Comments on
Climate Action Reserve Nitrogen Management Project Protocol
Reducing N2O Emissions through Improved Nitrogen Management in Crop Production

Version 1.0 for Public Comment (April 24, 2012)

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We are pleased for the opportunity to submit our public comments to the Climate Action Reserve on Version 1.0 of Nitrogen Management Project Protocol (NMP v1.0).

For the past five years MSU and EPRI have been working on a collaborative research project to explore the potential to reduce nitrous oxide (N_2O) emissions by improving nitrogen management practices on croplands in the U.S. During the first three years of our R&D collaboration, we conducted fundamental scientific research to improve the scientific understanding of N_2O emissions based on the amount of nitrogen fertilizer applied to corn grown in the 12 states that comprise the North Central Region (NCR) and more broadly across the U.S. Based on this work, we have published a number of peer-review research articles describing the research conducted as part of this project, key findings, and implications for crediting emissions reductions associated with reduced use of N fertilizer on croplands.

Based on this and other work, the MSU-EPRI team developed a draft N_2O Offsets Protocol that has been submitted to the American Carbon Registry (ACR) and the Verified Carbon Standard (VCS) for validation and approval for use in their voluntary GHG emissions offsets programs.

Two of us have also actively participated in the development of the NMP v1.0 by participating in the CAR NMPP Working Group (Millar) and Scientific Advisory Committee (Robertson). We very much appreciate the opportunity to have worked with CAR to develop the NMP v1.0 and appreciate CAR's explicit consideration of many of the approaches incorporated in the MSU-EPRI N2O Offsets Protocol in the design of the NMP v1.O.

General Comments

CAR is to be commended for assembling a comprehensive nitrogen management offsets protocol that in general is robust, verifiable, conservative, and based on the best-available peer-reviewed science. The method's flexibility is a strength, as is its clarity in most places.

Specifically, we support several key design approaches of the protocol, including:

- Inclusion of nitrogen rate reductions as a management practice to reduce N_2O emissions in crop production and for potential crediting as GHG emissions offsets;

- Inclusion of the MSU-EPRI "Tier 2" quantification approach to quantifying N_2O emissions reductions associated with reducing nitrogen fertilizer application in corn production in the 12 state North Central Region;

- Inclusion of the potential to accept additional management practices that may also qualify to be credited with N_2O emissions reductions in the future once additional scientific information can be developed and evaluated.

- The intent to consider additional Tier 2 and Tier 3 quantification approaches (e.g., biogeochemical modeling) in the future once they can be further developed, calibrated and validated for specific regions and cropping systems.

- The intent to consider the circumstances under which N_2O emissions reductions may be "stacked" along with credits for nitrogen management practices that may be creditable under evolving water quality credit trading programs.

- Consideration of the need for offset aggregation in order to scale up emission reductions and reduce transactions and verification costs. We support the decision to incorporate aggregation guidelines within the NMP v1.0 methodology itself. We also appreciate the flexibility provided by allowing single field as well as multi-field projects to participate in an N2O project.

While we support many of the specific elements adopted by CAR in the NMP v1.0, there are several major issues we believe need both further clarity and revision if the protocol is be useful and used. We believe several elements of the NMP v1.0 will significantly reduce the potential uptake of CAR's approach by farmers.

Our specific concerns relate to the following elements in the NMP v1.0.

- Description and use of the RTA performance standard. We believe the RTA approach is unnecessarily complex, unnecessarily restrictive, and when used ex-post, inappropriate, especially when used with a threshold based on statewide statistics. A simpler Best Management Practice (BMP) approach is available and more agronomically appropriate.

- The 25% uncertainty deduction to be applied to emissions reductions achieved in the NCR based on application of the MSU-EPRI Tier 2 quantification approach. The uncertainty deduction is too high and we provide mathematical justification for a lower deduction.

- Manure management and discounting of emissions reductions associated with the use of organic N fertilizer. There is insufficient scientific evidence to justify the stated discounts.

- Exclusion of Tier 1 approaches for crediting GHG emissions reductions achieved by reducing N fertilizer rates for regions outside of the NCR and crops other than corn.

We discuss each of these concerns in more detail below.

1. Performance Standards

We appreciate CAR's efforts to develop an appropriate performance standard to be used to determine if proposed N rate reductions projects are "additional," and so may qualify to receive N_2O offsets based on reductions in the rate of N fertilizer applied to croplands. We also appreciate CARs efforts to develop the RTA approach, RTA Performance Thresholds and Default RTA rates for use in crediting emissions reductions. And, we understand CAR's desire not to credit so-called "bad" actors who may be using excessive amounts of N fertilizer.

However, we are concerned that the proposed RTA Performance Thresholds and Default RTAs shown in Table A9 are too stringent and will make it very difficult for most farmers to utilize the NMP v1.0. In effect, the performance standard that has been proposed is likely to result in very few farmers using the protocol, as it appears that only those farmers who already have made significant strides to increase their N use efficiency would be eligible to participate and receive credits for N rate reductions. This would be a very unfortunate outcome.

We believe that it is important to incentivize farmers who legally use excessive amounts of N fertilizer to reduce their N fertilizer usage both to reduce greenhouse gas emissions and reduce nitrate losses. To this end, we encourage CAR to revisit the design of the RTA, and most importantly to reconsider use of the RTA and in particular the 75% RTA performance threshold that is proposed to be adopted.

A better and more agronomically defensive approach is to require farmers to comply with Best Management Practices as adopted by state departments of agriculture or the USDA/NRCS. These practices include nutrient management requirements based on accepted 4R nitrogen management strategies: right rate, right place, right time, and right kind.

While we are concerned that the proposed RTA performance threshold and Default RTA's are unnecessary and too stringent, we do recognize and appreciate CAR's attempts to incentivize farmers to use the protocol who do not meet the performance threshold for the first two years of the implementation of an N-rate reduction project. This additional flexibility afforded in the protocol for farmers to incrementally move toward reducing their N use efficiency over three years to achieve the RTA performance threshold is important and we encourage CAR to maintain this flexibility in the final version of the NMP.

The performance standard, based on the ratio of removed to applied N (incorrectly called a general measure of N use efficiency), seems overly stringent as it provides a means test that will exclude most producers from participating in the market, is confusingly described with at least one incorrect calculation, and inappropriately applies an *ex-post* exclusion.

a. Equation 3.1 creates a very high bar for existing good land stewards to be credited with N2O emissions reductions, and excludes those who have been using greater quantities of nitrogen on their lands.

For example, a corn farmer harvesting 150 bushels/acre (bu/ac) who conservatively applies 134 lbs N/ac (150 kg N/ha) has an RTA of 0.90, below the RTA threshold of 0.93 for Illinois corn and well below the threshold of 1.37 for Michigan. The same farmer fertilizing at a more liberal 200 lbs/a (224 kg/ha) has an RTA of 0.75, substantially below the threshold.

Not only does this threshold inhibit the good steward from participating, but it will exclude the less efficient nitrogen users who should be targeted by the protocol if CAR's intent is to positively affect climate change by reducing N2O emissions in crop production. This seems to be a perverse outcome. If the formula is kept it needs to be evaluated against current rates of N fertilizer applications based on actual and recommended rates used by most farmers (using, for example, the common yield-goal approach and rates recommended by farmers' main source of information – fertilizer and seed dealers).

b. Part of the problem may be a units issue – Table A2 reports N values in lbs/bu, not kg/bu as called for by the equation. But converting Table A2 values to kg/bu makes the threshold even more difficult to achieve. Additionally the 0.8 lbs N/bu for corn grain is based on a 1.4% N content – a value itself too low; using more common values for corn grain (1.6-1.8% as reported in the literature depending on hybrid age) will further exacerbate the problem as it will raise the RTA.

c. More importantly, the ex-post test evaluation seems inappropriate. Fertilizer is put onto crops at rates that are designed to *anticipate a normal yield*, not at rates based on actual yields. If, in a given year, the fertilizer rate is lowered as a project activity, at the end of the season less N2O will have been released than if the project had not been in place – even if there is complete crop failure such that RTA is zero.

Likewise, in Section 5.3, calculating the historic average RTA value, which will depend on historic yields subject to year-to-year climate variability, will unduly penalize producers in more variable climates. The important metric is historic fertilizer application rates – not historic yields. Again, fertilizer is applied in anticipation of yield – not because of yield.

The protocol should reward N2O reductions that result from intentional fertilizer reductions, irrespective of actual yields that will vary with weather and other factors out of the producer's control. N2O reductions will occur if fertilizer is reduced regardless of yield.

d. Using statewide averages for RTA Performance Thresholds (Table A.8) is an additional problem. RTAs are dependent not only on fertilizer inputs but also on soil fertility – in particular, on soil organic matter mineralization. Assuming that all farmers within a state share the same soil fertility (Table A.8) is a major limitation of the RTA threshold approach. Even relaxing the threshold to some arbitrary percentage value will penalize farmers who manage fields far from the mean fertility level.

Moreover, the Agricultural Resource Management Survey (ARMS) data is self-reported and do not necessarily overlap with the NASS yield data, which are collected differently. Differences among states may largely be artifacts, and some differences make little sense –

for example, that corn following corn receives 30% less fertilizer than corn following soybeans in Michigan (Table A7) is clearly wrong.

e. Given these considerable shortcomings, we recommend CAR remove the RTA Performance Thresholds to improve the accuracy, transparency, and fairness of the protocol. As noted above, BMPs are the better alternative.

   If, however, the Performance Thresholds are maintained, we recommend at the very least taking the following steps: i) remove the ex-post test as above, and ii) make the threshold percentiles more realistic and achievable. With respect to the latter, we recommend using yield-goal approaches, i.e., N-to-yield-goal ratios, along with simple N management criterion and national and state (where available) survey data to generate realistic RTA performance thresholds and default values obtainable by a large proportion of farmers. We provide in the following subsections f, g, and h evidence and rationale for this recommendation

f. In Ribaudo et al. (2011; referenced in the NMP v1.0), the basic practice for improving NUE in the context of N rate is defined as "*applying no more nitrogen (commercial and manure) than 40 percent more than that removed with the crop at harvest, <u>based on the stated yield goal</u>, including any carryover from the previous crop*." From this definition, an annual RTA value for a field can be calculated. For example, if N removed in the crop (e.g., corn for grain in a continuous corn rotation) is 100 kg N ha^{-1}, then annual N input must be less than 140 kg N ha^{-1}. This gives us a minimum RTA value of 100 / 140 = 0.71.

   This RTA value defined by the USDA as a practice that improves NUE is substantially lower than every NCR states' performance threshold RTA for corn grain (irrespective of preceding crop) shown in Table A9 of the NMP v1.0. The lowest value of 0.85 (corn following corn in Ohio) is still ~20% higher than the back-calculated USDA suggested value for good practice, and in the majority of states >30 to >100% more. Despite this apparently low benchmark, the USDA survey discussed in Ribaudo et al (2011), found that the application rate criterion was not met on over 53 million acres (32%) of US cropland treated with N. Thirty five percent of N treated corn acres did not meet the rate criterion, accounting for half of all treated crop acres not meeting the rate criterion. Ribaudo et al (2011) also noted that "*about 14 percent of corn acres receive applications of 10 percent or less over the criterion rate."* Reducing application rates on these acres would mean that nearly 80 percent of all US corn acres would meet the rate criterion. The RTA for a corn field to which 10% above the USDA criterion N rate is applied is 100 / (140 + [140 × 0.1]) = 0.65.

   So, ~20% of N treated corn acres would not meet or exceed an RTA of 0.65, and 35% would not meet or exceed an RTA of 0.71. This suggests that very high percentages of land would not meet the substantially higher RTA performance standard values (0.85 to 1.52 for corn grain in the NCR) required for project participation using the NMP v1.0. Based upon this analysis, default state RTAs for baseline calculation may also be too high. Fields with historical RTAs that do not meet or exceed the default RTA may have low calculated baseline N rates such that reductions below them are essentially impossible without a high risk of yield reductions.

g. In Appendix A4 is the statement "*The MRTN approach to decide on N fertilizer rate is more commonly used today* than *the yield-goal approach*". This claim is not substantiated by evidence from data or information presented in the NMP v1.0 or otherwise. The USDA definition for improving NUE in the context of N rate (Ribaudo et el. 2011) requires the use of yield-goal calculations, and shows their ongoing and important function in N management at the national scale.

In fact, few farmers in NCR states are using the new MRTN approach today to determine the economically optimal amount of N to apply to their crops. The MRTN is now the official university-based recommendation in only 7 of the 12 NCR states, and in most states has only been in effect for the past few years (Michigan, for example, adopted it only last year). The NMP v.1.0 points out that the yield-goal approach has been the dominant approach to determine N rates for corn for the last four decades, and we are not aware of any research or other information that suggests this approach has been supplanted by the MRTN or other approaches to determine the recommended application rate of N fertilizer.

Very few studies have quantified the impact that the many factors and their interactions have on farmer decision-making regarding N rate. The few studies available imply that the majority of farmers rely heavily on their own experience. For example, in Appendix A4 (Table A4 and Table 4.1 in Ribaudo et al. (2011)), results show that "*over 70 percent of growers base N rates on their routine practice (Table A.4)*." However, this data does not inform us of the rationale used, and the decisions made by a farmer to arrive at this routine practice.

A recent MSU survey sent to 1000 Michigan farmers (Stuart et al. 2012, in review) shows that over 70% of commercial corn farmers use simple yield-goal calculations to derive their N rate. The percentage of farmers who stated that they fertilized at an N-to-yield-goal ratio (lbs N per bushel of corn) of >1.3, 1.1 to 1.3, 0.8 to 1, and <0.8 was 3.4, 14.9, 39.4, and 13.8%, respectively (71.5% total). Using the average Michigan yield for corn (grain) of 153 bushels per acre in 2011, we can use these ratio values to derive equivalent RTA values using equation 3.1 (units modified) in the NMP v1.0:

$$RTA_{f,c,t} = \frac{(Y_{f,c,t} \times NC_c)}{NR_{f,c,t}}$$

Where

Y_{fct} = 153 bushels per acre, NC_c = 0.8 lbs N per bushel, and NR_{fct} = 153 × (1.3, 1.2, 1.0, or 0.8) lbs N per acre.

N to yield *goal = 1.3:* RTA_{fct} = (153 × 0.8) / (153 × 1.3) = **0.62**
N to yield *goal = 1.1:* RTA_{fct} = (153 × 0.8) / (153 × 1.1) = **0.73**
N to yield *goal = 1.0:* RTA_{fct} = (153 × 0.8) / (153 × 1.0) = **0.80**
N to yield goal *= 0.8:* RTA_{fct} = (153 × 0.8) / (153 × 0.8) = **1.00**

So under these real scenarios we can estimate that 3.4 / (71.5 * 100) = 5% of Michigan farmers who use yield goal approaches fertilize at a N-to-yield-goal ratio of less than 1.3 and would have fields with an RTA value of less than 0.62. Similarly, 21% would have an RTA value of between 0.62 to 0.73, 55% would have an RTA value of between 0.80 to 1.00, and 19% would have an RTA value greater than 1.00.

These results suggest that only a very small percentage of Michigan farmers would meet the very high RTA performance threshold values (1.37 and 1.10 for corn following corn and corn following soybean, respectively), and that few others would be able to reduce N rate to obtain them. The 55% of farmers who have an RTA value of between 0.80 and 1.00 are already good N stewards: using N to yield goal ratios of 0.8 to 1.0 is currently best practice.

h. The assumption that "*simple state-average RTA values implicitly take into account the adoption of best management practices with respect to N rate*," (Appendix A3) is difficult to justify. It is not clear that a higher RTA ratio in one state when compared to another reflects greater adoption of best management practices with respect to N rate. The state average RTA is a simple ratio of N removed to N input. Prevailing environmental conditions and soil type in a state are likely the major drivers of the magnitude of the RTA ratio - conditions that are conducive to high crop yield will tend to increase RTA. Weather and soil type are of course not under the control of farmers and landowners. Also as noted above, differences among states may largely be artifacts of the differing methods of reporting and data collection.

i. We recommend that if RTAs remain in the NMPP, a threshod at or around the 40th percentile might be reasonable. For Michigan, the 40th percentile value is 0.72 (Figure A4). This is very similar to the RTA value derived from USDA nation-wide survey data (0.71; 35% of corn acres are below this) and Michigan survey data (0.73; 26% of farmers apply N at a rate below or equal to this). This percentile is more appropriate and represents a realistic and obtainable threshold for a large proportion of farmers across the NCR states. Raising the RTA percentile much above this risks excluding farmers that were they included, would be most likely to provide environmental benefit through N rate reduction on their land. However, the match of the 40th percentile value to actual fertilizer use in Michigan may be coincidental – even the 40th percentile may inappropriately exclude farmers in other states. The uneven quality of the data underlying the percentiles plus the other problems underlying RTA calculations argues for dropping the RTA approach entirely.

2. Uncertainty analysis

We appreciate that CAR have included an uncertainty analysis based upon the original MSU-EPRI approach. However, we have concerns regarding the suitability of the structural uncertainty and the accuracy deduction equations (section 5.4, Eqn. 5.17 [steps 1 and 2]) used in the NMPP. We outline these concerns below and suggest alternative equations with justification.

a. Currently, the structural uncertainty equation is:

$$UNC_{PER,f} = \frac{1}{\sqrt{nrFields}}\left(100 - 63 \times e^{-40 \times 10^{-6} \times NR_{P,f}^{2}} + 25\right)$$

We recommend this be revised to:

$$UNC = \left(100 - 61\, e^{-46\, 10^{-6}\, NR^2}\right)\left(1 + \sqrt{\frac{32}{nrFields}}\right)$$

In the new recommended equation, the expression in the first brackets represents the structural uncertainty of the model (i.e., the possible bias in the model). Here, the uncertainty procedure for the MSU-EPRI uncertainty equation was adapted to include a cross-validation based on a bootstrap or 'leave-one-out' algorithm. Briefly, cross-validation is a technique for assessing how the results of a statistical analysis will generalize to an independent data set. One round of cross-validation involves separating a sample of data into a complementary subset, performing the analysis on the subset (training data), and validating the analysis on the other subset (validation data). To reduce variability, multiple rounds of cross-validation are performed using different separations, and the validation results are averaged over the rounds. The 'leave one out' cross validation involves using a single observation from the original sample as the validation data, and the remaining observations as the training data. This is repeated such that each observation in the sample is used once as the validation data. Depending on the fertilizer input level, the uncertainty increases by only 2 to 4% in the new equation when compared to the original MSU-EPRI equation.

b. In the expression in the second brackets (i.e., adjustment to the number of fields), the first term (1) represents the multiplier for the uncertainty of the model itself (structural uncertainty) and cannot be attenuated by increasing the number of fields in the study. The second term (√ (32/nrFields)) represents the additional uncertainty from the finite number of fields that are in the study. Thirty two is used because the term in first brackets is the uncertainty of emission reductions for the mean of 32 fields (8 site years × 4 replicates) in the MSU-EPRI training dataset.

c. **Recommendations**:
   i. Remove the additional and arbitrary increase in the uncertainty (25%)
   ii. Drop the term "nrFields", because:

      - It is negligible when participation in the program is widespread, and does not create large underestimations in uncertainty;

      - It is a large deterrent to early adopters of the program. In the case of a small number of fields, the term √(32/nrFields) and overall uncertainty would be large. This potential overestimation of uncertainty for early adopters will be reduced when more fields are added to the program.

   iii. If a term for the number of fields is allowed to stay, it should represent the total number of fields in the program and not the number of fields in a project or aggregate for the following reasons:

      - Aggregates are arbitrary entities unnecessary in uncertainty analysis
      - Using the total number of fields will reduce the added uncertainty and increase confirmed emission reductions for all participants

d. Currently, the accuracy deduction equation is:

$$\mu_{struct,f} = 138 \times 10^{-7} \times \quad UNC_{PER,f}{}^{2} - 395 \times 10^{-5} \times \ UNC_{PER,f} \quad + 0.999$$

While this quadratic function (Fig 1 b, below) is a conservative approximation of the step-wise function (Fig 1 a below) it is not the simplest approximation of the original step-wise function.

e. **Recommendation**: Use either (i) or (ii) below; preferably (i):

i. $\mu_{struct,f}$ = (**exp$^{(Unc / 330)}$**)

a simple function with a small deviation (maximum of ~2 %) from the more complex quadratic function (Fig 1 c).

ii. $\mu_{struct,f}$ = (**1 - 2.3 × 10^{-3} Unc)**

a linear function, that has a slope derived from the integration of uncertainty approach (pdf [File Integration of the Uncertainty] attached), again with a small deviation (maximum of ~ 4%) from the more complex quadratic function (Fig 1 d). The linear approach is the only one that allows us to discard a constant proportion of the emission reductions we are uncertain of, without the need to relate it back to the relative % of total emission reduction it represents.

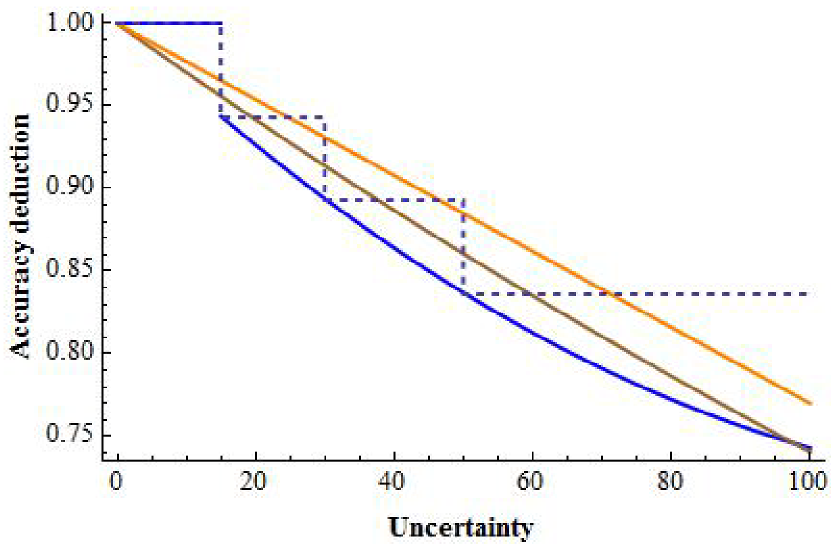

Fig.1. Uncertainty deduction functions: a) original step-wise CDM reduction function (dashed), b) NMPP quadratic reduction function (solid blue), c) exp$^{(Unc/330)}$ (brown), d) 1-2.3 × 10^{-3} Unc (orange).

3. Manure Management

We appreciate the attempt by CAR to encourage an increase in organic N application to cropland through the allowance of an increase in total organic N applied to the project area (5.1). We also understand CARs conservative approach in reducing the offsets credits generated by use of organic N sources (5.4.1), and their attempt to take account of secondary emissions related to changes in organic N rates (5.5). However, we feel that the overall effect of these proposals will be to unfairly punish farmers who currently use organic N sources and disincentivize those who would wish to use them in the future. Below we detail these concerns and offer suggestions to counter them.

a. **Recommendation 3.1**: Until further field studies in the NCR and elsewhere in the US are identified that show large differences in the non-linear (or other) N_2O response to varying organic (typically manure) N inputs when compared to synthetic N inputs, N from organic sources should be treated equally to N from synthetic sources. Justification for this appears in subsection b-d below:

b. Currently CAR justifies the 20% reduction in the emission factor for direct N_2O emissions for organic N sources by referencing the publications of Bouwman et al. (2002) and Davidson (2009). The first is a meta-analysis of recent global agricultural N_2O emissions data that underpins the choice of current IPCC Tier 1 emissions factor for direct N_2O emissions for N fertilizer (1%), and the second is a historical (since 1860) reconstruction of global atmospheric N_2O concentrations and related N inputs. While not questioning the rigor and quality of these publications, the use of these global analyses to inform this fundamental component of the N_2O methodology, which operates at the farm scale, appears inconsistent with CAR's previous reluctance to consider global data sets and Tier 1 approaches in the US. (Notwithstanding, we believe that Tier 1 approaches should be considered in future versions of the NMP where appropriate; see section 4 below).

c. The derivation of the 0.8 ratio from a comparison of the emissions factors for direct emissions from manure N and synthetic N fertilizer application to soil (SSR 1) cannot be inferred from Davidson (2009). Here "*The regression coefficients suggest that roughly 2.0% of annual manure-N production and 2.5% of fertilizer-N production have been converted to* N_2O." As noted in the NMPP (footnote 52), these values include SSR 1 emissions as well as N_2O emissions from N leaching and volatilization (SSR 2) and manure derived N_2O emissions associated with storage (SSR 5) and handling of manure (SSR 6).

d. Although field studies in the US are few, justification for the use of the same emissions factor for organic N sources (for both linear and non-linear N_2O emissions responses) in the NCR can be found in Jarecki et al (2009). In this study, one of the major objectives was to quantify field N_2O emissions in response to different rates of fall-applied liquid swine manure in an Iowa Mollisol soil. As with the Michigan-based studies of synthetic N response that underpins the MSU-EPRI methodology (Hoben et al. 2011), N_2O emissions increased non-linearly with increasing application of manure N. Moreover, the magnitudes of emissions and emissions factors were also very similar to Hoben et al (2011).

e. **Recommendation 3.2**: We recommend that CAR introduce a more consistent approach to the inclusion or exclusion of secondary emissions related to changes in fertilizer rates from organic and synthetic N sources. Either a complete Life Cycle Analysis with respect to CO_2 emissions should be conducted for both synthetic or organic fertilizers (production, storage, transport) or none at all. An inconsistent approach (e.g. decrementing credits for transport of manure but not for synthetic N) will introduce biases towards or against particular farm management practices. As a compromise, consider just including emissions from both synthetic and manure transport. The current approach in NMP v1.0 seems likely to bias farmers against using or increasing their use of organic N fertilizer sources. Currently, the

NMP v1.0 considers increased CO_2 emissions associated with organic (manure) N transport and longer storage off site, but does not consider reduced emissions from decreased synthetic fertilizer production. We outline further rationale in subsections f-g below:

f. There is a strong environmental rationale for farmers to switch from synthetic to organic fertilizer sources. However, an increase in the rate of organic N applied to a field (aggregate level) is penalized though the associated increase in CO_2 emissions from transportation - due to the greater weight per unit of N and less efficient distribution of organic fertilizer (footnote 43). This would likely discourage widespread adoption of organic manure applications. Individual or multiple farmers in an aggregate would be unlikely to increase their organic N input, knowing that these associated emissions would be taken into account to reduce their credit payments. Similarly, depending on the makeup of the aggregate, farmers that do not use organic fertilizer but who reduce their synthetic N fertilizer rate can have their credits reduced if the total organic N input increases in the aggregate. This seems unfair and could have a perverse environmental outcome.

g. On the other hand if a farmer who currently uses organic fertilizer reduces this use, the NMP v1.0 assumes that these reductions will result in greater amounts of storage, for instance in a CAFO, with higher GHG emissions compared to the baseline organic N input. In effect this pins the responsibility on the farmer for emissions sources typically outside their control. For farmers who predominantly use organic sources of N, there appears only to be disincentives for continuing or expanding that operation. However, as noted above, a farmer does not gain any benefit from a reduction in synthetic fertilizer production outside the farm. Also possible is that reductions in the use of manure by one farmer in an aggregate may be balanced by increase in use by another farmer in the same or different aggregate. Under the current NMP v1.0 both would be penalized.

4. Exclusion of Tier 1 approaches

As described in the IPCC Good Practice Guidance (IPCC 2003), methodologies to calculate emissions of N2O from agricultural soils can fall under three main tiers:

Tier 1 consists of equations and default emission factors provided in the IPCC Guidelines (IPCC 2006) and IPCC Good Practice Guidance; Tier 2 uses the IPCC Guidelines default equations, but requires country-specific parameters that better account for local climate, soil, management, and other conditions; and, Tier 3 methods are based on more complex models (e.g., biogeochemical models such as DNDC and Daycent) and inventory systems, typically using more disaggregated activity data.

Based on the IPCC guidelines, the Tier 1 emissions factor for N2O emissions in agricultural production is equal to 1% of applied N fertilizer (i.e., EF1 value of 0.010). [See 2006 IPCC Guidelines for National Greenhouse Gas Inventories; Revised Aug. 2011, Vol. 4, Ch. 11, IPCC 2006)].

This 1% Tier 1 estimate is widely considered to be a conservative estimate of N2O emissions from agricultural production that utilizes additional fertilizer inputs. This emissions factor is based on a large number of studies conducted globally across many crops and regions. For instance, 1,008 N_2O emission measurements from peer reviewed agricultural field studies (Stehfest and Bouwman, 2006) was a major driver for adopting the IPCC EF1 value of 0.010.

Again, we support CAR's proposed adoption of the MSU-EPRI Tier 2 quantification approach for corn grown in the NCR given the scientific validity of this approach. At the same time, we urge CAR to consider increasing the geographic breadth and range of crops included in the NMP v1.0 by reconsidering use of an IPCC Tier 1 approach to quantify N_2O emissions reductions in other states and crops where a scientifically valid, peer-reviewed Tier 2 approach has not yet been developed.

As noted in a recent CAR webcast, the use of a Tier 1 approach may reduce the number of N_2O emissions reductions offsets generated from a reduction in N fertilizer inputs, but it will nonetheless provide these farmers with an incentive to reduce their N application rate without threatening the environmental integrity of the resulting offsets.

More and more studies in recent years have shown that N_2O emissions increase exponentially as more nitrogen is applied to croplands. Given this, it is clear that using the IPCC Tier 1 default emissions factor is a conservative approach to crediting N_2O emissions reductions, particularly given that the NMP v1.0 is targeting farmers who can reduce their "excess" use of nitrogen and still maintain their crop yields.

Thank you again for the opportunity to provide these public comments on the CAR NMP v1.0. We hope CAR will fully consider the comments we have offered here. We look forward to seeing CAR complete the NMP process soon with the adoption of a final version of the NMP.

1. Integration of the Uncertainty

To adjust emission reduction for the uncertainty, split all possible emission reduction levels corresponding to a particular baseline and project application rates into three nonintersecting intervals:

1. Take full amount of emission reduction that happens with certainty above 95%.

2. Take incremental emission weighted by the corresponding certainty level for certainties from 95% to 50%.

3. Do not take into account any incremental emission reductions with certainty less than 50%.

Sum of values from all three intervals equals:

$$x_{0.95} + \int_{x_{0.95}}^{x_{0.5}} F(x)dx.$$

where $F(x)$ - certainty of emission reduction, $x_{0.95}$ - emission reduction that has 95% certainty, $x_{0.5}$ - median emission reduction (equal to mean for symmetric distributions).

For standard normal distribution (range from -1.645 to 0) this value equals -0.38, or an adjustment of about 23%.

For example, for MSU-EPRI methodology at 160 kg N baseline and 140 kg N project fertilizer input there is a mean emission reduction of 12.27 $\frac{gN_2O-N}{kgN}$, with uncertainty interval of 71.2% (this is the level that corresponds to emission reduction with 95% certainty). Thus, we are more than 95% confident in 28.8% of emission reduction or 3.53 $\frac{gN_2O-N}{kgN}$. MSU-EPRI emission reduction follows normal distribution thus we need to use an adjustment of 23%. We take 77% of emission reduction that occurs with 50-95% confidence (interval from 3.53 to 12.27 $\frac{gN_2O-N}{kgN}$), which equals to of 8.74 * 0.77 = 6.73 $\frac{gN_2O-N}{kgN}$ and add it to the 3.53 $\frac{gN_2O-N}{kgN}$. And we get an uncertainty-adjusted average emission reduction of 10.26 $\frac{gN_2O-N}{kgN}$.