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Towards a National NERP Carbon Management Strategy

Prepared by Viresco Solutions, on behalf of Fertilizer Canada

April 24, 2018

A Call to Action

This document is intended to catalyze a national dialogue on how Canadian governments and agriculture supply chain players[1] can align on action to realize the Vision of:

> *"Every Grower in Canada has the opportunity to implement the Nitrous Oxide Emission Reduction Protocol and play a role in reducing carbon emissions on their farm."*

This strategy complements Fertilizer Canada's goal of achieving 20 million acres under 4R Nutrient Stewardship by 2020 – 20 per cent of Canada's crop land. Fertilizer Canada and its members have invested significantly in the 4R Nutrient Stewardship Program; 4R Research Network; 4R Designated advisors training/certification programming; and continued refinements to the Nitrous Oxide Emission Reduction Protocol (NERP) over the last decade. The institutional platform necessary for a roll-out of this scale is in place – now the coordinated effort to unleash the potential must begin. Given that almost every province has identified an opportunity for the agriculture sector to participate voluntarily in generating carbon offsets under the Pan Canadian Framework (PCF), the timing is ripe for agriculture to contribute to the low carbon economy and have the revenue from carbon pricing systems drive the needed implementation across the country. A national NERP strategy that allows Canadian growers to quantifiably demonstrate carbon reductions helps position Canadian-sourced crops as 'Climate Smart' and contributes to a low carbon economy. Further, recent outcomes of the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) discussions with Canadian environment ministers supported a nationally consistent offset framework (see call-out box).

> ***CCME Direction on PCF Offset Harmonization (Nov 3, 2017)***
> *Ministers directed officials to continue to work on identifying best practices that could be included in a Canada-wide framework for greenhouse gas (GHG) emissions offsets. The framework could provide guidance to jurisdictions that wish to develop their own offset systems. It could also support cooperation among jurisdictions that wish to explore collaborative approaches to shared offsets administration.*
> (http://www.ccme.ca/en/whats_new/article.html?id=82)

What is NERP?

The NERP is a science-based protocol that gives growers a way to benefit from reducing greenhouse gas (GHG) emissions from their farms. Soon, Canada will have a nationally consistent NERP protocol, with common and comparable Canadian-based science, procedures, carbon accounting rules, data and supporting evidence driving its GHG metrics[2]. This protocol will meet international standards for

[1] Farm groups, agri-retailers, crop advisors (private and public sector), farm machinery manufacturers, applied researchers, carbon project developers and ICT technology providers.

[2] The Ontario-Quebec Cap and Trade Linked Initiative is adapting the Alberta NERP protocol with the intent to have it nationally applicable to every province in Canada.

quantifying and verifying carbon offsets. Under the NERP, growers can generate revenue from N_2O reductions by switching to an integrated set of Best Management Practices (BMPs) for applying nutrients, referred to as 4R Nutrient Stewardship. 4R Nutrient Stewardship, in the context of the NERP, involves applying nitrogen sources in a more sophisticated way following the 4R framework - Right Source @ Right Rate, Right Time and Right Place®. Implementing 4R Nutrient Stewardship, under the guidance of an accredited professional, results in applied nitrogen being used more effectively. This increases economic performance for growers by reducing the input costs per unit of crop yield produced – an enhanced return on investment (ROI) on their fertilizers, which is one of the highest variable costs on the farm.

In addition to reducing GHG emissions, broad-scale implementation of NERP could:

- Increase food security and prosperity for the country;
- Deploy precision farming in the agricultural supply chain by employing variable rate nitrogen fertilizer application, along with other inputs;
- Improve soil health and water quality through the application of regionally-specific BMPs; and
- Provide domestic emission reductions, contributing to Canada's Paris commitment as identified in the Pan Canadian Framework on Clean Growth and Climate Change (PCF).

The Canadian NERP is becoming a Global Standard

The Canadian innovation of 4R Nutrient Stewardship is gaining global acceptance as a simple, systems-based stewardship platform for agriculture that supports the United Nations (UN) Sustainable Development Goals (SDGs). Recently, the NERP and 4R Nutrient Stewardship were recognized in the SDG Industry Matrix, published by the UN Global Compact, as an example solution to Climate Change and a global good practice. The NERP approach is also being deployed through shared value partnerships with members of the agriculture supply chains. For example, a significant Canadian contribution to GHG reductions in the US has occurred due to the NERP approach being adopted by Field to Market members[3]. NERP has also been endorsed by the United Nations Food and Agriculture Organization (FAO) as a climate-smart agricultural practice.

The NERP is globally scalable. Partnerships continue to grow with the World Business Council for Sustainable Development members and others, likely resulting in a meaningful impact. This aligns with Canada's emerging alliances focused on sharing best practices in measuring, monitoring, reporting and verifying GHG emissions. These practices will inform future program design, including common

[3] See: https://fieldtomarket.org/update-proposed-revision-greenhouse-gas-emissions-metric-approved/

accounting and transfer across systems and borders with our implementation partners [4]. Acting on this strategy and continuing to export Canadian 'know-how' can potentially brand Canada as a Global Climate Leader, and connect Canada with a larger network of Climate Smart and Sustainable networks for transference of best practices and science. Furthermore, publicly traded corporations are increasingly looking for ways to improve their environmental, social and governance ratings to demonstrate that they are responsible and provide good value to shareholders.

Definition of Success

The agriculture sector is on the cusp of a digital data revolution that will further enhance crop performance, productivity, and enable the sector to advance evidence-based systems of performance metrics, while reducing GHG emissions. To achieve these objectives the sector must effectively deploy these clean technologies. Earlier this year, Dominic Barton, chair of the Minister of Finance's Advisory Council on Economic Growth, released a report titled "Unleashing the Growth of Potential Key Sectors."[5] The document highlights Canada's agriculture sector as one with massive potential for growth. The report identifies the need for increased investment in infrastructure related to crop connection, crop aggregation and marketing facilities; high speed internet, data connectivity, farm data and information collection systems; high tech GPS-guided machinery on-farm, sensors and data-driven analytics; quantification platforms and the formation of technology hubs that encourage innovation by providing immediate opportunities to pilot, integrate and scale new agriculture technology on farm. 4R Nutrient Stewardship (within the context of the NERP), its supporting research and the trained 4R agri-retailer membership through Fertilizer Canada's 4R Metrics and Adoption Working Group, are uniquely positioned to be a flagship of innovation as a systems-based stewardship platform with supply chain relevance. A strategic approach is outlined below.

Strategic Intentions

Key stakeholders across Canada familiar with the context described above have provided input to this Strategy Discussion Paper[6]. These stakeholders are actively engaged in building the institutional platforms needed to scale NERP across the country. Based on their input, five strategic intentions

[4] See: Canada-Pacific Alliance MRV Governance Collaboration Initiative: http://www.ieta.org/page-18192/5473324

[5] Economic Advisory Growth Council's Barton Report: 'Unleashing the Growth Potential of Key Sectors; Advisory Council on Economic Growth', Feb 2017. See http://www.budget.gc.ca/aceg-ccce/pdf/key-sectors-secteurs-cles-eng.pdf

[6] Stakeholders consulted: Federal Government - Kathleen Rich, Environment Canada and Climate Change; Keith Reid, Agriculture and Agri-Food Canada; Provincial Governments – Len Kryzanowski, Alberta Agriculture and Forestry; Matt Wiens, Manitoba Ag and Food; 4R Research Network – Dr. Claudia Wagner-Riddle, University of Guelph; Dr. David Burton, Dalhousie University; Dr. Mario Tenuta, University of Manitoba; Dr. Miles Dyck, University of Alberta; Farm Groups- Erin Gowrliuk, Alberta Wheat Commission; Don McCabe, Ontario Precision Ag and Food; Susie Miller –Canadian Roundtable on Sustainable Crops; Farm Crop Advisors – Dr. Dan Heaney, Random Cross Consulting.

towards implementing a National NERP strategy at scale are put forward below to provide scope and direction to this Strategic Discussion paper:

1. **Aligned and Consistent** - Federal and Provincial governments harmonize and align on a common, consistent definition of a 'NERP-reduced tonne of carbon' across the country - to provide confidence and incentivize adoption investments;
2. **Science and Evidence-Based** – Canada's best science is applied in an efficient and pragmatic manner to estimate, verify and recognize carbon reductions on farm;
3. **Comparable and Standardized** – Internationally consistent carbon accounting rules, along with quantification procedures and supporting farm data/evidence, provide verifiable NERP GHG metrics on a common methodology and standard – this will be important for investment;
4. **Practical and Flexible** – The NERP (and thus, the 4R Nutrient Stewardship) approach enables best available local and regional evidence to support site-specific NERP management practices suitable and feasible for a grower's conditions; and
5. **Supply Chain Enabled** – Supply chain engagement results in a demonstrated shared value, systems-based approach that scales and drives improvements in policies, products, services and practices that are recognized and realized by growers implementing NERP.

On strategic intention No. 5, there has to be demonstrated value to the grower to turn the tide of thinking that the carbon price is a tax burden or cost to the farm operation to one of financial benefit with ancillary gains in operational efficiency and addressing risks (similar to risks below) in farming and the farm supply sector. The development of partnerships with supply chain players to channel investment on-farm to provide carbon reductions and other benefits will drive adoption.

Current state

According to the FAO, Canada is one of only six countries with an arable land base that is able to significantly increase agriculture exports and help meet the estimated 70 per cent increase in crop production needed to feed nine billion people by 2050. The FAO estimates one billion hectares of natural land has been preserved from crop production between 1961 and 2005 because of increases in yield and productivity – this sustainable intensification needs to continue. Reconciling the dual objectives of increased food production and reduced emissions requires increasing the efficacy of agricultural practices so growers can get more out of all the inputs and resources they use. This is what the NERP is designed to do, but adoption of the 4R Nutrient Stewardship system in the context of the NERP to access carbon markets is still out of reach. Nevertheless, the need to sustainably intensify agricultural production can be accelerated by carbon market revenues and enabled digital technologies can help create other ecosystem marketplaces to potentially trade wetland, nutrient and other credits.

An excellent case study on the power of aligned, comparable and nationally consistent metrics enabled by supply chain actors in Canadian agriculture can be found in the quiet revolution of no till or conservation tillage farming in the prairies. Since the early 1980's, innovative collaborations between members of the value chain in agriculture including federal government researchers, provincial government extension specialists, equipment manufacturers, input suppliers, farm groups and growers themselves have reached the point of adoption in conservation tillage where farmlands across Canada are now removing over 10 Mt of CO_2e from the atmosphere every year. A recent study at the University of Saskatchewan [7] quantified the impacts of conservation tillage between 1985 and 2010. The study identified on-farm benefits (fuel, equipment, labour and productivity) worth $24.3 B (2014 CAD$). Fifty percent of the benefit captured in this figure is from technology innovation, and the resulting jobs in the no-till, direct seeding equipment manufacturing sector in Canada. The off-site benefits (GHG reductions and carbon sequestration for the public good) resulted in over $1B (2014 CAD$) worth of value at $5/tonne of emission reductions, of which, $417M was attributed to reductions in N_2O and fossil fuel CO_2 emissions saved. The return on investment (ROI) in the research and development (R&D) and shared value partnerships in extending/deploying this technological shift in conservation farming is valued at a benefit:cost ratio of 60.8:1, relative to a delayed adoption scenario. If we apply a ten-times uplift to the carbon price (i.e. $50/tonne), which the current Federal government has signaled will be the price of carbon in Canada by 2022, the driver could be ten times more powerful. This example shows the power of value chain partners to scale emission reductions and removals across landscapes in the cropping sector in Canada. This would not have happened without the sustained and strategic investment of all players in the supply chain.

A catalyst for innovation collaboration similar to the above case study is afforded by the federal government's announcement to invest $950 million in Innovation Super Clusters. This call for proposals recognizes the entire supply chain must be involved, requiring technology hubs aimed at fostering public-private partnerships in industries across the country. The Agri-food sector was identified as one of five key candidates with the right conditions and abilities to contribute significantly to the growth of the Canadian economy. Estimates completed by Viresco Solutions Inc[8] on the potential contribution of a national NERP, deployed across Canadian landscapes, with proper investments, is shown in Table 1.

Table 1. Estimated Cumulative Reduction Potentials for the Implementation of the Basic and Intermediate Performance Level (representing the range in the numbers) of the Nitrous Oxide Emission Reduction Protocol (Viresco Solutions Inc.)

[7] Awada L., Gray R.S., and Nagy C., "The Benefits and Costs of Zero Tillage RD&E on the Canadian Prairies." *Canadian Journal of Agricultural Economics.* Volume 64 (3), 2016, 417-438.
[8] Viresco Solutions Inc. 2017. Analysis available upon request.

NERP			
Province	Cumulative Constrained Potential ($MtCO_2e$)*		
	Short Term (2018 - 2022)	Medium Term (2023 -2027)	Long Term (2028 - 2037)
Saskatchewan	0.34 - 0.57	1.00 - 1.67	3.51 - 5.85
Alberta	0.38 - 0.63	1.10 - 1.84	3.86 - 6.44
Manitoba	0.24 - 0.40	0.70 - 1.17	2.45 - 4.08
Ontario	0.25 - 0.42	0.73 - 1.21	2.55 - 4.25
Quebec	0.15 - 0.25	0.43 - 0.72	1.52 - 2.53
British Columbia	0.01 - 0.01	0.02 - 0.03	0.07 - 0.12
Total:	**1.37 – 2.28**	**3.98 – 6.64**	**13.96 – 23.27**

*Potential reductions were estimated for years 1 to 5, 6 to 11 and 11 to 20.

Pan Canadian Framework on Clean Growth and Climate Change (PCF)

One of the key drivers of opportunity is the PCF, which was built by Canada's First Environment Ministers building on the momentum of the Paris Agreement (Government of Canada, 2016). The PCF details how Canada aims to reach a projected GHG emission reduction target of 219 Mt by 2030 (a 30 per cent reduction from 2005 emission levels). The Government of Canada supports an economy-wide carbon pricing benchmark that will apply to all provinces by the end of 2018 (Government of Canada, 2016). Jurisdictions are given flexibility to implement their own carbon pricing system that must apply to a broad set of emissions sources, and consist of either:

- an explicit price-based system, such as a carbon tax or levy, or,
- a cap-and-trade system, or hybrid system whereby emissions of regulated entities are limited.

The carbon pricing benchmark will increase from a starting price of $10/tonne of CO_2e up to $50/tonne by the end of 2022 (increasing by $10/tonne of CO_2e/year). If a jurisdiction does not have a carbon pricing system by the end of 2018, the federal government will introduce an explicit price-based system, i.e. a carbon tax, levy or similar. The federal backstop regulation and output-based pricing system regulatory framework have been published and are out for comment before finalization. Further, the federal government has developed a PCF Offset Harmonization Framework that was presented to the Canadian Council for Ministers of the Environment (CCME) with the intent that as provincial programs evolve, a common and consistent definition of what constitutes an offset under the varying protocols would exist.

At the time of writing, the Canadian carbon pricing landscape of current policies and evolving policies in response to the PCF mandate creates carbon offset market opportunities in the major jurisdictions of Canada (Figure 1). The provinces of British Columbia, Alberta, Saskatchewan, Manitoba and Newfoundland/Labrador all have or have signaled they will have an Offset system in place. Ontario and Quebec are linking to California's cap and trade system for a harmonized marketplace.

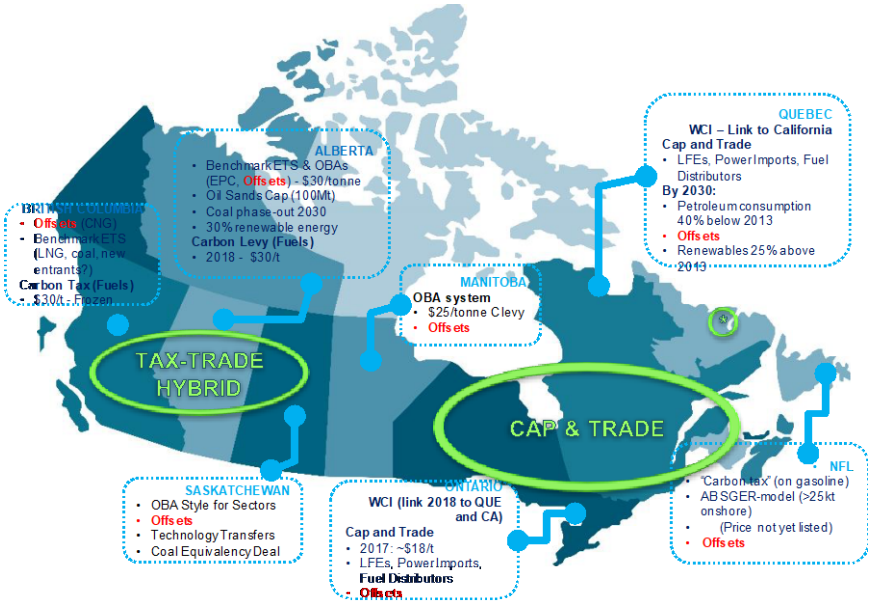

Figure 1. Pan Canadian Framework of Existing and Evolving Carbon Pricing Policies across Canada (graphic courtesy of the International Emissions Trading Association).

The Ontario-Quebec protocol adaptation process represents the best opportunity to have a Pan-Canadian NERP-based Offset Protocol which could be the flagship of the PCF Offset Harmonization Framework and meet the Strategic Intentions of this strategy. Protocols adapted under the Ontario/Quebec process must be applicable to all provinces in Canada. 4R researchers, experts, 4R practitioners and stakeholders are currently being mobilized across the country to develop a Pan-Canadian NERP and update the science in accordance with the most recent N_2O research on 4R practices.

In addition to carbon pricing systems, the NERP approach is being adopted by several supply chain initiatives such as US-based Field to Market, Fieldprint Calculator and Canada's version of the Fieldprint calculator. The US-based Field to Market group encompasses over 150 member organizations representing every link in the agricultural value chain, including growers, agribusiness companies, brands, retailers and civil society, academic and public sector partners, each committed to catalyzing

continuous improvement in the sustainability of U.S. commodity crop production. A collaborative project between US Field to Market and the Canadian Fieldprint Calculator group will demonstrate supply-chain enabled scaling with consistent, comparable metrics based on the NERP-4R approach.

4R Nutrient Stewardship BMP Guidance –Supporting Infrastructure for the NERP

Fertilizer Canada's 4R Nutrient Stewardship program (Right Source @ Right Rate, Right Time, Right Place ®) is a voluntary initiative that growers, crop advisers and agri-retailers can take advantage of, to demonstrate what they are doing in their businesses to be forward-thinking and maintain their social license to operate. Along with The Fertilizer Institute (TFI) and the International Plant Nutrition Institute (IPNI), Fertilizer Canada's goal is to measure implementation of 4R Nutrient Stewardship. The association set a target of achieving 20 Million acres (approximately 20 per cent of Canadian crop land) under 4R Nutrient Stewardship by the year 2020.

On the membership's behalf, Fertilizer Canada's **Nutrients Committee** provides strategic direction, guidance and advocacy for sustainable nutrient management under 4R Nutrient Stewardship, resulting in environmentally responsible product use and earning the industry's social license to operate. The Nutrients Committee is comprised of agronomic and other related experts of Fertilizer Canada member companies who report to Fertilizer Canada's Board of Directors.

To support achievement of the 2020 goal, Fertilizer Canada is engaging its agri-retailer membership and providing the tools they need to measure 4R Nutrient Stewardship implementation at a company-level. This would then allow Fertilizer Canada to roll-up acreage being identified as '4R Designated' (see also 4R Designation on the Fertilizer Canada website). To this end, the Nutrients Committee agreed to establish a ***4R Metrics & Adoption Working Group (WG)*** to address a need for:

1) 4R implementation guidance tables; and
2) reportable metrics.

These deliverables will serve to foster implementation at the farm level on a regional basis, bridge knowledge gaps to agri-retail, quantify nutrient loss reduction potential related to practices and identify research opportunities.

There are currently 24 participants in the WG. Collectively, they are a representative group across Canada with identified expertise in 4R Nutrient Stewardship and include:

- Agri-Retail members

- The Canadian 4R Research Network – nine leading Canadian soil science researchers quantifying economic, environmental and social benefits of 4R BMPs
- 4R experts and trainers
- IPNI - who developed the 4R Plant Nutrition Manual, the foundation document of 4R Nutrient Stewardship
- Regional Memorandum of Understanding participants – stakeholders from conservation groups, commodity groups and government specialists who have regional expertise in agronomy and provide support for 4R extension and program implementation (Figure 2)

Over a period of six months, the WG has lent their expertise and input via emails, conference calls, regional meetings, webinars and broader stakeholder consultation, which has resulted in the Version 1.0 4R BMP Guidance Document. Reflecting a nation-wide consensus, this document provides an initial set of practice suites for different cropping systems in three areas of Canada: Canadian Prairies, Southern Ontario, and Atlantic Canada (in particular Prince Edward Island). In each of those regions, suites of Nitrogen and Phosphorus practices have been developed at each performance level for one or more important cropping system. The document intends to be a *guide* for determining what is a 4R Nutrient Stewardship practice. This supports the industry members and stakeholders in then selecting key metrics related to efforts and interests in nutrient stewardship. Once reportable metrics are identified, stakeholders can develop a baseline for tracking performance to identify and establish areas in need of improvement.

Figure 2. 4R Nutrient Stewardship Initiatives across Canada

4R Research Network in Canada

The activities under the Canadian 4R Research Network have been selected to overcome gaps in adoption of 4R Nutrient Stewardship. These gaps include lack of BMP evaluation of multiple nutrient loss pathways of N and P, evaluation of BMPs under diverse soils, weather and cropping systems in Canada, and decision-making tools for tailoring BMPs to local needs and conditions. The Canadian 4R

Research Network will provide needed support in measuring and documenting the economic, social and environmental benefits of 4R Nutrient Stewardship based on grower uptake of BMPs. In particular, the research will focus on reducing greenhouse gas and ammonia emissions, losses of phosphorus to surface waters and nitrate leaching in groundwater. These research activities will assist in expanding the 4Rs beyond being solely an industry outreach effort and towards becoming a viable, evolving strategy providing defendable benefits to improve cropping system productivity and reduce nutrient losses to the environment.

Network activities will include field trials and other projects in Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia and Prince Edward Island covering key field crops including: wheat, irrigated wheat, corn, potatoes, canola, barley and forages. Results of the project will be communicated through websites, scientific journal publications, meetings and decision support systems. This will provide information as a basis for 4R Nutrient Stewardship knowledge extension to reach stakeholders in all major agricultural regions of Canada. In doing so, reductions in greenhouse gas emissions, N losses to the atmosphere and groundwater, and P losses to surface waters will be realized. This will position Canadian agricultural systems as a leader in environmental stewardship.

The project is innovative in that it aims to substantiate and improve 4R BMPs through research in major crop production regions with particular soil and weather characteristics; simultaneously considers the major nutrient loss pathways having environmental and economic impacts (nitrous oxide emissions, nitrate leaching, ammonia volatilization and phosphorus runoff) from cropping systems; and provides decision support systems tailored to grower location and production system requirements.

Fertilizer Canada has provided a total industry financial contribution of $1.1 million to the project over three years, leveraged by a 1:1 match from the Canadian government under its Agri-Innovation Program: Growing Forward II. The project emphasizes collaboration with university researchers, professional advisors, provincial agriculture departments and Agriculture and Agri-Food Canada researchers (see Appendix 1 for a summary of themes and topics).

Perhaps one of the strongest arguments for a Pan-Canadian NERP that is an aligned, consistent, science-based, flexible, supply chain initiated and incentivized through the carbon offset marketplace, is presented by Dr. Mario Tenuta from the University of Manitoba (Figure 3). In this Red River valley scenario, Dr. Tenuta demonstrates that at a carbon price of $50 a tonne there is greater potential to drive greenhouse gas reductions from fertilizer use through the incentive structure offered by a carbon offset marketplace, than through taxes on fertilizer or fuels. Taxing a grower on the fertilizer or the fuel results in a higher burden than the carbon cost of making the fertilizer, and since it's not likely that the

government will tax emissions from soil, the opportunity to generate carbon offsets through the NERP will drive greater adoption of the 4Rs and reductions overall. In general, taxes do not incentivize practice changes on farm that improve productivity, reduce emissions and more broadly improve economic and environmental outcomes.

Carbon Costing/Offsetting- Anhydrous Ammonia Use

	$/t CO2 C cost	$ /t N NH3	$ /t NH3 NH3	kg N2O-N/kgN EF%	100 kg N/ha rate	User tax $ tax/ha	Manufacture Tax $ tax/100kgN/ha	Total C tax $/ha	Fert Cost no tax $/ha
½ Fertilizer Cost	10	975.61	800	2	100	9.43	2.05	11.48	97.56
	20	975.61	800	2	100	18.86	4.10	22.95	97.56
	30	975.61	800	2	100	28.29	6.15	34.43	97.56
	40	975.61	800	2	100	37.71	8.20	45.91	97.56
	50	975.61	800	2	100	47.14	10.24	57.39	97.56
> Fertilizer Cost	60	975.61	800	2	100	56.57	12.29	68.86	97.56
	70	975.61	800	2	100	66.00	14.34	80.34	97.56
	80	975.61	800	2	100	75.43	16.39	91.82	97.56
	90	975.61	800	2	100	84.86	18.44	103.30	97.56
	100	975.61	800	2	100	94.29	20.49	114.77	97.56

More opportunity in offsets from field emission reduction than fertilizer production reduction

Message: Emphasis on grower to benefit from N_2O emission reductions

Figure 3. Comparison of potential outcomes from a fertilizer cost-driven approach versus grower incentive driven offset adoption approach.

Challenges and Pinch Points

Pinch points in implementing the NERP at scale were identified by a set of stakeholders in late 2017 during the collaboration catalyzed by the Smart Agri-Food Super Cluster initiative. This involved using a systems-based approach (Figure 4). If we want to achieve the strategic intentions outlined above, the systems-based approach offers a way to approach complex and persistent challenges more effectively, ensuring that all parts of the system interrelate with each other and within the context of larger global systems.

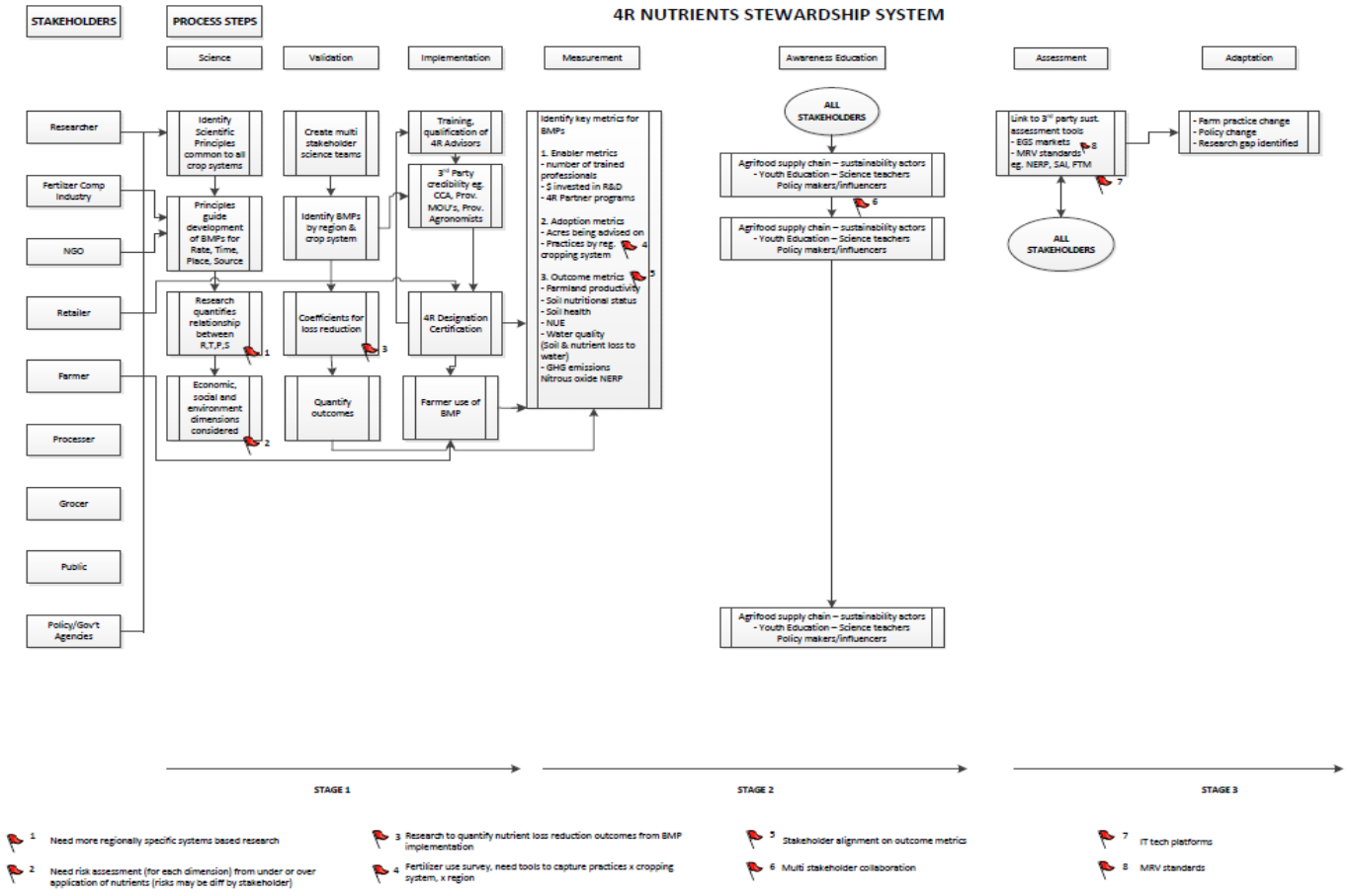

Figure 4. 4R Nutrient Stewardship System Map identifying critical issues or pinch points within the process steps.

The 4R Nutrient Stewardship System Map developed under the Supercluster application process demonstrates how investments can be directed towards critical issues or pinch points within the process steps – by all stakeholders. This ensures that solutions address not only scientific aspects, but also the needs and interests of education, measurement, implementation, and adoption; which are essential to achieving strategic intentions. The reality is that publically traded corporations are looking for ways to improve their EG&S - Environmental, Governance and Social ratings by the investment rating agencies to demonstrate good shareholder value and responsibility. Commodity sourcing is an increasingly challenging business function according to Ceres, and a growing risk facing food and agribusiness companies. Traditional procurement strategies for managing agricultural supply risks are becoming less effective in managing supply volatility in an era of climate change and increasingly erratic weather patterns. Widespread groundwater depletion and soil erosion are further compromising agricultural

productivity and increasing procurement costs. Campaign groups are shining a light on questionable and illegal practices in supply chains, including deforestation and the use of forced labor, creating risks to brand equity and reputation.

While the severity of environment and social impacts vary by commodity and region, the collective trends are producing tangible business risks that are increasingly affecting company bottom lines. Specific financially material risks include:

- **Operational risks** include reduced primary crop and livestock production.
- **Reputation risks** include damage to brand equity due to conflicts over scarce resources or environmental or social issues highlighted in advocacy campaigns.
- **Regulatory risks** include compliance costs due to violations of environmental or social guidelines.
- **Market risks** include loss of contracts or market access due to environmental or human rights impacts.
- **Litigation risks** include legal actions or sanctions for failure to address negative environmental or human rights impacts.

To maintain growth and profitability in this new, more challenging landscape, food companies must develop agricultural sourcing strategies that are climate resilient and fundamentally decoupled from environmental degradation and adverse human impacts. This creates the opportunity for partnerships for investment through multi-stakeholder collaboration as portrayed in Figure 4.

The six main pinch points identified in Figure 4 under the various process steps are:

1. More regionally-specific systems-based research;
2. Social, environmental and economic risk assessment from over or under-applying nutrients (may vary by stakeholder);
3. Research to quantify nutrient loss reduction outcomes from BMP implementation;
4. Fertilizer use survey to capture practices by cropping system by region;
5. Stakeholder alignment on outcome metrics; and
6. Multi-stakeholder collaboration to raise awareness of benefit of outcomes from implementing NERP.

Ultimately, the agricultural industry (from fertilizer manufacturer/retailer, to grower, to grain buyer and food processor, and Brands) have to **believe in the value of NERP**. They need to see the value opportunity that is created with a carbon strategy, so a “marketing campaign,” education approach involving all stakeholders will be important to get momentum behind this strategy.

Appendix 1- Summary of Canadian 4R Research Network Projects

Principal Investigator	Title of 4R Project
N STUDIES-develop and substantiate 4R BMPs through evaluation of major nitrogen loss pathways, complements of practices and improved understanding of loss pathways across major production regions and cropping systems in Canada	
David Burton (Dalhousie University)	Can the use of in-season foliar urea increase the efficiency of N use and reduce nitrous oxide emissions and nitrate leaching in potato production in Atlantic Canada?
Claudia Wagner-Riddle (University of Guelph)	Can single application of enhanced efficiency fertilizers at planting reduce N losses from grain corn production in Ontario?
Craig Drury (AAFC, Ontario)	Combined effects of nitrogen fertilizer placement and enhanced efficiency fertilizers to reduce N losses from grain corn production in Ontario
Mario Tenuta (University of Manitoba)	Reducing rates and not total nitrification to limit loss of fall applied N fertilizer in the humid condition of Manitoba using enhanced efficiency fertilizers
Miles Dyck (University of Alberta)	1. Nitrogen stabilizers to enhance nitrogen use efficiency and reduce greenhouse gas emissions in Alberta
	2. Coordinated nitrogen and sulfur management in S-deficient soils and in-crop N fertigation in irrigated systems to reduce N losses in the western Prairie environment of Alberta
P STUDIES- target 4R BMPs to reduce runoff losses of phosphorus in the contrasting production systems and environment of the Great Lakes-St. Lawrence Lowlands and Prairie Canada	

Jeff Schoenau (University of Saskatchewan)	Placement of phosphorus fertilizer to limit snowmelt P losses in the Canadian Prairies
Ivan O'Halloran (U of Guelph)	Synergists: Management of placement timing of phosphorus fertilizers to reduce P runoff losses in the Lake Erie watershed
SYNTHESIS– Foster the assimilation of discoveries of the Canadian 4R Nutrient Stewardship Research Network into decision support system tools and outreach for improved environmental health and crop productivity in Canada	
Nicolas Tremblay (AAFC, Quebec)	Development of decision support mechanisms for 4R optimization of nitrogen fertilization placement, rate and timing based on the integrated use of soil, weather and market data
Alison Eagle (Duke University)	Integrating results of the Canadian 4R Nutrient Stewardship Research Network for improved environmental health and profitability