Nitrous oxide emissions protocols for the Pacific Northwest

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Nitrous oxide (N_2O) emissions from the use of nitrogen (N) fertilizers are a potent source of global greenhouse gas and also represent an economic loss to farmers. Reducing agricultural N_2O emissions improves environmental quality and potentially saves farmers money. Greenhouse gas emission reduction programs (e.g., Cap & Trade) establish the potential that voluntary farmer actions to reduce N_2O emissions may be eligible for incentive payments through carbon offsets. REACCH stakeholders have indicated significant interest in this strategy. Methodologies for quantifying emissions reductions have been developed for agricultural N_2O from N management, but available protocols have not been evaluated for the inland Pacific Northwest (PNW) (Table 1).

IMPACT

The financial incentive from carbon-offset credit alone is not likely to encourage any management changes. Stacking of offset credit revenue, along with other incentive-based approaches, is likely to be required in order to realize N_2O reductions in the region.

We reviewed five available N_2O reduction protocols and performed a road test to quantify N_2O emission offsets generated under PNW dryland wheat-based cropping systems. Our specific objectives were to: (1) use the protocol methodology to quantify emission reductions, (2) evaluate the relevance of the protocol methodology to PNW wheat-based cropping systems, and (3) consider the relative importance offsets may play in incentivizing future N_2O emission reduction strategies.

Using data and modeling assessments from the Washington State University Cook Agronomy Farm (CAF), three N_2O emission reduction scenarios were developed that could be feasible under PNW dryland wheat production: (1) switching from hard red to soft white winter wheat, (2) switching from hard red to soft white spring wheat, and (3) adoption of variable-rate N application in soft white winter wheat. Based on the CAF management records, estimated reductions as high as 75, 100, and 300 lb N/acre applied annually are possible for these three scenarios, respectively.

We evaluated the three scenarios under the two emissions protocols most likely to be eligible for PNW cropping systems—the Verified Carbon Standard and the American Carbon Registry. The first critical factor we encountered is the lack of a protocol-ready regional emissions factor (Tier 2) for the PNW. Without this factor, all protocols default to the Tier 1 emissions factor from the Intergovernmental Panel on Climate Change (IPCC) of 1% of applied N.

Using estimates from published experiments and modeling studies conducted in the region, we estimated an 0.2% emission factor as a potentially more realistic value for our region. For example, in our analysis of the CAF, shifting from hard red to soft white winter wheat resulted in a reduction of 20 tons of CO_2 equivalent for Tier 1, but only 8 tons of CO_2 equivalent for our estimated regional emission factor (Figure 1). Using the Tier 1 factor could significantly over-estimate both N2O emissions and potential N_2O reductions in our region. Therefore, an important

Table 1. *Protocol quantification methodologies reviewed and general eligibility requirements.*

Program	Protocol title	Eligible project locations	Eligible crops
Alberta Offset System	Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions	Canadian province of Alberta	Fertilized agricultural crops
American Carbon Registry	ACR1—The American Carbon Registry Methodology for N2O Emission Reductions through Changes in Fertilizer Management	Global	Fertilized agricultural crops
	ACR2—Methodology for Quantifying Nitrous Oxide (N2O) Emissions Reductions through Reduced Use of Nitrogen Fertilizer on Agricultural Crops	Global	Fertilized agricultural crops
Climate Action Reserve	Nitrogen Management Project Protocol	North-central region of U.S.	Corn
Verified Carbon Standard	Quantifying N2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction	U.S.	Fertilized agricultural crops

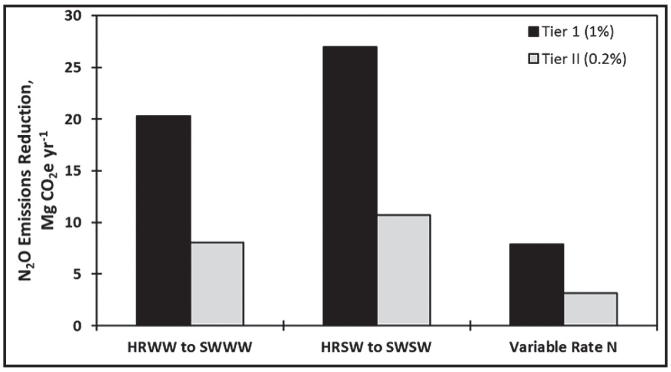

Figure 1. *Reductions in N_2O emissions for Tier 1 and Tier 2 emissions for three management scenarios.*

outcome of REACCH could be to develop protocol-ready emissions factor(s) for the region.

The second critical factor we encountered is that all of the existing N_2O reduction protocols utilize reductions in N application rate as a proxy for reductions in N_2O emissions. At least one prior study in the PNW indicates that the relationship between N application and N_2O emissions is not linear. Therefore, using N rate reductions and a constant emission factor to estimate N_2O reductions is not likely to be accurate. Realistically, using a model to estimate N_2O emissions reductions (IPCC Tier 3) would be the best strategy and is planned in the REACCH project.

The third critical factor we examined was the question of whether the value of a carbon offset credit for N_2O reductions would provide a sufficient incentive for farmers to implement any of the three scenarios we assessed. For carbon prices of $5 and $10 per ton CO_2 equivalent, the incentive ranges from $0.40 to $7.30/ha across the scenarios and Tiers. This incentive is not expected to be sufficient in itself to incentivize a management change. For carbon prices at $50 per ton CO_2 equivalent, the incentives range from $4.20 to $36.50/ha. However, when the value of expected cost savings on fertilizer application is included, the total monetary incentive ranges from $29 to $134/ha—an order of magnitude greater than the "carbon value," making the likelihood of implementation more realistic.

In order to support the participation of PNW farmers in offset credit markets for N_2O reductions, one or more of the existing protocols should be adapted for the region. At least a Tier 2 emissions factor will need to be determined or a model (Tier 3) will need to be utilized. However, the take-home message from this road-test assessment is that the financial incentive from the carbon offset credit alone is not likely to encourage any management changes. Therefore, stacking of offset credit revenue, along with other incentive-based approaches, is likely to be required in order to realize N_2O emissions reductions in the region.

Experiments using different N fertilizer rates help researchers and growers use N more efficiently. Photo by Slyvia Kantor.