KPU | Institute for Sustainable Food Systems

Yukon Food System Design and Planning Project:

Foundational Food System Design

Prepared in January 2015 by
Institute for Sustainable Food Systems
Kwantlen Polytechnic University

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The Institute for Sustainable Food Systems

The Institute for Sustainable Food Systems at Kwantlen Polytechnic University (ISFS) is based on Kwantlen's Richmond campus and operates in conjunction with the Sustainable Agriculture program. The Institute's applied research, extension, and outreach programming focuses on regional-scale, human intensive, ecologically sound food systems as foundational to sustainable community. Our past and current work falls under two categories: MESA projects and Bio-Region Food Systems projects.

Through our MESA ("Municipally Enabled Sustainable Agriculture") projects, we work with municipalities in south-west BC to investigate the direct economic, environmental, and social benefits that could result if municipalities supported small scale agriculture in their communities through policy (such as bylaws allowing urban farming and farm gate sales) and programs (such as education programs and demonstrations). Our work has demonstrated significant potential for increased food security, a reduction of farmland loss to urban sprawl, job creation, and wealth generation.

In our Bio-Region Food Systems projects, we are working to evaluate the potential for a food system sector organized and operating at the eco-region scale and comprised of low input, human intensive, and ecologically sound supply chain components. This eco-regional scale food sector complements the current food system, to improve food self-reliance, minimize environmental impact, improve economic viability of farms and ancillary businesses, contribute to the local economy, create opportunity for the development of small and medium sized businesses and strengthen communities.

More information about ISFS can be found at www.kpu.ca/isfs.

Report Prepared in January, 2015 by:

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Background on the Yukon Food System Design and Planning Project

Food security is increasingly a concern of all contemporary societies and communities. Rising costs for fuel, production inputs, processing, storage, transportation and marketing have resulted in increasing household food costs. For Canadians, in 2008, when general inflation was 1.3%, overall food cost inflation was 7.3%. Cereal grains products' cost increased 12.4% and the cost of fruits and vegetables a whopping 26.9%. Canada's northern communities experience increased cost of food acutely. The vulnerability of the Yukon was highlighted in July 2012, when the Alaska Highway washed out and Whitehorse grocery stores were emptied of perishable foods within forty-eight hours. Factor in climate change and economic volatility, and no longer can we rely on the global system to provide cheap food.

While the Yukon has a growing agriculture sector, still only about 2% of food consumed in the Yukon is produced in the Yukon. Interestingly, this figure is not unique to the Yukon but much like the majority of North American jurisdictions. We have all have become largely dependent upon a global food system and as such vulnerable to food system perturbation. In other words, most communities and jurisdictions have put all their eggs in one food system basket. As communities and jurisdictions begin to examine alternatives, it is realized that significant economic and community development and small and medium sized business creation potentials exist in the substantive re-regionalization of our food systems. Understanding those potentials and how to achieve them is what the Yukon Food System Design and Planning project is all about.

The Yukon Food System Design and Planning project was conceptualized in August, 2010 when leaders of the Yukon - Canadian Agricultural Adaption Program (CAAP), Yukon Agriculture Association (YAA) and Kwantlen Polytechnic University Institute for Sustainable Food System (ISFS) staff met in Hay River, NWT while attending the Territorial Farmers Association Annual Conference. There, they discussed nascent Yukon agriculture, the significant potential for an expanded Yukon food system sector, and the ability/desire to advance Yukon food self-reliance. They discussed a project to bring forth necessary information and a compelling, data-based argument for public and private sector commitment to and support for concerted development of Yukon's agri-food sector.

Subsequently, IFSF worked with YAA, CAAP, Yukon Agriculture Branch and Agriculture and Agri-food Canada for two years to conceptualize, develop and garner funds for the project. IFSF assembled a project team based in British Columbia and the Yukon. Each project team member has been involved in a research and/or community engagement capacity. The majority of research team members are BC-based while most of the community engagement team members are based in the Yukon.

85% of cash funding for the first phase of the project was garnered from Agriculture and Agri-food Canada's Growing Forward program (locally overseen by the Yukon-CAAP Council). The YAA, as Industry Proponent, contributed the remaining 15% of cash funding. KPU contributed in-kind funding (staff salary and overhead) commensurate with funding from the YAA. The purpose of the federal Growing Forward funding program was to facilitate the ability of agriculture and the agri-based products sector to seize opportunities, respond to new and emerging issues, and pilot solutions to new and ongoing issues in order to adapt and remain competitive.

Through research and community engagement it is the objective of the Yukon Food System Design and Planning Project to build on previous work and existing Yukon expertise to develop:

- A realistic design for a future Yukon food system that improves Territorial and community food security and food self-reliance while fostering economic growth and community development, and
- A plan for its implementation and sustainability.

The outcomes of this project are intended to demonstrate how the Yukon can increase food self-sufficiency through local agriculture and food related business, harvesting of traditional food species, enhance economic, job creation, and business and economic opportunities in the food and agriculture sector, and build increased capacity for community health and environmental stewardship.

It is planned that this project be executed in two overlapping phases. The first encompassing baseline assessment and preliminary system design, and the second to produce a comprehensive Yukon Food System Design and implementation action plan in substantial consultation with the Yukon agriculture and food sector, government and community leadership. At the time of this report's publication, Phase II of the project has not been funded.

All Phase I reports are available for download from www.kpu.ca/isfs. They include:

- The State of the Yukon Food System in 2011/2012 (released in January 2015)
- Report on Agri-Food Industry Engagement (released in January 2015)
- Foundational Yukon Food System Design (released in January 2015)
- Our Food Security Today and Tomorrow in Carcross-Tagish First Nation (released in January 2015)
- Food Security in Tr'ondëk Hwëch'in Nation (forthcoming)
- Report on Yukon Community Food Security Engagement (forthcoming)

Acknowledgements

Many people have contributed to this ambitious project, from conceptualization to execution. We of the Institute for Sustainable Food Systems at Kwantlen Polytechnic feel very fortunate to have connected with and learned so much from so many in the Yukon. We are truly grateful.

Rick Tone (retired Yukon Agricultural Association Executive Director) and Len Walchuck (former Canadian Agriculture Adaption Program Chair) first worked with us to conceive of and plan the project, as well as secure funding. The insight and openness to diverse thinking they exhibited is rare. Once the project began, Len Walchuck's ongoing engagement and guidance was also instrumental. Valarie Whelan (Agriculture and Agri-food Canada), Tony Hill (Yukon Government Agriculture Branch Director), Matt Ball (Yukon Government Agriculture Branch Agrologist), and Bradley Barton (Yukon Government Agriculture Branch Agriculture Research Technician) provided critical guidance and input throughout the duration of the project. Sylvia Gibson (former Yukon Agricultural Association Executive Director) also provided valuable support during the early implementation of the project.

The Yukon Food System Design and Plan project benefited immensely from ongoing review and feedback from Monitoring Committee members: Chief Danny Cresswell (Carcross/Tagish First Nation), Dr. Ansylie Ogden (Yukon Government Senior Science Advisor), Len Walchuck (Canadian Agriculture Adaptation Program), Sylvia Gibson (Yukon Agricultural Association), Alan Stannard (Yukon Agricultural Association), and Bev Buckway (Yukon Agricultural Association).

Similarly we greatly value the willingness of our project Advisory Committee members formed to provide insight and guidance going into the second phase of this project. They are: John Lenart (Dawson area farmer), Joan Norberg (Whitehorse area farmer), Kim Melton (Growers of Organic Food Yukon), Dr. Chris Hawkens (Vice President Research and Community Engagement, Yukon College), and Tony Hill (Yukon Government Agriculture Branch Director). We look forward to their substantial contribution going into phase II.

Technical information and support was graciously provided by Kam Davies (Yukon Government Agriculture Branch Agricultural Lands Technician), Kevin Bowers (Yukon Government Agriculture Branch, Agriculture Development Officer and Supervisor, Meat Inspection), Gary Brown (Yukon Bureau of Statistics), and Sebastien Markley (Yukon Bureau of Statistics).

Community engagement has been and will continue to be a critical element and focus of this project; after all, regional food systems (like all elements of the human economy) should be about and for the people and their communities in that region. We feel extremely fortunate to have partnered with the Arctic Institute of Community Based Research (AICBR) in Whitehorse. This organization is dedicated to facilitating and promoting community-based, Northern-led health research activities aimed at improving the health of Yukon First Nations and non-First Nations residents. Norma Kassi (AICBR Director of Indigenous Collaboration) and Jody Butler Walker (AICBR Executive Director) guided and facilitated our engagement with communities and First Nations in the Yukon. Norma Kassi did a lot of heavy lifting in this regard and taught all of us many important lessons about the Yukon, its peoples and cultures. Katelyn Friendship (AICBR Research Officer) was also very helpful. Lynn Rear and Michelle Parsons

skillfully served as our community coordinators in Dawson and Carcross and Tagish respectfully, setting up interviews. We are very grateful to the many Indigenous and non-indigenous interview participants in Carcross, Tagish, and Dawson.

We very much want to thank the many Yukon farmers who participated in personal interviews and completed the Farmer Survey. Similarly we are grateful to the processors and suppliers who we interviewed in person and by telephone. It is important to acknowledge that Growers of Organic Food Yukon (GoOFY) was instrumental in recruiting farmers for survey participation. Tom Rudge, long time Yukon farmer and food system advocate and GoOFY leader was hugely supportive and provided much valuable guidance.

Additionally we would like to recognize the exceptional leadership of and support received from Chief Danny Cresswell of the Carcross/Tagish First Nation. Chief Cresswell contributed significantly to the early dynamic thinking around this project, its implementation, and its effective, on-going execution.

We express our great gratitude to the First Nations that graciously and enthusiastically agreed to work with us on this project, including Tr'ondëk Hwëch'in First Nation, Na-Cho Nyak Dun First Nation, Carcross/Tagish First Nation and Kluane First Nation.

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Purpose and scope of foundational design

Food system design and planning begins with an assessment of natural resource capacity for crop and livestock production and capacity for food self-reliance, which is defined as the ability of a region to satisfy its populations' food needs with food grown locally. From this foundation of information, feasible levels of agricultural production can be designed, agricultural production's outcomes and impacts can be evaluated, and post-production food system components can be designed based on what is needed to support agriculture and food provision (Figure 1).

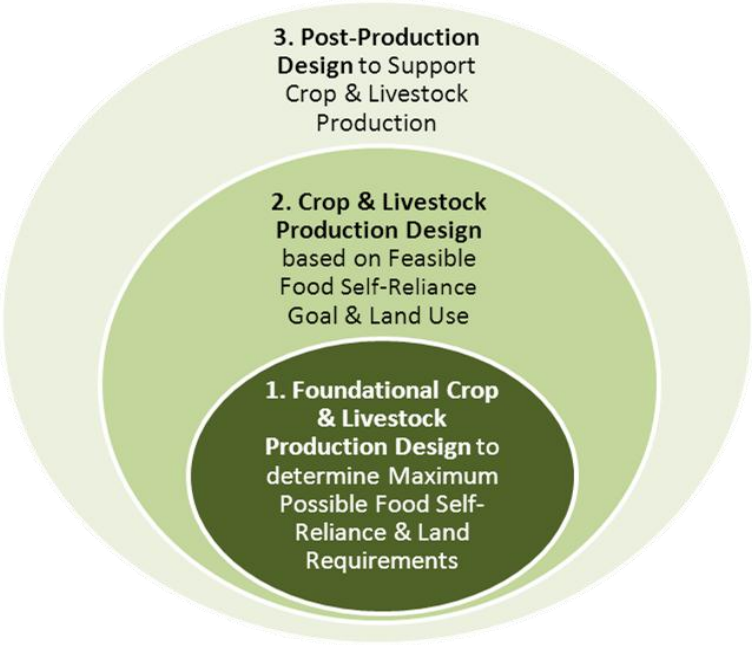


Figure 1: Food System Design and Planning Process

For this Foundational Food System Design we therefore set about to:

1) Determine the maximum level of food self-reliance that can be attained in Yukon based on contemporary limitations to crop production and the average assumed dietary pattern of Yukon residents.
2) Estimate the amount of land that would need to be put into production in the baseline study year (2011) and in the future (2050) in order to realize the levels of food self-reliance determined in Part 1. This was estimated at the Yukon scale, and for the specific communities of Dawson, Watson Lake, and Whitehorse, given "low", "average", and "high" crop yield scenarios and "low" and "high" future population growth scenarios.

This report describes the modeling methodology used to conduct the above assessments and estimations, describes the model results and discusses their implications in the Yukon context. The relationship and applicability of these calculations and estimations to the planned subsequent phases of the Yukon Food System Design and Plan project are also described.

Methods, data, and findings

To determine the maximum level of food self-reliance that could be achieved given the dietary pattern of the Yukon, we compared Yukon's food need to its food production potential. We then calculated the land area required to support these levels of maximum food self-reliance and compared this to the quantity of land available for agriculture. The methods and data sources used to do so are described below.

Food need

We estimated food needed given two diets – a "Typical Diet" in which all food need is satisfied by agricultural products and a "Traditional/subsistence diet" in which 25% of need for animal protein is satisfied by Traditional/Subsistence foods that are hunted, trapped, or fished.

The "Typical Diet"

Yukon-specific consumption data was unavailable and not feasible to collect (see Milestone 3, Indicator 1.1 for further discussion). Therefore to determine the Yukon's food need (defined as the quantity of food needed to meet dietary recommendations within preferred diet parameters), we followed methods developed by Kantor and Buzby et al., wherein the typical dietary pattern of the population is adjusted to meet dietary recommendations. These methods are described fully by *Kantor (1998)* and *Dorward et al. (2014; forthcoming)* and summarized here.

This typical diet was estimated using a Canadian food availability dataset that is developed by subtracting exports, manufacturing, waste, and ending stocks from the total national food supply (Statistics Canada - Agriculture Division, 2007; Statistics Canada, 2011). It has been used as a proxy for the typical diet of British Columbians (British Columbia Ministry of Agriculture and Lands, 2006) and studies of other countries have used similar national datasets in comparable ways. All foods were included in this study except those that are not in Canada's Food Guide and those reported in aggregated categories that cannot be compared to agricultural production data (Table 1). Traditional/ subsistence foods such as caribou, wild cranberries, etc. are not tracked in this dataset. Our approach to recognizing that these are important food sources for many Yukoners is described in the next section.

Table 1: Foods per Food Group in the typical Yukon diet

Fruit & Vegetables				**Milk & Alternatives**	**Meat & Alternatives**
Fruit		**Vegetables**			
Apples	Mangoes	Asparagus	Manioc	Dairy	Beans, dry
Apricots	Lemons	Beans, green	Mushrooms		Peanuts
Avocados	Limes	Beets	Peas, green		Beef
Bananas	Oranges	Broccoli	Peppers		Chicken
Blueberries	Papayas	Brussels sprouts	Potatoes		Lamb
Cherries	Peaches	Cabbage	Pumpkins		Pork
Coconut	Pears	Carrots	Radishes		Turkey
					Fish[1]
					Seafood[1]
Cranberries	Pineapple	Cauliflower	Rutabagas	**Grains**	**Fats& Oils**
Dates	Plums	Celery	Spinach	Barley	Canola Oil
Figs	Prunes	Corn, sweet	Sweet potatoes	Corn	Butter
Grapefruits	Raspberries	Cucumbers	Tomatoes, fresh	Oat	
Grapes	Strawberries	Onions	Turnips	Rye	
Guavas		Lettuce	Tomatoes, processed	Wheat	
				Rice	

[1]*Fish and seafood were included in the diet when the adjustment to meet Canada's Food Guide was performed but removed from any further analysis. Food self-reliance potential in this report is therefore only assessed for the land-based portion of the diet.*

The quantity of foods from different Food Groups in the typical diet was then compared to dietary recommendations from Canada's Food Guide. For some Food Groups (Fruit & Vegetables, Milk & Alternatives), the quantity of these foods consumed in the typical diet to not meet Canada's Food Guide recommendations. We therefore adjusted the quantities of food in the typical diet so that they cumulatively met these recommendations. Finally, to derive total need per person (specific to age and gender groups outlined in Canada's Food Guide), waste factors were applied to account for food waste at the household, retail, and institutional levels and the food needed per individual was multiplied by the total population per age and gender group to determine the total food needed given a typical diet satisfying Canada's Food Guide recommendations.

We used three different populations so that we could determine contemporary and future food needs. 2011 population data was retrieved from the Yukon Bureau of Statistics and 2050 high and low population projections were developed based on Statistics Canada population projections to 2038. High population growth projections see population increasing by 50% over 2011 levels while the low growth projection sees population increasing by only 10%. Population data was determined by age and gender group but is reported here as totals per community for brevity (Table 2).

Table 2: Population estimates and projections for Yukon and three Yukon communities

Population Scenario	Community	Total Population
2011 Estimate[1]	Dawson	1,882
	Watson Lake	1,518
	Whitehorse	26,713
	Yukon	35,177
2050 High Growth Projection[2]	Dawson	2,813
	Watson Lake	2,267
	Whitehorse	39,934
	Yukon	52,586
2050 Low Growth Projection[2]	Dawson	2,071
	Watson Lake	1,667
	Whitehorse	29,400
	Yukon	38,718

[1]*Retrieved from Yukon Bureau of Statistics Population Report June 2011. We assumed the population's composition to be 50% male/50% female.*

[2]*Projection based on Statistics Canada CANSIM Table 052-0005. We assumed the same growth rate projected from 2026-2038 to continue from 2038-2050. We assumed the portion of total population in Dawson, Watson Lake, and Whitehorse to remain unchanged from 2011 and retrieved this percentage from the Yukon Bureau of Statistics Population Report June 2011.*

Contribution of Traditional or subsistence foods to Yukon food need: The "25% Traditional/ Subsistence Diet"

Traditional/subsistence foods, defined as those that are hunted, trapped, fished, or gathered, are an important component of Yukon's food system from both a cultural and nutritional standpoint. As discussed above, these foods are not tracked in the dataset used to estimate the "typical diet".

In interviews conducted by the Institute for Sustainable Food Systems in Carcross, Tagish, and Dawson with First Nation and non-First Nation community members, many interviewees described the important place these foods have in their culture and/or diets (Institute for Sustainable Food Systems, 2015). The Yukon Health and Social Services "Yukon 2012 Health Status Report" indicates that over 20% of rural residents and over 8% of Whitehorse residents obtain more than 50% of the food they eat from home-grown or harvested sources. Furthermore, over 30% of Whitehorse residents and over 50% of rural residents report obtaining food through berry picking, hunting, and/or fishing (Yukon Health and Social Services, 2012).

While the specific amount of Traditional/subsistence food that Yukoners consume has not been measured, this data indicates that the contribution of Traditional/subsistence foods to Yukon diets should not be overlooked, especially as it would result in lower overall consumption of farm produced meats. As such, in addition to estimating food need under the "Typical Diet" we also assessed a "25% Traditional/Subsistence diet" in which 25% of the total Food Need for animal protein is assumed to be satisfied through hunting and fishing.

Yukon's food production potential

What foods can be produced in the Yukon?

The Yukon's climate and short growing season limit its potential to produce the full range of foods in the Preferred Diet of Yukoners. Given contemporary agricultural techniques and limited use of greenhouses, Table 3 outlines the crops in the Yukon diet that we assumed could and could not be grown in the Yukon. This was determined based on available data, results from the Institute for Sustainable Food System's Yukon Farmer Survey, and personal communication with farmers and Yukon Agriculture Branch staff. Note that the determination is based on agronomic, not economic/financial feasibility. We recognize that experimentation and crop development may expand the list of crops that are possible to produce in the Yukon in the future (e.g., pears).

Table 3: Foods in the Yukon diet that generally can and cannot be produced in the Yukon[1]

Possible to Produce in Yukon				
Fruit & Vegetables			**Milk & Alternatives**	**Meat & Alternatives**
Fruit	***Vegetables***			
Apple[2]	Bean, green	Lettuce	Dairy	Bean, dry
Blueberry	Beet	Mushroom		Beef
(Haskap)[3]	Broccoli	Pea, green		Chicken
Raspberry	Brussels sprout	Pepper (green et al.)[4]		Lamb
Strawberry	Cabbage	Potato		Pork
	Carrot	Pumpkin		Turkey
	Cauliflower	Radish	**Grains**	**Fats & Oils**
	Celery	Rutabaga	Barley	Canola oil
	Cucumber[4]	Spinach	Oat	Dairy
	Onion	Tomatoes, fresh[4]	Rye	
		Turnip	Wheat	
Not Possible to Produce in Yukon				
Fruit & Vegetables			**Milk & Alternatives**	**Meat & Alternatives**
Fruit		***Vegetables***		
Apricot	Guava	Asparagus		Peanut
Avocado	Mango	Corn, sweet		
Banana	Lemon	Manioc	**Grains**	**Fats & Oils**
Cherry	Lime	Sweet potato	Rice	
Cranberry[5]	Orange	Tomato, processing	Corn	
Coconut	Papaya			
Date	Peach			
Fig	Pear			
Grapefruit	Pineapple			
Grape	Plum			
Coconut	Prune			

[1] *Determined based on available data, results from the Institute for Sustainable Food System's Yukon Farmer Survey, and personal communication with farmers and Yukon Agriculture Branch staff. Based on agronomic, not economic/financial feasibility. Experimentation and crop development may expand the list of crops that are possible to produce in the Yukon in the future.*

[2] *Assuming the availability of northern-adapted cultivars.*

[3] *Haskaps assumed to be a suitable substitute for blueberry consumption and possible to grow in Yukon*

[4] *In general these crops require protection such as an unheated hoophouse or a heated greenhouse.*

[5] *Commercial cultivars not feasible however wild cranberries can be harvested in the Yukon.*

Crop yield and seasonal availability of Yukon-grown foods

For those crops that can be produced in the Yukon, no comprehensive dataset of Yukon-specific yields is currently available, although various reports and anecdotal evidence do exist, primarily for grain and berry crops. Much of this Yukon-specific data has been collected by the Yukon Government Agriculture Branch from field trials at their Whitehorse-area research and demonstration plot. According to personal communication with Yukon agricultural experts, crop yields can be achieved in the Yukon which are similar to those currently attained in British Columbia (BC), as long as proper management techniques are used and in all likelihood with greater crop inputs than would be required to achieve those yields in BC.

As such, with the exception of haskap, raspberry, fodder, and pasture we used crop yield data from BC as proxy for Yukon yields. BC provincial average yields were obtained from various CANSIM tables (Statistics Canada, 2013). CANSIM yields are calculated based on seeded or cultivated area and marketable yield, and therefore take into account post-harvest losses and land that goes un-harvested. It is important to note that, because these yields are reported in aggregate as provincial averages, they are not reflective of individual farms but rather the average yield at the overall food system scale. It is assumed that crop yields on individual farms could differ from those used here.

Using this data we developed three crop yield "scenarios": low yield, average yield, and high yield. For all crop yields derived from CANSIM tables except apple, "average" yields were assumed to equal the average of 10 years (2002-2011) of CANSIM data. For apple, the 10 year average was reduced by 50% to account for regional differences in production potential and that apple is a nascent commercial crop in the Yukon. For haskap, "average" yield was estimated based on the recommended commercial planting density (Prairie Plant Systems Inc., 2015) and reported yield per bush (Bors and Thompson, 2009). For fodder, "average" yields were calculated based on the average yield of dryland oats in trials run by the Yukon Agricultural Branch (Ball and Reaume, 2012). For raspberries, "average" yields were calculated based on the average yield of kiska raspberries in trials run by the Yukon Agricultural Branch (Ball and Taylor, 2009). For pasture, "average" yield was derived from the Soil Survey and Land Evaluation of the Yukon Territory, which reports that Class III or IV grazing land in the Yukon yields 100-450 kg dry matter/hectare. We took the median of this range (280 kg dry matter/hectare) as "average" (Rostad et al, 1977). To determine "low" and "high" yields we multiplied "average" yield by 0.75 and 1.25 respectively. See Appendix I (p.26) for a complete list of crop yields used in this study.

Alaska data on the seasonal availability of fresh produce was used as proxy for Yukon data (Table 4). We assumed that crops grown in the Yukon but consumed in processed or dry form (e.g.: frozen peas, frozen chicken, oatmeal) would be available year-round.

Table 4: Assumed fresh availability of select Yukon-grown food crops[1]

Food Crop	Months Fresh Avail'	Food Crop	Months Fresh Avail'
Apple	9	Cucumber[2]	5
Blueberry(Haskap)	2	Lettuce	6
Strawberry	4	Mushroom	6
Bean, green and wax	3	Onion	9
Beet	10	Peas, green	2
Broccoli	4	Pepper[2]	7
Brussels sprout	4	Pumpkin and squash	9
Cabbage	6	Radish	7
Carrot	9	Rutabaga and turnip	7
Cauliflower	3	Spinach	4
Celery	2	Tomato[2]	7

[1] *Adapted from Alaska District of Natural Resources Seasonal Availability chart, retrieved from http://dnr.alaska.gov/ag/sourcebook/2014SBimages/Seasonalproduce.pdf.*
[2] *Including greenhouse production*

Livestock product yields

We estimated the hectares of barn, pasture and/or feed crops that would be required per tonne of livestock product produced in the Yukon without feed imports using the method developed by *Cowell and Parkinson* (2003), which accounts for the land requirements of the breeding and/or replacement stock in addition to the slaughtered, milking, or laying animal itself. Data used included: livestock feed requirements, Yukon pasture and feed crop yields, livestock lifecycle data including the rearing period, breeding lifespan, age at cull, and carcass weight or milk or egg production/year. This data was sourced from BC industry sources whenever possible, and Canadian sources otherwise. A full list of data used is reported in *Dorward et al, 2015 (forthcoming)*. See Table 5 for livestock land requirements calculated using this method. Land requirements for beef and lamb production are highest due to their large pasture requirement and the relatively low dry matter yield we assumed possible from Yukon grazing lands (see previous section on crop yields). If they were pastured on managed pastures with higher yields of dry matter/hectare, the land requirements for their production would be smaller. To be conservative, we used yields indicated in Rostad et al, 1977.

Table 5: Hectares land required for Yukon production of livestock products given three crop yield scenarios (hectares barn, pasture and/or feed per tonne livestock product). For beef, dairy, and sheep & lamb the pasture component of total land requirements is indicated in brackets[1]

Crop Yield Scenario	Beef cattle	Dairy cattle	Sheep & Lamb	Hog	Layer	Broiler	Turkey
Decreased	73.0 total (64 pasture)	0.7 (0.2 pasture)	58.2 (54 pasture)	2.4	1.4	1.1	1.1
Average	54.0 total (49 pasture)	0.5 (0.2 pasture)	43.7 (41 pasture)	1.8	1.1	0.8	0.8
Increased	43.2 total (39 pasture)	0.4 (0.16 pasture)	35.0 (33 pasture)	1.4	0.9	0.7	0.7

[1] *Estimated using Cowell and Parkinson (2003); accounts for land requirements of breeding and/or replacement stock*

How Food Self-Reliant could the Yukon become?

To determine what portion of total food need could be satisfied by Yukon production, we assumed that no substitution between foods in the diet occurs (e.g., haskap cannot be substituted for tropical fruit), and that Yukoners consume fresh food outside of their season of Yukon fresh availability (e.g., broccoli consumed fresh in February). The portion of Food Need for foods consumed fresh outside of their Yukon availability, and for foods which cannot be grown in Yukon (e.g., tropical and citrus fruit), can only be satisfied by imports. Given these assumptions, Yukon production could never satisfy 100% of food need across all food types.

To calculate the maximum portion of need for food f that can be satisfied by Yukon production, for each food in the diet, we used:

$$Maximum\ portion\ of\ need\ for\ food\ f\ that\ can\ be\ satisfied\ by\ Yukon\ production = \frac{Annual\ need\ for\ food\ f}{12} \times Months\ Yukon\ availability\ food\ f$$

For this study, food self-reliance is defined as the percentage of the total diet that is satisfied by Yukon production. The corresponding maximum level of food self-reliance that could be achieved in the Yukon is calculated as:

$$Max\ Yukon\ food\ self\ reliance = \frac{Max\ portion\ of\ need\ for\ all\ foods\ that\ can\ be\ satisfied\ by\ Yukon\ production}{Total\ need\ for\ all\ foods} \times 100\%$$

Using these equations we calculate that, given the typical contemporary Yukon dietary pattern and contemporary limitations to crop production at most 75% of Yukon's food need could be satisfied by Yukon-grown food (Figure 2).

Within each food group, the portion of total food need that could be satisfied by Yukon production ranges from 100% for livestock products (Dairy, Egg, Meat) and Fats & Oils to 62% for Vegetables, 31% for Legumes, and 27% for Fruit (Figure 3).

Figure 2: Maximum percentage of Yukon diet that could be satisfied by Yukon produced foods and minimum by imported foods

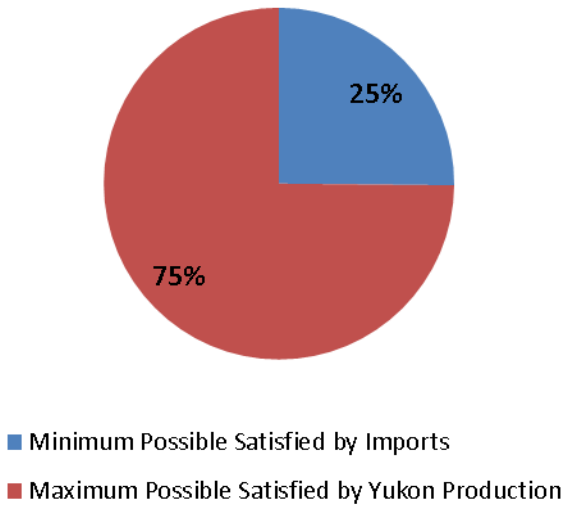
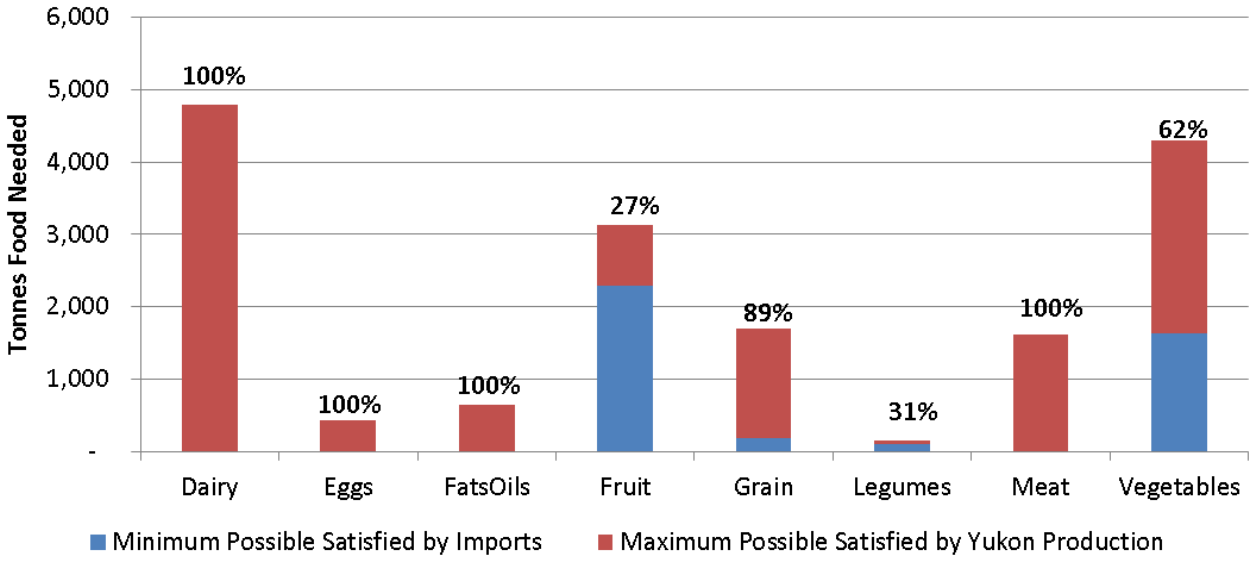


Figure 3: Maximum possible total food need that could be satisfied by Yukon production and minimum that could be satisfied by imports, by food group. Percentages indicate the maximum percent of total need that could be satisfied by Yukon production



Maximum possible food self-reliance could be increased if Yukoners were to substitute consumption of processed foods grown in the Yukon for those consumed fresh out of season (e.g., substitute frozen Yukon produced peas for imported fresh peas consumed in January), or to substitute consumption of crops that can be produced in the Yukon for those that cannot (e.g., substitute raspberries for mangoes).

How much land would need to be farmed to achieve maximum food self-reliance?

Scenarios evaluated

We determined the quantity of land required per crop to achieve the maximum possible levels of food self-reliance under four 2011 scenarios and eight 2050 scenarios that are based on differing populations, crop yields, and the two diets, for a total of twelve scenarios (Table 6).

- The 2011 scenarios estimate how much land would need to be farmed to achieve maximum food self-reliance in 2011 and are intended to be a point of reference for comparing to the future (2050) scenarios when population has grown.
- The high, average, and low crop yields illustrate the degree to which land requirements are affected by crop yield and inform a discussion about food self-reliance potential given the uncertainty surrounding current and future crop yields.
- The two diets ("typical" and "25% Traditional/Subsistence") will inform discussion about how incorporating Traditional/subsistence foods into the diet reduces the need to raise domesticated livestock to satisfy food need for meat products.

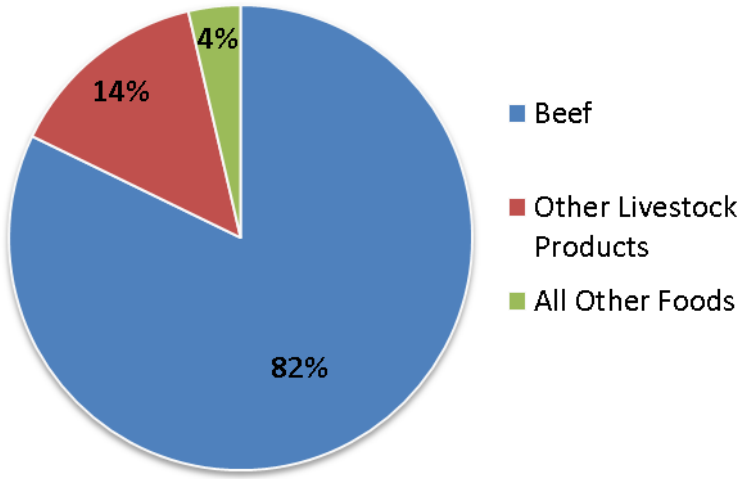
Table 6: Scenarios to assess land requirements for food self-reliance

Scenario	Year	Yukon Population	Crop Yield	Diet
1	2011	2011 Estimate	"High"	Typical
2	2011	2011 Estimate	"Average"	Typical
3	2011	2011 Estimate	"Average"	25% Traditional/Subsistence
4	2011	2011 Estimate	"Low"	Typical
5	2050	Low Growth Projection	"High"	Typical
6	2050	Low Growth Projection	"Average"	Typical
7	2050	Low Growth Projection	"Average"	25% Traditional/Subsistence
8	2050	Low Growth Projection	"Low"	Typical
9	2050	High Growth Projection	"High"	Typical
10	2050	High Growth Projection	"Average"	Typical
11	2050	High Growth Projection	"Average"	25% Traditional/Subsistence
12	2050	High Growth Projection	"Low"	Typical

Results – Patterns across all scenarios

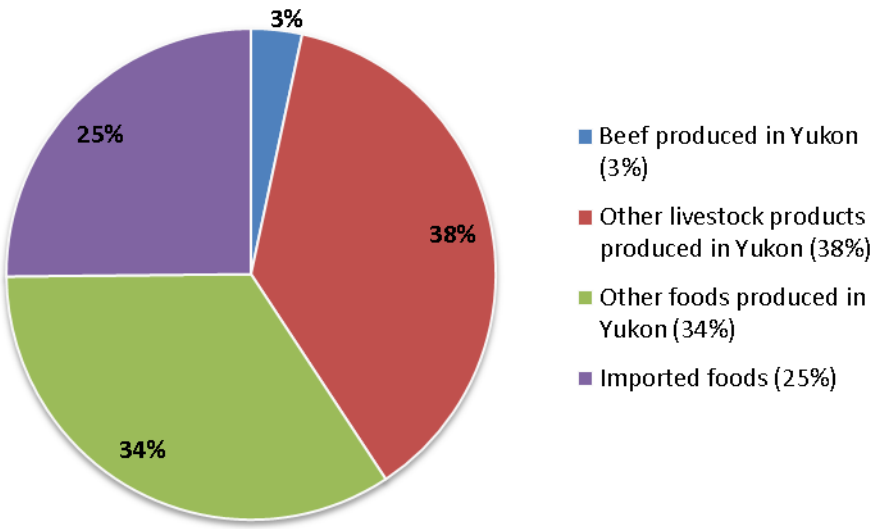
Requirements for livestock products compared to other foods: In all scenarios, land required for beef production represents the largest single land requirement at an average of approximately 82% of total land requirements. 14% of total land is required for other livestock products and the remaining 4% for all other foods (Figure 4). Note that land for livestock production includes not only the area needed to house livestock but also the area required for pasturing and/or growing feed crops.

Figure 4: Approximate percentage of total hectares farmland required to achieve maximum Yukon food self-reliance associated with production of beef, other livestock products, and all other foods



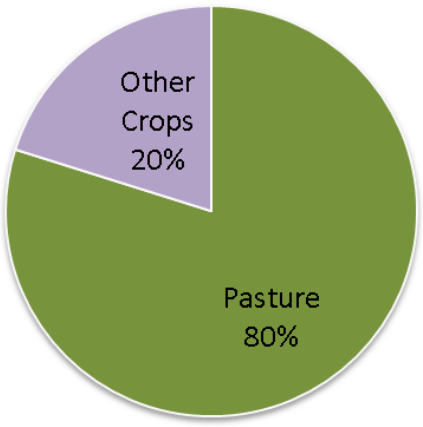
While land for beef production comprises 75% of total land required for maximum Yukon food self-reliance, the actual contribution of that beef production to self-reliance is only 3%. This highlights how land intensive beef production is relative to other foods in the diet. Figure 5 illustrates the relative contribution of beef produced in Yukon, other livestock products produced in Yukon, other foods produced in the Yukon, and imported foods to the total diet on a percentage weight basis.

Figure 5: Percentage contribution to the total diet, by weight, of various food types in a scenario of maximum Yukon food self-reliance



Land requirements for pasture compared to more intensively managed crops: In all scenarios, pasture for beef, dairy, and sheep and lamb comprises approximately 80% of total area required. The remaining 20% is required for fruit, vegetable, food grain, legume, oilseed, and fodder production (Figure 6).

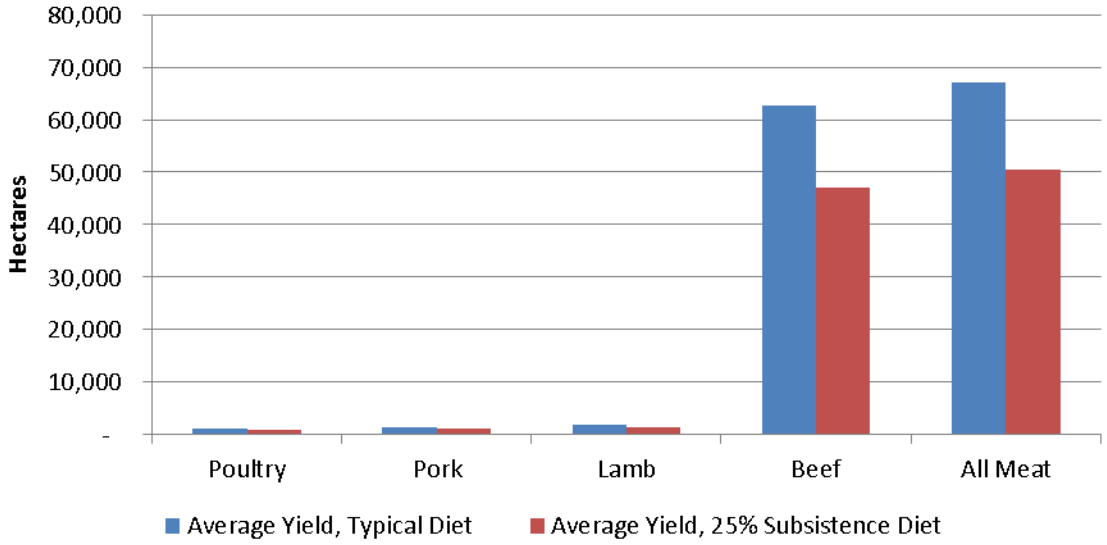
Figure 6: Approximate percentage of total farmland required to achieve maximum Yukon food self-reliance associated with pasture compared to all other crops



Land requirements in the 25% Traditional/Subsistence Diet: The impact of the "25% Traditional/Subsistence Diet" on land use requirements is seen only in the land requirements for meat production (poultry, pork, lamb, and beef). Across all scenarios, substituting Traditional/Subsistence foods for 25% of farmed meat reduces the total need for land in meat production by 25% and total land requirements across all food groups by about 20%.

Even in the Traditional/Subsistence diet scenario, however, land used for meat production represents the majority of total land used for farming. Figure 7 compares the land requirements in the Typical Diet to the 25% Traditional/Subsistence Diet, by food livestock product. Figure 7 is specific to a 2011 population, but 2050 scenarios follow the same pattern.

Figure 7: Farmland requirements for self-reliance in meat products in 2011 given the "Typical Diet" compared to the "25% Traditional/Subsistence Diet", assuming average crop yields (hectares)



Results – 2011 land requirements

Land requirements for Yukon: For the "Typical Diet" scenarios, total land required to achieve maximum (75%) self-reliance in the 2011 scenarios ranged from approximately 61,000 hectares to 102,000 hectares depending on the diet followed and the crop yield scenario (Table 1).

Table 7: Area of farmland (hectares) required to achieve maximum Yukon food self-reliance in 2011 assuming a Typical Diet, across three crop yields, by food type.

Food Type	High Yield	Average Yield	Low Yield
Legumes	25	31	41
Fruit	121	151	202
Vegetables	175	219	292
Eggs	441	551	734
Grain	893	1,116	1,488
Poultry	953	1,189	1,584
Pork	996	1,245	1,661
Non-Dairy Fats & Oils	1,189	1,486	1,982
Lamb	1,463	1,829	2,438
Dairy	4,603	5,753	7,670
Beef	50,750,	62,678	83,567
Total	***61,004***	***76,249***	***101,659***

Results – 2050 Scenarios

Land requirements for Yukon increase with population growth: Recall that two populations were modeled – a 2050 high population scenario and 2050 low population scenario. Figure 8 illustrates the increase in total farmland required to support maximum levels of food self-reliance as population increases from the 2011 level.

Results of 2050 scenarios follow the same pattern as that seen for 2011 but with overall increased land area requirements due to a higher population, with the smallest total land requirement (low population, high crop yield scenario) totaling approximately 67,000 hectares and the largest (high population, low crop yield scenario) totaling approximately 149,000 hectares (Table 8).

Figure 8: Total area of farmland (hectares) required to achieve maximum Yukon food self-reliance assuming a Typical Diet and average crop yields, across three population scenarios.

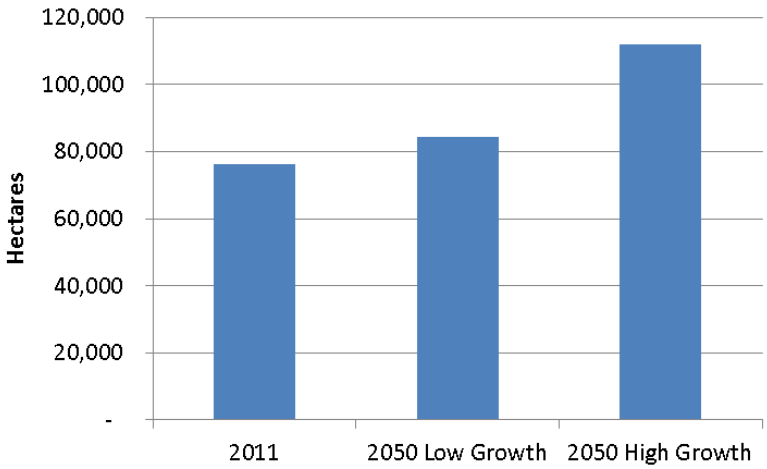


Table 8: Area of farmland required to achieve maximum Yukon food self-reliance in 2050 assuming a Typical Diet, across three crop yields, and two population growth scenarios, by food type (hectares)

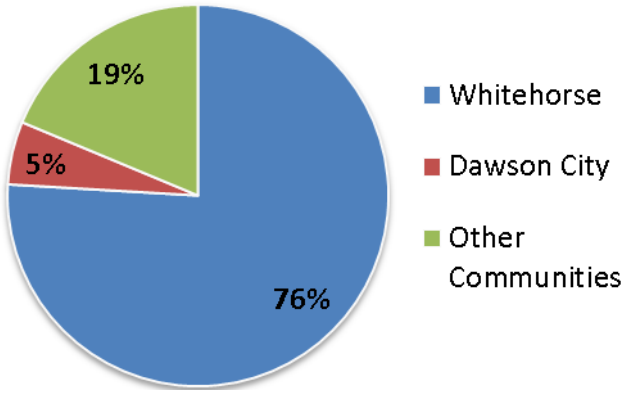
2050 Population:	Low			High		
Crop Yield: / Food Type:	High	Average	Low	High	Average	Low
Legumes	27	34	45	36	45	60
Fruit	132	165	220	178	222	296
Vegetables	191	239	318	257	321	428
Eggs	487	608	810	645	806	1074
Grain	983	1229	1638	1335	1669	2225
Poultry	1051	1312	1747	1394	1740	2317
Non-dairy Fats & Oils	1097	1371	1828	1489	1862	2482
Pork	1312	1640	2186	1740	2174	2899
Lamb	1614	2017	2690	2140	2675	3567
Dairy	5221	6525	8700	7056	8820	11759
Beef	55322	69150	92196	73361	91697	122257
Total	67436	84290	112379	89631	112031	149365

Land requirements for Whitehorse and Dawson City: across all scenarios, land associated with food production for Whitehorse comprises the largest proportion of total farmland requirements (approximately 76%). To offer an idea of the amount of land that would be required to achieve maximum foods self-reliance in some smaller communities, we use Dawson city as an example. Relative to total Yukon farmland requirements, land required for food self-reliance within Dawson City comprises only 5% (Figure 9).

Table 9: Hectares of farmland required to achieve maximum Yukon food self-reliance in 2050 assuming a Typical Diet and average crop yields, across two population growth scenarios, by food type

2050 Population:	Low	High	Low	High
Location: / Food Type:	Dawson	Dawson	Whitehorse	Whitehorse
Legumes	2	2	26	34
Fruit	9	12	125	169
Vegetables	13	17	181	244
Eggs	33	43	462	612
Grain	66	89	933	1267
Poultry	70	93	996	1321
Non-dairy Fats & Oils	73	100	1041	1414
Pork	88	116	1245	1651
Lamb	108	143	1532	2032
Dairy	349	472	4955	6698
Beef	3699	4904	52506	69634
Total	*4509*	*5992*	*64002*	*85076*

Figure 9: Approximate percentage of total Yukon farmland required to achieve maximum Yukon food self-reliance associated with production for Whitehorse, Dawson City, and all Other Communities



Comparison to land suitable for farming

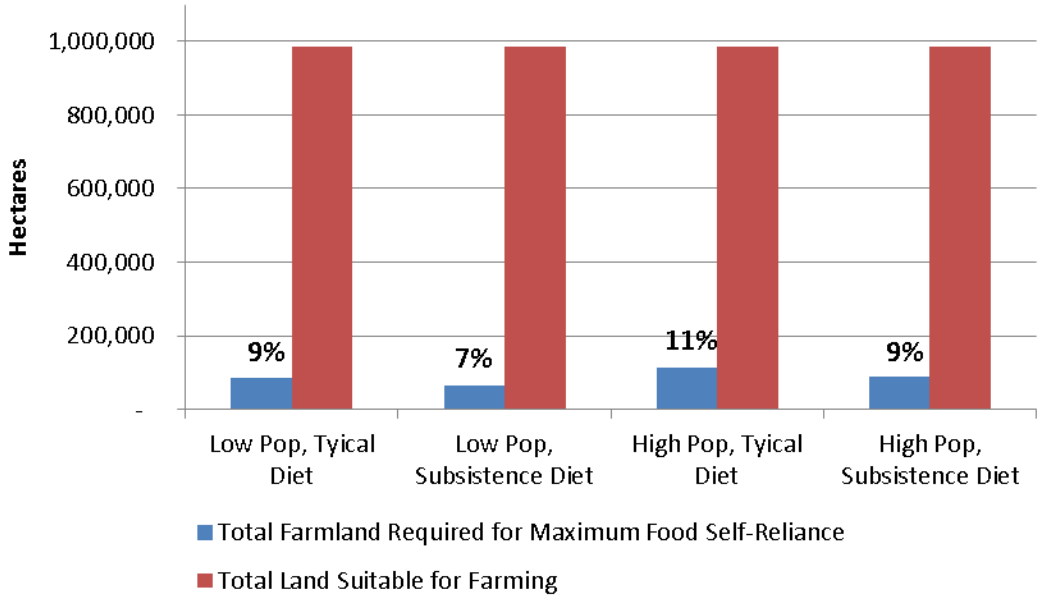
The 1977 Soil Survey and Land Evaluation of the Yukon Territory, conducted by Rostad et al, provides the most comprehensive single dataset available on soil quality for agriculture. It reports on land identified as having potential for agriculture in seven regions of the Yukon (Dawson-Stewart Crossing-Mayo, Pelly Crossing-Carmacks, Watson Lake, Faro-Ross River, Whitehorse, Takhini-Dezadeash, and Snag). Table 10 summarizes findings from the Rostad soil survey. In total, according to that study, the Yukon has almost 1,000,000 hectares of land that is suitable for agricultural production, and over 63,000 hectares of land that is rated as class 3 and 4 land. Due to the Yukon's adverse climate, no land is rated as Class 1 or 2. Compared even to the 2050 low crop yield, high population scenarios, total land required to achieve maximum food self-reliance is much less than the total land suitable for farming in the Yukon (Figure 10).

Table 10: Agricultural Land Availability in the Yukon

Survey Area	Areal Extent of Agricultural Capability (Hectares)			
	Class 3 and 4	Class 5	Class 6	*Total*
Dawson - Stewart Crossing - Mayo	24,380	166,912	17,238	*208,530*
Pelly Crossing - Carmacks	27,730	143,721	17,127	*188,578*
Watson Lake	10,447	209,267	267	*219,981*
Faro - Ross River	644	31,912	67,235	*99,791*
Whitehorse		73,240	17,472	*90,712*
Takhini - Dezadeash		126,215	14,887	*141,102*
Snag		35,821	2,081	*37,902*
Total	*63,201*	*787,088*	*136,307*	
GRAND TOTAL				**986,596**

Source: Rostad, Kozak, and Acton. 1977. Soil Survey and Land Evaluation of the Yukon Territory. Saskatchewan Institute of Pedology Publications S174.

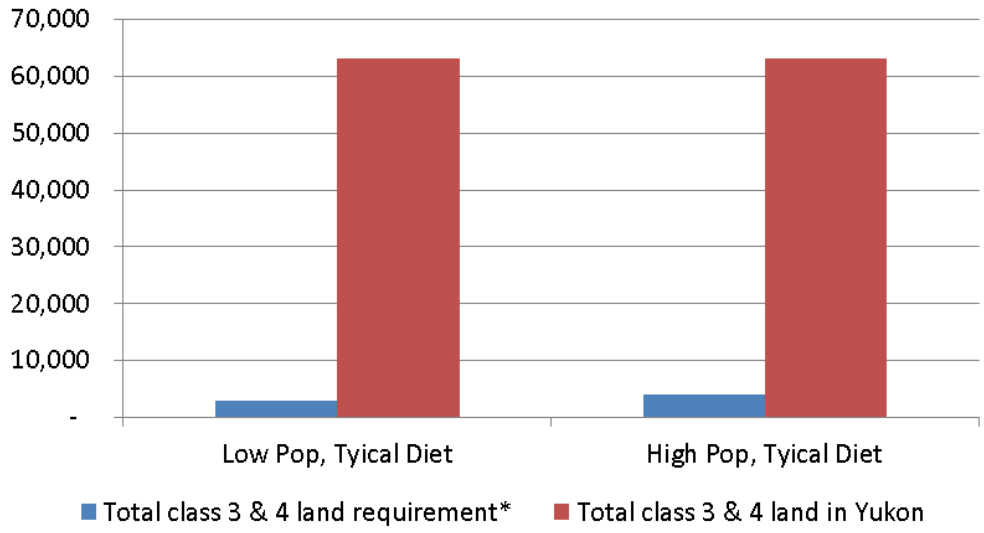
Figure 10: Hectares of farmland required to achieve maximum Yukon food self-reliance in 2050 assuming average crop yields, across two population growth scenarios and two diets, compared to total hectares of land suitable for farming in the Yukon. Percentages indicate what percentage of total land suitable for farming the total farmland required comprises



Class 3 land is suitable for cereal production, Class 5 is suitable for seeded forages, and Class 6 is suitable for native grazing. Vegetable production is most successful on Class 3 and 4 but possible on all of these classes, although from Class 3 to Class 6 the range of vegetables that can be grown decreases and the need to use protective culture (i.e., greenhouses, hoophouses, etc.) and the management required increases (Rostad, Kozak, & Acton, 1977).

We found that total land requirements for class 3 and 4 land (including land for Non-dairy Fats & Oils, Fruit, Grain, Legumes, and Vegetables) in a scenario of maximum 2050 food self-reliance are far less than land available (Figure 11). Regardless, however, the current concentration of Yukon farms is in the Whitehorse area, where no class 3 or 4 land is available, and is a good indicator that production of these crops is also possible on Class 5 or 6 land in the Yukon, given appropriate management to overcome inherent soil/climate limitations. Regardless of how much land is available, however, any expansion of Yukon agriculture onto currently unfarmed land will remove land from habitat. This must factor into future decision making around future agricultural expansion.

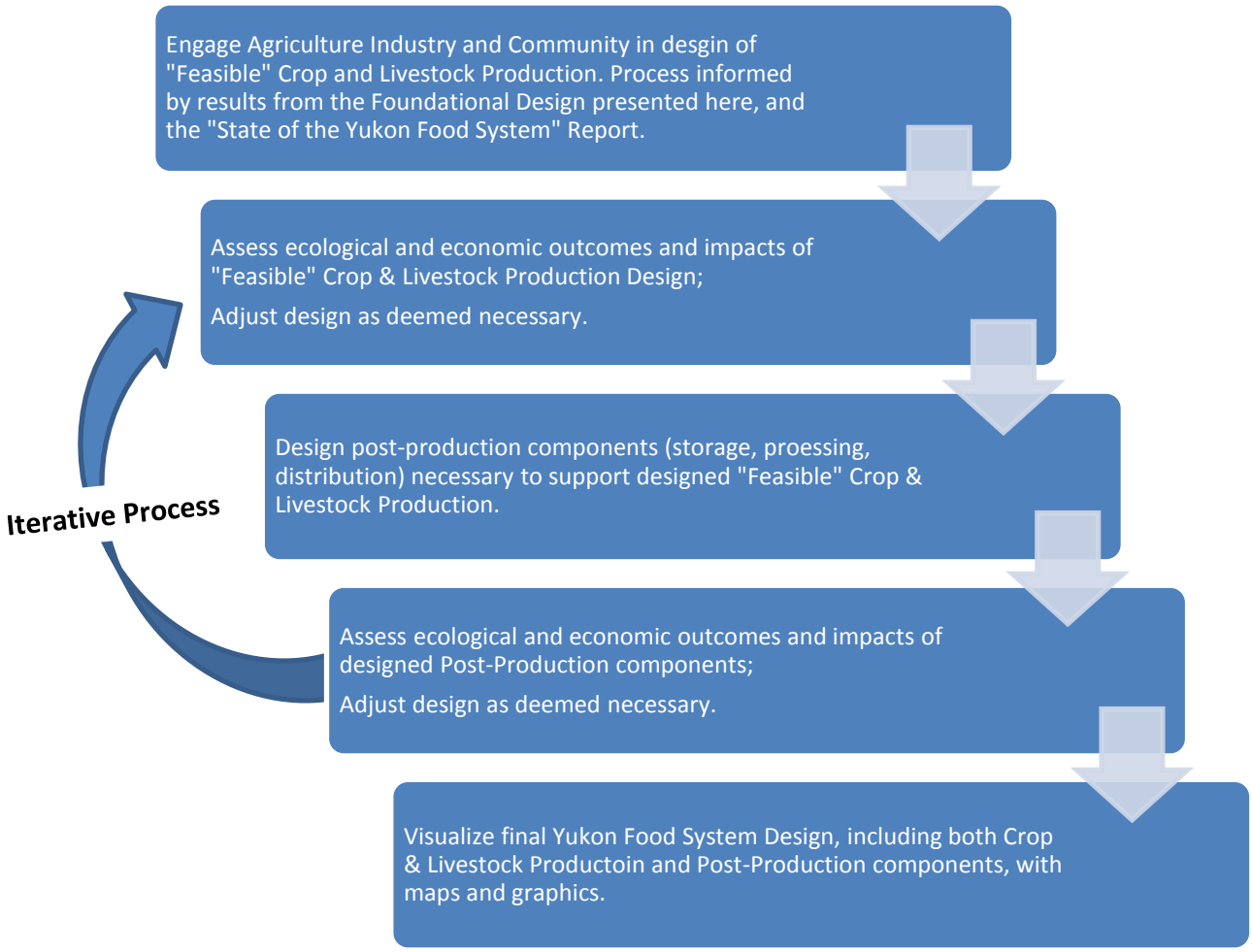
Figure 11: Hectares of Class 3 and 4 farmland required to achieve maximum Yukon food self-reliance in 2050 assuming average crop yields, across two population growth scenarios, compared to total hectares of land suitable for farming in the Yukon. Percentages indicate what percentage of total class 3 and 4 land is total class 3 and 4 required comprises



Next steps

Work done thus far, to establish the Foundational Design, positions our research team well to develop a comprehensive Yukon Food System Design in the second planned phase of the Yukon Food System Design and Planning Project (which was not funded at the time this report was published). Next steps toward the development of this comprehensive design will be an iterative process that builds on work completed thus far.

Food system design and planning must start with an assessment of natural resource capacity and preliminary design of crop and livestock production. Evaluation of agricultural production outcomes and impacts, and design of post-production food system components, must be based on this foundation. In this Foundational Design we have modeled the “maximum” levels of food self-reliance attainable in the Yukon and associated land use requirements to achieve these. Using this information, next steps planned for Phase II of the Yukon Food System Deisgn and Planning project include:



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Appendix I: Crop yields used in this study

Commodity	Assumed Yukon Yield (tonnes/hectare)[1]		
	Low	Average	High
Apples	8.72	11.63	14.53
Asparagus	1.12	1.5	1.87
Barley	1.51	2.01	2.51
Barley, grain	1.51	2.01	2.51
Beans, green and wax	4.91	6.54	8.18
Beans, other dry	1.4	1.87	2.34
Beets	15.59	20.78	25.98
Blueberries	2.55	3.4	4.25
Broccoli	3.54	4.73	5.91
Brussels sprouts	8.81	11.74	14.68
Cabbage	14.51	19.34	24.18
Canola, meal from seed	1.05	1.4	1.75
Canola, meal from seed	1.05	1.4	1.75
Canola, oil from seed	1.05	1.4	1.75
Carrots	21.19	28.25	35.31
Cauliflower	6	8	10
Celery	16.42	21.9	27.37
Cucumbers, field	8.61	11.48	14.36
Dry Peas	1.28	1.71	2.14
Grapes	3.89	5.18	6.48
Hay	2.55	3.4	4.25
Hay	2.55	3.4	4.25
Lettuce	17.19	22.92	28.65
Mushrooms	583.54	778.06	972.57
Oat, grain	1.05	1.4	1.74
Oats	1.05	1.4	1.74
Onions	24.48	32.65	40.81
Pasture	0.21	0.28	0.34
Peas, dry	1.28	1.71	2.14
Peas, green	3.39	4.52	5.65
Peppers, field	10.85	14.47	18.09
Potatoes	22.74	30.32	37.91
Pumpkins	18.41	24.54	30.68
Radishes	9.22	12.29	15.36
Raspberries	0.92	1.23	1.54
Rutabagas and turnips	16.6	22.13	27.67
Shallots and green onions	11.95	15.93	19.92
Silage	4.48	5.97	7.46
Soybean, meal from seed	1.94	2.58	3.23
Spinach	9.33	12.44	15.55

Squash and zucchini	10.74	14.32	17.9
Strawberries	3.61	4.81	6.01
Tomatoes, field	13.13	17.51	21.89
Wheat	1.86	2.48	3.1
Wheat, grain	1.86	2.48	3.1

[1]*With the exception of haskap, raspberry, fodder, and pasture we used crop yield data from BC as proxy for Yukon yields. BC provincial average yields were obtained from various CANSIM tables (Statistics Canada, 2013). CANSIM yields are calculated based on seeded or cultivated area and marketable yield, and therefore take into account post-harvest losses and land that goes un-harvested. It is important to note that, because these yields are reported in aggregate as provincial averages, they are not reflective of individual farms but rather the average yield at the overall food system scale. It is assumed that crop yields on individual farms could differ from those used here.*

Specific CANSIM Tables used were: Table 001-0013 (Area, production and farm gate value of vegetables), Tables 001-0014 (Area, production, and farm value of potatoes), Table 001-0012 (Area, production and sales of mushrooms, annual), CANSIM Table 001-0010 (Estimated areas, yield, production and average farm price of principal field crops, in metric units), CANSIM Table 001-0009 (Area, production and farm gate value of fresh and processed fruits, by province).

For all crop yields derived from CANSIM tables except apple, "average" yields were assumed to equal the average of 10 years (2002-2011) of CANSIM data. For apple, the 10 year average was reduced by 50% to account for regional differences in production potential and that apple is a nascent commercial crop in the Yukon. For haskap, "average" yield was estimated based on the recommended commercial planting density (Prairie Plant Systems Inc., 2015) and reported yield per bush (Bors and Thompson, 2009). For fodder, "average" yields were calculated based on the average yield of dryland oats in trials run by the Yukon Agricultural Branch (Ball and Reaume, 2012). For raspberries, "average" yields were calculated based on the average yield of kiska raspberries in trials run by the Yukon Agricultural Branch (Ball and Taylor, 2009). For pasture, "average" yield was derived from the Soil Survey and Land Evaluation of the Yukon Territory, which reports that Class III or IV grazing land in the Yukon yields 100-450 kg dry matter/hectare. We took the median of this range (280 kg dry matter/hectare) as "average" (Rostad et al, 1977). To determine "low" and "high" yields we multiplied "average" yield by 0.75 and 1.25 respectively.