The Protein Highway

A Whitepaper for Creating a Regional Approach to Enable Innovative Agricultural Technology Solutions from Plant Proteins

Prepared for:
Consulate General of Canada in Minneapolis

Prepared by:
Dr. David Gauthier (Saskatoon Regional Economic Development Authority) and
Dr. Larry Sernyk (Retired)

dgauthier@sreda.com
jlsernyk@att.net

February 12, 2016

Executive Summary

The Protein Highway is an initiative to enhance cross-border collaboration among entrepreneurs, researchers and investors across the Canadian Prairies and Upper Midwest/Great Plains region and stimulate economic growth and prosperity in innovative agricultural technology solutions to meet the ever-growing global demand for plant-derived protein.

Key activities of the Protein Highway include:

- Creating an innovation hub that facilitates collaboration among world class researchers to develop novel, value-added products from regional protein crops;
- Connecting ideas with entrepreneurs;
- Enabling companies for scale-up; and
- Showcasing regional opportunities to investors in agricultural innovation.

As the global population grows to 9 billion by 2040, the demand for protein will double. Although animal-based protein is often preferred by increasingly wealthy consumers, there will be a corresponding increase in demand for plant-derived protein to feed these animals. Changes in cultural, health and environmental factors are also anticipated to increase direct demand for whole format protein crops, novel plant-derived protein ingredients, meat replacements and specialty industrial ingredients.

The US-Midwest/Great Plains and Canadian Prairies region is well positioned to be a key player in the development of value-added plant proteins for domestic and global markets. The region possesses strong capabilities in producing and processing a number of crops that are ideal feedstocks for processing into value-added protein products for human consumption, pet foods and aquaculture. Technologies for economical extraction of value-added proteins have been scaled by companies in the region, which is also known for its high quality agricultural production, innovative human and capital resources and proximity to business, population, transportation and education centers.

Through collaborative promotion, research, business development and investment, the Protein Highway will become globally recognized as the region of choice for secure and sustainable production of high-quality plant proteins.

Table of Contents

Canada

The Consulate General of Canada in Minneapolis represents Canada in Iowa, Minnesota, Nebraska, North Dakota, and South Dakota. Canada enjoys close ties with all five of these Upper Midwest states – in fact, Canada is the largest export customer for all of them. Annual two-way goods trade between this region and Canada averages $36 billion, supporting 376,400 jobs per year. The Consulate General is part of a network of Canadian offices working to promote trade and investment links, to engage citizens and decision-makers on many matters of shared interest, and to assist Canadians living and traveling in the United States.

The Protein Highway Opportunity

Background

During the summer of 2015, the Consulate General of Canada in Minneapolis assembled a diverse working group representing Canadian and U.S. stakeholders from industry, academia, government and investor organizations to explore the concept of branding the Canadian Prairies and U.S. Upper Midwest/Great Plains region as a "Protein Highway." This bi-national region is a global powerhouse for crop production and value-added agriculture. Enhancing cross-border collaboration among entrepreneurs, researchers and investors in value-added agriculture holds enormous potential for stimulating economic growth and prosperity in innovative agricultural technology solutions to meet the ever-growing global demand for plant-derived protein.

The primary goal of the Protein Highway is to spur the creation of an innovation hub that facilitates collaboration among world class researchers at such institutions to develop novel, value-added products from the protein crops produced in the region; connects ideas with entrepreneurs and enabling companies for scale-up; and showcases regional opportunities to investors in agri-innovation. This whitepaper outlines the socioeconomic case for the initiative and will serve as a resource as the Protein Highway is launched in 2016—the International Year of Pulses.

The Case for Plant Proteins

Supply vs. Demand

Global population is on par to reach approximately 9 billion by 2040[1]--presenting tremendous challenges for meeting basic food requirements. As developing countries become wealthier, the demand for quantity and quality of food is not linear with population growth: higher wealth results in rapid increases in caloric intake and consumption of animal protein that eventually plateaus at 3000 calories per day and 50 grams of animal protein per day, respectively.[2] Recent estimates suggest that twice as much animal protein will be needed to feed 9 billion people than the current 7 billion on the planet.[3]

To meet the demand for additional dairy, poultry, beef, pork and other animal proteins, more agricultural land will have to be allocated to feed-based products and away from other crops for human consumption and bio-energy production. These challenges will be compounded by climate change, the decreasing availability of agricultural land per capita, and environmental degradation caused by free-

[1] *"World Population Clock". Worldometers. Retrieved 24 October 2011*
[2] Zulauf, C. "China, India, the Food Transition, and Future Demand Growth." *farmdoc daily* (5):122, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, July 2, 2015
[3] Boland, M. "Global Food Supply: the world's need for protein." Riddet Institute

grazing.[4] In the shorter term, opportunities exist to improve feed crops for enhanced palatability, protein content, digestibility, and feed conversion for animal uses. However, in the future, much more of the protein consumed by humans will likely have to come directly from crops and from more efficient animal sources, such as fish.

These converging forces are creating a pending protein crisis in developing economies—especially in India, Pakistan, Indonesia and Africa.[5] As an illustration, India passed the National Food Security Act in 2013 to ensure access to adequate food at affordable prices. The act allows two-thirds of its population access to five kg of rice, wheat or cereals per month at highly subsidized prices, but it has been suggested that pulse crops could create better nutrition outcomes for humans, while coarse cereals could be deployed to raise animals.[6] To meet these commitments, India is likely to actively pursue food supply agreements, similar to the case with its energy security strategy (e.g. India signed a five-year $350 M uranium deal with Canada in April 2015).

Health and Cultural Drivers

Numerous scientific studies have demonstrated significant health benefits of plant-based diets, including reductions in obesity, diabetes, heart disease, high blood pressure and mortality.[7] Health conscious consumers in wealthier nations are driving an opposite trend when compared to their developing economy counterparts: consumption of meat in the U.S. has decreased 7% since 2007,[8] approximately 4% of the population is vegetarian or vegan and 47% of consumers eat at least one vegetarian meal each week.[9] As consumers move away from meat products, there has been a corresponding rise in products advertised as "high in protein." These products primarily contain soy proteins, but other plant proteins are beginning to emerge.

To increase this trend further and more rapidly, innovation is required to improve the palatability, aroma, digestibility, and functionality of plant-derived proteins for direct human consumption. A wider variety of protein-rich crops is also needed to satisfy a health conscious consumer that desires tasty and varied food options. Consumers and food processors in North America could be educated on both the health benefits and positive taste profiles of plant-based food ingredients incorporated into popular items such as cereals, granola bars and other snack items. This represents a huge market opportunity for North American pulse growers that supply the majority of peas, lentils, beans, etc., to the developing world (particularly Asia) for whole-format consumption, but relatively little to consumers closer to home.

---

[4] Churchouse, P. "Agricultural Investments—The New Big Thing, The Next Big Bubble?" The Churchouse Letter, Churchouse Publishing, July 2011

[5] Boland, M. "Global Food Supply: the world's need for protein." Riddet Institute

[6] Kishore, A., Joshi, P.K., and Hoddinott, J. "India's Right to Food Act: A Novel Approach to Food Security. http://www.ifpri.org/publication/india%E2%80%99s-right-food-act-novel-approach-food-security"

[7] Tuso et. al. "Nutritional Update for Physicians: Plant-Based Diets." The Permanente Journal, 2013 Spring; 17(2): 61-66

[8] NCC. 2014. Per capita consumption of poultry and livestock, 1965 to estimated 2014, in pounds. National Chicken Council, Washington, D.C.

[9] VRG. 2012. How often do Americans eat vegetarian meals? And how many adults in the U.S. are vegetarian? Press release, May 18. Vegetarian Resource Group, Baltimore, Md.

Cultural and religious factors also play a role in the amount of plant protein consumed compared to animal protein. Growth of animal protein consumption is lower in India than China, due to high vegetarian rates (25 to 30%) among Hindus.[10] Lentils, pigeon peas, mung beans, chickpeas, kidney beans and black-eyed peas are also traditional staples in India—attenuating demand for animal proteins to a degree.[11] As a result, the need for plant proteins for direct human consumption is likely to increase rapidly in India as wealth increases in addition to feeds for livestock.

In China, there has been a dramatic increase in caloric intake since market-oriented reforms were launched in 1978.[12] Protein intake has doubled over this same period—three-quarters of which is livestock-based. In contrast to India, the shift from traditional staples to a western diet does not appear to be mitigated by cultural or religious factors. The rapid increase in demand for meat has tripled the need for cereals as feed ingredients, making it more difficult for China to maintain food self-sufficiency targets, although it will not be as reliant on imports as India.

Value-Added and Specialty Products

Markets for both plant and animal proteins as ingredients in value-added products are growing.[13] The global market volume for animal-derived protein ingredients in 2012 was 2.3 M metric tons, compared to 1.7 M metric tons for plant-derived protein ingredients. The global market for protein ingredients is projected to reach almost $34 B by 2020.[14]

Plant-derived proteins can offset market share from animal-derived protein where they meet or exceed the functionality of animal-derived proteins and can be produced at competitive prices. There is limited consumer knowledge of plant-derived proteins other than soy, but new alternatives are gaining traction and popularity—including pea protein isolates and proteins from oats, rice, potato, canola, hemp, alfalfa, algae, fava bean, nuts, ancient grains, corn-based dried distillers grains and others.[15] Traditionally, North American consumers are not widely accustomed to eating whole-format plant proteins like pulses, creating an enormous short term market opportunity for new plant protein ingredients.

Approximately half of protein ingredients are used in non-food applications, such as personal care and cosmetics, pet foods and various industrial applications. Again, demonstration of equivalent, superior or novel functions and economics compared to existing alternatives is essential to their market success.

---

[10] *Simoons, Frederick (1994).* Eat not this flesh: food avoidances from prehistory to the present*. Univ of Wisconsin Press. p. 6.* ISBN 978-0-299-14254-4*.*

[11] *Bruce F. Johnston (1958). The Staple Food Economies of Western Tropical Africa. Stanford University Press. p. 14. ISBN 978-0-8047-0537-0. Retrieved 2 June 2012*

[12] https://www.worldbank.org/content/dam/Worldbank/document/EAP/China/China_Economic_Update_June2014.pdf

[13] Frost and Sullivan. http://www.globalfoodforums.com/wp-content/uploads/2013PTT-Strategic-Insights-into-the-Global-Protein-Ingredient-Market-C.Shanahan.pdf

[14] http://globenewswire.com/news-release/2015/07/01/749005/10140356/en/Protein-Ingredients-Market-Analysis-By-Product-Plant-Proteins-Wheat-Soy-Protein-Concentrates-Soy-Protein-Isolates-Textured-Soy-Protein-Pea-Canola-Animal-Dairy-Proteins-By-Applicati.html

[15] http://www.grandviewresearch.com/industry-analysis/protein-ingredients-market

Sustainability

Food production requires an extraordinary amount of inputs and must be balanced with other demands for land, energy and water.[16] Despite impressive improvements in resources required to produce a kg of animal protein, the overall efficiency of feed conversion to produce animal protein remains low. To produce 1 kg of animal protein requires 10 kg of feed for beef, 5 kg of feed for pork, 3 kg of feed for poultry, 4 kg of feed for eggs and 5 kg of feed for milk.

Aquaculture presents a critical opportunity for food production as the need for feeding efficiencies begin to influence production economics. AquaBounty Technologies Inc. (Massachusetts and Prince Edward Island) claims a feeding efficiency of 1 kg per kg of animal gain for their transgenic Atlantic salmon. Specialized plant-derived protein feed products will be required to realize aquaculture opportunities.

Other sources of protein also have promise to meet increased protein demands. For example, Solazyme (California) is using algae to produce AlgaVia®, which makes reduced fat foods taste richer and vegan protein fortification simpler. Whey proteins from milk could also be an important market for the Protein Highway, due to the large number of dairy cattle present in parts of the region. Sapphire (California) is also using algae for feed, food and energy industries.

Increasing competition for water between industrial, domestic and food production uses will also influence food choices. The production of one kg of grain generally requires much less water than one kg of animal protein, although the magnitude of difference varies greatly depending on crop/animal type, local environment and production practices.[17] As the global demand for protein increases, the inefficiencies of the incremental step of converting plant proteins into animal proteins is not likely to be sustainable at the current pace.

Producers are continually looking for new, valuable crop alternatives that fit well within a robust rotation scheme. Climate change and continued advances in the development of new varieties/hybrids will allow producers in the target region to grow a wider variety of crops than before—as evidenced by the dramatic increase in soybean acres in Manitoba over the past few years. As the global demand for plant-derived protein increases, continuous cropping of only one or two crop species may become more economically attractive in the short-term—but also risks increased incidence of disease, herbicide-resistant weeds, poorer soil quality, and need for more fertilizers. Crop rotation and on-farm decisions will also be influenced by the environmental footprint of various crop alternatives over a 3 or 4 year rotation cycle. For example, anchoring a cropping system in a pulse crop/brassica combination could demonstrate increased carbon capture and reduced need for nitrogen fertilizers.

Development of new protein-rich crops and new processing technologies needs to occur now to generate solid agronomic data prior to potential protein shortages, which might incentivize continued reduction in cropping diversity in the region.

[16] Boland, M. "Global Food Supply: the world's need for protein." Riddet Institute
[17] http://unesdoc.unesco.org/images/0021/002154/215492e.pdf

The US-Midwest/Great Plains and Canadian Prairies Advantage

The US-Midwest/Great Plains and Canadian Prairies region is well positioned to be a key player in the development of value-added plant proteins for domestic and global markets. The region has very strong capabilities in producing and processing a number of crops that are ideal feedstocks for processing into value-added protein products for human consumption, animal feed, pet foods and aquaculture.

Current capabilities of the US-Midwest/Great Plains and Canadian Prairies Region

To identify current capabilities in the region, the Manitoba Agri-Health Research Network facilitated a mapping of key assets in the Protein Highway region: Iowa, Minnesota, Montana, Nebraska, North Dakota and South Dakota in the US-Midwest/Great Plains and Manitoba and Saskatchewan in the Canadian Prairies (See Appendix).[18]

Protein Crops Produced in the Region

The region is well suited to producing a number of crops that yield high quality plant proteins including soybean, canola, peas, lentils, flax and edible dry beans as summarized in Table 1.

[18] Alberta to be include in the Protein Highway and asset mapping in the future.

Table 1: High Quality Plant Proteins Grown by State/Province

State/Province	Soybean Area Harvested / Production (2006-2015)	Canola Area Harvested / Production (2006-2015)	Peas[19] Area Harvested / Production (2006-2015)	Lentils Area Harvested / Production (2006-2015)	Flax Area Harvested / Production (2006-2015)	Edible Dry Beans[20] Area Harvested / Production (2006-2015)
Manitoba	0.68 MM acres 0.62 MM MT	3.1 MM acres 2.4 MM MT	0.073 MM acres 0.072 MM MT	-	0.19 MM acres 0.11 MM MT	0.12 MM acres 0.090 MM MT
Saskatchewan	0.23 MM acres 0.15 MM MT	9.0 MM acres 6.5 MM MT	2.5 MM acres 2.0 MM MT	2.4 MM acres 1.5 MM MT	1.0 MM acres 0.57 MM MT	0.18 MM acres 0.12 MM MT
Alberta	-	5.7 MM acres 4.7 MM MT	0.90 MM acres 0.90 MM MT	0.098 MM acres 0.074 MM MT	0.065 MM acres 0.049 MM MT	0.046 MM acres 0.049 MM MT
Minnesota	7.0 MM acres 8.2 MM MT	0.025 MM acres 0.017 MM MT	-	-	0.004 MM acres 0.0017 MM MT	0.15 MM acres 0.13 MM MT
North Dakota	4.4 MM acres 3.3 MM MT	1.2 MM acres 0.8 MM MT	0.37 MM acres 0.33 MM MT	0.14 MM acres 0.08 MM MT	0.33 MM acres 0.15 MM MT	0.60 MM acres 0.41 MM MT
Montana	-	0.034 MM acres 0.023 MM MT	0.30 MM acres 0.22 MM MT	0.16 MM acres 0.84 MM MT	0.017 MM acres 0.005 MM MT	0.023 MM acres 0.018 MM MT
South Dakota	4.3 MM acres 4.6 MM MT	-	-	-	0.008 MM acres 0.003 MM MT	0.012 MM acres 0.010 MM MT
Iowa	9.5 MM acres 12 MM MT	-	-	-	-	-
Nebraska	4.9 MM acres 6.8 MM MT	-	-	-	-	0.13 MM acres 0.13 MM MT

Sources: Stats Canada Crop Statistics (*http://www.statcan.gc.ca/agriculturestatistics*) and USDA NARS Quick Stats (*http://quickstats.nass.usda.gov/*)

Over the last decade, soybean production has continued to spread north in the region. In 2015 there were 33.5 MM acres of soybeans in the Northern US states, and in the Canadian Prairies, Manitoba had 1.4 MM acres and Saskatchewan (which first produced soybeans in 2013) had 0.26 MM acres. Canola area in the region has grown significantly over the past decade and has been steady over the last 4 years at about 20 MM acres in Western Canada and 1.5 MM acres in the Northern US states. In 2015, flax area in the region was close to 1.6 MM acres in Western Canada and 0.45 MM acres in the Northern US states, having come back from lower levels of production in preceding years. The area of pulse crops (peas, lentils and edible dry beans) in the region continues to expand. In 2015, western Canada produced nearly 8.5 million acres, with lentils alone comprising almost 3.5 million acres. Adding in the

[19] Includes green and yellow peas (for edible uses) and feed peas (for animal feed)
[20] Includes great northern, navy, pinto, small red, chickpeas (large and small), pink, dark red kidney beans

Northern U.S. states results in nearly 11 million acres of pulse crops. This growth in pulse crops parallels the historical growth that canola experienced in this region.

Soybean is the major protein crop in the region and is grown primarily to produce a protein meal for livestock rations with the oil making its way into food uses and biodiesel production. Soybean meal is highly desirable as an animal feed as it contains about 49-50% protein and only 3% crude fiber from de-hulled soybeans (44-46% protein and 6-7% crude fiber from hulled soybeans)[21]. Soybean is considered the reference standard protein source for livestock rations against which all other protein sources are compared when formulating diets.

Canola is a commodity crop grown in this region for the production of canola oil: a very healthy oil that is low in saturated fatty acids and high in the heart-healthy Omega-9 monounsaturated fatty acid oleic acid. The protein meal[22] remaining from canola after oil extraction is further used as animal feed, making it an efficient crop with multiple value-added opportunities. Canola meal is especially desirable for use in dairy rations where it has been shown to increase milk production—and it commands a premium for this market. The lower protein and higher fiber contents of canola meal relative to soybean meal limits its use in mono-gastric animals (poultry and swine) and results in a discounted price relative to soybean meal for these markets. Canada has established breeding efforts to increase the protein and reduce the fiber content of canola meal to improve its suitability in mono-gastric diets.

Flax[23] is a multi-purpose commodity crop produced in this region. Flaxseed (linseed) oil had originally been produced for industrial uses, as it's very high content of the Omega-3 fatty acid linolenic acid gave it unique properties for use in linoleum flooring, paints and other industrial products. Today, the high alpha-linolenic acid content and other components of flaxseed oil have been shown to decrease inflammation in humans; this is why flaxseed oil is thought to be useful for treating rheumatoid arthritis and other inflammatory (swelling) diseases. Flaxseed meal was also originally used for animal feed but is now making its way into human food uses. The fiber from flax straw is used in woven materials and paper.

Peas[24, 25] grown in the region are made up of several different types: green and yellow peas (for edible uses) and feed peas (for animal feed). About two thirds of the peas produced in the region are exported with the majority going to India, China and Bangladesh, where they are predominantly consumed in their whole format.

Lentils[26, 27] produced in the region include large green, small green, and red types, all for edible consumption. The majority of these lentils are exported, primarily to India, Turkey and the United Arab Emirates.

[21] http://www.feedipedia.org/node/674
[22] http://www.canolacouncil.org/oil-and-meal/canola-meal/
[23] http://flaxcouncil.ca/
[24] http://www.pulsecanada.com/
[25] http://www.pea-lentil.com/
[26] http://www.pulsecanada.com/

Edible dry beans[28] produced in the region consist of a number of different types including great northern, navy, pinto, small red, chickpeas (large and small), pink, and dark red kidney beans all produced for human consumption.

All these protein crops grown in the region have protein rich seeds or seed meals/flours which have the potential to be processed into value-added proteins for human consumption, pet foods and aquaculture. In addition, some non-protein crops produced in the region including corn[29] and barley[30] offer potential sources of value-added proteins.

Value-Added Protein Products

Of the protein crops produced in the region, the greatest amount of research and development of value-added protein products has been in soy.[31] The development and use of value-added soy products in the US and other industrialized countries dates back to the 1960s. By using large-scale, sophisticated processing techniques, methods have been developed for the economical extraction of proteins from defatted soybean meal and transforming them into a wide range of food products[32] that can be found today in nearly every grocery store aisle. The protein products from soy are: Soy Protein Concentrate, which is a white powder containing 65-90% protein (average 70%), plus most of the soybeans vitamins, minerals, and finely pulverized dietary fiber from the defatted meal; Soy Protein Isolate which is essentially soy protein concentrate minus almost all their dietary fiber making it a very bland, white powder containing at least 90% protein; and Textured Soy Protein Products, made by texturizing concentrates, isolates, or defatted soy flour. There are three main types of Textured Soy Protein Products: Textured Soy Flour (TSF) made by extrusion cooking soy flour, Spun Protein Fibers (SPF) made by spinning a thick soy protein isolate solution into slender monofilaments; and Textured Soy Concentrates (TSC) made by steam extrusion of soy protein concentrates to give small textured granules. By adding flavoring and coloring agents to these textured products, which already have much the same fibrous and chewy texture of meat, food technologists have been able to extend traditional meat and seafood products, and create new "meat analogs," in remarkably good imitation of chicken, bacon, ham, sausage, and beef. The soy protein industry has evolved over the years with a number of players being involved including DuPont/Bunge forming Solae[33], and Cargill Foods selling their soy protein line to Solae[34]. Today, DuPont/Danisco[35] and ADM[36] dominate the soy protein market[37].

---

[27] http://www.pea-lentil.com/
[28] http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/pulses-and-special-crops-canadian-industry/dry-bean/
[29] http://cornandsoybeandigest.com/energy/high-protein-ddgs-provide-options-producers
[30] http://cerealchemistry.aaccnet.org/doi/abs/10.1094/CCHEM-06-10-0097?journalCode=cchem
[31] http://www.soyinfocenter.com/HSS/protein_concentrates.php
[32] http://www.soyconnection.com/soyfoods
[33] http://www.feednavigator.com/Suppliers/DuPont-Bunge-join-forces-in-soy-proteins
[34] http://www.foodnavigator-usa.com/Suppliers2/Solae-acquires-Cargill-s-soy-protein-line
[35] http://www.dupont.com/products-and-services/food-ingredients/soy-protein/brands/solae-soy-protein.html
[36] http://www.adm.com/en-US/products/food/proteins/Pages/default.aspx
[37] http://www.foodnavigator-usa.com/Markets/Cost-and-supply-benefits-are-icing-on-the-cake-for-soy-proteins

Canola meal contains two classes of proteins[38], napin and cruciferin, each of which has unique nutritional and functional properties. Napin is rich in sulfur amino acids and has cysteine levels two times that of whey protein. Cysteine is converted to glutathione in the body which is a powerful antioxidant. Napin is highly soluble at low pH and heat stable with no off flavors and has unique foaming properties; it is suitable for use in ready to drink beverages, powdered beverages, frozen desserts, aerated desserts, nutrition bars and other functional foods. Cruciferin is a good emulsifier and produces opaque heat-induced gels, making it suitable as an egg replacement in food. It also has potential for use as a meat extender, and in baked goods and snack bars. The development of such technologies for extraction of proteins from canola has been attempted most notably by MCN BioProducts[39], BioExx Specialty Proteins[40] and Burcon NutraScience Corporation[41]. Burcon NutraScience is the only company that has been successful to date in developing commercial edible protein products from canola utilizing a unique, patented aqueous extraction processes (***see side panel at right***). They have completed GRAS[42] notification for their two human use protein products and have made a substantial equivalence[43] claim for their animal feed protein product.

Canola and Pea Proteins from Burcon NutraScience

Burcon NutraScience has been successful in developing novel aqueous extraction processing technologies for the production of high quality edible proteins from canola and peas. Burcon's canola processing technology produces three protein streams: Supertein®, Puratein® and Nutratein®. Supertein is a napin protein isolate and Puratein is a cruciferin protein isolate and are targeted to human food uses. Nutratein contains mixture of both napin and cruciferin and is targeted to animal nutrition markets. Burcon has completed GRAS notification to the US Food and Drug Administration (FDA) for Supertein and Puratein and have made a substantial equivalence claim for Nutratein. Burcon's newest product for human food use is Peazazz® a protein isolate from peas. Burcon also produces CLARISOY™ soy protein isolate. Full details on Burcon's plant protein products can be found on their website: http://www.burcon.ca/.

High value protein products can also be produced from other protein crops grown in the region including peas, lentils, edible beans, and flax. The functionalities and thus the potential uses of proteins extracted from each these crops will depend on the physical properties of protein(s) produced by the crop. Pea protein isolate is the most advanced and Burcon NutraScience has developed a

[38] http://www.burcon.ca/health_and_wellness/canola_health.php
[39] http://www.marketwired.com/press-release/mcn-bioproducts-sells-technology-assets-to-bunge-1640992.htm
[40] http://www.soyatech.com/news_story.php?id=19688
[41] http://www.burcon.ca/products/canada_protein.php
[42] Generally recognized as safe (GRAS) is an American Food and Drug Administration (FDA) designation that a chemical or substance added to food is considered safe by experts, and so is exempted from the usual Federal Food, Drug, and Cosmetic Act (FFDCA) food additive tolerance requirements: http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/ucm2006850.htm
[43] Submission of a Substantial Equivalence claim is the first step in the process for securing approval for a new food or feed product in the USA

proprietary technology to produce a commercial pea isolate which they have branded Peazazz®[44]. This product is highly water soluble and is well-suited for use in low pH and neutral pH beverages, dairy alternative products, meal replacements and a variety of other healthy and great tasting food and beverage product applications.

All crops have some level of protein in their seeds and as these proteins can have unique attributes, there could be additional opportunities for the development of value-added protein products from non-protein crops, either alone or in combination with other proteins. For example with buckwheat, the Manitoba Agri-Health Research Network[45] is leading a project looking at complimentary proteins from pulses and buckwheat, and Springfield Mills[46] is leading an interesting model that connects plant breeding for health attributes[47]. Other opportunities could be to develop value-added protein products from corn dried distillers grains with solubles (DDGS) and barley brewery solids.

Protein Extraction and Processing Technologies

The development of technologies that enable the economical extraction of value-added protein products from seeds and/or seed meals is critical to the success of the Protein Highway. Soy processing technology[48] is now well advanced and being utilized to produce soy protein isolate, concentrate and textured soy protein from soy meal. In addition, there is a readily available supply of protein meal at economic prices to use as protein feedstocks.

For canola, Burcon NutraScience has developed viable processing technology for producing protein isolates and concentrates from canola meal but it is critical that the protein meal feedstock is produced in a manner that retains the functionality of the proteins. The high temperatures in the typical DT (Desolventizer Toaster) processing of the meal stream employed at most canola crush plants denatures the proteins thus destroying the highly desirable properties of the proteins. In order to provide suitable feedstocks for processes like those employed by Burcon NutraScience, canola crush plants that utilize gentler processing of the seed/meal such as cold pressing or vacuum desolventization will be required.

Burcon NutraScience has extended their proprietary processing technology to developing novel protein ingredient from peas. Burcon's processing technologies could be further extended with some modifications to cover other protein crops according to Martin Schweizer, VP of Technical Development for Burcon NutraScience[49].

The development of value-added protein products from other protein crops grown in the region such as edible beans and lentils will require economical processing technologies and reliable supplies of protein feedstocks at an economical cost.

---

[44] http://www.burcon.ca/products/pea_protein.php
[45] http://mahrn.ca/
[46] http://www.springfieldmillsinc.com/buckwheat-varieties
[47] LeeAnn Murphy personal communication
[48] http://www.oilmachineworld.com/soybean-protein-isolate-technology.html
[49] Personal communication

Key Advantages of the Region

The Upper US-Midwest/Great Plains and Canadian Prairies region is ideally suited for the establishment of a Protein Highway that can offer secure production of high-quality, protein-rich crops and value-added protein products in an environmentally sustainable fashion.

Land, Natural Resources and Existing Ecosystem

The region has a large land base and temperate climate which is highly suitable for growing canola, peas, lentils, flax and dry beans in the northern part of the region and soybeans more so in the southern part although new soy varieties with earlier maturity are making soybean production possible in Manitoba and Saskatchewan. All of these crops are very suitable for use in crop rotations with spring cereals and corn, helping to control diseases and weeds. The use of nitrogen fixing legume crops such as soybean, peas, lentils and dry beans in the rotation also provides benefits for the crops that follow in the rotation.

Agriculture must move away from yearly crop acreage decisions to planned 3- to 4-year crop rotations in order to be sustainable[50]. Inclusion of pulse/Brassica crops in the cropping system will enhance the carbon capture of the system[51] and enhance the sustainability of cropping in the region.

It is projected that in the future mandates will require companies marketing agricultural products such as protein-based food products to show the environmental footprint of the products marketed, and the life cycle analysis of these food products will need to include the production system of the feedstocks[52].

High Quality Agricultural Production

The region is recognized for high quality agricultural production: it encompasses about 40% of the US soybean production and the majority of the canola and flax production in North America and produces very high quality oils and protein meals from these crops for both domestic and export markets. For peas and lentils, Saskatchewan is a major producer and exporter. In 2012, Saskatchewan was responsible for 37 per cent of the value of the world pea exports and 47 per cent of the value of world lentil exports.[53] The outputs of these crops also offer great potential for the production of novel protein products for human consumption, pet foods and aquaculture.

The quality of the plant proteins grown in the region is recognized throughout the world. One example is when India's Prime Minister Modi visited Canada in 2015 for the uranium agreement signing, he asked how India could secure a priority position to purchase plant proteins from Western Canada, highlighting the need for secure volume combined with high quality to achieve a solid nutrition foundation for the

[50] http://www.ucsusa.org/food_and_agriculture/solutions/advance-sustainable-agriculture/crop-diversity-and-rotation.html
[51] http://www.nrcresearchpress.com/doi/abs/10.4141/cjss2012-078
[52] John Oliver personal communication
[53] 2013 Specialty Crop Report, Saskatchewan Ministry of Agriculture, http://www.agriculture.gov.sk.ca/specialty_crop_report

human diet.[54] India's competitiveness with China rests on its ability to provide a daily diet of high nutrition for its citizens.

Innovation Hub and Human/Capital Resources

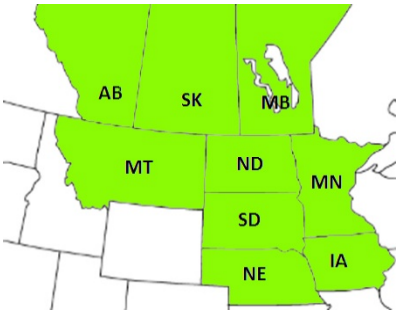
Another advantage of the US-Midwest/Great Plains and Canadian Prairies region is the extensive network of research institutions conducting world class public and corporate research on crop improvement and innovative approaches to crop utilization, along with governmental and commodity groups who support and help with crop development in the region. **Appendix A** summarizes the key institutions and organizations by province and state who are envisioned to be stakeholders in the Protein Highway. The goal of the Protein Highway is to help create an innovation hub to facilitate collaboration among such researchers at institutions and organizations to develop novel, value-added products from the protein crops produced in the region—and ultimately showcase these results to investors, entrepreneurs and multinationals that can move promising ideas to scale-up.

Proximity to Business, Population, Transportation, and Education Centers

Most of the businesses involved in agricultural crop production, processing and utilization as well as food processors have offices and/or plants in the region. The region is crisscrossed by East-West and North-South rail systems and roads that move feedstocks and finished products to domestic and international markets—although it will likely require capital investment in storage and rail cars to handle the segregation and transport of smaller quantities during product scale up. Each of the target crops also have crop production organizations (**Appendix A**) geared towards supporting the production and marketing of crops and value-added products.

The Protein Highway Solution

The creation of a Canada/US "Protein Highway" is proposed to exploit the many advantages of the Upper US-Midwest/Great Plains and Canadian Prairies region in plan proteins. The region encompasses the production crop areas of the three Canadian Prairie provinces of Manitoba, Saskatchewan and Alberta and the US-Midwest/Great Plains states Minnesota, North Dakota, Montana, Nebraska, South Dakota, and Iowa.



The Protein Highway region has all the components of a flourishing innovation hub, including the production of a number of diverse protein crops, processing facilities, proximity to large cities and links to other markets via truck and rail—an evident destination for plant protein research, production, processing and food ingredient manufacturing, as well as entrepreneurial and investment activity. The region also boasts an extensive network of research centers conducting topnotch public and corporate

[54] John P. Oliver, personal communication

research on crop improvement and innovative approaches to crop utilization. The region also has access to health and wellness resources which can be leveraged to studies that further evaluate the health benefits of plant proteins in human diets.

The Protein Highway stands poised to serve as a virtual incubator for connecting research and researchers on both sides of the US/Canada border to achieve greater synergies. Ultimately, it can facilitate follow-on regional and global access to technology and intellectual property that results in new, valuable markets for novel protein products.

The Protein Highway will focus on plant proteins for a number of reasons:

- There is very significant unrealized economic value from producing high value edible protein products from the more significant protein crops soybean, canola, peas, lentils, flax and edible dry beans already produced in the region.
- There could also be opportunities for protein production from other oilseed crops in the region such as sunflower and safflower and minor crops in the region such as buckwheat, hemp, camelina, chia and quinoa based on economic merit.
- High value edible proteins from the byproduct streams of corn ethanol facilities and barley brewery solids is another potential opportunity for the future.
- High value plant protein products and ingredients can make valuable meat analogs / replacements.
- Plant protein food products offer another approach to help feed the growing world population in a potentially more sustainable way.
- Plant proteins provide a more economical solution to providing protein for human consumption than passing protein through an animal.
- There is evidence that plant proteins can contain healthy amino acid components such as higher levels of cysteine which can have beneficial health effects.
- Reduction in animal protein consumption will also have the benefit of reducing saturated fat intake.

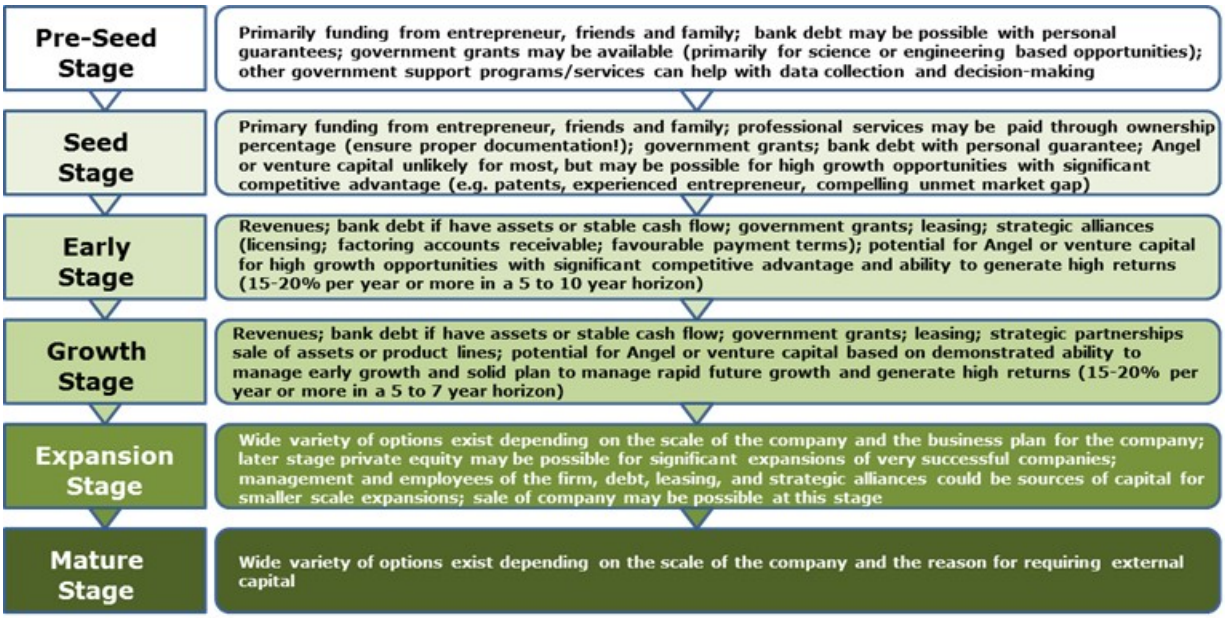
Through collaborative promotion, research, business development and investment, the Protein Highway will become globally recognized as the region of choice for secure and sustainable production of high-quality plant proteins.

The Case for Investment

Types of Investment

Similar to other sectors, successful development of a robust Protein Highway will require a diverse range of financial investment at all stages of commercialization. The options available to companies vary, depending on stage of development and activities of the business (See **Table 2** below).

Table 2: Types of Investment Available to Companies as they Grow



Source: Gauthier, D. 2012

Unfortunately, many areas are lacking in one or several types of investment at the local level. Angel networks are not mature in many places and large venture capital and private equity funds are becoming increasingly more concentrated in major financial centers. A regional approach that builds strong networks will enable a broader pool of investment options for companies, and a larger pool of investment opportunities for private capital.

Agricultural Technology and Food Investment Trends

Investment dollars are a good measure of the relative economic importance and potential of various industry sectors. Additionally, risk capital investment provides insight into investors' beliefs about future trends. Investments relevant to agriculture and food development are often lumped into other industry categories such as biotechnology, cleantech, or manufacturing, making it difficult to determine the actual share of investment dollars flowing to the sector. Nonetheless, it appears that agriculture and food investing is on the rise. By the end of 2014, there were 240 agriculture investment funds existing globally with $45 M in total assets, compared to just 33 funds in 2005.[55] In 2014 alone, 26 new

[55] http://www.responsability.com/investing/data/docs/en/15524/market-news-doc-valoral-03072015.pdf

food and agriculture specific funds were launched globally and seven of these were in the U.S.: AgTech Innovation Fund, Boulder Food Group LP, The Cascadia Foodshed Funding Project, Farmland LP REIT, Made in Rural America, RSF PRI Fund, and the Rural Infrastructure Opportunity Fund.[56]

It was reported by the Chicago Tribune that total dollars invested in agricultural technology and food deals across the U.S. has doubled to $1.4 B in 2015 compared to 2014—17 times more than the amount invested in 2011.[57] Investment deals in the Midwest U.S. have experienced more modest increases over the same periods. Chicago is home to Take Seed 2 Growth Ventures (a new $125 million fund) and Cultivian Sandbox, which just raised a $115 M second fund. Fargo, ND based Linn Grove Ventures is also focused on food industry investments in the Midwest U.S. and Canada. Mainstream venture firms have also demonstrated a willingness to invest in the sector. For example, Khosla Ventures has invested in Hampton Creek and Impossible Foods and agricultural investing is a major part of the Bill and Melinda Gates Foundation investments.

Other than government-related investment, focused private investment in agriculture is less developed in Canada. The overall pipeline of investment deals is much smaller than the U.S., creating a need for large investment funds to be more diversified. These funds often find ICT, oil and gas, real estate, mining and health-related investments more compelling than agri-food.

Organized Angel investment is beginning to fill some of the need for early stage investment, but inconsistent tax credit rules between different provinces put some areas (e.g. Saskatchewan) at a disadvantage to others. Crowd-funding—where an entrepreneur raises smaller amounts of loans or equity from a large number of small investors through an on-line portal—is also a growing trend. Amounts invested in 2011 were $1.5 B compared to estimated amounts of $5 B in 2013.[58] Agfunder (www.agfunder.com) is a specialized agriculture and food based crowd-funding portal.

Industry Investment in Plant-Derived Proteins

Big industry and investment funds are also validating the need for plant-derived proteins. Dupont, through its subsidiary Solae, produces soy protein isolates for a wide variety of foods.[59] Burcon Nutrascience has partnered with ADM to produce Clarisoy®—soy protein isolate that is clear, better tasting and acid soluble. Burcon is also developing canola and pea protein products, as previously discussed. Other entrepreneurs are attempting to replicate the taste, feel and experience of eating meat based on plant protein products.[60] Examples are:

[56] http://www.foodtechconnect.com/2015/01/15/21-food-agriculture-focused-funds-launch-in-2014/
[57] Chicago Tribune; November 6, 2015. "The big money of changing food and agriculture tech"
[58] http://www.crowdfundingstatistics.com/
[59] http://seekingalpha.com/article/738081-the-fight-is-on-for-plant-derived-protein
[60] http://www.ift.org/food-technology/past-issues/2014/december/features/a-new-crop-of-plant-protein-pioneers.aspx?page=viewall

- Beyond Meat of California is producing chicken free strips and beef-free crumbles to directly replace real meat alternatives.
- Impossible Foods of California, is developing a beef burger substitute based on legume proteins that actually bleeds in a way compared to the real thing.
- Ripple foods of California is producing a milk substitute using split yellow peas.
- Canadian-based Gardein provides a wide variety of substitutes for pork, beef, chicken and fish based on soy and bean products.
- Hampton Creek (California) is using proteins from yellow pea to replace egg proteins in foods.

As these and other companies continue to grow, they will be looking for a wider variety of plant proteins for different functionality, tastes and sensory qualities to expand their product offerings. The Protein Highway region could be the primary supplier to these West-Coast companies and is also poised for additional growth of its own plant-derived protein ingredient companies. Alliance Grain Traders (Saskatchewan and North Dakota), Burcon Nutrascience (Manitoba), Embria Health Sciences (Iowa), Kellogg (Nebraska) and GTC Nutrition (Montana) are just a few examples of companies already located in the Protein Highway region (See **Appendix 1** for additional companies in the region).

Connecting Opportunities and Investors across the Canadian Prairies and Midwest U.S.

Trade, investment and collaboration is often difficult across provincial, state and national borders due to differences in regulations, trade rules, tax laws, foreign ownership rules, etc. Fortunately, there is growing recognition among some governments that protectionist policies can do more harm than good. In a recent speech in Saskatoon, North Dakota Lieutenant-Governor Drew Wrigley touted the benefits of removing obstacles that hamper trade between the Canada and the U.S. He was quoted as stating "Protectionism, at the end of the day, isn't really protectionism at all. It is harmful to the economy, local and otherwise."[61]

Examples of Canadian and U.S. attempts to act regionally are:

- The New West Partnership Trade Agreement (NWPTA) is attempting to create a single economic region encompassing British Columbia, Alberta and Saskatchewan (Manitoba has been invited, but has not yet joined). Some of the benefits of NWPTA will be labor mobility, common business registration, streamlined regulations, enhanced competitiveness and open procurement.[62]
- The Pacific Northwest Economic Region (PNWER) Foundation is a statutory nonprofit created by Alaska, Idaho, Oregon, Montana, Washington, British Columbia, Alberta, Saskatchewan, Yukon and Northwest Territories. The purpose of PNWER is to facilitate the economic well-being and

[61] http://thestarphoenix.com/authour/alex-macpherson-saskatoon-starphoenix
[62] http://www.newwestpartnershiptrade.ca/the_agreement_benefits.asp

quality of life for all citizens of the region, while maintaining and enhancing our natural environment.[63]

International collaboration between academic researchers is common, but restrictions of granting agencies regarding where monies are spent can limit the overall effectiveness of a research network. For some technologies, strict export control laws also restrict the type of information that can be exchanged in international collaborations. Private investment is easier to deploy across provincial and national borders, but foreign ownership rules may limit tax benefits in some cases. Additionally, it is more difficult for entrepreneurs to develop relationships with investors across large distances, particularly at earlier stages of investment when there are few resources for extensive travel.

In the Canadian prairies, non-profit organizations such as Ag-West Bio Inc., AVAC Ltd., the Manitoba Agri-Health Research Network and the Life Sciences Association of Manitoba can help with this networking and early stage financing in some cases. Other nodes of entrepreneurial activity, such as University Industry Partnering offices, accelerators, incubators and research institutions and economic development/trade agencies play important roles in ensuring that local activity is networked with other regions.

Measures of Success

There are a number of economic indicators that can and will be used to measure success of the Protein Highway including:

- Job creation at research institutions,
- Research MOUs,
- New or expanding companies in the plant protein area, and
- Private sector investment in R&D, processing and production facilities and new companies.

In the longer term, tremendous socio-economic benefits can be realized. In addition to meeting and enhancing basic global nutrition requirements and diets, increased plant protein consumption could dramatically reduce healthcare costs for diet-related illnesses. It has been estimated that obesity alone can be associated with individual healthcare costs in excess of $10,000.[64] The Protein Highway region is rich in medical institutions and research organizations that can contribute to clinical studies that evaluate the health benefits of existing and new plant proteins in human diets (see **Appendix A**.).

[63] http://www.pnwer.org/background--history.html
[64] http://www.ncbi.nlm.nih.gov/pubmed/10527295

Conclusions and Next Steps

Based on strong current and growing global demand for a wide variety of plant-based proteins, and the robust assets currently in place across the Canadian Prairies and U.S. Upper Midwest/Great Plains region, there is a tremendous opportunity for the region to become a plant-protein powerhouse. A regional Protein Highway that links researchers, companies and investors to advance value-added opportunities in plant-protein production and value-added products based on a wide variety of regional crops has tremendous potential for sustainable benefit for the economy and for the needs of a growing and increasingly wealthy global population.

The working group has identified the following steps to transforming their concept into action:

- Linking key universities with new agricultural technologies that are ready for investment and commercialization to promote collaboration and develop new curricula in association with industry leaders (Deadline August 2016)
- Promote investor engagement via outreach and marketing (Launch planned at ABIC 2016 in Fargo, North Dakota, September 2016)
- Additional promotion and outreach at various regional conferences, forums and meetings (ongoing)
- Connecting communities, such as Brookings, SD and Saskatoon, SK

Short term activities required to achieve these outcomes include:

- Continuation of Asset Mapping activities—visual maps; additional companies; market opportunity mapping—(MAHRN and others)
- Create a subcommittee for ABIC 2016 planning in Fargo (Consulate and AgWest Bio)
- Potential structured committee via regional ag experiment stations network and tap into various talent pools
- Develop branding and marketing tools
- Connect with and inform key political leaders
- Attract additional Advisory Committee participants—companies; Venture Capital-backed start-ups; commodity groups

Appendix A

Canadian Protein Highway Stakeholders by Province

Manitoba

Provincial Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations
• Food Development Centre • MAFRD - Crop Diversification Centers • Manitoba, Agriculture and Rural Development	• Canadian International Grains Institute • Canadian Oilseed Processors Association • Canola Council of Canada • Flax Council of Canada • Manitoba Pulse and Soy Growers Association • Pulse Canada	• AAFC - Brandon • Agriculture and Agrifood Canada (AAFC) Research Centre – Morden	• MAHRN - Manitoba Agri-Health Research Network (Not for Profit) • PAMI - Innovative solutions for agriculture and beyond	• Canadian Centre for Agri-Food Research in Health and Medicine • Red River College - Applied Research • University of Manitoba • Animal Science • Food Science and Nutrition • George Weston Sensory and Food Research Lab • Plant Science • Richardson Centre for Functional Foods and Nutraceuticals • Technology Transfer Office	• Ag Quest Inc • Bayer • Best Cooking Pulses • Bestco Grain • Brett Young Seeds • Bunge Canada • Burcon NutraScience • Canadian Prairie Garden Puree • Canterra • Cargill • Central Grain Company • DL Seeds • Emerson Milling • Global Grain Canada Ltd • Gorp Energy Bars • H & W Seed Service • Hemp Oil Canada • Husky Energy • ICMS • Inland Seed Corp • Legumex Walker (Scoular Company) • MB Harvest Hemp Foods • Monsanto • Nutra-Pea • Nutri-Pea • Parland Industrial Hemp Growers • Pitura Seed Service Ltd. • Pizzey Ingredients • Prairie Flax Products Inc • Rawnata • Richardson Group • SeCan • Shape foods • Springfield Mills • Stone Milled • T & S Seeds • Viterra

Saskatchewan

Provincial Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations

• Crop Development Centre (CDC) (Dept. of Plant Science U of S)
• Saskatchewan Department of Agriculture
	• Indian Head Agricultural Research Foundation
	• Irrigation Crop Diversification Corporation
	• Northeast Agriculture Research Foundation
	• Saskatchewan Pulse Growers
	• South East Research Farm
	• Western Applied Research Corporation
	• Wheatland Conservation Area
		• AAFC - Saskatoon
		• AAFC - Swift Current
		• Canadian Light Source Synchrotron
		• NRC - Plant Biotech
		• Plant Gene Resources of Canada
			• PAMI - Innovative solutions for agriculture and beyond
			• POS – Biosciences
			• SK Food industry Development Centre
				• Parkland College
				• University of Saskatchewan
				  • Bioprocessing Pilot Plant
				  • Breeder Seed Facility
				  • Canadian Feed Research Centre
				  • Controlled Environment Facility (Phytotron)
				  • Crop Development Centre
				  • Department of Food and Bioproduct Sciences
				  • Feeds Innovation Institute
				  • Industry Liaison Office
				  • KnowPulse
				  • Prairie Aquaculture Research Centre
					• ADM Canada
					• Avena Foods
					• Bunge
					• Canmar
					• Daybreak Mill
					• Diefenbaker Seed Processors Ltd
					• Globeways
					• LDC (Louis Dreyfus)
					• Legumex Walker
					• LewisMCarter
					• Monsanto Bio Ag
					• Naturally Nutritious Foods
					• Norquin
					• Northern Nutriceuticals Inc
					• P&H Milling
					• Parrheim Foods
					• Prairie Pulse
					• Richardson Pioneer
					• Simpson Seeds
					• TA Foods Ltd
					• Three Farmers
					• Viterra
					• Western Ag
					• Western Grain & Processing Division (wholly owned by Toepfer International)

Alberta – to be identified in the future

Provincial Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations
•	•	•	•	•	•

US Protein Highway Stakeholders by State

Minnesota

State Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations
•	• Agricultural Utilization Research Institute	•	• Dry Edible Bean Research & Promotion Council • Northarvest Bean Growers Assoc • Northstar Genetics • Northern Crops Institute	• University of Minnesota • Applied Plant Sciences • Center for International Food & Agricultural Policy • Food Industry Centre • Healthy foods, Healthy Lives Institute • Institute on the Environment • Minnesota Institute for Sustainable Agriculture • Office of Commercialization • Stakman-Borlaug Center for Sustainable Plant Health	• ADM • Ag Motion • Batory Foods • Burley Foods • Cargill • CHS • Dow AgroSciences / Mycogen Seeds • Fiberich • General Mills • Grain Millers Inc • Great River Milling • Homestead Mills • InHarvest • Innovative Food Products • Kraft Food Ingredients • Lea Bean & Seed Inc • Marathon Foods • Meadowland Soy • Natural Way Mills, Inc. • PGP International • Schafer Seed Co • Scoular Company • SK Food Specialty Processing • Slauson Trading Co • Summit Brewing Co • World Food Processing

North Dakota

State Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations

• North Dakota Department of Agriculture	• Northern Pulse Growers Association (NGPA)	• USDA – ARS – Grand Forks Human Nutrition Research Center (GFHNRC)
		• USDA – ARS – Natural Resource Management Center
		• USDA – ARS – Red River Valley Agricultural Research Centre. Northern crop science lab
		• USDA-NRCS-PMC – Natural Resources Conservation Service, Plant Material Center)
			•	• North Dakota State University
				  • Animal Nutrition & Physiology Center
				  • Carrington Research Extension Center
				  • College of Agriculture, Food Systems, and Natural Resources"
				  • Dept. of Agriculture and BioSystems Engineering
				  • NCI Feed Mill
				  • North Dakota Agricultural Experiment Station (AES)
				  • Northern Crops Institute (NCI)
				  • Technology Transfer Office
				• University of North Dakota (UND)
					• ADM Edible Bean Specialities
					• AGT Food and Ingredients
					• AGT Foods
					• Archer Daniels Midland Co. (ADM)
					• Cargill
					• Central Valley Bean Cooperative
					• Centrol Ag Consulting
					• Dakota Dry Beans
					• Dakota Specialty Milling
					• Dupont
					• Great Northern Ag
					• Heartland Flax
					• Hurdsfield Grain, Inc.
					• J.R. Simplot Company
					• JM Grain
					• Johnstown Bean Company
					• Legume Logic
					• Legume Matrix, LLC
					• Mehl's Flour Company
					• Meridian Seeds
					• Northern Prairie Envirofuels LLC
					• Premium Gold Flax Products
					• Pulse USA
					• Red River Commodities (SunGold Foods)
					• Safflower Technologies International
					• Sanford Health
					• SB&B
					• SK Food International
					• Valent USA

Montana

State Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations

• Beartooth RC&D Food & Agricultural Development Center
• Food & Ag Development Center Network
• Mission Mountain Food Enterprise Center
• Montana Dept of Agriculture
	•	• USDA – Agricultural Systems Research
		• USDA – Northern Plains Agricultural Research Laboratory
			•	• Montana State University
				  • Agriculture Experimental Research Centers (7)
				  • Barley & Plant Biotech Lab
				  • Dept. of Chemistry and Biochemistry
				  • Functional Genomics Core Facility
				  • Plant Growth Center
				  • Plant Science & Plant Pathology
				  • Proteomics and Biological Mass Spectrometer Facility
				  • Schutter Diagnostic Lab
				  • Technology Transfer Office
					• Columbia Grain
					• GTC Nutrition (A Division of Ingredion)
					• Montana Milling
					• Montana Specialty Mills
					• Timeless Foods

Nebraska

State Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations
• Nebraska Department of Agriculture	•	• USDA - ARS	• Core for Applied Genomics and Ecology (CAGE) • FAARP - Food Allergy Research & Resource Program	• University of Nebraska • Agricultural Research Division • Center for Biotechnology • Center for Plant Science Innovation • Crop Watch • Dept of agronomy & Horticulture • Dept of Plant Pathology • Food Innovation Center • Industrial Agriculture Products Center • Institute of Agriculture & Natural Resources • Plant Sciences Program • Plant Transformation Core Research Facility • Technology Transfer Office	• ADM • Bunge • Cargill • Cargill • Columbian Grain • Con Agra • Con Agra • Crop Production Services • DuPont Pioneer • Farmers Cooperative • Frenchman Valley Farmers • International Nutrition • Kelley Bean Co • Kellogg • Koch Industries • Louis Dreyfus • Michael Foods • Monke Brothers • Nature's Variety, Inc • Sensory Effects Cereal systems • Syngenta Seeds

South Dakota

State Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations
• South Dakota Department of Agriculture • South Dakota Department of Game, fish and Parks	•	• USDA - ARS - North Central Agricultural Research Lab • USGS EROS Data Center	• SD Crop Improvement Association • SD Oilseeds Council • South Dakota Pulse Growers • South Dakota Soybean Association (SDSA) • South Dakota Soybean Processors, LLC • South Dakota Soybean Research and Promotion Council (SDSRPC)	• South Dakota State University • Agricultural Experiment Stations • Dakota Lakes Research Station • Northeast Research Station • Southeast Experiment Station • Extension Service • igrow (a service of SDSU) • Research Park • Tech Transfer Office • University of South Dakota	• Bel Brands • Dakota Mill & Grain • DuPont • Frontier Mills, Inc • Gabby´s roasted garbanzos (part of Dakota Valley products, Inc) • Glanbia Nutritionals Inc. • Heintzman Farms • Hesco • Hesco Dakota Organic products • Hubbard feeds • J&R Distributing, Inc • Mustang Seeds • POET. Dakota gold • Prairie AquaTech • Pride Grain • Purina Animal Nutrition LLC • Purity Seeds • Sanford Health • SD Innovation Partners • Sexauer Discount Farm Services, Inc. • SmartLic Supplements • South Dakota Pulse Processors

Iowa

State Government	Applied Research Associations	Federal Government Research Labs	Specialty Organizations	Academic Research Institutions	Corporations
• Iowa Department of Agriculture and land Stewardship	• Iowa Soybean Association • Soy Bean Meal Info Center	• USDA - National Laboratory for Agriculture and the Environment • USDA National Institute of Food and Agriculture • USDA-Agriculture Research Service	• North Central Soybean Research Program	• Iowa State University •Agriculture and Home Economics Expt Station •BioCentury Research Farm •BioSafety Institute for Genetically Modified Agricultural Products •Center for Agricultural and Rural Development •Center for Crops Utilization Research •Center for Designing Foods to Improve Nutrition •Center for Plant Responses to Environmental Stresses •Dept of Food Science and Human Nutrition •Experiment Research Stations (20) •Nutrition and Wellness Research Center •Raymond F. Baker Center for Plant Breeding •Seed Science Center •Tech Transfer Office •The Protein Facility of the Office of Biotechnology •WM Keck Metabolomics Research Laboratory • University of Iowa	• A to Z Drying • ADM • Ag Logic (Yield Igniter) • Algae Protein Powder • Beaver Creek R&D • Cardiostrong • Cargill • Devansoy • Diamond V • DuPont • DuPont Pioneer Johnston Innovation Center • Embria • Grain Processing Corporation • Harvest Innovations • Harvest Innovations • Horan Bio Production • John Deere Intelligent Solutions Group Development • Kemin Technologies • Kerry Ingredients • Metabolic Technologies • Monsanto • Naturally Recycled Protein • Nutriant - a Kerry Company • Proliant Inc • Roquette America, Inc • The Scoular Company

Appendix B

Protein Highway Advisory Committee and Partner Organizations

ADVISORY COMMITTEE		
Stevyn Arnt	Strategic Lead, Agri-Food	Saskatchewan Ministry of the Economy
Barb Birr	Co-Founder	Step One Foods
Charles Boyer	VP Dean and Director of Ag	Montana State University
Doug Cameron	Co-President	First Green Partners
Gavin Conacher	Director of International Engagement	Saskatchewan Ministry of the Economy
Daryl Domitruk	Director Ag Innovation and Adaptation	Manitoba Ministry of Agriculture, Food, & Rural Development
Ken Grafton	VP Agricultural Affairs	North Dakota State University
Jay Han	Sr. Research Scientist	Alberta Agriculture and Forestry
Wallie Hardie	President & CEO	Leading Edge Fund
Dr. James House	Prof. & Dept. Head--Human Nutritional Sciences	University of Manitoba
Dr. Baraem (Pam) Ismail	Professor, Food Science Major Coordinator	University of Minnesota
Jeff Jacobsen	Executive Director	North Central Regional Association of Ag Experiment Stations
Ron Kehrig	VP of Operations-Canada	Nutriati
Wilf Keller	President and CEO	AgWest Bio
Kevin Kephart	Vice-President for Research and Development	South Dakota State University
Arlen Leholm	Former Executive Director	North Central Regional Association of Ag Experiment Stations
Paul McGarvey	President	Chadron Capital Markets LLS
Murray McLaughlin	Executive Director	Bioindustrial Innovation Canada
Ron Meeusen	Managing Partner	Cultivian
Dr. Mark Messina	Executive Director	Soy Nutrition Institute
Andrée-Lise Méthot	Founder and Managing Partner	Cycle Capital
Lee Anne Murphy	Executive Director	Manitoba Agri-Health Research Network

Mike Nickerson	Food Science Department	University of Saskatchewan
John Oliver	President	Maple Leaf Bio-Concepts
Jade Proulx	Food Scientist	Hampton Creek
Dr. Martin Scalon	Professor of Food Technology, Associate Dean (Research)	U of MB
Jen Wagner-Lahr	Executive Director	Agricultural Utilization Research Institute
Brent Willett	Executive Director	Iowa Cultivation Corridor
Dr. Bill Wilson	Distinguished Professor, Agribusiness and Applied Economics	North Dakota State University
Sara Wosje	Sr. Research Scientist	General Mills--GTECH
Sam Ziegler	Director, Project ABE	Greater Mankato Growth

PARTNER ORGANIZATIONS	
INDUSTRY CANADA	
Janet Dorey	Regional Manager
Sylvie Verdon	Manager
Anna Mackay	Sector Analysis Officer, Manufacturing and Life Sciences Branch
PULSE CANADA	
Gordon Bacon	CEO
Julianne Curran	VP Food and Health
Tanya Der	Food Innovation and Marketing Manager
Chris Marinangeli	Director of Nutrition, Scientific and Regulatory Affairs
AGRICULTURE AND AGRI-FOOD CANADA	
Carla St. Croix	Director of Innovation and Growth Policy Division
Bob Nawolsky	Regional Director-Manitoba
Bruce Radburn	Senior Advisor, Innovation Policy-Strategic Policy Branch
Troy Hennigar	Chief Innovation Policy

Pam Ominski	Senior Analyst
US DEPARTMENT OF AGRICULTURE	
Mihai Lupescu	Ag Specialist, Foreign Ag Service-Ottawa