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ORIGINAL RESEARCH

Impact of Euro-Canadian agrarian practices: in search of sustainable import-substitution strategies to enhance food security in subarctic Ontario, Canada

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ABSTRACT

Introduction: In Canada, food insecurity exists among Aboriginal (Inuit, Metis and First Nations) people living in remote northern communities, in part, because of their reliance on the industrialized, import-based food system. Local food production as a substitute to imports would be an adaptive response, but enhancement of food security via food localization requires reflection on previous failings of conventional agricultural strategies so that informed decisions can be made. In light of potential reintroduction of local food production in remote First Nations communities, we investigated the cultural, social and ecological effects of a 20th century, Euro-Canadian agrarian settlement on the food system of a subarctic First Nation; this will act as the first step in developing a more sustainable local food program and enhancing food security in this community.

Methods: To investigate the socio-cultural impacts of the Euro-Canadian agrarian initiative on the food system of Fort Albany First Nation, purposive, semi-directive interviews were conducted with elders and other knowledgeable community members. Interview data were placed into themes using inductive analyses. To determine the biophysical impact of the agrarian initiative, soil samples were taken from one site within the cultivated area and from one site in an undisturbed forest area. Soil properties associated with agricultural use and productivity were assessed. To compare the means of a given soil property between the sites, one-tailed *t*-tests were employed. Vegetative analysis was conducted in both sites to assess disturbance.

Results: According to the interviewees, prior to the agrarian initiative, First Nation families harvested wild game and fish, and gathered berries as well as other forms of vegetation for sustenance. With the introduction of the residential school and agrarian initiative, traditional food practices were deemed inadequate, families were forced to work and live in the settlement (becoming less

reliant on traditional foods), and yet little knowledge sharing of agricultural practices occurred. When the residential school and agrarian movement came to an end in the 1970s, First Nation community members were left to become reliant on an import food system. The mission's agrarian techniques resulted in overall degradation of soil quality and ecological integrity: compared the natural boreal forest, the cultivated area had been colonized by invasive species and had significantly lower soil levels of nitrogen, magnesium and organic carbon, and significantly higher levels of phosphorus and bulk density.

Conclusions: Because the agrarian initiative was not a viable long-term approach to food security in Fort Albany, the people became more reliant on imported goods. Taking into account climate change, there exists an opportunity whereby fruits and vegetables, historically stunted-in-growth or outside the distributional range of subarctic Canada, could now grow in the north. Together, agroecosystem stewardship practices and community-based, autonomous food security programs have the potential to increase locally grown food availability in a sustainable manner.

Key words: agroecosystems, climate change, Euro-Canadian agriculture, First Nations, food security, import-substitution, subarctic Canada, sustainability

Introduction

Food security can be defined as 'access by all people at all times to enough food for an active, healthy life, including availability of nutritionally adequate and safe foods that can be acquired in socially acceptable ways' (p73)[1]. In Canada, numerous studies have identified food insecurity among Aboriginal (Inuit, Metis and First Nations) communities as being pervasive, particularly in remote areas of the north[2-5]. Importing goods to remote, northern Canadian communities at least doubles the cost of goods relative to more southerly communities[5,6] – and if produce is available at the community store, it is too costly and/or of poor quality. The importation of produce is a barrier to healthy eating[2,7-10]. Although traditional foods are still an important part of the First Nation diet[11], First Nation people of northern Ontario most frequently source grocery stores and convenient stores for food[4]. Further, fruits and vegetables are among the least purchased foods and tend to be purchased frozen or canned, or in the form of sugary juice crystals[1]. Despite support from the Food Mail Program (originally called the Northern Air Stage Program[12]), which partially subsidized the transportation of produce and other essential goods to northern communities by individuals, retailers and organizations, fruits and vegetables have not become a common part of the northern diet[7]. Recently, the Government of Canada deemed the Food Mail Program inadequate; it was phased out and replaced by Nutrition North. Nutrition North is also based on an import-subsidization strategy, but the subsidy goes to the retailers supplying goods in the northern communities, rather to the person or organization shipping the goods[13]. The change in the subsidy program has been controversial, and the main premise of both programs is that an import food system is a viable and sustainable strategy to address food security issues in the north.

Unfortunately, by relying on the industrialized import food system, northern communities are both enablers of the globalized food system and victims of it. Food security and fossil-fuel supply are tightly linked, with northern communities being particularly vulnerable to dwindling oil supplies and rising oil demands[14]. In addition to being incredibly vulnerable to market fluctuations[15] and petroleum-related issues[14], it has been suggested that remote communities also suffer losses in local self-sufficiency, alternative knowledge systems, cultural and ecological diversity, and social and ecological resilience; ultimately leading to a loss of capacity with respect to locally-based food security[14,16,17]. Local food production as a substitute to imports is an adaptive response to socio-economic issues

associated with northern food systems. Bellows and Hamm define 'import substitution' as a process in which 'community food security efforts lead to substituting local production for what has previously been imported' (p271)[15]. As well as reducing transport pollution and costs, local food production can help communities enhance self-reliance, reduce vulnerability to fluctuations and inequities of the global market[15,18,19], increase food freshness and offer choice of food variety[15], and maintain a traditional lifestyle and unique community culture[19].

Historically, a lack of food security among Aboriginal communities has been well recognized, especially with reference to northern First Nations[20]. Food insecurity did not abate even after the missionaries initiated some agricultural activities in northern climes, such as the western James Bay region[21]. At present, food insecurity still exists in northern Canada (eg western James Bay region)[22], with food quality being only one of the influencing factors[23,24]. Yet only within the past decade have political organizations and non-governmental organizations throughout Canada directed notable efforts towards local and autonomous subsistence food production as an intervention strategy[25,26], and research of local food initiatives within Ontario has been restricted to urban areas of the south[27,28]. With the exception of the Lakehead University Food Security Research Group[29], most local food efforts for Aboriginal populations have developed in more southern First Nations, where growing conditions are more hospitable, despite the greater food security challenges experienced by geographically remote communities of the north. The potential to extend local food production strategies to northern regions of Canada is promising as, historically, both European immigrants and Aboriginal communities have successfully grown a variety of crops in subarctic[30,31] and arctic regions of North America[32]. Future initiatives are also expected to be more prosperous, as the capacity for food production in northern climates is predicted to increase with global climate warming[33]. However, prior to reintroduction of some form of agriculture to the north, it is important to consider ecological and socio-cultural consequences of historical food security initiatives, and to question why agricultural programs of the 20th century did not persist in Aboriginal communities, leaving present-day communities dependent on an unsustainable, import-based food system. Enhancement of food security via food localization in remote First Nations communities requires reflection on previous failings of conventional agricultural strategies and colonial settlements, so that informed decisions can be made with respect to long-term planning. In this article we investigate the effects of a Euro-Canadian agrarian settlement on the food system of a remote subarctic First Nation as a guide to developing a more sustainable local food system that can enhance long-term food security in this community.

Methods

Fort Albany First Nation

Fort Albany First Nation (52°15′N; 81°35′W) is located along the south channel of the Albany River, approximately 20 km inland from the west coast of James Bay, in northern Ontario, Canada (Fig1). This Cree community of 850 people is situated in the western portion of the James Bay Lowlands, which is nestled in the Hudson Bay Lowlands, one of the largest wetland areas in the world[34]. The James Bay region is dominated by poorly drained muskeg[29]. The area has a mean annual precipitation of 700-800 mm and a mean annual temperature of -2°C[35]. A significant warming trend has been noted for the region, for the time period 1960-2006[36]. Despite a relatively successful (yet unsustainable) agricultural initiative in Fort Albany First Nation by the Roman Catholic Mission (hereafter cited as the Mission) beginning in the 1930s[37], this geographically isolated, subarctic community is currently experiencing food security challenges[2,5,9].

Analysis

A mixed-methods approach (qualitative and quantitative) was employed in the present study.

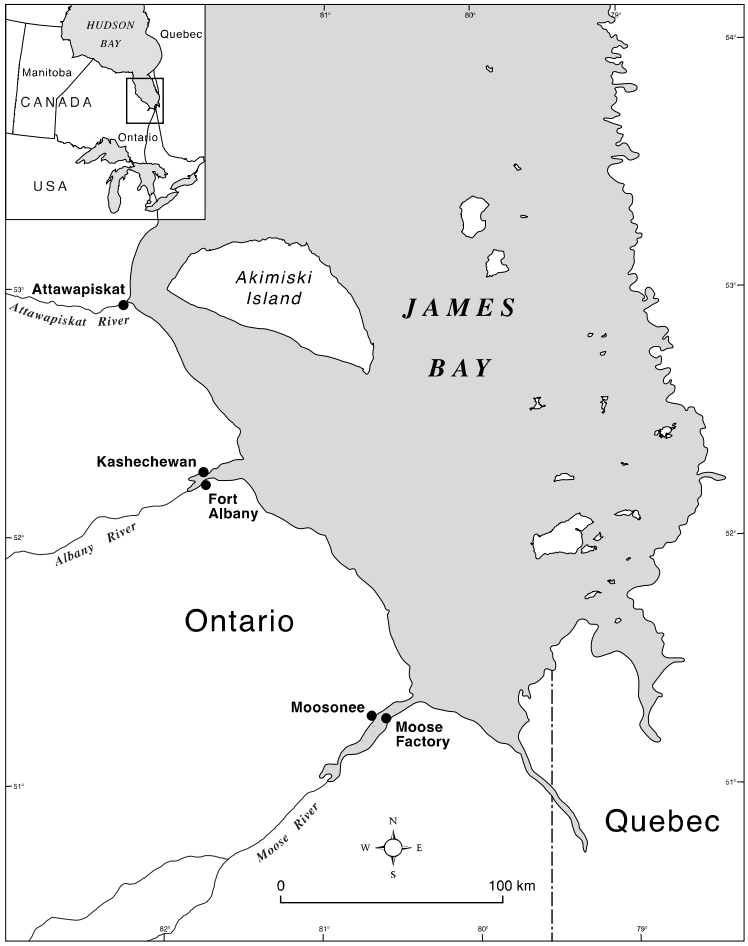

Figure 1: Map of James Bay and the surrounding James Bay region, including Fort Albany First Nation.

Analysis: qualitative

Following Tsuji et al[38], culturally appropriate, semi-directed interviews with Fort Albany First Nation community members (n=8) were conducted (in English or Cree) in June 2010, to investigate the effect of the Mission's agrarian settlement on Fort Albany's food system, and to identify current food system challenges in the community. Community members were selected purposively based on knowledge of past community agricultural initiatives; that is, community members were selected who had experience working with the Mission and gardening within the community. Two of the interviewees were involved in initiating the Food Security Working Group in Fort Albany. Oral consent for the semi-directed interview was given by all participants. Interviewees were coded for anonymity and identified by 'FN#'. The length of the interview was dependent on the interviewee, with a range from one to eight hours. Themes were created from the interview data using inductive analyses, whereby themes emerged from the interview data itself[39] and the data analysis process was iterative.

Analysis: quantitative

Site characterization: Fort Albany community members identified the area farmed by the Mission (Fig2). Soil samples were taken from one site within the cultivated area and from

one site in an undisturbed forest area, in order to determine the effects of the Mission's agrarian settlement on the area. Site 1 was chosen within the area previously cultivated at a minimum distance of 58 m from the undisturbed forest and was known to have been forested prior to land management by the Mission. Site 1 was composed of a spatially heterogeneous mixture of early pioneer species in approximately equal proportions: *Symphyotrichum lanceolatum* (panicled aster), *Solidago spp.* (goldenrod), *Taraxicum officianales* (dandelion), *Vicia cracca* (cow vetch), *Cirsium arvense* (Canada thistle), *Agrostis Stolinifera* (creeping bentgrass), and *Eupatorium maculatum* (spotted Joe-Pye weed). Site 2 was selected in an undisturbed section of forest near the cultivated area, to be representative of undisturbed boreal forest conditions of the subarctic. The dominant overstorey species of Site 2 were typical boreal forest species: *Picea mariana* (black spruce), *Populus tremuloides* (trembling aspen), *Alnus viriclis* (green alder), *Viburnum edule* (mooseberry) and *Larix larcina* (tamarack).

Soil sampling: An inventory study[40] was used to assess soil properties associated with agricultural use and productivity. Spatial dynamics of soil properties were not of interest and both sites appeared heterogeneous in terms of flora and topography. Thus, both of these sites were sampled randomly, which assisted in eliminating bias and allowed for a general site inventory with low costs[40,41]. For each site, a 20 m^2 plot was divided into 20 one-square-metre quadrants, from which three quadrats were randomly chosen as sample points for each site.

As standard procedure for agricultural research, soil samples were taken in the topsoil, up to 20 cm in depth, where most available nutrients are found and where the soil is manipulated by tillage[41-43]. A small, lightweight soil corer (20 cm height x 4.5 cm diameter) was used for ease of transportation. Each soil sample was composed of three sub-samples, or three soil-core extractions, within a 0.5 m radius of the sample point. While 5 to 25 sub-samples per composite sample are common for an area with similar management history, it has been suggested that fewer sub-samples are needed where little to no fertilizer has been used[43].

At each sample point, an additional soil sample was taken with a bulk density ring (5.2 cm height x 4.5 cm diameter)[41] within the same 0.5 m radius of each sample point. Samples were taken from 6-10 August 2010, when the ground was not frozen or waterlogged and the growing season appeared to peak, allowing for more accurate information about nutrient status during the growing season[39].

Soil analysis: Approximately 50 g of dry soil for each sample was sent to the Soil and Nutrient Analysis Laboratory at the University of Guelph (which specializes in agricultural research), Ontario, Canada, for analysis of soil texture and content of total nitrogen (N), extractable phosphorus (P), potassium (K), and magnesium (Mg), pH, organic carbon (SOC) and inorganic carbon (IC), for all composite soil samples (n=3 for Site 1, n=3 for Site 2). Soil organic matter (SOM) was estimated from SOC under the assumption that 58% of SOM is SOC[41]. Samples from the bulk density ring were used to determine bulk density (BD) at the University of Waterloo, Ontario; the dry soil mass was also used to calculate BD from the known sample volume[41].

Data analysis: PASW Statistics 18 software (SPSS, www.spss.com) was used for all statistical analysis. Data were normal and homogeneous; therefore, one-tailed t-test were used to compare means of a given soil property of the cultivated and uncultivated sites. Significance was set at $p<0.05$.

Ethics approval

Research methods were approved by the Office of Research Ethics at the University of Waterloo (ORE # 16313).

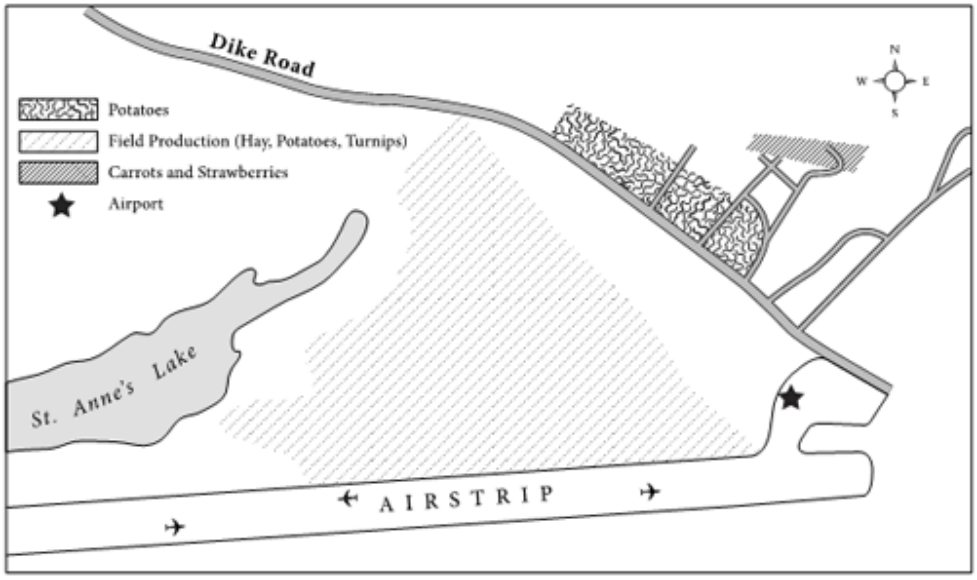

Figure 2: Land-use of mainland Fort Albany by the Euro-Canadian settlers during the period 1940–1970.

Results

Qualitative

Traditional fruit and vegetable food systems in Fort Albany First Nation: Prior to Mission settlement, Fort Albany community members harvested berries, such as *Vaccinium macrocarpon* (cranberries), *Rubus ideaus* (raspberries), *Fragaria ananassa* (strawberries), *Ribes grossularia* (gooseberries), *Viburnum edule* (moooseberries), *Vaccinium uliginosum* (blueberries) and *Gaultheria procumbens* (ground berries) (FN 1; FN 2[44]). *Cladonia rangiferina* (caribou moss), *Larix laricina* (tamarack) root and *Picea spp.* (Spruce) and *Thuja occidentalis* (cedar) boughs were also taken as food or for tea (FN 3; FN 3).

History of study sites and surrounding area: The Mission introduced agriculture to Fort Albany in 1930 (FN 3; FN 5; FN 6), directing most produce to the residential school established in the community (FN 6). Areas of the mainland were cleared for a barn, chicken coup, grazing lands and crop land, which supported inclusion of cows, horses, pigs and egg-laying chickens (FN 1; FN 5; FN 6; Fig2). The majority of acreage was dedicated to field production of rotated *Solanum tuberosum* (potato), *Brassica rapa* (turnip) and hay (FN 11). *Beta vulgaris* (beet), *Daucus carota* (carrot), *Raphanus sativus* (radish), *Lactuca sativa* (lettuce), *Fragaria ananassa* (strawberry), *Brassica oleracea* var. *capitata* (cabbage), *Solanum lycopersicon* (tomato), and *Allium spp*. (onion) were also grown in small gardens near the school (FN 1; FN 2; FN 5; FN 6; FN 7). A couple of interviewees also recall growth of rice and some sort of grain that supplied flour (FN 4; FN 6).

Drainage ditches were dug around the fields to maintain suitable soil moisture; during rare dry periods, pails of water from St. Anne's Lake would be used to irrigate (FN 1; FN 4). The agricultural area would flood in the spring approximately every 10 years. The Mission would wait until after the river-ice, break-up of the Albany River, when the floodwaters receded, to seed or transplant crops (FN 6).

Two respondents recall having to throw 'some powdery stuff' over the fields to control the bugs or worms (FN 4; FN 1).

'Everyone was kept busy' working six days a week clearing the fields, farming and constructing buildings, so the Cree schoolchildren did not have time for traditional pursuits (FN 1; FN 3). Respondents did not recall the Mission taking soil, such as, peat, from other land to add to the local soil; the land was cleared and productivity was enhanced by the use of cattle manure as fertilizer (FN 1; FN 4) and farm machinery, such as, ploughs and potato diggers (FN 1). In Attawapiskat, a Cree First Nation north of Albany (Fig1), Honigmann recalled the small addition of coastal suckers to the soil prior to potato planting[30], but this was not reported in Fort Albany First Nation (FN 1; FN 4). However, some of the Mission's agricultural techniques may have gone unnoticed by the people, as FN 1 recalled: 'They did a lot of things, the Brothers. They did a lot of things, but I didn't see them.'

The Mission started seedlings of carrots, lettuce, turnips, onions and tomatoes in a greenhouse and transplanted them into the gardens (FN 4; FN1). Turnips, potatoes and carrots were stored in underground structures earlier on (FN 1; FN 4), and later stored in the basement of the school where it was cool all year (FN 1). Interviewee FN 2 says that he does not know how the Missionaries preserved food, but remembers hearing that they had it all year-round.

The Missionaries destroyed indigenous artifacts and suppressed indigenous behaviours that were considered integral to Fort Albany First Nation traditions, weakening their spiritual and physical wellbeing (FN 3). The grandfather of a modern Fort Albany First Nation elder was told that his traditions followed the works of the devil (FN 3). Consequently, this grandson 'grew up not knowing anything at all'; he explains that 'it took a long time for everybody to wake up, especially when you're put to sleep some more in residential school. There was the abuse of the autonomous person' (FN 3). While one other respondent was grateful to the Mission in providing her with the opportunity to learn in school and get a job, she still regrets that she lost her culture and does not remember how to prepare traditional foods (FN 1). Time-consuming jobs and high gasoline prices are blamed for preventing frequent hunts (FN 1); 'Everyone was kept busy' working six days a week clearing the fields, farming and constructing buildings, so they did not have time to go fishing or to fix the boat, motor or snow shoes (FN 1; FN 3).

Relatively large-scale agriculture by the Mission came to an end in about 1970 (FN 3; FN 5; FN 6) when Indian Affairs took over the residential school (FN 1) and the local grocery store was introduced (FN 5). Most of the Mission people left with the residential school (FN 6), halting community agriculture. Employment increased, as well as government social assistance, and community members began to source food at the local store (FN 1). Although the community of Fort Albany never returned to agriculture for sustenance, the Mission did have some residual impacts on small-scale cultivation in the area. A couple of Elders kept their own potato and strawberry patches (FN 2). Although successful in providing more than enough potatoes for their family, the Elders were limited in time and energy to keep up with the work in their increasingly busy and increasingly Western lifestyles (FN 2). Up until about 20 years ago, some Fort Albany residents would travel to nearby islands to grow potatoes, with little to no maintenance or land preparation (FN 1; FN 2; FN 4). For reasons unknown, the islands became vandalized by youth, deterring gardeners from continuing their potato cultivation.

The current food system in Fort Albany: Although older members of the community were raised primarily on canned food during the Mission period (FN 3), they tried to maintain traditional food harvest and consumption (FN 1). One resident explained that relatively few people gather or harvest because few have the money to afford a boat and fuel (FN 3). Most people get their food from the store and the new generation consumes mostly junk food, notably pop and chips, and cares little for traditional foods (FN 1; FN 3; FN 7). In Attawapiskat, Honigman noticed a decline in wild vegetation and berry harvest as early as the 1930s, attributing this loss to the increase in imported food[30] .

Local food initiatives in Fort Albany – successes and challenges: In recent years, two immigrants to the community have maintained diverse gardens at their home. They have had some success growing potato, turnip, beet,

carrot, radish, lettuce, strawberry, tomato, yellow and green onion, *Cucurbita spp.* (squash), *Leguminosae spp.*(beans), *Pisum sativum* var. *saccharatum* (snow peas), *Solanum melongena* (eggplant), *Apium graveolens* (celery), *Piper spp.* (peppers), *Brassica oleracea var. gemmifera* (brussel sprouts) and *Brassica oleracea var. botrytis* (broccoli).

The recently formed community Food Security Working Group developed a community garden plan in 2009, but had difficulty implementing the program; they were unable to come to consensus on a garden location and were concerned about potential soil contamination by historical garbage dumps and outhouses of unknown locations, as well as known contamination from the Mid-Canada Radar Line. Site 050 of the Mid-Canada Radar Line was abandoned in the 1960s and not properly decommissioned – it became a point source of polychlorinated biphenyl (PCBs) and dichlorodiphenyltrichloroethane (DDT) – and as it was located on nearby Anderson Island, environmental contamination and human exposure was a concern[44-46]. The Food Security Working Group also felt constrained by a lack of knowledge, funds, time, resources and support necessary to implement the plan (FN 1; FN 4). Gardening within the town centre has been limited by disturbances to plants and equipment by dogs and vandals, and fear of soil contamination (FN 4). Community members have expressed a preference for personal gardens close to their homes over community gardens (FN 3; FN 4). In addition, FN 3 and FN 4 emphasized, that the community at this time lacks enough knowledge and initiative for subsistence production.

Several respondents liked the idea of a community garden in which to grow food in Fort Albany (FN 1; FN 3), stating, 'It was done before, why not do it again?' (FN 1). Respondents who were around during the Mission settlement stressed the amount of work that would be needed to garden, especially weeding (FN 1; FN 6). Gardens were regarded by community members as a means to acquire produce at a cheaper price, especially potatoes, which are favoured but very expensive in Fort Albany (FN 1). Others viewed a collective gardening initiative as a means to bring youth and elders together to share stories of the past, to conserve traditional knowledge and to unify the community (FN 3; FN 7). Two participants expressed concern for a loss of traditional medicinal knowledge and suggested that the garden could host culturally important medicinal plants (FN 7). Others would like to see aromatic plants, such as *Abies spp.* (balsam), and flowers in the community, for their influence on wellbeing (FN 3; FN 4).

Quantitative

Although the undisturbed forest (Site 2) had higher levels of sand and clay and lower levels of silt, compared to the cultivated site (Site 1; Table 1), both sites were classified as having a silt–loam texture. Significant differences between sites were found for all soil properties except K (p=0.144) and pH (p=0.053). Statistical analysis revealed that the undisturbed forest (Site 2) had significantly higher levels of N (p=0.04), Mg (p=0.007) and SOC (p=0.03), and significantly lower levels of P (p=0.017) and BD (p=0.025) than the cultivated site (Site 1).

Discussion

Impact of the Mission's Agrarian Initiative

Socio-cultural: As a process of assimilation into Euro-Canadian culture in the 20th century, Aboriginal children were sent to residential schools, separated from their Elders and prevented from speaking their native tongue or practising traditional ceremonies[47]. These nomadic peoples were forced into sedentary communities of the agrarian lifestyle, thereby decreasing time and energy available for gathering and harvesting[48]. According to Loring and Gerlach[32], Euro-Canadians viewed Aboriginal diets of the subarctic and arctic as far less diverse, reliable, and nutritious than they truly were. Traditional gathering and harvesting knowledge was weakened by the residential schools[1] and time-consuming farm work. Consequently, a loss of knowledge of gathering and harvesting practices including preparation and preservation of traditional foods is evident in current populations of northern communities[1,4].

Table 1: Minimum, mean and maximum values of measured and estimated soil properties in the cultivated site (Site 1) and an undisturbed boreal forest control site (Site 2) in Fort Albany First Nation, Ontario

Soil property	Site	N†	Value		
			Minimum	Mean	Maximum
Sand (%)	1	3	13.30	17.23	22.80
	2	3	19.90	20.73	21.90
Silt (%)	1	3	65.80	66.40	67.60
	2	3	49.80	57.03	66.30
Clay (%)	1	3	11.30	16.37	19.10
	2	3	13.60	22.17	28.20
N (ppm)	1	3	2800.00	5766.67	7900.00
	2	3	8100.00	10900.00	13500.00
P (ppm)	1	3	7.60	8.17	9.20
	2	3	5.70	6.13	6.90
K (ppm)	1	3	27.00	32.67	38.00
	2	3	33.00	37.33	40.00
Mg (ppm)	1	3	240.00	313.33	370.00
	2	3	820.00	960.00	1200.00
pH	1	3	7.60	7.77	7.90
	2	3	7.10	7.40	7.60
BD (g/cm^3)	1	3	0.60	0.68	0.73
	2	3	0.24	0.39	0.57
SOM (%)	1	3	7.52	14.14	18.97
	2	3	21.90	36.38	50.34

BD, Bulk density; SOM, soil organic matter.
†Number of samples taken from site.

Although the food provided by 20th century missionary agriculture in Fort Albany was a valuable resource for families, the Mission's efforts were directly tied to the operation of the residential school. Fields on which much of the community came to depend became unproductive with closure of the school and the Mission's departure in the 1970s. A lack of equity during the Mission's settlement meant that Fort Albany residents lacked autonomy and self-determination over local food production. The Mission's lack of knowledge sharing of agricultural strategies with the people of Fort Albany made it even more challenging to grow food in an unpredictable environment with a short growing season after the Mission left. This type of scenario is not unique to Fort Albany; it also occurred in Attawapiskat First Nation, as well as other northern Aboriginal communities[31].

Ecological: The Mission's agricultural program affected more than the socio-cultural dimensions of Fort Albany. The previously cultivated area had significantly lower soil N, Mg, and SOM, and significantly higher levels of P and BD than the undisturbed forest (Table 1). Cultivation appeared to have little to no effect on soil texture, with both sites being classified as a silt loam. High levels of N in forest site are suspected to be a result of high SOM and low decomposition rates of subarctic boreal forest[49,50], while lower levels of N in the cultivated area may be the result of extensive harvesting and tillage. The mean Mg levels of the undisturbed forest were more than three times that of cultivated site, suggesting high Mg use by cultivated plants or high leaching of this cation in low clay soils of the cultivated sites. Low levels of P is common in natural soils like the forest site that lack fertilizer

additions[41,51]; higher levels of P in the cultivated site are likely to be a result of manure additions by the Mission, as reported by the interviewees.

Bulk density represents the density of a known volume of soil, with lower BD allowing for greater movement of roots, water, air and nutrients[41,51]. The low BD levels in the forest site are common in organic soils with higher carbon, especially if the area is not cultivated[52,53]. Higher BD is observed in the cultivated site because conventional cultivation increases BD and reduces soil porosity through compaction by machinery, and by replacement of trees and other diverse flora with crops that have smaller root systems[41,54]. Natural soils of the James Bay Region below the tree line are very high in SOM[35,55]. Soil organic matter regulates nutrient availability, acidity and water-holding capacity, provides substrate for biota, and acts as a carbon sink[41]. Soil organic matter decreases rapidly within the first 10 years of tillage[52] and is reduced by approximately 50% after 40-70 years of continuous cultivation[53]. With a mean value of SOM of 14.14% in the cultivated site and 36.38% in the undisturbed site, it is estimated that initial SOM was reduced by about 61.23% after the 40 years of cultivation by the Mission. Since trees have high net primary production of plant carbon[56], the lack of mature vegetation in the cultivated area may be limiting the rate of organic carbon and SOM replenishment.

Typically, subarctic forest soils are acidic, due to dominance of conifers that lower soil pH[57], and the presence of organic soils, which tend to have low pH[58]. A pH around neutral in both sites may be explained by the presence of IC, which has a buffering effect on soils[59]. The source of IC in this area is likely to be marine sediments[60] deposited from the retreat of the Tyrrell Sea that once covered this region.

Considerations for sustainable local food production in remote First Nations

Skinner et al[2] identified empowerment as the central issue related to healthy eating in Fort Albany, defining the term by quoting Wallerstein[61]: 'a social action process that promotes participation of people, organizations, and communities towards the goals of increased individual and community control, political efficiency, improved quality of community life and social justice' (p157)[2]. Fort Albany participants in the Skinner et al[2] study felt disempowered by a lack of access to healthy foods, a lack of capacity to influence grocery store stock and pricing, as well as a lack of trust in the grocery store management. In the present study of Fort Albany, a loss of empowerment was also expressed as a sense of being forever, and increasingly, indebted to the grocery store. Polack et al[14] characterize a sustainable, local food system as one using ecologically sound production and distribution practices, and enhancing social equity and democracy for all community members. Referring specifically to poor communities, Ekin[62] argues that such communities need to meet their own needs from their own resources in order to take an independent stand, become self-determining, and make their own contribution to the common good. The recently developed Food Security Working Group in Fort Albany is an important stride towards an autonomous food system in the community and, thus, the present study further defines underlying issues and potential solutions surrounding food security in Fort Albany as a tool for the Working Group.

It should be stressed that consumption of healthy market produce may also be impacted by personal choice or preference, lack of food-usage familiarity, and monetary issues not directly related to cost of consumables. Indeed, Stroink and Nelson[4] revealed that unhealthy consumption patterns may be rooted in a common experience of social insecurity and continuous environmental change, as First Nations community members in northwestern Ontario reported health, ease, taste, familiarity, convenience, and affordability as factors driving their choice of food. Yet, Stroink and Nelson[4] note that more bananas and oranges are being consumed than blueberries and raspberries, despite the abundance of the latter in the wild. This study suggests that remote First Nations may feel more secure about the dominant food system than the local food system, and were comforted by the consistent convenience. Nevertheless, local food production may alleviate grocery store debt and dependence on limited, low-quality produce. Further support

(financial, garden supplies and knowledge) of food security programs such as the Food Security Working Group in Fort Albany is necessary for these programs; with greater support such initiatives can ensure local agriculture systems are reliable, take time to engage the community in food production and decision-making related to the food system, and focus on increasing food familiarity and knowledge of food usage.

Like food security, community food security ensures that all households have nutritionally adequate and safe food that is acquired in socially acceptable ways[63]; it differs, with its emphasis on community self-reliance, empowerment, social justice, and democratic decision-making[63,64]. It involves decreasing the distance that food needs to travel, ensuring food security and adequate wage earning and working conditions, and inclusion of all participants in the food system in decision-making about availability, cost, price, quality and attributes of their food. Hamm and Bellows (p37)[64] describe community food security as: 'a situation in which all community residents obtain a safe, culturally acceptable, nutritionally adequate diet through a sustainable food system that maximizes community self-reliance and social justice'. In contrast to simplistic food assistance and emergency food distribution programs in North America, the Community Food Security Coalition claims to address the underlying causes of hunger and food insecurity, reaching for long-term system-based solutions[63]. The complex history of northern food systems and inter-related socio-economic issues call for the systems-based approach of community food security, rather than food security initiatives alone.

Food sovereignty is a culturally appropriate approach to food security in First Nations that specifically represents Aboriginal/Indigenous food systems and their unique complexities. It is defined by the Working Group on Indigenous Food Sovereignty as the 'newest and most innovative approach to addressing the complex issues impacting the ability of individuals, families and communities to respond to their own needs for healthy culturally adapted Indigenous foods' (p11)[22]. The Working Group coined the term 'food sovereignty' in 2007 and began engaging Aboriginal communities in discussion that would enable the group to support their work on increasing food security. From these discussions, the group highlights four key principles of Indigenous food sovereignty (p12)[22]:

1. Sacredness: nurturing healthy, interdependent relationships with the land, plants and animals.
2. Self-determination: responding to their own needs and freedom from dependence on grocery stores or corporately controlled food production and distribution in market economies.
3. Participatory: maintaining traditional food strategies.
4. Policy: impacting traditional land and food systems.

The Working Group also concluded that Indigenous food systems are best described in ecological rather than neoclassical economic terms: 'Indigenous food systems include all of the land, soil, water, air, and culturally important plant, fungi, and animal species that have sustained Indigenous peoples over thousands of years or participating in the world' (p5)[22]. Values of interdependency, respect, reciprocity and ecological sustainability were identified[22]. Consideration of these Indigenous perspectives and values, which were notably lacking in the missionaries, is vital to the successful introduction and sustainability of local food systems in Fort Albany, and the food security initiatives in other First Nations.

Potato gardens have been known to support the bulk of the nutritional requirements of cold-climate communities in Newfoundland and Austria, who are similarly challenged by unpredictable weather, pronounced seasonality, short growing season and marginal soils, or competition with peak fishing times[65,66]. The known success and low-maintenance of potato gardens in the Mission-cultivated fields and on the islands near Fort Albany begs their re-introduction as part of the food security initiative. Personal home gardens may not be suitable as an immediate means of import substitution in Fort Albany to enhance food security at present time, because residents reportedly lack the knowledge of food production and interest, and are challenged by soil quality and potential

soil contamination within the Fort Albany community centre. Community plantings and workshops, however, have proven to initiate greater interest in personal gardening in First Nations across Canada[67]. Fort Albany community members also recognize the additional benefits of community gardens as a means to bring the community together to share and preserve their knowledge of culturally significant plant species, as well as provide healthy food. Fort Albany residents showed concern for the amount of work and time necessary for local food production, emphasizing the need for a low maintenance community initiative. FN 3 suggested that a community garden would be an effective way to initiate home gardening in the area:

> *You have to start first. You have to teach people by having something in common, how to care for the community garden and then … it will spread. You're just planting a seed … they'll talk about the best seed they have found …They'll start experimenting with the local things, and watch them grow (in) what kind of soil they like. And they develop (as) an expert. It's also a good way, I think, for developing a community, a cohesive community, a sociable community, from talking about something in common: our garden.*

It is apparent that conventional agricultural strategies utilized in Fort Albany by the Mission in the 20th century have degraded long-term viability of the land (Table 1). Soil studies demonstrate significant losses of vital soil properties since cultivation, and vegetative inventory used to characterize the sites revealed that, unlike the undisturbed forest, the cultivated area has been colonized by non-native and invasive species, including dandelion, cow vetch, Canada thistle and creeping bentgrass. As Bellows and Hamm[15] explain, conventional agricultural techniques may not be suitable as part of a sustainable, local import-substitution strategy. The agricultural boom in 20th century North America encouraged intensive agriculture to displace natural areas, resulting in extreme land and water degradation, including loss of soil fertility, excessive soil erosion and soil compaction[56,68]. Accompanied by the use of crop monocultures, conventional agricultural production on increasingly degraded lands became increasingly dependent on high use of pesticides, fertilizers and herbicides, further degrading natural resources and displacing native biodiversity[15,69]. Monocropping systems associated with conventional agriculture also created biological dependency on expensive, non-local technologies and inputs, resulting in unsustainable working conditions and inconsistent labour requirements[15]. Careful consideration of alternative agricultural strategies must be part of a sustainable approach to food security, less we risk similar impacts on the unique cultural and ecological communities and valuable natural resources of the north.

It should be mentioned that, when one takes into account that the subarctic and arctic regions are being disproportionately impacted by climate change[69-71], innovative alternative agricultural strategies are now a possibility. Rather than reintroducing unsustainable conventional agricultural practices to the pristine north, where fertile land is especially limited, foresight must be given to more sustainable local food strategies. Agroecosystems utilizing techniques such as permaculture or agroforestry have the potential to act as adaptable and diverse food systems that maintain soil fertility, soil organic matter as well as wildlife habitat, and do not require importation of expensive and polluting chemical fertilizers and pesticides. This shift to more sustainable food production is vital in high-latitude communities that are particularly vulnerable to rapid cultural and ecological change, and where resource availability is unpredictable and patchy[72]. The potential use of agroecosystems as a sustainable import-substitution strategy to enhance food security in subarctic Ontario, Canada, should be explored.

Conclusions

The Mission's agrarian initiative impacted the socio-cultural dimensions of Fort Albany with respect to food security, whereby the Cree became more dependent on goods imported to their region. In addition, the soil of the Mission-cultivated fields was significantly impacted by unsustainable agricultural practices. Although the Mission's agricultural movement was not a viable long-term approach to food

security, it does act as witness to the area's potential ecological capacity to support basic fruit and vegetable cultivation, despite challenging subarctic conditions. Moreover, the changing climate can be viewed as an opportunity to grow fruits and vegetables in remote northern regions that have been historically stunted in growth or are outside the distributional range of subarctic Canada, due to limiting climatic factors. Agroecosystem stewardship practices may foster adaptive capacity and increase resilience to climate change in these communities by ensuring the long-term sustainability and security of locally grown food availability, concomitantly improving human health in First Nations' people. The current study provides a foundation on which future research will be based. For example, the exploration of the technical requirements for farming in this region will include the following: the identification of suitable garden areas, soil sampling for nutrients and contaminants, recommendations with respect to site management, and the identification of a type of agroecosystem suitable for supporting socio-ecological and cultural sustainability.

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