Sustainable Agriculture and Food Security in the Circumpolar North

Proceedings of the 8th Circumpolar Agricultural Conference &
University of the Arctic Inaugural Food Summit

September 29 – October 3, 2013

Girdwood, Alaska, USA

CIRCUMPOLAR AGRICULTURAL ASSOCIATION

UArctic

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School of Natural Resources & Agricultural Sciences

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PO Box 757140

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About the Cover:

The colors of our cover depict the colors of our northland and its agricultural potential. The gold brings to mind the fall harvest and grain fields that could help feed the growing world population. The lush green of our forests and green of our crops hold promise for new products and growing concepts such as agroforestry and controlled environments. The red/brown stands for sustainable and alternative livestock industries in the North, and for our soils that inspired early surveyors and settlers to imagine a thriving agriculture that is increasingly possible with new crops and technologies. Finally, the ice blue of the polar ice caps, glaciers, and the multitude of waterways, lakes, and shorelines of the North remind readers of the abundant waters of our northland and the need to use them wisely.

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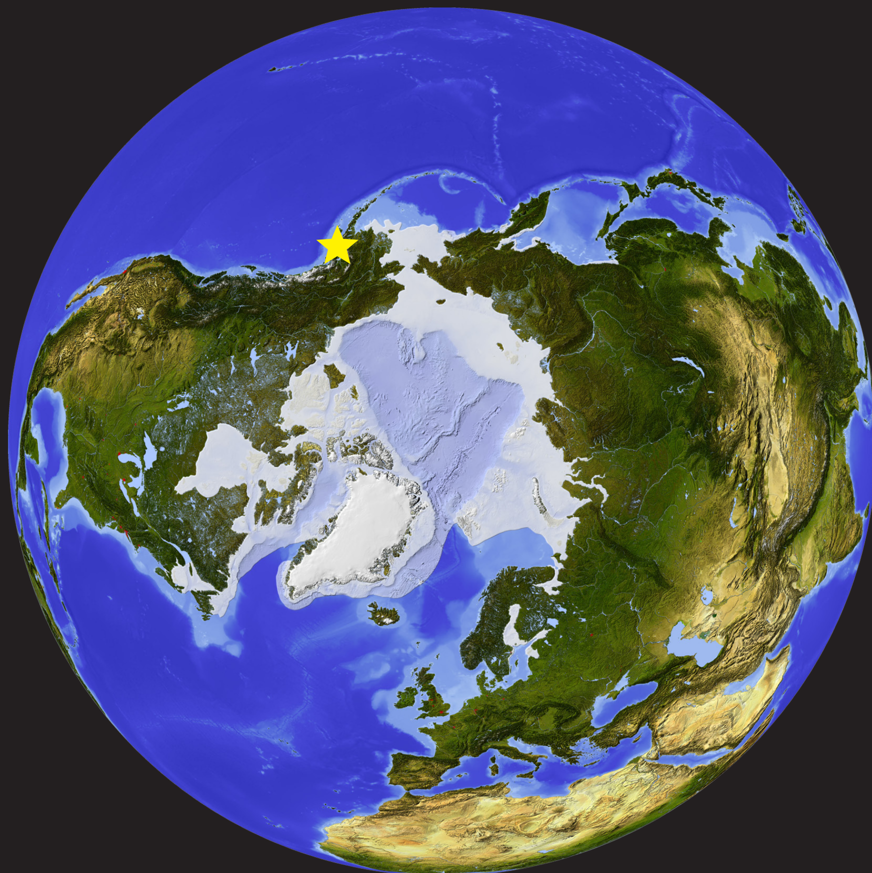
Below: Bison at the Alaska Wildlife Conservation Center, near the conference hotel.

—PHOTO BY NANCY TARNAI



8th Circumpolar Agricultural Conference
UArctic Inaugural Food Summit

Sustainable Agriculture and Food Security in the Circumpolar North

September 29–October 3, 2013 • Girdwood, Alaska, USA

CIRCUMPOLAR AGRICULTURAL ASSOCIATION

UArctic

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Above: globe illustration by Michael Smelling, Dreamstime.com.
Left: David Poppe of Nenana Urban Farms with Dexter cow and calf, Nenana, Alaska, photo by Nancy Tarnai. Middle: 4th-grade children in local greenhouse in Kuujjuaq, Nunavik (northern Quebec), Canada, photo by Ellen Avard. Right: Pink delphiniums off the Glenn Highway in Alaska, photo by Heidi Rader.

land use planning & community partnerships • arctic geopolitics • food security • food policy • small business development • food production
First Nations food resources • food safety & human health • horticulture in the High Arctic

Introduction

The Circumpolar North has not reached its full agricultural potential. Hunting and gathering, historically, has been the primary method of supplying food for a large segment of the population residing in smaller migratory communities. Change was inevitable with wars and resource extraction such as the fur trade, whaling, mining, lumbering, and drilling. Populations increased and permanent settlements became the norm. Settlers brought agriculture with them and began to cultivate the land and raise domestic livestock. Because roads, ships, and planes used to transport raw materials to areas outside the circumpolar north could also be used to bring food, feed, and supplies from more temperate southern climes to the people of the North, agriculture saw minimal growth. Though supply lines into the North are fragile and can be broken by natural disasters or world conflict, economic policy has not always supported expansion of the agricultural industry, and diverse cultures have not always favored a unified approach to food production. A changing climate may open sea lanes in the Arctic Ocean, or alter native vegetation and soil temperatures, thus affecting hunting and gathering patterns, and affecting the potential for new crops in different regions of the circumpolar world. We need to know what can be done in the face of continuing change to unlock the full potential of northern agriculture.

The Circumpolar Agricultural Association and the University of the Arctic Northern Food Security Thematic Network sponsored a conference and workshop, "Advancing Food Security and Sustainable Agriculture in the Circumpolar North," in Girdwood, Alaska, from September 29 through October 3, 2013. Attendees explored the potential for expanding the circumpolar region's food economy and security, solutions to potential and future barriers, and strategies that will lead toward a sustainable food supply. Approximately 140 delegates from across the Circumpolar North and Japan attended the conference and workshop. Researchers, educators, producers, administrators, and policy makers were invited to speak and present posters, including nine invited speakers sponsored by the Organisation for Economic Co-operation and Development's Co-operative Research Programme. We thank them for their generosity. Thanks are due to all sponsors of our conference and workshop. They are listed on our inside front cover.

Topics at the workshop and conference were grouped in four areas: Global Food Policy and Food Safety Issues, Food Production and Economic Development, Food Production and Sustainable Practices, and Global Perspectives in Advancing Food Security in the Circumpolar World. Each paper and abstract in these proceedings may be found grouped under broad subject headings that pertain to these areas (see Contents). Presenters addressed the problem that an estimated 80 to 95% of food consumed by northern residents comes through long supply lines that can be disrupted. The effect of a changing climate was noted; there is a potential for an extended growing season and expanded types of crops that can be grown, but while water is currently abundant and pests are limited, this could change with changing temperatures and precipitation. Sustainable agricultural production was stressed as the population grows, food needs will increase as well as demand for local products. There was emphasis on the need to be sensitive to the diverse cultural foodways of northern peoples and the importance of expanding research to take account of this diversity. Speakers and poster presenters pointed out that poverty is an underlying issue in the North where food costs are high and income levels are low. Holistic cost accounting must consider the costs of health care and energy. A multidisciplinary approach is a must for future food and feed alternatives. The conferees recognized that food security is a driver of community development, and coined the phrase 'One North' to stress a need for all nations to work together to end the fragility of food supplies in the north.

We hope this proceeding makes readers more aware of the needs and potentials of the Circumpolar North and its people. 'One North' is a concept extremely important to northern peoples. It is also an important concept in helping to feed a growing world population from a land rich in resources and agricultural production potential far greater than are realized at present.

— Steven Seefeldt and Carol Lewis

Program

Alyeska Resort Hotel

Girdwood, Alaska

September 29 – October 3, 2013

Sunday September 29

Settle into your accommodations and explore the Resort and spectacular surroundings.

6:00 – 8:00 pm • REGISTRATION

(Alyeska Resort Hotel Lobby)

Monday September 30

8:00 am – 5:00 pm • REGISTRATION AND INFORMATION DESK OPEN (Foyer)

7:00 – 8:30 am • BREAKFAST (Columbia and Foyer)

Conference Moderator: Carol E. Lewis, University of Alaska Fairbanks

8:30 – 9:50 • WELCOME (Columbia)

8:30 – 9:10 • Chancellor Brian Rogers, University of Alaska Fairbanks, Chair of the UArctic Board of Governors

9:10 – 9:50 • John Sadler, Organization for Economic Co-operation and Development (OECD), Theme Coordinator, The Natural Resources Challenge, Biological Resource Management for Sustainable Agricultural Systems, Cooperative Research Program

9:50 – 10:20 • BREAK (Columbia Foyer)

GLOBAL FOOD POLICY & FOOD SAFETY ISSUES

David Bubenheim, NASA/Ames Research Center, Moffit Field, CA - Session Moderator

Invited Keynote Talks (Columbia)

10:20 – 10:50 • "Redefined Northern Security - a challenge to Arctic Geopolitics?" Lassi Heininen, Univ. Arctic Thematic Network Lead, Geopolitics, Finland

10:50 – 11:20 • "Cross-Border Dimensions of Vuntut Gwich'in Food Security" David Natcher, Director, Indigenous Land Management Institute, University of Saskatchewan, Canada

11:20 – 11:50 • "Indigenous Community Food Security in the Yukon Territory" Norma Kassi, Director Indigenous Collaboration Arctic Institute of Community Based Research, Yukon, Canada

11:50 – 12:20 pm • "Food safety in the arctic and human health: Contaminant exposure by dietary intake" Arja Rautio, Univ. Arctic Thematic Network Lead, Arctic Health, Finland

12:20 – 12:40 • PANEL DISCUSSION: Global Food Policy and Food Safety Issues

Panel members: Lassi Heininen, David Natcher, Norma Kassi, Arja Rautio

Panel Moderator: David Bubenheim

12:40 – 2:00 • LUNCH (Kahiltna Court)

"Alaska Flour Company: Farm to Fork" Bryce Wrigley, Owner, Alaska Flour Company, Delta, Alaska

FOOD PRODUCTION & ECONOMIC DEVELOPMENT

Karen Tanino, University of the Arctic and University of Saskatchewan - Session Moderator

Invited Keynote Talks (Columbia)

2:00 – 2:30 • "Developing Sustainable Small Businesses in the North: The Case of Northern Food Producers and Distributors" Svein Johansen, Univ. Arctic Thematic Network Lead, Managing Small and Medium Sized Enterprises in the North, Norway

2:30 – 3:00 • "The Bioeconomy of the Arctic" Torfi Jóhannesson, V.P. Circumpolar Agricultural Association, Iceland representative

3:00 – 3:30 • "The Land Grant University System in the U.S.: Its role in agricultural development in the Arctic and Subarctic" Carol E. Lewis, University of Alaska Fairbanks

3:30 – 4:00 • BREAK (Columbia Foyer)

Invited Abstracts (Columbia)

4:00 – 4:20 "Yukon Agricultural Association – Initiatives and Projects" Sylvia Gibson and Kirsten Scott, Yukon Agricultural Association Yellowknife Commons Co-operative Ltd.

4:20 – 4:40 • "Stimulating Yellowknife's local food economy and Success stories of local agri-food skills activities in the Northwest Territories Canada" Amy Lizotte and Lone Sorensen,Yellowknife Commons Cooperative, Yellowknife Garden Collective, Ecology North and Territorial Farmers Association

4:40 – 5:00 • PANEL DISCUSSION: Food Production And Economic Development Panel members: *Svein Johansen, Torfi Jóhannesson, Carol Lewis, Sylvia Gibson, Lone Sorensen*

Panel Moderator: *Karen Tanino*

5:00 – 6:30 • POSTER PRESENTATIONS (Columbia and Foyer)

6:30 – 8:30 • RECEPTION (Kahiltna Court)

Dress is business casual

Tuesday October 1

7:00 – 8:30 am • BREAKFAST (Columbia and Foyer)

8:00 am – 5:00 pm • REGISTRATION AND INFORMATION DESK (Columbia Foyer)

FOOD PRODUCTION & SUSTAINABLE PRACTICES

Session I - Horticulture

Julie Riley, Cooperative Extension Service, University of Alaska Fairbanks, Moderator

Invited Keynote Talks (Columbia)

8:30 – 9:00 • "Experimental horticultural projects in the Canadian Mid- and High Arctic in the early 1980s: Lessons Learned" Josef Svoboda, Professor Emeritus, University of Toronto

9:00 – 9:30 • "Costs and Benefits of a Northern Greenhouse" Tom Allen, Professor, Dept. Bioresources Policy, Business and Economics, University of Saskatchewan

Invited Abstracts (Columbia)

9:30 – 9:50 • "Alternative soil nutrient sources: meeting the needs of rural Alaskan growers" Lydia Clayton, Janice Chumley, Pam Compton, Meg Mueller University of Alaska Fairbanks-Cooperative Extension Service; USDA- Natural Resource Conservation Service

9:50 – 10:10 • "Agricultural Production of Biomass as Energy Crops in Alaska: Is It Feasible?" Stephen D. Sparrow, Darleen Masiak, Amanda Byrd, Agricultural and Forestry Experiment Station and Alaska Center for Energy and Power, University of Alaska Fairbanks

10:10 – 10:40 • BREAK (Columbia Foyer) Invited Keynote Talk (Columbia)

10:40 – 11:10 • "Ten Years of Creating Partnerships towards Community Food Security and Northern Rural Development in Manitoba" Kreesta Doucette, Founding Director, Food Matters Manitoba

Invited Abstracts (Columbia)

11:10 – 11:30 • "The Kuujjuaq Greenhouse Project: Sustainable Community Development through Food Production" Ellen Avard (PhD Candidate), Université Laval, Département de Géographie, Quebec

11:30 – 11:50 • "Bilberry – wild superberry from Europe" Laura Jaakola, Eivind Uleberg, Inger Martinussen, Climate laboratory, Department of Arctic and Marine Biology, University of Tromsø, Norway

11:50 – 12:10 • "Antioxidant Levels in Alaska Berry Products" Julie Cascio, Roxie Dinstel; University of Alaska Fairbanks, Cooperative Extension Service

12:10 – 12:30 • PANEL DISCUSSION: Food Production and Sustainable Practices - Session I - Horticulture

Below: Alaska Cooperative Extension Agent Steven Seefeldt, second from left, in discussion with visiting conference participants. At far left is Tórfi Johannesson, senior advisor, Rural Affairs, Ministry of Industries and Innovation, Iceland Department of Economic Development, who became the new president of the Circumpolar Agricultural Association at the event.

—photo by Nancy Tarnai

Panel members: Josef Svoboda, Tom Allen, Lydia Clayton, Amanda Byrd, Kreesta Doucette, Ellen Avard, Laura Jaakola, Julie Cascio

Panel Moderator: Julie Riley, University of Alaska Fairbanks

12:30 – 2:00 • LUNCH (Kahiltna Court)

2:30 – 5:00 • Tour - Alaska Wildlife Conservation Center

Meet in the Hotel Alyeska Lobby

Dinner On Your Own

Wednesday October 2

7:00 – 8:30 am • BREAKFAST (Columbia and Foyer)

REGISTRATION AND INFORMATION DESK OPEN

FOOD PRODUCTION & SUSTAINABLE PRACTICES

Session II - Livestock Production

Milan Shipka, University of Alaska Fairbanks, Session Moderator

Invited Keynote Talks (Columbia)

8:30 – 9:00 • "Sustainable Livestock Production Systems in Alaska: production practices and marketing" Milan Shipka and Jan Rowell, University of Alaska Fairbanks

9:00 – 9:30 • "Animal Health Issues for Alaska Agriculture" John Blake, University of Alaska Fairbanks

9:30 – 10:00 • "Veterinary Medicine Professional Program at the University of Alaska Fairbanks" Todd O'Hara, Institute of Arctic Biology, University of Alaska Fairbanks

10:00 – 10:30 • BREAK (Columbia Foyer)

Invited Abstracts (Columbia)

10:30 – 10:50 • "Losses of sheep on summer range in Norway" Inger Hansen and Rolf Rødven, Bioforsk Nord, Norway

10:50 – 11:10 • "Small Scale Poultry Production Education in Alaska" Stephen C. Brown. University of Alaska Fairbanks Cooperative Extension Service

11:10 – 11:30 • "Building Educational Programs to Promote Food Security for Indigenous Populations in the Americas" Diane Holland Rickerl, South Dakota State University

11:30 – 11:50 • PANEL DISCUSSION: Food Production and Sustainable Practices – Session II Livestock Production.

Panel members: Jan Rowell, John Blake, Todd O'Hara, Inger Hansen, Stephen C. Brown, Diane Holland Rickerl

Panel Moderator: Milan Shipka

11:50 – 1:00 pm • LUNCH (Kahiltna Court)

1:00 – 2:30 • POSTER PRESENTATIONS (Columbia and Foyer)

2:30 – 3:00 • BREAK (Columbia Foyer)

3:00 – 4:30 • BREAKOUT SESSION: All attendees

Session Moderator: Karen Tanino, University of Saskatchewan and University of the Arctic

4:30 – 6:00 • Meeting of interested persons to elect CAA president and to discuss combination of goals/interests of the Circumpolar Agricultural Association and the University of the Arctic Northern Food Security Thematic Network.

6:30 • BANQUET (Kahlitna Court)

Dress is business casual

Thursday October 3

7:00 – 8:30 am • BREAKFAST

8:30 – 10:30 • GLOBAL PERSPECTIVES IN ADVANCING FOOD SECURITY IN THE CIRCUMPOLAR WORLD—Conference Summary and Discussion

Opening Remarks: Matsuo Uemura, Dean, the United Graduate School of Agricultural Sciences, Iwate University, Morioka, Japan

Berndt Skarstad, Leader, Northern Norwegian Council of Agriculture

Øystein Ballari, CAA representative from Norway

PANEL DISCUSSION: Representatives from Norway, Finland, United States, Canada, and Japan.

10:30 – 11:00 • BREAK (Columbia Foyer)

11:00 – 11:30 • GO FORWARD PLAN

Results of Wednesday "Break Out Session"

Publication of proceedings detailing the Conference and Summit

University of the Arctic and Circumpolar Agriculture Association meeting outcomes

11:30 am • FINAL WORDS AND CLOSING (conference co-chairs)

Friday October 4

Optional tour of Matanuska Valley farms and lunch at the UAF Matanuska Experiment Farm

Below: Conference attendees photographing a black bear at the Alaska Wildlife Conservation Center, near the conference hotel.

—photo by Nancy Tarnai

This publication is for all those
dedicated and hardworking individuals in northern communities
who are creating greater food security for all of us.

In these proceedings, we use the definition of "food security" as described by Ken Meter and Megan Phillips Goldenberg in *Building Food Security in Alaska*, a report published July 28, 2014 and commissioned by the Alaska Department of Health and Social Services in collaboration with the Alaska Food Policy Council. While the definition speaks of Alaskans and Alaska Natives, it applies broadly to circumpolar peoples, and was echoed in the comments throughout the conference and summit. Polar peoples understand that food is more than just food, and embodies culture, tradition, and togetherness, as well as biological need.

> Food security is commonly used by Alaskans to signify the security of the food supply from potential disruption due to weather incidents, flooding, war, breakdown of supply lines, etc.
>
> Often the definition of "food security" in the Lower 48 is more focused on ensuring that low-income residents have a secure food supply. Increasingly this term has come to mean that low-income communities produce food for themselves.
>
> In this report "food security" is used in the Alaska sense, captured best by University of Alaska researchers below.
>
> "In the context that we use it here, food security describes more than merely whether sufficient food is being produced, or a one-size-fits-all food-nutrition relationship, and incorporates all of the various ways in which a food system supports health in its various biophysical, social, and ecological dimensions (Loring & Gerlach, 2009). These include matters such as the importance of certain foods, food choice, local perceptions of hunger, uncertainty and worry about food safety or shortages, and any other psychosocial, sociocultural, or environmental stresses that result from the process of putting food on the table (S. Maxwell, 2001).
>
> In rural, predominately Alaska Native communities, for example, wild fish and game are important for food security, not just because they are readily available, but also because they are important to the preservation and transmission of traditions and cultural practices, for the maintenance of social networks and interpersonal relationships, and for supporting individuals' sense of self-worth and identity (Fienup-Riordan, 2000; Loring & Gerlach, 2009; Loring, Gerlach, & Harrison, 2013).

— report available at the Alaska Food Policy Council website, https://akfoodpolicycouncil.wordpress.com, or the Crossroads website, at www.crcworks.org/akfood.pdf

Abstracts agricultural development

Potential for Using Biochar to Improve Soil Fertility and Increase Crop Productivity in the Sandy Soils of Happy Valley-Goose Bay, NL

Joinal Abedin, Diego Cerrudo, Keith Chaulk, Mano Krishnapillai, and Desmond Sellars

Memorial University, Newfoundland and Labrador, Canada

e-mail: jabedin@mun.ca

The majority of foods that are sold in northern and remote communities like Happy Valley-Goose Bay, Labrador, Canada, are transported from distant places. Due to handling and long distance transport, food quality deteriorates and prices increase. The long-term sustainable solution for local food security in northern regions such as this is to find ways to produce more local food. The factors that hinder successful crop production in this region include: late spring and early fall frost; lack of availability of short-duration crop varieties; high soil acidity; low soil organic matter; and sandy soil texture. Because of coarse soil texture, soils have low cation exchange capacity (CEC), low nutrient and water holding capacity, and poor soil structure. Among these, late spring and early fall frost can be avoided by choosing a short-duration food crop. However, it is not possible to avoid cold temperatures because weather patterns are not predictable. Although we cannot change soil texture, there are management practices that can be used to enhance retention of nutrients and water, increase soil organic matter, increase CEC, improve soil structure and reduce soil acidity. Biochar (a carbonaceous material that can be produced from any organic feed stock through pyrolysis) is a unique material that, when applied as a soil amendment, can effectively improve physical, chemical, and biological properties of soil, thereby solving many of the soil limitations stated above. This study will examine the effect of biochar on soil pH, water/nutrient retention, soil structure, plant growth, and crop yield. This study will also evaluate the nutritional value of biochar by comparing inorganic fertilizers and fishmeal, which are commonly used by local farmers. Finally, this study will determine how much supplemental fishmeal and/or inorganic fertilizers the biochar requires to maximize soil quality and crop productivity.

Effect of Potato Seed Spacing on Tuber Size

Matt Ball

Department of Energy, Mines and Resources, Yukon, Canada

e-mail: matthew.ball@gov.yk.ca

The objective of this trial was to determine if increasing the in-row distance between seed potatoes increased the average and maximum size of potatoes produced. Guidelines for commercial potato production recommend 31 cm (12 inches) in-row spacing. The trial was conducted at two locations near Whitehorse, Yukon. At the Yukon Grain Farm, potatoes were harvested mid-August in accordance with normal commercial production timing. Potatoes at the Yukon Government Research Farm were left in the ground for as long as possible to provide ample opportunity to maximize potato size and yield. The trend of larger potatoes due to wider spacing was observed at both sites. Yet, at the research farm, yields were compromised with wider spacing. The Yukon Gold yield was nearly 39 t/ha with 31 cm spacing, whereas the wider 62 cm spacing yielded 25 t/ha. At the Yukon Grain Farm, yield was not affected by in-row spacing. There was only a 2.2 t/ha difference between 31 and 62 cm spacing due to the increased number and size of tubers produced by wider spaced plants. The correlation between in-row spacing and tuber size is very clear where in-row spacing had a significant effect on tuber size over an 80-day commercial production cycle. Based on the single year of work, the indications are that over a commercial season increasing the in-row spacing of potatoes has the potential to increase tuber size without compromising yield. For a later harvest, the differences between spacing

did not result in a larger gap between potato sizes. This poster will include details of potato production equipment required for northern farms.

Comparing Adaptive Capacity in Hybrid and Heritage Barley *(Hordeum vulgare)* Cultivars Under Varying Levels of Water Stress

Serena Black[1] and Scott Green[2]

[1]Natural Resources and Environmental Studies (NRES) Graduate Studies Program
[2]Ecosystem Science and Management Program, NRES Institute, University of Northern British Columbia, British Columbia, Canada

e-mail: blacks@unbc.ca

There is growing potential for strengthening and expanding the capacity, competitiveness, and profitability of the grain sector in the Omineca Region of British Columbia, Canada, through applied research that is connected to producer needs. Still, agriculture production systems must also incorporate strategies and practices to address current and future risk associated with climatic variation and increasing costs of inputs. Identifying cultivars with greater adaptive capacity to environmental stress (e.g. water availability, temperature, nutrients, etc.) will be critical in developing resilient practices. Modern hybrids are bred to exhibit specific traits, which may limit their ability to adapt to adverse environmental conditions or low-input systems. Preliminary consultations with producers in the region helped identify the crop and stress to be studied. A greenhouse study was conducted to explore the adaptive capacity and production potential of 10 barley *(Hordeum vulgare)* cultivars, including six modern hybrids (AC Lacombe, CDC Cowboy, CDC Bold, CDC Dolly, Xena, and McBride) and four heritage cultivars (Bere, Black Hulless, Himalayan, and *Hordeum zeocrithon*), to varying levels of water stress. Plants were measured for responses in maturation traits (days to heading, days to maturity), physical traits (plant height, tiller capacity, total aboveground biomass), biomass allocation traits (root:shoot ratio), and yield traits (thousand kernel weight, harvest index). Preliminary results suggest varietal and treatment responses, with certain traits showing notable differences between hybrid and heritage cultivars. Study results will be used as a baseline to determine cultivars for future field trials in the region to help inform regional producers which cultivar(s) may be best suited to their operation.

Livestock Production in the North: The Producer-Veterinarian Relationship

John Blake

Director, Animal Resources Center, University of Alaska Fairbanks, Alaska USA

e-mail: jeblake@alaska.edu

Most farmers or ranchers make hundreds of decisions daily. Big or small, directly related or not, many of these decisions impact the health and wellbeing of their animals. In farming, making informed decisions and understanding all the possible outcomes is vitally important. A component of the overall production management program is a well-functioning preventive medicine program. This requires a good working relationship between a progressive, adaptive producer and an enthusiastic, competent veterinarian. Operating a family farm is a complicated business that must address personal values, financial reality, land use, soil, plants and water, as well as the health and welfare of your livestock. Production management is all related and the farm decisions need to be addressed in their entirety. The veterinarian will focus on the health of livestock but, since any aspect of farm management can impact animals, nothing is immune to assessment, evaluation or change. Key to the success of production systems, small or large, is a monitoring system that is tailored to the needs of the farm, is easy to maintain and provides reliable data that can be used to make sound decisions. The best measures will inform the most important decisions. This paper will review some of the basic principles important to understanding health and disease processes, evaluate simple monitoring programs, and discuss how to use the monitoring program to plan, re-plan and, if necessary, change farm management.

Primary Copper and Cobalt Deficiency in Farmed Muskoxen

John Blake[1] and Jan Rowell[2]

[1]Animal Resources Center
[2]School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks, Alaska USA

e-mail: jeblake@alaska.edu

Hay and forage crops grown in southcentral and interior Alaska contain low levels of copper and cobalt. Livestock maintained solely on these forages are at risk for deficiencies of these trace minerals. Recommended dietary trace mineral levels are available through National Research Council guidelines for most domestic species. However, no such recommendations exist for muskoxen. Muskoxen have been farmed in Alaska since 1960. Because of their many similarities to sheep, it was initially thought that muskoxen may be equally susceptible to copper toxicity. This is not the case. Copper deficiency in muskoxen was identified more than 25 years ago in the University of Saskatchewan muskox herd and 15 years ago at the University of Alaska Fairbanks (UAF). After several experimental trials and direct feeding experience, it is very clear that muskoxen have high copper requirements. This presentation documents clinical and pathological findings collected the past 25 years in a captive muskox herd at UAF. From 1989 to the present, necropsies and diagnostics were conducted on all muskoxen from the UAF herd that died or were euthanized. These records, combined with herd health records going back to the establishment of the captive herd in 1980, describe a population of animals marginally deficient in trace minerals, which culminated in 2010 with complete reproductive failure and a mortality event. The clinical findings are presented along with new recommendations for feeding farmed muskoxen.

Recovery of Water from Sewage for Use in Agriculture

David Bubenheim[1], Michael Flynn[1], Greg Schlick[2], David Wilson[2], Carol Lewis[2], Meriam Karlsson[2], and Raymond Carruthers[3]

[1]NASA Ames Research Center, California USA
[2]School of Natural Resources and Extension, University of Alaska Fairbanks, Alaska USA
[3]Agricultural Research Service, United States Department of Agriculture, California USA

e-mail: David.L.Bubenheim@NASA.gov

This project involves the transfer of technology from the National Aeronautics and Space Administration's (NASA) program developed for recycle of human wastewater to food production for use in circumpolar agriculture. The University of Alaska Fairbanks School of Natural Resources and Extension, NASA Ames Research Center, and USDA Agricultural Research Service have joined forces to develop high-efficiency, low-energy consuming techniques for water treatment and food production in rural circumpolar communities. Phase one successfully demonstrated the potential for utilization of Forward Osmosis (FO) technology for recovery of water from sewage and the acceptability of that recovered water for agricultural utilization (irrigation, fertigation, hydroponic production, etc.). Forward Osmosis treats wastewater using a hydrophobic membrane similar to reverse osmosis (RO), but unlike RO, which uses a hydraulic pressure difference, FO uses an osmotic pressure difference as the driving force for water diffusion across the membrane. In this system, we use a concentrated fertilizer solution on the opposite side of the membrane from the sewage to provide the osmotic driving force for water movement. Advantages of the FO process include low fouling potential, low energy consumption, simplicity, and reliability. The system extracted up to 70% of the water from sewage and rejected up to 92% of ions in the sewage with no carryover of toxic effects with the recovered water. Biological testing results showed that plant growth using recovered water in the nutrient solution was equivalent to that using high-purity water.

Impacts of Cover Cropping and Tillage on Weed Density and Weed Seedbanks in the Subarctic Environment

Erin Carr[1], Mingchu Zhang[1], and Steven Seefeldt[2]

[1]School of Natural Resources and Agricultural Sciences,
[2]Cooperative Extension Service,
University of Alaska Fairbanks, Alaska USA

e-mail: elcarr@alaska.edu

One of the biggest challenges for organic crop and vegetable producers is weed control. Traditional practices, such as cover cropping and tilling, aid in controlling weeds on fallow land. For producers in interior Alaska with a limited growing season, these practices would remove valuable farmland from production for at least a year. The objective of this study was to determine cover cropping and tilling intervals that would reduce weed seedbank size without taking land out of production for multiple growing seasons. A two-year (2008 and 2009) study at two interior Alaska farms (the UAF Agricultural and Forestry Experiment Station [AFES]'s Fairbanks Experiment Farm and Rosie Creek Farm) measured weed density and weed seedbank size among seven treatments: continuous tillage (TILL), continuous cover crop (CC), tillage plus middle season cover crop (TC), and cover crop plus middle season tillage (CT). Two species, Albright barley (*Hordeum vulgare* L.) and Austrian winter field peas (*Pisum sativum* subsp.

arvense), were planted for each cover crop treatment. Field weed estimates were measured prior to treatment applications (tillage or planting) followed by soil core samples post treatment for weed seedbank analysis. In 2008 at UAF AFES, weed density among treatments were different mid-season ($p = 0.0012$) and the subsequent growing season ($p < 0.0001$), TILL and TC treatments yielded decreased weed populations. Weed seedbank size was different among treatments the subsequent growing season ($p = 0.0033$). In 2008 at Rosie Creek, differences of weed density were measured among treatments ($p = 0.0273$). In 2009, both study sites were similar among treatments at any sample period. Continuous tillage and tilling through the first half of the growing season has a greater impact on reducing the weed population. Cover cropping hinders the growth of weeds during the current growing season, but does not reduce the weed seedbank for future cropping years.

Antioxidant Levels in Alaska Berry Products

Julie Cascio[1] and Roxie Rodgers Dinstel[2]

[1]Associate Professor and [2]Professor of Health, Home and Family Development, Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA

e-mail: jmcascio@alaska.edu

In the last few years, antioxidants have been identified as having beneficial impacts on human health. Antioxidants are important in terms of their ability to protect against oxidative cell damage that can lead to conditions like Alzheimer's disease, cancer, heart disease, and conditions linked with chronic inflammation. The antioxidant and anti-inflammatory effects of wild berries in Alaska may have the potential to help manage these diseases. Research was conducted to determine the antioxidant level of berries that grow wild in Alaska. Alaska wild berries have extraordinarily high antioxidant levels. This research was centered on products made from the berries. The first year a variety of wild berries were tested to determine the Oxygen Radical Absorption Capacity (ORAC) in the raw berries. ORAC measures the amount of antioxidants present in the berries. The wild berries ranged from three to five times higher than cultivated varieties. For instance, cultivated blueberries have an ORAC scale of 30; Alaska wild blueberries measure 93. All of Alaska's berries have a level of antioxidants considered nutritionally valuable, ranging from 29 for watermelon berries to 206 for lingonberries. The focus of this aspect of the research project was to determine how much of the antioxidants remained after processing into berry products typically eaten. A series of 11 products were made from blueberries, lingonberries, salmonberries, highbush cranberries, currants, and crowberries. These products were tested for both ORAC as well as specific antioxidants. One of the unexpected outcomes of the research was that the berries continued to have high levels of antioxidants despite the effects of commonly used heat processing techniques. The high antioxidant levels of Alaska wild berries can provide an opportunity to develop new businesses based on production of value-added products.

Alternative Soil Nutrient Sources: Meeting the Needs of Rural Alaska Growers

Lydia Clayton[1], Janice Chumley[1], Pam Compton[1], and Meg Mueller[2]

[1]Associate Professor and Integrated Pest Management Technicians, University of Alaska Fairbanks, Alaska USA
[2]U.S. Department of Agriculture Natural Resources Conservation Service

e-mail: lclayton2@alaska.edu

Historically, Alaska has not been well known as an "agricultural state," however, the US Department of Agriculture Natural Resources Conservation Service (USDA NRCS) EQIP cost-share program for high tunnel structures has increased the number of produce growers, at least within the state of Alaska. Since the initiation of the high tunnel EQUIP program in 2010, USDA NRCS has cost-shared more than 510 high tunnels with Alaskans both on the road system and in remote areas, with the majority of them growing diversified vegetable crops. While there are a number of ways to receive a cost-share through the program, nutrient management cost-share high tunnel managers are charged with submitting soil samples for analysis and then amending with nutrients according to professional recommendations. In the Kenai Peninsula region, the University of Alaska Fairbanks Cooperative Extension Service (UAF CES) is working in collaboration with USDA NRCS to provide growers with effective and economical nutrient management options. Obtaining nutrient sources commonly available in other parts of the country is both difficult and expensive in all of Alaska. For growers in remote village and island communities, particularly those located off the road system, it has proven to be ever more so. Fortunately for these growers, research that quantifies the nutrient content and availability from many local, natural sources is often readily available. Currently, UAF CES is working with growers using crab shell meal, fresh kelp and dried kelp meal, and clam viscera, as well as meals made from a number of local fish species. These locally available nutrient sources are helping Alaska growers to meet their soil nutrient needs economically.

Effects of Changing Permafrost Conditions on Agriculture and Agricultural Capability Classification in Yukon

Kam Davies

Agriculture Branch, Energy Mines and Resources, Yukon Government, Yukon, Canada

e-mail: kam.davies@gov.yk.ca

The effects of changing permafrost impact agricultural development, infrastructure, and production. Past and present Yukon farmers have adapted conventional agricultural methods to accommodate for permafrost conditions. This project aims to: identify challenges to agriculture caused by changing permafrost conditions; document permafrost-specific adaptations; and summarize best management practices. This project will also examine key permafrost indicators for the Land Suitability for Agriculture Rating System and consider how changing permafrost conditions affect existing agricultural capability ratings. Researchers will use GIS analysis to identify areas of past and current agricultural development prone to changing permafrost conditions. GIS modeling will be used to predict regions most affected by changes and will examine future scenarios involving effects of changing permafrost conditions and agricultural capability. Researchers will interview farmers to gather information, timelines, and best management practices within the Yukon agricultural community. This four-year project will focus on four distinct agricultural regions: Whitehorse/Southern Lakes, Haines Junction, Dawson, and Central Yukon. Year 1 is the Whitehorse/Southern Lakes region. Agriculture in this area is most affected by changes in near-surface permafrost and thermokarst. Challenges related to changing permafrost conditions include: excessive wetness, ground/infrastructure subsidence, changing moisture regimes, intensifying hummocky topography, fence creep, salinity, etc. Site-specific mitigations involve careful development and management of agricultural land. Examples include: clearing land while it is frozen; allowing four to seven years for site development; modifying machinery for hummocks; flattening terrain; ensuring necessary drainage; converting cropland to pasture; etc. Visual indicators for key permafrost criteria were identified to use in conjunction with the Land Suitability for Agriculture Rating System. Knowledge gathered from this project will assist current and future Yukon farmers as they adapt their agricultural operations to changing permafrost conditions.

Electronic Ear Tags on Reindeer: New Possibilities in Reindeer Herding

Svein Morten Eilertsen, Rolf Rødven, and Lise Aanesen

Norwegian Institute for Agricultural and Environmental Research

e-mail: svein.eilertsen@bioforsk.no

Use of electronic ear tags on reindeer with modern technology (electronic scales and sorting systems) will contribute to optimization of the production on limited winter pastures through tracing reindeer meat from mountain pastures to the table. This system will improve animal welfare, resulting in better meat quality and increased value creation and expertise in reindeer herding. In a research project in Finnmark County, Norway, 5,000 semi-domesticated reindeer *(Rangifer tarandus tarandus)* are already individually marked with electronic ear tags. An electronic scale that communicates with a smart gate is under development for reindeer. Pilot field experiments during sorting of animals, weighing, and ear tagging using this system compared to traditional handling of reindeer will be conducted during August 2013. Animal welfare, meat quality, and reindeer herder's welfare will be measured. Pregnant young female (1.5–2.5 years old) reindeer that are not followed by calves in winter are bigger and in better condition the next calving season compared to young females followed by calves. By slaughtering their calves in autumn, the young female reindeer are expected to be healthier and produce bigger calves the following spring. Through individual ear tags, the reindeer herders get information about the age and the lactation status of the females and can slaughter unproductive animals. Through systematic slaughtering of small calves, calves from young female reindeer and unproductive females in autumn, meat production and the number of animals will be optimized to achieve a sustainable utilization of limited winter pastures in pace with changing climatic conditions. Electronic ear tags follow the reindeer throughout the slaughter process, which increases accuracy in settlement, and traces the product all the way to the consumer. It will be a useful tool in other situations like purchasing, transportation, and handling.

Agronomy: Basic for Food Production in Arctic Areas

Odd Arild Finnes

Norwegian Institute for Agricultural and Environmental Research, Norway

e-mail: odd-arild.finnes@bioforsk.no

Over the last few years, a general flattening and partial reduction in crop yield has been observed in Norway. At the same time, the Norwegian government aimed to increase general food production to meet the need for food from an increasing population. Therefore, there is a national challenge to maintain and increase crop yield. The northern part of Norway is more exposed to harsh climates and agriculture is close to its northern limit. Therefore, agriculture is more demanding and vulnerable, especially when climatic conditions are changing. The main governmental changes observed were structural and they led to agricultural management where biologic and agronomic conditions are less emphasized. Our recent unstable winter climate has resulted in massive yield declines in some regions. The North Norwegian Council of Agriculture, together with Bioforsk, has initiated a project to strengthen focus on agronomy and develop better knowledge and solutions for future agriculture and food production in the North. Improved agronomy is fundamental for the future of the agriculture industry and food security, and the project objective is to reverse the negative trend. We assume that the challenges related to agronomy that we face are the same for other regions within the circumpolar area.

Production and Nutritional Characteristics of Kentucky Nugget Bluegrass and Smooth Bromegrass and Their Effect on Reindeer Intake, Production, and Meat Quality

Greg Finstad[1], George Aguiar[1], Eva Wiklund[1], and Peter Bechtel[2]

[1]Reindeer Research Program, School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks, Alaska USA
[2]Food Processing and Sensory Quality Research, Agricultural Research Service, United States Department of Agriculture, Louisiana USA

e-mail: glfinstad@alaska.edu

Domestic reindeer *(Rangifer tarandus tarandus)* produced under free range or captive settings have the potential to be the largest contributor of red meat in Alaska's food system. The supplementary use of pasture in a captive setting could reduce feed costs, but the effect on animal production and meat quality is unknown. In this study, we compared the production and nutritional profile of two pasture grasses—smooth bromegrass *(Bromus inermis)* (SBG) and Kentucky Nugget bluegrass *(Poa pratensis)* (NBG). We evaluated the dry matter intake (DMI), off-take, weight gain, carcass yield, and nutritional characteristics of meat from reindeer steers fed in a pasture or a concentrate feeding regime. We also evaluated DMI, weight gain, and milk composition of cow-calf pairs under the three feeding regimes. Mean annual production for NBG (391.2 g/m2 ± 38.2) was less ($p = 0.001$) than SBG (562.7 g/m2 ± 49.1). Fiber and nutrient concentrations of grasses varied between species and during the growing season. DMI was different ($p < .0001$) across feeding regimes while there was no difference in mean weight gain ($p = 0.3$), carcass yield ($p = 0.5$) or CP ($p = 0.6$) and lipid content ($p = 0.9$) of meat of reindeer steers. Females and calves reduced intake of concentrate by 20% on SBG pasture and 16 percent on NBG pasture. Cow-calf groups gained more weight (35.0 kg) on NBG pasture than pairs on SBG pasture (33.0 kg) or the concentrate diet (32.5 kg). Females on NBG pasture progressively produced milk with higher ($p < 0.05$) crude protein (10.7 percent), but lower ($p < 0.05$) lipid concentrations (15.0%) than either animals on SBG pasture (9.4%); (19.3%) or a concentrate diet (9.6%); (18.5%). Reindeer producers now can evaluate the cost/benefit of developing pastures to supplement the feeding of reindeer in an intensively managed operation.

Lessons Learned from Reduced Tillage Systems in Alaska

Catherine Hadley

Natural Resources Conservation Service, United States Department of Agriculture, Alaska USA

e-mail: catherine.hadley@ak.usda.gov

The benefits and mechanics of reduced tillage systems are well known. However, reduced tillage systems are a rather new phenomenon for interior Alaska. The Natural Resources Conservation Service has worked closely with small grain producers for the past 10 years. Cold soils and shortened growing seasons sometimes have unexpected effects on agronomic systems when converting to reduced tillage systems. Lessons learned over the years include information on herbicide persistence, organic matter breakdown and utilization, soil health, equipment selection and modifications, and economic viability.

Rhodiola rosea as a New Sustainable High-Latitude Crop for North America

Petra Illig[1], Stephen C. Brown[2], and Kwesi Ampong-Nyarko[3]

[1]Alaska Rhodiola Products, Alaska USA
[2]Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA
[3]Ministry of Agriculture and Rural Development, Alberta, Canada

e-mail: scbrown4@alaska.edu

Rhodiola rosea is a perennial plant that is harvested for the medicinal compounds in its root. It grows in sandy or rocky slightly acidic soil at high elevations in the arctic areas of Europe, Asia, eastern Siberia, Canada, Greenland, and Scandinavia. At maturity, it reaches a height of 12 to 30 inches. There are more than 50 *Rhodiola* species, but *Rhodiola rosea* is unique in that it produces adaptogenic compounds called rosavins. The Soviet Union researched these compounds and their physiologic effects after World War II in order to improve the physical and mental performance of its athletes and soldiers. Long considered a "Soviet military secret," *Rhodiola rosea* products are becoming quite mainstream in the herbal supplement industry. Currently, most of the world supply of high quality plants comes from wild harvest in Siberia and China. In the wild, the plant can take up to 25 years to mature, but when cultivated it only takes four to five years before it becomes commercially useful. In Alaska and Canada, Rhodiola production is being explored as a potentially high-profit new crop. Because Rhodiola is native to high latitudes and does not require or benefit from traditional agricultural inputs such as season extension and fertilization, Rhodiola will likely be a more environmentally sustainable alternative crop. In Alberta, Rhodiola growers formed a cooperative in 2008 named the Alberta Rhodiola Growers Organization. Growers in Alaska have also formed a cooperative, Alaska Rhodiola Products, which is in its early stages of development. Experiences from the two Rhodiola cooperatives have demonstrated that cultivation of *Rhodiola rosea* could contribute to rural development in circumpolar areas.

Food System Design and Implementation Planning for the Yukon

Kent Mullinix[1], Caitlin Dorward[1], and Sylvia Gibson[2]

[1]Institute for Sustainable Horticulture, Kwantlen Polytechnic University, British Columbia, Canada
[2]Yukon Agricultural Association, Yukon, Canada

e-mail: kent.mullinix@kwantlen.ca

Yukon agriculture accounts for less than 2% of territorial food expenditures. Yukon residents are acutely aware that climate change and rising food and oil prices increase food system vulnerability. Community, government, and agriculture sector leaders seek to address this, and see substantial economic and business opportunity in doing so. Kwantlen Polytechnic University and the Yukon Agricultural Association have undertaken, and are concluding the first year of, an ambitious, three-year project to fully engage Yukoners in the development of a realistic and practical Yukon Food System Design and Implementation Plan. The food system includes pre-production, production, wild and traditional foods, processing, storage, distribution, sales, and waste management. Focus will be on smaller-scale, human-intensive, low-input, direct-market agriculture, and ancillary small businesses. Food system design objectives include: generating income; creating jobs; developing small- and medium-size businesses; maximizing regional food self-reliance; reducing ecological footprint and greenhouse gas emissions; and fostering food security and public health. Resources and challenges will be clearly delineated, and the potentials of a Yukon agri-food system will be empirically based. Implementation plans will include prioritized, sequential strategies, tools and policy recommendations. Our goal is to produce a vision and roadmap for the Yukon's agri-food system future, and indicate how this can be fostered, supported, and pursued by Yukon farmers and food sector entrepreneurs, consumers, and community, government, and First Nations leaders. Methods include baseline assessments of resource, environmental, and infrastructure assets and limitations; extensive community and stakeholder engagement; iterative food system design; delineation of economic, food self-reliance, community health, and environmental stewardship potentials; and a post-design development of implementation plans. We will present detailed project methodology and progress to date, including baseline assessment results, initial community engagement processes and outcomes, and preliminary food system design directives.

New, Unique Low Light Tolerant Crops—Windowsill Farming

M.P.M. Nair

Canadian Low Light Indoor Plants & Products Research Inc., Saskatchewan, Canada

e-mail: mpmnair@msn.com

The concept of home "Windowsill Farming" is a rapidly growing industry. Homes in northern regions need to be heated. Development of low light tolerant, edible crops produced on the windowsill takes advantage of existing heat, light, and higher carbon dioxide within the home environment while providing edible greenery year round. With increasing urbanization and decreasing access to land, along with high interest in food security and healthy fresh foods, the demand for such crops is high. This demand creates an opportunity for garden centers to diversify and increase profit margins with minimal capital investment. However, specific edible/ornamental crops adapted to indoor environments are virtually nonexistent because of the lack of productive germplasm that can tolerate low light intensities and dry indoor environments. For more than 30 years, I have bred low light tolerant citrus plants that will produce 12–14 commercial size lemons in a 6-inch pot that are seedless, thin skinned, and juicy. Amaranthus crosses have also been selected for indoor production. Both types of crops will be presented as well as future areas of research.

Evapotranspiration from Subarctic Agricultural Ecosystems

Watcharee Ruairuen[1], Mingchu Zhang[1], Javier Fochesatto[2], Elena Bautista Sparrow[3] and William Schnabel[4]

[1]School of Natural Resources and Agricultural Sciences,
[2]Geophysical Institute,
[3]International Arctic Research Center,
[4]Institute of Northern Engineering,
University of Alaska Fairbanks, Alaska USA

e-mail: ruairuen@gmail.com

Understanding evapotranspiration (ET) cycles in high-latitude agricultural ecosystems is essential in terms of water management and sustainability and projection of agricultural activity. At high latitudes the period for agriculture production is very short and strongly depends on the availability of soil water for vegetables to grow. Thus, the ET cycle is the key variable modulating moisture gradients and soil dryness. To investigate the ET cycle in farming soils, a field experiment was conducted in the summer of 2012 at the University of Alaska Fairbanks Agricultural and Forestry Experiment Station combining micrometeorological and hydrological measurements in the experimental plots where lettuce (*Lactuca sativa*) plants were grown. The experiment evaluated several components of the ET cycle such as actual evapotranspiration, aerodynamic evaporation, and potential evaporation, as well as soil moisture and temperature profiles to link them to the vegetable growing functions. In this presentation, we report water loss across the growing season as a function of the ET cycle and we illustrate the dependence on the ET cycle on the Atmospheric Boundary Layer flow patterns set by the synoptic large-scale weather patterns.

Fate of Herbicides in Alaska Soils

Steven S. Seefeldt[1], Dave Barnes[2], and Patrick Tomco[3]

[1]Cooperative Extension Service and [2]College of Engineering and Mines, University of Alaska Fairbanks, Alaska USA
[3]Chemistry Department, University of Alaska Anchorage, Alaska USA

e-mail: ssseefeldt@alaska.edu

Microbial degradation of pesticides is known to slow as temperatures decline. A reduction in herbicide degradation can result in crop injury in the year following application if a susceptible crop is planted. Because of the extremes of cold temperature in Alaska, it is important to measure rates of herbicide degradation in the field. To date, only a few studies have been conducted in high-latitude soils with herbicides such as glyphosate, triclopyr, and 2,4-D. The results of these studies indicate a distinct pattern of degradation. During summer months, herbicide breakdown proceeds at rates expected for the soils, moisture conditions, and temperatures experienced. Once soils freeze microbial degradation stops, resulting in herbicide concentrations after soils thaw in April and May equivalent to the concentrations measured in September and October when soils are freezing. Crop rotations can be designed to utilize the extended activity of soil active herbicides. For example, a triallate application in barley may be able to reduce weeds in a subsequent canola crop. There is a concern that increased longevity in the soil may result in increased movement of the herbicide. In addition, other forms of herbicide degradation, such as chemical, adsorption, or photo-decomposition, may play a more important role in herbicide fate in high-latitude soils. Research is currently underway to determine pathways of degradation and half-lives of soil active herbicides in Alaska.

Sustainable Livestock Systems for Alaska: Production, Processing, and Marketing

M.P. Shipka[1], J.E. Rowell[1], S.C. Gerlach[3], J. Greenberg[2], and T. Paragi[4]

[1]Department of Agriculture and Horticulture, 2Department of Natural Resources
School of Natural Resources and Extension, University of Alaska Fairbanks
[3]Department of Anthropology, Sustainability Science, University of Calgary
[4]Alaska Department of Fish and Game, State of Alaska

e-mail: mpshipka@alaska.edu

The complex relationship between food production, distribution, and accessibility is the foundation for food system sustainability and food security. In Alaska both the ecology and geographic isolation of the state combine to impose logistic stressors on the food system, stressors that are not shared in the same way by any other state in the USA. Alaska and Alaskans are at the end of a very long and vulnerable food chain. Despite high demand for locally produced red meat, a very small percentage of red meat consumed within the state is produced locally. We have the capacity and the land base to produce enough meat to feed many more Alaskans—but we haven't done it! Why not? With the example of a single component of a complex food system—the red meat system—we have engaged the agricultural community in Alaska to help define barriers and identify strategies for the establishment of research priorities and for the development of programs in education and extension that will: a) identify best farm practices, from the production of healthy meat to the health of the ecosystem; b) identify barriers to sustainable red meat production, from farm to market issues including consumer access, affordability, attitudes, and preferences; and c) identify how the University of Alaska can work in collaborative ways with all stakeholders to support the development of sustainable agriculture through research, education, and extension.

Key words: Alaska, food system, northern agriculture, red meat, sustainable livestock production

(see page 32 for paper)

Arctic Agriculture—Program for Development in the North of Norway, Norway

Bernt Skarstad

Farmers' Organization of the Arctic, Norway

e-mail: berntsk@start.no

The North Norwegian Council of Agriculture (NNCA) of the Program for Development of Arctic Agriculture is working systematically to improve the prospects of agriculture in our region, which includes the three northernmost counties in Norway. NNCA wants to use the term "Arctic Agriculture" on terrestrial food production that takes place in northern Norway. The vision for this work has been to promote the distinctiveness of this production because of the unique growing conditions and exceptional quality. Therefore, we have opted for a Program for Development of Arctic Agriculture to enhance and expand production and income opportunities for agriculture in the region. In addition, we have focused on research that could increase knowledge about arctic agriculture and the challenges encountered in producing food under such challenging conditions. Issues such as food security are a current topic and we believe that consumers will eventually appreciate arctic quality. This may be a way to increase the profitability of products grown in the Arctic.

Agricultural Production of Biomass as Energy Crops in Alaska

Stephen D. Sparrow[1], Amanda Byrd[2], darleen masiak[1], Mingchu Zhang[1], Robert Van Veldhuizen[1], William E. Schnabel[3]

[1]Agricultural and Forestry Experiment Station
[2]Alaska Center for Energy and Power
[3]Water and Environmental Research Center
University of Alaska Fairbanks

Alaska is an energy-producing and -exporting state, but even so, energy is expensive. Many rural communities, especially those not on the road or rail system, use mostly diesel fuel, which is shipped in at high cost, for all or most of their electricity and heating energy needs. If rural

communities in Alaska are to be sustainable, they must find cheaper and more sustainable sources of energy. Biomass energy has been proposed as one potentially sustainable energy source that may be cheaper than fossil fuels in many parts of Alaska. A question often raised is: Does it make more sense to harvest naturally grown biomass or is it feasible to grow biomass as an agricultural crop? We have begun several studies in various regions of Alaska, including those in maritime, transitional, and continental climate regions to determine the feasibility of growing either shrubs/trees or grasses as biomass crops. All of these studies are new, so only limited data is available. Data collected so far indicates that under proper conditions and with good management, yields comparable to economically viable yields in other regions are possible. At Fairbanks (continental climate) willows *(Salix)* and balsam poplar *(Populus balsamifera)* produced less than 1 Mg woody dry matter per ha per year on a moderately well drained site and up to 2.5 Mg per ha on a poorly drained site. Grass dry matter yields ranged from about 3 to 9 Mg per ha per year. At the transitional climate zone site, poplars produced an annual yield of almost 5.5 Mg per ha. We do not yet have yield data for the maritime site. At this stage, results are incomplete so we cannot yet determine the long-term sustainability or the economic feasibility of growing biomass as a crop in Alaska.

Key words: alder, bio-energy, biomass, grasses, poplar, willow

(see page 38 for paper)

Input of Clover-derived N to the Soil-Plant System During the Growing Season and the Risk of N Losses During the Winter

Levina Sturite
Arctic Agriculture and Land Use Division, Norwegian Institute for Agricultural and Environmental Research, Norway

e-mail: ievina.sturite@bioforsk.no

From an economic as well as ecological point of view, transfer of clover nitrogen (N) to the subsequent growing season should be maximized and the risk of environmental pollution minimized. About 80% of clover N is derived from the atmosphere and is incorporated into clover biomass through symbiosis with Rhizobium bacteria. The amount of clover in the field is important for the protein content and general quality of the forage produced. Clover is sensitive to climates with low temperature resulting in poor growth leading to winter damage. The objective of this study was to evaluate clover as a N source during the growing season and clover ability to conserve N throughout the winter under northern climate conditions. The field experiment was carried out on mineral soil in northern Norway. Four seed mixtures (0, 15, 30, 100% clover in total seed weight), two N fertilizer rates (110, 170 kg N ha-1) were examined. Nitrogen losses from the plant material during the winter were quantified as nitrous oxide (N_2O). Increased N fertilizer rate significantly decreased clover growth and N_2 fixation, confirming that grass species compete better than clovers for soil N. Clover inclusion rates decreased over time and during the second growing season there was no difference in clover content between grass-clover mixtures. Simple calculations determined that N_2 fixation by clovers contributed a considerable amount of N to the system up to 111 kg ha-1y-1. However, N largely was lost from the plant biomass (from 71 to 90%) due to climate conditions during the winter. Measurements of N_2O emissions during the winter indicated that pure clover stands containing both white and red clover had significantly higher gaseous losses in the form of N_2O than pure grass stands. These losses recovered only 2% of the foliage losses during the winter.

Northern Vigour®

Karen Tanino
College of Agriculture and Bioresources, University of Saskatchewan, Saskatchewan, Canada

e-mail: karen.tanino@usask.ca

Northern Vigour® was initially observed in seed potatoes where seed potatoes sourced from relatively northern regions (Saskatchewan, Canada, 52°7′N) outperformed seed potatoes sourced from more southern sites. Subsequently, the potential Northern Vigour® response in strawberries (*Fragaria* x *ananassa* Duch.) was examined with the primary objective to develop Saskatchewan as a supplier of high quality, superior yielding planting material for national and international markets. Twelve greenhouse and field studies were conducted over a 15-year period. The project coordinated research between several US cooperators and up to nine Canadian sites. “Camarosa,” “Festival,” and “Treasure” strawberry crowns were produced in Saskatchewan and tested in California and Florida for Northern Vigour® potential. Due to space limitations, only fruit yield and modeling results will be presented in this poster. Saskatchewan-sourced crowns expressed higher fruit yields (40–60%) in the first two months of marketable fruit production compared to other sources. This response was most consistent in Florida. Modeling studies identified the optimum crown harvest date and temperature parameters of the crown, which were associated with subsequent fruit yield. Northern latitude regions with strong day/night diurnal temperature regimes during the growing season show promise to be a source for high quality planting material to more southern latitude regions.

Strawberry Field Trials With and Without Sheet Plant Cover in Tromsø, Norway

E. Uleberg, R.T. Samuelsen, and I. Martinussen

Arctic Agriculture and Land Use Division, Norwegian Institute for Agricultural and Environmental Research, Norway

e-mail: eivind.uleberg@bioforsk.no

Field trials were started in 2004 with five strawberry cultivars planted on woven black poly-fiber ground cover sheets and with or without translucent sheet plant coverage during the winter and the growing season as combined treatments. A paralleled field trial with other cultivars, but with the same treatment combinations, was established in 2005. One early cultivar (Polka) and one late cultivar (Korona) acted as standard cultivars, while the other cultivars planted in 2004 and 2005 were newly named or unnamed (labeled) selections from Norwegian, Finnish, and Swedish breeding programs. Spring vigor, earliness (expressed by flowering dates and harvest period), usable and total berry yield, and berry size and berry quality were registered in 2005 and 2006. A combination of fiber sheet winter and spring coverage and more open net sheet harvest season coverage showed favorable results for earliness and berry yield of the three highest-yielding cultivars: Hanibal, Babette, and Polka. Covering treatment enhanced the ripening process in all the cultivars. The cultivars differed in characteristics like earliness, berry size, color, shape, tendency of cracking, firmness, taste, and grey mold resistance. Hanibal had the highest proportion of usable berries and was the most promising cultivar among the five planted in 2004.

Sustainable High-latitude Food Production as it Relates to Thermal Conductivity on Soil and Soil-Surface Atmospheric Temperatures and Horticultural Plant Production

Susan A. Woods

University of Alaska Fairbanks, Alaska USA

e-mail: sawoods2@alaska.edu

In high latitudes, food production is limited. Most rural communities are dependent on imported food resources for survival. These globalized food systems are vulnerable to environmental and economic conditions, which place rural communities at risk in regard to nutritional food security. My research results indicate that principles of thermal conductivity can address issues dealing with nutritional food security by expanding horticultural plant production in high latitudes and increasing a community's ability to access important food resources. Developing energy-efficient food production systems (STES), especially ones that use waste-heat/renewable thermal energy, are important for the ability of high-latitude rural communities to become more self-reliant in regard to food resources. Strengthening local food production systems will decrease the need for expensive imported food resources. My objectives are: to develop an energy-efficient underground radiant-heating system that can facilitate a seasonal extension in high-latitude environments; to use thermal-conductive processes to increase soil and soil-surface atmospheric temperatures for horticultural plant growth; to increase the seasonal edible plant varieties that can be produced in high latitudes; and to address food security in high latitudes by increasing a community's access to locally produced nutritional foods. Results indicate that STES can facilitate frost-free temperatures of approximately 140 days for a warm-season plant and approximately 160 days for a cool-season horticultural plant. All experiments indicate that the design of the plant-growing container was beneficial in increasing temperatures. Thermal sensors placed deep into the plant-growing container responded to cold-soil temperatures and triggered the zone-valves to maintain increased temperatures. Once a thermal-energy system is built it should last for years. Also, horticultural plant species naturally produced in high latitudes can benefit with this system by incorporating a mobile structure that can be moved after temperatures become fit for plant growth. This research can be used to address food security in high latitudes.

Varieties and Harvesting Methods for Growing Polish Canola in Interior Alaska

Mingchu Zhang and Robert Van Veldhuizen

School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks, Alaska USA

e-mail: mzhang3@alaska.edu

Canola is one of the major oilseed crops in the world. Polish canola *(Brassica rapa)* has a short growing season and has been tested as a crop in interior Alaska. In the past, canola was not a successful crop in Alaska due to late maturity and high green seed content. With the introduction of new Polish canola varieties and the development of better harvesting technologies, canola now has potential as a rotational crop in the area. The objective of this presentation is to summarize the research of selecting suitable canola varieties and harvesting technologies that can make canola a rotational crop in the Interior. Four Polish canola varieties (Maverick, Reward, Hysin 110, and Sunbeam) and three harvesting technologies (direct combining, pushing, and use of a desiccate) have been evaluated in the Fairbanks and Delta Junction areas of Alaska since 2007. Hysin 110 and Sunbeam in combination with the use of a desiccate generated the lowest green seed content (<2%) and higher seed yields in comparison with other varieties and harvest methods. This high yield and low green seed content was even achieved in the wet and low heat unit year of 2008. Thus, with the use of the new varieties and harvesting method, canola now can be used as rotational crop in interior Alaska.

ABSTRACTS
agricultural education

Community Gardens as a Health Intervention in Alaska Communities

LEIF ALBERTSON
Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA

e-mail: leifalbertson@gmail.com

In many parts of Alaska, one commonly stated barrier to a healthy diet has been poor availability of fresh, inexpensive produce. Recently, there has been renewed interest in gardens as a way to provide healthy food to rural communities. There is, however, a dearth of research supporting community gardening as a viable dietary intervention that can affect health outcomes. Furthermore, experience suggests that the realized outcomes of community gardening in the state of Alaska often fall short of intentions. Through evaluation of published health literature as well as an informal survey of gardens throughout Alaska, the author has compiled information suggesting realistic, attainable goals for community gardens. Through this process, the author was also able to compile a list of the characteristics shared by successful gardens; this information will be useful to those planning or funding community gardens.

Cooperative Breeding of Horticulture Crops and Education of Volunteers

BOB BORS AND KAREN TANINO
Department of Plant Sciences, University of Saskatchewan, Saskatchewan, Canada

e-mail: bob.bors@usask.ca

In the Far North, there are comparably little or no funding opportunities available for "expensive programs" to breed horticulture crops. Conversely, there is an increasing need to breed crops for northern climates as most varieties are not adapted. By engaging high school and university students, Master Gardeners and growers in various educational and testing activities, the University of Saskatchewan fruit program has been able to push forward the breeding of apples, hazelnuts, haskap, coleus, cherries, and a few other fruit and vegetable crops despite low or no funding. Many of our volunteers have effectively become apprenticed in good orchard practices and are now leaders in our local fruit industry despite no previous horticultural training. Once barely funded, but now well-funded through royalties and grants, our fruit program retains its grassroots activities and has begun to help other growers and fruit programs in colder regions including Mongolia, Russia, Norway, Belgium, Yukon, Alaska, and most provinces in Canada. Hands-on workshops, good photography, frequent lectures, website building, article writing, plant sales, publicity events, grower experiments, and fruit tasting are important components of creating a dynamic, effective, and fun program.

"Chicken University": Small-Scale Poultry Production Education in Alaska

STEPHEN C. BROWN
Cooperative Extension Service, University of Alaska Fairbanks

e-mail: scbrown4@alaska.edu

There are many reasons why Alaskans have shown a renewed interest in small-scale home poultry production. These include a concern for Alaska food security, higher grocery costs, a desire for foods with a reduced carbon footprint, a relaxation of poultry keeping ordinances in some communities, and a greater preference for naturally grown poultry. Based upon Cooperative Extension Service client observations, chickens are the preferred poultry in Alaska. Recognizing the public need for high latitude-based poultry-rearing information, the University of Alaska Fairbanks (UAF) Cooperative Extension Service Mat-Su/Copper River District created a program called Chicken University. The objective of the program is to educate participants on how to raise and manage small

poultry flocks in cold climates using sustainable methods with or without electricity. Chicken University is presented as a two-hour program that is free to the public. Topics that are presented include "why raise your own flock," "selecting Alaska-appropriate breeds," "coop design," "incubation," "brooding," "appropriate nutrition," and "disease control." Since 2010 more than 1,000 individuals have participated in Chicken University and it remains one of the most popular UAF Cooperative Extension Service programs in Southcentral Alaska. Of greatest interest to participants is appropriate coop design for protecting flocks from temperature extremes and large predators such as bears. Although most participants choose food security as a reason for raising small poultry flocks, they report they primarily purchase feed made outside of Alaska. Such a situation significantly reduces the actual food security benefits realized by small flock production.

Key words: chickens, education, food security, poultry

(see page 45 for paper)

Bridging the Language Gap: Alaska Field Guide to Potato Pests

Janice Chumley[1], Lydia Clayton[1], Ronda Hirnyck[2], and Tom Jahns (retired)[1]

[1]Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA
[2]University of Idaho Extension, Idaho USA

e-mail: jichumley@alaska.edu, lclayton2@alaska.edu

English is a second language for many potato producers in Alaska, with Russian being the most often native spoken language. While many field guides are readily available in both English and Spanish, there is very little for Russian-speaking producers in Alaska. To meet this need, collaboration between the University of Idaho and the University of Alaska Fairbanks, funded by the Western Integrated Pest Management Center, created the Alaska Field Guide to Potato Pests and Beneficial Insects. The field guide was designed to support field workers and farmers and is sized for convenient use in the field. It offers assistance with proper pest identification at various crop stages and provides scouting techniques to aid producers in creating workable Integrated Pest Management programs. Alaska is free of many pests that are endemic worldwide, due to remote growing regions, seed laws, and state regulations regarding transport. With information in both English and Russian, growers across Alaska can access information needed to identify new pests, know beneficial insects, and establish economic thresholds for field production.

Training Alaska's Remote, Beginning Farmers With a Distance Delivered Course—The Alaskan Growers School

Glenna Gannon and Heidi Rader

Cooperative Extension Service, University of Alaska Fairbanks, and Tanana Chiefs Conference, Alaska USA

e-mail: glenna.gannon@tananachiefs.org

Alaska is the largest state in the US, with nearly half of the population living in rural communities. The Alaskan Growers School was developed in collaboration with Cooperative Extension Service experts and funding from the USDA Beginning Farmer and Rancher Development Program as a way to reach and educate rural Alaskans, especially Alaska Natives, who wanted to learn how to start a farm or ranch in Alaska. The course was distance delivered by teleconference, Blackboard (an online classroom platform), elluminate-Live! (a webinar delivery system) and correspondence. These distance delivery methods were compared with classroom-based instruction. The course has 22 lessons divided into two segments: the Beginning Alaskan Growers School (BAGS) and the Advanced Alaskan Growers School (AAGS). The goal of the course is to provide students with the knowledge and skills necessary to grow enough food for themselves and 10 other families. In addition, students learn how to develop a whole farm business plan. The curriculum for the Alaskan Growers School was developed and peer reviewed through collaboration with extension agents from the University of Alaska Fairbanks and other state specialists. We used what we learned from teaching the course in four distance-delivered ways to improve the second course, which was delivered using a mixed method approach. We will share our experience of developing best practices for delivering a non-credit extension course via distance delivery in Alaska.

Working with Anchorage Area Youth and Public to Determine if Invasive Chokecherry Trees Affect Winter Moose Browse Behavior in an Urban Forest and Potential Impacts to Native Trees and Shrubs

Gino Graziano

Cooperative Extension Service,
University of Alaska Fairbanks, Alaska USA
e-mail: gagraziano@alaska.edu

Moose are an iconic species in Alaska, both valued and feared by residents and visitors who rely on moose for food and enjoy seeing these magnificent animals. The urban moose is challenged as it negotiates neighborhoods, pets, fences, and cars while seeking food in greenbelts and yards. During the winter of 2010 and 2011, three moose calves were reported dead at three Anchorage residences after consuming planted chokecherry trees (*Prunus* spp.), which are known to contain cyanide. Invasive species biologists have documented two chokecherry species, *Prunus padus* and *P. virginiana*, established in Anchorage, Fairbanks, and other forested areas. Some infestations in Anchorage and Fairbanks are particularly dense with chokecherries dominating the under and mid-story vegetation. Anchorage Extension sought to involve youth and the public in determining how the density of chokecherries in the forest affects moose browse choices. Anchorage area middle, high school, and university students, as well as the public, collected data on winter moose browse behavior and condition of trees and shrubs in wild areas around Anchorage. Data collected in 15-meter-radius plots included the ratio of bites to available browse, tree architecture and diameters of current annual growth, and the bites of species. A census of tree species in the plot and the general age of the species (mature, sapling, or mixed) were recorded to compare browse behavior and impact to trees and shrubs in different densities of chokecherry trees. Students entered data in Google forms and data summary tables in Google spreadsheets. Using Google technology, students were able to explore data entered around Anchorage by multiple schools. The Google spreadsheets were pre-loaded with pivot tables that updated whenever data was entered. Students used these tables to identify trends in moose browse behavior, and infer potential impacts to native vegetation in high and low densities of chokecherry trees.

Developing a Northern Foods Program

Owen E. Hachey

Agriculture and Agri-foods Consultant, Government of the Northwest Territories, Canada
e-mail: gene_hachey@gov.nt.ca

How do we encourage local foods production in remote communities with limited access to resources and educational opportunities? Perhaps by introducing a sense of community, making things fun, and creating an environment of involvement. The Government of the Northwest Territories through the Canada/NWT Growing Forward program introduced the Small Scale Foods/Community Gardening Initiative in 2006 with an aim to develop an awareness and interest in local foods production. The premise of the program: As much as we want things to grow, so does the seed. Give it an adequate environment, some basic needs, and it will respond. This program is not about the big picture, or micromanagement of our growing environment, as seems to be the trend associated with gardens. This program is about learning, developing confidence, and having fun. We use phrases such as "Composting is simply managed rotting" and "What would you do if you were a seed?" We deliver programming in the schools where the primary advertisement is "You will get dirty and have fun and say you learned something; how much fun is that?" The program has evolved to involve greenhouses and small poultry operations.

Youth Education: An Essential Component of Agricultural Sustainability

Lee Hecimovich

Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA

e-mail: dahecimovich@alaska.edu

In 1902, land grant universities realized that by creating agricultural education opportunities for youth, adults would also gain knowledge. Thus, the 4-H program began. More than 100 years later, with less than three percent of the population yet farming, the need to educate our youth may be even more critical to the future of agriculture. An understanding of basic sustainable agricultural principles needs to be developed in youth. We will examine a variety of agriculture education opportunities for youth in Alaska, the United States, and other counties with applications to the circumpolar north. The 4-H program, Future Farmers of America, Agriculture in the Classroom, Farm to School and other programs will be presented as well as their role in formal and informal education venues. The role of educators, organizations, administrators, producers, and youth will be further reviewed for additional opportunities, collaborations, and strategies for implementation into the program.

Bilberry – Wild Super Berry from Europe

Laura Jaakola[1,2], Eivind Uleberg[2], Hely Häggman[3], Inger Martinussen[2]

[1]Climate laboratory, Department of Arctic and Marine Biology, UiT The Arctic University of Norway, NO-9037, Tromsø, Norway
[2]Norwegian Institute for Agricultural and Environmental Research, Bioforsk Nord Holt
Box 2284, N-9269 Tromsø, Norway
[3]Department of Biology, University of Oulu, P.O.B. 3000, FI-90014, Oulu, Finland

e-mail: laura.jaakola@uit.no

Bilberry, or European blueberry (*Vaccinium myrtillus* L.), is economically one of the most important wild berries in Europe. Bilberry grows most abundantly in the area of boreal forests in Northern Europe to Northern Asia and it is recognized for its bioactive properties and high yields of anthocyanin pigments both in the skin and pulp of the berry. Due to these properties there is an increasing interest for utilization of bilberry. Northern European wild berries are a rich and valuable resource with high but unrealized economic potential. Approximately 90–95% of the whole wild berry crop is left unpicked in Nordic forests every year, where they provide valuable nutrition to wild animals and birds. Although increasing, wild berry production has many challenges due to the yearly fluctuations in crop yields, with logistics and questions related to uniform quality of the berries. One critical challenge is, for instance, to differentiate bilberry from other berries, especially blueberries, in global markets. In recent years, a lot of new information has been developed on environmental and genetic factors that affect the content of anthocyanins and other bioactive compounds in bilberries. Studies have also focused on developing DNA-based and chemical methods for authenticity analyses for discrimination of wild and cultivated berries. Also trials for cultivation and semi-cultivation of bilberry have been initiated. Moreover, attempts have been made to increase cooperation between wild berry producers in Nordic countries.

Keywords: anthocyanins, bilberry, *Vaccinium*, wild berries

(see page 48 for paper)

The Land Grant System in the United States: Its Implications and Impacts

Carol E. Lewis

Dean, Director, Professor Emeritus, School of Natural Resources and Agricultural Sciences, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks, Alaska USA

e-mail: celewis@alaska.edu

The land grant university system in the United States is unique in the world with its integrated academic, research, and extension/outreach programs. It, and the US Department of Agriculture's (USDA) Agricultural Research Service (ARS), has been the driving force that makes the United States a world agricultural leader. Created in 1862 by the Morrill Act and signed into law by President Abraham Lincoln during the Civil War, the colleges promoted the liberal and practical education of the industrial classes in pursuits and professions in life—agriculture and the mechanical arts, not excluding scientific and classical studies and the military arts. The 1890 Morrill Act brought higher education to former slaves, forbidden entrance to white institutions. The 1887 Hatch Act followed with agricultural experiment stations directed to conduct research contributing to establishment and maintenance of an effective agricultural industry and to bring new knowledge into the land grant classrooms. Farmers and ranchers were not being served; the 1917 Smith-Lever Act created the Cooperative Extension Service to bring information to farms and ranches. In 1922, ARS was formed with a national and regional mission working hand in hand with the land grants. The 1962 McIntire-Stennis Act saw the start of a vehicle within the USDA for forestry and range research. The Alaska Agricultural Experiment Station, now headquartered in Fairbanks, began in Sitka in 1898. Of nine experiment farms, two remain in Fairbanks (1906) and Palmer (1915). The College of Agriculture and School of Mines (now the University of Alaska Fairbanks) began in 1917; the Cooperative Extension Service became a part of the system in 1930. The Alaska land grant system has touched every Alaskan with specialized crops, adapted livestock, appropriate healthy living, and youth leadership. Without it and the USDA/ARS, it is doubtful Alaska's agricultural industry, though small, would exist.

Building Educational Programs to Promote Food Security for Indigenous Populations in the Americas

Diane H. Rickerl, Professor Emeritus

Timothy J. Nichols, Dean

Van D. and Barbara B. Fishback Honors College, Honors Hall 119
Box 2705A, South Dakota State University, Brookings, SD 57007

e-mail: timothy.nichols@sdstate.edu

Our objective was to build collaboration between South Dakota State University (SDSU) and tribal colleges and universities (TCUs). After a whirlwind, information-seeking trip to TCUs in the region, the consensus was that we needed to develop a graduate program for TCU faculty. In 2003, we developed the "Prairie PhD," a graduate cohort for professionals serving Native American communities (Lakota, Mohawk, Anishnabeg, and Native Hawaiian). Coursework was multi-disciplinary and included introductions to research methods in both qualitative and quantitative research, human nutrition, land appraisal, ecology, sociology, and environmental management. Two-thirds of those who completed graduate degrees investigated food production and nutrition within their communities. Topics included diabetes education, native food production, native food preparation and nutritional value, cultural traditions and education, and eating habits. One study investigating tribal bison herds identified education as an important part of sustainability.

A component of the "Prairie PhD" program was an international experience at Unidad Academica Campesina (UAC), a rural university in Bolivia serving primarily indigenous populations of the Andes (Aymara and Quechua). During the exchange, students shared knowledge about their traditional foods and medicines, gardening, and the importance of food in cultural traditions. There was shared concern among TCU and UAC representatives about the availability and access to healthy foods in their rural communities. Currently, two students from UAC are completing graduate programs at SDSU and have spent a semester teaching at a nearby tribal college. Results of the exchange have included the development of culturally sensitive collaboration approaches, research methods, ethics education and in the future, shared apps about nutrition, health, and food production. Building graduate programs to meet the needs of faculty in colleges and universities serving indigenous communities has contributed to local food access and improved nutrition.

Key words: education, indigenous nutrition, native foods

(see page 53 for paper)

Expanding Agriculture in Fairbanks, Alaska

Steven S. Seefeldt

Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA

e-mail: ssseefeldt@alaska.edu

More than 100 years ago, when gold mining was the primary industry in the Fairbanks area, an effort was made to expand agriculture to provide the majority of the food needed to feed the population in and around the city. From that time, agricultural production has waxed and waned and farms of various sizes have come and gone. Recently, there has been a push for more Alaska grown produce for a variety of reasons such as to keep money in the local economy, provide better quality food, increase employment opportunities for youth, and improve food security. Fairbanks has more than 20 small farms in the area; many sell at the farmers' markets and offer Community Supported Agriculture shares. All produce a variety of vegetables and some raise livestock. There is an interest in expanding agriculture at all levels of the community and efforts are underway to disclose bottlenecks to establishing new farms and selling produce. A cooperative market has recently opened and many of the growers are working toward establishing a growers' co-op that would result in larger volumes of sales and less direct marketing. In an effort to assist with the increased demand for farming, the Tanana District Office of the Cooperative Extension Service has sponsored workshops to teach people how to grow, harvest, mill, and cook with grains on small pieces of ground and how to graft and grow apple trees. More than 50 people attended the grain growing workshop and more than 100 people learned how to graft apple trees, with each of them taking at least four trees home. Expanding agriculture in the Fairbanks area has been positively championed in newspaper, television, and radio by a variety of people. The hope is to measurably and continuously grow the agriculture economy in Fairbanks.

Family Outdoor Skills: Extension 4-H Programs Partner to Help Families Learn Skills to Participate in a Sustainable Harvest Culture

Darren G. Snyder

Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA

e-mail: darren.snyder@alaska.edu

The objective of this program is to support families who want to learn the skills necessary to safely and effectively harvest, process, and consume wild and cultivated foods in Alaska. Twenty years of efforts by 4-H volunteers and staff have resulted in the training of thousands of youth and hundreds of families through developing partnerships with agencies, organizations, businesses, and individual Alaskans. The assumption that Alaskans can go out and harvest from the land and sea an endless bounty of products at will is an unmet reality for many of us. Due to the fact that many Alaskans are transplants from distant places and many families are a generation or more from either the true frontiers or subsistence-reliant members of our families, many of the skills that were a part of everyday life are now nonexistent for many Alaskans. Because of this, many resources are unavailable. Through creating networks of adult volunteers, agencies, organizations, and businesses, extension volunteers and staff have created and facilitated mentorship and training programs to connect families who want to learn with others who want to share the skills to hunt, fish, boat, camp, garden, and wild harvest. A model that takes management and stewardship, but yields satisfied and competent stakeholders through 4-H Outdoor Skills Clubs and Sustainable Harvest Camps, is welcoming many Alaskans of all ages into a new culture of learning what a healthy, Alaska way of life can be when we are able to fully engage with our natural resources.

Success Stories of Local Agri-food Skills Activities in the Northwest Territories, Canada

Lone Sorensen

Yellowknife Commons Cooperative, Yellowknife Garden Collective, Ecology North and Territorial Farmers Association, Northwest Territories, Canada

e-mail: lsorensen@northern-roots.ca

The development of food skills in the Northwest Territories (NWT), Canada, primarily in the North Slave Region, has been a result of efforts from many organizations. This presentation will highlight success stories and lessons learned from these local agri-food skills programs. The presentation includes an overview of activities carried out by various nonprofit organizations in recent years, as well as a brief look at how networking and collaboration are vital components to the development of local food security in the NWT. This presentation will focus on four programs: 1. The first season of the Northern Farm Training Institute workshops in Hay River (NWT) — Live classroom instruction for adult learners in sustainable food production in the North. This program brings leaders from all NWT regions to Hay River to learn advanced (northern) farming and gardening skills during the growing season. 2. Indoor School Gardening Programs 2013 — How students and teachers were inspired by being gardeners and how they learned not only about biology, but also about mathematics, science, reading, and essential life skills (food skills). 3. Inspiring stories from new community gardens—How building trusting and respectful relationships results in co-creating and knowledge sharing through the Spirit Garden Teachings. 4. A new program for young offenders, corrections staff, and teachers. This program is in its early stages and will be an ongoing food production skills training on site in Yellowknife. This presentation invites a discussion about the challenges and opportunities of local agri-food skills programs. How can the exchange of information and materials best be encouraged, with the objective of expanding food security in the North?

ABSTRACTS
food economy

Costs and Benefits of a Northern Greenhouse

TOM ALLEN

Associate Professor, Department of Bioresource Policy, Business & Economics, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8 Canada

e-mail: tom.allen@usask.ca

In Canada efforts to address food insecurity have tended to be reactive in nature and have included initiatives such as the Food Mail Program, Nutrition North Program, food banks, and meal services like school lunch programs. In addition there have been numerous examples of community food production projects in small northern communities. Most, if not all, are supported by government subsidy and/or volunteer labour. The problem is that both subsidies and volunteer labor are inconsistent in the long term.

Over the last several months there has been a renewed interest in developing sources of locally produced food for remote northern communities as centered on using greenhouses as a food production method. The question we are interested in is “Can healthy food be produced in remote northern communities in an economically sustainable way using a greenhouse?” This question is of vital importance as both federal and provincial agencies have expressed an interest in supporting remote communities but want to do it as an exercise in community economic development.

The question was approached using two methodologies: first, a financial feasibility analysis where we are concerned with whether the bills can be paid, and second, an examination of a number of areas of benefit—both quantified and non-quantified. The analysis regarding financial feasibility (quantified benefit) suggests that there is just not a big enough market to support a greenhouse in a northern community of 1,000 people. Regardless of the type of greenhouse you construct or what type of heat you use—when it comes down to the fundamental question of generating enough cash flow to sustainably support the initiative, you can’t do it.

This does not necessarily mean that a community should not consider a greenhouse. As the conversation about locally produced food in northern community greenhouses moved forward with colleagues and experts from other provinces and territories, it was apparent that many are convinced that the benefits of community greenhouses extend well beyond sustainable economic development. For example improved health outcomes, developing an understanding of what constitutes a healthy food system, supporting education, contributing to the social and therapeutic benefits of community members, and contributing to community pride and engagement are a few of the benefits identified. However, the ability to quantify a number of areas of benefits, especially in social and environmental categories, is limited and such benefits are therefore potentially undervalued in the project evaluation process and worthy projects are not moved forward.

Key words: biomass heating, food security, full cost accounting, greenhouses, healthy communities, northern food production

(see page 58 for paper)

Losses of sheep on summer range in Norway

INGER HANSEN[1] AND ROLF RØDVEN[2]

[1]Bioforsk Nord Tjøtta, P.O. Box 34, N-8861 Tjøtta
[2]Bioforsk Nord Holt, P.O. Box 2284, N- 9269 Tromsø
Norway

e-mail 1: inger.hansen@bioforsk.no
e-mail 2: rolf.rodven@bioforsk.no

The majority of two million Norwegian sheep graze on open mountain-range pastures during summer, and are neither fenced nor guarded. Each year about 125,000 ewes and lambs are lost on summer range. Mortality due to predation is increasing in many areas and wildlife administration

pays about $12 million USD annually in compensation for sheep killed by protected large carnivores. Red fox, not a protected species, is also considered a main predator. In addition to predation, accidents, common diseases, and lack of micro-minerals increase the complexity of sheep mortality. In this study we have reanalyzed data from radio-telemetry-based mortality studies performed during the last 10 years, including 1,170 lambs from 15 farms, with the object of documenting some characteristics of lambs killed by red fox, wolverine, and lynx specifically, and to find farm management factors which may be significant for reducing mortality on summer range. Results show that in a grazing area dominated by wolverine as the main cause of lamb losses, probability of survival was not influenced by the body mass of the lambs at release, whereas in areas dominated by lynx, survival increased significantly with increasing body mass at release. This link was even stronger within a red fox habitat. These results indicate that the "weaker" the predator, the more important the size of the prey. Mitigation measures are discussed.

Key words: carnivores, depredation, grazing, losses, sheep

(see page 64 for paper)

Bartering: Cornerstone of the Local Food and Agricultural Economy

Derrick Hastings
Dawson City Community Garden, Full Circle Farm and Dawson Young Agrarians, Yukon, Canada

e-mail: yukoner.hastings@gmail.com

One of my oldest friends in the Klondike, Ryan Peterson, is an avid fisherman and hunter. He has excellent knowledge of the hunting grounds and salmon runs around Dawson. Over the last eight years, he and I have exchanged moose for seedlings, caribou for gardening advice, eggs for salmon strips, and fish guts for cleanup. It is always a pleasure to trade with Ryan because we each walk away feeling like we got the better end of the deal. Trading with Ryan allows me to diversify my food stock, obtain natural fertilizers, and access wild foods. My friend Louie Gerberding was travelling to Whitehorse with an empty car so I asked if he could bring back chicken feed. When he returned, I was short of cash so I gave him a large roast/ham to make up the difference. I was happy and Louie was elated. A week later, I started to receive compliments from town folk about the tenderness of our pork and how great it tasted. Louie had shared the large piece of pork with eight others so now I had eight new customers! Not only did I receive my feed, I also marketed my product and gained market share with one trade. Recently, my friend Flynn Fezatte proposed a trade in which we started seedlings for her in exchange for the soy candles she makes. It seemed a great deal for us: a few extra plants under our already lit grow lights in exchange for enough candles to get us through the winter. I would not have purchased the candles because all of my money goes into seed and feed, animals and building materials, but I do adore them. This trade has allowed me the luxury of the candles without incurring debt.

From the Land to the Freezer: Cooperation Between First Nations and Outfitters

Joella Hogan
First Nation of Nacho Nyak Dun, Yukon, Canada

e-mail: heritagemgr@nndfn.com

In recent years, there have been efforts to connect the meat from animals harvested through "outfitter hunting" with people in the local communities. The First Nation of Nacho Nyak Dun, in the community of Mayo, Yukon, is one such community that has developed a program to distribute the meat to those in need. This paper will focus on the benefits to such a program for providing access to traditional foods and the distribution of the meat, as well as the barriers to the program's success. During hunting season, moose, caribou, sheep, and other traditionally harvested species are hunted by non-residents led by a guide. This form of tourism is known as "outfitting" and is strictly regulated by the Yukon government. There are 19 registered concessions throughout the Yukon, seven of which are in the First Nation of Nacho Nyak Dun traditional territory. The outfitters all have "a legal and moral obligation to ensure that all edible and wild game meat from harvested animals is not wasted or left in the field" (YOA website, April 16, 2013). We want to ensure that the meat harvested within our traditional territory is given to those in need and that it is properly cared for during transport and delivery. The system of distribution of meat in the community is simple—contact is made from the outfitting company to a First Nation representative who then coordinates the storage and delivery of the meat. Although this system has improved greatly in recent years, we still face several challenges including the lack of a proper storage facility, communication with camps, and ensuring proper care of the meat.

Developing Sustainable Small Businesses in the North: The Case of Northern Food Producers and Distributors

Svein Tvedt Johansen
Harstad University College, NO9480 Harstad, Norway

phone: +47 77058262

e-mail: svein.johansen@hih.no

Food security and healthy northern communities depend on commercially viable, locally owned small producers. Northern locally owned food producers share a series of characteristics: They tend to be strongly embedded in and share a common interest in the wellbeing of local communities. Northern food producers hence depend on local communities for legitimacy, services, and infrastructure whereas local communities rely on local food producers for jobs, tax revenues, and local demand to support other businesses. This paper develops a series of related arguments; first the paper argues that locally owned food producers and distributors help further food security through an emphasis on place and local relationships. The paper then goes on to show how these businesses are vulnerable to demographic and environmental shifts as well as competition from large, vertically integrated food companies. To address these challenges, northern locally owned firms will need to develop resilience and ambidexterity—combining tradition and identity with innovation. The last section of the paper looks at how resilience can be developed.

Key words: ambidexterity, food producers, resources, small firms, social sustainability

(see page 69 for paper)

Stimulating Yellowknife's Local Food Economy and Success Stories of Local Agri-food Skills Activities in the Northwest Territories, Canada

Amy Lizotte[1] and Lone Sorensen[2]

[1]Yellowknife Commons Co-operative Ltd., Yellowknife Garden Collective, Ecology North and Territorial Farmers Association, Yellowknife, Northwest Territories, Canada
[2]Northern Roots, Yellowknife, Northwest Territories, Canada

e-mail: amyruthlizotte@gmail.com

In 2012, interdisciplinary research on the viability of commercial gardening in Yellowknife, Northwest Territories, Canada, as a local food solution was conducted. Although Yellowknife is a subarctic community, with virtually no arable soil and a short growing season, historical evidence and successes from local food enthusiasts suggest that a local agricultural economy is possible. The research results were highly positive. A collaborative business model, one that exemplifies community benefit, would facilitate the greatest leverage with locally available resources. Research participants suggested that profits made in more southern jurisdictions through Small Plot Intensive (SPIN) Farming techniques could be comparable with simple technology employed in Yellowknife gardens. Yellowknife residents identified 99% would buy local produce, 88% would pay a premium, and 96% are willing to attend a farmers' market. Further research was gathered on vegetable preference. Stakeholders were brought together in the fall of 2012 to discuss urban farming in Yellowknife. From this visioning session, the establishment of a Yellowknife farmers' market was set in motion. The Yellowknife Commons Co-operative Ltd. (YCC) was officially formed in 2013 to increase access to land for urban farmers and to promote local food production. Over the course of roughly six months, YCC has made significant progress on all fronts. A Yellowknife farmers' market is set to open June 6, 2013, and to date almost 30 food vendors have expressed interest. The summer of 2013 will serve as a pilot project on many fronts: commercial garden production yields will be compared across growers and contribution to local economy will be estimated through the farmers' market. The unofficial results from the 2013 farmers' market and urban agriculture development will be shared with participants of the conference. Lessons learned and key policy issues will be identified.

Refugees Contribute to Local Food Economy while Acquiring High-Latitude Production Skills

Julie Riley

Cooperative Extension Service, University of Alaska Fairbanks, Alaska USA

e-mail: jariley@alaska.edu

In Alaska, a group of Anchorage's newest residents have been learning to grow vegetables and herbs at 61°N latitude. They are refugees from Togo, the Democratic Republic of the Congo, Sudan, Nepal (Bhutanese), China, and Thailand (Hmong). Since 2007, the Refugee Farmers' Market project has been a collaboration of the University of Alaska Fairbanks Cooperative Extension Service and Refugee Assistance and Immigration Services (RAIS). The refugees sell the vegetables they grow at two farmers' markets under the name Fresh International Gardens. In Alaska, the number of farmers' markets has doubled the last five years and sales of produce by Fresh International Gardens makes a contribution to the local food economy. The market gives participants a chance to practice their English and learn basic marketing and customer service skills. The value of produce raised on the 8,000-square-foot plot located on city parkland has ranged from $3,000 in 2008 to $9,000 in 2012 despite record cold temperatures. The United States is not alone in accepting refugees for resettlement. According to the United Nations High Commissioner for Refugees, the Nordic countries reported the largest relative increase in annual asylum levels in Europe for 2012. Sweden, Norway, Denmark, Finland, and Iceland received 62,900 asylum requests during 2012, a 38% increase. For the same year, Japan registered its highest number of requests for asylum. With collaboration between refugee resettlement programs, universities, city governments, nongovernmental organizations, and private enterprise, large garden and small farming enterprises can be developed. When refugees learn skills to grow food in northern countries and have access to enough land to grow produce to sell at farmers' markets, they feel welcome in their new communities and make a contribution to the local food economy.

Sustainable Qiviut Farming—An Economic Feasibility Study

Laura Starr, Joshua Greenberg, and Janice Rowell

School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks, Alaska USA

e-mail: lauramariestarr@yahoo.com

Qiviut is the soft, downy underwool produced by muskoxen and is their primary protection from the arctic cold. Every spring, qiviut is shed in large clumps or can be combed from tame individuals in thick sheets and sold to the spinning market or processed into yarn for knitters. As a fiber, qiviut rivals cashmere for softness and quality. This characteristic, combined with qiviut's relative scarcity, translates into a high price on the fiber market. The qiviut produced by the muskoxen at the Robert G. White Large Animal Research Station (LARS) is collected every year and sold to offset costs of maintaining the animals. The objective of this project is to evaluate whether muskoxen can be farmed for qiviut production in an economically sustainable manner. A market description and production analysis will be conducted to evaluate the feasibility and market potential of qiviut production. These assessments will address demand by investigating the market and market potential, price points along the production and market chain (such as raw, processed, and retail pricing), dominant suppliers and markets, substitute goods (such as cashmere and alpaca), non-market price determinants (subsidization and volunteer labor), production costs (labor, infrastructure, and feed), and bottlenecks that limit the supply of qiviut to the marketplace and affect potential growth. These data will then be used to develop an enterprise budget based on a model from the University of Wisconsin-Madison and identify market characteristics such as determinants of supply and demand, which will help guide this emerging enterprise towards sustainable development.

Abstracts
food security

The Effect of Freezing on Meat Quality of Reindeer *Longissimus dorsi* Across Three Periods

George Aguiar[1], Eva Wiklund[1], Peter J. Bechtel[2], and Greg Finstad[1]

[1]Reindeer Research Program, School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks, Alaska USA; [2]Food Processing and Sensory Quality Research, Agricultural Research Service, United States Department of Agriculture, Louisiana USA

e-mail: gaaguiar@alaska.edu

Food systems throughout Alaska are vulnerable to disruptions in supply and costs because of their dependence on imported food. Reindeer *(Rangifer tarandus tarandus)* meat can assist in meeting the demand for red meat and provide a form of economic sustainability in rural communities. Reindeer are generally slaughtered in the winter, making availability of a fresh product limited and inconsistent. Providing that there are no adverse effects on meat quality, a frozen product could be available to the consumer year-round, which would promote food security throughout Alaska. No studies to date have evaluated the effects of freezing on reindeer meat quality. In this study, nine reindeer steers were raised and fed a balanced milled ration on the University of Alaska Fairbanks (UAF) Reindeer Research Program (RRP) facility at the Agricultural Forestry Experiment Station (AFES). Strip loins *(Longissimus dorsi)* were removed from the carcasses for meat quality analysis at four different times: fresh (control), freshly frozen, 6 months, and 12 months to simulate commercial cold storage effects on meat quality through a one-year period. Shear force values were not significantly different amongst treatment groups (P = .99). Proximate analysis determined no differences in moisture, ash, and protein content, while lipid content was different across treatment groups (P = .99, .99, .99 and .0000013 respectively). Tenderness and juiciness attributes were not different among treatment groups (P = .92 and P = .60); however, an off flavor attribute was different (P = 0.028) amongst treatment groups suggesting that off flavor diminishes with freezing. While not detected in sensory evaluation, mean TBARS (rancidity) values increased (P = .0000026). Results of this study suggest reindeer meat can be frozen for up to a year without compromising quality to the consumer.

The Kuujjuaq Greenhouse Project: Sustainable Community Development through Food Production

Ellen Avard (PhD Candidate)

Université Laval, Département de géographie - Faculté de foresterie, de géographie et de géomatique

e-mail: ellen.avard.1@ulaval.ca

Inuit villages in Nunavik currently face complex social challenges as well as numerous food security issues. In 2009, a preliminary study was conducted in order to assess the social and cultural acceptability of greenhouse initiatives in this region. Since then, research has continued on the subject through the facilitation and documentation of a greenhouse pilot project in the village of Kuujjuaq. This work, which is being elaborated within the paradigm of Community-Based Participatory Research, actively involves not only academics, but also stakeholders from all levels of government, representatives from Inuit organizations, NGOs, local businesses and, most important, community members. This approach ensures community ownership of the research and the results generated by this co-production of knowledge are being integrated into a model for a new type of local food system in the North. The Kuujjuaq Greenhouse Project currently involves the development of eight micro-projects. The most notable are the revitalization of the existing community garden (including the construction of a new greenhouse), and a compost collection initiative that has not only created soil for the greenhouse, but has

also created a precedent for innovative waste management in the North. The project also has created employment opportunities for marginalized members of the community and ways for local companies to "give back" to the village. Other micro-projects of note include a small horticultural therapy initiative, school visits to the greenhouse, and the development of field trials for potatoes. This research will not only contribute to the advancement of knowledge on food security, ecological design, and community capacity building in the North, but it will also contribute to policy development and will help address the social, economic, and environmental challenges facing arctic communities in a sustainable, culturally appropriate manner.

Key words: arctic sustainable development, Community-Based Participatory Research, local food, northern greenhouses, Nunavik

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Food Security and Sustainable Agriculture in Carmacks, Yukon

Alice Boland and Philip Boland
Little Salmon/Carmacks First Nation, Yukon, Canada

e-mail: pboland63@live.ca

Our goal is to teach local youth how to grow vegetables in a chemical- and pesticide-free manner. We begin in mid-April (dependent upon the weather) and continue until mid-September, with young adults and youth employed and trained by the Little Salmon/Carmacks First Nation to grow vegetables such as: beets, cauliflower, broccoli, turnips, cabbage, corn, beans, tomatoes, peas, onions, carrots, cucumbers, zucchini, melons, potatoes, radish, lettuce, bok choy, and rutabaga. These vegetables are grown in an unheated cold frame greenhouse and are also grown in an outdoor garden using a chemical- and pesticide-free approach. This approach is achieved through making our own compost from organic materials taken from the greenhouse and garden. The result of using this method is that the youth receive training in growing vegetables. This leads to them being able to grow their own food and to teach others. In so doing, the end result is better food security for our community. The youth also learn how to produce food in a sustainable method by using non-chemical means. By using this method, youth garden in a manner that will help keep the land fertile and productive for a longer period of time than through chemical means. Additionally, as the vegetables are grown and harvested, the food gets distributed to the local people including diabetics, single parents, and pregnant women, and to visitors who come to tour the greenhouse.

When Subsistence and Farming Are Not Enough: The Experiences of Rural Users of Food Pantries

Tracey Kathleen Burke[1] and Cara Durr[2]
[1]Associate Professor of Social Work, University of Alaska Anchorage, Alaska USA
[2]Program Manager, Alaska Food Coalition/Food Bank of Alaska, Alaska USA

e-mail: tkburke@uaa.alaska.edu

The discourses of food security in rural Alaska typically focus on the importance of subsistence hunting and fishing and on "locally grown" products that need not be imported. However, food security is also associated with economic security, and low-income people tend to suffer the most when subsistence or locally grown food resources are limited. This poster reports on a study conducted in spring/summer 2013 with rural users of the Alaska charitable food system. We sampled people who use food pantries—people who by definition cannot access sufficient food in other ways. We engaged in one-to-one interviews about what people eat, what people would like to eat if they could, and how they think about acquiring food for their families. We asked questions such as: "To what extent do you participate in subsistence or local agriculture?" "At what point do you turn to formal assistance such as the pantry and what are the social meanings associated with doing so?" and "How do you juggle the costs of food and other costs of daily living?" These questions are important because within the usual discourses of food security, "market foods" (what can be purchased at the store) are often seen as less desirable than local foods, whether subsistence or agricultural. However, market foods are a mainstay of the US charitable food system (pantries, soup kitchens, etc.); thus, these foods are still important for the people who use those services. In our efforts to improve the amount and quality of local foods we must ensure genuine access to those who are already the most vulnerable.

Nutritional Formulation Comprised of Essential Amino Acids, Protein and Phytosterols Reduces Risk Factors for Metabolic Disease in Overweight Individuals with Mild Hyperlipidemia

Robert H. Coker[1,3], Scott Schutzler[3], Nicolaas E. Deutz[2], Jeanne Wei[3], and Robert R. Wolfe[1,2,3]

[1]Center for Alaska Native Health Research, Institute of Arctic Biology1, University of Alaska Fairbanks, Alaska USA
[2]Department of Health and Kinesiology, Texas A&M University, College Station, Texas US
[3]Center for Translational Research in Aging and Longevity, Reynolds Institute on Aging, University of Arkansas for Medical Sciences USA

e-mail: rcoker@alaska.edu

Hyperlipidemia and insulin resistance are risk factors in the development of metabolic syndrome. Studies from our laboratory have demonstrated the efficacy of essential amino acid (EAA) supplementation in lowering plasma triglycerides, and they may also have a beneficial influence on glucose metabolism. We have now included phytosterols in the current formulation, since cholesterol was not lowered in the previous study by EAAs alone. We hypothesized that a smaller amount of EAAs, when combined with whey protein and phytosterols, would facilitate improvements in plasma lipids and insulin sensitivity in adults with mild hypertriglyceridemia. We also hypothesized that the gene expression of lipid enzymes involved in the regulation of lipid metabolism would influence the efficacy of supplementation on hyperlipidemia and hypertension. We enrolled nine subjects who were 50 years or older, had a documented plasma TG >150 mg/dl, and had not recently taken statin medications (within 6 weeks). These individuals performed an Oral Glucose Tolerance Test (OGTT) before and after 4 weeks of thrice-daily (TID) consumption of the oral nutritional supplement. Plasma total cholesterol and LDL levels decreased significantly in all volunteers. In six of the nine subjects, plasma triglycerides fell by 95±13 mg/dl. Gene expression of ZNF259, GCKR, LPL, or APOB was not associated with the responses to the nutritional supplementation. Insulin sensitivity (ISI) and the total AUCins/glucose were significantly affected by leucine/EAAs and phytosterol supplementation. Dietary supplementation of leucine/EAAs and phytosterols may promote favorable reductions of blood lipids and insulin resistance in individuals with hypertriglyceridemia.

Food Security and Local Food Production in Alaska: Status, Challenges and Opportunities

Shannon Donovan[1] and Elizabeth Hodges Snyder[2]

[1]Department of Geography and Environmental Studies,
[2]Department of Health Sciences,
University of Alaska Anchorage, Alaska USA

e-mail: ehodges4@uaa.alaska.edu

Researchers with the University of Alaska Anchorage (UAA) Department of Geography and Environmental Studies and the Department of Health Sciences were commissioned by the Rasmuson Foundation to characterize the challenges, opportunities, and needs associated with promoting and supporting the expansion of local food options in Alaska, and with improving overall food security within the state. Research included a literature review, 46 key informant interviews, and a workshop with key stakeholders and experts of Alaska food systems. Workshop activities included Strengths, Weaknesses, Opportunities, and Threats (SWOT) analyses of various components of food security in Alaska; project idea worksheets; and group prioritizations of Alaska food security needs. Integrated results identified four primary themes: the need for increased production; increased processing and packaging capabilities; improved efficiency and targeting of distribution, retail, and marketing; and increased and coordinated communication and education opportunities. Categories of fundable activities in support of the key themes were also identified. The key themes were then matched with the corresponding Alaska Food Policy Council (AFPC) strategic plan goals and objectives. A summary of the findings will be provided in this presentation, and the complete report is publically available.

Ten Years of Creating Partnerships towards Community Food Security and Northern Rural Development in Manitoba

Kreesta Doucette, Chloe Donatelli, Kelsey Evans
Food Matters Manitoba
640 Broadway
Winnipeg, Manitoba, R3C 0X3, Canada

e-mail: kreesta@foodmattersmanitoba.ca

Food Matters Manitoba (FMM) partners with northerners, newcomers, farmers, and families towards good food. FMM works with youth, families, and elders in 13 northern and remote First Nation Manitoba communities to increase healthy food access, create food growing and preserving programs, and rediscover lost food skills including cooking and harvesting. FMM partners with community members, First Nations, local, provincial and federal governments, schools, businesses, farmers, retailers, and chefs using community economic development principles to build and initiate community food plans and regional initiatives such as the Northern Grocers Forum. Food Matters is a partner in the Manitoba Northern Healthy Foods Initiative (NHFI). NHFI has supported the growth of nearly 1,000 family and community gardens, northern poultry and goat projects, northern greenhouses / geodesic domes, and revolving loan freezer purchase programs in more than 90 communities in Northern Manitoba. The NHFI gardening projects have led to the production of more than 170,000 lbs of vegetables, the purchase of nearly 500 individual and community freezers for food storage, and more than 50 greenhouses, some made from up-cycled landfill-diverted trampoline frames. Food Matters Manitoba has also initiated the federally funded Our Food Our Health Our Culture project (http://ourfoodhealthculture.com) to rediscover traditional land-based food practices and food literacy through a healthy fusion food approach (e.g., northern sushi featuring local fish, mushrooms, and wild rice) and increase access to healthy culturally based foods in schools, communities, agencies and retail settings. The NHFI is also a partner in these emerging programs around Anishinabe foods. The opportunity for microeconomic development is slowly emerging through northern horticulture and greenhouse businesses, seed development, and northern poultry projects. Community development and community economic development approaches that draw on cultural and traditional skills, are rooted in community, and allow for sufficient time for partnership and capacity development are essential to sustainable northern food security and circumpolar agriculture.

Key words: community development, community food security, Manitoba, partnerships

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Store Outside Your Door: Hunt, Fish, Gather, Grow

Gary Ferguson and Desiree Bergeron
Alaska Native Tribal Health Consortium, Alaska USA

e-mail: gferguson@anthc.org

The Alaska Native Tribal Health Consortium (ANTHC) Store Outside Your Door (SOYD) Initiative focuses on the promotion of traditional and local foods by expanding on the concepts of hunting, fishing, gathering, and growing in Alaska. The program works with Alaska Native communities to highlight their local bounty in the “store outside.” Our rural communities are often considered “food deserts,” if just comparing to what is available in the local store. The SOYD program has been working for the past two years to educate and empower communities in the knowledge of how to live vibrantly off the bounty of the land around them. We highlight successful hunters, fishers, and gatherers and help share elder wisdom that has helped our First People survive for thousands of years in the oftentimes harsh landscape in which many of our communities are located. Through workshops, written materials, and mostly through the creation of “webisodes” and social media, we are working with Alaska Native families so children can grow up with healthy, local foods. SOYD addresses food security and its connections to chronic disease and also helps link traditional foods with reinforcing the wisdom in our many cultures and languages. The SOYD program has created a well-received webisode series called “Traditional Foods, Contemporary Chef,” highlighting five regions of Alaska with traditional food recipes and how to hunt, fish, gather, and grow in that region. It continues to expand statewide with more webisodes currently in production. The Alaskan Plants as Food and Medicine (APFM) is another SOYD project that works at re-integrating traditional knowledge of local plants that can be used as both food and medicine. Through workshops, publications, and webisodes, APFM aims to keep traditional knowledge alive and engage our younger Alaska Native audience. Links to ANTHC’s Store Outside Your Door: www.storeoutside.com, www.youtube.com/anthcstoreoutside, www.facebook.com/storeoutside, www.apfm2013.org.

Yukon Agricultural Association – Initiatives and Projects

Sylvia Gibson and Kirsten Scott
Yukon Agricultural Association, 203-302 Steele Street
Whitehorse, YT Y1A 2E5, Canada

phone: 867-668-6864
fax: 867-393-3566

e-mail: admin@yukonag.ca

Farming the Yukon Territory has occurred from the late 1800s to present. During the mid-twentieth century transportation improved, making the demand for local farming less urgent. By the 1970s, interest in Yukon agriculture recovered. This continues today, characterized by various farming ventures, both subsistence and commercial, as well as local food movements and markets throughout the territory. The Yukon Agricultural Association (YAA) evolved from the Yukon Livestock and Agriculture Association established in 1974. The association represents industry in dealing with governments and other organizations and provides cross-commodity support in fostering agricultural development in the Yukon. YAA recognizes the challenges facing Yukon agriculturalists, including the semi-arid climate, cold winters, shorter growing seasons, and lack of large-scale processing and marketing infrastructure. The organization sees these as growth opportunities and works to facilitate such development for its members and the larger Yukon agricultural community. For the last 10 years, YAA has been involved in several infrastructure and equipment projects. These include purchasing farming equipment for Yukon farmers to rent, as well as bringing fertilizer bins to the territory to enable bulk fertilizer use. In August 2012, YAA signed a 30-year lease agreement with the Government of Yukon for a 65-hectare lot. Planning to develop this land as a central agricultural facility to best serve industry needs is in its early stages. YAA also provides information to its 140+ members in the form of speaker seminars, a quarterly newsletter, and website. Members are given the opportunity to advertise their produce through a blog. Also, YAA recently updated the *Yukon Farm Products and Services Guide*, a booklet and website showcasing local farms and businesses to the general public. YAA also works with the territorial government and other food and farming groups to comment on and develop beneficial funding programs, legislation, and development ventures.

Key words: Canadian Agricultural Adaptation Program, history of agriculture, infrastructure development, local food, market expansion, Yukon Agricultural Association, Yukon Territory

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Redefined Northern Security—A Challenge to Arctic Geopolitics?

Lassi Heininen
University Arctic Thematic Network Lead, Geopolitics, Rovaniemi, Finland

e-mail: lassi.heininen@ulapland.fi

Mainstream interpretation is that climate change is the (major) trigger for the recent significant change(s) in the arctic region. Indeed, the arctic ice cap is melting so fast that we behave as if we have “discovered” a new ocean. Although this is a “geopolitical imagination,” and the region is stable with common rules by the UNCLOS, there is a growing uncertainty related to a state of arctic geopolitics as well as a need to redefine northern security: The Arctic has witnessed a manifold growth in its geo-strategic importance. There is a growing global interest toward the region’s energy resources, and their governance plays an important role in arctic geopolitics. All this has been seen as a threat or risk. In addition, there are other kinds of relevant regional and global security problems, such as long-range air and water pollutants, radioactivity, and the impacts of climate change. Also, there are major attractions for mass-scale utilization of natural resources, such as off-shore deposits of hydrocarbons and the potential of northern sea routes for global shipping. Changes in the Arctic are complex and multidimensional and include aspects of geopolitics, geo-economics, and the environment, as well as state sovereignty and globalization, in addition to climate change. Because of these new dimensions, challenges and consequent policy responses, northern security has been changed and broadened. Unlike in their national strategies and policies, the littoral states emphasize “state sovereignty” and national security. If climate change causes a change in problem definition for security paradigms, then preconditions for change must be established. As a result, there would be a new kind of northern security which may be less mystified and controlled by individual states and its (security-) political elite. Finally, much depends on the arctic states, and the criteria by which they make their decisions on the future of the (globalized) Arctic.

The Cross-Border Dimensions of Vuntut Gwitchin Food Security

Tobi Jeans[1], Glenna Tetlichi[2], Norma Kassi[2], and David Natcher[3]

[1]Department of Natural Resources and Sustainability, School of Natural Resources and Extension, University of Alaska Fairbanks
[2]Vuntut Gwitchin Nation
[3]Indigenous Land Management Institute, University of Saskatchewan

e-mail: david.natcher@usask.ca

While food security among arctic communities is undoubtedly being influenced by climatic change, maintaining access to reliable and nutritious food sources is also part of the larger social and political system in which food procurement occurs. It is in this context that this paper will explore the social and political dimensions of food security, with a particular focus on the unique challenges faced by the Vuntut Gwitchin (Old Crow, Yukon) due to their close proximity to the US border. By focusing on the social and political dimensions of food security, this paper will explore: 1) how the enforcement of the US/Canada border has affected the Vuntut Gwitchin's ability to harvest wild foods; and 2) how political and legal restrictions relating to cross-border travel have affected traditional/contemporary food sharing networks between the Vuntut Gwitchin and Gwich'in communities in Alaska. It will be argued that these issues relate directly to indigenous sovereignty and the rights of the Vuntut Gwitchin to define their own policies and strategies for the production, distribution, and consumption of sustainable and healthy food sources.

Key words: Alaska, border policy, food security, Gwitchin, Yukon

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Research in Northern Yukon: What Do Our Changing Homelands Mean for Our Long-term Food Security?

Norma Kassi[1], Katelyn Friendship[2], and Jody Butler Walker[3]

[1]Director of Indigenous Collaboration, [2]Research Officer and [3]Executive Director,
Arctic Institute of Community-Based Research, Yukon, Canada

e-mail: norma@aicbr.ca

For some time, Vuntut Gwitchin First Nation (VGFN) Elders of Old Crow, Yukon Territory, Canada, have been advising the community that hard times are coming and it is time to plan for long-term changes related to food security. In 2008, the Arctic Institute of Community-Based Research (AICBR) was invited to work with Old Crow on climate change and food security issues, work that continued for the next three years. This presentation will describe the work that took place in Old Crow during those three years and what the outcomes were, and also provide a context for additional food security work in the Yukon that is just getting underway. Recently, Kwantlen Polytechnic University (Institute for Sustainable Horticulture) has begun the Yukon Food System Design Project, funded by the Yukon Agricultural Association. AICBR has been invited to contribute to the community engagement aspects of this project. The outcomes of the work in Old Crow will provide an understanding of key factors that need to be included in a territorial-wide food system design, and also contribute to other communities building from this earlier work. The project in Old Crow involved three phases and was guided by the principles of community-based participatory research. Phase I included a workshop that involved researchers, elders, youth, and community members sharing their knowledge on climate change. In Phase II, the community focused on adaptation and evaluating what options and strategies are available in the face of a changing climate. In Phase III, focus groups discussed the next steps for implementing adaptation strategies. Key results included recommendations for the following: creating a long-term storage facility; exploring the possibilities of animal farming; developing land-based and cultural skills in youth; surveying and documenting local areas for fish and small animal populations; increasing opportunities to develop gardening skills; promoting traditional value systems of sharing; and promoting education on healthy diets. The project contributes to ensuring that the citizens of Old Crow will have access to a nutritionally, culturally, and economically sound food system. Recommendations from this project will continue to inform VGFN policy and activities specific to addressing food security issues in the community of Old Crow.

Alaskan Adolescent Nutrition Project

Carol McCarty and Elizabeth Hodges Snyder

Department of Health Sciences, University of Alaska Anchorage, Alaska USA

e-mail: cmccarty@gci.net

Research reveals adolescents fail to consume the recommended quantities of fruits and vegetables, leading to dietary inadequacy. Plant-based foods are needed for life-supporting vitamins and for the subtle effects of phytonutrients that moderate chronic diseases. There are many personal and environmental factors that affect youth food preferences including genetics, food neophobia, education, parental and peer influence, and taste. The Alaskan Adolescent Nutrition Project (AANP) was implemented in a middle school to assess food preferences, behaviors, and knowledge before and after a gardening-based project. The project employed five lessons based on growing plants to maturity in vertical drip irrigation (VDI) units, with measurements from pre- and post-test questionnaires covering plants, nutrition, health, and agriculture. A mixed-method, single-sample, cross-sectional survey of the participants revealed significant findings related to food preferences and gardening plans. Participants preferred a variety of fruits and vegetables, particularly those that are, or have a potential to be, Alaska grown crops—especially berries, broccoli, carrots, lettuce, and potatoes. The implementing teacher and most students were satisfied with the indoor garden, plant viability being the main predictor of student satisfaction and engagement. Some modifications are recommended for better VDI efficiency and to ensure plant viability. A formative evaluation exposed the complications of implementing an indoor garden and complex lesson plans in a crowded science curriculum. While the results showed significant changes in attitude toward fresh foods, changes in plans regarding eating or gardening behaviors were not significant. Results of the project also suggest future efforts should specifically target male youth, emphasize the importance of caregivers' influence, and explain plant-based food health benefits and their role in the prevention of chronic disease. Followup research could measure the persistence of indoor garden effects on youth, if a change in youth behavior affects caregivers, and the sustainability of garden-based instruction.

Food Safety in the Arctic and Human Health: Contaminant Exposure by Dietary Intake

Arja Rautio

Professor, Centre for Arctic Medicine, Thule Institute, University of Oulu, Finland

e-mail: arja.rautio@oulu.fi

Human health and wellbeing are the result of complex interactions between genetic, social, and environmental factors. Global climate change has the potential to remobilize toxic metals and other environmental contaminants, and also to alter contaminant transport pathways, fate, and routes of exposure through diet in humans. The multidisciplinary ArcRisk project (FP-ENV-2008-1, 2009-2014) focuses on human health, and aims to determine how climate-mediated changes in the environmental fate of contaminants affect the exposure of human populations via the food web now and in the future in the Arctic. The project is coordinated by AMAP (Arctic Monitoring and Assessment Program), and there are altogether 20 partners from Denmark, Norway, Sweden, Finland, Russia, Canada, Spain, Germany, Switzerland, Slovenia, the Czech Republic, and the United Kingdom. The ArcRisk project will also provide information about the future scenarios for the development of policies to reduce levels of contaminants and human exposure. Concentrations of persistent organic pollutants (POPs) and toxic metals are still high, especially in traditional food. At the moment, the increasing political and economic interest for the resources of the North may also affect food and water security. For this reason, human health expert groups of the AMAP and SDWG (Sustainable Development Working Group) have in their joint meeting in January 2013 selected 12 indicators to be used for monitoring changes in food and water security in all arctic countries. It is important to start monitoring work immediately.

Mobile Farmers' Markets in Anchorage, Alaska

Shaina Seidner and Elizabeth Hodges Snyder

Department of Health Sciences,
University of Alaska Anchorage, Alaska USA

e-mail: shaina.seidner@gmail.com

The goal of the proposed project is to help improve food security in Anchorage, Alaska, by increasing access to fresh, healthy, and affordable food for low-income populations. A mobile farmers' market could help achieve this goal. Mobile markets are essentially farmers' markets on wheels, taking food to where consumers live. Such markets are gaining popularity in the Lower 48 and data documenting their successes are emerging. Mobile farmers' markets can improve food security by increasing community access to local foods, and in turn raise demand for products of local farmers and producers (Markowitz, 2010). A stronger local food system, where food grown and money used to purchase the product stays in the state, helps support local economies and links local markets (Caster, 2011). After utilizing data from a previously conducted community food assessment, current census tract information and additional existing research on local foods in Anchorage, two or three neighborhoods needing improved access to fresh and affordable foods will be identified. Key informant interviews and surveys will then be used to characterize how to best serve the identified populations through a mobile farmers' market.

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Community Emergency Food Preparedness: The Alaska Food Policy Council Tackles a Statewide Issue

Darren G. Snyder

Cooperative Extension Service, University of Alaska Fairbanks, and Alaska Food Policy Council Governing Board Member, Alaska USA

e-mail: darren.snyder@alaska.edu

The objective of this project is to provide Alaska communities with the tools to address vulnerabilities and increase readiness for disruptions in the supply of Outside food sources. The Alaska Food Policy Council's Emergency Preparedness Committee has created, and is piloting, innovative tools to help communities address their concerns and needs in case of disruptions in food supply. The pervasive question of "What happens if the barges stop coming?" is asked on a daily basis in Alaska communities, sometimes in private homes, other times at the governor's press conferences. In an effort to address this question specifically in the context of food and to provide real solutions to Alaskans, members of the Alaska Food Policy Council (AFPC) have focused on the issue primarily on a community readiness level. This is distinct from either the individual or the statewide levels of food-related preparedness on which the State of Alaska is focused. Two tools thus far created by members of the AFPC for communities are the Alaskan Community Emergency Food Cache System and the Alaska Food Emergency and Community Resilience Template. They are both intentionally broad in their scope to allow for benefit and use by any Alaska community, and are specific enough that they can direct users to begin answering questions that are prevalent in every Alaska community, such as: "How much food is stored or available to harvest in my community at any given time?" "How many days will the stored food last and how many people will it feed?" and "Is it secure from natural and human-related threats?" These are just a sample of the questions that communities are guided to answer for themselves so that they can develop plans and systems to be truly more self-reliant and secure if, or when, the need arises.

Food Security Research at the University of Alaska Anchorage

Elizabeth Hodges Snyder

Department of Health Sciences,
University of Alaska Anchorage, Alaska USA

e-mail: ehodges4@uaa.alaska.edu

Food security is the product of a diverse, integrated food system that sustainably supports food availability, food access, and food utilization for all members of a community. In turn, community access and utilization of safe, nutritious, and culturally preferred foods can contribute to improved physical, mental, and social health. Research can contribute to improving community food security and health by providing insight into specific needs and gaps in the local food system; informing development of innovative solutions and interventions; and characterizing food inequities. Food security and health research has greatly expanded in recent years at the University of Alaska Anchorage (UAA) to meet both the unique needs of Alaska communities and the research interests of UAA faculty and students. This presentation will highlight recent projects conducted at UAA with community partners, and address areas such as nutrition education, local food access mapping, community garden impacts, mobile markets, food justice, and food access adaptation.

Experimental Horticultural Projects in the Canadian Low and High Arctic in the Early 1980s: What Did We Learn?

J. Svoboda, B.M. Bergsma, J.A. McCurdy, M.J. Romer, and W.R. Cummins

Department of Biology, University of Toronto at Mississauga, Ontario, Canada

e-mail: josef.svoboda@utoronto.ca

The high cost of transporting fresh produce to northern settlements was the motivation to investigate the feasibility of growing vegetables in arctic conditions. Native tundra plant species, traditional foods of the Inuit, potato and several short-season vegetables were grown at: Keewatin Gardens near the Arctic Circle at Rankin Inlet, Northwest Territories, in the summers of 1979–1982. A series of 40 A-frame sun-heated greenhouses (area = 3.55m^2) filled with a mix of local soil and organic matter were successfully used, with surplus produce offered to local residents. In 1985–1986 the testing continued in a solar greenhouse at Pond Inlet Gardens; and at Green Igloos Farm, established downslope of two outlet glaciers in high arctic coastal lowland at Alexandra Fiord, Ellesmere Island. Here, from 1982 to 1984, researchers tested growth feasibility in outdoor and indoor conditions. Outdoor treatments were: black plastic "grow bags," filled with cultivated local tundra soil; grow bags covered with plastic mulch; and tundra soil with windbreak. Indoor treatments included two walk-in (area = 28m^2) and 11 reach-in (area = 7m^2) igloo-shaped structures covered with translucent woven polyethylene. Seven potato varieties and seeds of many common garden vegetables were planted in early June to test growth effects of low temperature and photoperiods of 18 or 24 hours. In some treatments tundra plants increased their biomass 400% in one season. In Rankin Inlet armfuls of produce were offered to local residents. In Alexandra Fiord sufficient yield was obtained from the various treatments, especially from the two walk-in greenhouses, to feed a ten-member research group, with the surplus of several cardboard boxes sent south occasionally to the kitchen at Polar Continental Shelf Project, Resolute Bay and to the Commissioner of Northwest Territories, Yellowknife.

Key words: arctic horticulture, cold frame greenhouses, food economy, Green Igloos Farm, Keewatin Gardens, native plants, Pond Inlet Gardens, potato, vegetable production

(see page 98 for paper)

Food Production and Supply Issues in Northern Japan in the Era of Global Climate Change and the Role of the United Graduate School of Agricultural Sciences, Iwate University

Matsuo Uemura

Cryobiofrontier Research Center and United Graduate School of Agricultural Sciences, Iwate University, Morioka 020-8550, Japan

e-mail: uemura@iwate-u.ac.jp

Many Japanese people think that Japan has a relatively mild and stable climate. However, Japan does have severe climatic events (such as low and high temperatures, water shortages, tornados, heavy rains, floods, and snowfall) at various times throughout the year and the frequency is increasing significantly, often resulting in economic crop loss. From 1988–2013, crop losses totaled over 795 billion yen (ca. $7.2 billion US) due to low temperature-related events. Furthermore, few areas in Japan are frost-free year round, and therefore, research is focused on agricultural practices and research programs to meet the needs of growing crops in cold regions. Major crops in the Hokkaido and Tohoku region include rice, grains, potatoes, beans, vegetables, and fruit. The United Graduate School of Agricultural Sciences, Iwate University, was established in 1990 with agricultural schools of four universities (Obihiro University of Agriculture and Veterinary Medicine, Hirosaki University, Yamagata University, and Iwate University) located in northern Japan and provides basic and applied knowledge to develop expertise in agricultural sciences in cold regions. This paper provides information on food security-related activities in our graduate school and examples of how people in northern areas of Japan participate in increasing food production and supply in an era of global climate change.

Key words: cold tolerance, food production, food security, freezing injury, molecular breeding, northern Japan, plants, plasma membrane, United Graduate School of Agricultural Science System

(see page 112 for paper)

Papers Presented
agricultural development

key words:
Alaska, food system, northern agriculture, red meat, sustainable livestock production

M.P. Shipka*[1],
J.E. Rowell[1],
S.C. Gerlach[3],
J. Greenberg[2],
and T. Paragi[4]

[1]Department of Agriculture and Horticulture
[2]Department of Natural Resources
School of Natural Resources and Extension
University of Alaska Fairbanks

[3]Department of Anthropology
Sustainability Science
University of Calgary

[4]Alaska Department of Fish and Game
State of Alaska

*corresponding author,
mpshipka@alaska.edu

Sustainable Livestock Systems for Alaska: Production, Processing, and Marketing

Abstract

The complex relationship between food production, distribution, and accessibility is the foundation for food system sustainability and food security. In Alaska both the ecology and geographic isolation of the state combine to impose logistic stressors on the food system, stressors that are not shared in the same way by any other state in the USA. Alaska and Alaskans are at the end of a very long and vulnerable food chain. Despite high demand for locally produced red meat, a very small percentage of red meat consumed within the state is produced locally. We have the capacity and the land base to produce enough meat to feed many more Alaskans—but we haven't done it! Why not? With the example of a single component of a complex food system—the red meat system—we have engaged the agricultural community in Alaska to help define barriers and identify strategies for the establishment of research priorities and for the development of programs in education and extension that will: a) identify best farm practices, from the production of healthy meat to the health of the ecosystem; b) identify barriers to sustainable red meat production, from farm to market issues including consumer access, affordability, attitudes, and preferences; and c) identify how the University of Alaska can work in collaborative ways with all stakeholders to support the development of sustainable agriculture through research, education, and extension.

Introduction

Alaska is the largest state in the nation, almost one-fifth the size of the continental United States of America, yet Alaska shares no common border with any other American state. Although the majority (67.7%) of the estimated 692,314 people (State of Alaska Department of Labor and Workforce Development, 2009) live in one of the two major urban centers, Anchorage and Fairbanks, a significant proportion of the population is dispersed among rural communities scattered throughout the state. Very few of the rural communities, however, are connected to urban centers by a road or rail system (Fig. 1), and it is the urban centers that are the primary distribution points for commodity foods shipped by barge or air to remote, off-road communities. Collectively, this isolation places Alaskans at the end of a very long food chain (Meadow, 2009; Pirog et al., 2001). The majority of food destined for Alaska travels an estimated

Figure 1. City and village locations within the state of Alaska with reference to the existing road system. The current rail system follows highways #9 and #3. The Marine Highway System (#7) exists along coastal regions of southeast and southcental Alaska. (Map reference: http://geology.com/cities-map/alaska.shtml)

1,600–3,000 miles (Pirog et al., 2001) from producer to the central distribution hubs of Anchorage and Fairbanks and from there several hundred miles more to reach remote communities throughout the state. Foods that best survive this journey are highly processed, boxed or canned and generally of lesser nutritional quality. Increased dependence on this food has contributed to a multiplicity of diet-related health outcomes, with Type II diabetes just one example of a diet-related epidemiological problem (Popkin et al., 2004).

At this outer limit of the food chain, extreme remoteness amplifies not just costs, but also the vagaries and vulnerabilities of production. In recent years Alaskans have come to rely on cash economies and on imported foods. The increasingly high cost of fuel has resulted in fresh food prices that are unaffordable. High fuel costs have also made local food gathering less accessible to many local people because of the cost of accessing food locations Taken together, the net effect has been a dramatic increase in food insecurity for many Alaskans (Gerlach and Loring, 2012). A "perfect food system storm" occurred in many Yukon River communities in 2009. This was driven by the closure of the salmon fisheries followed by fuel prices that made it almost impossible for many to harvest local foods, such as moose meat, and drove up food prices in the local stores to unprecedented levels. It is essential to underscore the fact that the high price of food does not reflect quality, with industrially processed, packaged, and preserved foods being most capable of surviving the many food-miles traveled (Loring and Gerlach, 2010a).

In general, production and procurement options for alternative, healthful foods are limited by the costs and challenges of transport from southern supply centers and by lack of in-state agricultural and manufacturing infrastructure (Colt et al., 2003). Many locations in the USA currently operate with food systems based on a 'just in time' food delivery system. However, few lack redundancy in the delivery system to the extent experienced by Alaska.

With only a single overland route from the contiguous lower 48 states and a single major port serving the main population centers of the state, the risk of food delivery interruption is higher than elsewhere in the country. Add to this the fact that most of Alaska is not served by roads, but by seasonal barge service or airlines at best, and the risk calculation increases dramatically. In this way Alaska's remote communities are akin to islands, with the imposition of seasonality.

Focusing on the red meat component of the Alaska food system, we hosted a discovery conference designed to bring together agricultural producers, scientists, extension agents, representative community leaders, and food policy professionals to address two broad questions: 'Why doesn't Alaska have a sustainable red meat industry?' and 'Can we develop a sustainable livestock production system as a cornerstone for food security in Alaska?' This paper summarizes the main points addressed at the meeting, specifically, those opportunities that fall within the university's tripartite role of education, research, and extension. The full report can be accessed on line (Rowell et al., 2013).

Livestock production: Current situation and barriers to growth

Historically, outpost agriculture—informal and community gardens—filled the gaps created by variations in the harvest of wild game and the unpredictability of the food supply from the lower states (Loring and Gerlach, 2010b). Alaska's northern latitude, remote geography, and distinctive ecological characteristics precluded an agricultural boom as experienced in the contiguous United States (Martin et al., 2008). Instead, agricultural practices developed a uniquely Alaska character due to the ecological limitations of a short growing season and limited infrastructure. The government of the State of Alaska undertook a major effort to stimulate livestock production during the late 1970s and early 1980s. The primary model embraced during that effort mimicked the medium and large-scale agricultural practices of the Lower 48, with limited success. Few of those farms continue today owing to difficulties associated with the application of such practices, competition by federal agricultural programs aimed at reducing rather than increasing crop production, crops designated for livestock feed, and by a contentious lack of cooperation by various groups within the state concerning everything from ports and means of shipment, to land ownership and ability of farmers to gain clear title to the land they were farming.

Lean red meat has been a prominent component of the Alaskan diet throughout history and remains an important part of the culture and human ecology in the state today. Live animals also afford a greater flexibility in processing when compared with high-latitude crops that must be harvested in a short and climatically challenging growing season. Depending on the region and the species, Alaska naturally supports large numbers of indigenous ungulates. At the peak of reindeer herding activity in Alaska during the early 1930s, more than 2.5 million pounds of reindeer meat were exported annually from Alaska to markets in the contiguous 48 states (Hansen, 1952). At that time the number of semi-domestic reindeer was estimated at 641,100 animals (Stern et al., 1980).

Spread across the state are examples of small farms and ranches that produce meat from reindeer, beef cattle, bison, goats, sheep, elk, and yaks, with production models as varied as are the species being raised. Livestock production in Alaska is a diverse, fragmented, and highly independent production system, creating both barriers and opportunities for producers. Some of the prominent and immediate barriers to growing a healthy livestock production system are highlighted below.

Availability of land for agriculture

Alaska may be the largest state in the United States but agricultural land is at a premium, frequently priced beyond what agricultural production can support, largely inaccessible to the road and rail system, and often requires extensive modification to be put into production. Clearing land and conditioning soil is expensive. Available farm equipment is limited and aging and the chronic shortage of skilled labor drives costs up: like other areas of the United States and Canada, the average age of the farmer or rancher is going up too, with one challenge being how to draw a younger and better educated farmer to the field, the system, and the industry. High land and labor costs encumber livestock producers with inflated debt. This is further compounded by many local and state regulations that block agricultural expansion and/or favor urban development, with urban development typically the winner in this game of economics and choice. Effective and strategic land use planning is one solution to this problem, but at present there are only a handful of community development plans in Alaska that even mention food production. Many government programs are contradictory, even working at cross-purposes with one another. For example, the Conservation Reserve Program (CRP) takes land out of production, while at same time other federal and state programs are attempting to expand land availability.

In addition, political and cultural issues continually affect efforts to expand agriculture. A very high-profile issue in Alaska is the interface between private and public lands. Successful expansion of red meat production in the state will depend on our ability to integrate domestic or semi-domestic livestock with the natural and cultural systems of Alaska. This is critical for public acceptance and political support. Zoning the landscape to separate the developed agricultural footprint from wild land values must be undertaken with a proactive agenda and with all affected parties at the table.

Affordable quality and quantity of feed

A livestock industry that depends on imported feed will never be sustainable, anywhere, but especially in an area such as Alaska where the distance from the production source to consumption by livestock is so great. While hay is produced within the state, current hay prices are driven by limited production and the recreational horse market, rather than by the livestock or red meat industry. Alaskans need to be able to produce a greater quantity and consistent quality of nutritious and affordable hay coupled with the infrastructure for storage. Most supplemental livestock feeds are imported, incurring all the vulnerabilities and costs associated with imported food for human consumption.

Processing and distribution

Currently, in-state meat production is destined predominately for home use or farm gate sales. In many of these situations, the producer must fill all roles in the marketing channel, from slaughter to packaging and sale of the meat. While this model returns all revenue to the farmer, farm gate sales preclude commercial sale of the meat because of the lack of inspected slaughter. Despite Alaska's size, there are only six US Department of Agriculture-inspected slaughter facilities in the state. This includes one new operation on a barge permitting access to free-ranged beef cattle on islands in the Gulf of Alaska and the Aleutians as well as another mobile unit specifically aimed at the Native Alaskan reindeer industry on the Seward Peninsula. To gain a market share of the restaurant trade, commercial retail outlets, and export potential, meat products must have federal meat inspection. The regulations governing federal meat inspection were designed and developed for use in the contiguous US and will require creativity, innovation, and skill to adapt to Alaska conditions.

Production models

Farming practices and the species being raised are largely imported and based on farming models developed in the contiguous states. Most livestock operations generally employ low technology. Technologies such as automated feeding, feeding total mixed rations, use of reproductive technologies (artificial insemination, embryo transfer), and computerized record keeping occur only sporadically or not at all. Housing systems are minimal, and systematic grazing management is not widespread. Adoption of many modern technologies has potential to significantly increase production efficiency but introduction and acceptance of new techniques requires education. The lack of place-based agricultural education is also a barrier to recruiting new farmers and retaining professionals (i.e., large animal veterinarians).

Livestock production: Opportunities for growth and expansion

Communication and education

At the discovery workshop education and communication were the predominate needs expressed among all participants, rising to the forefront in virtually every context. This reflected a wide range of needs, agendas, and vested interests. Education has multiple meanings and applications, from classical, didactic learning, to basic and applied research to outreach and extension, all of which form the tripartite mission of the university. The need for fundamental education relevant to northern agriculture came up in all contexts: the education of new farmers; education of children through programs like 4-H and Future Farmers of America; continuing adult education; single-source websites; 'how to' videos; books; pamphlets; and workshops. The need for more site-specific research was clearly emphasized, specifically, research on grazing native and planted pastures for traditional species, such as cattle, sheep, and goats, native and non-traditional species (i.e., reindeer, bison, elk, and yak), as well as multispecies successional and rotational grazing strategies. More research on efficient production of local feeds is needed—what crops are best suited to different regions. Production of local feeds must be coupled with developing storage and transportation capacity at both an infrastructure and social structural level (i.e., cooperatives). Developing low-cost alternatives for clearing and conditioning land is an imperative. The ability to improve soils through recycling local products like fish waste has the potential to reduce costs and when this is coupled with local milling, the benefits spread and remain within the state. All of the above represent small steps that remain compatible with the distinctive ecology of the state and help move small farms towards sustainability.

Research alone is not enough. Research results have to be applied to real farming situations and must be evaluated in the context of economic sustainability. The development of economic tools like enterprise budgets, presented in user-friendly formats on websites or via distance delivery, enables producers at all levels to estimate the real costs of taking on new risks. Communication today is multifaceted, and to be effective, all modes of communication technology need to be engaged. Staying connected is vitally important for farmers and stock growers who need unfettered access to constantly evolving information from agricultural experts, meteorologists, climate scientists, large animal veterinarians, and other professionals.

There are clearly state and federal government regulatory and policy issues that unintentionally obstruct agricultural growth. While policy change is outside the purview of the university, the ability to raise awareness of these issues and enhance the agricultural profile through communication and education is the first step in invoking policy change. Enhancing the profile of Alaska agriculture is critical in any effort to gain public support, especially for agricultural land policy changes.

Livestock Production: Outcomes

It has been two years since the discovery conference. Of all the ideas tabled at the two-day meeting, the formation of a stakeholder group is perhaps the most powerful. A stakeholder group (comprised of volunteer farmers representing different regions in the state) is a mechanism that facilitates dialogue between farmers and the university community. Establishing and maintaining this partnership ensures relevancy in research and facilitates adoption of new techniques. The white paper (Rowell et al., 2013) that summarizes the results of the meeting has served as our initial stakeholder input. The School of Natural Resources and Extension, University of Alaska Fairbanks, is revamping its curriculum in ways that will enable us to incorporate stakeholder ideas more effectively in developing sustainable agricultural courses into a new multidisciplinary program and degree offering. At the university-wide level, the development of a cooperative veterinary medicine program with the College of Veterinary Medicine and Biomedical Sciences, Colorado State University, is accepting its first students in the spring of 2015 with entrance of the first class at UAF during fall semester 2015. This will provide Alaskan students with an opportunity to start a professional career in Alaska as well as exposing professionals from other states to the unique challenges of remote, rural veterinary medicine. Information provided by the stakeholders led to the development and early recruitment of an extension veterinarian, a position designed to interact with livestock producers and providing them with desperately needed veterinary input while bringing producers' issues back to the curriculum. These opportunistic events were made possible because of the communication established with stakeholders.

Research has been initiated on planned grazing in a non-traditional species (muskoxen) and studies using a simulated grazing model will investigate the impact of grazing intensity on soil microbial populations. These studies (to begin spring 2014) have been set up as a demonstration project that will enable local producers to follow the progress and monitor the results for themselves. With a collective voice and cooperative efforts we can move Alaska agriculture forward, developing a food system, uniquely northern in flavor, while laying the framework for Alaska food security.

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alder, bio-energy, biomass, grasses, poplar, willow

Agricultural Production of Biomass as Energy Crops in Alaska

Stephen D. Sparrow[1], Amanda Byrd[2], Darleen Masiak[1], Mingchu Zhang[1], Robert Van Veldhuizen[1], William E. Schnabel[3]

[1]Agricultural and Forestry Experiment Station
[2]Alaska Center for Energy and Power
[3]Water and Environmental Research Center

University of Alaska Fairbanks

Stephen D. Sparrow, corresponding author; e-mail: sdsparrow@alaska.edu

Abstract

Alaska is an energy-producing and -exporting state, but even so, energy is expensive. Many rural communities, especially those not on the road or rail system, use mostly diesel fuel, which is shipped in at high cost, for all or most of their electricity and heating energy needs. If rural communities in Alaska are to be sustainable, they must find cheaper and more sustainable sources of energy. Biomass energy has been proposed as one potentially sustainable energy source that may be cheaper than fossil fuels in many parts of Alaska. A question often raised is: Does it make more sense to harvest naturally grown biomass or is it feasible to grow biomass as an agricultural crop? We have begun several studies in various regions of Alaska, including those in maritime, transitional, and continental climate regions to determine the feasibility of growing either shrubs/trees or grasses as biomass crops. All of these studies are new, so only limited data is available. Data collected so far indicates that under proper conditions and with good management, yields comparable to economically viable yields in other regions are possible. At Fairbanks (continental climate) willows *(Salix)* and balsam poplar *(Populus balsamifera)* produced less than 1 Mg woody dry matter per ha per year on a moderately well drained site and up to 2.5 Mg per ha on a poorly drained site. Grass dry matter yields ranged from about 3 to 9 Mg per ha per year. At the transitional climate zone site, poplars produced an annual yield of almost 5.5 Mg per ha. We do not yet have yield data for the maritime site. At this stage, results are incomplete so we cannot yet determine the long-term sustainability or the economic feasibility of growing biomass as a crop in Alaska.

Introduction

In rural Alaska, home heating accounts for 89% of all energy generated and diesel fuel accounts for the majority of home heating (WH Pacific, 2012). Heating oil is either flown or barged into communities at a high cost, more than $2.50 per liter in some communities (Alaska Department of Commerce, Community, and Economic Development, 2013). Finding a suitable alternative for home heating in rural Alaska, like biomass energy, could reduce the cost of heating and possibly offer energy security in these communities.

We measured the growth rates and biomass yield of both woody and grass biomass when grown as energy crops at four locations in Alaska (Fig. 1). Fast-growing poplars and willows regrow from their base after harvesting (coppicing) and show promise as an energy crop in the right conditions.

Understanding the growth rates, optimum harvest interval, best management practices, and production economics is important for understanding the feasibility of producing biomass in Alaska. If remote communities can successfully grow and manage energy crops, their energy costs could potentially be reduced and the economy, including new jobs, could be increased.

A measurement tool for estimating the standing woody biomass is needed in communities to understand and manage their biomass resources. Allometric

Figure 1. Map of Alaska showing location of study sites.

equations offer a fast estimation of woody biomass using one predictor such as diameter at breast height (DBH) or diameter at 30 cm above the ground (D30). But allometric equations may differ significantly from one location to another, even within the same species.

The primary objective of this study was to determine yield potential for various woody and grass plant species as biomass-energy crops, under agricultural production practices, in different climate zones in Alaska.

Methods

Balsam poplar study in Southcentral Alaska

At Anchorage (16.25°N, 149.81°W, transitional climate, mean annual temperature [MAT] 1.9°C, average annual precipitation [AAP] 410 mm), two-year-old balsam poplar (*Populus balsamifera*) saplings were transplanted in fall 2004 from nearby forests onto a 20 m x 10 m experimental landfill cap on Joint Base Elmendorf Richardson (JBER) (Byrd, 2013). The trees were spaced to provide a population density equivalent to 7,330 trees per ha. The soil in the experimental area consisted of a gravelly sand-silt mixture base layer 180 cm thick and a top layer of sandy-silt with high organic matter (Munk et al., 2011). In March 2011 all trees were measured for diameter at 30 cm and 1 m height and then harvested by cutting 30 above ground level. Total field weight was measured and subsamples collected and dried at 65°C for dry mass. After the harvest, the study area was divided into four quadrants with two quadrants receiving 0 N and the other two receiving a polymer-coated, slow-release fertilizer at 112 kg N ha^{-1} broadcast on the soil surface. The N was in the form of ammonium nitrate. In September 2012 three randomly selected trees from each quadrant were measured for height and diameter and harvested and weighed for regrowth estimations. Sampled trees were dried for total biomass and allometric equation

Table 1. Shrub and tree species tested as potential biomass crops at Yakutat, Alaska.

Botanical name	Cultivar name (for improved or artificial strains) and common name	Indigenous to Yakutat area	Remarks
Alnus rubra	Red alder	No	
Alnus sinuata	Sitka alder	Yes	
Populus trichocarpa	Black cottonwood	Yes	
Populus deltoids x P. petrowskyana	'Green Giant' hybrid poplar	No	Artificial hybrid
Salix alaxensis	Felt-leaf willow	No	
Salix barclayi	Barclay willow	Yes	
Salix caprea x S. cinera	'S365' hybrid willow	No	Artificial hybrid
Salix hookeriana	Hooker willow	Yes	Artificial hybrid
Salix lasiandra	Pacific willow	Yes	
Salix purpurea	'Oncondaga' purple willow	No	
Salix purpurea x S. miyabeana	'Milbrook' hybrid willow	No	Artificial hybrid
Salix sachalinensis	'SX61' dragon willow	No	
Salix schwerinii x S. viminalis	'Tora' hybrid willow	No	Artificial hybrid
(Salix schwerinii x S. viminalis) x S. viminalis	'Tordis' hybrid willow	No	Artificial hybrid
(Salix schwerinii x S. viminalis) x S. viminalis	'Torhild' hybrid willow	No	Artificial hybrid
Salix sitchensis	Sitka willow	Yes	
Salix viminalis x S. miyabeana	'Otisco' hybrid willow	No	Artificial hybrid

development, and analyzed for energy, ash, and nutrient content.

Woody species at Yakutat

We used dormant cuttings of 10 willow species or hybrids and two species of poplar and used transplants to establish two alder species at Yakutat (59.55°N, 139.73°W, strongly maritime climate, MAT 3.9°C, AAP 3835 mm, silt loam soil) in June 2011 (Table 1). We used a randomized complete block experimental design with three replications. We have not yet harvested the plots so yield data are not yet available.

Willow/poplar study in Central Alaska

We established two locally indigenous willow species (feltleaf willow, *Salix alaxensis*, and Pacific willow, *S. lasiandra*) and balsam poplar from dormant stem cuttings at a moderately well-drained site at Fairbanks (strongly continental climate, MAT -2.8°C, AAP 267 mm, silt loam soil) in 2008 and on nearby poorly drained site in 2009. All plots received broadcast application of 50 kg P (as triple-super phosphate) ha-1 and 95 kg K (as potassium chloride) ha-1 at time of planting and were fertilized with 100 kg N (as urea) ha-1 in the second year after establishment. We harvested the plots by hand clipping at approximately 10 cm height at the end of the fourth growing season. Plots at each location were laid out in a completely randomized experimental design with four replications of each species.

Grass biomass trials in Central Alaska

We tested 15 perennial grass species, and one perennial forb (tall fireweed) of which seven were indigenous to Alaska (Table 2). We established grasses by direct seeding in 2010 (a few species were established in 2011) at Delta Junction (strongly continental climate, MAT -1.5°C, AAP 290 mm, sandy loam soil) on well drained soils and at Fairbanks on a moderately well drained site and a poorly drained site. Not all grass species were tested at all locations, and some species were established in single plots at any given location. Replicated trials were laid out in a randomized complete block design with four replications at each site. The entire plot area at each site received 50 kg P (as triple-super phosphate) ha-1, 95 kg K (as potassium sulfate) ha-1, and 40 kg S ha-1, all broadcast applied and incorporated by tillage. Each plot was divided into three parts which received 10, 50, or 100 Kg N (as urea) ha-1 in each year. Plots were harvested in autumn of each year with a flail mower set at 10 cm height.

Table 2. Grass and forb species tested as potential biomass crops in Central Alaska.

Botanical name	Common name	Indigenous to Alaska	Remarks
Delta Junction			
Bromus bieberrsteini x Bormus inermis	Hybrid bromegrass	No	
Bromus inermis	Smooth bromegrass	No	
Calamagrostis canadensis	Bluejoint reedgrass	Yes	Slow to establish, no harvest as of 2012
Chamerion angustifolium	Tall fireweed	Yes	A forb. Did not establish well so plots were abandoned
Deschampsia beringensis	Bering hairgrass	Yes	
Deschampsia cespitosa	Tufted hairgrass	Yes	
Elymus sibiricus	Siberian wildrye	Probably not*	
Panicum virgatum	Switchgrass	No	Poor establishment, no survival over winter, no harvest
Phalaris arundinacea	Reed canarygrass	No	Poor establishment, no harvest
Fairbanks, moderately well drained site			
Bromus bieberrsteini x Bromus inermis	Hybrid bromegrass	No	
Bromus inermis	Smooth bromegrass	No	
Calamagrostis canadensis	Bluejoint reedgrass	Yes	
Calamagrostis nutkatensis	Nutka reedgrass	Yes	Did not establish well, did not harvest
Chamerion angustifolium	Tall fireweed	Yes	Forb
Deschampsia beringensis	Bering hairgrass	Yes	
Deschampsia caespitosa	Tufted hairgrass	Yes	
Elymus sibiricus	Siberian wildrye	Probably not*	
Panicum virgatum	Switchgrass	No	Poor establishment, no survival over winter, no harvest
Phalaris arundinacea	Reed canarygrass	No	Poor establishment even with replanting, no harvest
Fairbanks, poorly drained site			
Agrostis latifolia	Polargrass	Yes	
Beckmania syzigachne	American sloughgrass	Yes	
Bromus bieberrsteini x Bromus inermis	Hybrid bromegrass	No	
Bromus inermis	Smooth bromegrass	No	
Calamagrostis canadensis	Bluejoint reedgrass	Yes	
Chamerion angustifolium	Tall fireweed	Yes	A forb. Did not establish well so plots were abandoned
Deschampsia beringensis	Bering hairgrass	Yes	
Deschampsia caespitosa	Tufted hairgrass	Yes	
Elymus macrourus	Tufted wheatgrass	Yes	
Elymus sibiricus	Siberian wildrye	Probably not*	
Leymus racemosus	Mammoth wildrye	No	
Phalaris arundinacea	Reed canarygrass	No	Considered an invasive weed in Alaska
Thinopyrum intermedium	Intermediate wheatgrass	No	

*Scientists are unsure if these species are indigenous to Alaska, but most authors think not.

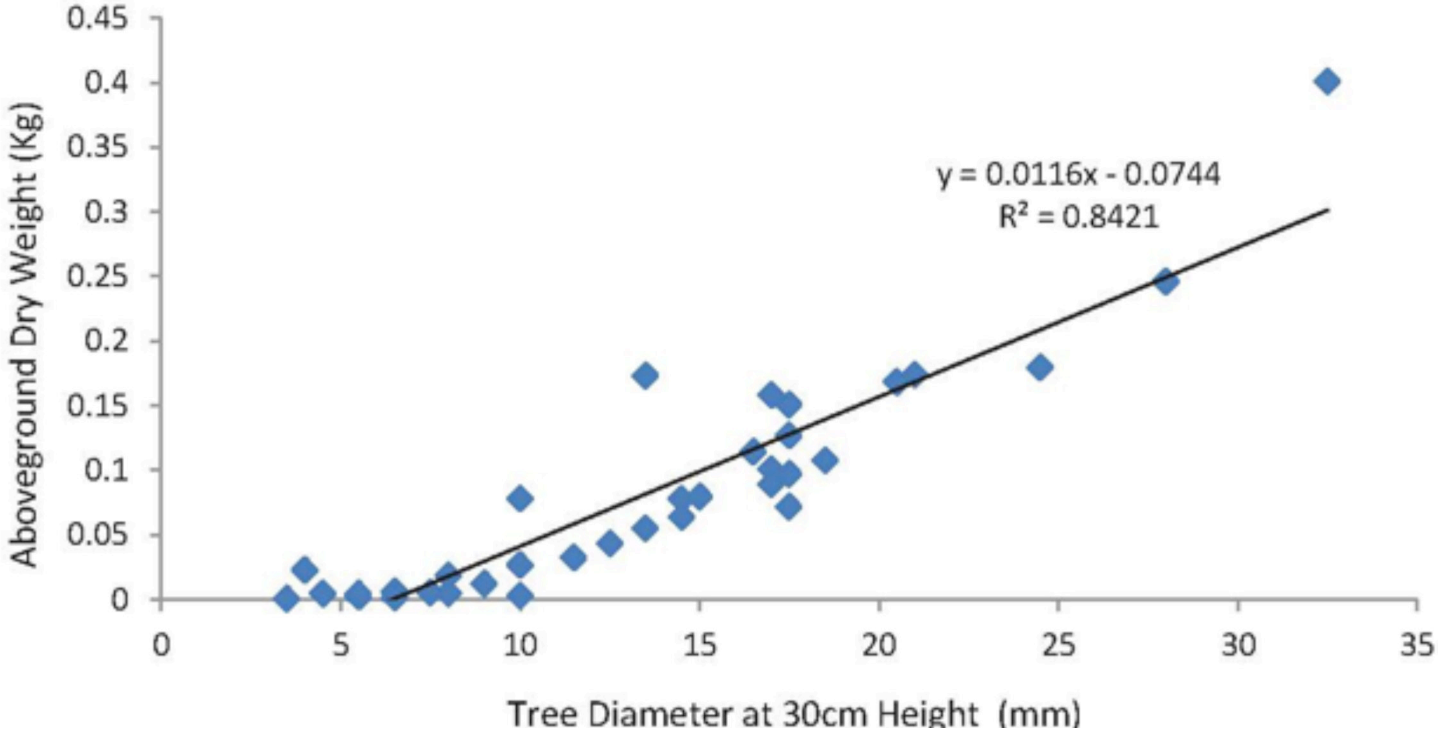

Figure 2. A linear allometric relationship between D30 (diameter at 30 cm height) and dry weight of P. balsamifera *after second-year regrowth.*

Results

Biomass of *P. balsamifera* at the Anchorage site accumulated at an average annual rate of 5.53 Mg ha^{-1} yr^{-1} in the two years after harvest. The energy concentration of the harvested wood averaged 19,685 kJ/kg, for a total energy production of 217,715 MJ/ha after two years, which is equivalent to 5,700 liters of diesel fuel.

Addition of nitrogen fertilizer did not result in increased biomass accumulation of the trees, but instead seemed to promote the growth of the understory weeds.

A linear allometric equation developed for the two-year regrowth (Fig. 2) best described the data, though allometric equations for the seven-plus year first harvest was best described by an exponential equation suggesting that faster growth occurs in the first few years followed by slower growth.

Woody biomass yields at Fairbanks were higher at the poorly drained site than at the well-drained site, with feltleaf willow producing the highest yields at each location (Table 3). If we ignore the establishment year when there was very little aboveground growth, and thus calculate annual growth accumulation based on the three subsequent growing seasons, annual woody biomass yields at the well-drained site never exceeded 1.0 Mg ha-1 yr-1. At the poorly drained site, annual biomass yield for feltleaf willow was 2.25 Mg ha-1 yr-1 and balsam poplar annual yield was 1.16 Mg ha-1 yr-1.

Table 3. Average wood biomass yields at end of the fourth growing season after establishment at two locations at Fairbanks, Alaska.

Species (common name)	Dry matter yield Mg ha^{-1}
Moderately well drained site	
Balsam poplar	1.85 (0.57†)
Feltleaf willow	2.98 (0.28)
Pacific willow	0.42 (0.18)
Poorly drained site	
Balsam poplar	3.47 (0.71)
Feltleaf willow	6.78 (1.00)
Pacific willow	0.70 (0.39)

†Standard deviation, based on four replications.

For grasses at the poorly drained site, where we tested numerous species, we presented only the top three to five yielding indigenous and introduced species (Table 4) in order to save space and because yields of other grasses were very low. Highest yields were for reed canarygrass, which greatly outyielded other grasses with a mean yield of greater than 9 Mg dry matter per hectare in the third year after establishment. Bromegrass produced greater than 7 Mg ha-1 at the moderately well-drained site in Fairbanks in its third year (Table 4). Mean annual yields of other grasses were typically between 3 and 5 Mg ha-1 (Table 4). Yields at Delta Junction were typically lower than those at Fairbanks, probably because the site tends to be droughty, so water deficiency limits growth. Ash concentrations in wood were typically near 2%. Tissue ash concentrations for the grasses varied greatly, ranging from about 3.5% to over 10% with no apparent relationship with grass species.

Discussion

Although biomass yields for this study were lower than has sometimes been reported for high-yielding grasses and woody species in temperate climates, yields for poplars in Southcentral Alaska and grasses in Central Alaska were comparable to yields often reported for cooler regions (Hofmann-Schielle et al., 1999; Landström et al., 1996; Lehtomäki et al., 2008; Mola-Yudego and Aronsson, 2008; Telenius, 1999). Low yields of woody species at Fairbanks may have been because the plants were newly established and had not yet reached their full yield potential. Others (Kopp et al., 2001; Mola-Yudego and Aronsson, 2008) indicated several years may be required for willow and poplar to reach maximum growth potential.

High ash concentrations in grass tissue could be problematic if used for bioenergy. High ash concentrations reduce heating efficiency for direct combustion and increase operating costs due to problems with slagging and fouling of the combustion chamber (Lewandowski and Kicherer, 1997), and cause more air pollution (Launhardt and Thoma, 2000).

Results of this study indicate it may be possible to produce biomass yields high enough to make farming grasses or woody species as feedstock for bioenergy feasible in subarctic Alaska. However, before recommending their use, we need to know more about the determinants of yield for these species and we need research to answer questions about best management practices for optimum yield and quality. We did not have enough information to determine production costs for biomass crops in Alaska and we do not know what price as an energy feedstock they might bring in remote, rural Alaska. Thus, we have not determined the economic feasibility of growing biomass in Alaska.

Table 4. Average annual mean grass biomass yields at three locations in Alaska. Except where noted, yields are averaged over three years.

Species (common name)	Dry matter yield kg ha^{-1}		
	2010	**2011**	**2012**
Delta Junction			
Bering hairgrass	4341 (410†)	3283 (874)	4065 (1139)
Slender wheatgrass	2817 (403)	2940 (298)	4943
Tufted hairgrass	3767 (912)	2424 (339)	3666 (319)
Hybrid bromegrass	No data	4691 (236)	4204 (822)
Siberian wildrye	2580 (358)	2272 (413)	4672 (451)
Smooth bromegrass	2603 (326)	3216 (418)	4950 (429)
Fairbanks, moderately well-drained site			
Bering hairgrass	3723 (1346)	2995‡	3233‡
Bluejoint reedgrass	No data	1893 (459)	4806 (372)
Slender wheatgrass	4496 (1106)	2802‡	2138 (287)
Tufted hairgrass	5088 (785)	2223‡	3307 (861)
Tall fireweed	2112 (510)	2972 (111)	2668 (327)
Hybrid bromegrass	No data	5279 (526)	7216 (1845)
Siberian wildrye	2606 (560)	5111‡	4252‡
Smooth bromegrass	6625 (868)	5023 (382)	7916 (1842)
Fairbanks, poorly drained site			
American sloughgrass¶	1788	2252	5353
Bluejoint reedgrass	1946 (270)	3172 (597)	5374 (1206)
Polargrass¶	1674	3725	3857
Tufted hairgrass	1778 (199)	3729 (641)	4547 (1159)
Tufted wheatgrass¶	1637	2221	4532
Hybrid bromegrass¶	No data	2021	5339
Intermediate wheatgrass¶	4659	2508	5473
Reed canarygrass	4335 (930)	6282 (1296)	9323 (1660)
Siberian wildrye	3159 (628)	3059 (617)	3738 (528)
Smooth bromegrass	2771 (587)	3397 (749)	5294 (1039)

†Standard deviation, based on four replications
‡Two replication harvested, did not calculate standard deviation
¶No replications planted

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agricultural education

"Chicken University": Small-Scale Poultry Production Education in Alaska

key words:
chickens, education, food security, poultry

Stephen C. Brown

Cooperative Extension Service
University of Alaska Fairbanks

e-mail: scbrown4@alaska.edu

Abstract

There are many reasons why Alaskans have shown a renewed interest in small-scale home poultry production. These include a concern for Alaska food security, higher grocery costs, a desire for foods with a reduced carbon footprint, a relaxation of poultry keeping ordinances in some communities, and a greater preference for naturally grown poultry. Based upon Cooperative Extension Service client observations, chickens are the preferred poultry in Alaska. Recognizing the public need for high latitude-based poultry-rearing information, the University of Alaska Fairbanks (UAF) Cooperative Extension Service Mat-Su/Copper River District created a program called Chicken University. The objective of the program is to educate participants on how to raise and manage small poultry flocks in cold climates using sustainable methods with or without electricity. Chicken University is presented as a two-hour program that is free to the public. Topics that are presented include "why raise your own flock," "selecting Alaska-appropriate breeds," "coop design," "incubation," "brooding," "appropriate nutrition," and "disease control." Since 2010 more than 1,000 individuals have participated in Chicken University and it remains one of the most popular UAF Cooperative Extension Service programs in Southcentral Alaska. Of greatest interest to participants is appropriate coop design for protecting flocks from temperature extremes and large predators such as bears. Although most participants choose food security as a reason for raising small poultry flocks, they report they primarily purchase feed made outside of Alaska. Such a situation significantly reduces the actual food security benefits realized by small flock production.

Small-Scale Poultry Production Education in Alaska

More than 100 years ago small-scale home poultry flocks were quite common (Hamre, 2008). This was necessary because many yet-to-be-conquered diseases made large-scale commercial poultry farms too risky. Over time, and partly because of advances in disease control, transportation, refrigeration, and even the conception and development of large-scale farming production, that situation changed, causing small-scale flocks to become much less common (Hamre, 2008). In Alaska, as well as the rest of the United Sates, this trend may have begun to reverse (Gwin and Lev, 2011).

Beginning in 2008, the University of Alaska Fairbanks Cooperative Extension Service (UAF CES) began noticing an increase in the requests for information on rearing poultry in small-scale operations (Brown, 2008b). Prior to 2008 this author received one or two poultry-related inquiries per year, but this increased to its current rate of more than 100 inquiries per year. In response, Chicken

University was developed in 2008. The publicity resulting from Chicken University no doubt fueled a further increase in inquiries in later years. No peer-reviewed research has been found to explain this renewed interest in small-scale flocks, but news and popular media reports hint at the answers. In Alaska the reasons can be broken down into two categories: an interest in returning to more natural/green food sources and an interest in food security (Aronno, 2011; Woginrich, 2011).

For people who want a more natural/green food source, knowing where their food comes from is very important. There is a concern over what kind of drugs the poultry have been given and a concern for what kind of feeds the birds have consumed. Many of these people are also concerned that Alaska's long shipping distances create a very large carbon footprint (Aronno 2011; Woginrich, 2011). Small-scale home rearing of poultry allows the producer to be in control of these issues.

In Alaska there is an often-cited statistic that the state imports 98% of its food supply (Benz et al., 2009). While some question whether this is actually the case when you factor in home gardens, hunting/fishing, and foraging, the percentage is still likely to be high. Because the imported food supply follows a very long multimodal transportation chain, the state is extremely vulnerable to supply disruptions. Despite perceived high costs of small-scale poultry production, many producers believe the higher cost is worth the food supply security (pers. comm.). There is no recently published economic research to support this claim for Alaska. Thus, it appears that the majority of small-scale flock owners fall into the food security and natural food source categories.

In personal interviews with individual growers, the majority of small-scale flock owners cite food security as a reason for keeping a flock. However, informal observation indicates that a majority feed their birds commercial feed produced in part or in whole outside of Alaska. Such a scenario improves Alaska food security by only a small amount compared to flocks being fed entirely by Alaska-derived feedstocks. UAF CES faculty have observed that chickens account for the vast majority of small-scale flocks in Alaska and they are kept primarily for egg production. Flocks are also kept for meat production, but to a much lesser extent than for egg production. Turkeys, ducks, geese, peafowl, pheasants, and quail are also raised in Alaska. The number of small-scale flocks in Alaska is unknown.

Information requests UAF CES received in 2008 indicated that the public's general knowledge of poultry rearing was low. Thus, UAF CES faculty developed outreach programming for small-scale poultry production. The two programs are Chicken University (Brown, 2008a) and Winter Chickens (Bacsujlaky, 2011).

Chicken University is a two-hour overview of the fundamentals of raising a small-scale chicken flock in the Subarctic. It is intended for novices and is a general overview. Many people attending the program have reported they decided not to raise chickens because they were not aware of how much work it entails. UAF CES views a decision not to raise chickens after attending the program as an equally positive outcome as deciding to raise birds. "Chicken dumping" is becoming a problem in the United States as the result of people making uninformed decisions to raise home flocks, realizing it is too much work, and then leaving the unwanted birds at transfer sites, in the wild or in parks, or at animal shelter drop-offs. (Aleccia, 2013). Chicken University has become one of the most popular programs requested by audiences in Southcentral Alaska and around the state, as measured by the number of program requests. In addition to addressing cold-weather husbandry issues, it addresses: "why raise your own flock," "selecting Alaska appropriate breeds," "coop design," "incubation," "brooding," "appropriate nutrition" and "disease control." Since 2010 more than 1,000 individuals have attended Chicken University. The "Winter Chickens" program is very similar in content and delivery as Chicken University program except that it is also available as a DVD for home watching.

These programs are examples of how the University of Alaska Cooperative Extension Service identified an under-met programming need and responded to it. Based upon the growing requests for Chicken University (Brown, 2008b, 2009, 2010, 2011), it is anticipated that the number of small poultry flocks will continue to grow.

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Bilberry – Wild Super Berry from Europe

Laura Jaakola[1,2], Eivind Uleberg[2], Hely Häggman[3], Inger Martinussen[2]

[1]Climate laboratory
Department of Arctic and Marine Biology
UiT The Arctic University of Norway,
NO-9037, Tromsø, Norway

[2]Norwegian Institute for Agricultural and Environmental Research,
Bioforsk Nord Holt
Box 2284
N-9269 Tromsø, Norway

[3]Department of Biology,
University of Oulu
P.O.B. 3000
FI-90014, Oulu, Finland

Corresponding author: Laura Jaakola,
e-mail: laura.jaakola@uit.no

Abstract

Bilberry, or European blueberry (*Vaccinium myrtillus* L.), is economically one of the most important wild berries in Europe. Bilberry grows most abundantly in the area of boreal forests in Northern Europe to Northern Asia and it is recognized for its bioactive properties and high yields of anthocyanin pigments both in the skin and pulp of the berry. Due to these properties there is an increasing interest for utilization of bilberry. Northern European wild berries are a rich and valuable resource with high but unrealized economic potential. Approximately 90–95% of the whole wild berry crop is left unpicked in Nordic forests every year, where they provide valuable nutrition to wild animals and birds. Although increasing, wild berry production has many challenges due to the yearly fluctuations in crop yields, with logistics and questions related to uniform quality of the berries. One critical challenge is, for instance, to differentiate bilberry from other berries, especially blueberries, in global markets. In recent years, a lot of new information has been developed on environmental and genetic factors that affect the content of anthocyanins and other bioactive compounds in bilberries. Studies have also focused on developing DNA-based and chemical methods for authenticity analyses for discrimination of wild and cultivated berries. Also trials for cultivation and semi-cultivation of bilberry have been initiated. Moreover, attempts have been made to increase cooperation between wild berry producers in Nordic countries.

Introduction

Bilberry, or European blueberry (*Vaccinium myrtillus* L.), is one of the most significant wild berries in Northern Europe, especially recognized for its bioactive properties (Prior et al., 1998; Canter & Ernst, 2004). Bilberry is a deciduous shrub characteristic in moist boreal forests dominated by Norway spruce *(Picea abies)*, but it will grow in drier upland forests, heaths, and mountains. It grows most abundantly from the west coast of Northern Europe to the Caucasus toward the northern Asia Pacific coast. In western North America and central Japan a few disjunct populations have been reported (Vander Kloet & Dickinson, 1999). Two subspecies have been delineated according to morphological differences: *Vaccinium myrtillus* ssp. *myrtillus* and *V. myrtillus* ssp. *oreophilum* (Rydb.), but scientific consensus in this issue is not clear (Figure 1). The aroma of bilberry is regarded as special and delicious and no allergenic compounds have been reported in bilberry. Therefore, it can be considered an excellent source for functional food, which means food products that may increase health or reduce disease burden.

Health benefits

Epidemiological studies have demonstrated that a diet rich in fruits and vegetables reduces the risk of certain types of cancer, cardiovascular disease, and other chronic diseases (Hertog et al., 1993, 1995). The health benefits of berries have become widely accepted after the reports of highest antioxidant activity and phenolic compounds in *Vaccinium* berries compared with other fruits and vegetables (Prior et al., 1998). Bilberry is one of the best sources of anthocyanins, the reddish- to bluish-colored phenolic compounds that are strong antioxidants. Bilberry has anthocyanins both in skin and flesh, which explains the high anthocyanin yields compared with many other *Vaccinium* berries (Riihinen et al., 2008). These compounds have been reported to have multiple biological activities including antioxidant, anti-mutagenic, anti-carcinogenic, anti-inflammatory, anti-proliferative, and anti-microbial effects (Landete, 2012). Bilberry also contains high yields of carotenoids, especially lutein, which is also shown to provide protection to eye health (Grover and Samson 2013). Berries are also a good to moderate source of vitamins, in particular vitamin C. (Cocetta et al., 2012). Numerous studies have been performed on health benefits of bilberries and other *Vaccinium* species. Recently, bilberry extracts have been shown to have potential against ulceractive colitis (Ogawa et al., 2011; Biedermann et al., 2013) and Alzheimer's disease (Vepsälainen et al., 2012). Regular bilberry consumption may also reduce the low-grade inflammation related with the cardio-metabolic risk (Kolehmainen et al., 2012; Triebel et al., 2012) and the metabolic syndrome related with obesity and type II diabetes (Suzuki et al., 2011; Lehtonen et al., 2011).

*Figure 1. Bilberry (*Vaccinium myrtillus *L.) leaves and berries at different developmental stages.*

Worldwide markets

Wild berries are a valuable part of European nature and tradition. In the northern and eastern parts of Europe wild berries grow abundantly, and picking wild berries and mushrooms is an important recreation for people in these areas. About half of the utilized wild berries are picked for personal consumption and the rest for commercial use. Wild berries are a speciality that could be used and marketed better. The average bilberry yield in the Nordic countries has been estimated to be over 500 million kg/year, from which only 5–8% is currently exploited (Salo, 1995).

Bilberries have been traditionally used as food and medicinal plants in Europe since ancient times. Nowadays, most bilberries picked commercially in North Europe are exported as frozen unprocessed raw material to the East Asian or Middle European food industry. China and Japan are the biggest buyers, increasingly focusing on health products. The wild berry industry in Europe is typically fairly small and fragmented. One reason for the inefficient berry picking is that the annual wild berry crop yields vary markedly in different areas and crop estimations have been inaccurate using currently available methods. Also the distinctions in forest policies, access rights, and berry picking traditions differ to some extent inside Europe. However, in Nordic countries access rights are fairly similar, and are based on "everyman's rights," which means that berry and mushroom picking is allowed for all people in private forests. One challenge is to find labor for commercial wild berry picking. Moreover, sustainable methods for improving the logistics of wild berry picking are needed. A marketing survey that was conducted recently within the Nordic Bilberry Project, financed by the New Nordic Food Programme, indicated broad interest in increased cooperation between all parties in northern European wild berry businesses and research (Paassilta et al., 2009).

Effect of climate and origin on quality

To better utilize this valuable raw material more knowledge on improving the uniformity of wild berries growing in different areas is needed. Recent studies have revealed that bilberry clones originating from higher latitudes contain more anthocyanins and other phenolic compounds compared with southern counterparts (Lätti et al., 2008; Martz et al., 2010; Åkerström et al., 2010; Uleberg et al., 2012). It has been shown that both the northern growth conditions (long day, cool temperature) and the genetic origin of the bilberry clones affect the content of phenolic compounds (Uleberg et al., 2012). The northernmost bilberry clones had the greatest capacity to produce phenols and anthocyanins and had higher antioxidant capacity compared to southern clones under equal growth conditions (Åkerstöm et al., 2010; Uleberg et al., 2012). Moreover, qualitative differences have been detected in anthocyanin profiles among the different bilberry origins. The northern bilberries have higher proportions of the more hydroxylated anthocyanins, delphinidin glucosides, which are responsible for the bluish hues in berries and flowers. Interestingly, these quantitative and qualitative traits increase linearly from south to north (Lätti et al., 2008; Åkerström et al., 2010). Characterising the attributes related to the growing places of the best wild berry crops could provide sustainable and natural ways to improve the future prospects of wild berry production in a changing climate.

Authenticity

Authenticity analyses of berry raw material as well as berry products are a fundamental part of quality assurance in food supply markets and in non-food applications (Mafra et al., 2008). Especially in wild berry markets, different species are sold under the same name, which may lead to misrepresentation in labeling but also to much more severe consequences depending on the application or type of the product. This is not only a problem with raw material, but with value-added goods. For instance, the relatively high price of authentic bilberry extract has made it a target for adulteration (Dentali, 2007). Thus, authenticity analyses are needed both on raw material and on product to ensure consumer protection and regulatory compliance. Authentication of plant material will take chemical analysis methods, such as high-performance liquid chromatography (HPLC), mass spectrometry (MS), thin-layer chromatography (TLC), NMR (nuclear magnetic resonance) spectroscopy, and Fourier transform infrared (FT-NIR) spectroscopy, (Fügel et al., 2005). However, for more accurate information, DNA-based authentication methods are of interest (Mafra et al., 2008). Related to quality assurance, one such identification interest is to prove the origin or growth place of the species or population. Recently, specific methods have been reported to reveal bilberry adulterations or differences between bilberry origins. A method based on the use of DNA barcode regions and high-resolution melting of amplicons, i.e., multiplied DNA fragments, was developed to distinguish bilberry from other berry species (Jaakola et al., 2010). Primetta et al. (2013) suggested the use of anthocyanin profiles, especially the sugar moieties, for discrimination of bilberries from different geographical origins.

Cultivation/Semi-cultivation

To secure availability of bilberries for commercial exploitation, methods for field cultivation and/or semi-cultivation of natural stands could be a solution. Semi-cultivation of wild stands of *Vaccinium* spp. has been done with great success in North America for decades. The North American relative of bilberry, *Vaccinium angustifolium*, commonly known as the lowbush blueberry, is semi-cultivated using modern agricultural practices such as mechanical harvesting, pruning, and fertilization. Attempts to semi-cultivate *V. myrtillus* were started in Norway and Finland a few years ago in the project "Cultivation of bilberry," supported by the Norwegian Research Council. Knowledge needed for cultivation of bilberries has recently been reviewed by Nestby et al. (2011).

Conclusion and future prospects

There is increasing international interest in the use of bilberry, which is an excellent source for different functional food and non-food products. Clinical studies provide more evidence of the benefits of bilberries and other berries in a regular diet. Yet more studies are needed to show, for example, the benefits of using whole berries vs. specific fractions. Due to its special taste that differs from other blueberries, bilberry is also an important traditional ingredient, especially in the Nordic kitchen. Natural bilberry resources enable much more efficient use of the crop, but there is still a need to develop field and semi-cultivation methods to assure the sustainable production of the raw material in the future. Using wild crops demands more efficient methods for the estimation of crop yields and for improving the logistics of berry picking. Better logistics can also be achieved through the value chain and the use of whole plant material. For instance, side streams from the juice production can be used for other products instead of considering them waste. New methods for authentication enable a better guarantee of high-quality products. Increased cooperation inside the wild berry sector would be beneficial in the promotion of more efficient marketing of the products.

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Building Educational Programs to Promote Food Security for Indigenous Populations in the Americas

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DIANE H. RICKERL[1]
TIMOTHY J. NICHOLS[2]

[1]Professor Emeritus
[2]Dean

Van D. and Barbara B. Fishback Honors College
Honors Hall 119 Box 2705A
South Dakota State University
Brookings, SD 57007 USA

corresponding author:
timothy.nichols@sdstate.edu

Abstract

Our objective was to build collaboration between South Dakota State University (SDSU) and Tribal Colleges and Universities (TCUs). After a whirlwind, information-seeking trip to TCUs in the region, the consensus was that we needed to develop a graduate program for TCU faculty. In 2003, we developed the "Prairie PhD," a graduate cohort for professionals serving Native American communities (Lakota, Mohawk, Anishnabeg, and Native Hawaiian). Coursework was multidisciplinary and included introductions to research methods in both qualitative and quantitative research, human nutrition, land appraisal, ecology, sociology, and environmental management. Two-thirds of those who completed graduate degrees investigated food production and nutrition within their communities. Topics included diabetes education, native food production, native food preparation and nutritional value, cultural traditions and education, and eating habits. One study investigating tribal bison herds identified education as an important part of sustainability.

A component of the "Prairie PhD" program was an international experience at Unidad Academica Campesina (UAC), a rural university in Bolivia serving primarily indigenous populations of the Andes (Aymara and Quechua). During the exchange, students shared knowledge about their traditional foods and medicines, gardening, and the importance of food in cultural traditions. There was shared concern among TCU and UAC representatives about the availability and access to healthy foods in their rural communities. Currently, two students from UAC are completing graduate programs at SDSU and have spent a semester teaching at a nearby Tribal College. Results of the exchange have included the development of culturally sensitive collaboration approaches, research methods, ethics education, and in the future, shared apps about nutrition, health, and food production. Building graduate programs to meet the needs of faculty in colleges and universities serving indigenous communities has contributed to local food access and improved nutrition.

Introduction

The Tribal College movement in the US began in the 1960s. From their beginnings in 1968 with the founding of Navajo Community College, 34 institutions are now members of the American Indian Higher Education Consortium.

Although enrollment in higher education by American Indians and Alaska Natives has increased, there is still a gap in postsecondary educational attainment (Pavel et al., 1998). Barriers include isolation (American Indian Higher Education Consortium, 1999), poverty (Carter, 1999), poor academic preparation, unsupportive educational environments, institutional racism (Feagin, 1996), and cultural discontinuity between Native communities and mainstream higher education institutions (Huffman, 1999; St. Germaine, 1995; Wright and Tierney, 1991). As a result, Native Americans lag behind other US ethnic minority groups in many measures of educational attainment (Harvey, 2001; Pavel et al., 1998).

Nichols (Nichols and Kayongo-Male, 2003) interviewed state university and tribal college collaborators in the upper Midwest. Based on their analyses, they developed a collaboration model with contextual, individual, and organizational factors and collaboration and empowerment strategies. In the model, contextual factors influencing collaboration include history, culture, politics, economics, and geography; likewise individual and organizational factors influence the development of collaboration and empowerment and eventual outcomes. Measures of success on collaboration include development of people (i.e. the educational, personal, and/or professional growth experienced by participants and beneficiaries of collaborative work), policy, resources, and systems (National Network of Collaboration, 1996).

Tribal colleges have an explicit mission to explore tribal cultures and reinforce them using curricula and institutional settings conducive to the success of American Indians (American Indian Higher Education Consortium, 1999). With the development of tribal colleges and mainstream collaboration have come curricula designed to be culturally relevant. Wynia (1999) has identified numerous Native American values, practices, and philosophies to be infused into existing speech curricula. She links important values such as bravery and generosity to speaker apprehension and taking responsibility in interpersonal relationships. She provides examples of how kinship and giveaway practices can be blended into standard speech communication curriculum.

Forbes (as cited in Fox et al., 1992) discusses Native American values with consideration for educational applications. For example, the values of cooperation and face-saving may prevent a student from correctly answering a question if it has already been incorrectly answered by another student. Another example is the view of time as relative and accomplishment as respect building. An understanding of Native American values is essential to understanding Native American students and has become an important criterion for faculty selection and curricula development in tribal institutions.

Also important for collaboration between tribal and mainstream institutions is the development of culturally appropriate research. Cheryl Crazy Bull (1997) commenting on the research agenda said, “We, as tribal people, want research and scholarship that preserves, maintains, and restores our traditions and cultural practices.” Crazy Bull identifies critical differences between Western and indigenous research paradigms. The Western paradigm requires the researcher to remain outside of the experience as an observer and to base conclusions on observation. She believes that qualitative methods are more in line with traditional Native ways of knowing and are more holistic than the European model. The qualitative approach seeks to describe and understand processes, interactions, and relationships, rather than to test hypotheses. Cajete (2000) describes indigenous epistemologies and approaches to science as holistic, emphasizing relationships and connectedness. This approach has been embraced by disciplines such as ecology with a focus on interactions and cycles rather than linear hypotheses.

Since 1993, South Dakota State University (SDSU) has had a growing and productive relationship with Unidad Academica Campesina (UAC) in the cloud forests of Bolivia. The UAC serves rural people of predominantly Aymara and Quechua cultures. South Dakota State University was originally asked to serve a consulting role in the development of a private university system modeled after the US land grant universities. This remote area in the Andes Mountains had little access to educational opportunities and almost no education for women. In their mission statement UAC commits:

> *to make higher education available to young people of rural areas and those who, for whatever reason, are marginalized from the possibility to pursue such studies,*
>
> and
>
> *to integrate the work of the university community into the countryside, developing and strengthening progress and socio-economic liberation through academic, research and extension activities.*

Now more than 800 students in agronomy, veterinary, nursing, and education majors are studying at the UAC. As the UAC has matured, the role of SDSU has also changed. Although many UAC students were able to pass their coursework, few had the opportunity to complete the research projects required for the *licenciatura*. Problems included both a lack of funds for research and a lack of supervision from UAC faculty advisors, who carry a heavy teaching load and often make an eight-hour commute to and from La Paz to teach at the UAC. To address this problem, SDSU faculty have paired with UAC advisors to work directly with students on their research projects. The research collaboration has also improved UAC academic programs through special seminars and workshops. Applied research and outreach programs developing community swine and goat projects, a recycling center, a honey cooperative, and coffee processing projects which have resulted in improved quality of life for UAC students and the community.

Goal and Objectives

The goal was to build a three-way link among SDSU, UAC, and TCU to cooperatively build agriculture/food systems teaching and research models that would serve the needs of impoverished indigenous/international communities. In this dynamic cross-cultural context the objectives were to: (1) build cooperation networks among multi-disciplinary teams of administrators, faculty (teaching, research, and extension), and students from indigenous and mainstream institutions; (2) identify critical components of culturally based education and design coursework/curricula around these components; and (3) identify critical components of culturally based research and design cooperative research projects around these components.

Approach

This year marks the twentieth anniversary of the collaboration between UAC and SDSU, and the tenth anniversary of the publication of the collaboration model proposed by Nichols and Kayongo-Male (2003). Cooperators have included South Dakota State University, Brookings, South Dakota; four TCUs (Oglala Lakota College and Sisseton Wahpeton College in South Dakota, United Tribes Technical College in North Dakota and Nebraska Indian Community College in Nebraska); the Lakota Campus of Presentation College, Eagle Butte, South Dakota; and Unidad Academica Campesina in Carmen Pampa, Bolivia. We used the indigenous collaboration model of Nichols and Kayongo-Male (2003) to develop an international-indigenous approach to education and research. In 2003, the UAC and our TCU collaborators did not have institutionalized international programs. They generally lacked funding for international experiences and thus had not established collaborative programs. Also, the UAC and several of the TCUs did not have institutional review boards to guide research protocol. We knew from collaboration research with the TCUs that initial contact must be personal. There must be a building of respect and trust so that the partners feel empowered and collaboration can build. Our approach was to introduce TCUs to UAC, and using the Nichols-Kayongo-Male model, develop respect, build resource partnerships, improve accessibility, and begin the integration and coordination needed for empowerment. The model (Nichols and Kayongo-Male, 2003) takes into account contextual factors such as history, culture, politics, language, and geography; individual and organizational factors influencing collaboration; and conceptualizes collaboration and empowerment as a dynamic process. With this framework, and by building a strong cohort from this three-way collaboration, we had a base from which to make our education and research programs international and to continue our work to seek additional research resources and to design new curricula. Whether for teaching or research, the general approach was to gain an understanding of needs, seek funding, and build, implement, assess, and adapt programs.

Results

The objectives listed above were not accomplished sequentially, but looped back to each other as the programs grew and continued. Selected examples from objectives two and three are presented here and include the building of collaboration to accomplish the objective.

Examples from objective two identify critical components of culturally based education and design coursework/curricula around these components. SDSU had engaged in a variety of teaching and research projects with TCU. As an outgrowth of this relationship, TCU faculty in the area expressed the need for a program that would allow them to complete terminal degrees. This would significantly enhance research and academic programs at TCU. SDSU responded with the “Prairie PhD.” The Prairie PhD was a cohort graduate education program designed to meet the unique educational and research needs of tribal college faculty, and support reservation agriculture, food systems, and natural resource professionals. Courses were taught by faculty from South Dakota State University and faculty from a consortium of participating tribal colleges. Delivery methods included short courses offered at the Brookings campus and in reservation communities, along with classes via interactive television. The program was envisioned as a one-time offering that would help build capacity and develop human capital in agriculture, food systems, and natural resource professions for reservation communities across the region. Twenty students enrolled during the course of the program and included representation from Lakota, Mohawk, Anishnabeg, and Native Hawaiian cultures. Eighteen completed a graduate degree. The majority are working in professions that serve tribal communities, e.g., TCU faculty and administrators, Indian Health Service professionals, Natural Resource and Conservation Service employees, tribal agency leaders, and private environmental consultants.

Many of the SDSU faculty involved in the Prairie PhD program had also been active participants in UAC research collaboration. In July of 2005, Prairie PhD students and faculty advisors traveled to UAC to share their research and teaching experiences and their cultures. Seminars were presented by students from each country on the topics of education, culture, nutrition, and environmental issues. Co-led tours studying bird and plant diversity were also conducted. During the class reflection, Prairie PhD students shared deep-felt change in their perceptions about linking education and research to community needs, and in their understanding not only of their own cultures, but those of other indigenous peoples. The commonalities between UAC and TCU were realized as participants talked about a desire for research to serve their communities and be culturally sensitive, about limited resource availability, and about problems related to distance and isolation. At the same time, SDSU faculty gained insights into indigenous approaches where teaching and research is both driven and held accountable to the community. These insights offer solutions for many problems that plague 1862 Land Grant Universities such as SDSU. One is the difficulty of building meaningful collaboration with TCU. By building on the strength of this unique three-way partnership we achieved the outcomes of enhanced research, teaching, and community engagement for all participating institutions.

Examples from objective three identify critical components of culturally based research and design cooperative research projects around these components. Research projects with a food systems focus, developed by the Prairie PhD students, included investigations of: re-establishment of native fruit trees, tribal bison management, diabetes prevention, native food and medicine plants, and eating habits. One student designed a research model that was appropriate for Lakota culture and resulted in the establishment of new guidelines for the Institutional Review Board at her tribal college.

As a result of the exchange between the Prairie PhD and UAC students, research funding was developed around the theme of enhancing land use for food production. The approach began with immersion experiences in Lakota and Aymara cultures. It included introductions to language, culture and institutional structures. Next, research priorities were identified and scientific methodologies shared. UAC focused on the reclamation of abandoned coca fields and TCU developed native food plots on lands previously cultivated for row crops.

The shared research experience revealed a need for ethics education for scientists that included cultural perspectives. Funding was procured and a bilingual, distance course was piloted at UAC, SDSU, OLC, SWC, and Presentation College. The development of this course links us back to the education and collaboration objectives, keeping the ideas of interconnectedness, important in many indigenous cultures, as part of the approach.

A recent collaborative proposal is to develop smart phone apps to disseminate research results in rural communities. The information will be presented at three levels: scientist to scientist within discipline, scientist to scientist across disciplines, and university to community. University faculty and students will be involved in the development of information and elementary school students will be involved in bringing the technology to their own families.

Conclusion

One of the Prairie PhD students investigated the reintroduction of bison to tribal lands. Through interviews, surveys, and review of management plans, she identified components of sustainability. Almost all bison herds were initially reintroduced because of the **cultural importance** of the buffalo. Once the herd was located, an immediate concern was "**the land,**" defined broadly as the interaction of land with animals, plants, and people. The herd served the **community** needs for food and culture. **Economics** was of lesser concern, as long as fences could be maintained and a herd manager retained. There was mixed concern for bison genetic diversity and purity, usually handled through transfer and/or harvesting of animals. An unexpected component of sustainability identified was **education**. This included topics from cultural importance to nutritional value of the bison for both tribal and nontribal audiences of all ages. These components may be included in the future development of management plans (recorded by the Inter-Tribal Bison Council) for tribal bison herds. This approach could provide a model for investigating the role of sustainable food systems in building food security in other indigenous communities. Components of sustainability could be identified and their importance weighted according to community concern.

The cross-cultural, cross-continental collaboration described in this paper has been remarkably successful in its work, building educational and research programs to promote food security for indigenous populations in the Americas. Impacts have been positive at the individual, institutional, and community levels. The empowerment perspective, famously articulated by Freirie (1970), reflected in the Nichols and Kayongo-Male (2003) model, and echoed in the mission statements of participating colleges, was foundational to the positive impacts of this work. Positive, trusting relationships, and shared commitment to the larger aims of the collaborative work are among the critical factors that have allowed the shared work to evolve and respond to emerging community needs and program opportunities. These same factors bode well for the partnership's future collaborative work, and may provide a model for others seeking similar outcomes in their work with diverse groups.

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food economy

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Tom Allen

Associate Professor, Department of Bioresource Policy, Business & Economics
University of Saskatchewan
51 Campus Drive
Saskatoon, SK
S7N 5A8 Canada

e-mail: tom.allen@usask.ca

Costs and Benefits of a Northern Greenhouse

Abstract

In Canada efforts to address food insecurity have tended to be reactive in nature and have included initiatives such as the Food Mail Program, Nutrition North Program, food banks, and meal services like school lunch programs. In addition there have been numerous examples of community food production projects in small northern communities. Most, if not all, are supported by government subsidy and/or volunteer labour. The problem is that both subsidies and volunteer labor are inconsistent in the long term.

Over the last several months there has been a renewed interest in developing sources of locally produced food for remote northern communities as centered on using greenhouses as a food production method. The question we are interested in is *"Can healthy food be produced in remote northern communities in an economically sustainable way using a greenhouse?"* This question is of vital importance as both federal and provincial agencies have expressed an interest in supporting remote communities but want to do it as an exercise in community economic development.

The question was approached using two methodologies: first, a financial feasibility analysis where we are concerned with whether the bills can be paid, and second, an examination of a number of areas of benefit—both quantified and non-quantified. The analysis regarding financial feasibility (quantified benefit) suggests that there is just not a big enough market to support a greenhouse in a northern community of 1,000 people. Regardless of the type of greenhouse you construct or what type of heat you use—when it comes down to the fundamental question of generating enough cash flow to sustainably support the initiative, you can't do it.

This does not necessarily mean that a community should not consider a greenhouse. As the conversation about locally produced food in northern community greenhouses moved forward with colleagues and experts from other provinces and territories, it was apparent that many are convinced that the benefits of community greenhouses extend well beyond sustainable economic development. For example improved health outcomes, developing an understanding of what constitutes a healthy food system, supporting education, contributing to the social and therapeutic benefits of community members, and contributing to community pride and engagement are a few of the benefits identified. However, the ability to quantify a number of areas of benefits, especially in social and environmental categories, is limited and such benefits are therefore potentially undervalued in the project evaluation process and worthy projects are not moved forward.

Financial feasibility of a community greenhouse

The question for this study is "Can healthy food be produced in remote northern communities in an economically sustainable way using a greenhouse?"

There have been numerous examples of community food production projects in small northern communities. Most, if not all of the projects that the author is aware of are supported by government subsidy and/or volunteer labor. The problem is that subsidies are not available long-term and volunteer labor is often exhausted and when this happens the project is no longer sustainable.

This question was approached from two perspectives; first, a financial feasibility analysis was completed. In this analysis we were concerned with whether the bills could be paid. The second perspective consisted of an examination of the various areas of benefit related to a community greenhouse, both quantifiable and non-quantifiable.

It was important to look at the financial analysis based on the typical size of a northern community in Saskatchewan. In the Northern Administration District of Saskatchewan there are about 40,000 people living in 37 communities so the model was based on a typical community of about 1,000 people with a greenhouse of 600 square meters built at a cost of about $200,000 CAD. This poly greenhouse would provide an eight- to ten-month growing season with minimal heat and lighting provided. It was expected that the greenhouse could operate as a sustainable commercial venture that produced and sold healthy food ideally generating a minimal profit.

Unfortunately the financial analysis that was completed indicated that it would be very difficult to operate a greenhouse in a community of 1,000 people with no subsidies and no volunteer labor and still break even from a financial perspective.

There are just not enough consumers in a northern community of 1,000 people to make a greenhouse venture economically sustainable. Statistics Canada reported that in 2009 the per-capita consumption of fresh tomatoes in Canada was 7.43 kilograms per year. They also reported that the per-capita consumption of fresh cucumbers was 4.76 kilograms per year. If a modest price of $3 per kilogram is considered for both tomatoes and cucumbers and people purchase these vegetables at the national consumption rate a total revenue of less than $40,000 per year is realized from the top two crops (Statistics Canada, 2009). This revenue is not enough to pay for the labor bill, much less all the other costs of running a greenhouse. The Agriteam group in their report for Agriculture and Agri-food Canada (2013) estimated that on average the total costs of operating a small stand-alone greenhouse would be $43,994, not counting the cost of labor and return to management (2013).

To make the problem even more of a challenge, the people of the typical northern community in Saskatchewan consume vegetables at a level far below the national average. Recently the author of this paper worked with a group of University of Saskatchewan students and completed a survey regarding vegetable consumption in a small community in Northern Saskatchewan. They found the vegetable consumption of more than two thirds of the respondents was below the level of consumption for average Canadians.

It does not matter what type of greenhouse you construct, what type of heat you use, when it comes down to the fundamental question of generating enough revenue to cover expenses in a community greenhouse serving a community of 1,000 people, it is not economically viable.

Similar results were reported in 2013 by the Agriteam group in their report for Agriculture and Agri-food Canada. It is technically feasible to grow food in greenhouses for profit in the northern latitudes. It is the size of the communities that is problematic. It was noted in the Biomass Energy Resource Center's (BERC, 2010a) case studies of biomass systems that there are greenhouses in Finland such as the Nordstrom and Nordmyr greenhouses (the one is 80,000 sq ft, the latter is 160,000 sq ft) producing tomatoes and cucumbers and using wood and peat as fuel. They are financially successful and they are located at about 63 degrees latitude (about as far north as Yellowknife). The difference is that these greenhouses have a market of over 100,000 vegetable-eating consumers within an hour's drive. Finland has an area almost exactly the same as the Northern Administration District of Saskatchewan but a population of about five and a half million, which is more than 100 times the population of the Northern Administration District of Saskatchewan.

One could argue that a single greenhouse could grow vegetables for several communities, thus increasing the market size. This would require establishing a distribution network and selling the vegetables at a wholesale price to retailers in other communities, resulting in a greatly reduced price for the community greenhouse. In fact, the author of this paper worked with one community in northwest Saskatchewan to explore the possibility of a commercial greenhouse supplying vegetables to neighboring communities. Before they even finished their feasibility study two of the neighboring communities also expressed interest in building their own greenhouses and in the end no greenhouses were built.

In an effort to generate additional revenue from a greenhouse various alternatives were explored. It was determined that in some instances there may be other local markets for vegetables, such as larger urban centers or mines, but only a very few communities would have this luxury. In some instances growing other non-food revenue crops may be an option, crops such as bedding plants, flowers, or restoration plants for example, but for most communities these were not a viable alternative. The market for restoration plants was saturated and the market for bedding plants and flowers was too small.

This study initially focused on a traditional model of generating revenue from the sale of greenhouse-produced vegetables. It became apparent that the focus needed to be on reducing costs and finding additional revenue streams. Most northern communities are forced to rely on expensive energy sources and heating a greenhouse using fuel oil, propane, or electricity is prohibitively expensive. A possible alternative is to build the greenhouse with an oversized biomass heating unit and integrate it as part of a district heating system in the community. It would change the whole economic picture, especially if the heating system used local biomass (woodchips) to replace heating oil, propane, or electricity as a source of energy. In essence the greenhouse would become a supplier of heat to the community.

A number of years ago the state of Vermont introduced a *Fuels for Schools* program that pioneered the use of automated woodchip heating systems in schools. Today more than one-third of the schools in Vermont have joined the program and survey results released in 2011 reported that on average the schools each saved almost $50,000 per year on heating costs. That study compared wood to heating oil priced at less than $1.00 per liter (BERC, 2011), which would likely translate to even higher cost savings in northern Canada's climate where winters are considerably colder and longer. A significant savings on heating costs for other community buildings would help offset the revenue shortfall in the greenhouse.

A greenhouse connected to a district heating system involving one or more public buildings (school, band office, store, etc.) appears to be a great match. The greenhouse could utilize surplus capacity of the heating system in spring and fall when the heat demand in the public buildings is low. As the weather gets colder sections of the greenhouse can be shut down. As it warms up in the spring the community can start opening up the greenhouse again. The greenhouse may not end up in full production all year but the vegetable-producing season would be greatly extended. In northern Saskatchewan woodchips should be the least expensive fuel available for a greenhouse. Gibson, et al. (2014) report that the annual cost of heating a school hospital complex in the northern community of Île-a-la-Crosse was $55,891 with woodchips, $226,998 with propane, and $256,598 with fuel oil. They also report that the use of woodchips would keep energy dollars in the local economy, create jobs for citizens of the community and could improve forest health around the community.

The challenge for this model of producing healthy local food is that the wood heating system is external to operation of a greenhouse and local community leaders may choose to use the savings achieved from biomass heating for other needy projects.

Non-financial benefits of a community greenhouse

With this renewed interest in developing sources of locally produced food for remote northern communities much of the discussion has centered on using greenhouses as a food production method. The author is convinced that the discussions related to community greenhouses need to extend well beyond access to fresh and affordable food to include the array of other benefits for community members.

Some of the benefits of community greenhouses that have been identified by the author include:

A. Growing healthy food for local communities.

This goes beyond just accessing healthy food to include the knowledge and skills involved in the production, preparation, and consumption of healthy foods.

B. Increasing consumption levels of vegetables.

Access to healthy foods is important, but so is an increased consumption level of healthy foods. Involvement in the production of foods does appear to lead to increased consumption levels. In an assessment of the school lunch program in

California it was determined that children who actively participated in the production of vegetables consumed more helpings of vegetables in comparison to children who had access to vegetables but were not involved in the production of the vegetables (Wang et al., 2010).

C. Achieving improved health outcomes.

Access to healthy and affordable food, improved nutrition related to the accessibility to good food, and combined with lifestyle changes resulting from working in a horticultural environment can contribute significantly to the health outcomes of participants. It has been widely noted (Vozoris and Tarasuk, 2003; Guicciardi et al., 2009) that there is a strong positive correlation between healthier diets and improved health outcome.

D. Contributing to the social and therapeutic benefits of community members.

This includes improving emotional and mental health through light therapy for the management of Seasonal Affective Disorder (SAD) and by addressing issues of "nature deprivation" as described by Richard Louv (Louv, 2005).

E. Supporting education.

A greenhouse/horticultural operation provides an opportunity to teach environmental sustainability and life science to young people. Bill Swan was project leader when a community greenhouse was built in Invermere, British Columbia. He argues that a greenhouse is the ultimate science laboratory and every school should have access to a greenhouse. This appears to be especially important for students who are less engaged in school, as children thrive in greenhouses in terms of engagement and learning. (Swan, November 2012, pers. comm.)

F. Improving the economic wellbeing of the community.

This benefit is achieved by providing training for employment opportunities, creating jobs for those with limited employment skills, providing business opportunities such as value-added food processing or aquaculture (fish farming) integration, and could provide a hub for promoting entrepreneurship (both social and for-profit).

G. Contribute to community pride and engagement.

Saul and Curtis (2013) note in their description of the evolution of "The Stop" in Toronto that the power of healthy foods can also transform lives and communities.

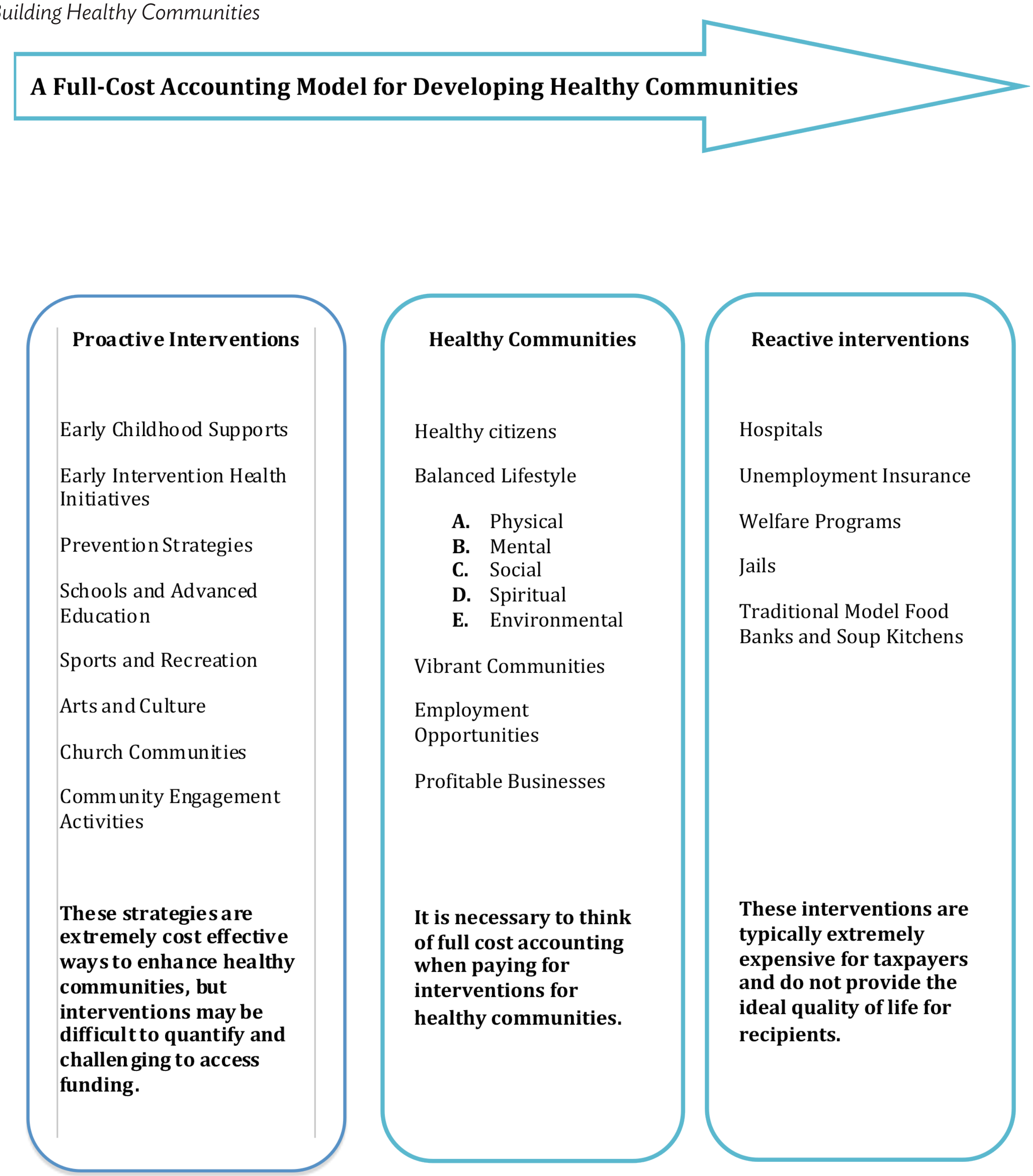
To determine the economic value of a community greenhouse in a northern community one cannot just look at the economic value of the food produced in a greenhouse. Somehow one must factor in the many additional benefits derived from an investment in a community greenhouse. While these can be difficult to quantify, it would be a disservice not only to northern communities but also to taxpayers to omit this information. We have some idea of the cost to society for reactive interventions related to medical needs, the judicial system, unemployment and welfare programs, and food support systems such as food banks and soup kitchens. We know for example that the average direct health costs of a person with diabetes are three to four times the health costs of a person without diabetes (Public Health Agency of Canada), but unfortunately it is very difficult to determine accurately the value of other non-economic benefits of a community greenhouse.

The Challenge

It is obvious that we need a different model to evaluate a community greenhouse other than simply using financial feasibility to address a "build-or-not build" question. In the full-cost accounting model illustrated in Figure 1 it is proposed that if a healthy community is a desired outcome proactive interventions need to be developed. However, if challenges exist in establishing a healthy community, reactive interventions must be put in place. For instance if "healthy citizens" is a desired characteristic of a healthy community we establish early intervention health initiatives. If the desired characteristic of healthy citizens is not achieved we are forced to provide reactive interventions such as building more hospitals to address the shortfall.

Food security is a critical component of any healthy community and as such a community greenhouse should be viewed as a proactive intervention and not simply a profit-generating venture. The decision to build or not build a community greenhouse should be determined by comparing the cost of building and operating the greenhouse with the cost savings from reduced reactive

Figure 1. Building Healthy Communities



interventions. However, a major challenge exists in identifying all the various benefits, and quantification of the value of the benefit is even more difficult. For instance, we know that access to healthy foods is a prerequisite for a healthy diet, but how do we determine what proportion of the monetary value of improved health outcomes should be allocated to access of healthy food? This does not mean that the benefit of healthy food is not real, or has no value, but rather the determination of monetary value is very difficult.

Conclusions

A community greenhouse has the potential to provide significant benefits to the community and society in general. However, we need to ensure that the lack of substantial quantifiable evidence regarding positive benefits does not become a reason to ignore potentially high-value outcomes from proactive interventions such as community greenhouses. Public funding for projects is often based on quantified benefits to communities and the public in general; however, there may be significant health, social, and environmental benefits that are undervalued because of challenges faced in measuring or quantifying them.

What is required is a strong 'weight of evidence' case including the accumulation of rigorous evidence of how a community greenhouse would provide health, social, and community benefits for remote northern communities. A successful case should result in senior levels of government supporting community greenhouses in those instances where there is a strong likelihood that cost reductions in reactive interventions are greater than costs incurred in the construction and operation of the greenhouse.

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Losses of Sheep on Summer Range in Norway

Inger Hansen[1] and Rolf Rødven[2]
Bioforsk Nord

[1]Bioforsk Nord Tjøtta
P.O. Box 34
N - 8861 Tjøtta
Norway
Inger.hansen@bioforsk.no

[2]Bioforsk Nord Holt
P.O. Box 2284
N - 9269 Tromsø
Norway
rolf.rodven@bioforsk.no

Abstract

The majority of two million Norwegian sheep graze on open mountain-range pastures during summer, and are neither fenced nor guarded. Each year about 125,000 ewes and lambs are lost on summer range. Mortality due to predation is increasing in many areas and wildlife administration pays about $12 million USD annually in compensation for sheep killed by protected large carnivores. Red fox, not a protected species, is also considered a main predator. In addition to predation, accidents, common diseases, and lack of micro-minerals increase the complexity of sheep mortality. In this study we have reanalyzed data from radio-telemetry-based mortality studies performed during the last 10 years, including 1170 lambs from 15 farms, with the object of documenting some characteristics of lambs killed by red fox, wolverine, and lynx specifically, and to find farm management factors which may be significant for reducing mortality on summer range. Results show that in a grazing area dominated by wolverine as the main cause of lamb losses, probability of survival was not influenced by the body mass of the lambs at release, whereas in areas dominated by lynx, survival increased significantly with increasing body mass at release. This link was even stronger within a red fox habitat. These results indicate that the "weaker" the predator, the more important the size of the prey. Mitigation measures are discussed.

Introduction

Around two million Norwegian sheep are grazing on unimproved mountain-range pastures during summer, and are neither fenced nor guarded. Each year about 125,000 ewes and lambs are lost on summer range. How many of these are taken by predators is uncertain and a subject of disagreement between farmers and the wildlife administration. The administration has annually paid between 61 and 77.5 million Norwegian kroner (approximately $12 million USD) in compensation for sheep killed by protected carnivores the last five years (www.rovbase.no).

The mortality rate during summer grazing in Norway has increased substantially the past 20 years. In 1990 2.3% of ewes and 4.8% of lambs from a total of 1.5 million sheep registered by the Norwegian Agricultural Authority were lost compared to 3.4% of ewes and 8.1% of lambs in 2010 (www.skogoglandskap.no/kart/beitestatistikk). There is large spatiotemporal variation in the magnitude of losses of sheep in Norway, both between areas, between herds within the same area, and within areas and herds across years. This variation in sheep losses is often speculated to mirror the geographical and temporal pattern in the abundance of predators, but remains to be verified in scientific investigations.

Radiotelemetry-based studies utilizing mortality transmitters have shown that increasing populations of large predators [lynx *(Lynx lynx)*, brown bear *(Ursus arctos)*, wolverine *(Gulo gulo)*, wolf *(Canis lupus)* and golden eagle *(Aguila chrysaëtos)*] are an increasingly important cause of sheep mortality in large parts of the country (Mysterud and Mysterud 1995; Sagør et al., 1997; Kvam and Jonsson, 1998; Nilsen et al., 2002; Andersen et al., 2003; Knarrum et al., 2006; Hansen, 2009). In coastal and lower altitude areas red fox *(Vulpes vulpes)* might be the main predator, even killing lambs weighing more than 30 kilos (Hansen, 2006). Other studies indicate that causes of sheep death are complex and may be related to, e.g., lack of micro-minerals, tick-borne diseases, and the combination of carnivores and disease (Hansen, 2006; Grøva, 2010).

In this study we have reanalyzed data from four radiotelemetry-based mortality studies performed the last 10 years (Nilsen et al., 2002; Hansen, 2006; Hansen, 2007; Hansen et al., 2012), including 1170 lambs from 15 farms, to identify characteristics of lambs related to loss to red foxes, wolverines, and lynx specifically, and to find farm management factors which may be significant for the mortality on summer range.

Material and methods

A total of 963 lambs from four different years and areas were equipped with VHF radio transmitters in order to document the reason for mortality (Table 1, Figure 1). Individual birth weight, spring weight (when released on open summer range), sex, age of the dam, and litter size were registered for all lambs within each herd (N = 1170), in order to document whether the probability of survival was influenced by these predictors.

Every year field personnel monitored for carcasses every day throughout the grazing season from the beginning of June until mid-September. This included animals with and without mortality transmitters. Carcasses found were examined by experts in national wildlife service (Statens naturoppsyn). Carcasses that were not documented as killed by carnivores were sent to the Norwegian Veterinary Institute for further autopsy.

Statistics

Generalized linear models were used to scrutinize how body mass when released into the field, sex and litter size, and their interaction, influenced the probability of survival. Binominal distribution was assumed; hence a logit link was used in the models. As interactions and covariance complicated interpretation of single predictors, Akaikes Selection Criterion adjusted for small sample sizes (AICc) was used to select the most parsimonious models. AICc is a penalized likelihood based selection criterion, where precision and complexity of the model are balanced (Burnham and Anderson, 2002). As the youngest and oldest mothers had lower litter sizes than average, maternal age was excluded from the models to avoid

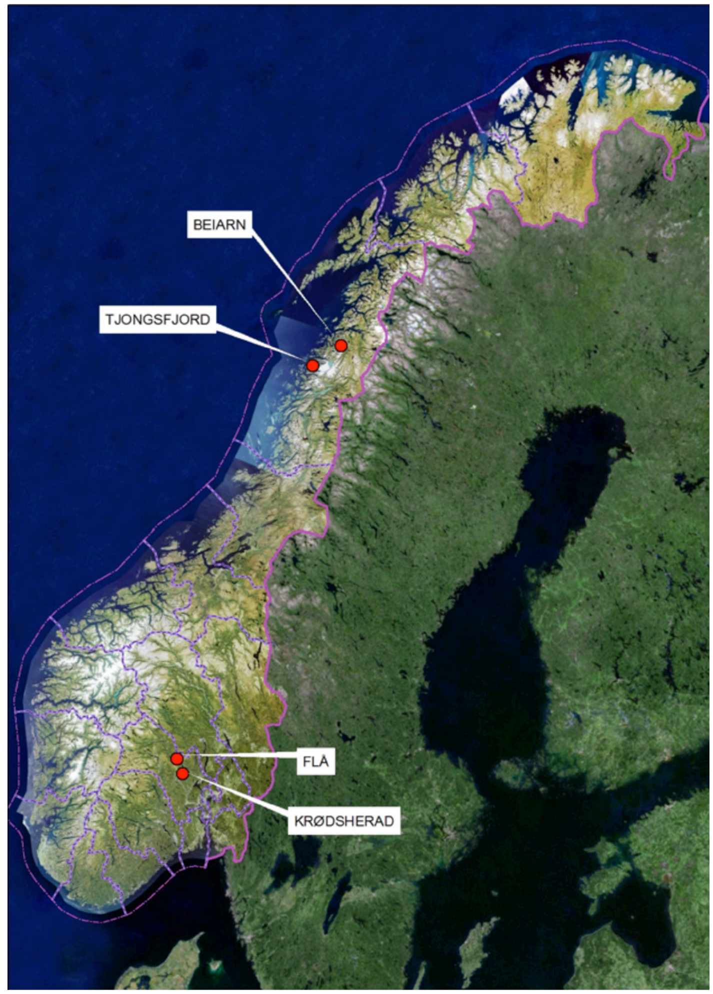

Figure 1. Map pointing out the four study areas.

Table 1. Flocks, animals, and locations of the four mortality studies performed.

Year	# of flocks	# of lambs with mortality transmitters vs. total # released on summer range	Area
2002	4	272 / 288	Beiarn, Nordland county
2006	6	277 / 277	Tjongsfjord, Nordland county
2007	3	182 / 182	Krødsherad, Buskerud county
2011	2	232 / 423	Flå, Buskerud county
In total	15	963 / 1,170	

unbalance. Predictors are referred to as significant if their 95% confidence interval (95% CI) does not include zero.

Results

Losses and causes of death within the different study areas

In Beiarn 84 lambs out of 272 lambs with mortality transmitters were lost (31%, Table 2), of which 53 carcasses were found. For eight of these we were unable to document the cause of death. Out of 45 lambs with known mortality cause, 38 lambs (84%) were killed by wolverine, one (2%) was killed by golden eagle, three (7%) died from disease/starvation, and three (7%) died in accidents. The probability of survival was not influenced by the body mass of the lamb at release or any other of the predictors (ΔAICc>0.59, Fig. 2).

In Tjongsfjord 62 out of 277 lambs with mortality transmitters were lost on summer range (22%, Table 2). Of these, 53 carcasses were found, of which the mortality of 28 was classified "unknown cause of death." Out of 25 lambs with a documented reason for mortality, 13 lambs (52%) were depredated by red fox, 10 (40%) died of illnesses, and two died in accidents (8%). The probability of survival increased strongly with increasing body mass at release (logit estimate: 0.17, 95% confidence interval [0.03,0.31], Fig. 2). None of the other predictors were included in the most parsimonious model (ΔAICc>1.13).

In Krødsherad 34 out of 182 lambs with mortality transmitters were lost on summer range (19%, Table 2). Five lambs had an unknown cause of death. Out of 29 lambs with a documented cause of mortality, 27 were killed by lynx (93%), one died of illness (3.5%) and one died in an accident (3.5%). Survival increased with increasing body mass at release (-0.78, 95%CI [0.22, 1.48], Fig. 2). However, the most parsimonious model included lower survival for males than females (-2.87, 95%CI [-6.29, 0.27]), as well as an interaction between litter size and sex (1.17, 95%CI [-0.27, 2.75]) and litter size and body mass (-0.35, 95%CI [-0.68, -0.08], ΔAICc>0.68).

In Flå 16 out of 232 lambs with mortality transmitters were lost on summer range (7%, Table 2). Out of 15 lambs with a known mortality cause, 13 (87%) were killed by lynx and two died in accidents (13%). There was no significant difference in losses on range between lambs with and without mortality transmitters. The results correspond to the findings in Krødsherad and document that lynx are the main reason for lamb mortality on range in these two areas.

Table 2. Lamb losses and mortality causes for radio-tracked lambs lost on summer range within the four study areas.

Study area	Lamb losses (%)	Causes of death (%)		
		Carnivores	Disease	Accidents
Beiarn	31	84 (wolverine) 2 (golden eagle)	7	7
Tjongsfjord	22	52 (red fox)	40	8
Krødsherad	19	93 (lynx)	3.5	3.5
Flå	7	87 (lynx)	0	13

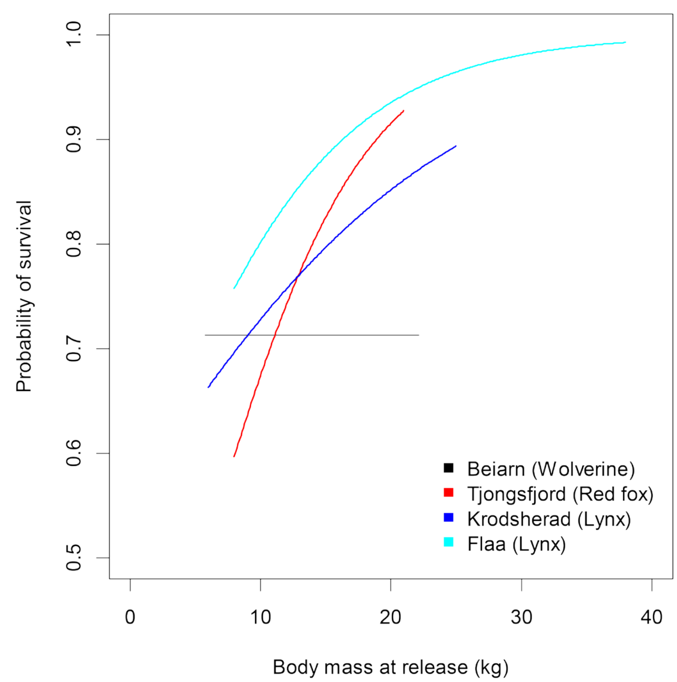

Figure 2. Probability of survival versus body mass of lambs at release for the four different areas. The main predators in these areas are indicated in brackets.

Survival increased with increasing body mass at release (0.13, 95%CI [0.04, 0.23], Fig. 2). No other predictor was included in the most parsimonious model (ΔAICc>0.79).

Characteristics of lambs killed by the different carnivore species

The wolverine most often kills by an effective and strong neck bite. Losses of lambs in Beiarn were relatively low in the beginning of the grazing season, but accelerated around August 25, mainly due to an increase in the number of lambs killed by wolverines. This is typical for wolverines, which hoard prey during autumn for the winter.

The red fox has a less powerful bite than the wolverine; consequently, lambs killed by foxes have many bites around the neck region. The red fox, like the wolverine, may decapitate its prey. In Tjongsfjord, killings by red foxes and diseases [coccidiosis, micromineral deficiency (selenium, copper, cobalt), and poisoning by the plant called bog asphodel *(Narthecium ossifragum)* causing kidney failure], were the dominating causes of death the first two months on summer range. However, a lamb weighing more than 35 kg was depredated by fox as late as September 18. Additionally, three other lambs above 20 kg were killed by foxes. A majority of the depredated lambs had coccidiosis and may have been weak at the time of attack. Two of the heaviest lambs killed by foxes had marginal Se-status, which might result in weak muscles and stiff legs.

The lynx kills its prey by a very precise and effective throat bite. Lambs were depredated by lynx in Krødsherad and Flå throughout the whole grazing season and the majority of these carcasses were located in the lower elevations (woods) of the grazing area.

Discussion

Throughout three of four areas in this study, mortality is linked to body mass of the lambs when released, indicating that the "weaker" the predator, the more important the size of the prey. We have also seen from these and other mortality studies that flocks that are well managed by farmers following best practices regarding preventive health care measures lose less animals due to disease. When such herds graze unprotected on free range in carnivore habitat, close to 100% of the losses might be caused by predation, as in Beiarn, Krødsherad, and Flå. In Tjongsfjord, the farmers did not always follow best practice, resulting in more diseases and deficiencies and which made some of the lambs easy prey, even for the small red fox. This was also indicated by the rapid increase in survival among heavier lambs. We recommend all sheep farmers join the Sheep Health Services (SHS) run by the Norwegian meat and poultry research center, Animalia (www.animalia.no). The SHS offers examination of the herds and management system and gives advice about feeding, management, animal welfare, and preventative health care.

Hunting during the ordinary hunting season is the most effective measure against red fox damages. Improving the condition of the lambs also increases the survival rate from attack by red fox. This measure may, however, be less likely for stronger predators.

As wolverine is a protected species, the best mitigation measure against wolverine predation is to take the sheep home from the mountain range a month earlier (in mid August) than usual, presupposing that there are lowland pastures available for the flock. In Norway only licensed hunting (motivated by the need for reduced damages) is allowed from September 10 until February 15. However, in the northern parts of Norway there are only a few hours of light during the day at this time of year, which makes hunting extremely difficult.

Trapping of lynx and wolverine is hard, since the regulation states that traps (wooden boxes) should be inspected physically twice a day. Red fox traps have to be examined once a day. Other types of trapping, like snaring, are not allowed. In management zones where increasing lynx population is a national goal, as in Buskerud, the best mitigation measure is to separate the sheep from the lynx by moving the herds from forest ranges up to mountain ranges. This will have a long-lasting effect on the losses due to lynx. To achieve reduced losses in lynx habitat there will be a need for grazing within enclosed pastures, with additional preventative support by electric fencing or by the use of guardian dogs. Licensed hunts of a specific number of lynx is taking place each year, hence this quota hunting may be an important stock regulating measure.

Conclusion

Mortality is linked to body mass of the lambs when released, indicating that the "weaker" the predator, the more important the size of the prey. Mortality caused by red foxes and diseases are factors the livestock farmers in some way can prevent, whereas mitigation measures against protected carnivores and accidents are harder to find. The most effective measures toward depredation are those that separate livestock and carnivores in time and space, like electric fencing or early gathering. However, these measures are in conflict with traditional sheep management in Norway based on free range summer grazing.

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Developing Sustainable Small Businesses in the North: The Case of Northern Food Producers and Distributors

key words:
ambidexterity, food producers, resources, small firms, social sustainability

Svein Tvedt Johansen
Harstad University College
NO9480 Harstad, Norway

phone: +47 77058262

e-mail: svein.johansen@hih.no

Abstract

Food security and healthy northern communities depend on commercially viable, locally owned small producers. Northern locally owned food producers share a series of characteristics: They tend to be strongly embedded in and share a common interest in the wellbeing of local communities. Northern food producers hence depend on local communities for legitimacy, services, and infrastructure whereas local communities rely on local food producers for jobs, tax revenues, and local demand to support other businesses. This paper develops a series of related arguments; first the paper argues that locally owned food producers and distributors help further food security through an emphasis on place and local relationships. The paper then goes on to show how these businesses are vulnerable to demographic and environmental shifts as well as competition from large, vertically integrated food companies. To address these challenges, northern locally owned firms will need to develop resilience and ambidexterity—combining tradition and identity with innovation. The last section of the paper looks at how resilience can be developed.

Introduction

Locally owned small- and medium-sized firms, or SMFs, play an essential role in the production and distribution of food in the circumpolar North. They also play an important role in enhancing food security in the North, which is why developing resilient local SMFs in the form of northern food producers and distributors constitute a critical yet perhaps less obvious way of enhancing food security in the circumpolar North.

Most food companies are small: Using the Norwegian food industry as an example, 77% of Norwegian food producers employ less than 20 people; only 5% employ more than 100. Small producers generate 6% of the total revenues within the Norwegian food industry while medium sized (20–99) and large (>100) generate 47% each (Steine and Kjus, 2011). The food industry in Norway is also evenly distributed, providing an important source of employment particularly in rural areas, including northern rural regions (e.g. Finnmark). Among small food producers, a vast majority of these are locally owned (Steine and Kjus, 2011). Locally owned SMFs differ in several ways from non-local firms in ways that have important consequences for both local communities and the environment.

Local owners by definition form part of their local community and as a result are more likely to feel an affinity to their local community and hence be more willing to contribute to the community by hiring local people, supporting community purposes, or supporting other local businesses. As such, locally owned businesses are more likely to contribute to the development of social capital in the form of relationships and a common sense of shared solidarity within the community than non-local firms.

Locally owned firms and their owners hence are likely to have goals that extend beyond profit maximization. In fact profitability may, in many cases, constitute a side constraint or a condition for developing the business and, by extension, the community rather than an absolute end in and for itself. Many small, locally owned companies operate out of very small communities in which the distinction between the business and the community becomes blurred as the interests of the community and that of the business become closely intertwined. For some businesses (including indigenous businesses) a family business may often constitute a means of preserving a heritage and a traditional way of life. Success here entails not only financial success but the success of maintaining heritage.

A recent study based on US-register data (encompassing a total of 34 million establishments between 1990 and 2007) concludes that the prevalence of locally owned small firms (10–99 employees) has a positive effect of per capita income growth in their respective communities (Fleming & Goetz, 2011).

Locally owned firms are more likely to source locally and take advantage of local suppliers. This can be contrasted with larger non-local firms where sourcing is usually managed centrally, drawing on a limited number of large suppliers. As a result locally owned firms tend to create more wealth and more work in their communities than non-local firms (Fleming and Goetz, 2010).

Locally owned businesses may help secure food security and environmentally sound food production and distribution through four related mechanisms. First, locally owned firms (e.g., food retailers) tend to be closer to their customers and enjoy shorter lines of command. As a result of their proximity to their markets they are more likely to be motivated as well as able to detect and cater to local needs and demands than are non-local firms. Locally owned firms, because of their stronger identification with the community, are also more likely to forego short-term profits in serving community needs. Because local firms begin their strategizing with the premise of a specific location and identifying with a community their strategies are likely to be developed around how such strategies affect and benefit local communities. This can be contrasted to the more rootless larger food producers and retailers, where location often becomes a question of convenience—given what we seek to produce or our ambitions of growth, where should we be located?

Managers of locally owned SMFs tend to live closer to the environment they affect (rivers, farmlands, etc.) and as a result develop a better and more intimate understanding of their environmental impact. As a result they are better positioned to make adjustments when needed (Andersen, 2011).

Local firms' association with the local community and the physical location in which they are situated also means that they will have a greater interest in preserving the local environment than non-local firms, which may just as easily move to a different community.

Finally and somewhat more indirectly, locally owned firms may, through their reliance on local sourcing and local customers, help develop strong local communities which may again help secure environmentally sustainable food production by preventing unsustainable food production. Jentoft (2000) makes a convincing case that strong communities can effectively reduce the likelihood of over-taxing common natural resources by developing a sense of shared identity and solidarity between members in the community and by developing and enforcing a set of common norms.

Challenges

Yet, locally owned northern food producers and distributors face a number of challenges.

Locally owned firms in rural communities are challenged by demographics: An exodus from smaller communities to larger cities is taking place across the circumpolar North, to cities that include Anchorage in Alaska, Tromsø or Alta in northern Norway, or Rovaniemi in Finland. Arctic regions of Russia are losing population with young people seeking employment elsewhere. The flow of people from rural areas to larger settlements or cities means shrinking local markets, greater difficulties attracting employees, and fewer local businesses with which to interact and cooperate.

Other challenges include costly distribution resulting in often extreme disparities in the prices offered to northern communities when compared to retail outlets further south. *Huffington Post* thus recently described the situation in Nunavut where a head of cabbage cost $28 CAD (Strapagiel, 2012). A dispersed population and demanding weather conditions are constant aspects of doing business in the circumpolar North.

Because local food producers tend to be small and embedded in their communities they are also likely to be more severely affected by altered weather patterns or pollution—local producers, unlike larger firms, cannot easily move their business without substantial and in some cases insurmountable costs to the company.

Smaller firms are also facing relentless competition from larger food firms that bring with them economies of scale and scope, more efficient, dedicated distribution systems, and extensive leverage with respect to suppliers. Four chains thus control nearly all food consumption (for home use) in Norway and have a combined market share of nearly 100% (Valvik, 2011). More recently one of the four chains claimed that they would need to discontinue their line of grocery stores in northern Norway (many in rural areas) if they were not allowed to cooperate with another of the big four on procurement and distribution (Anda, 2014).

New regulations and control regimens intended to further food security often favor larger firms that can afford to make the necessary investments in people, equipment, and organization but can be relatively much more costly for smaller firms that still face the same set of regulations. On the other hand, other regulations such as stricter regulation of CO_2 emissions may favor local food producers over the larger multinationals which transport food using ships fueled by hydrocarbons (Golicic, Boerstler, and Ellram, 2010).

Resilient northern SMFs

These challenges raise the question of resilience or how locally owned SMFs can withstand and even prosper given these challenges. An elaborate, yet useful definition of resilience is offered by Horne and Orr (1998: 31) which defines it as "a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior". Resilience here is the opposite of threat rigidity in which firms faced with an approaching crisis stiffen and respond by just doing more of the same (Staw, Sandelands, and Dutton, 1981).

If northern communities are undergoing change we need local food firms capable of adapting to and dealing with change, including the ability to sense and shape opportunities and threats, seize opportunities where these exist (in the form of unused farmland or through identifying innovative combinations of tourism and food production), and finally maintain competitiveness through enhancing, combining, protecting, and where necessary reconfiguring business assets (Teece, 2007). Together these capabilities constitute what Teece refers to as dynamic capabilities.

Successful adaptation implies combining what appear to be contradictory capabilities—on the one hand the ability to exploit existing technologies and knowledge, in some cases including centuries-old traditions, and on the other hand the ability to explore and benefit from new opportunities when and where these arise (March, 1991).

At the extremes, doing one thing over the other (exploring or exploiting) may bring companies down. Simply doing more of the same, exploiting existing knowledge, is likely to create rigidities and incompatibilities between a company and the environment that can eventually destroy the company or impose radical changes on the firm. Continuous exploration without exploitation, on the other hand, is likely to result in firms with no real competencies or competitive advantage on which to capitalize (March, 1996).

Thus, successful firms, in order to *preserve traditions* and *maintain their identity* will need to continually change and reinvent themselves, yet without compromising their very identity. Small companies will need to effectively align exploration of new markets and technologies with exploitation of existing ones. A sense of place and identity can help firms to steer exploration and better align that exploration with exploitation (Scott and Yanow, 1993).

Ambidexterity in the organization literature refers broadly to "an organization's ability to pursue two disparate things at the same time" (Adler, Goldoftas, and Levine, 1999). Examples include aligning manufacturing efficiency and flexibility or customer orientation (Gibson and Birkinshaw, 2004). Gibson and Birkinshaw differentiate between two types of ambidexterity: structural ambidexterity, in which different ends are served through structural separation with one organizational unit focusing on efficiency while another unit works towards serving customers; contextual ambidexterity refers to building a business unit context that encourages individuals to make their own judgments on how to divide their time between conflicting demands (Gibson and Birkinshaw, 2004). Contextual ambidexterity thus refers to a meta-level ability that permeates all functions in an organization (Duncan, 1976).

Small locally owned northern food producers or distributors are unlikely to have the size or resources needed to attain structural ambidexterity. Instead they will need to either develop an alignment between different ends, such as for exploiting existing technologies and know-how while simultaneously pursuing innovation, or they can achieve ambidexterity through connecting and cooperating with other SMFs such as by pursuing innovation and product development in collaboration with other firms.

As a result, ambidexterity in locally owned small food producers can here be seen as resting on two critical resources. The first resource is the quality of the management. Owners and entrepreneurs often profoundly shape the companies they lead. Effective managers will need to have the oversight, understanding, and creativity to detect and react to weak signals. Effective leaders also need to be able to explain the need for change and the content of change to other stakeholders and employees. Aligning the message of continuity and change constitute one way of bridging the potential conflict between exploration and exploitation.

The second resource lies in local firms' relationships with other individuals, institutions, and firms and their ability to access resources from such relationships. Networks are particularly important for small firms and northern SMFs which are unlikely to control all essential resources (Nootebom, 1994).

Small local firms are likely to depend on two types of networks: local networks and non-local, more distant relationships. Local networks here include relationships between the firm and other firms, and organizations within the local community. Non-local relationships or more distant relationships includes relationships outside the local community and can include distributors, advertising agencies, funding agencies, and more. Strong ties within a community are likely to be important to leverage valuable resources including loyalty and support. Yet non-local and more distant relationships are more likely to offer different perspectives and insights. Research demonstrates how strong but heterogeneous ties with other companies foster innovation in small firms (Gronum, Verreynne, and Kastelle, 2012).

Different relationships are likely to impose different types of demands on a business. While a sense of citizenship or loyalty is likely to be important within a local community and with respect to committed partners, non-local contacts will more likely value efficiency and effectiveness and have questions about the expected pay-off from interacting. Managing different relationships will as a result be likely to involve managing different expectations while attending to different types of logics.

A market logic in the more distant relationships as opposed to e.g. a more communitarian, local logic may in effect be seen as constituting different 'languages.' Effective managers and entrepreneurs as a consequence may need to be 'bilingual' or well versed in the different logics that underlie different relationships (Fiske, 1992) in order to effectively access critical resources in different types of relationships.

Developing resilient locally owned SMFs

This then raises the next question: how do we go about developing resilient locally owned firms in the North? Traditional approaches tend to work from the outside in. That is, government agencies provide capital incentives, support schemes, or subsidize knowledge transfer between academia and local SMFs. Results, however, have been sparse. An outside-in approach works from the following assumption: that doing business in the North entails specific challenges in the form of challenging logistics, a dispersed population with small local markets and an often shallow talent pool. Government interventions seek to redress and compensate for what are seen as disadvantages. The outside-in approach, however, is problematic for two reasons: first, attempting to compensate for the challenges associated with doing business in the North are by themselves unlikely to be effective, because incentive schemes or tax subsidies may soften but are unlikely to undo some of the major challenges associated with doing business in northern regions.

A second reason is that we still know very little about what happens on the receiving end of small and medium-sized firms. For small firms to benefit from university collaborations there needs to be a management capable of sensing the commercial potential of academic knowledge for their own markets, as well as exploiting this potential. For firms to benefit from financial aid or support, we need entrepreneurial managers capable of transforming capital into new business ventures. Without such entrepreneurial capabilities within the firm, the various support schemes are unlikely to have any effect, as there is no one in the firm to transform these resources into better-performing products or services.

Rather than trying to change the business environment, we would be better served to identify and help develop existing or new business models that do work given the particular contexts facing SMFs in the circumpolar North. This can be likened with identifying resilient plants that prosper in the Arctic. This is not to say that we should not do anything about the conditions for doing business—we should, but realistically, this is not likely to be enough.

An outside-in perspective, moreover, tends to emphasize a rather one-sided comparison with other business contexts, emphasizing the difficulties of developing and running northern businesses at the expense of the often unique opportunities that exist in many northern communities. Thus in developing resilient SMFs the argument here is we would be better off adopting an inside-out perspective. Therefore we need to study how locally owned northern SMFs are organized, managed, and financed. We need to ask ourselves, given what we do see of small firms operating in the circumpolar North, what seems to work and what does not work?

Developing resilient and sustainable northern SMFs will also mean educating new entrepreneurial managers with an affiliation to northern regions and provide them with the knowledge, competencies, and self-efficacy knowledge needed to accommodate effective adaptation.

To educate managers we need new courses, new programs and new knowledge to fill those courses. We still know very little about northern SMFs. The vast majority of studies on organizations have been conducted on a very small fraction of all companies, mostly large (and even very large) firms with headquarters in major metropolitan areas.

Studies on northern businesses tend to emphasize description over prescription. The overarching perspective has in some cases been economic geography, which seeks to understand the pattern and variation in economic activity between people and regions. While this is valuable we also need to complement those studies with research that looks at strategies and tactics from the perspective of individual companies and managers, i.e., how different strategies create value. This may mean combining insights from psychology and social anthropology with strategic theories, including Teece's theory about dynamic capabilities (Teece, 2007) to understand how community identities and values influence strategy formation in local SMFs (Barney, 1986).

We also need a greater emphasis on organizational innovation as opposed to product innovations. A common bias or misconception is to think of innovation as new technologies, new patents, and production technologies; in short, innovation is often thought of as things or new compounds. Yet, many innovative companies may have few product innovations. Research results suggest that organizational and strategic innovations in the form of new modes of organizing, collaborating, or configuring production of goods and services are equally if not more important for economic development in most firms (Nelson, 2005). Innovation for locally owned food producers may instead consist of finding new ways of collaborating with other firms across distances; it may involve combining different products or incomes in ways that make local businesses financially sustainable.

Some organizational problems that may need to be addressed include:

- How can northern food producers and distributors effectively collaborate to emulate the economies of scale and scope associated with larger non-local firms?
- How do institutional forms or governance structures influence strategies and adaptation to change in the North? To what extent do different governance structures stimulate or stifle innovation?
- Given the perennial challenge of attracting talent in many northern regions, how can northern food producers and distributors attract and retain highly qualified people, including managers? What do such best-practice practices look like?
- What is the relationship between local embeddedness and local networks and non-local networks? Do strong local ties bind firms and stifle innovation or contrarily, do local networks stimulate the formation of non-local networks enabling innovation?
- How do managers' and entrepreneurs' background, experience, and contacts influence strategic choices and the developmental trajectories of their firms?
- What role does identity (community and firm) have on the formation of SMFs' strategies and adaptations?
- How can we capitalize on indigenous traditions of leadership and organizations in developing more resilient and sustainable local businesses?

Addressing these and other organizational problems and developing solutions entails organizational exploration and innovation, albeit of a different type than commonly envisioned when thinking of business innovations.

Conclusion

In summation: To enhance food security in the North, we will need to develop and strengthen resilient northern SMFs with a local identity. Such firms, through their connection with local communities and physical locations, are more likely to have a vested interest in environmentally and socially sustainable practices. They are also more likely to have an interest in as well as an ability to serve the vulnerable needs and demands of northern communities. Ensuring resilience, however, is not about conserving an existing *modus operandi*. Protecting and preserving implies continuously changing in order to conserve an organizational identity—developing resilient organizations, moreover, may mean developing businesses with better connected and better educated managers capable of adapting and exploiting opportunities. Developing managers presupposes the development of a body of knowledge relating to strategies and organizational designs for northern businesses. While the relationship between food security and organization theory and strategy may seem less obvious and even remote it remains vitally important, yet largely ignored.

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food security

The Kuujjuaq Greenhouse Project: Sustainable Community Development Through Food Production

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Ellen Avard
(PhD candidate)

Université Laval
Département de géographie - Faculté de foresterie, de géographie et de géomatique

e-mail: ellen.avard.1@ulaval.ca

Abstract

Inuit villages in Nunavik currently face complex social challenges as well as numerous food security issues. In 2009, a preliminary study was conducted in order to assess the social and cultural acceptability of greenhouse initiatives in this region. Since then, research has continued on the subject through the facilitation and documentation of a greenhouse pilot project in the village of Kuujjuaq. This work, which is being elaborated within the paradigm of Community-Based Participatory Research, actively involves not only academics, but also stakeholders from all levels of government, representatives from Inuit organizations, NGOs, local businesses and, most important, community members. This approach ensures community ownership of the research and the results generated by this co-production of knowledge are being integrated into a model for a new type of local food system in the North. The Kuujjuaq Greenhouse Project currently involves the development of eight micro-projects. The most notable are the revitalization of the existing community garden (including the construction of a new greenhouse), and a compost collection initiative that has not only created soil for the greenhouse, but has also created a precedent for innovative waste management in the North. The project also has created employment opportunities for marginalized members of the community and ways for local companies to "give back" to the village. Other micro-projects of note include a small horticultural therapy initiative, school visits to the greenhouse, and the development of field trials for potatoes. This research will not only contribute to the advancement of knowledge on food security, ecological design, and community capacity building in the North, but it will also contribute to policy development and will help address the social, economic, and environmental challenges facing arctic communities in a sustainable, culturally appropriate manner.

Introduction

The driving force behind this work is the knowledge that the rapid modernization of the Arctic is bringing about significant changes in the Canadian North. Villages in Nunavik (the Inuit region of the province of Quebec, Canada) currently face complex social, economic, and environmental challenges. For example, these isolated communities face acute food security issues, notably, problems relating to the availability, quality, and cost of fresh fruit and vegetables. With this in mind, a research project was formulated to develop a viable way to mitigate these food security issues, while at the same time addressing some of the larger social and environmental issues affecting the North.

The general objective of this work, which was based on an action-research approach, was to develop a sustainable, culturally appropriate, northern agricultural model. The specific objective of this research was to participate in and document the development of a greenhouse pilot project in Kuujjuaq and, through this process, develop potential alternatives to the current food system in Nunavik. The working hypothesis of this research is that a new type of greenhouse-based local food system in Nunavik can be a sustainable, culturally appropriate initiative (that can contribute to community capacity development) if it is informed by ecological design, grounded in Inuit praxis and developed in a manner that meets the distinctive current and future needs of Inuit communities.

Context & background

It is widely acknowledged that food insecurity is an urgent public health issue for all aboriginal peoples in Canada; Inuit included (Chan et al., 2006: Power, 2008; Damman et al., 2008). In a recent discussion paper issued by Food Secure Canada, the authors state: "Indigenous people, especially from the North, encounter many problems in accessing healthy, inexpensive and nutritious foods" (Food Secure Canada, 2011). High rates of poverty, the effects of climate change, pollution of traditional food systems and high rates of diet related diseases are all understood to be the principal contributors to aboriginal food insecurity (Power, 2008; Food Secure Canada, 2011). To fully appreciate the complexity of the food security issues faced by Nunavimmiut (residents of Nunavik) it is important to take into consideration the current social situation in the region. Inuit in Nunavik, especially those living in the village of Kuujjuaq are experiencing socio-cultural change at a very rapid pace compared to populations living in the Canadian South. This change in way of life has engendered serious socio-economic problems—problems mirrored in Inuit communities across all of northern Canada. The socio-economic issues that generally receive the most attention in the media include: substance abuse, high rates of suicide, crowded living conditions due to lack of available housing, low rates of academic success, high rates of unemployment, and a rapidly growing population (more than 60% of the population in Nunavik is under the age of 30) (Makivik Corporation, 2013). All of these issues enter into the vicious cycle of poverty that affects a disproportionate number of northern residents (compared to residents of southern Canadian communities), and these issues are further compounded by the very high cost of living in arctic communities.

Methods

This research is grounded in an action-research methodological approach commonly termed Community-Based Participatory Research (CBPR). The Harvard Clinical and Translational Science Centre (2010) defines CBPR as: "An emerging orientation to research which involves scientific inquiry that equitably involves both community stakeholders and investigators at all levels of the research process from design to dissemination. CBPR involves a partnership between the community and the investigator(s) where each group shares equal ownership of the process and products of research collaboration". Concretely, the data that has informed this research was collected over a period of five years and was gathered in several different, complimentary ways. Data collection began in 2009 with a series of more than 60 qualitative interviews conducted with community members, community leaders and potential stakeholders/supporters. In 2010 the results of this preliminary research were presented (and feedback was gathered) in a series of community consultations as well as in a number of formal meetings with representatives from municipal, regional, and provincial government departments, research institutions, and the nongovernmental and paragovernmental sector. In 2011 and 2012 the principal researcher was given a mandate to act as project coordinator for Phase I and Phase II of the Kuujjuaq Greenhouse Project, and together with local volunteers, staff from the Kativik Regional Government, the Northern Village of Kuujjuaq, and the Ungava Supervised Apartments (a community group home for people with mental illness), eight horticultural micro-projects were launched. Finally, in 2013, a concluding study was conducted to gauge perception of potential greenhouse development in the North in general and the Kuujjuaq Greenhouse Project specifically. In this final phase of the research more than 30 qualitative interviews were conducted with community members and local and regional leaders. It is important to note that this research was formulated as a case study (focusing on one particular community in Nunavik) and, hence, the protocol and methodology is site specific.

Results

The results of the preliminary research in 2009 were overwhelmingly positive: not only were a significant number of northern agricultural precedents in the region identified (i.e.: former government experimental farms and personal greenhouses), but a real interest in greenhouse project development was demonstrated by the community. Following the consultation process in 2010, a number of interest groups from all levels of government; from research institutions, and from the nongovernmental and paragovernmental sector pledged their support for a pilot greenhouse project initiative in Kuujjuaq. At this time greenhouse development was also included in the Quebec Government's "Plan Nord" as well as in the operational framework of the Nord-du-Québec Bio-Food Network. In 2011 funding was secured to begin project development and eight horticultural micro-projects linked to the existing community greenhouse in the village were launched (these micro-projects will be discussed in detail in the following paragraphs). Following positives outcomes in 2011, Phase II of the Kuujjuaq Greenhouse Project was initiated in 2012, and all the micro-projects were further developed. It is important to mention that while the project itself is ongoing, the bulk of the results presented in the following paragraphs stem from research carried out during 2011 and 2012.

Existing Greenhouse: Community Garden

The existing greenhouse in Kuujjuaq is home to a community garden that has been operating since the mid-1990s. In 2011 and 2012 much effort went into completing basic tasks such as repairs to the structure and the creation of a management committee. This greenhouse has no extra heating, yet it is possible to grow produce in it from May until October. From late July to mid August temperatures regularly soar to above 30° Celsius in the greenhouse, and occasionally even rise to over 40°C. Harvesting of the first crops (lettuce and herbs) generally begins in late June, with the majority of crops maturing in late August and early September, and the final cool season crops (lettuce, Swiss chard, and scallions) remaining viable until mid to late October. Based on data collected in 2011, as well as anecdotal evidence, the following conclusions can be drawn: cool-loving crops (lettuce, herbs, Swiss chard, bok choy, etc.) perform exceptionally well; root crops (potatoes, onions, carrots, beets, etc.) are easy to grow and achieve respectable sizes, and heat-loving crops (tomatoes, peppers, etc.) rarely mature unless they have been started at home well before the beginning of the season.

Construction of New Greenhouse

One of the main issues at the existing greenhouse in Kuujjuaq in 2011 was that there was not enough space; there were more people interested in gardening than there were garden beds available. So, during the summer and fall of 2011 funding was secured and in 2012 planning of the new greenhouse got underway. During the summer of 2012 construction of the gravel foundation began, and in the fall of 2012 the greenhouse structure and a shipment of soil were sent to Kuujjuaq via Sealift. In early summer 2013 the greenhouse was erected (Fig. 1) and plots were available for the community in the spring of 2014.

Figure 1. New greenhouse (left) beside existing one.

Compost Collection

While the initial reason for starting a composting project in 2011 was to create a soil amendment for the greenhouse garden beds (the local soil is characterised by sandy and rocky substrate), the project has in fact evolved much further beyond that one initial goal. The Kuujjuaq Compost Project now also contributes to a waste reduction strategy (diverting waste from landfill); it serves as a way for companies (local food stores, construction camps, a daycare, and the research center) to give back/contribute to the community; and, last but not least, it provides a beautiful opportunity for the social re-integration of marginalized community members through the creation of unconventional employment opportunities (the project is staffed by residents of the Ungava Supervised Apartments). This project is a true example of a successful sustainable development initiative, generating positive outcomes in the realms of the environment, society, and the local economy. It has created a precedent in the North and is a testimony to the power of grassroots innovation.

Potato Production

Since the beginning of the preliminary study in 2009, it was clear that potatoes were among the most consumed vegetables in Nunavik. As such, it comes as no surprise that there has been a great deal of interest in exploring the possibility of producing potatoes in Kuujjuaq; something that a number of intrepid local gardeners have already proven is possible in the sandy soil around town. To this end, with the help and advice of the Conseil québecois de l'horticulture and two bags of seed potatoes donated by Progest (a potato research center in southern Québec), preliminary trials were undertaken in the greenhouse in 2011 and 2012. These initial trials proved conclusive (quality potatoes can be grown in Nunavik), and plans have since gotten underway for field trials.

Horticultural Therapy

In the fall of 2010 (during the community consultations), the coordinator of the Supervised Apartments inquired about the possibility of starting a small project to introduce gardening to the residents of the home, and in July 2011 plans began to take shape for a small indoor garden. Using the concept of "horticultural therapy" as a jumping-off point, a simple project using indoor window boxes was designed and implemented. The window boxes that had been prepared and planted with herbs and lettuce greens during the 2011 season were still in use in 2012 and a number of them were placed on window shelves that were specially installed in the apartments for this purpose. In addition, several other types of containers were planted with different types of vegetables, including peppers and cherry tomatoes. A variety of potted houseplants were also brought into the apartments over the following months, and residents commented favourably on the new ambience in their home.

Youth Employment and Training

An issue that repeatedly came up in discussions about the greenhouse project was the importance of involving local youth in as many ways as possible. To this end, contact was made with the coordinator of Youth Employment Services (the youth office that is run out of the Sustainable Employment Department of the Kativik Regional Government) in the spring of 2011, and meetings were held to discuss possible projects that would be best suited to local youth, as well as help meet the overall goals of the greenhouse project. While there was a great deal of potential in all of these ideas, this project was placed on the back burner for the 2012 season due to unforeseen circumstances. However, in 2013, this organization expressed continued willingness to be involved with the Kuujjuaq Greenhouse Project in the long term. It is important to underscore the fact that, while no youth projects were actually mobilized in 2011 and 2012, much of the planning and groundwork was done, and this in itself is very valuable.

Kativik School Board

In the summer of 2012, one of the greenhouse garden beds was assigned to a teacher at Jaanimmarik Secondary School who undertook plans to plant a garden with the express purpose of introducing one of the grade four classes to gardening in the fall of 2012. In early September the students made their first trip to the greenhouse (Fig. 2, opposite). The students were first given a short tour of the greenhouse and were then each allowed to harvest their own carrots. This was followed by a lesson in Inuktitut on how to plant radishes and the benefits of eating fresh vegetables. Students were then given the opportunity to water their newly planted seeds, as well as the lettuce in their garden bed. The morning was capped off by a picnic lunch outside the greenhouse and then everyone was given the chance to harvest a few potatoes to take home.

Hydroponic Production

While the main focus of the Kuujjuaq Greenhouse Project has been horticultural development for community and social advancement, one of the long-term goals of this endeavor is to eventually produce fresh food on a reasonably large (village) scale. Since challenges associated with soil and substrates are many in Nunavik, it was deemed logical to begin investigating the potential of hydroponic technologies for eventual use in a commercial-size venture. To this end, initial planning for the development of a series of pilot projects (of different scales and models) was begun to test proof of concept for these types of systems in Nunavik. In 2011, Kuujjuamiut, Inc., (a local ethnic organization) expressed willingness to participate in the maintenance and operation of one of these test systems. Funding has since been secured and a small system was installed in the fall of 2013. Initial results are promising; the system seems to be both technologically feasible and socially acceptable.

Discussion

The results presented above suggest that greenhouse-based local food initiatives could be successfully implemented in high-latitude regions such as Nunavik, because not only are they technically feasible, but Northerners seem ready to embrace the idea. Tailored to meet the specific needs of individual villages, these initiatives could target issues such as food security, education, social re-integration, and job creation, as well as lead to the creation of positive community development spirals. Greenhouse projects, while first and foremost food production initiatives, can also generate many valuable spin-offs in northern communities. Whether these greenhouse projects eventually take the form of community gardens, vocational centers, or commercial operations, local food systems are places where community capacity can be fostered and strengthened. By incorporating elements of ecological design into all aspects of the development of a local food system, social, economic, and environmental benefits to communities can be maximized. By drawing upon resources from all levels of government, from ethnic and non-ethnic organizations, as well as from specialized nongovernmental organizations, local greenhouse projects can become places for engaged stakeholders to work together towards a sustainable future in the Canadian North.

Conclusion

Through the co-construction of knowledge by northern and southern interested parties, research on new types of local food systems in the North has the potential to contribute to the creation of viable strategies that could serve to meet food security needs in remote communities, and community development goals across the circumpolar

Figure 2. Grade 4 students visit the community greenhouse.

region. The information obtained through the course of this work demonstrates that food-based projects generate significant positive outcomes in many fields—for example: food security and nutrition; education; public health and social services; economic development; and environmental protection. Innovation in all of these areas has the potential to contribute to the sustainable development and resiliency of the North, and to the empowerment of northern residents and to the valorization of the cultural and natural integrity of the region.

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Ten Years of Creating Partnerships Towards Community Food Security and Northern Rural Development in Manitoba

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Kreesta Doucette,
Chloe Donatelli,
Kelsey Evans

Food Matters Manitoba
640 Broadway
Winnipeg, Manitoba
R3C 0X3
Canada

Corresponding author e-mail:
kreesta@foodmattersmanitoba.ca

"It brings us great joy and pleasure to feed our people 'fruit' from the labour of our hands."

Abstract

Food Matters Manitoba (FMM) partners with northerners, newcomers, farmers, and families towards good food. FMM works with youth, families, and elders in 13 northern and remote First Nation Manitoba communities to increase healthy food access, create food growing and preserving programs, and rediscover lost food skills including cooking and harvesting. FMM partners with community members, First Nations, local, provincial and federal governments, schools, businesses, farmers, retailers, and chefs using community economic development principles to build and initiate community food plans and regional initiatives such as the Northern Grocers Forum. Food Matters is a partner in the Manitoba Northern Healthy Foods Initiative (NHFI). NHFI has supported the growth of nearly 1,000 family and community gardens, northern poultry and goat projects, northern greenhouses / geodesic domes, and revolving loan freezer purchase programs in more than 90 communities in Northern Manitoba. The NHFI gardening projects have led to the production of more than 170,000 lbs of vegetables, the purchase of nearly 500 individual and community freezers for food storage, and more than 50 greenhouses, some made from up-cycled landfill-diverted trampoline frames. Food Matters Manitoba has also initiated the federally funded Our Food Our Health Our Culture project (http://ourfoodhealthculture.com) to rediscover traditional land-based food practices and food literacy through a healthy fusion food approach (e.g., northern sushi featuring local fish, mushrooms, and wild rice) and increase access to healthy culturally based foods in schools, communities, agencies and retail settings. The NHFI is also a partner in these emerging

programs around Anishinabe foods. The opportunity for microeconomic development is slowly emerging through northern horticulture and greenhouse businesses, seed development, and northern poultry projects. Community development and community economic development approaches that draw on cultural and traditional skills, are rooted in community, and allow for sufficient time for partnership and capacity development are essential to sustainable northern food security and circumpolar agriculture.

Food Matters Manitoba (FMM) is a registered food security charity that partners with northerners, newcomers, farmers, and families towards good food. FMM was founded in 2006 and currently coordinates more than 20 projects in 55 communities and First Nations across Manitoba. FMM works with community members, First Nations, local, provincial, and federal governments, schools, businesses, farmers, retailers and chefs using community economic development principles to build and initiate community food plans and regional initiatives such as the Northern Grocers Forum. In the North FMM partners with youth, families and elders in 13 northern and remote First Nation Manitoba communities to increase healthy food access, create food growing and preserving programs, and rediscover lost food skills.

Context

A 2003 Northern Food Prices report highlighted the limited access to healthful foods in northern Manitoba due to high food prices, low incomes, and lack of availability of healthy choices (Northern Food Prices Steering Committee, 2003). A 2010 report by Thompson et al. details the expense and environmental contamination concerns related to harvesting traditional foods off the land; an increase in transportation costs because of the price of fuel and the shorter and less predictable winter road (frozen lakes) season; and that "at present northern Manitoba communities suffer from a food security crisis. At 75% food insecurity, households in the 14 communities studied have eight times the food insecurity rate as the Canada food insecurity rate ... approximately one third of households report experiencing severe food insecurity manifested as reduced food intake and disrupted food patterns, while a further 42% report moderate food insecurity as measured by compromised food quality and quantity" (Thompson et al., 2010:ii). Thompson describes food insecurity as "a consequence of inadequate or uncertain access to healthy food in terms of quantity or quality," and uses the 1996 World Food Summit definition that "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

In the Northern Health Region 15.7% of people age one and older have diabetes; compared to the entire province at 8.0% (Province of Manitoba 2012b, p. 23) and in 2002–2003, over half (54%) of on-reserve First Nations adults in Manitoba were diagnosed with a chronic health condition (Province of Manitoba, 2012a, p. 74).

Northern Healthy Foods Initiative

Food Matters is one of five regional partners delivering the provincially funded Manitoba Northern Healthy Foods Initiative (NHFI) that has seen the growth of nearly 1,000 family and community gardens, northern poultry and goat projects, northern greenhouses / geodesic domes, and revolving loan freezer purchase programs in more than 80 remote communities in Northern Manitoba over the past 10 years (Northern Healthy Foods Initiative, 2012a). The NHFI emerged from a mandated Healthy Child Committee of Cabinet Northern Food Prices Report (2003), which examined current food prices and recommended options for increasing access to healthful foods in northern Manitoba communities. The report was a product of more than 25 stakeholder consultations (Northern Food Prices Steering Committee, 2003). The Northern Healthy Foods Initiative works with community members towards food self-sufficiency by increasing access to healthful foods through garden and greenhouse projects, community food programs, and food business development. The initiative also supports reclaiming food literacy skills to increase healthier food choices, it encourages economic development toward a more sustainable northern food system, and it fosters community innovation (Northern Healthy Foods Initiative, no date).

Community Development

Food Matters Manitoba northern community projects have emerged from a community development process which involves local government, community members, and local food champions. Our community development approach puts people at the center of finding solutions. Food Matters Manitoba aims for community well-being as a result of the support provided to northern people (holistic projects with broad impacts). An imperative within this work is listening to northern voices and learning from northern people.

As part of this process FMM staff facilitate community planning sessions to determine each community's unique needs and priorities and then engage partners from both inside and outside the community. A community development approach is key for several reasons. Community members know local soil and social conditions, community preferences, and can identify unique solutions not readily apparent to others. Decisions regarding what to plant are especially important.

Partners

Each community is unique and there is a diversity of community food champions in northern Manitoba. Champions are often local community members or local Aboriginal Diabetes Initiative workers. Sometimes seasonal teachers, local health care staff, or band or community councilors take the lead in providing ongoing on the ground assistance that ensures the success and sustainability of a project.

Diverse organizational partnerships are considered critical to past and continued success of Food Matters Manitoba and the Northern Healthy Foods Initiative. Partnerships range from providing technical support to jointly funded projects, to community partnerships providing in-kind support and community groups collaborating on coordinating conferences, resource materials, and project model developments such as northern seed varieties and chicken cooperatives. Additional partnerships include federal, First Nation, and other levels of government including other provincial departments, and the private sector.

History

All the communities have unique histories and food traditions based on original cultural food practices and disrupted food traditions as a result of forced resettlement, hydroelectric flooding, residential schools, current retail availability, and access to traditional foods.

Northern Growing

Northern growing projects include raised bed and container gardens. Also, some communities have built geodesic domes and greenhouses, some made from up-cycled landfill diverted trampoline frames.

There has been some interest in large-scale greenhouse operations; however, the current small-scale low-technology greenhouses are serving as pilot projects with the opportunity for training and community capacity building. In addition, community preferences are for root crops such as carrots, onions, and potatoes, which do not need greenhouse support, so at present greenhouses are primarily being used to extend the growing season. There is a growing interest in fruit trees and bushes, with several new community orchard and fruit patches planted in the summer of 2013.

Northern Cooking

Food-growing projects highlighted the need to rediscover traditional land-based food practices and food literacy through a healthy fusion food approach (e.g. northern sushi featuring local fish, mushrooms, and wild rice) and increase access to healthful culturally based foods in schools, communities, agencies, and retail settings.

Northern Poultry

Based on successes in other northern Manitoba communities, Cross Lake community members expressed interest in establishing a northern poultry project. The Cross Lake Chicken Club was founded in 2012, as a collective of seven families who raised 350 chickens, all of whom raised chickens for the first time. In 2013 nine families are participating in raising 425 chickens. Through this project the families build chicken coops, learn to raise the chickens and use the poultry and eggs to sustain their families. Chicken Club members also spoke of many additional benefits such as community building, bringing people together, and the chicken raisers spoke of improved mental and physical health. Last year, one participant gave 31 chickens away to elders and community members, explaining that it was a way of giving back to the elders for all that they have done for the community.

Students at the local elementary school are raising 50 chickens as a class project while learning responsibility through caring for the poultry and also discovering that food doesn't just come from the grocery store. From young to old, each member is helping to strengthen their community's food self-sufficiency. The successes of this project are documented in the 2012 Food Matters Manitoba report, "Feeding Our People ... From The Labour Of Our Hands: The Cross Lake Chicken Club.

> "It brings us great joy and pleasure to feed our people 'fruit' from the labour of our hands. There were so many more we could've given to. I wish we could raise more! Hand some out and maybe sell to help out with the expenses." (Food Matters Manitoba, 2012:4).

Horticultural Therapy

Community members have reported a high incidence of individuals suffering addictions and subsequent prevalence of Fetal Alcohol Spectrum Disorder (FASD) in Shamattawa First Nation, and historically Shamattawa has had challenges with youth suicide (*Thompson Citizen*, 2010). Due to the increased probability of vandalism some community members indicated that community gardening would not be feasible in this community. To introduce gardening and engage community youth, Food Matters Manitoba applied for provincial funding to initiate a horticultural therapy program with the local school. Therapeutic horticulture is a therapy that uses interactions with "plants, gardens and the natural landscape to improve cognitive, physical, social, emotional and spiritual wellbeing" (Canadian Horticultural Therapy Association, 2013). Youth, some of whom had difficulty concentrating due to FASD, got very involved in the hands-on horticultural therapy activities of classroom planting and growing, nature crafts, and making salves and lip balms from plant materials. The program was so successful the school matched the existing funding to have the horticultural therapist, also a trained counselor, visit the community twice as often.

Traditional Foods: Our Food Our Health Our Culture

In response to increasing community requests for traditional food projects, Food Matters Manitoba sought out funding partners and initiated the federally funded Our Food Our Health Our Culture project (http://ourfoodhealthculture.com) to rediscover traditional land-based food practices and food literacy through a healthy fusion food approach (e.g., northern sushi featuring local fish, mushrooms, and wild rice), and to increase access to healthful culturally based foods in schools, communities, agencies, and retail settings. The project is based in Fox Lake First Nation in Manitoba, Winnipeg's North End, and La Ronge, Saskatchewan.

There are many other traditional foods projects that Food Matters helps to support in various communities, ranging from community freezer programs to smoke houses and community hunts. Over the last year, Food Matters conducted a scan of traditional food assets and initiatives in Manitoba and created a resource guide to share success stories and help communities access tools and resources in implementing their own traditional food programs. (The guide can be found at: www.foodmattersmanitoba.ca/sites/default/files/OFOHOC_Trad%20Foods_report%20 2013%20_online.pdf.)

Successes

The NHFI gardening projects have led to the production of more than 170,000 lbs of vegetables, the purchase of nearly 500 individual and community freezers for food storage, and the construction of more than 50 greenhouses. While exact in-kind contributions are harder to track, community members and partner agencies have contributed an estimated $264,200 in in-kind donations (NHFI, 2012b).

In working alongside our community partners, it has been exciting to see how people have taken a deep interest in creating healthier communities through food. There is a growing desire and vision in the North to deal with the food challenges that many communities are facing. In the last few years, communities have become very excited about the opportunity of re-skilling youth—offering the hope of a healthy diet that doesn't rely on expensive imports from the South. Capacity is building; in each community this looks different, but in all communities it is helping to strengthen the social fabric and address local issues with local skills and solutions.

Challenges

Each community faces unique challenges that can include short growing season and increasingly unpredictable weather, difficult soil conditions, the turnover of local community champions (especially teachers), community crises, youth vandalism, and animal destruction (dogs, horses, etc.). Access to water can also be a challenge as many northern houses do not have taps on the outside of houses, while some communities do not have running water. Eight hundred seventy-six homes out of all First Nations in Manitoba have no water service—most of these are concentrated in the Island Lakes area of Manitoba (National Assessment of First Nations Water and Wastewater Systems, 2011).

Cultural food practices around First Nations foods are being rediscovered in the context of the current food system. Some communities have faced challenges integrating the cultural and social aspects of food with the current economically driven system, while some southern First Nations youth partner with Food Matters Manitoba on determining the environmental contaminant levels present in traditional foods.

While the NHFI program is very promising, Provincial funding for the entire program is $635,000 for more than 90 communities. Aside from special project grants and conference funding, which are also available through the NHFI program, general funding for each community is limited. Due to the high cost of travel FMM has funds only to visit each community once per year and an average of $1,000 per community for materials and supplies. Food Matters has used these funds to leverage additional donor dollars; however, the resources available are very limited in comparison to the scale of the challenges involved and the interest from some communities. There are many opportunities to expand this initiative.

Future

The opportunity for microeconomic development is slowly emerging through northern horticulture and greenhouse businesses, seed selection and development, and northern poultry projects. Many communities and community members view community economic development from a collective rather than individual perspective, preferring to share the benefits of a successful harvest rather than sell surplus foods. While this is an important distinction in planning, implementation, and evaluation, the outcomes are still rooted in community economic development. The creation of local employment opportunities is always a large focus and goal for all of the communities with which Food Matters Manitoba works.

Community development and community economic development approaches that draw on cultural and traditional skill reclamation, are rooted in community priorities, and allow for sufficient time for diverse partnership and capacity development are essential to sustainable northern food security and circumpolar agriculture.

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Yukon Agricultural Association – Initiatives and Projects

Sylvia Gibson and Kirsten Scott

Yukon Agricultural Association
203-302 Steele Street
Whitehorse, YT Y1A 2E5
Canada

phone: 867-668-6864
fax: 867-393-3566

e-mail: admin@yukonag.ca

Abstract

Farming the Yukon Territory has occurred from the late 1800s to present. During the mid-twentieth century transportation improved, making the demand for local farming less urgent. By the 1970s, interest in Yukon agriculture recovered. This continues today, characterized by various farming ventures, both subsistence and commercial, as well as local food movements and markets throughout the territory. The Yukon Agricultural Association (YAA) evolved from the Yukon Livestock and Agriculture Association established in 1974. The association represents industry in dealing with governments and other organizations and provides cross-commodity support in fostering agricultural development in the Yukon. YAA recognizes the challenges facing Yukon agriculturalists, including the semi-arid climate, cold winters, shorter growing seasons, and lack of large-scale processing and marketing infrastructure. The organization sees these as growth opportunities and works to facilitate such development for its members and the larger Yukon agricultural community. For the last 10 years, YAA has been involved in several infrastructure and equipment projects. These include purchasing farming equipment for Yukon farmers to rent, as well as bringing fertilizer bins to the territory to enable bulk fertilizer use. In August 2012, YAA signed a 30-year lease agreement with the Government of Yukon for a 65-hectare lot. Planning to develop this land as a central agricultural facility to best serve industry needs is in its early stages. YAA also provides information to its 140+ members in the form of speaker seminars, a quarterly newsletter, and website. Members are given the opportunity to advertise their produce through a blog. Also, YAA recently updated the *Yukon Farm Products and Services Guide*, a booklet and website showcasing local farms and businesses to the general public. YAA also works with the territorial government and other food and farming groups to comment on and develop beneficial funding programs, legislation, and development ventures.

Where we have come from…

For thousands of years the area now known as the Yukon Territory in Canada provided First Nations with game, fish, and edible plants (Kuhnlein et al., 2004; Kuzyk et al., 1999; Wein and Freeman, 1995). Initially, non-First Nations inhabitants brought with them much of their food supplies; however, transportation and supply was fraught with difficulty. With the development of the fur trade, the Hudson's Bay Company, expecting self-sufficiency at its outposts, planted small agricultural test plots at three locations in south and central Yukon beginning in 1842 (Tompkins, 2006). Over the course of a decade these all proved fairly unrewarding as the locations had been chosen for non-agricultural factors. They were all eventually abandoned (Robinson, 2010; Tomkins 2006).

Gold prospecting joined the fur trade in the mid 1880s. Enterprising traders and miners planted kitchen gardens both to augment supplies and to ward off scurvy. They enjoyed a certain amount of success with root vegetables, greens, and barley (Robinson, 2010). When abundant gold was discovered in the Klondike in 1896, the stampede, and the need to feed the rush of miners, began in earnest. The Canadian government expressed interest, and, in its 1898 paper *Possibilities of Agriculture in the Yukon District,* declared, “The best sites for the growing of vegetables are along the banks of rivers, where the soil is warmer and sandy” (Saunders: 4). Some 115 years later, the same holds true in the Yukon, where much of current agriculture takes place along the Takhini, Yukon, and Klondike River valleys.

The gold rush saw rapid expansion for vegetable farmers in the Dawson area: lettuce, radish, cabbage, cauliflower, root vegetables, and even cucumbers and celery abounded on small five-acre plots. Farms were selling up to $6,000 worth of vegetables a summer (Robinson, 2010). Again, this is similar to modern times where, despite inflation, many producers are working to earn comparable amounts from their market gardens (T. Zakus, pers. comm., 2013). As drovers moved beef cattle and hogs to Dawson and horses slowly replaced dogs as the main form of transportation, hay became a high-demand crop, either cut locally or brought via the river on rafts from further south (Lynch, 1967; Steinberg, 1908). Hay for equestrian and outfitting horses remains in demand; in 2007 hay accounted for an estimated 45–50% of total Yukon farm income (Serecon Management Consulting Inc. et al., 2007).

In 1899, agriculture in the Yukon felt the first sting from the double-edged sword of transportation improvements. Refrigeration in railcars, riverboats, and steamers brought imports of fresh meat, providing stiff competition for the local industry, but at the same time sternwheeler traffic on the rivers allowed local farmers to deliver their summer produce to market (Robinson, 2010; Lynch, 1967). This was a reliable means of reaching customers until the shipping network folded in the 1950s.

As the gold rush ended, the Yukon’s population decreased three-fold in the first decade of the twentieth century but, paradoxically, Yukoners purchased more local produce than before due to improved production (Robinson, 2010). However, in subsequent decades, production of human and animal food declined as the territory’s population shrank and mechanisation replaced horses. When World War II brought the Alaska Highway through the Yukon, transportation again altered the face of the area’s agricultural industry. The road, along with a highway connection to Dawson, meant food could be delivered from southern Canada at prices that local farmers could not beat (Serecon Management Consulting Inc. et al., 2007; Robinson, 2010). From the 1950s to the mid 1970s, Yukon’s agricultural industry hit low points with, at one stage, only 12 active farms using just over 2,200 acres (Robinson, 2010; Hill et al., 2000).

What we have done…

The Yukon Agricultural Association was formed in 1974 as the Yukon Livestock and Agricultural Association by a group of individuals concerned about land availability and revitalising the industry. First Nations’ land claims and the lack of territory-wide agriculture policy meant the federal government halted disposition of rural land for agriculture (Hill et al., 2000). Policy development in 1982 led to a federal-territorial agreement that the Yukon government could assess applications on federally-owned Crown Land. In the ten years between 1986 and 1996, “the Canada Census shows a four-fold increase in the number of farms, a six-fold increase in the value of agricultural sales, and a three-fold increase in land in crops” (Hill et al., 2000:5).

During this time, the association changed its name to the Yukon Agricultural Association (YAA) and actively promoted local products and supported farmers. There were association chapters in Whitehorse, Mayo, and Dawson. From 1994 to 2006 the YAA ran the Klondike Harvest Fair in Whitehorse, and from 1985 to 1998 the Whitehorse chapter also hosted the Six Carrot Farmers’ Market. The YAA also organized the first North of 60° Agriculture Conference in 1987. Now run by the Yukon government’s Agriculture Branch, and in its twenty-fifth year, this has become a core activity in the region’s agriculture community with speakers attending from across Canada and Alaska.

Following success with the North of 60° symposia, the YAA decided to go bigger and better and invited nine circumpolar countries to Whitehorse in 1992 for the inaugural Circumpolar Agriculture Conference (CAC). The theme was sustainable agriculture in a circumpolar environment, and the typewritten handbill states, “[the conference] will provide a vision and understanding of the potential of feeding ourselves and decreasing our dependence on the Outside” (Lewis, 1992:2). Twenty-one years later, the CAC is still looking at these issues through policy, research, and marketing lenses.

Another important step for the YAA was establishing a committee to oversee project approvals and administer funding for the Canadian Adaptation and Rural Development (CARD) program in the Yukon. This committee was responsible for fostering and promoting “sustainable agriculture in the Yukon through the use of new technology, better farming practices, new products and marketing opportunities, skills development and better environmental practices" (Yukon Agriculture Branch, 2002:7). From 1997 to 2004, the program provided "close to $400,000 in funding for approximately 50 agricultural projects" (Yukon Agriculture Branch, 2003:10). These included field trials of berries and potatoes; funding to train an organic inspection officer and a meat inspector; guides and workshops on wild mushrooms, horse care and gardening; educational programs for grades 3/4 and career development for grades 11/12; public service announcements promoting Yukon products; and funds for 4H projects and the Whitehorse Downtown Urban Garden.

The Canadian federal government followed the CARD program with the Advancing Canadian Agriculture and Agri-Food (ACAAF) program, "to help implement new projects that will benefit the Yukon's production and processing sector and bolster its capacity to address current and emerging issues" (Agriculture and Agri-Foods Canada, 2004). The Yukon Council administered ACAAF in the territory from 2004 to 2009 by assessing project proposals and providing funding approval to those that met criteria under one of three program pillars of innovation, technology transfer, and agricultural information gathering. This resulted in studies on, for example, soil mesofauna, legume culture, craft fiber mill, and oilseed production potential that continue to provide constructive information for farmers looking to commence production in these fields. ACAAF also funded the publication of a popular book on boreal herbs; development of a meat processing infrastructure working group; and a multi-year (2008–2012) development plan for Yukon's agri-foods industry.

Throughout the CARD and ACAAF programs, the Yukon Council also participated in collective outcomes projects with other provinces and territories, sharing agricultural knowledge and resources across Canada.

Additionally, in the 1990s and 2000s, the YAA was active in addressing key issues such as the availability of agricultural land, monitoring the territorial government's revision of its agriculture policy and investigating the feasibility of a multi-use agricultural facility (Serecon Management Consulting Inc. et al., 2007; Department of Renewable Resources, 1996).

Where we are...

Now, as then, the issues around land and infrastructure availability are still crucial to expansion of agriculture in the Yukon and the YAA is working to find solutions. Starting in 2003, the association purchased, with the assistance of the Growing Forward program, 22 bulk fertilizer bins that are located at various farms throughout the territory, enabling farmers to purchase large quantities of fertilizer from southern Canada at lower transportation costs. The YAA also owns a number of pieces of farm machinery, also purchased through Growing Forward, made available for rental to local agriculturalists (Ball et al., 2010; Tobin, 2009).

The main recent development for the association occurred in 2012 when it signed a 30-year lease agreement with the Government of Yukon for a 160-acre parcel of land. Many years in the making, this lease will enable the YAA "to proceed with planning for a central agriculture facility to serve the industry and the Yukon public" (Department of Energy, Mines and Resources, 2012). Currently vacant, the land is a blank slate that will, in the words of the YAA Past President, "position the YAA one step closer to achieving our vision of creating the infrastructure required for the Yukon agriculture industry to grow and supply more local food to Yukon residents" (Department of Energy, Mines and Resources, 2012:1).

The YAA continues to maintain a membership base of about 100 Yukon farmers, gardeners, and interested members of the public. The organization recently published the 2013 *Yukon Farm Products and Services Guide,* a 72-page booklet available free to the public that lists farms, gardens, and related industry services and organizations.

A new venture for the YAA in 2011 was establishing the Yukon Young Farmers (YYF). This subcommittee is run by farmers under age 45 and aims to encourage and empower young farmers, and to create networks to foster sharing, education, and help amongst young farm families. YYF members have attended the Canadian Young Farmers' Forum meetings across Canada, bringing valuable information and contacts back to the Yukon's relatively isolated agricultural community. Education for a new generation of agriculturalists is especially important given the average age of Yukon farmers is 54.4 years old, slightly above the national average of 54 (Statistics Canada, 2012).

The YAA's other current subcommittee is the Yukon Council of the Canadian Agricultural Adaptation Program (CAAP). A successor to CARD and ACAAF, this industry-led federal program has flexibility to respond to small or large project proposals and includes agriculture, agri-food, and agri-based businesses (Agriculture and Agri-Foods Canada, 2013). In the Yukon, this has translated into projects on meat processing; waste management; a community food and market expansion strategy for Dawson; and an irrigation strategy for the territory. Ongoing projects include partnership with researchers at the University of Alaska Fairbanks into soil amendment with biochar. Research is also being done on designing and planning a Yukon-wide food system; trialling a hydrokinetic agriculture power plant; and using microalgae as an animal feedstuff.

The CAAP program ends in March 2014 and the federal government has indicated it will not renew this nearly 20-year old model of funding delivery through regional agriculture councils (Agriculture and Agri-Foods Canada, 2012). This leaves agriculture in the Yukon, and the YAA, exploring options for the future, both generally and in research and development.

Where we could go and how we might get there…

The Yukon's current industry comprises around 130 farms covering slightly more than 26,000 acres and generating $3.7 million CAD in gross receipts in 2010 (Statistics Canada, 2012). These figures are down slightly from the 148 farms and $4 million CAD reported in the 2006 census.

The past shows that the Yukon is capable of producing a significant amount of food, much more than is currently grown locally. At the turn of the twentieth century Dawson produced many staples for its population of 30,000 whereas now the whole Yukon manages to grow only 1–2% of its own food for a total population of just over 30,000 (Serecon Management Consulting Inc. et al., 2007). While the territory's northern climate and soils may be limiting factors to some extent, they are not insurmountable. The Yukon government's Agriculture Branch, in conjunction with local farms, conducts and publishes an annual research demonstration report on northern hardy crops; in 2012 alone they studied soil amendments and varieties of oats, wheat, peas, and potatoes (Ball and Reaume, 2012).

What primarily continues to beleaguer industry expansion are issues similar to those noted in a 1959 report from the Dominion Experimental Farm (near Haines Junction in the southwest Yukon) that concluded local agricultural production was not a profitable endeavour due to high transportation costs and a small local market (Canadian Department of Agriculture, 1963).

As farmers in the 1950s discovered after the failure of the sternwheeler network limited local distribution via boat and the Alaska Highway brought cheap food north in trucks, today's farmers and consumers in the Yukon are somewhat at the mercy of products coming in from 'Outside.' In fact, the Yukon's reliance on an external supply chain was highlighted in June 2012 when the Alaska Highway washed out and trucks were cut off, leaving grocery stores bare of fresh produce within a few days (Keevil, 2012).

While there is increasing enthusiasm among Yukon consumers for local food due to its health and environmental benefits, finding a price point that engages consumers while being profitable for producers remains complicated (Zapisocky and Lewis, 2010). And although some farmers have successfully carved out niche markets in the organic sector, land-clearing trade, or hay business, few Yukon farms function without off-farm income (Robinson, 2010; Serecon Management Consulting Inc. et al., 2007). Taking the plunge to full-time farming is challenging for many due, in part, to the seasonal nature of the Yukon's agricultural industry.

Many farmers currently sell all they grow either through farm gate or market sales and would like to expand but are unable to do so because of land or labor shortages, storage constraints, and high fixed overhead costs (fuel, seeds, power, etc.). For individual farms, securing a larger local market, such as a restaurant or grocery store, would support growth; however, such markets may be hesitant to carry local produce due to problems with a lack of guaranteed supply and government-approved food inspection facilities (Serecon Management Consulting, Inc., et al., 2007). As it is, producers must be generalists: raising, butchering, and marketing their own meats, or planting, harvesting, and canning vegetables because no industry subsectors exist to process food entering the supply chain. This places an added cost and time burden on producers, and hence also discourages sales to retailers when the cost is passed on to them.

The YAA recognizes it is well placed to help farmers and gardeners in the Yukon overcome some of these challengers, realise industry potential and capture the willing local market. In this vein, numerous feasibility studies for multi-use facilities, agri-plexes, abattoirs, and community kitchens have been commissioned by various groups since the late 1980s but no clear and conclusive results have arisen from these, often due to a lack of land (Klassen, 2013).

What makes the present situation unique is the YAA's newly obtained lease land. This represents a significant opportunity to bridge the gap between agricultural supply and demand via the development of some form of cooperative infrastructure. Ideas for this type of joint project range from a cold storage facility smoothing the produce bottleneck caused by an intense, short growing season, to a government-inspected abattoir or docking station for the existing mobile abattoir, to a community hall, to food-processing facilities, to an equestrian facility, to any combination and permutation thereof (Klassen, 2013). How and what form these projects take has yet to be determined but involvement of and consultation with industry and key groups such as the Growers of Organic Food Yukon, the equestrian community, agricultural researchers, and the Government of Yukon is vital.

While such a facility would be closer to the Yukon's main population center of Whitehorse, farmers in Dawson and the smaller communities would still benefit. Depending on the nature of the developments, this could be through research outputs, an overall increase in territorial food sovereignty and security (especially helpful in the event of a natural disaster), or access to federally approved processing facilities.

Another important factor in the way forward to strengthen the Yukon's agri-food industry is the ongoing Yukon Food System Design and Planning project conducted by Kwantlen Polytechnic University's Institute of Sustainable Horticulture on behalf of the YAA, funded by CAAP. This project aims to design a territory-wide food system that supports agriculture, strengthens the economy, promotes environmental stewardship, fosters food security and public health, and builds social capital. Furthermore, an implementation plan consisting of targeted tools to be used by existing and future farmers and food-sector entrepreneurs, consumers, and community leaders will be developed to actualize the bioregional food system design (Mullinex, 2012). In its first of three years, the project is currently surveying the Yukon's existing food system and its relationship with communities, the environment, and the economy. Final results from the project should assist in guiding infrastructure development to maximize regional potential (Mullinex, 2012).

Will we get there?

Agriculture in the Yukon faces many challenges. Some remain fixed, such as frosts and poor soils that nipped the hopes and destroyed the crops of the territory's first farmer-researchers 150 years ago (although even these issues have been tackled by enterprising individuals through various new greenhouse technologies, crop varieties, and soil amendments). Overhead costs will always be higher in the North due to the need to transport many raw materials long distances, and the small population means labor is in short supply.

Other challenges, like small markets, limited distribution networks, and a lack of infrastructure, are potentially navigable by bringing together the industry's various sectors. Given opportunities such as the YAA land, consumer interest, and the expertise and enthusiasm of local farmers and groups, the YAA is well placed to work toward common goals of putting more Yukon-grown food on the plates of the territory's people and in the feed buckets of its animals.

Being clear and realistic about how to cooperatively define and achieve these common goals will go a long way to expanding the Yukon's agriculture industry. While climate change will undoubtedly affect the Sub-arctic (Hinzman et al., 2005), it is unlikely to turn it into a densely populated tropical paradise, so juicy mangos may forever remain beyond the Yukon's capacity. It is not inconceivable, however, to imagine the territory producing, adding value to, and distributing more of what it already excels at growing—berries, root vegetables, brassicas, red meat, poultry, hay, oats, etc. (Serecon Management Consulting Inc. et al., 2007). Regulatory, financial, research, and marketing decisions need to be focused, practical, and part of a cohesive industry plan for sectors that do or could excel in the Yukon.

The YAA has worked in the past to support farmers, guide policy, and promote local industry. Through its continued involvement and development, the YAA is working to assist the Yukon's agricultural industry in getting there: to a place where Yukon farmers can make a reasonable livelihood offering a range of quality products at competitive prices in a variety of marketplaces for most of the year.

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The Cross-Border Dimensions of Vuntut Gwitchin Food Security

Tobi Jeans,[1]
Glenna Tetlichi,[2]
Norma Kassi[2], and
David Natcher[3]

[1]Department of Natural Resources and Sustainability, School of Natural Resources and Extension, University of Alaska Fairbanks

[2]Vuntut Gwitchin Nation

[3]Corresponding author: David C. Natcher, Indigenous Land Management Institute, University of Saskatchewan
e-mail: david.natcher@usask.ca

Abstract

While food security among arctic communities is undoubtedly being influenced by climatic change, maintaining access to reliable and nutritious food sources is also part of the larger social and political system in which food procurement occurs. It is in this context that this paper will explore the social and political dimensions of food security, with a particular focus on the unique challenges faced by the Vuntut Gwitchin (Old Crow, Yukon) due to their close proximity to the US border. By focusing on the social and political dimensions of food security, this paper will explore: 1) how the enforcement of the US/Canada border has affected the Vuntut Gwitchin's ability to harvest wild foods; and 2) how political and legal restrictions relating to cross-border travel have affected traditional/contemporary food sharing networks between the Vuntut Gwitchin and Gwich'in communities in Alaska. It will be argued that these issues relate directly to indigenous sovereignty and the rights of the Vuntut Gwitchin to define their own policies and strategies for the production, distribution, and consumption of sustainable and healthy food sources.

Introduction

Across the Canadian North, aboriginal communities are being challenged to secure the necessary foods to satisfy basic nutritional needs. Owing to complex interactions between social and ecological changes, food insecurity represents one of the most pressing issues affecting the health and wellbeing of Canada's aboriginal peoples. While food insecurity is undeniably tied to changes in the natural environment, maintaining access to reliable and healthy food sources is also influenced by the social, economic, and political systems in which food procurement occurs. For example, food security has become increasingly challenged by the high costs associated with wildlife harvesting (i.e., purchase of gas and equipment) (Ford et al, 2008), limited wage earning opportunities in northern communities (Trainor et al., 2007), changing dietary preferences of aboriginal youth (Natcher et al., 2009), and various wildlife harvesting restrictions imposed by territorial and federal governments. Together, these conditions have resulted in an increasingly dire situation for many northern communities.

The Vuntut Gwitchin, whose members reside predominantly in the community of Old Crow, Yukon, find themselves among the many communities confronted by conditions of food insecurity. Depending largely on the harvest of migratory wildlife species to satisfy much of their nutritional needs (Wesche et al., 2011), the Vuntut Gwitchin have become increasingly concerned over declining wildlife populations. For instance, the Porcupine Caribou Herd, which ranges from northeastern Alaska across the northern Yukon to the Mackenzie River in the Northwest Territories, has had an annual decline of approximately 4% of its herd size since 1994 (PCMB, 2011a). Reaching a high of 178,000 in 1989, recent estimates (2010) indicate a herd size of approximately 169,000 caribou (PCMG, 2011). While the exact cause for the decline is unknown, biologists attribute the reduced herd size to weather conditions characterized by high snow accumulations on the wintering grounds and short summers in the early 1990s (Griffith et al., 2002). This decline may also reflect natural cyclical trends in caribou populations (Hummel & Ray, 2008). During this same period salmon returns to the Porcupine River have also been in decline. Because returning salmon traverse the Yukon River system through Alaska, they are subject to intense harvesting pressure, both from commercial (Thiessen, 2010) and subsistence (Moncrieff, 2007) harvesters. In addition to harvesting pressure, fisheries biologists believe that ocean conditions (poor marine survival) are also responsible for the low returns of chum salmon to the Porcupine River (Gisclair, 2010). For whatever reasons, declining numbers of returning chum salmon have motivated the Vuntut Gwitchin to adopt a voluntary fishing closure to aid salmon conservation efforts. The Vuntut Gwitchin have in the past decade noticed dramatic changes occurring in hydrology of their territory. Specifically, Old Crow residents have observed water levels of the Old Crow Flats dropping and water levels of lakes and marshes receding (Wolfe et al., 2011). This decline in water levels is a considerable concern given that the Old Crow Flats serves as a crucial breeding and staging ground for more than 500,000 waterfowl annually (Conant and Dau, 1990).

With the decline of primary subsistence species, the Vuntut Gwitchin may be forced to purchase greater amounts of commercial foods to supplement their nutritional needs. However, with no road or marine access, the exorbitant costs of purchasing healthy commercial foods may be prohibitive. For example, to meet weekly nutritional needs of a family of four, the cost to purchase a healthy food basket in Old Crow is estimated to be $496/week compared to $206/week for the same food basket purchased in the Yukon's capital city of Whitehorse (AAND, 2011). Given these costs, together with the limited wage-earning opportunities available to Old Crow residents, it is unlikely the purchasing of commercial foods shipped from the south can serve as a viable remedy to offset conditions of food insecurity.

While the challenges faced by the Vuntut Gwitchin are considerable, they are in many ways shared with other aboriginal communities across northern Canada. Faced with declining wildlife populations and high costs of store-bought commercial foods, the Vuntut Gwitchin are among many who are dealing with food insecurity. Yet, unlike other communities, the Vuntut Gwitchin are faced with the additional challenge of having their traditional territory bisected by an international and territorial border that is enforced by territorial, state, and federal government agencies that most often fail to respect the territorial rights and interests of the Gwitchin people. Due to Old Crow's close proximity to the US-Canadian border (90 km), the Vuntut Gwitchin have, over the course of nearly a century, been systematically excluded from accessing much of their traditional lands. This territorial exclusion has not only limited their ability to physically access and harvest country foods found in Alaska and the Northwest Territories but has also obstructed the social networks that exist with other Gwitch'in communities that have long facilitated the exchange of country foods in times of need. Although more than 30 other First Nation and Native American tribes are affected by an arbitrary border or "medicine line" that separates Canada and the United States (O'Brien, 1984), the Vuntut Gwitchin are unique in their degree of isolation and their continued reliance on traditional food sources. The cross-border dimension of food insecurity represents one of the most pressing policy concerns of the Vuntut Gwitchin and it is this dimension of food security that serves as the focus of this paper.

Background

Old Crow is the most northerly community in the Yukon Territory, and the only community in the Yukon without road or marine access. Located at the confluence of the Crow and Porcupine rivers, Old Crow is located 800 kilometers north of Whitehorse and 90 kilometers east of the Alaska border. Today, approximately 300 people reside in Old Crow, 270 of whom are Vuntut Gwitchin. The Vuntut Gwitchin, or 'people of the lakes,' are part of the Gwitchin people whose traditional territory extends across western Alaska, through the Yukon, and into the Northwest Territories.

Due primarily to geography, the Vuntut Gwitchin remained relatively isolated from European encroachment until the beginning of the nineteenth century (VanStone, 1974). Vuntut territory, with only three reasonable routes of access, was said to be one of the most remote fur trade destinations in Canada: those routes being limited to travel up the Yukon River through Alaska; south on the Mackenzie River from eastern Canada; or by ship through the Arctic Ocean and then traversing south across difficult northern terrain (Leechman, 1954). This remoteness however, did not restrict Vuntut trade with neighboring peoples. In fact, the Vuntut were reported to have traveled considerable distances to trade with other aboriginal groups and were viewed as astute middlemen by European traders (Hadleigh-West, 1963).

The latter half of the nineteenth century ushered in greater European contact and influence. With greater involvement in the fur trade, Gwitchin settlement patterns began to change, as permanent log homes were built near trading posts, and replaced to some extent seasonal trapping and fishing camps (VanStone, 1974). Despite becoming more centralized, trade with neighboring Nations continued as it had for centuries before, as the international border between Russia and Canada was largely unenforced. However, on March 30, 1867, the United States Senate approved the $7.2 million purchase of Alaska from Russia. As noted by Vuntut Gwitchin Elder Donald Frost, the purchase of Alaska by the United States resulted in no immediate impacts on the Vuntut Gwitchin: "There was no real border at that time. At least for the people like us, Gwitchin people could go wherever you want." (2010, pers. comm.) Nonetheless, with the purchase of Alaska, the Gwitchin territory was under the administrative authority of two governments—the US and Canada. With the 141st meridian being officially declared the international boundary separating Alaska and the Yukon, new restrictions soon came into effect, and by 1912, the Gwitchin first began to experience the effects of having an international border transect Gwitchin territory. As noted by Vuntut Gwitchin Elder John Kyikavichik, in the decades that followed the US purchase of Alaska, the Vuntut Gwitchin right to hunt, trap, and even travel in a large portion of their traditional territory were treated as criminal offenses.

> "They [Government] made a law for everything, caribou, fish, rabbit, porcupine, even if you had relatives on other side and this side, you still could not hunt on either side." (John Jo Kyikavichik, 2010, pers. comm.)

Land Claims and the Right to Share

In 1993, the Vuntut Gwitchin First Nation Final Agreement came into effect. With the signing of the Vuntut Final Agreement (1993), Vuntut rights to traditional lands and resources were affirmed and protected. This includes a guaranteed right to allowable harvest levels of country foods, as well as harvesting rights throughout their territory; boundaries defined by negotiators of the Agreement and not necessarily reflective of the full extent of the Vuntut Gwitchin traditional territory. The Vuntut Final Agreement also guarantees the Vuntut:

> "... the right to give, trade, barter or sell among themselves and with beneficiaries of adjacent Transboundary Agreements *in Canada* all Edible Fish or Wildlife Products harvested by them pursuant to 16.4.2, or limited pursuant to a Basic Needs Level allocation or pursuant to a basic needs allocation of Salmon, in order to maintain traditional sharing among Yukon Indian People and with beneficiaries of adjacent Transboundary Agreements for domestic purposes but not for commercial purposes (emphasis added, Vuntut Gwitchin First Nation Final Agreement, 16.4.4 - 1993).

These transboundary agreements were developed to clarify subsistence activities and harvesting rights in areas where the Vuntut Gwitchin traditional territory overlapped into land claims or traditional territories of neighboring aboriginal governments. However, the Vuntut Final Agreement does not guarantee the right of the Vuntut to transport and share caribou or other country foods with family and friends in Alaska. Rather, the Vuntut Gwitchin are required to secure an export permit prior to transporting any food or other goods across the Alaska-Yukon border.

The Canadian Customs and Revenue Agency (CCRA) is responsible for the administration and the issuing of permits under the authority of the Games Export Act (1985) that regulates the transportation of wildlife products across borders with Alaska, British Columbia, and Northwest Territory. Following the signing of the Vuntut Final Agreement, the federal government did agree to modify the Games Export Act so that the Vuntut could transport goods for traditional, and non-commercial purposes across the US border (as well as the Northwest Territory and British Columbia borders). Unfortunately, such modifications in the necessary legislation have yet to be made, so today, federal legislation still requires the Vuntut Gwitchin to complete an export permit for approval prior to transporting country foods to Alaska.

Failing to secure an export permit can result in a number of responses from government, ranging from turning a blind eye to actual charges being laid. During conversation with Yukon Government officials, they acknowledged that there exists considerable ambiguity in the process and inconsistency in enforcement (2010, pers. comm.). This uncertainty has resulted in considerable anxiety among the Vuntut who fear potential repercussions for trying to share food with relatives in Alaska. In a study conducted in western Alaska, it was similarly found that the regulations surrounding customary trade were so poorly understood by community members, that uncertainty concerning rules and regulations had likely affected the extent to which customary trade and barter now occurs (Magdanz et al., 2007: 10).

The uncertainty the Vuntut Gwitchin have concerning cross-border travel also includes the fear of having food and hunting equipment confiscated by border authorities if there is suspicion of illegal hunting in Alaska. For most people in Old Crow this is a risk that simply cannot be taken, as noted by a community member:

> "I make few trips down to Fort Yukon with boat, but I was scared to take meat from here down over the border I was scared to take it down for my relatives." (2010, pers. comm.)

Many community members who would regularly travel to Fort Yukon or Arctic Village have forgone those trips due to the chance they would not be able to bring food home. If a trip to Old Crow has the potential to yield no food, then gas money is better spent on excursions closer to home with the resulting harvest shared with family and friends in Fort Yukon.

Acquiring the necessary export permit can also be problematic. Aside from the general complexity of the forms, the issuing agency for the Vuntut Gwitchin is the Royal Canadian Mounted Police (RCMP) detachment in Old Crow. Although the relationship between the RCMP and the community is generally positive, there can nonetheless be some reluctance among Vuntut Gwitchin to approach RCMP staff about acquiring the necessary permits and approvals. The apprehension of being questioned about other, perhaps unrelated and perfectly legal activities is enough to dissuade some community members from approaching the RCMP to complete the necessary paperwork. By placing the responsibility of issuing export permits in the hands of the RCMP detachment there is also the perception that severe repercussions can result if a permit is not acquired.

Conclusion

> "We should not feel threatened, it is our tradition to trade, you know, we should not be afraid to go across that border and shake hand with a Gwich'in person you know for a long time and then cross border without fear. We should have that freedom. We had that freedom long time ago but as soon as that border came, there were restrictions and some people paid penalty for it because of regulations. But if we can work together our young generation will not lose their identity, not lose their family tree, who they are related to, I want to see that continue."

The above appeal was made by a Vuntut Gwitchin Elder and mirrors the concerns expressed by Gwitchin on both sides of the border. Since its establishment in the early 1900s, the border has come not only to restrict physical access to Gwitchin territory but has also affected the social, cultural, economic, and political ties that have long united the Gwitchin people through the simple act of sharing food. Yet the significance of sharing food is so deeply entrenched within Gwitchin culture that its importance cannot be minimized. One can turn to Gwitchin oral history to appreciate the importance of food sharing, for instance in the story of the man who became a Nanaa'in (bushman) by "violating the social obligation to share food" (as told by Moses Tizya in Smith, 2009: 49) or Shanaghan, or Old Woman story, where Sarah Abel describes the virtues of sharing food (Smith, 2009). During our interviews with community members, Roger Kyikavichik acknowledged the social and personal consequences of not being able to share food, noting that it results in "a lot of pain for the Vuntut Gwitchin." (2010, pers. comm.)

With the settlement of the Vuntut Final Agreement it was hoped that the issue of territorial access and the right to share country foods with family and friends in Alaska would be secured. However, because there is no explicit statement made in the Vuntut Final Agreement to specify that import and export permits for harvested wildlife are not required, and having yet to establish their own policies for transboundary trade, the Vuntut Gwitchin are required to secure the appropriate permit prior to the transport of country foods. In cases where the necessary permit is not received, the Vuntut Gwitchin can now find themselves in violation of subsection 6(2) of the Yukon Act, (S.C. 2002), sections 6(3) and 7(1) of Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA – 1992), as well as a violation of subsection 105(1) of the Yukon Territory Wildlife Act (2002). The magnitude of this legislative bureaucracy is made that much more complex by having the traditional territory of the Vuntut Gwitchin administered by one territorial government (Yukon), one state government (Alaska), two federal governments (US and Canada), and two comprehensive land claims (ANCSA, 1971, and VGFNA, 1993). Arguably the Vuntut Gwitchin now find themselves with more territorial restrictions upon their lives and livelihoods than any other aboriginal group in North America.

Compounding the legalities that now influence Gwitchin food sharing are the rising costs associated with harvesting and travel between communities to share. The chance of being turned back due to missing or incomplete paperwork, having food confiscated, or even being charged criminally has in many cases deterred families and friends from making trips across the border. For some Gwitchin this has impeded food sharing, for others it has stopped it all together. Yet declining food sources has created an even greater need for sharing food. As warned by Vuntut Elder David Lord, 'hard times are coming:'

> "The hard time is coming and we gotta learn to share more of what we have. ... That's the way they used to do it long ago when and I don't see anything wrong with it. You gotta let the government know that this is our way of life. And hope they understand it." (2010, pers. comm.)

The sharing of food will be critical to the survival of the Gwitchin when those hard times come. To overcome the challenges associated with the border will require a concerted effort by not only the Vuntut but all Gwich'in, as noted by Vuntut Gwitchin Elder Robert Bruce Jr.:

> "Our strength comes from our Nation, not individual villages. The only way it will work is to make a Nation across two Nations, one people, one voice. That's the only way it will work. We belong to the Gwich'in Nation and it must be recognized by both Canada and the US—all governments." (2010, pers. comm.)

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arctic horticulture, cold frame greenhouses, food economy, Green Igloos Farm, Keewatin Gardens, native plants, Pond Inlet Gardens, potato, vegetable production

Experimental Horticultural Projects in the Canadian Low and High Arctic in the Early 1980s: What Did We Learn?

J. Svoboda, B.M. Bergsma, J.A. McCurdy, M.J. Romer, and W.R. Cummins

Department of Biology,
University of Toronto at Mississauga,
Ontario, Canada

Corresponding author: Josef Svoboda
e-mail: josef.svoboda@utoronto.ca

Abstract

The high cost of transporting fresh produce to northern settlements was the motivation to investigate the feasibility of growing vegetables in arctic conditions. Native tundra plant species, traditional foods of the Inuit, potato and several short-season vegetables were grown at: **Keewatin Gardens** near the Arctic Circle at Rankin Inlet, Northwest Territories, in the summers of 1979–1982. A series of 40 A-frame sun-heated greenhouses (area = 3.55m^2) filled with a mix of local soil and organic matter were successfully used, with surplus produce offered to local residents. In 1985–1986 the testing continued in a solar greenhouse at **Pond Inlet Gardens**; and at **Green Igloos Farm**, established downslope of two outlet glaciers in high arctic coastal lowland at Alexandra Fiord, Ellesmere Island. Here, from 1982 to 1984, researchers tested growth feasibility in outdoor and indoor conditions. Outdoor treatments were: black plastic "grow bags," filled with cultivated local tundra soil; grow bags covered with plastic mulch; and tundra soil with windbreak. Indoor treatments included two walk-in (area = 28m^2) and 11 reach-in (area = 7m^2) igloo-shaped structures covered with translucent woven polyethylene. Seven potato varieties and seeds of many common garden vegetables were planted in early June to test growth effects of low temperature and photoperiods of 18 or 24 hours. In some treatments tundra plants increased their biomass 400% in one season. In Rankin Inlet armfuls of

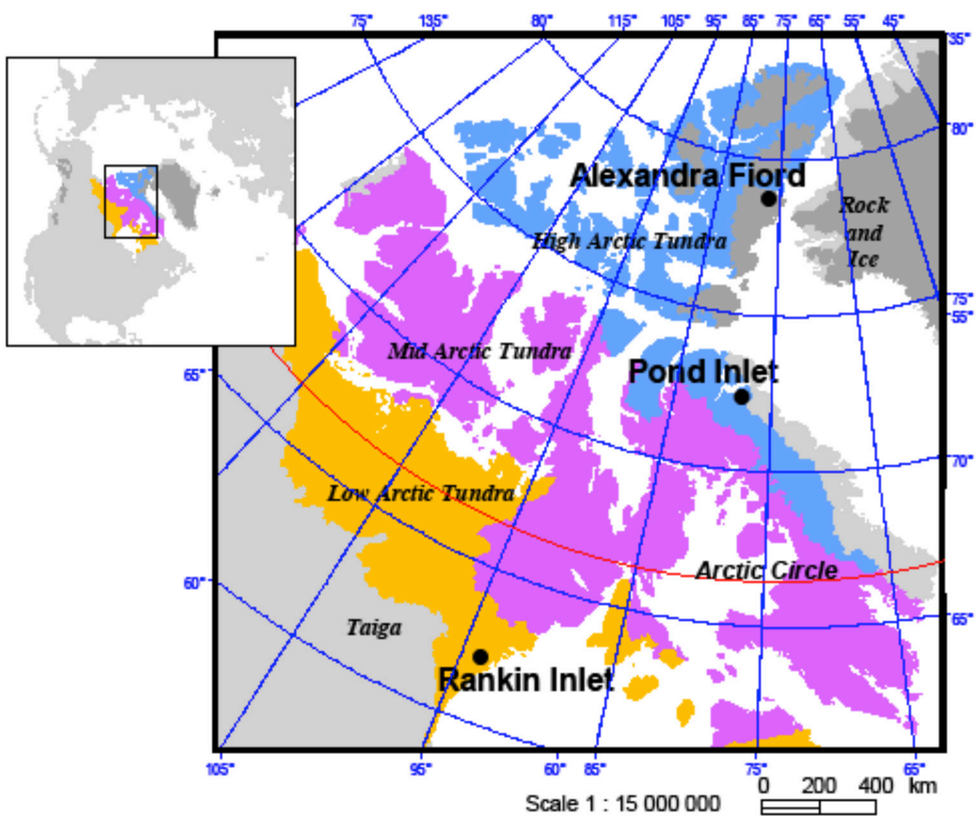


Figure 1. Study sites in the Low and High Arctic tundra ecozones in Canada.

produce were offered to local residents. In Alexandra Fiord sufficient yield was obtained from the various treatments, especially from the two walk-in greenhouses, to feed a ten-member research group, with the surplus of several cardboard boxes sent south occasionally to the kitchen at Polar Continental Shelf Project, Resolute Bay and to the Commissioner of Northwest Territories, Yellowknife.

Introduction

Many tundra plant species have traditionally been utilized to supplement the predominantly meat diets of Native peoples. In the eastern Canadian Arctic, for example, the use of numerous berries including blueberries, bearberries, cloudberries, and cranberries has been well documented (Anderson, 1939; Porsild, 1953). Edible roots of woolly lousewort, oxytrope, and alpine bistort were combined with seal fat and berries and stored for winter months (Romer, 1983). The succulent leaves of arctic sorrel, lacerated dandelion, and several species of saxifrage are still eagerly collected by children and families at their summer campsites (Cummins et al., 1988).

In the North American Arctic, attempts to grow vegetables as a means to relieve symptoms of scurvy date to times of Hudson Bay traders, whalers, pioneer settlers, and early Christian missions (Moodie, 1978). In the 1930s, Oblate Father Joseph Adam grew giant cabbages behind his mission house at Inuvik (68°N) (Canada Department of Agriculture, 1970). Since then there has been a steady progress. In Churchill, Manitoba, the Boreal Gardens enterprise pioneered in 1973 has been sustained to the present day by Bill and Diane Erickson (personal observations, JS). The town Inuvik, with a population of almost 4,000, currently features a large, year-round community greenhouse.

In the 1960s and early 1970s new gardening attempts in arctic zones were made. These largely failed due to lack of continuity on the part of the organizers but also due to a lack of community participation or government support (Nowasad, 1958, 1963; Nowosad et al., 1967; Campbell, 1976a, 1976b; Williams, 1976). The demographic policies of the Canadian government in the 1950s resulted in the settlement of traditionally nomadic native peoples into fixed communities where fuel, energy, and food supplies were more readily available. The utilization of native land for traditional food has steadily declined and the establishment of a food economy dependent on southern imports increased with serious nutritional and economic consequences for arctic peoples (Romer et al., 1981).

The strong reliance of northern communities on food sources that are over 3,000 km away from food resources has many social and economic problems. As a direct result of high transportation rates, food prices in northern communities are much higher than in southern areas and the high costs place a burden on governments that subsidize the transportation of essential foods. (Larsen and Gilliland, 2008). The northern consumer has few alternatives to limited supplies of fresh fruit and vegetables, characteristics of a "food desert" (Poole, 1985; Romer, 1987; Larsen and Gilliland, 2008).

Between 1979 and 1986, the University of Toronto conducted horticultural experiments at three locations: in the Northwest Territories: Keewatin Gardens (KG) in Rankin Inlet (Romer, 1983), Pond Inlet Gardens (PG) on Baffin Island (Romer, 1987), and Green Igloos Farm (GIF) in Alexandra Fiord, Ellesmere Island (Bergsma, 1986; McCurdy, 1988). The objectives at KG and PG were: (1) to determine the feasibility of low-cost, small-scale gardening in arctic communities, (2) to examine the effects of improvements of simple-design cold frame gardens on environmental conditions and crop production, (3) to compare the production of edible tundra plants with conventional temperate zone crop plants, and (4) to identify the benefits of small-scale community level projects. GIF objectives were to test and evaluate (a) the effectiveness of simple agricultural techniques applied to outdoor plots and in specially designed "green igloo" structures, and (b) to compare the effectiveness of low-tech amelioration of light, temperature, moisture, and nutrients on growth of potato, a temperate zone crop, and other vegetables under 24-hour continuous photoperiod. Native arctic plants were also tested for their response to amelioration of their growth conditions. This paper summarizes that research and proposes their findings as a solution to the food and nutritional inadequacy experienced in northern communities.

Methods

KG - Keewatin Gardens (1979–1982) was established at Rankin Inlet (Kangirliniq; 62°45′N), an Inuit hamlet on Kudlulik Peninsula of Hudson Bay in the Keewatin District. The coastal climate is harsher than in sites more inland with a mosaic of regosols and shallow organic soils. Yet the area is still classified as Low Arctic. (Fig. 1).

At this locality we examined the productivity of selected edible arctic plants and temperate vegetables under open field conditions or in small cold frame gardens (Romer,

Figure 2. Temperate zone cultivars growing in cold frames at Keewatin Gardens, Rankin Inlet on August 22, 1982.

1983; Romer et al., 1983; Cummins et al., 1984; Cummins et al., 1988).

A total of 40 A-shaped cold frames (3.55m²) were constructed from plywood and standard structural lumber, and insulated from the permafrost by polystyrene foam board (40 mm, R=7.5). The structures were filled to a depth of 15 to 20 cm with a soil mixture composed of equal parts of local lake sediments, tundra peat and roadside sand. The soil was enriched with 20-20-20 all-purpose fertilizer (+N) and selected gardens were ameliorated with clear polyethylene covers (+T) (Fig. 2).

Native tundra plants. Plants of five native edible herbs were extracted from nearby tundra and transplanted to the cold frame gardens. Three have edible shoots: sorrel *(Oxyria digyna)*, lacerated dandelion *(Taraxacum lacerum)*, nodding bulbous saxifrage *(Saxifraga cernua)*. Two have an edible rootstock: alpine bistort *(Polygonum viviparum)* and Bell's oxytrope *(Oxytropis Bellii)*. These plants were monitored in their natural habitats as the control condition. Botanical names of tundra plants follow Porsild and Cody (1980).

Temperate zone vegetables. Horticultural feasibility of growing temperate zone vegetables in the Low Arctic was evaluated in cold frames under natural and ameliorated conditions (+N, +T). The vegetables tested were: beet, broccoli, carrot, cabbage, Chinese cabbage, cauliflower, endive, kale, kohlrabi, lettuce, onion, spinach, radish, rutabaga, and turnip (Romer, 1983).

PG - Pond Inlet Gardens (1985–1986): An extension of the Rankin Inlet project was carried out at the High Arctic locality Pond Inlet on North Baffin Island, Northwest Territories (72°42′N) (Fig. 1) using cold frames, hydroponic systems, and a conventional solar greenhouse. Eighteen temperate zone crop species and 65 varieties were grown over a six-month season each in 1985 and 1986. Plant performance was rated on growth and development (adaptability to the growing regime), productivity (yield and relative yield), and quality of produce (appearance, texture, taste) (Romer, 1987).

GIF - Green Igloos Farm (1982–1985). Greenhouses were dome-shaped and solar heated (area = 7 m² reach-in or 28 m² walk-in) (Fig. 5). The light umbrella structure

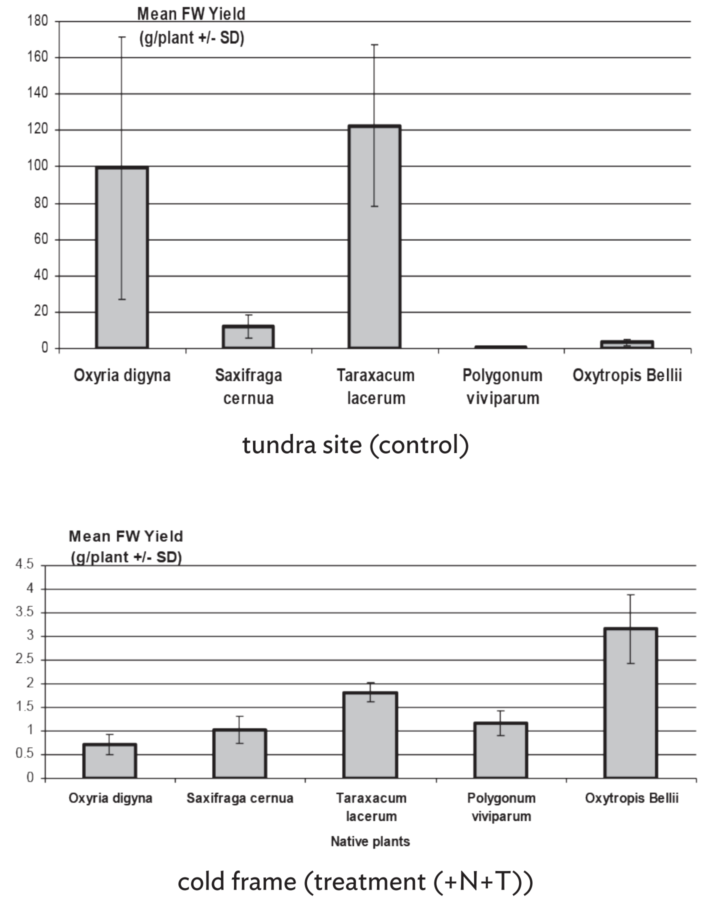


Figure 3. Fresh weight yields (grams/plant) of native species in native tundra site (control) versus transplanted to ameliorated cold frames (+N+T) at Keewatin Gardens, Rankin Inlet 1982. Note change in y-axis scales.

rested on a 50-cm-tall octagonal plywood frame. The plywood was painted black on the outside to absorb radiation and white on the inside to reflect light and re-radiate heat. The circular greenhouses were covered with translucent (to optimize natural illumination during the 24-hour continuous light) interwoven DuPont Fabrene™ plastic equipped with zippers for reach-in access and ventilation. Local soil, i.e. *in situ* herb-dominated Regosolic Static Cryosol with a shallow organic layer overlying well-drained sandy loam substrate (Muc et al., 1994), was used for growing potatoes and in 1984 for vegetables. Initial preparation of the study site was done by Bergsma (1986).

Potato study

Objectives. Potato plants were grown in the summers of 1982–1984 at Green Igloos Farm to assess the agricultural potential of potato at high latitudes under conditions of continuous (24h-LL) photoperiod, low irradiance, low soil temperature, low nutrient availability, and a short growing season.

Potato varieties tested at Green Igloos Farm were provided by the University of Guelph, with a caution that the potato has evolved in the tropics with a 12:12h (LD) photoperiod: "Above the Arctic circle, they may prolifically flower but won't produce tubers!" The potato variety Yukon Gold, developed at the University of Guelph, was chosen as the most viable potato cultivar to test under all treatment settings (n = 20). Seven other early-maturing varieties (Campbell-13, Conestoga, F72217, G581-25, Jemseg, Serrana, and Superior) were also tested in a simplified treatment plan described below.

The Growing Degree Days (GDD), unique to each treatment, were determined by summing the average of daily air temperature minimum and maximum measurements on days that the average daily temperature exceeded 0°C and again when average daily exceeded 5.0°C.

Soils for T1 through to T11a were fertilized every two weeks from June 21 to August 1 with water soluble 20-20-20 fertilizer mixed at an application rate to give a seasonal total of 550 kg/ha (0.83 g per 19L bag per application); T11b and T11c were fertilized at the same frequency but at concentrations of 2x and 4x, respectively. In addition, 1,270 kg/ha stonelite lime was added to increase soil pH from 4.9 to 5.5. Soils were watered with glacier meltwater warmed to 15–18°C by the sun in oil drums over 24 hours.

Tubers were "chitted" by exposure of green sprouts to continuous light for 10–12 days in a controlled environment growth chamber to initiate early growth; these were hardened off in cool outdoor temperatures for three to five days, then planted on June 20 in all three years. Both non-destructive and randomized destructive sampling was done to determine net primary production, that is, the biomass of dried flowers, leaves, stems, roots, stolons, and tubers. At final harvest (August 21–24) tubers from each plant per treatment were counted, weighed, and measured and data expressed as mean yield per plant in grams and converted to tonnes per hectare (t/ha). Quality (specific gravity, dry matter accumulation, cooking quality, color, and flavor) was measured at the University of Guelph Potato Quality Laboratory in the fall of each year, soon after harvest (Coffin, 1982; Bergsma, 1986).

Experimental design: outdoor and indoor treatments

The outdoor treatments were: T1) ambient cultivated tundra soil, T2) tundra soil with windbreak, T3) tundra soil protected by clear plastic mulch and windbreak, T4) black plastic soil bags (19 L) filled with soil placed on the ground, T5) black plastic soil bags placed on the ground, additionally protected by clear plastic mulch and windbreak, T6) soil bags individually topped with ventilated “hot caps” made of pre-cut clear plastic sheeting (0.5m^2).

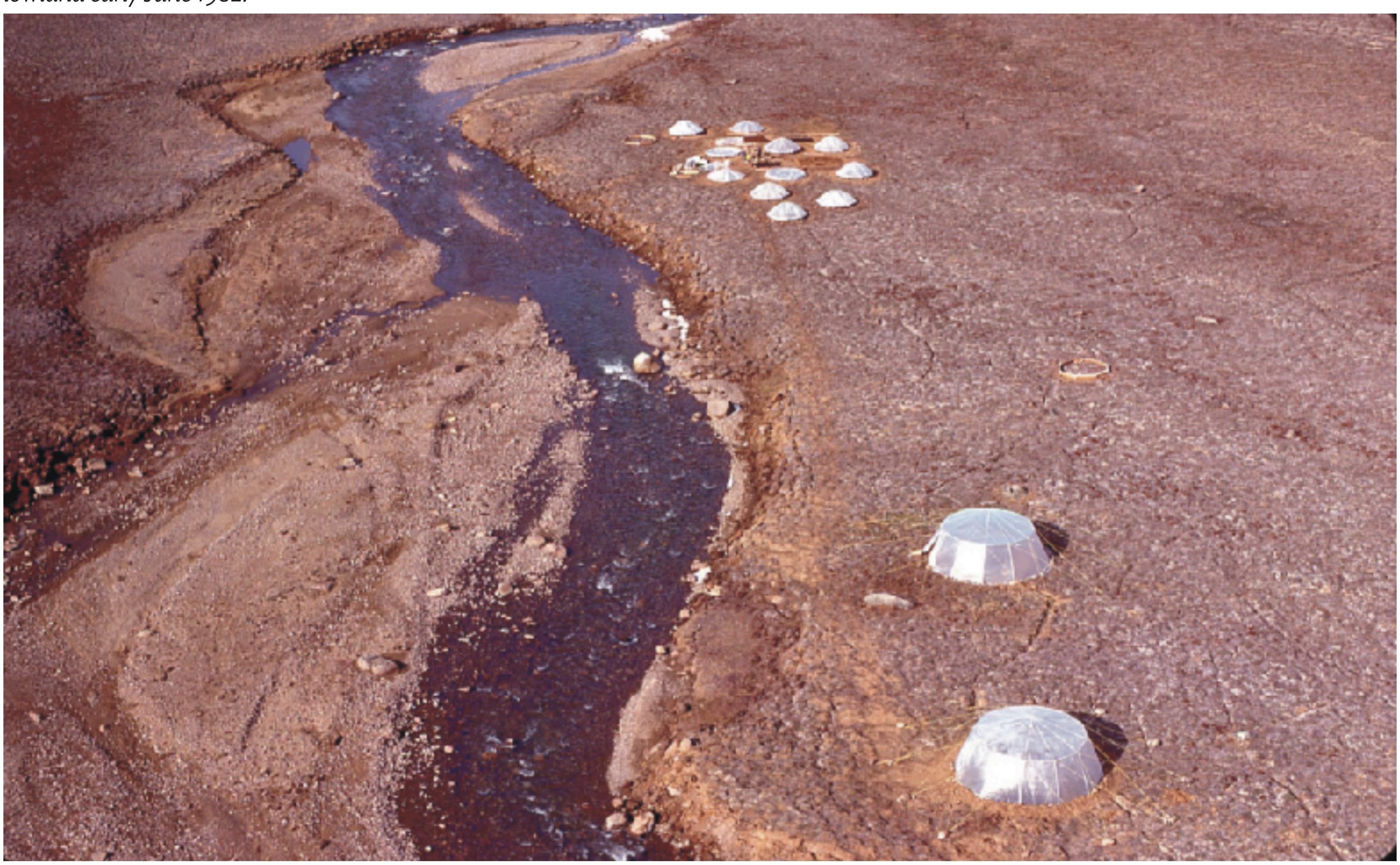
The indoor treatments were within “green igloos”: T7) direct planting in tundra soil, T8) planting in soil bags buried in the ground, T9) soil bags standing on the ground were either exposed to (a) 24h light-light (LL) or (b) a 18:6 hour light-darkness (LD) photoperiods by applying black tarp for 6 hours at night, T10) direct planting in tundra soil insulated from the permafrost by a Styrofoam™ sheet and T11) soil bags with fertilizer rates of 1x (11a), 2x (11b) or 4x (11c) (550, 1100, 2200 kg per hectare equivalent, respectively).

Vegetable and native plant study: Four varieties of temperate zone vegetables were grown under various treatments and fertilization rates: cabbage (*Brassica oleracea* var. *capitata* cv. Copenhagen Market Early), turnip (*Brassica rapa* cv. Purple Top White Globe), carrot (*Daucus carota* var. *sativa* cv. Coreless Amsterdam), and lettuce (*Lactuca sativa* cv. Grand Rapids Forcing).

Radish (*Raphanus sativus* var. Cherrybelle) was sown and grown in a green igloo in succession at 10-day intervals and harvested at 30 days for each of five trials from June 12, 1984 (harvest July 21) to July 20 (harvest August 20). This fast-growing crop plant was selected to test the effect of delayed seeding on the harvestable yield.

Figure 4. Inuit student with an armful of lettuce from the Keewatin Gardens.

Figure 5. Oblique view of the Green Igloos Farm under construction on a large polygon tundra at a site of a glacial rivulet in Alexandra Fiord lowland early June 1982.



Median fresh weight production was used as the better representation of the centre of the non-normally distributed data set. Dispersion about the median is represented by QD (quartile deviation = ½(Q3-Q1) (McCurdy, 1988). Linear regression was used to express the correlation of radish yield to each of the average daily temperature and the daily photosynthetically available radiation over the course of the accumulated successive planting period.

Plants of nodding saxifrage (*Saxifraga cernua*), and arctic poppy (*Papaver radicatum*) were transplanted immediately after snowmelt from local tundra into one of the "green igloos." Growth and productivity were measured over two growing seasons in 1982 and 1983. The fertilization and watering regime described for potato, above, was used for the four varieties of temperate zone vegetables and the two tundra plants.

Results and discussion

KG: At Keewatin Gardens, the mean seasonal air and soil temperatures measured daily at 1400h were 6.5°C higher in covered (+T) cold frames and 4.1°C in uncovered frames than ambient temperatures between the frames. The foam board insulation reduced heat loss to the ground and contributed to warmer soil temperatures for plant roots.

Native species began flowering and matured seeds an average of two weeks sooner and senescence was delayed until fall frosts under the ameliorated conditions. Compared to the native tundra control, sorrel and lacerated dandelion that were grown in nutrient and temperature ameliorated cold frames produced the greatest biomass of native species with fresh weight (FW) yields averaging 99.3 and 122.6 grams per plant, that is 67% and 138% greater than control, respectively. Yields of saxifrage were 12% higher while alpine bistort and Bell's oxytrope showed no change with respect to the control (Fig. 3).

Productivity and horticultural feasibility of vegetable varieties. Table 1 presents a list of 15 temperate zone plants grown within a ten-week growing season. The Spanish onion produced inadequate shoot mass by end of growing season. The three plants grown for the edible flower head (broccoli, cabbage, cauliflower) grew slowly and did not produce a harvestable crop in the cold frame setting before the first fall frost. Of those grown for the swollen hypocotyls, the Purple Top White Globe turnip yielded the best (203 g/plant). Beet, rutabaga, radish, and

Table 1. Temperate zone crop cultivar performance: fresh weight yield (mean g/plant, ±SD) and length of season at Rankin Inlet, 1982.

Botanical name	Crop	Cultivar	Mean FW (g/plant)	SD (n=8)	Season (days)
edible portion					
bulb					
Allium cepa	Onion	Sweet Spanish	no yield		62
flower head					
Brassica oleracea var. *capitata*	Cabbage	Early Copenhagen Market	no yield		71
Brassica oleracea var. *botrytis*	Cauliflower	Early Snowball	no yield		73
Brassica oleracea var. *botrytis*	Broccoli	Green Sprouting	no yield		73
hypocotyl					
Brassica rapa var. *longifolia*	Turnip	Purple Top White Globe	203.5	17.5	74
Beta vulgaris	Beet	Detroit Dark Red	118.2	33	71
Brassica napus var. *napobrassica*	Rutabaga	American Purple Top	61	5	71
Raphanus sativus	Radish	Early Scarlet Globe	32.8	28.8	54
Brassica oleracea var. *caulorapa*	Kohlrabi	Early White Vienna	32.5	32.5	73
root					
Daucus carota var. *sativa*	Carrot	Red Cored Chantenay	6	1.6	59
leafy					
Brassica rapa var. *pekinensis*	Chinese Cabbage	Michihli	783.8	439	74
Lactuca sativa	Lettuce	Black Seeded Simpson	148.5	0	73
Spinacea oleracea	Spinach	Long Standing Bloomingsdale	107.8	37.2	70
Cichorum endiva	Endive	Large Green Curled	90.2	33.4	73
Brassica oleracea var. *acephala*	Kale	Dwarf Blue Curled	84.1	21.9	73

Figure 6. Outdoor black grow bags with hot caps and an igloo greenhouse; Twin Glacier in the background, Alexandra Fiord 1984.

kohlrabi ranged from 32 to 118 g/plant (6.8–7.8 kg/m²). Carrots were restricted by the shallow depth of soil in the cold frames. Leaf crops performed extremely well in the ameliorated cold frames. Amongst the leafy types grown in the ameliorated cold frames, Chinese cabbage yielded the greatest biomass but of varying sizes (783 g/plant; 16.8 kg/m²). Lettuce and spinach yielded up to 148.5 g/plant (8.9 kg/m²), kale and endive up to 90.2 g/plant (7.6 kg/m²). Armful quantities of the fresh produce was offered free to local residents on a weekly basis (Fig. 4).

Table 2. Soil temperatures, degree-days and average tuber yield of Yukon Gold for applicable treatments in 1982, 1983, or 1984 at Green Igloos Farm.

	Temperature °C		Degree-Days		Average Tuber Yield		
Growing Medium, tundra soil	at surface	at 10 cm depth	> 0 °C	% > 5.6 °C	number per plant	gram per plant	tonnes / ha
exposed to ambient conditions							
1 exposed	9	7	324	23	< 1	0.7	0.1
2 exposed, windbreak	8	7			2.2	5.9	0.4
3 exposed, windbreak, mulch	14	12	558	35	3.8	64.1	4.5
4 in black plastic bags, windbreak	10	10			0.6	1.7	0.1
5 in black plastic bags, windbreak, mulch	12	11			9.2	128.5	9.0
6 in black plastic bags, hotcaps	15	12			11.0	199.4	13.9
inside igloo							
7 exposed	18	10	522	33	6.7	182.1	12.7
8 in black plastic bags, buried	15	10			8.2	211.8	14.8
9a in black plastic bags, 24 h PP	18	12	664	49	5.9	214.6	15.0
9b in black plastic bags, 18 h PP	16	11	576	46	7.3	166.7	11.7
10 insulated from permafrost	18	15	702	53	6.1	246.1	17.2
11a in black plastic bags, 1x fertilizer	18	12	664	49	9.0	195.7	13.7
11b in black plastic bags, 2x fertilizer	18	12	664	49	6.0	281.9	19.7
11c in black plastic bags, 4x fertilizer	18	12	664	49	9.0	403.0	28.1

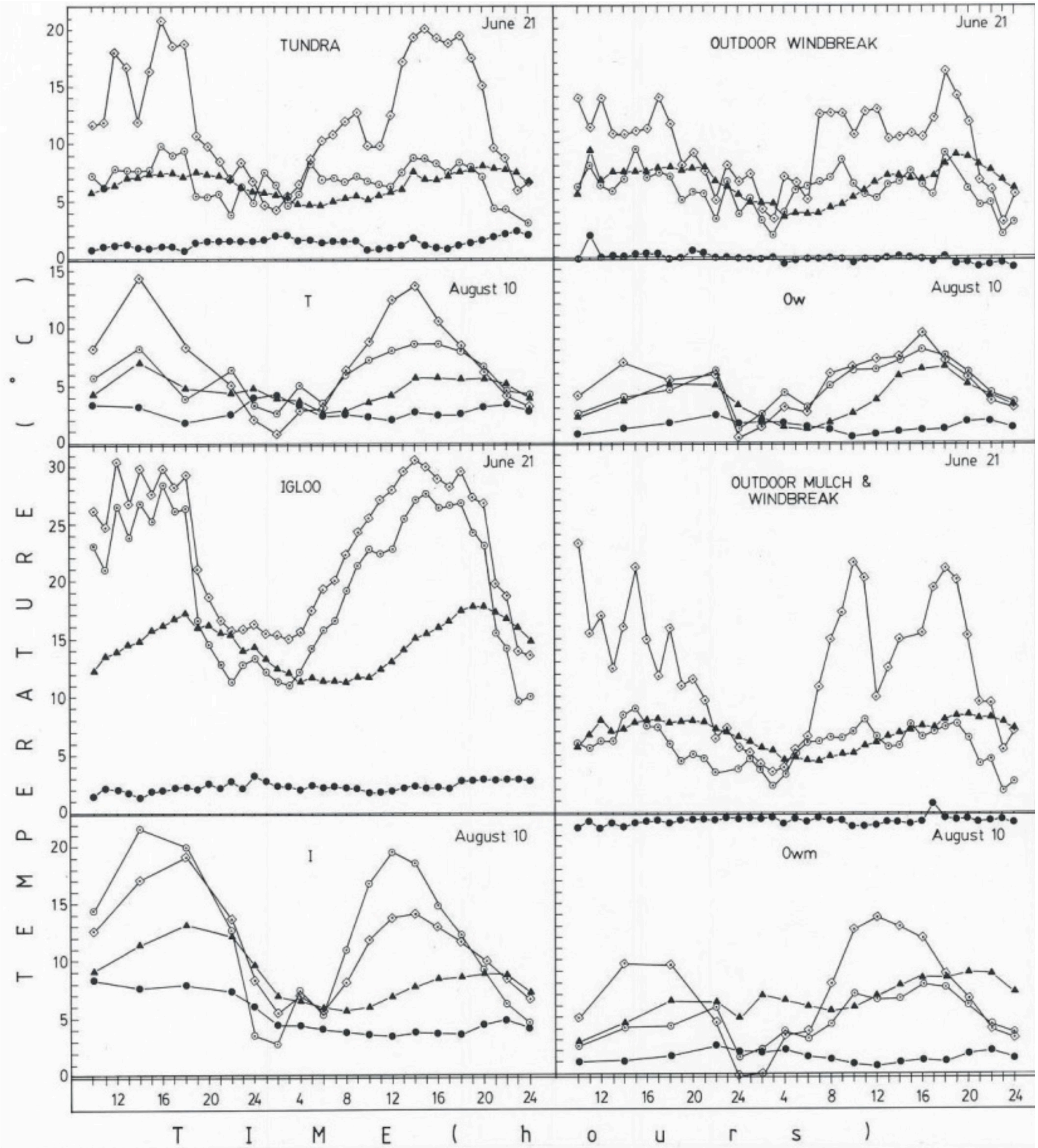


Figure 7. Diurnal temperature profiles of air at 25 cm (open circles), soil surface at 0 cm (open triangles), below soil surface at 10 cm (closed triangles) and at 25 cm (closed circles) monitored at regular intervals at thermocouple stations in four treatments on June 21 and August 10, 1982 at Alexandra Fiord.

Economic and social benefits. **PG:** In terms of productivity and quality, plants most suitable for greenhouse production included: beans, beets, Chinese cabbage, cucumber, lettuce, tomato, turnip, and zucchini. Leaf crop yields for Chinese cabbage and lettuce increased significantly when grown under hydroponic culture. Cold frames with local soil mixtures were suitable for Chinese cabbage, radish, and spinach (Romer, 1987).

GIF: The horticultural experimental station Green Igloos Farm operated from 1982 to 1985 in the Alexandra Fiord lowland (78°53'N) on Ellesmere Island (Fig. 1). It was established in the centre of the lowland flat valley along a glacier-fed river in large-polygon tundra (Fig. 5). This study became a parallel project to a multi-year team research of the lowland's enclosed (ca. 8 km^2) high-arctic polar oasis ecosystem (Svoboda and Freedman, 1994).

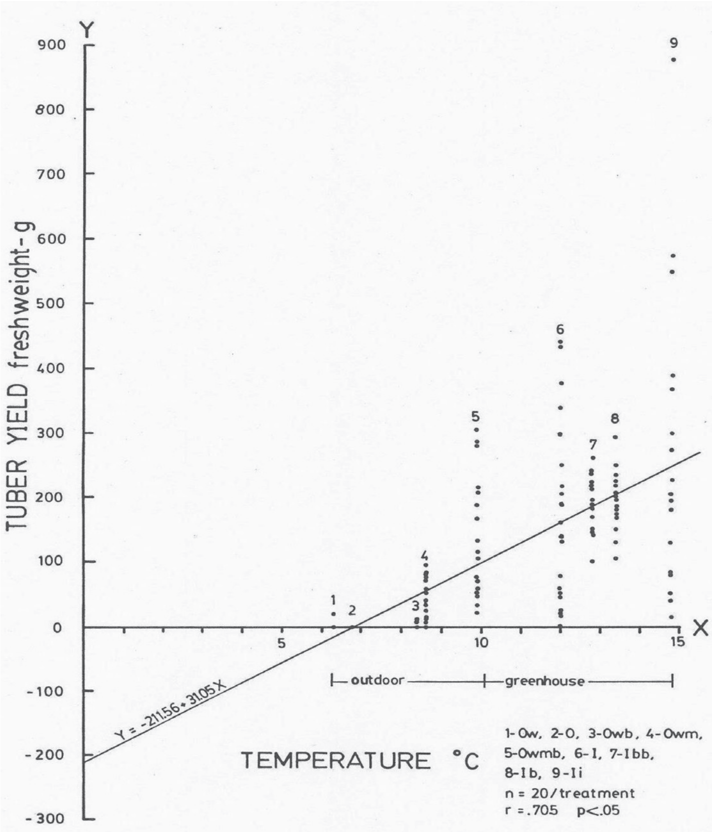


Figure 8. Linear regression of tuber yield versus mean temperature in nine treatments for Yukon Gold variety, Green Igloos Farm, 1983.

At the Alexandra Fiord research base the microclimatic and meteorological data for 1982 to 1984 show an average of 376 GDD using 0°C as the threshold value at the standard height (Labine, 1994). The 5.6°C threshold values were expressed as percentages of the 0°C GDD.

Figure 7 shows hourly temperature readings at time of planting (June 21) and late season growth (August 10) at treatment sites. On June 21, the average temperature in the vented greenhouses averaged 25°C at noon and 15°C at midnight. Photosynthetically active radiation (PAR) irradiance ranged from 400–200 μmoles/m²/s. During normal daytime, the Fabrene™ plastic cover reduced the transmittance of radiation (R) and PAR inside the green igloos to 68% and 65%, respectively. At midnight, with less condensation, R increased to 80% and PAR to 73% of ambient conditions.

Table 2 presents the soil temperatures, total degree-days >0°C, per cent growing degree-days (GDD) >5.6°C, and the average tuber yield for all treatments for Yukon Gold. The length of the growing season at Green Igloos Farm from planting/seeding to final harvest was 64 days (June 20–August 23) in 1982 and 70 days (June 20–August 28) in 1983 and 1984. The number of GDD ranged from 324 to 702 for least to most protection (T1 *vs.* T10). GDD for outdoor with windbreak and mulch (T3) were nearly equivalent to direct planting in the "green igloos" (T7). The artificial 18-hour photoperiod also reduced GDD (664 to 576) (T9a vs T9b).

Table 3. Tuber return ratio (TRR) and yield (g/plant) in selected treatments (Tx) for eight cultivars in 1982 at Rankin Inlet and in 1982, 1983, and 1984 at Alexandra Fiord.

Cultivar		TRR		Yield (g / plant)	
Tx	Year	Rankin	AlexF	Rankin	AlexF
Campbell-13					
T9a	1983	1.7	1.4	278.2	192.0
Conestoga					
T6	1984				185.0
F72217					
T6	1984				155.0
T9a	1983	2.3	1.8	334.9	236.1
T9a	1984				175.0
G581-25					
T9a	1982	0.9	0.7	52.0	91.0
Jemseg					
T6	1984				240.0
T9a	1982	0.7	1.3	87.9	265.5
T9a	1983	2.1	1.5	292.3	226.1
Serrana					
T9a	1982	1.8	2.2	148.7	136.4
Superior					
T6	1984				195.0
T9a	1982	0.9	2.1	88.5	392.0
T9a	1983	2.2	1.5	281.8	190.3
Yukon Gold					
T2	1982	0.6	0.0	77.4	2.1
T3	1982	1.3	0.4	224.3	50.6
T6	1984				140.0
T9a	1982	1.1	1.2	229.5	180.9
T9a	1983	1.3	1.2	188.6	189.8
T9a	1984				250.0

Figure 8 presents the results of a linear regression analysis of tuber yield (FW) versus treatment temperatures and this shows (a) the effect of increased temperature on growth of the potato and (b) that tuber production did not occur at soil temperatures less than 7°C ($r = 0.71$, $p < 0.05$).

In bare soil (T1) temperatures rarely exceeded 10°C. Plants grew but rarely formed tubers greater than 10 grams in weight. Potatoes grown under clear plastic mulch (T3) were the earliest to initiate tuber formation and the yield of Yukon Gold was 64.1 g/plant in 1982 (4.5 t/ha). The mulch improved the 0 to 10 cm depth soil temperatures by 3–6°C (Fig. 7).

In the green igloo where the soil was insulated from the permafrost (T10) the Yukon Gold yields were the highest: 246 g per plant (17.2 t/ha). Yields of Yukon Gold were 214 g/plant in green igloos with potatoes grown in black plastic soil bags placed on the ground surface (T9a). Planting directly in the soil (T7) yielded in 182.1 g/plant (Table 2). The effect of the reduced radiation due to the Fabrene™ was apparently compensated by the benefit of the temperature gain inside the "igloo." In 1984, the shoot and tuber production for five potato varieties increased with the extent of amelioration, mostly due to a seasonal increase of mean temperature (degree-days). The highest yield was achieved with potatoes planted outdoors in the growth bags with hot caps (T6): 199 g/plant (13.9 t/ha) and in the growth bags in green igloos (T9a) (Fig. 6, Table 2).

The average yield for Yukon Gold for 1982, 1983, and 1984 was 204 g/plant grown in bags in a green igloo with a 24-hour photoperiod and 1x fertilization (T9a, T11a). In the rates of fertilization trials with Yukon Gold, the maximum shoot development and highest tuber yields (28.1 t/ha) were measured with the highest (4x) fertilization rate (T11c).

There was greater mean leaf area for plants grown in the warmer green igloos compared to the outdoor conditions ($p < 0.05$). Analysis of variance showed that the production of tubers of all varieties grown under (T9a) the continuous 24hr-LL photoperiod was greater than that under (T9b) an artificial 18:6h LD-photoperiod ($F = 61.2$, $p < 0.05$), indicating that under greenhouse conditions, the continuous photoperiod in the high latitudes compensates for the shortness of the growing season.

The *tuber return ratio* provides an index of the production per unit of seed tuber planted, i.e., grams yield divided by grams of planted seed tuber. In Mid-Arctic conditions at Rankin Inlet the tuber return ratio in the outdoor windbreak and mulch treatment was equivalent to the green igloo treatment in either Mid or High Arctic conditions (Table 3). At Alexandra Fiord, in 29 trials in 1982, 1983, and 1984, the average yield (g/plant) ranged from < 1 to 392 with an average of 185 +/- 90 g/plant.

The comparison of early-maturing potato cultivars in all three years showed best tuber return ratios and highest yields per plant for F72217, Jemseg, and Superior in either LL or LD (T9 and T9b) in outdoor or indoor conditions (Table 3). The one cultivar exceeding the average yield by two standard deviations is Superior; the cultivars exceeding the average yield by one standard deviation are: Superior, F72217, Jemseg, and Campbell-13.

Challenges for potato cultivation in the permafrost regions. The wild ancestors of the cultivated potato (*Solanum tuberosum*) evolved in the tropical latitudes yet extend to the altiplano (high plateaus >3,800 m) of the Andes Mountains of Peru and Bolivia (Salaman, 1949; Hawkes, 1978). There, frost-resistant varieties are cultivated and used. In the Arctic the presence of permafrost offsets partially the low summer precipitation by retaining the snowmelt moisture within the active layer. However, arctic soils are too low in nutrients for potato cultivation without fertilization (MacEwan, 1954). In contrast to the equatorial regions of the Andes Mountains, high above the Arctic Circle there is continuous photoperiod during all or part of the growing season, with slightly higher total summer solar irradiance at high latitudes compared with lower latitudes (Maxwell, 1980). The historically most northerly Canadian agro-station at Aklavik, Northwest Territories (68°N) yielded 17–20 t/ha in 1956 (Brown, 1970). However, the development of regular air services to the Arctic and cheap fuel in the 1940s reduced the incentive for arctic agricultural self-sufficiency and during the 1960s most of the northern agricultural research stations above 60°N were closed.

Table 4. Median fresh weight yield (g per plant ±QD) for four vegetable species: cabbage, turnip, carrot, and lettuce grown under thermal insulation treatments in Green Igloos Farm, 1984.

	Cabbage			Turnip			Carrot			Lettuce
	Head	Loose Leaves	**Total**	Shoot	Hypocotyl	**Total**	Shoot	Tap root	**Total**	Shoot
non-insulated igloo										
Yield (g)	199.3	301.0	496.5	159.3	117.0	291.6	2.9	8.1	11.5	71.6
± QD	44.4	65.2	92.9	45.9	52.8	93.2	0.6	1.9	2.3	16.9
insulated igloo										
Yield (g)	151.8	181.2	338.0	179.9	269.0	423.8	3.7	12.1	15.2	80.7
± QD	85.6	31.2	111.2	50.6	53.7	110.9	1.1	3.9	4.8	7.8
igloo + grow bags										
Yield (g)	226.0	169.8	418.1	169.6	246.9	432.6	3.7	14.1	17.1	67.0
± QD	51.0	19.8	78.9	16.5	76.5	85.8	1.0	4.2	5.3	8.7

Temperate zone vegetable growth and productivity. The time of final harvest was August 21–24, 1984. Plants were analyzed according to their specific growth forms. The separation of the root zone from the cooler underlying soil temperature through the use of grow bags and an insulated sub-floor green igloo resulted in significant differences in final yields. Median yields (FW g per plant +/- QD; n=25) for four vegetable species: cabbage, turnip, carrot, and lettuce grown in the green igloo with thermal insulation are presented in Table 4.

Cabbage demonstrated significant differences in fresh weight among treatments for loose leaf ($p < 0.001$) and total plant ($p < 0.01$) components; there was no significant difference among treatments for the cabbage head; this vegetable is known for doing well in cool, long-day environments (Table 4).

Turnip responded positively to soil warming due to the thermal insulation from the permafrost with significant increase in size of the swollen hypocotyl ($p < 0.001$) and total fresh weight ($p < 0.05$). There were no significant differences for the shoot component (Table 4).

Carrot showed significant differences ($p < 0.001$) in fresh taproot weight for the uninsulated green igloo treatment, for the green igloo grow bags, and for the insulated green igloo treatments, thus demonstrating the benefits of soil thermal amelioration (Table 4).

Lettuce shoots did not differ significantly among the treatments. Median fresh weight of lettuce were: 67.0 g in a grow bag (T9a,) 71.6 g in an uninsulated green igloo (T7), 80.7 g in the insulated green igloo (T10); thus showing more sensitivity to ambient temperature versus soil temperature.

Effect of delayed planting on growth and yield. In the successive planting experiments, radish demonstrated striking reductions in shoot, swollen hypocotyl and whole plant fresh weight that was strongly correlated with measured declines in total radiation (Watts/m^2 x 10^3) and weakly correlated with the mean outdoor air temperature over the corresponding growth periods (Fig. 9). Correlation analysis of yield (total plant) versus total radiation showed a statistically positive relationship ($r = 0.982$, $p = 0.0008$; n=25) while yield versus mean outdoor air temperature showed a barely statistically positive relationship ($r = 0.769$, $p = 0.049$; n=25). These results suggest that reduced incoming radiation due to delayed planting during the advancing season accounts for reduced productivity of *Raphanus sativus* cv. Cherry Belle more than less rapidly declining outdoor temperatures over the same period. These observations underscore the shortness of the growing season in the High Arctic and the importance of sufficient levels of photosynthetically active radiation for the growth of temperate zone vegetables.

Native tundra plants. The small transplanted tundra plants, arctic poppy and nodding saxifrage, grown in enhanced temperatures and nutrients over a short growing season resulted in a 400% increase in biomass.

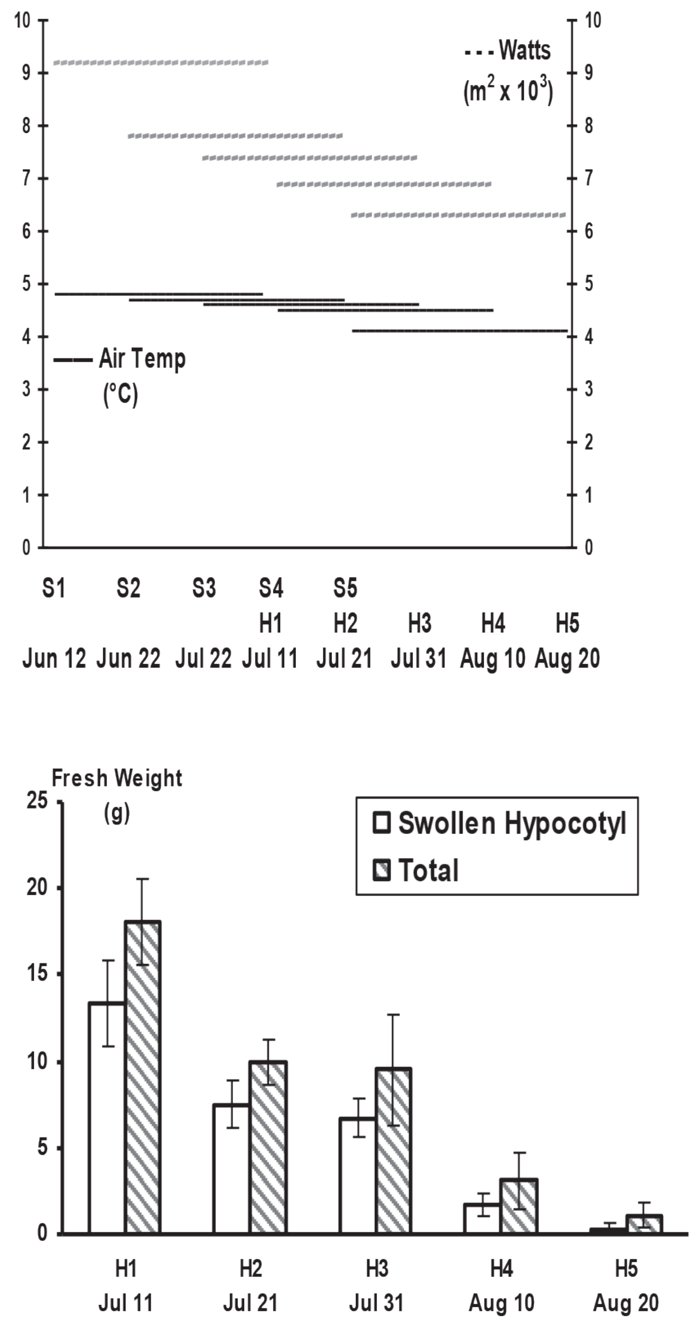


Figure 9. Upper panel: Mean outdoor air temperature (°C) and total incoming radiation Watts (m^2 x 10^3) for five successive 30-day growth periods (Seeding to Harvest (S1 to H1), etc.).
Lower panel: Median Fresh Weight production (g/plant) for Raphanus sativus *cv Cherry Belle (n=20) during the 1984 field season at Alexandra Fiord, Ellesmere Island.*

This clearly indicates the specialized adaptations to extreme temperatures and low nutrients that permit tundra plants to exploit this niche. The potential for Inuit to cultivate their traditional medicine and dietary plants is demonstrated (Svoboda, 2009).

Conclusions

General. The work carried out at KG demonstrated the benefit of home and small market gardening in arctic communities and detached outposts. We determined that a wide range of temperate crops and traditional native species could be successfully grown in the Arctic in simple sun-heated structures during the short summer season and in larger greenhouses heated in the early spring and the late fall, as in PG.

These experiments show that simple technology including ridged soil and separation of the root zone from the cooler temperature near the permafrost table are important improvements to grow potato and other temperate crops successfully in the permafrost region. Notably, the continuous light condition of the High Arctic compensates for the shortness of the growing season.

The production cost for most of the crops grown in the cold frame gardens was lower than for comparable imported produce. As an example, lettuce could be produced for $2.09/kg versus $4.59/kg (in 1982 dollars) for the imports. Other varieties produced price cost savings of 20% to 75%.

At PG the annual greenhouse operating costs were estimated at $298/m^2 with lighting costs accounting for 58%. Operating costs were $11.79, $9.29, and $34.30 /m^2/month (in 1984 dollars) during spring, summer, and early winter, respectively. The value of locally grown produce was competitive with imported produce at subsidized and regular freight rates. Lettuce and Chinese cabbage had lower annual unit costs than subsidized imports; five other varieties (beets, turnip, cucumber, tomato, and bush beans) matched the cost of imported products. For actual data consult (Romer, 1983; Poole, 1985; Romer, 1987).

Potato trials. At KG (62°N and PG (72°N) compared with GIF (79°N) there was a slightly higher total solar radiation gain, warmer climate but an increased risk of night frosts due to a slightly shorter day length. At Rankin Inlet in the outdoor conditions potatoes responded well to mulch and a windbreak. At Alexandra Fiord yields were lower for all three main amelioration treatments.

In 1984 at Alexandra Fiord, the addition of hot caps over the outdoor planted potatoes produced similar yields as those in the igloo greenhouses, demonstrating the necessity in the arctic environment to ameliorate both soil and air temperatures for maximum productivity of selected crops, but not necessarily requiring greenhouses.

Tubers produced under the 24-hour sun were high in dry matter content, of acceptable culinary quality, and could be used as seed tubers the following years.

Potato cultivars that performed well were: F72217, Jemseg, and Superior. These gave greater yields per plant and ranked higher for tuber return ratio. Yukon Gold performed better in Low-Arctic conditions. Desirable factors in the selection of genotypes suitable for the Far North include: frost-hardiness, cold tolerance, ability to expand leaves rapidly in the spring, achieving a large leaf area with efficient photosynthesis, rapid growth, and to remain photosynthetically active at temperatures <7°C and low insolation.

Vegetables. For the most part, short-season day-neutral vegetable crop plants can be successfully grown in the Low and High Arctic using fairly simple technologies that extend the length of the growing season; and that moderate the ambient soil and air temperatures. Soil temperature amelioration and adequate growing space are key considerations for successful production of root crops. Leafy vegetables are less sensitive to cooler soil temperatures at depth, and more sensitive to ambient air temperatures.

Native tundra plants. The experiments illustrate the adaptive evolution of originally temperate species, to grow in alpine and arctic climates: ability to miniaturize and to withstand snow abrasion, low temperature, short season, extended photoperiod, low nutrients and low soil moisture. Yet, their genotype extends over a broad range of conditions historically and respond vigorously to amelioration of the sub-optimal arctic environment (Svoboda, 2009). These Arctic-adapted plants are rich in nutrients and vitamins (Bliss, 1962; Savile, 1972) that have been a complementary part of the traditional Native people's diet; they have high potential to be developed as substantial edible crops.

The present studies showed that even slight amelioration of growth conditions such as temperature, moisture and nutrients resulted in a many-fold increase in lacerated dandelion and sorrel tested at Rankin Inlet and in arctic poppy and nodding saxifrage tested at Alexandra Fiord. Additional research would be desirable to evaluate the best means of their propagation, selection for favourable attributes, marketing and acceptance by the local and southern population (Romer et al., 1981; Romer et al., 1983).

How can we apply these results?

With devolution of lands and resources in the territories, a renewed interest in sustainable and self-sufficient agriculture may be timely. Based on our experiences, some recommendations can be proposed to northern communities interested in market garden projects. Development should start at the community level with low-cost, small-scale structures making effective use of the short summer season. With increased experience and refinement of growing procedures, the scale could be expanded to include larger, Quonset-type commercial cold frames. The growing season could be extended and yields increased by growing seedlings indoors in the early spring and/or through the addition of a heat source to protect plants from early and late season frosts, e.g. waste heat from power stations and large commercial buildings.

Successful development of northern gardens and greenhouses will be contingent on the accessibility of relevant information as well as research and extension services such as those offered to Alaskan growers by the University of Alaska's Agricultural & Forestry Experiment Station in Fairbanks and to Yukon growers by the Agriculture Branch of the Yukon Territorial Government. Information in the form of gardening guides with simple, clear instructions and procedures, sources for seeds, fertilizers and material, as well as blueprints for garden designs would be very helpful to home and market gardeners alike. Research is needed into the development of better-suited crop varieties, improved designs for greenhouse and inexpensive cold frame structures and improved methodologies for the utilization of soil and water resources.

Considering the recent social and economic changes related to northern food sources, small-scale home and market gardening provide a viable means to improve northern nutrition and reduce the strong dependence on southern imports. A novel approach to this challenge involves the possible cultivation of edible native tundra species as crop plants.

A return to traditional diets, enhanced by growing the native tundra plants under sun-heated structures would result in abundant harvests without compromising local populations of native species that may be locally rare or uncommon. Utilization of local supplements, like kelp, for mulch over the generally nutrient poor soil, would provide added nutrients to crops, decreasing reliance on imported chemical fertilizers or plastic mulch.

Ideally, the Canadian government should re-activate its Northern Agriculture Program initiated during the 1950s and establish a northern research station to support the existing and potential agricultural enterprises in the Arctic and Subarctic.

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Food Production and Supply Issues in Northern Japan in the Era of Global Climate Change and the Role of the United Graduate School of Agricultural Sciences, Iwate University

Matsuo Uemura

Cryobiofrontier Research Center and United Graduate School of Agricultural Sciences, Iwate University, Morioka 020-8550, Japan

e-mail: uemura@iwate-u.ac.jp

Abstract

Many Japanese people think that Japan has a relatively mild and stable climate. However, Japan does have severe climatic events (such as low and high temperatures, water shortages, tornados, heavy rains, floods, and snowfall) at various times throughout the year and the frequency is increasing significantly, often resulting in economic crop loss. From 1988–2013, crop losses totaled over 795 billion yen (ca. $7.2 billion US) due to low temperature-related events. Furthermore, few areas in Japan are frost-free year round, and therefore, research is focused on agricultural practices and research programs to meet the needs of growing crops in cold regions. Major crops in the Hokkaido and Tohoku region include rice, grains, potatoes, beans, vegetables, and fruit. The United Graduate School of Agricultural Sciences, Iwate University, was established in 1990 with agricultural schools of four universities (Obihiro University of Agriculture and Veterinary Medicine, Hirosaki University, Yamagata University, and Iwate University) located in northern Japan and provides basic and applied knowledge to develop expertise in agricultural sciences in cold regions. This paper provides information on food security-related activities in our graduate school and examples of how people in northern areas of Japan participate in increasing food production and supply in an era of global climate change.

Background

Japan has been facing a serious food security problem for the last couple of decades. Food self-sufficiency rate has been around 40% based on calories for the last 15 years (Ministry of Agriculture, Forestry, and Fisheries, Japan [MAFF] 2009; Tanaka and Hosoe, 2011) indicating that Japanese people heavily depend on imported food supply. The Japanese government has been trying to improve the situation by compiling a manual to increase food security in Japan (MAFF, 2006). The plan set by MAFF tries to promote domestic food production, manage emergency stocks, and control food markets. Thus, the improvement of plant performance under various environmental conditions plays an important role in increasing food production within Japan.

Many Japanese people think that Japan has a relatively mild and stable climate and might consider global climate changes to have only small effects on their life in general including agricultural production. However, the facts indicate that severe climatic events including sudden temperature fluctuations, water shortages, heavy rains and floods, tornados, and snowfall occur at various times throughout the year and the frequency of these extreme events is increasing significantly (Kobayashi et al., 2013), often resulting in significant agricultural loss. Increased winter temperatures would make plants vulnerable to untimely deacclimation (loss of winter hardiness) and hence, increase the probability of spring frost damage (Taulavuori et al., 1997, 2004). In 2007, an estimated $2 billion US crop loss occurred from Texas to New York due to an unseasonably warm spring followed by one weekend of frost (Gu et al., 2008). Further, increased winter temperatures will reduce snow cover during winter, which would increase damage to plants due to insufficient insulation from snow cover (Sakai and Larcher, 1987). In addition, there are few year-round frost-free areas in Japan and, therefore, research programs to deal with agricultural practices in cold regions are important (Sakazaki, 1998). Thus, farming of overwintering plants anywhere in Japan must include a plan to protect them against unexpected cold threats. In fact, low temperature-related weather events, including low temperature itself, frost, and heavy snow, cause serious damage in agriculture and put people in an economically difficult position (MAFF, 2013a; Table 1). Increasing snowfall in some regions in Japan is anticipated to elevate biotic stress problems such as snow molds (Matsumoto and Hoshino, 2013). The loss in agricultural production by low temperature from 1988 to 2013 (734.6 billion yen) is much larger than that caused by typhoons (548.3 billion yen).

Furthermore, Hokkaido Island, situated in the northernmost region of Japan, and the Tohoku region, at the northern part of Honshu Island, are the two major agricultural areas in Japan and produce a large amount of agronomic crops and livestock (Table 2). These two regions have relatively cool summers and long winters with snow and freezing temperatures. Thus, it is critical to maintain or expand arable areas in these regions for increasing food security of Japan.

Table 1. Loss of agricultural production due to cold-related factors in Japan[1]

Cold-related factors	Damage (billion yen)
Heavy snow	31.6
Frost	29.2
Low temperature[2]	734.6
Total	795.4

1. Data were sum from 1988 to 2013 and obtained from official report available from the Ministry of Agriculture, Forestry, and Fisheries, Japan in 2013 (MAFF, 2013a).

2. Loss by low temperature includes damage caused by the lack of sunlight during growing season according to MAFF's report.

Iwate University was established in 1949 in the city of Morioka (39°41'N and 141°9'E) in Iwate Prefecture, situated about 500 kilometers north of Tokyo. Iwate prefecture is one of the coldest in Japan and thus, one of the precursors of Iwate University, the Morioka Imperial College of Agriculture and Forestry was established in 1902 to contribute agriculture and forestry production information and training to address cold environment issues of the Tohoku region. In 1990, Iwate University decided to add a PhD program in agricultural sciences to stimulate further

Table 2. Agricultural production in Hokkaido and Tohoku regions in Japan in 2011[1]

Item	Production in Hokkaido + Tohoku (billion yen)	Production in Japan (billion yen)	% of production in Hokkaido + Tohoku
Rice	666.4	2035.1	32.7
Grains	29.5	52.2	56.5
Potatoes	39.7	67.3	59.0
Beans	61.2	185.0	33.1
Vegetables	399.5	2189.6	18.2
Fruit	173.5	747.1	23.2
Beef	144.3	519.4	27.8
Pork	130.0	540.9	24.0
Chicken	86.4	287.6	30.0
Milk	381.2	689.8	55.3
Egg	77.9	430.9	18.1

1.Data were obtained from official report available from the Ministry of Agriculture, Forestry, and Fisheries, Japan in 2011 (MAFF, 2013b).

research in agricultural sciences in very diverse disciplines from molecular biology to breeding biological resources both in plants and animals suitable for production in cold regions, food sciences to process local resources to enhance nutritional effects, agricultural engineering and technologies for utilization and sustainable use of land and water resources, and agricultural economics to establish effective marketing and distribution systems of agricultural products.

The United School of Agricultural School, Iwate University

The United Graduate School of Agricultural Sciences, Iwate University (UGAS-IU) is one of the six UGAS systems in Japan. These UGAS systems only have PhD programs in agricultural sciences. These six UGASs composing 20 universities throughout Japan operate cooperatively without the isolated character that is often found in the traditional graduate school systems in Japan. Among them, UGAS-IU is the northernmost school and is surrounded by the rich natural environment of the Hokkaido and Tohoku areas in Japan. UGAS-IU consists of four constituent universities, Obihiro University of Agriculture and Veterinary Medicine, Hirosaki University, Yamagata University, and Iwate University, all of which are situated in key areas for food production in Japan. At UGAS-IU, with biological research in cold climates as the main focus, advanced and academic research of various themes is actively carried out in four specialty areas: bioproduction science, bioresources science, cryobiosystems science, and biotic environment science.

With a solid education system supported by cooperation among the four constituent universities, UGAS-IU provides our students with the opportunity to develop expertise in the fields of agricultural sciences designed for cold regions. Our goal is to develop researchers who can conduct advanced, global-level research, academic staff with deep interest and abundant knowledge in agricultural sciences, and professionals with flexible, high-level problem-solving abilities. A brief description of the four specialties is:

Bioproduction Science: This specialty is designed for studies of technological developments in agriculture and biological resources, as well as basic and applied research in the physiology, genetics, and ecology of these resources. By providing knowledge and skills in environmental management for bioproduction, we prepare students to become professionals with solid problem-solving capabilities and advanced skills to explore and develop new technologies.

Bioresources Science: This specialty is focused on studies of the applications and genetics of agricultural and other biological resources and the knowledge to develop technologies for production of bioresources. We prepare students to become experts in biosciences, with well-developed problem-solving skills and advanced research capabilities, in addition to diverse knowledge.

Cryobiosystem Science: This specialty is organized to study a wide variety of life forms in cold regions, with a particular focus on the response mechanisms to different temperatures in the natural environment. We prepare students with an integrated knowledge of biology and engineering and skills needed to become experts capable of conducting creative and advanced interdisciplinary research.

Biotic Environment Science: This specialty is focused on environmental factors affecting the sustainable use of biological resources and the effective use of local resources. We prepare students with the advanced knowledge and skills needed to serve as engineering specialists and leaders of local communities who can meet the specific needs of each community.

Among them, scientists specializing in cryobiosytems science have been conducting research specifically focused on adaptation mechanisms of living organisms in cold regions. The responses of life systems in cold regions to higher temperatures are studied at different levels from molecular biology to biological systems. The analyses of these subjects are conducted using various technologies developed in basic biology, systems biology, and bioinformatics. Combined comprehensive research in the form of engineering and biology as well as research and education with an aim to develop bio-derived thermal engineering systems are also conducted.

Plant cold tolerance for increasing in crop production

One of the strong research programs at UGAS-IU is conducted on understanding how plants survive under low temperature conditions, and has been producing interesting results. The Cryobiofrontier Research Center, Iwate University, is the main driving force of this research program and has published a number of papers in plant cold tolerance research. For example, we have succeeded in revealing the role of the plasma membrane in the tolerance of plant cells against extracellular freezing (Uemura and Steponkus, 1999; Uemura et al., 2006; Kawamura and Uemura, 2013). Extracellular freezing is a typical freezing pattern occurring in a majority of herbaceous plant species including important winter crop species grown in northern areas of Japan. Destabilization of the plasma membrane is known to be the primary cause of injury in plants when exposed to extracellular freezing (Steponkus, 1984). In addition, the plasma membrane is considered to be the site of chilling injury (non-freezing but low temperature stress) (Yoshida et al., 1986) and warm season crops such as tomatoes, cucumbers, and peppers are particularly sensitive.

Most commonly in the freezing process, ice formation is initiated on the surface of plants by heterogeneous nucleation and then expanded into the intercellular matrix (i.e., between cells and/or in the cell wall) (Steponkus, 1984). Because the chemical potential of ice is lower than that of an unfrozen solution at a given subzero temperature, unfrozen water flows out and then freezes outside the cells, which results in severe dehydration inside the cells. Consequently, the increase of intracellular solute concentrations minimizes the probability of intracellular ice formation. During these processes, the plasma membrane plays a critical role in avoiding the seeding by extracellular ice into the super-cooled cytosol. Thus, survival of cells during extracellular freezing ultimately depends on the maintenance of the stability of the plasma membrane under freezing conditions.

Plasma membrane composition, both lipid and protein components, has been shown to significantly contribute to the increased cryostability of the plasma membrane. When plants increase their freezing tolerance during exposure to non-freezing, low temperatures for some periods (cold acclimation), the profiles of plasma membrane lipids alters considerably. For example, the plasma membrane becomes softer (i.e., there are more unsaturated fatty acids included in a major lipid class, phospholipids), lyotropically and thermotropically more stabilized (i.e., there are a decrease in the proportion of glucocerebroside, a less fluid lipid class with less bound water, and concomitantly an increase in the proportion of phospholipids, a more fluid lipid with more bound water) (Yoshida and Uemura, 1990; Steponkus et al., 1993; Uemura and Steponkus, 1994). Based on this information, we and others conclude that plant cells respond to low temperature and increase their freezing tolerance by alterations of the plasma membrane to retain its normal physiological functions under low temperature and freezing conditions.

Protein composition of the plasma membrane also changes considerably during cold acclimation. Pioneering work revealed that a number of proteins appeared, increased, decreased, or disappeared in the plasma membrane from various plant species during cold acclimation (Yoshida and Uemura, 1984; Uemura and Yoshida, 1984). Recently, using cutting-edge technologies such as mass spectrometry and data analysis software, a number of proteins that respond to cold acclimation have been identified (Kawamura and Uemura, 2003; Minami et al., 2009; Takahashi et al., 2013). Furthermore, functions of proteins that are closely associated with freezing tolerance have been elucidated using molecular biological tools such as gene cloning and transfer techniques. For example, we demonstrated that a plasma membrane protein, synaptotagmin A, which is thought to be involved in calcium dependent membrane repair processes during a freeze/thaw cycle, is functionally required to increase freezing tolerance in plants during cold acclimation (Yamazaki et al., 2008). Recent work in our laboratory indicates that another protein in the plasma membrane, dynamin-related protein 1E, thought to be involved in the endocytosis process, was determined to be important in increasing freezing tolerance during cold acclimation. Thus, these results identify some of how the functional/structural maintenance of the plasma membrane is critical for plant cells to survive under freezing conditions.

These studies suggest that the capacity of crop plants to tolerate low temperature can be increased with the improvement of the plasma membrane characteristics by modification of the plasma membrane composition. Practically, there would be at least two ways to accomplish these tasks. First, marker assisted selection to more efficiently select and breed cultivars or varieties with better cold hardiness characteristics has been employed (Mohan et al., 1997; Collard and Mackill, 2008). The locus of the gene of interest in a chromosome or quantitative trait loci can be identified using various techniques of molecular biology. The information obtained is used as a marker to select plant lines that might have a genetic trait of interest. In fact, a number of studies using this technique have been published to indirectly select a genetic determinant or determinants for plant abiotic stress tolerance (Ashraf and Foolad, 2013; Tester and Langridge, 2010). Ultimately, this has potential to improve food production and food security in relatively poor arable lands in northern areas.

Another way is a direct approach based on the function of the specific genes for improvement of the performance of crop species through gene transfer. Gene transfer techniques have been established with a variety of crop species including rice, wheat, tomato, and potato (Sinclair et al., 2004; Sinclair, 2011). There are a number of reports demonstrating an increase in plant cold tolerance using gene transfer technique (Sanghera et al., 2011; Amudha and Balasubramani, 2011). Although the human, animal, and environmental safety of genetically modified food crops are being debated, they could become important in providing us with more food in order to help improve crop productivity using genes that are functionally associated with an increase in cold tolerance.

Future perspective

Increasing food production and food security is a challenge for Japanese people because we have been facing a serious problem of very low food self-sufficiency rates for the past 15 years. The Japanese government is trying to enhance greater food self-sufficiency. Both basic and applied agricultural science-based research can significantly contribute to the improvement of the food security situation in Japan. Especially, understanding genetic regulation and physiological responses of plants to abiotic stress conditions, especially to cold stress conditions, has potential to improve plant performance during vegetative growth, flower differentiation and seed production in cold regions, which becomes more important to deal with the occurrence of unexpected weather events often seen in an era of global climate change. It is quite possible that elucidation of gene function under abiotic stress conditions would help us to breed new varieties that perform better in less suitable growing conditions while cultivating crop species more sustainably.

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ORGANIZATIONS:

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SPEAKERS:

Dr. Tom Allen, College of Agriculture & Bioresources, University of Saskatchewan, Canada

Dr. Øystein Ballari, CAA representative, Bioforsk Institute, Tromsø, Norway

Dr. John Blake, Associate Vice Chancellor for Research and Director, Animal Resources Center at University of Alaska Fairbanks, US

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Dr. David Natcher, Director, Indigenous Land Management Institute, University of Saskatchewan, Canada

Dr. Todd O'Hara, Professor and Associate Dean, Department of Veterinary Medicine, University of Alaska Fairbanks, US

Dr. Arja Rautio, Research Professor and Chair of the Center for Arctic Medicine at Thule Institute, University of Oulu, Finland

Chancellor Brian Rogers, University of Alaska Fairbanks, US

Dr. Jan Rowell, Assistant Professor of Animal Science, School of Natural Resources & Extension, University of Alaska Fairbanks, US

Dr. E. John Sadler, OECD Natural Resources Challenge Scientific Advisor, Supervisory Soil Scientist, USDA-ARS Cropping Systems and Water Quality Research Unit, University of Missouri, Columbia, Missouri, US

Dr. Milan Shipka, Professor of Animal Science, Extension Livestock Specialist, and Associate Director, Agricultural & Forestry Experiment Station, University of Alaska Fairbanks, US

Mr. Berndt Skarstad, Leader, Farmers Organization of the Arctic, North Norwegian Council of Agriculture

Dr. Josef Svoboda, Professor Emeritus at the Department of Biology, University of Toronto at Mississauga, Ontario, Canada

Dr. Matsuo Uemura, Dean, the United Graduate School of Agricultural Sciences, Iwate University, Morioka, Japan