The Nitrous Oxide Emission Reduction Protocol: A Canadian Case Study

The Nitrous Oxide Emission Reduction Protocol (NERP) is a science-based protocol for improving nitrogen management in cropping systems and estimating the nitrous oxide (N_2O) reduction associated with better nitrogen management. The NERP is a robust protocol designed to meet international standards for estimation and verification of carbon offsets. The concept and design of the NERP is simple and driven by data that producers are either already collecting or are interested in collecting to improve their overall farm management system.

Nitrous Oxide production from Cropping Systems: Nitrous oxide (N_2O) provides 8% of global anthropogenic greenhouse gas (GHG) emissions, has a global warming potential three hundred times greater than carbon dioxide (CO_2), and possess an atmospheric lifetime of 120 years. Approximately two-thirds of global N_2O emissions occur naturally as a result of biological and chemical transformations within the nitrogen cycle. Of the remaining anthropogenic N_2O sources, approximately 65% are directly or indirectly related to agricultural production. Global emissions of GHG associated with agriculture are predominantly methane (53%) followed by N_2O (36%) and CO_2 (11%). In Canada, N_2O accounts for about half of the GHG emissions from agriculture and is the major GHG released from cropping systems. Consequently, reducing N_2O is an important strategy in lowering agriculture's emissions overall and the carbon footprint of crop based products.

While all addition of nitrogen to cropping systems can drive up N_2O emissions, nitrogen fertilizer is the main driver of yield in modern high production systems. Through careful selection of nitrogen fertilizer source, rate, timing, and placement practices, the N_2O emissions per unit of crop produced can be substantially reduced, in some cases by up to half. Equally important, the practices that reduce N_2O emissions also tend to increase nitrogen use efficiency and the economic return on fertilizer dollars.

Global food demand is expected to rise at least 50% over the next four decades in response to population increases and greater emphasis on food selection and quality. Globally we may have already passed the peak in available farmland and total available acres may already be on the decline, consequently the bulk of new food will need to come through increasing the output on existing lands. At the same time, human activity is putting tremendous pressure on the world's natural capital and there is increasing pressure on agriculture to grow food more sustainably. It's not enough for farmers to say they are sustainable, increasingly they are being asked to demonstrate they are sustainable by having verifiable systems in place.

Developing the NERP: Fertilizer Canada has provided leadership and support to the development of the NERP as a tool to ensure the economically and environmentally responsible use of fertilizer. The NERP was developed using a consensus approach with input and review from Canada's top scientists in GHG emissions and abatement from cropping systems as well as leading agronomists from government and industry. In certain jurisdictions like Alberta, these reductions can be converted to tonnes of CO_2 equivalents and traded as carbon offsets to GHG emitters to meet their required reductions.

Fertilizer Canada originally developed NERP within the framework of Alberta's Specified Gas Emitters regulations and it is an Alberta Government approved protocol. Its main purpose within the Alberta system is to reduce on-farm emissions of N_2O in a quantifiable, credible and verifiable way that would allow farmers to produce saleable carbon credits within Alberta's regulatory carbon market.

NERP uses a modification of Canada's internationally accepted and peer reviewed Tier II inventory method to estimate N_2O emissions at the farm enterprise level. It is readily applicable as a tool for improving nitrogen management and estimating on-farm emissions from cropping systems throughout Canada. NERP can also easily be adapted to temperate region cropping systems outside Canada (for example the United States, Europe, and the Russian Federation) using Tier I or localized Tier II emission factors.

4R Nutrient Stewardship – the Driving Force behind Practice Change: Improved nitrogen management within the NERP is delivered through the incorporation of a 4R Nutrient Stewardship Plan. 4R Nutrient Stewardship is a universal science-based program developed by the International Plant Nutrition Institute. It promotes the application of the scientific principles of crop nutrition in combination with best available local and regional evidence to improve the site-specific management of nutrients. The 4R Nutrient Stewardship program is built for sustainable agriculture and seeks to balance nutrient management decisions within a framework of economic, social, and environmental goals.

Producers wanting to participate in the NERP develop a 4R Nutrient Stewardship Plan with an Accredited Professional Advisor (APA). An APA is a required element of a farm's participation in a NERP project, and helps the producer develop a set of sustainability goals that incorporate GHG reduction measures as well as other issues that are specific to the farm into their nutrient management. Reducing GHG per unit of crop produced, generating carbon offsets to help society adapt to climate change, and improving the return of dollars spent on fertilizer are examples of environmental, social, and economic goals that might be included in a 4R Nutrient Stewardship Plan under the NERP. The APA also assists in the development of practices that integrate the Right Source @ the Right Rate, Time and Place©. These Best Management Practices (BMPs) must meet certain thresholds to be NERP eligible at Basic, Intermediate, or Advanced levels. Requirements include site-specific nitrogen management with the field as the management unit at the basic level and subfield or zone management within fields at the intermediate and advanced levels. Practices (particularly Right Rate) are adjusted to meet the unique conditions of each field.

The NERP Estimates N_2O Emissions at the Eco-district Level: N_2O emissions are notoriously difficult and costly to measure directly. In place of direct measurement, emission factors were developed by Agriculture and Agri-Food Canada to estimate the N_2O emissions associated with nitrogen additions to the cropping system at the eco-district level. This ensures that emission estimates are based on local climate, soil types, and baseline management practices.

The NERP estimates take into account all sources of added nitrogen including fertilizer and manure, alternative sources like compose or other by-products, as well as the nitrogen recycled

from crop residues. The NERP's accounting of GHG emission is comprehensive; both direct emissions from the cropping system and indirect losses from nitrogen from the cropping system through ammonia volatilization or leaching are included in the estimate. While the NERP does not account for the complete lifecycle of fertilizer, it does account for things like increased (or decreased) fuel use on the farm that may be a result of practice change.

Calculating N_2O Reductions and Carbon Credits: The NERP calculates N_2O reductions by comparing historic emissions baseline to project or post 4R Nutrient Stewardship implementation emissions. The baseline is generated from three years of yield (or total production) and nitrogen use data for each crop grown on the farm and expressed as the average emission in crop event units ($kgCO_2e$/kg crop). The use of crop event units, an intensity measure, allows comparisons and averaging across different production years. Project emissions are estimated using current crop production and nitrogen use data. Emissions are expressed as crop event units ($kgCO_2e$/kg crop). The initial emission value is multiplied by a reduction modifier to adjust for the effect of BMP adoption on N_2O emissions. Actual reductions are estimated by subtracting the corrected project emissions from the baseline. Reductions are converted from $kgCO_2e$/kg crop to $kgCO_2e$ by multiplying by the mass of crop produced. A final step is adjusting the reduction estimate for differences in related sources of GHGs between the baseline and project. This can include for example, the additional fuel consumption associated with changing from a single time of application to a split application approach.

The initial project calculations are sensitive to changes in nitrogen application rate while the use for the reduction modifier takes into account the synergistic effects of integrated 4R Nutrient Stewardship practices. The reduction modifiers currently used estimate a 15% reduction for basic and a 25% reduction for intermediate and advanced BMPs. These values were derived from published peer reviewed data on nitrogen use efficiency and N_2O emissions. The reduction modifiers are conservative. Recent research suggests that the actual N_2O reductions achieved by applying 4R Nutrient Stewardship practices over large areas and multiple years are considerably higher than those estimated.

Data Requirements and Verification: NERP was developed following ISO 14064-2 guidelines for quantification and reporting of GHG reductions. It is designed to meet the requirements of verification at the standard for reasonable level of assurance. This is an evidence-based system that relies on verifiable measurements for quantitative data and documented proof for qualitative requirements.

Major quantitative data requirements are nitrogen inputs and crop outputs for each crop grown in the farm in each baseline and project year. Qualitative requirements include for example location of fields enrolled in the project, 4R Nutrient Stewardship practices used on each field, and configuration of banding equipment. The APA ensures that data and documentation meet the required standards of accuracy and completeness.