RESPONSE TO PUBLIC COMMENTS

A methodology for *Quantifying Nitrous Oxide (N_2O) Emissions Reductions in Agricultural Crops through Nitrogen (N) Fertilizer Rate Reduction* was developed by Michigan State University and the Electric Power Research Institute, and submitted to ACR for approval through the public consultation and scientific peer review process.

The methodology was submitted to ACR on March 10, 2011. ACR conducted its standard internal methodology screening and provided this to the authors on March 16. The authors submitted a revised methodology and supporting documentation on May 16.

The methodology was posted for public comment from May 23 – June 17, 2011. Public comments and responses by the authors are given below.

Following public consultation, the methodology will be submitted to three anonymous peer reviewers, experts in the field of fertilizer/nutrient management and GHG offset methodologies. Peer review comments and responses are summarized in a separate document.

General

	Comment	Commenter	Response
1	First of all, I want to congratulate the authors of this methodology. I acknowledge the important clarification and simplification efforts applied to the first methodology (N_2O Emissions Reductions through Changes in Fertilizer Management).	CDC Climat Research	

	Comment	Commenter	Response
2	On behalf of our members, the National Wildlife Federation appreciates the opportunity to comment on the proposed methodology to quantify nitrous oxide emissions reductions in US agricultural crops through nitrogen fertilizer reduction in the American Carbon Registry (ACR). While we support the wise use of offsets as a method to reduce greenhouse gas emissions, the proposed methodology, if accepted, could produce significant quantities of offsets that do not correlate to real, quantifiable and additional greenhouse gas emissions reductions. We have appreciated the protocol proponent's transparency in providing us with responses to our public comments on the Voluntary Carbon Standard (VCS) protocol which they proposed. We have sought to incorporate those responses into our comments.	National Wildlife Federation	

1.3 Applicability and Scope

	Comment	Commenter	Response
1	***"Greenhouse gas reductions associated with carbon sequestration in the soil and emissions reductions off-site caused by manufacture and distribution of N fertilizers are excluded."*** The effect of fertilizer rate reduction on soil carbon sequestration is still uncertain with current scientific knowledge. Excluding it is therefore a sound decision. Emissions due to fertilizers transportation are difficult to estimate, and are bound to be reduced with fertilizer rate reduction: excluding these emissions is therefore conservative. However, it is possible to integrate the CO_2	CDC Climat Research	We agree with the commentators' conclusion that excluding GHG reductions associated with soil carbon sequestration is appropriate. We also agree that excluding emissions reductions associated with transportation of fertilizers is sensible and conservative. We appreciate the commentator pointing out ways that our protocol incorporates conservative approaches to account for GHG emissions reductions. We propose to incorporate GHG emissions associated with the production of N-containing synthetic fertilizer. A reduction in synthetic N fertilizer rate during the project

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	emissions in the same way as in « The American Carbon Registry® Methodology for N_2O Emission Reductions through Changes in Fertilizer Management ».		period compared to the baseline period will be credited with GHG emissions reductions from its reduced production. These calculations are included in sections 6.1.3 and 6.2.3, for baseline and project periods, respectively.

2 Project Eligibility

	Comment	Commenter	Response
1	The proposed methodology excludes several variables which impact nitrous oxide emissions (listed below). The project proponents have stated their position that it is conservative to exclude all factors influencing nitrous oxide emissions except for nitrogen application rate. Our following comments are meant to respectfully disagree with this claim.	National Wildlife Federation	First we believe an important clarification is required. Our previous responses to the NWF in relation to their public comments on our methodology at the VCS have been over-simplified in this NWF comment. Conservativeness is an important principle in developing methodologies that seek to credit practices that mitigate agricultural GHG emissions. While we believe our methodology is conservative, this general principle is not the only rationale we have used for not including other factors that may affect N_2O emissions in our methodology. We are aware that a number of management and environmental factors can individually and / or in combination affect agricultural emissions of N_2O, and that evidence to support variability in emissions brought about by their variation exists in the peer-reviewed literature - as evidenced by specific examples cited by the NWF. Evidence that confounds or contradicts the assertions made in these publications can also be found in the peer-reviewed literature. As previously noted, few if any of these practices or factors are quantitatively or even directionally consistent in their

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			N_2O response to merit inclusion in a general N_2O reduction methodology. Therefore, their non-inclusion in our approach is based upon their current inadequacy as a means of reliably quantifying N_2O emissions. We are also unaware of any evidence (including assertions presented by the NWF here), that our proposed methodology will produce biased estimates of N_2O emissions because of factors left out of the estimation calculations. In the absence of this evidence we believe that the approach adopted in our methodology of using N rate as an estimator of N_2O emissions reductions is reliable, will lead to un-biased results and is justified. To date the vast majority of scientific evidence supports N input (annual N rate) as the most robust and reliable proxy for calculating N_2O emissions. It is consistent and straightforward to quantify as a metric and its use is substantiated by the IPCC, which uses annual N input as the Tier 1 factor for calculating annual N_2O emissions in national greenhouse gas inventories. The importance of this factor and its value was determined from statistical analyses of many hundreds of field-scale studies in agricultural cropland. We have additionally proposed a Tier 2 approach using N rate as the proxy in geographic areas where we are confident of its applicability. The Tier 2 factor was derived from empirical field measurements of N_2O emissions taken on commercial farms over eight site years (Hoben et al. 2011). Furthermore, our methodology does not exclude other N management practices (e.g., N fertilizer type, timing, and placement). During the project crediting period our methodology requires the adoption (or continuance), of

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			crop and site relevant Best Management Practices (BMPs) that specifically relate to N fertilizer formulation (or N content of organic additions) and dates and methods of application. Therefore, a project proponent may need to alter one or more of the N management criteria timing, placement, and formulation, as well as rate to qualify for project acceptance. However due to the lack of reliable N_2O response to N management factors other than rate (as discussed above) and conservative principles, only a reduction in N rate below the baseline N rate is proposed to be rewarded with offset credits.
2	**Fertilizer Nitrogen Sources (2.1)** Cover crops and leguminous crops provide nitrogen to cash crops and can produce nitrous oxide.[1] By excluding these nitrogen sources, the protocol could overestimate emissions reduction. For example, if a producer were to replace nitrogen fertilizer application with nitrogen from leguminous cover crops, the protocol would credit the reduction in emissions by reducing fertilizer rate, but not the nitrogen provided by the cover crops. The protocol proponents have suggested that any nitrogen provided by cover crops or leguminous crops will be incorporated into the farmer's nutrient management practices and will have already resulted in nitrogen application rate reduction. There is little evidence to suggest this is reflective of actual	National Wildlife Federation	Our methodology does not exclude the practice of introducing a cover crop or any other crop into a rotation, so long as its inclusion does not result in an increase in N rate from eligible N sources (as defined by our methodology) during the project period when compared to the baseline period. For example if a winter cover crop was planted between a summer annual corn and soybean crop, and no additional synthetic or organic N (as defined in our methodology) was added, then this practice would be eligible with our methodology. Likewise, if a producer shifted from a continuous corn system to a corn-soybean rotation in one field and the producer reduced the N rate to corn below a baseline N then this practice would be eligible and the N

[1] Kallenbach, C.M., D.E. Rolston, W.R. Horwath. Cover cropping affects soil N2O and CO2 emissions differently depending on type of irrigation. Agriculture Ecosystems and Environment. (2010) 137: 251-260.

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	farmer management practices. It is also unclear how this suggestion would address the adding of a legume to a rotation during the project period.		rate reduction would be credited. These examples show how increased rotational complexity is obtained with our methodology, and in the latter case how introduction of a crop during the project period can generate credits from emissions reductions. When a non-leguminous crop is planted as a cover crop during the project period, residue N from this crop will not be directly counted towards total N input to the crop rotation based on the methodology. N in this crop residue is not an external input – it is recycling of N already added to the system. To include this residue N would be double-counting, which would not be a conservative approach. As previously noted residue N from crops grown outside the project site and applied to fields during the baseline and / or project period are included in the methodology as an external source of N. Evidence of the impact on N_2O emissions following inclusion of soybean (legume) crop into continuous corn cropping systems is limited. The majority of the small number of studies that have compared N_2O emissions from corn and soybean cropping systems in North America have shown that N_2O emissions are higher from continuous corn systems than in corn-soybean rotations, which are in turn higher than continuous soybean systems. This evidence suggests that replacing corn with soybean reduces N_2O emissions. However, in accordance with conservative accounting, our methodology makes no such claim and is agnostic about its inclusion, so long as no additional eligible N inputs (as defined in our methodology) occur. If a reduction in N rate does not accompany the introduction of a crop during the project period, when that

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			crop was not present during a baseline period, then currently our methodology does not allow crediting solely for the introduction of that crop, nor does it penalize its introduction. While the introduction of a cover crop may be environmentally beneficial due to for example reduced soil erosion and increased soil water holding capacity its inclusion during the project period will not be rewarded with N_2O emissions reductions credits when it was absent during a baseline period. There is good reason for this. N_2O emissions from single and mixed leguminous and non-leguminous cover crops have not been well studied. There are limited data that do not allow robust quantitative N_2O responses to be determined. Their inclusion may increase or decrease N_2O emissions when compared to their non-inclusion in a crop rotation. In the absence of strong evidence for an increase or a decrease in N_2O emissions our methodology does not credit, but also does not prevent, their adoption. This agnostic approach, while not incentivizing the likely beneficial results of planting cover crops, does not hinder the practice. If new evidence emerges that cover crops can reduce N_2O emissions, our methodology can be adapted to include their use as a mitigation practice. Currently, environmental programs such as EQIP and CSP financially incentivize their adoption for reasons other than N_2O emissions reduction.
3	**Fertilizer Nitrogen Management (2.2)** Research has demonstrated that the timing and placement	National Wildlife	This comment and comments 4 and 5 below make the assumption that the impact of altering an individual practice (other than N rate) or a combination of practices

	Comment	Commenter	Response
	of nitrogen fertilizers significantly affects nitrous oxide emissions.[2] Exclusion of this variation is not conservative, as a farmer might reduce fertilizer rate application and choose an application method with a higher greenhouse gas emissions level.	Federation	has reliable, robust, and quantifiable impacts on N_2O emissions. This is not the case. Despite many empirical studies on the numerous factors that can affect N_2O emissions, such as fertilizer timing, placement, and type and tillage, strong scientific consensus is lacking as to the impact of these factors on emissions of N_2O. As noted previously our current state of knowledge is such that only N availability (annual N rate) can be used with any degree of confidence in predicting N_2O emissions. The assertion that a farmer can pick and choose practices with knowledge of the impact that these changes will have on N_2O emissions is incorrect and suggests a certainty not supported by the literature. Although NWF highlight a number of peer-reviewed articles to bolster their comments about the inclusion of N management practices other than N rate, as mentioned previously the literature also contains many studies that refute and contradict these studies. This in no way undermines their integrity or the conclusions drawn, rather it highlights the continuing debate surrounding N_2O emissions, the implementation of practices that mitigate it, and the pursuit of robust quantitative methodologies capable of predicting future emissions. The 'choice' of an application method that purports to counteract a reduction in N rate is therefore a false one. Available data are insufficient to enable N application methods (and other management choices, apart from N rate) to be used quantitatively.

[2] Smith et al. "Emissions of N2O and NO associated with nitrogen fertilization in intensive agriculture, and the potential for mitigation." Soil Use and Management. 2010 13: 296-304.

	Comment	Commenter	Response
			There is also no evidence to suggest that a farmer would alter his N application method as a strategy to buffer any potential yield loss from N rate reduction. As mentioned previously a practice change may be necessary for a project proponent to adhere to local BMPs associated with N fertilizer timing and placement, but this requirement does not serve as a compensatory strategy for N rate reduction. Concerning the timing of N fertilization: our methodology is based upon the application of N fertilizer in the spring of each year rather than the previous fall. Although consistent evidence is lacking, spring application of N fertilizer likely results in lower N_2O emissions on average than fall application. However, a farmer who changes the timing of his fertilizer application from fall to spring will not receive offset credits for this change alone using our methodology. This approach is conservative. Consequently, the NWF charge that our methodology is non-conservative is incorrect.
4	**Fertilizer Type** Different organic and synthetic fertilizers have been found to have nitrous oxide emissions differences on the order of 50%.[3] By switching between fertilizer types a farmer might increase greenhouse gas emissions, even while reducing nitrogen application rate. A 10% nitrogen application rate reduction might be offset by a 50% increase in nitrous oxide emissions between two different fertilizer types. The protocol's assumption of a baseline application rate of 0 for organic fertilizer is particularly susceptible to this kind of	National Wildlife Federation	Please refer to comment 3 above for our response as well as the information below. Strong scientific consensus is lacking as to the impact of fertilizer type on N_2O emissions. A farmer cannot pick and choose fertilizer type with knowledge of the impact that this change will have on N_2O emissions. The MSU-EPRI methodology does not assume that the baseline application rate is zero (0) for organic fertilizer. The contribution of organic fertilizer to N_2O emissions is

[3] Alluvione et al. "Nitrous Oxide and Carbon Dioxide Emissions following Green manure and compost fertilization in corn." Soil Science Society of America Journal 2010 74: 384-395.

	Comment	Commenter	Response
	overestimation of reductions.		included in the calculations for both baseline and project emissions.
5	**Tillage** Research demonstrates that tillage practices interact with fertilization to significantly vary nitrous oxide emissions.[4] Tillage affects soil moisture and compaction levels, which determine nitrous oxide emissions to a large extent. If a producer were to reduce fertilizer application while shifting tillage practice, this interaction would have an uncertain impact on nitrous oxide emissions. The interaction would depend on soil, climate, cropping system, etc. Depending on these factors, the protocol might over estimate greenhouse gas emissions reductions in such a case.	National Wildlife Federation	Please refer to comment 3 above for further response. There is no special consideration for tillage in our protocol. While there are many studies in the literature documenting how tillage practices affect N_2O emissions, a small fraction of which have been noted by NWF, there is no clear evidence that a particular tillage practice or interaction of a particular tillage practice with other N management practices, affects trends of N_2O emissions in a consistent and quantifiable manner.
6	**Best Management Practices (4-R Nutrient Management) (2.2.1)** The protocol requires that any producer demonstrate that they are following Best Management Practices in order to earn credits. As BMPs are differently understood, defined and enforced even between neighboring counties, the specific enforcement of this provision seems challenging. Further, BMPs are generally not understood to maximize greenhouse gas emissions reductions. They are implemented with a variety of goals, from optimizing a	National Wildlife Federation	We agree that the text in section 2.2.1 of the ACR methodology in relation to adherence to BMPs is not sufficiently specific to reflect our intention. We have amended the text to limit adherence to those BMPs that relate to a 4R nutrient management plan rather than a broader set of goals. This narrows the range of practices to those that increase N use efficiency, and when adhered to are most likely to reduce N_2O emissions from the cropping system. To provide N_2O reductions credits for these management practices in addition to credits

[4] Ussiri, D., R. Lal, M.K. Jarecki. “Nitrous oxide and methane emissions from long-term tillage under a continuous corn cropping system in Ohio.” Soil & Tillage Research. (2009) 104: 247-255 Steinbach, H.S., and R. Alvarez. “Changes in soil organic carbon contents and nitrous oxide emissions after introduction of no-till in Pampean agroecosystems.” Journal of Environmental Quality. 2009 35: 3-13; Ball, B.C., I. Crichton, G.W. Horgan. 2008. Estimated N_2O and CO_2 emissions as influenced by agricultural practices in Canada. Climatic Change. 65: 315-322; Oorts, K., R. Merckx, E. Grehan, J. Labreuche, B. Nicolardot. 2007. Determinants of annual fluxes of CO_2 and N_2O in long-term no-tillage and conventional tillage systems in northern France. Soil & Tillage Research 95: 133-148; Almaraz, J.J., F. Mabood, X.M. Zhou, C. Madramootoo, P. Rochette, B.L. Ma, et al. 2009. Carbon dioxide and nitrous oxide fluxes in corn grown under two tillage systems in southwestern Quebec. Soil Science Society of America Journal. 73: 113-119.

	Comment	Commenter	Response
	management system across many different objectives (soil health, crop yield, profitability) to maximizing farmer profitability. It may not be conservative for the project developer to assume that BMP use necessarily indicates that a farmer is doing 4-R nutrient management, and has accounted for any nitrogen inputs from cover crops or leguminous crops.		associated with N rate reduction would not be conservative. Our amended text is: "During the project crediting period adherence to Best Management Practices (BMPs) as they relate to the application of synthetic and organic N fertilizer at the cropping site are required. These BMPs are related to N fertilizer formulation (or N content of organic additions) and dates and methods of application." For example, in Michigan agricultural producers would adhere to Generally Accepted Agricultural and Management Practices (GAAMPs) for N fertilizer application as published by the Michigan Commission of Agriculture and Rural Development. The GAAMPS require for corn: 1) spring [not fall] N application; 2) N in ammonium [not nitrate] form be used under conditions of high leaching potential; and 3) split N applications, except on fine soils where it is optional. With regards to enforcement and project verification, farmer records of these practices, consistent with project documents such as custom application contracts or fertilizer sales records would be sufficient to demonstrate methodology compliance. The BMPs are defined by applicable state and federal programs and enforced by those entities. The methodology requires that farmers keep records of agronomic practices relevant to BMPs. Project verifiers are expected to review these records in light of relevant state and federal programs based on the project methodology.

3 Project Boundary

	Comment	Commenter	Response
1	**Carbon Dioxide Emissions (sections 3.3, 3.4 and Annex B)** Carbon dioxide emissions are excluded from the protocol on the basis that excess nitrogen fertilizer can "speed decomposition (Parton et al. 2007) and thereby lower (Khan et al. 2007) or maintain (Russell et al. 2009) C stocks that might otherwise increase." The proponents argue that fertilizer rate reductions may promote soil C sequestration, and thus excluding carbon dioxide is conservative. The negative impacts of nitrogen fertilizer on soil carbon sequestration have been observed for synthetic fertilizer, but not for organic fertilizer. A reduction in rate of organic fertilizer amendment, particularly if coupled with an increase in synthetic fertilizer use, may cause increased carbon dioxide emissions. While clear evidence on this topic is lacking, a conservative approach is needed.	National Wildlife Federation	First a clarification. Our methodology does not "argue that fertilizer rate reductions may promote soil C sequestration" and thereby exclude carbon dioxide from the calculations as it is conservative to do so. We justify exclusion of the soil C pool in Annex B of our methodology as below: "N fertilizer can increase soil C stocks by increasing crop growth and associated rates of crop residue production. Because this methodology will not result in significant crop growth (yield) declines and therefore no declines in residue inputs, there can be no associated decline in soil C stocks." We agree that "The negative impacts of nitrogen fertilizer on soil carbon sequestration have been observed for synthetic fertilizer". Our references in Annex B provide evidence for this. NWF are correct to point out that the studies we highlight relate only to increased inputs of synthetic N fertilizer. The vast majority of N applied to cropping systems in the USA and particularly in the NCR is in the form of synthetic fertilizer. From our understanding of the comment, NWF are proposing a scenario where overall N rate can be reduced with a decrease in organic N rate that is larger than a concomitant increase in synthetic N rate, such that C stocks decrease in the long-term. The implication being that the decrease in C stocks from this improbable practice during the project period are >3% of the total CO_2e benefits

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			accrued from the reduction in N_2O emissions. This is an interesting theoretical point. However, as noted by NWF, evidence to show that soil C stocks would diminish under this scenario is lacking. We also do not see how taking this practice into account in the methodology would be conservative. There is no demonstrable evidence that adopting this practice increases or decreases soil C in the long-term in any quantifiable or biased manner. Therefore, an impartial approach in this case makes sense, and this practice is not included from an accounting standpoint. Irrespective of the very low likelihood that a farmer would adopt this N management practice in order to generate N_2O reduction credits, we believe NWF misunderstand the conservative nature of our methodology in this respect. The exclusion of the soil C pool as a conservative (or de minimus) measure is not based upon the scenario above, or any other scenario, but rather on the fact that yields will not be negatively impacted and that any reductions in soil C that accrue, however unlikely, during the project period will not constitute >3% of the total CO_2e benefits as a result of the reduction in N_2O emissions. Notwithstanding that fact that measurements of soil C pools are required over many years (decades) to establish that altered practice has resulted in a measurable soil C change (i.e., greater than the project crediting period), any reduction of soil C would not exceed the >3% threshold. For example, a modest 0.5 tons CO_2e per acre per year reduction of N_2O emissions from N rate reduction would require a soil C reduction of about 4.7 tons per acre per year (assuming N_2O GWP of 310) to be non conservative in

	Comment	Commenter	Response
			its exclusion. This reduction is unrealistic.

6. Emission Measurements

	Comment	Commenter	Response
1	The proposed methodology is based on using emissions factors. In contrast to direct measurement of nitrous oxide emissions or a biogeochemical model of nitrous oxide emissions, an emissions factor assumes that, depending on the amount of fertilizer applied, a certain percentage will be released as nitrous oxide. The project proponents suggest that this approach is conservative. The following comments are meant to show that systematic factors such as soil, climate and weather impact nitrous oxide emissions, and thus the emissions factor could be consistently biased if applied in particular geographies or at a project scale. In addition, emissions factors assume no carry-over of nitrogen from one year to the next, and could therefore be non-conservative. The nitrogen cycle is extremely complex, but is known to be driven by temperature and moisture constraints and affected by soil and topographic issues. The following points are meant to suggest some examples of the kind of problems posed by an emissions factor approach. While no one point may be overwhelming, the combination of so many opportunities for non-conservative findings suggests that the protocol would present severe problems. In a semi-arid region, nitrous oxide varied consistently with landscape features and soil type. Footslopes had higher N_2O emissions than shoulders, and sandy soil had higher emissions than fine textured soils. This suggests that an emissions factor	National Wildlife Federation	The NWF is correct that there are many inter related factors that can affect agricultural emissions of N_2O, and that other parameters can help predict N_2O emissions. We agree. There are three main concerns embedded in this NWF comment: emissions factors are 1) inappropriate for calculating emissions of N_2O; 2) non-conservative, and; 3) biased. We break up our responses below based upon this interpretation. First, a clarification regarding the distinction NWF draws between emissions factors and direct measurements. Our methodology (Approach 2) uses ‘direct’ emissions of nitrous oxide to determine a regional emissions factor. The empirical data collected over eight site years on commercial farmer fields using multiple N rate comparisons is to our knowledge unique in the NCR. Please see Hoben et al. (2011) for details. Please also note that the IPCC Tier 1 factor for N_2O emissions is derived from empirical field data measured from agricultural cropland. A main distinction between this and our Tier 2 approach is that the Tier 1 factor encompasses many more studies conducted over a larger (global) scale.

	Comment	Commenter	Response
	approach might systematically overestimate emissions reductions from lowlands or sandy soils in arid regions. In the absence of further evidence on this systematic bias, it would be conservative to exclude those topographies or soil types.[5] In New Zealand and Europe soil water content correlated positively with nitrous oxide emissions, so an emissions factor approach might overestimate emissions reductions from particularly wet soils.[6] [7] In Europe, nitrous oxide emissions were also found to correlate to temperature, suggesting that an emissions factor would approach might overestimate emissions reductions from particularly warm areas.[8] In summary, in any case outside the North Central Region of the United States where the actual portion of N fertilizer that is released as nitrous oxide is less than 1% (the IPCC emissions factor), the protocol would over allocate credits. For example, consider a reduction from 100 units of N applied to 50 units N applied. Using the IPCC tier 1 emissions factor of 1% would suggest a reduction from 10 units nitrous oxide to 5 units nitrous oxide, and the awarding of 5 credits (converted to CO2e). However, if the actual emissions factor is lower, such as		While we understand that measuring emissions of N_2O directly from field(s) is unlikely to be a practical and widespread method for determining project emissions, the emissions factors used in our methodology are derived from just such field measurements and are justified for use as proxies for estimating N_2O emissions. 1. Emissions factors are scientifically robust and derived from empirical data. They are an essential element in calculating GHG emissions from agricultural practices at many scales, and are used frequently in many process based modeling approaches. They are currently used in the majority of countries for reporting agricultural N_2O emissions inventories under the Kyoto Protocol. Emissions factors are used in a variety of contexts and are not solely related to annual N rate, as indicated by the NWF. In our methodology (Approach 2) we use a regional emissions factor derived from empirical data generated from field-based measurements of N_2O emissions. In regions in the US outside the NCR and countries other than the US we use a global emissions factor derived from empirical data generated from field-based

[5] Corre, M.D., van Kessel, C. and Pennock, D.J. 1996. Landscape and seasonal patterns of nitrous oxide emissions in a semiarid region. Soil Sci. Soc. Am. J. 60:1806-1815.

[6] Choudhary, Akramkhanov, “Nitrous Oxide Emissions From A New Zealand Cropped Soil: Tillage Effects, Spatial and Seasonal Variability” Agriculture, Ecosystems & Environment (2002) 93:1-3, Pages: 33-43

[7] Schaufler, G.; Kitzler, B.; Schindlbacher, A.; **Skiba, U.**; **Sutton, M.A.**; Zechmeister-Bolternstern, S.. 2010 Greenhouse gas emissions from European soils under different land use: Effects of soil moisture and temperature. *European Journal of Soil Science*, 61. 683-696. DOI: 10.1111/j.1365-2389.2010.01277.x

[8] Schaufler, G.; Kitzler, B.; Schindlbacher, A.; **Skiba, U.**; **Sutton, M.A.**; Zechmeister-Bolternstern, S.. 2010 Greenhouse gas emissions from European soils under different land use: Effects of soil moisture and temperature. *European Journal of Soil Science*, 61. 683-696. DOI: 10.1111/j.1365-2389.2010.01277.x

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	.1%, then the actual reduction would be from 1 unit nitrous oxide to .5 units nitrous oxide, for an actual emissions reduction of .5 (converted to CO2e). Thus, the protocol will consistently overestimate emissions reductions in all cases where the IPCC emissions factor is higher than the actual value of nitrous oxide emission rate. While there will also be underestimation in the opposite case, data is inconclusive to establish precisely under what soils, climate and management this is conservative. As in the above examples, entire crops, regions or countries could have soils, climates or standard management practices that cause an overestimates of reductions using this protocol. Emissions factors in general can have a non-conservative bias. They only take annual nitrogen application rate as their inputs, thereby assuming that there is no carry-over effect from one year to the next. This suggests that all nitrogen added to cropland in a season completely cycles during that season. It does not allow for nitrogen to be stored in soils or biomass and contribute to nitrous oxide in future years. For example, if a farmer reduced nitrogen application rate between two years, under the protocol, the nitrous oxide emissions in the second year would be calculated based on the nitrogen application in the second year. However if additional nitrogen from the first year remained in the soil and contributed to nitrous oxide emissions in the second year, the protocol would have overestimated greenhouse gas emissions.		measurements of N_2O emissions. Both approaches are science driven. 2. Bias and non-conservativeness. Scientifically and practically, Tier 1 and Tier 2 emissions factor approaches are the most appropriate to use at the local (field) scale, and our empirical field studies provide strong evidence that Tier 2 emission factors are robust across a wide range of environmental conditions at a field (project) scale in the NCR. The NWF comment implies that emission factor approaches for estimating N_2O emissions are inferior to those used by process based biogeochemical models (Tier 3). We do not think our responses to NWF's comments presented here is the appropriate forum for an in-depth discussion of the merits and disadvantages of these two approaches to quantifying N_2O emissions. However, we do believe it is important to point out that our emissions factors are derived from actual measured emissions data. For legitimacy, process-based models, such as DNDC, require validation using these exact kinds of empirical data. Process-based models that have not been sufficiently validated using regional-specific empirical data cannot be used reliably to accurately estimate N_2O emissions or emissions reductions. Even when validated, use of these models involves many other uncertainties and challenges that can make them very difficult to use in practice. Irrespective of model validation, it is appropriate and

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			scientifically robust to use emissions factors. Emissions factors approaches are advantageous for many reasons including their transparency and practicality. Tier 3 approaches may be more appropriate to use at the national level; they do not yet provide the necessary spatial specificity to apply at the local (field-scale) level that constitutes projects within the methodology. They also lack simplicity and transparency for stakeholders. As noted by a recent expert report (T-AGG 2011): "Given the complexity of most process-based models and the amount of data they require, running them accurately and consistently requires a certain level of sophistication and expertise. Setting up the full process models and running them for individuals projects is complex, requires substantial expertise, may be prone to error or bias, and may be cost prohibitive for a project. One of the primary challenges in using these models for determining baseline and quantifying GHG impacts at farm-or regional-scales is to standardize how the technology can be made available to non-expert users such as project developers, consultants, and verifiers, in quantification protocols or program guidelines." 3. With regard to the annual nature of emissions factors and non-conservativeness We have also addressed this issue in relation to cover crops in Project Eligibility (Comment 2). With regards to the residual effects of applying N fertilizer (synthetic or organic), a fraction of the N applied in one year may be carried over into the next,

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			particularly if more recalcitrant organic N has been applied. However, there is limited and contradictory evidence from ^{15}N tracer studies as to the magnitude of this carry over; typically, it is very small. Much of the synthetic N that is applied (predominantly in one dose) to annual cropping systems (by far the most widespread practice) will likely be taken up by the crop or 'lost' from the field where it was applied during that growing season. Yearly (seasonal) emissions factors are therefore very relevant. Where leguminous crops are used in rotation, residual effects (N credits) will be taken into account by the farmer by a reduction in N rate. Any reduction in the project period from this baseline rate would further reduce the low potential of residual N_2O emissions. The specific example the NWF outline is difficult to follow. If a farmer reduced his N rate in the second year of a project to a rate lower than that of the first year, then yes he would receive extra credits for doing so. Any continued reduction in N rate below an established baseline is rewarded in our methodology. Note, the unit of time for N_2O emissions factors is typically presented on a yearly basis. However studies from which emissions factors are derived occupy a varying range of time over which emissions measurements were taken (i.e., sub yearly to multi-year). Analyses used by the IPCC in determining the global N_2O emissions factor for N rate concentrated on emissions studies that were aggregated to seasonal or annual timescales. These temporal scales make empirical relationships between N_2O fluxes and

	Comment	Commenter	Response
			management conditions useful for bridging the gap between site and landscape scales. The annual regional emission factor (Tier 2) is also very conservative as detailed in our previous response to NWF. Any residual N_2O emissions are compensated for.
2	This study compares a biogeochemical model (DNDC) to the IPCC emissions factor for China: http://nasa-ids.unh.edu/pdfs/Li_et_al_ncae01_DNDCIPCC_China_N2O.pdf. It suggests regional differences, not only randomly scattered differences.	National Wildlife Federation	We are aware of this publication and a number of others that relate to the DNDC model, however we see no need for a response as no query or question has been made.
3	The proposed methodology includes a non-linear emissions factor based on excellent research done in Michigan. However the application of this factor to the entire North Central Region may not be conservative due to climatic variation in the region. It is not clear that the non-linear relationship established in Michigan is applicable to soils, climates, and cropping systems outside of Michigan. The research sites had average rainfall of 820 mm, 800mm and 990mm. However the North Central Region is known for rainfall diversity, from 330 mm in North Dakota to 1,270 mm in parts of Missouri. As nitrous oxide emissions have been correlated with moisture and rainfall events, the proposed emissions factor would not be conservative for all parts of the NCR. The research in Michigan was also conducted entirely on fine loamy soils. Some research suggests that emissions might be higher in sandy soils, so the emissions factor might not be conservative for all parts of the NCR. [9] Research was conducted in sites with average temperature around 8 c. The NCR state of Iowa has an average	National Wildlife Federation	Our study sites do not cover the entire range of possible conditions encountered in the NCR, but are nonetheless broadly representative of the NCR, are non-biased and conservative, and as such are validly extrapolated to this region. In particular: ♦ During years with normal precipitation, crop yields at our sites are typical of the NCR. ♦ The N rates we employed (0 to 225 kg N ha^{-1}) are within the range commonly required for optimum corn grain production and recommended for the NCR. ♦ There is no evidence that soil and climate variations of typical crop fields across the NCR will lead to any greater variation in N_2O emission rates than at our sites.

[9] Corre, M.D., van Kessel, C. and Pennock, D.J. 1996. Landscape and seasonal patterns of nitrous oxide emissions in a semiarid region. Soil Sci. Soc. Am. J. 60:1806-1815.

	Comment	Commenter	Response
	temperature of 10 c and parts of Illinois have average temperatures as high as 12 c. As nitrous oxide is correlated with temperatures, the emissions factor may not be conservative for all of the NCR.		♦ There is no evidence that the soil and climate variations across the NCR are different from our sites in any way that is likely to lead to the methodology's making biased estimates of N_2O emissions. For these and other reasons, we consider our empirical results, in particular the N_2O response curve to be representative of the NCR. This view was also supported during the peer review process as part of the publications of Millar et al. (2010), Hoben et al. (2011), and Grace et al. (2011). • Millar, N., G. Robertson, P. Grace, R. Gehl, and J. Hoben. 2010. Nitrogen fertilizer management for nitrous oxide (N2O) mitigation in intensive corn (Maize) production: an emissions reduction protocol for US Midwest agriculture. Mitigation and Adaptation Strategies for Global Change 15:185-204. • Hoben, J. P., R. J. Gehl, N. Millar, P. R. Grace, and G. P. Robertson. 2011. Nonlinear nitrous oxide (N2O) response to nitrogen fertilizer in on-farm corn crops of the US Midwest. Global Change Biology 17:1140-1152. • Grace, P. R., G. P. Robertson, N. Millar, M. Colunga-Garcia, B. Basso, and S. H. Gage. 2011. Fertilizer-derived N2O emissions from maize production in the North Central Region of the USA: A regional estimate. Agricultural Systems 104: 292–296.

6.1 Baseline Emissions

	Comment	Commenter	Response
1	On section 6.1.1: ***"Method 1 - Equations (2) through (4) calculate direct, baseline N2O emissions from N fertilization for Method 1:*** $N_2O_{B\ direct,\ t} = (F_{B\ SN,\ t} + F_{B\ ON,\ t}) * EF_{BDM1} * N_2O_{MW} * N_2O_{GWP}$ **(2)** $F_{B\ SN,\ t} = M_{B\ SF,\ t} * NC_{B\ SF} * (1 - Frac_{LEACH})$ **(3)** $F_{B\ ON,\ t} = M_{B\ OF,\ t} * NC_{B\ OF} * (1 - Frac_{LEACH})$ **(4)"** Even though the factor (EF_{BDM1}= 0.01) is used as like in the IPCC Guidelines (2006), the same formula is not applied. The leached fraction is discounted in the formulas proposed in the methodology, this not being the case in the IPCC formula.	CDC Climat Research	We thank CDC Climate Research for these comments. They are correct. Our formula to calculate direct N_2O emissions is not identical to the most recent IPCC 2006, (revised Nov. 2008) document, or previous versions. Our formula discounts the leached fraction, whereas the IPCC document does not. In our own and the IPCC methodology the same Tier 1 default values are used - the fraction is either 0.30 or zero (0) dependent on whether leaching occurs or not, respectively. Calculations to determine this are given in Annex A. If the fraction is zero (no leaching) then our calculations and the IPCC calculations are consistent. If leaching is determined to occur then our approach removes this fraction (0.30) from the direct N_2O emissions calculations and uses it in the indirect emissions calculations. The IPCC inventory approach does not remove the fraction from the direct emissions calculations and uses it in indirect emissions calculations. Therefore, our approach reduces direct N_2O emissions when compared to the IPCC Tier 1 inventory approach if leaching is determined to occur. In this way our approach is more conservative (may underestimate) direct N_2O emissions when compared to the IPCC. From an inventory perspective, this is important but when dealing with N_2O emissions reductions, the removal of the leaching fraction will increase both baseline and project emissions to the same extent. Therefore, absolute reductions and credits generated will not change, as use of the same method for calculation is required for both project and baseline. We have therefore removed the $Frac_{LEACH}$ factor from the

	Comment	Commenter	Response
			relevant equations to provide further consistency with the IPCC approach and remove some potential confusion with terminology and definition as presented in comments 2 and 3.
2	On section 6.1.2: In this paragraph **$F_{B\ SN,\ t}$** doesn't have the same meaning as in paragraph 6.1.1: In paragraph 6.1.1: **$F_{B\ SN,\ t}$ = Mass of baseline synthetic N fertilizer applied, adjusted for leaching and runoff where applicable, Mg N ha-1 in year t;** While in paragraph 6.1.2: **$F_{B\ SN,\ t}$ = Mass of baseline synthetic N fertilizer applied adjusted for <u>volatilization as NH3 and NOx</u>, and leaching and runoff where applicable, Mg N ha-1 in year t;** This could results in problems to apply the methodology.	CDC Climat Research	Method 2 for calculating direct emissions uses the Tier 2 emission factor that is reliant on N fertilizer rate. The terms for N fertilizer input for synthetic and organic materials as used here does not include the removal of the leaching fraction, as leaching has already been taken account of in the previous estimation of synthetic and organic N input. This is explained in the note on page 11 (baseline) and page 14 (project). The note reads: "Note $F_{B\ SN,\ t}$ and $F_{B\ ON,\ t}$ as used in the calculation of EF_{BDM2} (equation 6) are equal to ($M_{B\ SF,\ t}$ * $NC_{B\ SF}$) and ($M_{B\ OF,\ t}$ * $NC_{B\ OF}$), respectively: the $Frac_{LEACH}$ component is zero – leaching and runoff at the site where applicable, are addressed in equations (3) and (4)." For consistency with IPCC we have removed the $Frac_{LEACH}$ term from the direct emissions equations in both the baseline and project emissions.
3	On section 6.1.2: I consider that indirect emissions are undervalued because of some formulation problems in the following equations: « $N_2O_{B\ volat,\ t} = [(F_{B\ SN,\ t} * Frac_{GASF}) + (F_{B\ ON,\ t} * Frac_{GASM})] * EF_{BIV} * N_2O_{MW} * N_2O_{GWP}$ (8) $N_2O_{B\ leach,\ t} = (F_{B\ SN,\ t} + F_{B\ ON,\ t}) * Frac_{LEACH} * EF_{BIL} * N_2O_{MW} * N_2O_{GWP}$ (9) » The fraction of volatilized nitrogen is calculated from the amount of nitrogen applied from which we had already	CDC Climat Research	Yes, we agree, as the equations are written and defined, we would double count reductions in the volatilization and leaching equations for indirect emissions. Again, this would underestimate emissions from an inventory perspective, but would have no effect on emissions reduction. Therefore, we have altered the equations to remove double counting.

	Comment	Commenter	Response
	removed the fraction volatilized: $F_{B\,SN,t} * Frac_{GASF} = M_{B\,SF,t} * NC_{B\,SF} * (1 - Frac_{LEACH} - Frac_{GASF}) * Frac_{GASF}$ $F_{B\,ON,t} * Frac_{GASM} = M_{B\,OF,t} * NC_{B\,OF} * (1 - Frac_{LEACH}) - Frac_{GASM}) * Frac_{GASM}$ Ditto for the fraction leached: $(F_{B\,SN,t} + F_{B\,ON,t}) * Frac_{LEACH} = [M_{B\,SF,t} * NC_{B\,SF} * (1 - Frac_{LEACH} - Frac_{GASF}) + M_{B\,OF,t} * NC_{B\,OF} * (1 - Frac_{LEACH} - Frac_{GASM})] * Frac_{LEACH}$ Therefore, the indirect emissions are undervalued.		

7. Leakage and Permanence

	Comment	Commenter	Response
1	***"As the project site is being actively maintained for commodity production during the project crediting period, leakage risks are negligible for ALM projects involving cropland management activities. Crop producers are highly risk averse and so are unlikely to intentionally suffer reduced crop yields in exchange for marginally increased revenue associated with ERTs from reducing N fertilization rates in a manner that affects expected crop yields."*** Concerning carbon leakage, I think it is important to impose a minimum yield level. Especially since carbon prices can increase so that it can become more profitable for crop producers to reduce N fertilization rates in a manner that affects expected crop yields.	CDC Climat Research	We appreciate the note of concern, but disagree that any yield reduction threshold needs to be considered. We believe that producers will rarely if ever intentionally reduce their crop yield by lowering their N rate, particularly for the low returns likely generated from the C market. In addition, we would anticipate that In the vast majority of projects, site-specific farmer records showing historical N rates will be available to verifiers. Very large reductions from these historical rates that obviously will negatively affect yield will be easy to identify, and lead to non-verification if necessary. Imposition of a minimum yield level could also easily lead to penalization of a producer carrying out management practice changes with good intent. Yield is variable from

	Comment	Commenter	Response
			year to year due to weather and other factors other than N rate, which are not under management control. To impose and enforce a yield reduction limit on a farmer who legitimately reduced his N rate to reduce N_2O emissions, but whose yield was subsequently reduced below an arbitrary threshold through no fault of his own is unjust. And in any case the N-rate reduction would have reduced N_2O emissions even in the event of a worst case scenario of a failed crop. Additionally, reducing N rates by adopting N rates based on economic optimization will not result in a reduction in crop yield. Extensive historical and current data from seven Midwestern states at typical crop-to-fertilizer price ratios suggest that there will be no significant change in crop yield as a result of lowering N fertilizer rate from current rates to the economic optimum. Consequently, with no reduction in productivity at the project site (and an increased profit margin), there will be no associated incentive for a shift of activity or increased production outside of the project site, which might in turn result in increased N fertilizer use and N_2O emissions. Leakage potential is therefore negligible.