbon market credit calculations.

Stakeholder	Role	Value	Permissions	What	Why	Audit Trail
Farmer	Data Originator		Full Control	All	Owner	Y
Outside Data Warehouse (Secure Cloud)	ETL	Create Usable Information	Full Control	All	Database Manager	Y
Crop Advisor (Agronomist)	Soil Advice	Unbiased opinion	Read	Specific	Cross-Check Nutrient Management	Y
Co-Ops	Network of Users	Shared Resources	None	N/A		
Agri-Business Machinery	Machines and Hardware	Technical	None	N/A		
Agri-Business Fertilizer	Fertlizer Supplier	Estimates Fert. Needs	Read	Specific	Analyze Feretilizer Needs	Y
Agri-Software	Enterprise Accounting	Data Management	Read and Execute	All	Enterprise Manager	Y
Local Interests, (Business, Water)	Community	Peer Support	None	N/A		
Supply Chain	Buyers	Market	None	N/A		
Government	Facilitator	Efficiency & Access to Loans and Programs	None	N/A		
NGOs	Facilitator	Manage Non-Government Programs	None	N/A		
Academics	Researcher	Innovation	Read	Specific	Scientific Modeling	Y
Aggregators	Project Developer	Risk Mitigation	Read	Protocal Inputs	Monitor Project	Y
Verifiers	Project Verifier	Risk Mitigation	Read	Protocal Inputs	Certifies Inputs	Y
Certification Bodies (Similar to HIPAA)	Best Practice	Software Security and Data Standards	None	N/A		
Agri-Insurance Agents	Payer	Risk Mitigation	Read	Specific	Acts as Farmer's Agent	Y

Special Permissions	Full Control	Modify	Read & Execute	List Folder Contents	Read	Write
Traverse Folder/Execute File	Yes	Yes	Yes	Yes	No	No
List Folder/Read Data	Yes	Yes	Yes	Yes	Yes	No
Read Attributes	Yes	Yes	Yes	Yes	Yes	No
Read Extended Attributes	Yes	Yes	Yes	Yes	Yes	No
Create Files/Write Data	Yes	Yes	No	No	No	Yes
Create Folders/Append Data	Yes	Yes	No	No	No	Yes
Write Attributes	Yes	Yes	No	No	No	Yes
Write Extended Attributes	Yes	Yes	No	No	No	Yes
Delete Subfolders and Files	Yes	No	No	No	No	No
Delete	Yes	Yes	No	No	No	No
Read Permissions	Yes	Yes	Yes	Yes	Yes	No
Change Permissions	Yes	No	No	No	No	No
Take Ownership	Yes	No	No	No	No	No

For each important agricultural stakeholder, the top of this chart describes that stakeholder's role in the market and the value they can bring through interaction with agricultural data, whether they should be allowed access to farmers' data and if so, in what capacity and why. The bottom of the chart describes, for these same stakeholders, possible levels of accessibility and manipulation of farmer data.

In reading the chart it is important to note that the information it contains is derived from a simple premise: that the farmer is the ultimate owner of the data and therefore reserves the full right of refusal to allow access to any other stakeholder. It is for this reason that many of the stakeholders permissions read as "none"- we have assumed in this case that the farmer will be very selective in the stakeholders to which they will allow access to sensitive on-farm data.

This chart describes only one of many scenarios; it may be modified by real-world experience as the agricultural data space begins to adopt enhanced organization and security.

Appendix C: Tables and Figures

Table 21: Potential nutrient credit supply from the North Central Region

Crediting rate	Description	Offsets from 7-10 million acres of corn	Offsets from 69 million acres of corn
.27	Average credits per acre derived from 28 test fields in Nitrace project (2014), including calculation outliers[29]	1,890,000-2,700,000	18,630,000
.13	Average credits per acre derived from 12 test fields in Protocol Road Test report (averaged across all tests for all methodologies)	910,000-1,300,000	8,970,000
.11	Coefficient used by NRCS COMET-Planner to calculate emission reductions from changes in nutrient management	770,000-1,100,000	7,590,000

Table 22: Existing nutrient management crediting methodologies

Methodology Name	Standard	Acronym
VM0022: Quantifying N2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction	Verified Carbon Standard	VCS-MSU-EPRI
Methodology for Quantifying Nitrous Oxide (N2O) Emissions Reductions from Reduced Use of Nitrogen Fertilizer on Agricultural Crops	American Carbon Registry	ACR-MSU-EPRI
Nitrogen Management Project Protocol Version 1.1	Climate Action Reserve	CAR-MSU-EPRI
N2O Emission Reductions through Changes in Fertilizer Management	American Carbon Registry	ACR-DNDC

[29] Actual credits per acre from the Nitrace fields varied between 0 (under the VCS-MSU-EPRI method for fields switching source and placement of fertilizer) to 1.97 (under the VCS-MSU-EPRI method for a field drastically reducing N rate).

Table 23: Nitrace field baseline scenarios

Farm ID	Field ID	Field Size (acres)	Cropping System	N Baseline Fall	N Baseline Spring
1	1	38	Continuous Corn	Bedded Cattle Manure	Ammonia Phosphate (AP) sidedress AA
1	2	39	Continuous Corn	Liquid Swine Manure	Sidedress AA
1	3	37	Soy-Corn	Bedded Cattle Manure	Sidedress AA
2	4	95	Soy-Corn	AA	-
3	5	38	Soy-Corn	AP + AA	-
3	6	75	Soy-Corn	AP + AA	-
3	7	55	Soy-Corn	AP + AA	-
3	8	160	Soy-Corn	AP + UAN	-
4	9	39.6	Soy-Corn	AA	UAN, after harvest AP
4	10	63	Soy-Corn	AA	UAN, after harvest AP
4	11	79	Soy-Corn	Liquid Swine Manure	UAN
5	12	65	Soy-Corn	AA	-
5	13	76	Continuous Corn	AA	-
6	14	53.5	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	15	78	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	16	64.9	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	17	77.8	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	18	74.1	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	19	87	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	20	114.9	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	21	109	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	22	77	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	23	39.8	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
6	24	194.1	Soy-Corn	Chicken Litter (January)	1/3 UAN with planter, 2/3 UAN in sidedress
7	25	107.5	Soy-Corn	-	1/2 UAN in spring, 1/2UAN in sidedress
7	26	122	Soy-Corn	-	1/7 AP in spring, 6/7 UAN in preplant
7	27	76.3	Soy-Corn	-	1/7 AP in spring, 6/7 UAN in preplant
7	28	157	Soy-Corn	Liquid Swine Manure	preplant UAN
total acres:		2,293			

Notes: AP=ammonia phosphate, AA = anhydrous ammonia, UAN=urea ammonium nitrate

Table 24: Marker scenarios on Nitrace fields

Farm ID	Field ID	Marker Scenario	**Practice Change Summary Based on 4Rs** Changes to N Management: Rate	Source	Time	Place	**Total N Rate** (organic + synthetic) Baseline (lbN/acre)	Scenario (lbN/acre)	Scenario Nitrogen Percent Reduction	Fertilizer Reduction (lbN/acre)
1	1	Switch to synthetic fertilizer (AP, AA) only	☑	☑			393	210	47%	183
1	2	AP in fall + BCM in spring + sidedress AA	☑	☑	☑	☑	384	373	3%	11
1	3	Switch to synthetic fertilizer (AA, AP) only	☑	☑		☑	352	183	48%	169
2	4	Switch to Urea in Spring , 15% N reduction	☑	☑	☑	☑	150	128	15%	22
3	5	AP in fall, UAN sidedress	☑	☑	☑	☑	158	153	3%	5
3	6	AP in fall, UAN sidedress	☑	☑	☑	☑	176	171	3%	5
3	7	AP in fall, UAN sidedress	☑	☑	☑	☑	158	153	3%	5
3	8	AP in fall, UAN sidedress + nitrification inhibitor		☑			163	153	6%	10
4	9	Switch to LSM in fall, reduce N input and UAN in spring (EQIP)	☑	☑	☑		215	200	7%	15
4	10	Switch to LSM in fall, reduce N input and UAN in spring (EQIP)	☑	☑	☑		215	200	7%	15
4	11	Reduced LSM in fall (EQIP contract)	☑	☑	☑		227	150	34%	77
5	12	Spring slow release urea		☑	☑	☑	150	150	0%	0
5	13	Switch to Urea, 30% reduction	☑	☑	☑	☑	200	140	30%	60
6	14	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	15	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	16	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	17	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	18	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	19	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	20	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	21	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	22	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	23	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
6	24	CL in Fall, rye cover crop after soy, UAN with planter and sidedress				☑	140	140	0%	0
7	25	1/2 UAN in spring, 1/2 UAN in sidedress reduce N input by 15%	☑				155	132	15%	23
7	26	1/7 AP in spring, 6/7 urea in sidedress reduce N input by 15%	☑	☑	☑	☑	164	139	15%	25
7	27	1/7 AP in spring, 6/7 urea in sidedress reduce N input by 15%	☑	☑	☑	☑	164	139	15%	25
7	28	Switch to synthetic fertilizer: preplant AP, sidedress UAN	☑	☑	☑	☑	232	164	29%	68

Notes: BCM=bedded cattle manure, LSM=liquid swine manure, CL=chicken litter, AP=ammonia phosphate, AA = anhydrous ammonia

Table 25: Summary of market barriers encountered by Nitrace

Barriers:
Enrollment: • No established market for credits • No widely acknowledged market price • No standard enrollment strategies
Data collection: • Too many variables to collect data for • Need historical data for five years for baseline calculation • Privacy and confidentiality concerns
Protocols: • Cumbersome to use
Policy: • No compliance offset market for nutrient management • Aggregation not guaranteed

Table 26: Emission reduction calculations for Nitrace fields under ACR-DNDC and VCS-MSU-EPRI

Farm #	Field #	Total N_2O (tCO_2e/field)					
		Baseline Scenario Total Emissions		Marker Scenario Total Emissions		Total Emission Reductions	
		ACR	VCS	ACR	VCS	ACR	VCS
1	1	92	96	52	21	**41**	**75**
1	2	82	92	61	84	**22**	**8**
1	3	75	68	32	16	**43**	**52**
2	4	49	29	27	23	**22**	**6**
3	5	42	13	15	12	**27**	**1**
3	6	94	30	51	29	**44**	**2**
3	7	57	18	42	17	**15**	**1**
3	8	98	57	91	57	**7**	**0**
4	9	65	23	37	21	**28**	**2**
4	10	88	36	46	34	**42**	**2**
4	11	120	54	89	27	**31**	**27**
5	12	54	20	20	20	**34**	**0**
5	13	149	38	81	21	**68**	**17**
6	14	15	15	8	15	**7**	**0**
6	15	23	22	12	22	**10**	**0**
6	16	19	18	10	18	**9**	**0**
6	17	22	22	12	22	**10**	**0**
6	18	22	21	12	21	**10**	**0**
6	19	26	24	14	24	**12**	**0**
6	20	35	32	19	32	**16**	**0**
6	21	33	31	18	31	**15**	**0**
6	22	22	22	12	22	**10**	**0**
6	23	11	11	6	11	**5**	**0**
6	24	57	55	31	55	**26**	**0**
7	25	70	35	57	27	**13**	**8**
7	26	71	44	44	33	**27**	**10**
7	27	55	27	39	21	**16**	**6**
7	28	130	112	66	56	**63**	**56**
TOTALS		1676	1065	1004	793	672	272
DIFFERENCE			**-611**		**-211**		**-399**

Table 27: Protocol comparison- Eligibility and applicability

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• Corn-row systems including continuous corn and rotations that include a corn component. • Crops must have been cultivated on the project site for at least 10 years prior to implementation. • Fertilizers applied according to BMP • Project must demonstrate N application is sufficient to maintain yield. • Project must use BMPs as described by state agricultural agencies, federal agencies or the global 4R Framework during crediting period • The project must take place in the United States. • Histosols are excluded • Soil C losses < 5% change	• Corn-row systems including continuous corn and rotations that include a corn component. • Crops must have been cultivated on the project site for at least 5 years prior to implementation. • Fertilizers applied according to BMP • Projects outside of the United States are eligible • Project must demonstrate N application is sufficient to maintain yield. • Project must use BMPs as described by state agricultural agencies, federal agencies or the global 4R Framework during crediting period • Histosols are excluded • Both the baseline and project condition take place on the same parcel of land and use the same crops	• Corn-row systems including continuous corn and rotations that include a corn component; in rotations only the corn component is credited • Only applicable to nitrogen fertilizer rate reduction, and only in the Northcentral region of the US • Project may start no more than 6 months prior to submission • Project must demonstrate N application is sufficient to maintain yield • Clear ownership of resulting credits must be established • Additional requirements for highly erodible land • GHG assessment boundary includes emissions from equipment and shifted production (leakage) • Histosols are excluded • Project activities must take place on land with annual precipitation between 600 and 1200mm • Irrigation is not permitted • Tile drainage is permitted if present in the baseline condition • Organic and synthetic fertilizers may be applied but only reductions in synthetic fertilizer are eligible for credit	• Project activities must be in valid reference regions, or geographic areas in which broad climatic and soil conditions are relatively homogenous. • Projects that involve a change in fertilizer rate, type, placement, timing and use of fertilizers. • Project must incorporate a minimum of 5 fields and must not lead to a decrease in crop yield (>5%) • These changes must be implemented for one year or longer. • This methodology is only applicable to crops, management systems, and regions where the DNDC model has been sufficiently validated to statistically quantify model structural uncertainty. • Histosols are excluded

Table 28: Protocol comparison- Additionality screening

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• VCS uses the performance method to calculate additionality: ○ Projects must meet requirements on regulatory surplus (i.e. the project activity is above and beyond what regulations or laws require); and. ○ Projects exceed performance benchmarks (i.e. a measure of "common practice" • Regulatory surplus: ○ No law requiring N reductions below BAU. • Performance benchmark ○ Site-specific BAU (Approach 1). ○ Countywide BAU (Approach 2).	• To be additional projects must: • Exceed approved performance standard and pass test for regulatory surplus or, • Pass 3-pronged additionality test of ACR. This requires demonstration that the project exceeds: ○ current laws and regulations; ○ common practice in the agricultural sector; and, ○ Face either financial, technological, or institutional barriers to implementation.	• Projects must meet the following standards for additionality: • Performance standard- requires completing the nitrogen use efficiency calculation in the protocol. • Legal requirement standard, which attests that the project is not required by any regulation. • Regulatory compliance standard, which attests that the project will comply with all applicable laws	• Projects using approach 1 or 3 must test for additionality using ACR's three-pronged additional test. This requires demonstration that the project exceeds: ○ current laws and regulations; ○ common practice in the agricultural sector; and, ○ Face either financial, technological, or institutional barriers to implementation. If a project is excluded through a financial analysis or demonstration of a barrier, then it is considered non-additional and non-eligible for crediting under the ACR meth.

Table 29: Protocol comparison- Crediting period and project boundaries

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
Crediting Period			
One full crop cycle (post-harvest to harvest)	Seven years (programmatic); no limit on crediting period renewals	Five eligible crop years, which may occur over a period of ten calendar years; may be renewed once	• 5 Years (Programmatic) • 1 full crop cycle (or longer)
Project Activities/Boundary			
• Projects within the United States (Method 1) • Projects involving corn within North Central Region of the US, including Iowa & Illinois (Method 2) • Projects involving crops other than corn (including rotations with corn) in NCR (Method 1). • The project activity is applying fertilizer at economically optimum N rates that do not harm productivity and requires the use of verifiable BMPs for N.	• Spatial boundary: Results of actions under project's control, including direct and indirect emissions • Temporal boundary: Projects may verify multiple project years at once; verification required every five years • Emissions boundary: Direct and indirect emissions of N2O from both the baseline and project conditions No change to soil carbon stocks	• Projects can be either a single field or an aggregate of many fields • "Field" means: • Under control of a single entity • Continuous • Management practice is homogenous • Cultivation cycle is defined as 365 days • Eligible crop years do not need to be continuous but records must be kept for ineligible crop years between eligible years to maintain credit eligibility	• Projects within Iowa & Illinois • Projects that change fertilizer management by adjusting application rate and other practices. • Project activities must take place in valid reference regions or geographic areas in which broad climatic and soil conditions are relatively homogenous.

Table 30: Protocol comparison- Establishment of the baseline condition

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• The baseline condition allows for 2 approaches: ○ #1 (site specific) must be used if site-specific data are available ○ #2 (county scale data) may be used in cases of limited data availability and relies on USDA county-level data ○ The baseline scenario requires 5 years monoculture or 6 years for a two-crop rotation	• The baseline condition allows for 2 approaches: ○ #1 (site specific) must be used if site-specific data are available ○ #2 (county scale data) may be used in cases of limited data availability and relies on USDA county-level data ○ Only approach 1 may be used outside the US	• Baseline is defined as five years prior to project implementation • If fewer than three eligible crop years occur in the five year period, this period will be extended until 3 eligible crop years are included • Baseline is calculated using equations in the protocol for all baseline years • Baseline years are averaged together to form a basis of comparison to the project condition	• There are 3 approaches for determining the baseline scenario: ○ #1: Projects that reduce application rate, without changing any other aspect of fertilizer management, must use a field historic baseline ○ #2: Projects that change fertilizer management by adjusting more than application rate, and for which the current adoption rate for the Project Activity is ≥5% within the reference region must a Common Practice Baseline. ○ #3: Projects that change fertilizer management by adjusting more than application rate, and for which the current adoption rate of the Project Activity is <5% must use a Field Specific Historical Baseline.

Table 31: Protocol comparison- Baseline records required

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• Baseline establishment requires management records of fertilizer application rates by crop going back: ○ 5 yrs. for a monoculture; or ○ 6 yrs. for rotating crops • The management records must include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or organic) in lbs. N $acre^{-1}$ yr^{-1}; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur ○ Planting and harvest dates	• Baseline establishment requires management records of fertilizer application rates by crop going back: ○ 5 yrs. for a monoculture; or ○ 6 yrs. for rotating crops • The management records must include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or organic) in lbs. N $acre^{-1}$ yr^{-1}; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur ○ Planting and harvest dates	• Baseline establishment requires management records of fertilizer application rates by crop going back: ○ 5 yrs.; or ○ More than 5 years if fewer than 3 eligible crop years are included • The management records must include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or organic) in kg N/ha for solid and liquid fertilizers and gallons/acre for liquid fertilizers only ○ Application rate data ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur. ○ Width of area covered by application equipment ○ Equipment speed and horsepower ○ Planting and harvest dates	• Management records must include the following data in order to quantify baseline conditions: ○ Location of each field; ○ Daily meteorology; ○ Soil characteristics, including clay content, bulk density, soil pH, soil organic carbon, soil texture, slope, depth of water retention layer, high groundwater table; ○ Crop type; ○ Planting date; ○ Harvest date; ○ Fraction of leaves and stem left in field after harvest; ○ Yield; ○ Season, depth and Type of tillage; ○ Source, rate time and placement of Fertilizer; ○ Source, rate time and placement of inorganic fertilizer and C:N ○ Number, type and amount of irrigation events per season.

Table 32: Protocol comparison- Project recordkeeping requirements

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• Annual management records are required of the following: ○ Mass and N content of fertilizer by fertilizer type (synthetic or organic) in lbs. N $acre^{-1}$ yr^{-1}; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield; and, ○ Yes/no response on whether leaching and runoff occur	• Annual management records are required of the following: ○ Mass and N content of fertilizer by fertilizer type (synthetic or organic) in lbs. N $acre^{-1}$ yr^{-1}; ○ If manure, manure N content and application rate; ○ If synthetic, purchase and application rate data; ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur	• Recordkeeping requirements include: ○ Mass and N content of fertilizer, by fertilizer type (synthetic or organic) in kg N/ha for solid and liquid fertilizers and gallons/acre for liquid fertilizers only ○ Application rate data ○ Precipitation during the growing season; ○ Potential evapo-transpiration during the growing season; ○ Total acreage applied by fertilizer type; ○ Baseline crop yield ○ Yes/no response on whether leaching and runoff occur. ○ Width of area covered by application equipment ○ Equipment speed and horsepower ○ Planting and harvest dates ○ Results of a corn stalk nitrogen test	• Project management records must include the following data: ○ Location of each field; ○ Daily meteorology; ○ Soil characteristics including clay content, bulk density, soil pH, soil organic carbon, soil texture, slope, depth of water retention layer, high groundwater table; ○ Crop type; ○ Planting date; ○ Harvest date; ○ Fraction of leaves and stem left in field after harvest; ○ Yield; ○ Season, depth and type of tillage; ○ Source, rate time and placement of Fertilizer; ○ Source, rate time and placement of inorganic fertilizer and C:N; and, ○ Number, type and amount of irrigation events per season.

Table 33: Protocol comparison- Quantification approach

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• A series of equations are used to calculate direct and indirect emission reductions • Depending on the approach used the methodology uses an IPCC Tier 1 methodology or a Tier 2 regional emission factor (applicable in the 12 states in the USDA's North Central Region)	• A series of equations are used to calculate direct and indirect emission reductions • Depending on the approach used the methodology uses either producer-specific records (Approach 1) or regionally-derived factors (Approach 2). Only Approach 1 may be used outside the US.	• A series of equations are used to calculate direct and indirect emission reductions • Calculations require field-specific records • Protocol calculates emissions from multiple SSRs (sources, sinks and reserves) • Many places in the protocol provide multiple ways to calculate an SSR depending on records available	• The DNDC model must be used to quantify direct and indirect emission reductions according to the methodology. • The methodology uses a combination of Tier 1 methodologies (IPCC) and Tier 3 (the DNDC model).

Table 34: Protocol comparison- Monitoring and verification

VCS-MSU-EPRI	ACR-MSU-EPRI	CAR-MSU-EPRI	ACR-DNDC
• All data points mentioned under the baseline and project condition must be monitored and recorded according to the methodology. • Data for monitored parameters are derived from farmer's records that are used for compliance with any mandated (regulated) farm-related programs, including state and federal BMPs.	• All data points mentioned under the baseline and project condition must be monitored and recorded according to the methodology. • Data for monitored parameters are derived from farmer's records that are used for compliance with any mandated (regulated) farm-related programs, including state and federal BMPs.	• CAR requires the creation of monitoring plans for both single fields and aggregates with participating fields; specifics appear in the protocol • Different recordkeeping is required for single fields and multi-field aggregates • Projects will be verified on an annual basis • Single fields can choose a verification period between 12 and 24 months • Aggregates chose their verification period based on timing of individual projects • Verifiers must be accompanied by a Certified Crop Advisor (CCA) or agronomist	• All data collected as part of the methodology must be archived electronically and retained for at least 2 years. • Information shall be provided & recorded to establish that: ○ The geographic position of the project boundary is recorded for all areas of land; and, ○ Commonly-accepted principles of agricultural land management are implemented.

Figure 12: Project field locations

Table 35: Baseline and project N loading data

No.	Field name	Field Acreage (acres)	Fertilizer N input Baseline (lb/ac)	Fertilizer N input Project (lb/ac)	Nitrogen Percent Reduction
Year 2013					
1	Briggs E	6.4	163	87	47
2	Briggs W	20	209	74	64
3	Carter E	14	57	43	25
4	Carter W	3.9	94	46	51
5	Geese S	34	138	106	23
6	Harrold E	22	175	97	44
7	Harrold W	55	175	93	47
8	Porky E	3.9	200	181	10
9	Porky W	3.9	220	165	25
10	Shearer W	8.3	80	42	48
11	Taulbee A	37	175	98	44
Total*		208	153	94	39
Year 2014					
1	Carter N	25.2	169	99	41
2	Carter S	34.1	169	84	50
3	Geese NW	45.7	169	130	23
4	Home S	28.9	162	100	38
5	Nicodemus A	112.3	144	129	11
6	Porky E	3.9	200	191	5
7	Porky W	3.9	220	165	25
8	Schrader E	11.7	140	118	16
9	Schrader W	34.0	140	108	23
10	Shearer E	4.3	80	54	33
11	Shearer W	8.3	81	41	49
Total*		312	152	111	27

*Sum for Acreage and Average for fertilizer N input

Table 36: Emission reductions from project fields

		Total N_2O Emissions Reduction					
	Protocol	ACR-DNDC		MSU-EPRI		ACR-DNDC	MSU-EPRI
		per acre	per ha	per acre	per ha	per field	
No.	Field name	(tCO_2e)					
Year 2013							
1	Briggs E	0.24	0.59	0.18	0.44	1.5	1.1
2	Briggs W	0.29	0.71	0.36	0.89	5.7	7.2
3	Carter E	0.02	0.04	0.02	0.05	0.2	0.3
4	Carter W	0.15	0.37	0.08	0.20	0.6	0.3
5	Geese S	0.10	0.26	0.07	0.18	3.5	2.5
6	Harrold E	0.20	0.49	0.20	0.48	4.4	4.3
7	Harrold W	0.23	0.56	0.20	0.51	12.5	11.2
8	Porky E	0.03	0.07	0.07	0.17	0.1	0.3
9	Porky W	0.17	0.41	0.20	0.50	0.7	0.8
10	Shearer W	0.12	0.29	0.06	0.15	1.0	0.5
11	Taulbee A	0.19	0.48	0.19	0.48	7.1	7.2
All Fields 2013*		0.16	0.39	0.15	0.37	**37.4**	**35.7**
Year 2014							
1	Carter N	0.13	0.33	0.24	0.59	3.4	4.3
2	Carter S	0.16	0.39	0.13	0.31	5.4	6.8
3	Geese NW	0.13	0.33	0.18	0.44	6.1	4.8
4	Home S	0.16	0.40	0.05	0.12	4.7	4.3
5	Nicodemus A	0.04	0.10	0.06	0.15	4.7	4.4
6	Porky E	0.05	0.11	0.25	0.61	0.2	0.1
7	Porky W	0.15	0.37	0.05	0.12	0.6	0.8
8	Schrader E	0.09	0.21	0.09	0.22	1.0	0.6
9	Schrader W	0.09	0.23	0.14	0.33	3.2	2.5
10	Shearer E	0.07	0.17	0.07	0.17	0.3	0.2
11	Shearer W	0.09	0.22	0.10	0.25	0.7	0.5
All Fields 2014*		0.11	0.26	0.12	0.30	**30.2**	**29.4**
All Fields 2013 and 2014*		0.13	0.33	0.14	0.34	**67.6**	**65.1**
*Average per unit area and sum for fields				Difference VCS - ACR -DNDC:			**-2.4**

Figure 13: Credit generation cycle

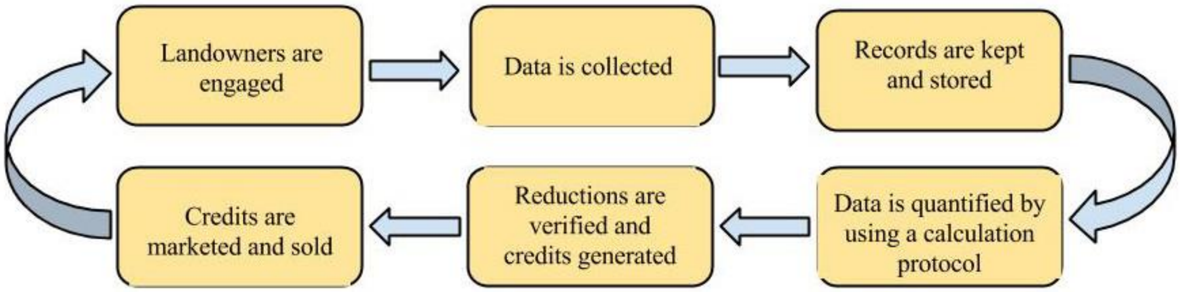


Figure 14: Risk profile of nutrient management

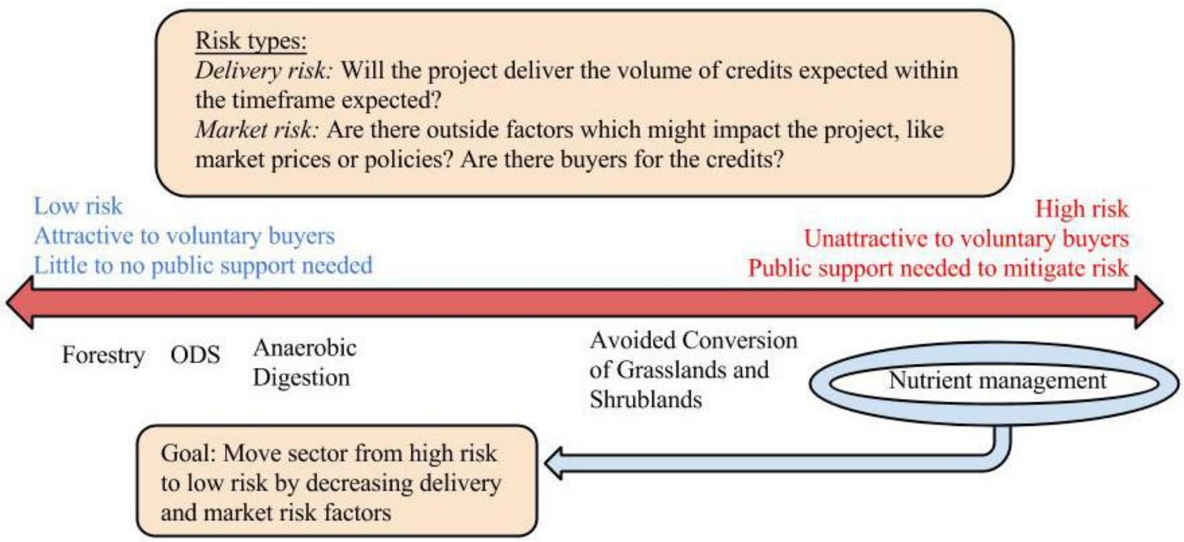


Figure 15: Interaction between farmers, the agricultural market, and the carbon markets

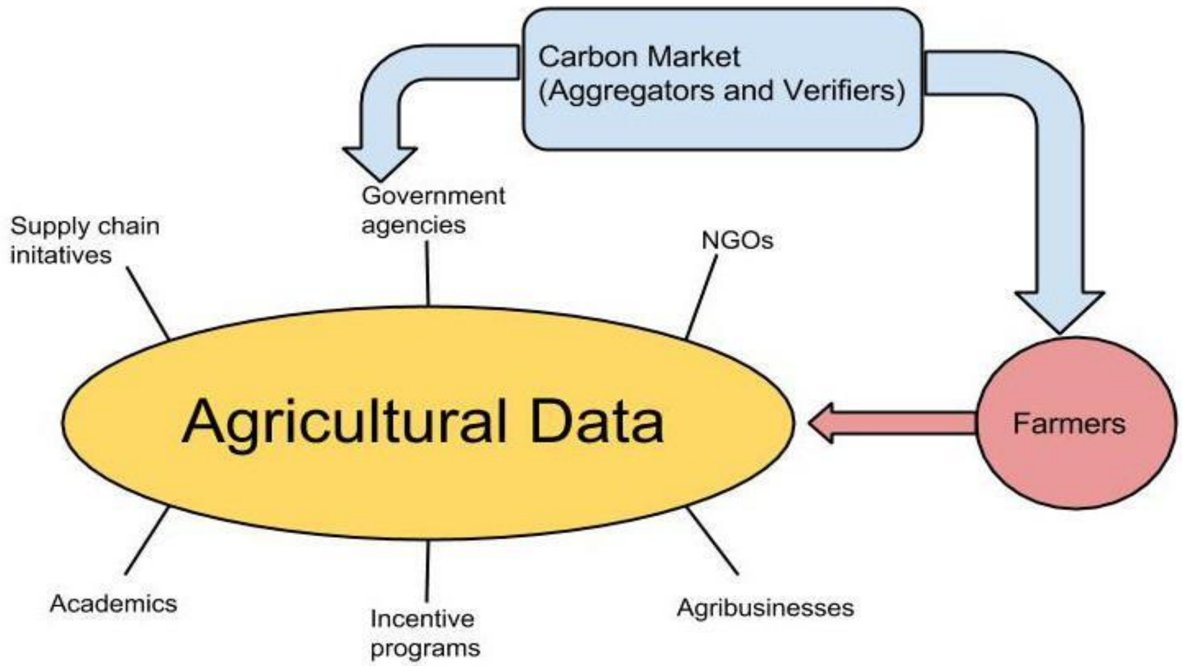


Table 37: Possible partnership scenarios for farmer enrollment

Potential partner for the carbon markets	How it might work
Supply chain initiatives	Supply chain buyer collects relevant fertilizer inputs, allows farmer to opt-in to data sharing through this data capture initiative.
Fertilizer retailers	Retailers promote practice changes to optimize N use and carbon credits as a potential revenue source. Farmers opt-in through the retailer, which partners with an aggregator to produce credits, and revenue is shared with the farmer.
Data service providers (data-supported decision software)	With farmer opt-in, information is fed to an aggregator directly from on-farm application equipment, is stored by the decision-support software, and is accessed by carbon markets.
Agribusinesses	Farmers pay agribusinesses to process their data to support planting and fertilizer decisions; with opt-in from farmer this information is shared to the carbon market and revenue is shared between the agribusiness and the farmer.
Government agencies	Relevant information is collected by existing government statistics servers (NASS, SSURGO and others); with farmer opt-in this information is accessible to carbon markets.
Academic institutions	Fertilizer data is collected for the purposes of scientific research; with farmer opt-in this information is accessible to carbon markets
Incentive programs	Information about fertilizer practices is collected to prove eligibility for conservation incentives or crop insurance; with farmer opt-in this information is accessible to carbon markets.

Table 38: Competition in agricultural value propositions

Value	Provider(s)
Financing for conservation practices	• NRCS subsidies • Other incentive programs • Grant funding from NGOs and others • Aggregators (in the form of carbon revenue)
Data-supported decision making	• Software developers • Equipment providers • Retailers • Extension services • Certified Crop Advisors

Figure 16: Data flow map for nutrient crediting

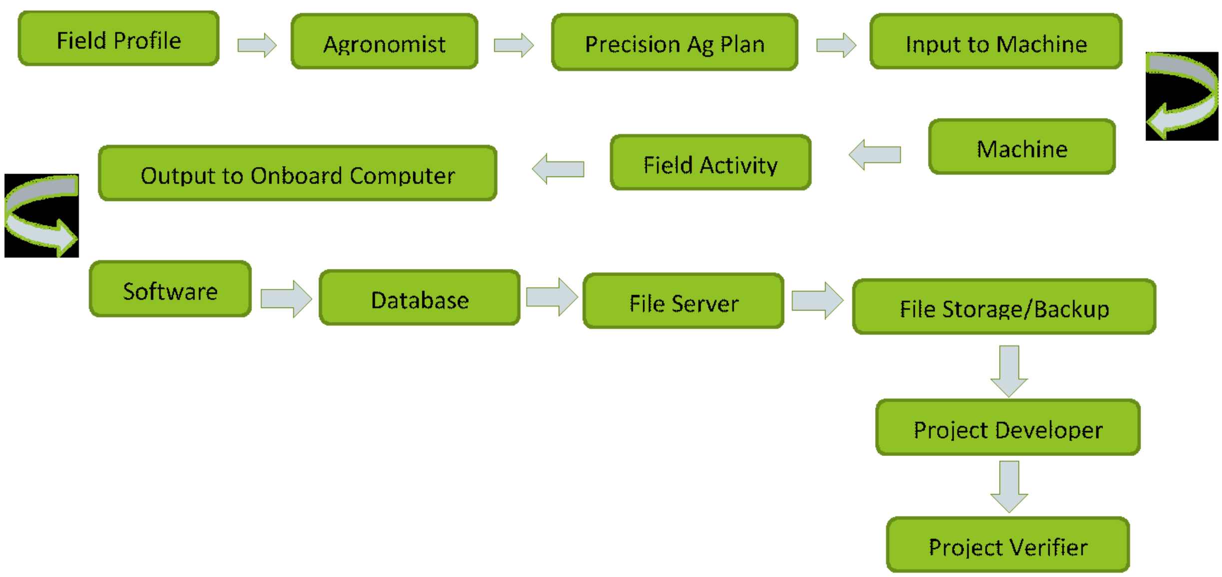


Figure 17: Workflow for structured data capture

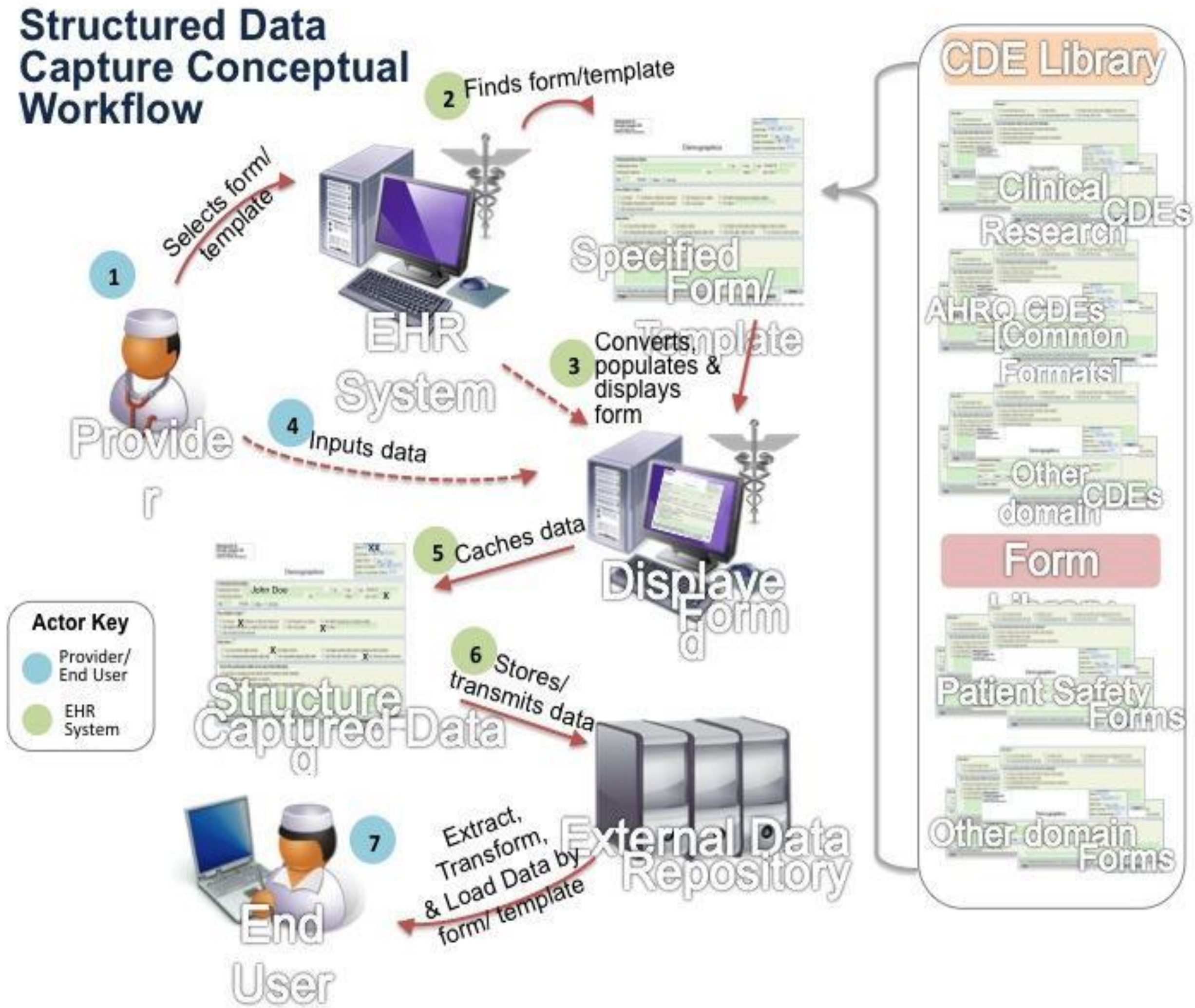


Figure 18: Data flow for nutrient management data storage

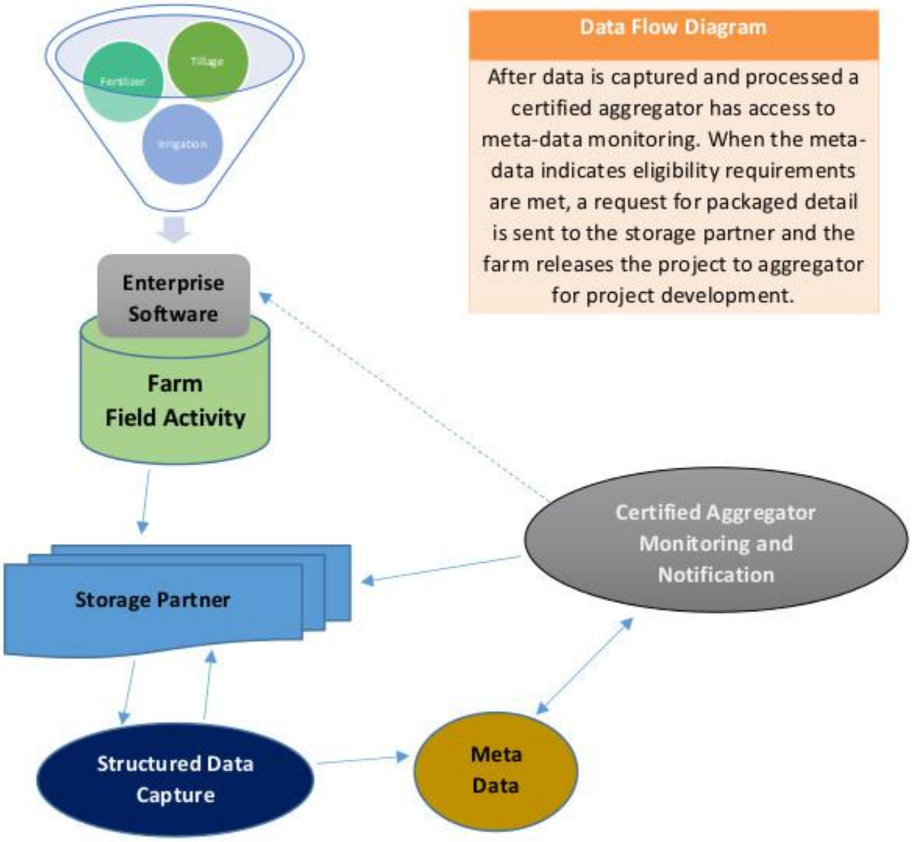


Table 39: Managing data storage in agriculture, by market actor

Step	Value Chain Actor	Value Chain Activity	Specific Actors
1	Field	Field ID, Soil Type, Acre Size, Weather	Farmer, Landowner
2	Machine	Nutrient Application, Tillage, Irrigation	Equipment manufacturers
3	Local Network	Collect and store raw data	Local Area Network, Local cloud
4	Software	Establish eligibility, user alerts	Agricultural software service providers
5	Database	Save to local storage and cloud back-up	Local cloud, other web-based storage system
6	Data Manager	ETL, Mapping	Independent third party
7	Data Warehouse	Storage and backup	Independent third party, government database
8	Data Mart	Access to Data	Certified aggregator

Figure 19: Inputs required for carbon calculation protocols

Crop type	GPS Location
Acres	Land use type
Baseline practice	Clay content
New practice	Bulk density
Organic fertilizer type(s)	Soil pH
Synthetic fertilizer type(s)	SOC at surface soil
Fertilizer application dates	Soil texture
Planting dates	Slope
Harvest dates	Depth of water retention layer
Mass Organic N fertilizer applied, Solid	High groundwater table
Mass synth N fertilizer applied, Solid	C/N ratio of the grain
N content organic, Solid	C/N ratio of the leaf & stem tissue
N content synthetic, Solid	C/N ratio of the root tissue
Annual potential evapotranspiration	Fraction of leaves, stem in field post-harvest
Annual precipitation	Number of tillage events
Mass Organic N fertilizer applied, Liquid	Date of tillage events
Mass synth N fertilizer applied, Liquid	Depth of tillage events
N content organic, Liquid	N fertilizer application method
N content synthetic, Liquid	Time release fertilizer
Mass organic per gallon fertilizer, Liquid	Nitrification inhibitors
Mass synthetic per gallon fertilizer, Liquid	Organic amendment C/N ratioNumber of
Width of area covered by operation equipment	irrigation events
Average speed of equipment	Date of irrigation
Horsepower of equipment	Irrigation type
Yield	Irrigation application rate

Key:

Required by all protocols

Required by CAR-MSU-EPRI only

Required by ACR-DNDC only

Table 40: Narrowing the focus of aggregators

Market role	Who could do it?		Market role	Who does it
Enroll farmers	Aggregators Supply chain initiatives Agribusinesses Equipment providers Extension, CCAs and others		**Enroll farmers**	Farmers automatically enrolled by selecting "opt-in" with a commodity buyer or equipment software developer
Collect data	Aggregators Supply Chain initiatives Agribusinesses Equipment providers Extension, CCAs and others		**Collect data**	Data is collected directly from onboard software on spreading equipment and uploaded to a storage system
Store data	Aggregators Supply Chain initiatives Agribusinesses Equipment providers Extension, CCAs and others Government entities Independent third party		**Store data**	Data is stored by a trusted organization; stakeholders have access via secret code
Process data (protocols)	Aggregators Individual Carbon Market Experts		**Process data (protocols)**	Aggregators are allowed access to data and manage the process of calculating credits. They work with verifiers and registries to ensure all steps are completed to the market's standards, and use their status as "preferred provider" to sell credits to a broker
Pay for verification	Aggregators Supply Chain initiatives Agribusinesses Equipment providers Government entities		**Pay for verification**	Verification is subsidized by government, or the private sector in the form of a corporate grant
Market credits	Aggregators Supply Chain initiatives Agribusinesses Equipment providers		**Market credits**	Credits are marketed by a broker
Buy credits	Corporate Social Responsibility programs Government entities Compliance buyers		**Buy credits**	Credits are purchased by compliance or voluntary buyers

Figure 20: The CIMO concept

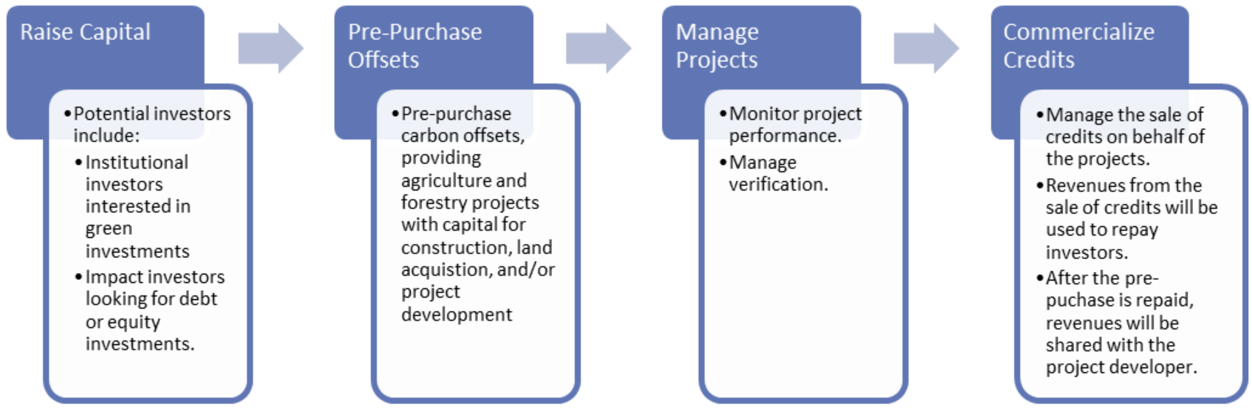


Figure 21: Acres vs. verification- Carbon margin over 10 years with voluntary average prices

Acres					
Verification	$10,000	$15,000	$20,000	$25,000	$30,000
10,000	$32,260.00	-$17,740.00	-$67,740.00	-$117,740.00	-$167,740.00
20,000	$204,520.00	$154,520.00	$104,520.00	$54,520.00	$4,520.00
30,000	$376,780.00	$326,780.00	$276,780.00	$226,780.00	$176,780.00
40,000	$549,039.00	$499,039.00	$449,039.00	$399,039.00	$349,039.00
50,000	$721,299.00	$671,299.00	$621,299.00	$571,299.00	$521,299.00

Figure 22: Potential credit stacking framework