

Sustainable Agriculture for Alaska and the Circumpolar North: Part I. Development and Status of Northern Agriculture and Food Security

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ABSTRACT. Alaska is food insecure, importing the vast majority of its agricultural products and commodities and maintaining a minimal year-round food supply. Much of the circumpolar North, with some notable exceptions, is also food insecure and similarly reliant on foods imported from outside regions. The stark differences in food policies, food security, and overall production that exist between individual countries and regions of the circumpolar North are likely due to variability in their physical and social environments, their varying agrarian histories (e.g., Old World vs. New World), and their different first-hand experiences with food insecurity, often during wartime. Alaska's agricultural history is unique, having progressed through periods of exploration and expansion and having experienced both success and failure. Agriculture exists today in Alaska as an underdeveloped natural resource-based industry that has been shaped by historical events and developmental processes and continually influenced by a host of environmental and socioeconomic factors. Continued interaction between stakeholders, agencies, and others will help the industry to progress to the point of meeting increasing food demands and improving food security.

Key words: Alaska, circumpolar, subarctic, sustainable agriculture, farming, resilience, food security, history, policy

RÉSUMÉ. L'Alaska est aux prises avec l'insécurité alimentaire en ce sens que l'État importe la grande majorité de ses produits et marchandises agricoles et qu'il maintient un approvisionnement alimentaire minime à l'année. Malgré quelques exceptions remarquables, une grande partie du Nord circumpolaire souffre d'insécurité alimentaire et dépend de produits alimentaires importés d'autres régions. Les importantes différences qui existent en matière de politiques alimentaires, d'insécurité alimentaire et de production générale entre les pays et les régions du Nord circumpolaire sont vraisemblablement attribuables aux divers environnements physiques et sociaux, à leur histoire agraire variée (celle de l'Ancien Monde par opposition à celle du Nouveau Monde) et à leurs différentes expériences directes en matière d'insécurité alimentaire, plus particulièrement en temps de guerre. L'histoire agricole de l'Alaska est unique, ayant passé par des périodes d'exploration et d'expansion, et connu tant des réussites que des échecs. De nos jours, l'agriculture en Alaska est une industrie sous-développée de ressources naturelles qui a été façonnée par des événements historiques et des processus développementaux, continuellement influencée par une panoplie de facteurs environnementaux et socioéconomiques. Les efforts collectifs déployés par les parties prenantes, les organismes et d'autres parties aideront cette industrie à progresser au point de pouvoir répondre à la demande croissante de nourriture et d'améliorer la sécurité alimentaire.

Mots clés : Alaska, circumpolaire, subarctique, agriculture durable, agriculture, résilience, insécurité alimentaire, histoire, politique

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I don't know what we can do to persuade the American people. They want to believe Alaska is a land of snow and ice. When I talk with persons in the States about our wonderful agriculture up here, most of them smile and say with their eyes, "Poor fellow, he's been away too long. Talks like a bad case of North Pole fever. There just can't be farms in Alaska as he describes."

George W. Gasser,
Alaska Commissioner of Agriculture (1945)
(Hischler, 1946; cited in Shortridge, 1976:584)

INTRODUCTION

Agriculture exists as a fixture of national economies throughout the North, and it represents a consistent and productive sector of the Alaska state economy. Circumpolar agriculture has previously been identified in basic terms as the cultivation of plants and animals occurring between 55° N and 70° N (ARDC, 1974). While definitions of terms such as "circumpolar," "Subarctic," or "Arctic" sometimes incorporate more specific boundaries, such as temperature isotherms (Soon et al., 2004) or tree lines, a more general and inclusive definition based upon latitude is sufficient for the broader scope of discussion in this paper. Therefore, for simplicity, we maintain the 55th parallel as a lower boundary for the circumpolar region.

Sustainable agriculture has been defined by the United States Department of Agriculture (USDA) through a legal definition in U.S. Code Title 7, Section 3103, as

an integrated system of plant and animal production practices having a site-specific application that will over the long-term - (A) satisfy human food and fiber needs; (B) enhance environmental quality and the natural resource base upon which the agriculture economy depends; (C) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; (D) sustain the economic viability of farm operations, and (E) enhance the quality of life for farmers and society as a whole.

Taken together, the above meanings of circumpolar agriculture and sustainable agriculture constitute what is meant by "sustainable circumpolar agriculture."

Production sectors and subfields of agriculture that exist in the circumpolar region include vegetable crops, root crops, edible grains, fruits, herbs, ornamentals, fodder crops (including grasses, hay, and grains), dairy products, meat products from both penned and free-ranging livestock, and aquaculture/mariculture (although finfish farming is prohibited in Alaska). Subsistence gathering, fishing, and hunting are more traditional practices that are important to the broader discussion of food security and resilience in Alaska and throughout the circumpolar North;

however, since they involve the harvest of wild foods rather than purposefully cultivated plant or animal products, they do not fit the definition of agriculture.

FOOD SECURITY, SUPPLY AND SUSTAINABILITY

Alaska is Food Insecure

The earliest permanently settled communities in the far North subsisted through hunting, fishing, trapping, and gathering. In Alaska, foods acquired through subsistence activities still comprise a substantial portion of many residents' diets, but the level of activity varies considerably depending on what region or community is examined. For many rural households, there has been a transition away from a full dependence upon subsistence, with imported or store-bought foods now helping to maintain a suitable level of food security in towns and villages (Reed, 1995; Caulfield, 2002; Loring, 2007).

The Division of Subsistence within the State of Alaska Fish and Game Department reported in 1990 that in rural Alaska, more than 170 kg (375 lb.) of wild foods per person were consumed per year, comprising an overall level of 20 million kg (44 million lb.) of wild foods per year (Wolfe and Bosworth, 1990). In 2000, it was reported that of all subsistence foods consumed, about 60% were fish (95% of rural households ate subsistence-caught fish), 20% were land mammals, 14% were marine mammals, and the remaining 6% comprised birds, shellfish, and plants (Wolfe, 2000). In contrast, Alaskans in urban areas were reported to have consumed only 10 kg (22 lb.) of subsistence foods per person per year, although this total does not include wild foods acquired through other permits or means, such as sport fishing, sport hunting, and personal use fishing. Subsistence foods represent only about 2% of all fish and game harvested annually in Alaska, while sport fishing and hunting account for about 1% (Wolfe, 2000). Commercial fishing is responsible for 97% of all animal species harvested statewide, with more than 900 million kg (2 billion lb.) taken annually (Wolfe, 2000), although most of this is shipped elsewhere and consumed out of state. Despite some dependence upon wild foods, the diets of most Alaskans in general include a substantial level of agriculturally derived products and commodities, most of which are imported.

Most regions of the United States maintain a reasonable balance between locally produced, imported, and exported foods, but Alaska does not. It has been roughly estimated and is generally believed that local agriculture accounts for only about 5% or less of Alaska's food demand, meaning that the remaining 95% or more is imported (as stated notionally by Alaska State Senate, 1976; Drew, 1977; UAF CES, 2006; Consenstein, 2010; Helfferich, 2010; Helfferich and Tarnai, 2010). Furthermore, only a three- to five-day supply of food is thought to exist; essentially, whatever can be found on grocery store shelves or in the few other areas where food is stored (see Rosen, 2008). Presumably,

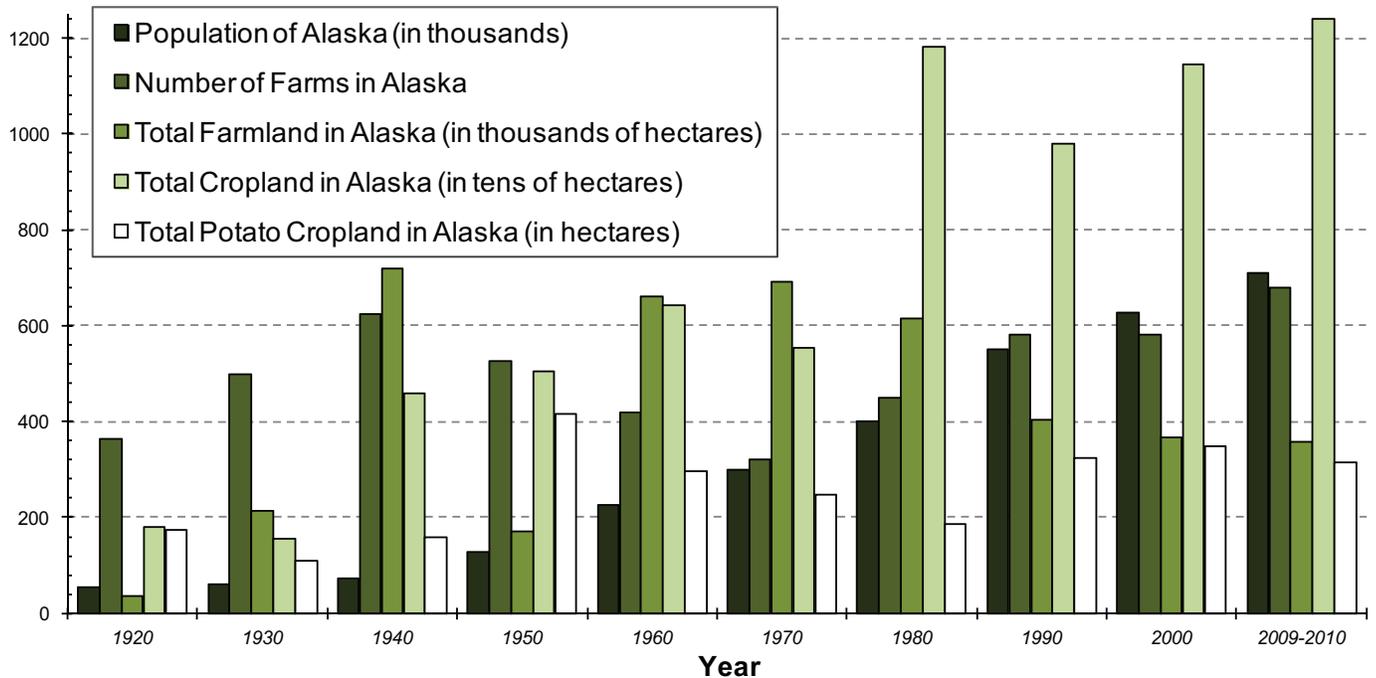


FIG. 1. The development of agriculture in Alaska (1920–2010). Data are derived from the U.S. Census Bureau (2010) and from USDA (2011b).

the estimates are rough averages derived from known levels of local production and sales, imported foods and commodities, and areas where food is stored. For instance, 85% of red meat from hoofed animals is imported into Alaska (Paragi et al., 2010), as well as many “warm-season” vegetables, almost all fruits, and 100% of farmed fish fillets. Future or ongoing statewide surveys and additional research should help solidify exact values (Helfferich and Tarnai, 2010).

The low level of local food production in Alaska can be contrasted with that of some circumpolar nations, such as Norway or Denmark, although direct comparisons are challenging because of several varying factors. In Norway, the food self-sufficiency ratio has been relatively stable at about 50% for the past half-century (Flaten, 2001; Flaten and Hisano, 2007). Denmark is a leader in food self-sufficiency for the circumpolar region, with exports doubling or tripling the level of imports and with self-sufficiencies of meat and dairy consistently above 100% (Landbrug & Fødevarer, 2010; Statistics Denmark, 2011).

Alaska’s isolation from the lower 48 contiguous states means that it is separated from the bulk of the nation’s food supply by thousands of miles. In the event of a crisis situation, Alaska’s cities, towns, and remote villages would be vulnerable. Rural village residents are on the very end of the supply chain, although they are generally less dependent on imported foods than urban residents. In contrast, urban residents generally depend more heavily on imported foods, but would receive barge and air support sooner than outlying areas. A food transportation network comprising several thousand miles of air, sea, and road is needed to deliver the most basic of needs to Alaska’s residents, but this means that the state is highly dependent upon fossil

fuel-based energy for transportation of its food, strongly tying Alaska’s food prices to fuel prices.

Alaska has not always been so food insecure. Its agricultural production has not kept pace with its population increase in the last century (Shortridge, 1976; as noted by Drew, 1977; Fig. 1). In 1955, about 55% of Alaska’s food came from in-state production (as noted by Consenstein, 2010), but this is no longer the case today. Few processing facilities exist (e.g., three slaughterhouses, a potato chip plant, an herb processor, a milk and cheese processor, two active creameries, and a few other operations). Aside from some potato farms with storage facilities that market year-round, Alaska maintains very little stored food. Few mature crops are available “on the vine” for nine months of the year because of the highly seasonal nature of the local environment. In 1983, the Matanuska-Susitna Borough (MSB, 1983:15) reported:

Farmlands now in cultivation in the Matanuska-Susitna Borough yield crops that are consumed as quickly as they are made available... The sign “local” on the market shelf quickly disappears following the growing season for vegetables, since there are no commercial freezing or processing facilities to ensure a year-round supply.

In the 1970s, the Alaska State Legislature addressed food insecurity when the Commerce Committee drafted a resolution proposing actions to combat the vulnerability of Alaska to food shortage and limited local production, stating that:

...a sound and sustained agricultural production, processing and marketing industry is necessary to the

healthy economic life and future well-being of Alaska... Whereas Alaska now produces less than five per cent of the food it consumes annually, agriculture, as a resource management tool, could provide a much larger percentage of the state's basic consumer needs in food, fiber, industrial raw materials, and aesthetic products at a reasonable price.

(Alaska State Senate, 1976:1)

Aspects of food security in Alaska have been discussed previously (Drew, 1977; Dearborn, 1979; Caulfield, 2002; Dunlap et al., 2007; Nord et al., 2007; White et al., 2007; Fazzino and Loring, 2009; Loring and Gerlach, 2009; Meadow, 2009; Stevenson, 2009a, 2011; Loring, 2010; Helfferich and Tarnai, 2010; Paragi et al., 2010), and it appears that increases in both rural and urban agriculture will be important for producing a more food-secure state, especially in view of some struggling wild food sources. Some authors report that federal and state resource management policies have made it difficult for Alaskan hunters to alter their harvest strategies effectively (Natcher and Davis, 2007), and others question whether changes in climate might affect movements and harvests of marine subsistence species such as walrus, seal, beluga whale, and salmon (Gofman and Smith, 2009). There is also no guarantee for the future that enough wild food will always be able to be harvested, processed, and stored to satisfy the needs of all communities or provide nutritious food throughout Alaska's long winters (White et al., 2007).

In recent decades, Alaska's rural communities have undergone significant economic, cultural, and demographic restructuring, and although these transitions are complex, there are some underlying issues of food insecurity and increased dependence on imported foods. As Fazzino and Loring (2009:159) report,

There has been a marked movement in rural diets away from country foods and toward foods purchased from the store (Kuhnlein et al. 2004; Bersamin et al. 2007). Whether driven by necessity, expedience, or both, this "nutrition transition" is widespread across the North American Arctic, although the extent to which diets are changing varies significantly from community to community and even within communities among different age groups. Some rural communities in Alaska enjoy a wide variety of readily available fish and game, maintaining a strong preference for a utilization of traditional foods, while others cope with near-food deserts.

More than 12% of Alaskan households are thought to be food insecure, meaning that they have difficulty providing enough food for all members of their household at some point during the year (Nord et al., 2007). Of these households, almost 5% report consistent reductions in food intake or disrupted eating patterns due to inadequate food resources. While Alaska's numbers do not significantly

differ from U.S. food insecurity averages, the rate at which food insecurity is increasing in Alaska does. In fact, Alaska tied for the highest rate of increase (+3.7%) from 1996–98 to 2005–07 (Nord et al., 2007). Thus, the role in food security of decreasing reliance upon wild foods and increasing reliance on a cash economy and an industrialized food system is being questioned more and more (Fazzino and Loring, 2009).

Local Agriculture as a Means of Improving Health

The health of Alaska Natives appears to be linked to levels of subsistence activities and consumption of wild foods. Notable statewide declines in the physical and psychological health of Alaska Natives have been documented, including higher rates of obesity, Type II diabetes, coronary heart disease, cancer, depression, suicide, substance abuse, alcoholism, and violence (Hamrick and Smith, 2004; Graves, 2005; ADHSS, 2006; Segal and Saylor, 2007; Wernham, 2007; Wolsko et al., 2007). Furthermore, it has been shown that the costs of village health care rise when the dietary contribution of industrial foods relative to subsistence or wild foods increases, and recorded decreases in activity and exercise levels could be related to a greater reliance upon imported store-bought foods (Kuhnlein et al., 2004; White et al., 2007).

An increase in local food production doesn't guarantee a proportional increase in the purchase or consumption of local foods. However, it is probable that healthier options will result in improved diets and stronger local economies. Additionally, the labor activities associated with farming and gardening can provide physical health benefits like those reported for participants in other means of food acquisition, such as hunting and fishing (Samson and Pretty, 2006).

Local agriculture could act as an important secondary or backup food system in areas where subsistence hunting and fishing might potentially be compromised by development or by contamination from pollutants that reach oceans, freshwater, air, or land. Contaminants, including metals, petrochemicals, and persistent organic pollutants, represent an environmental health and food system challenge that poses a risk to rural residents' food security (Dunlap et al., 2007; Mergler et al., 2007; Loring, 2010; Stevenson, 2011), especially in oceans and freshwater systems. If contaminants in traditional subsistence foods derived from the ocean bioaccumulate to levels that are no longer safe, there may be a greater need to incorporate more locally grown foods.

Alaska's Agriculture Potential and Availability of Natural Resources

Alaska is the largest state in the United States, has the lowest population density, and possesses the most publicly owned land. These characteristics help to keep Alaska wild, but they also mean that much of its arable land is

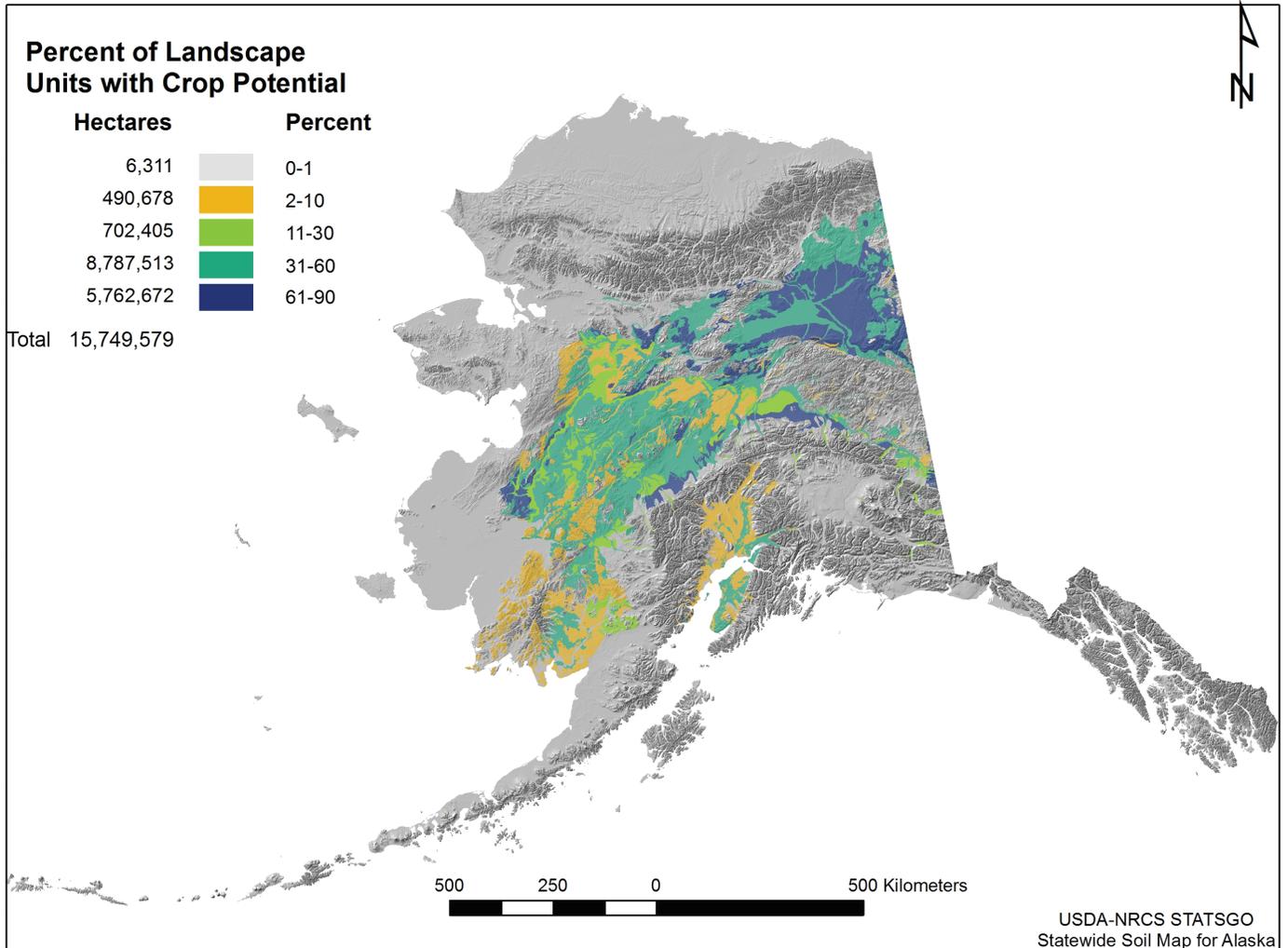


FIG. 2a. Landscape units with soils of agricultural potential for Alaska. Source: STATSGO, 2011.

restricted. Alaska contains millions of hectares of arable land with soils and climate suitable for farming; the Natural Resources Conservation Service (NRCS) of the USDA reports more than 16 million hectares of soils with agricultural potential in Alaska (Fig. 2; STATSGO, 2011).

Alaska has a population of more than 710 000 residents, but it possessed only 686 farms in 2007 and 762 farms in 2012, and most of these were relatively small (USDA, 2008b, 2009a, b, 2014; Helfferich, 2010; U.S. Census Bureau, 2010). Alaska ranks last among the 50 states in agricultural exports (USDA, 2008b). Despite the important existing contributions of Alaska's farmers and ranchers to the state economy, the agriculture industry makes up less than 1% of revenues earned from all resource industries in the state (UAF CES, 2006).

One reason Alaska is well suited for an expansion of sustainable farming is its ample freshwater resources. Current levels of water use by the agriculture industry in Alaska are negligible in comparison with those in the rest of the country and the world. In the continental United States, approximately 35% to 41% of all freshwater withdrawals

are devoted to agriculture (Solley et al., 1998; Kenny et al., 2009). Worldwide, 70% of all freshwater goes to agriculture (WRI, 2000), often resulting in regional water shortages, conflicts, and hardships where clean water is scarce (Alessa et al., 2011). In Alaska, however, only 0.1% of the state's total water withdrawal is used for agriculture (Kenny et al., 2009). The majority of Alaska's freshwater withdrawal goes to aquaculture (82%) to support ocean ranching at state-run hatcheries in Southeast and Southcentral Alaska that facilitate commercial, sport, personal use, and subsistence fisheries (Kenney et al., 2009). However, even when all freshwater devoted to aquaculture is excluded from water withdrawal statistics, there is only a half-percent increase, from 0.1% to 0.6%, in the level of freshwater withdrawn for agriculture (Kenny et al., 2009; Alessa et al., 2011).

Alaska possesses large, unused tracts of arable land and an adequate supply of clean and accessible freshwater, and it is also well situated to take advantage of integrating its food systems. For example, there exists a strong potential for using waste outputs from fish processing as nutrient inputs for agriculture; however, the logistics and costs

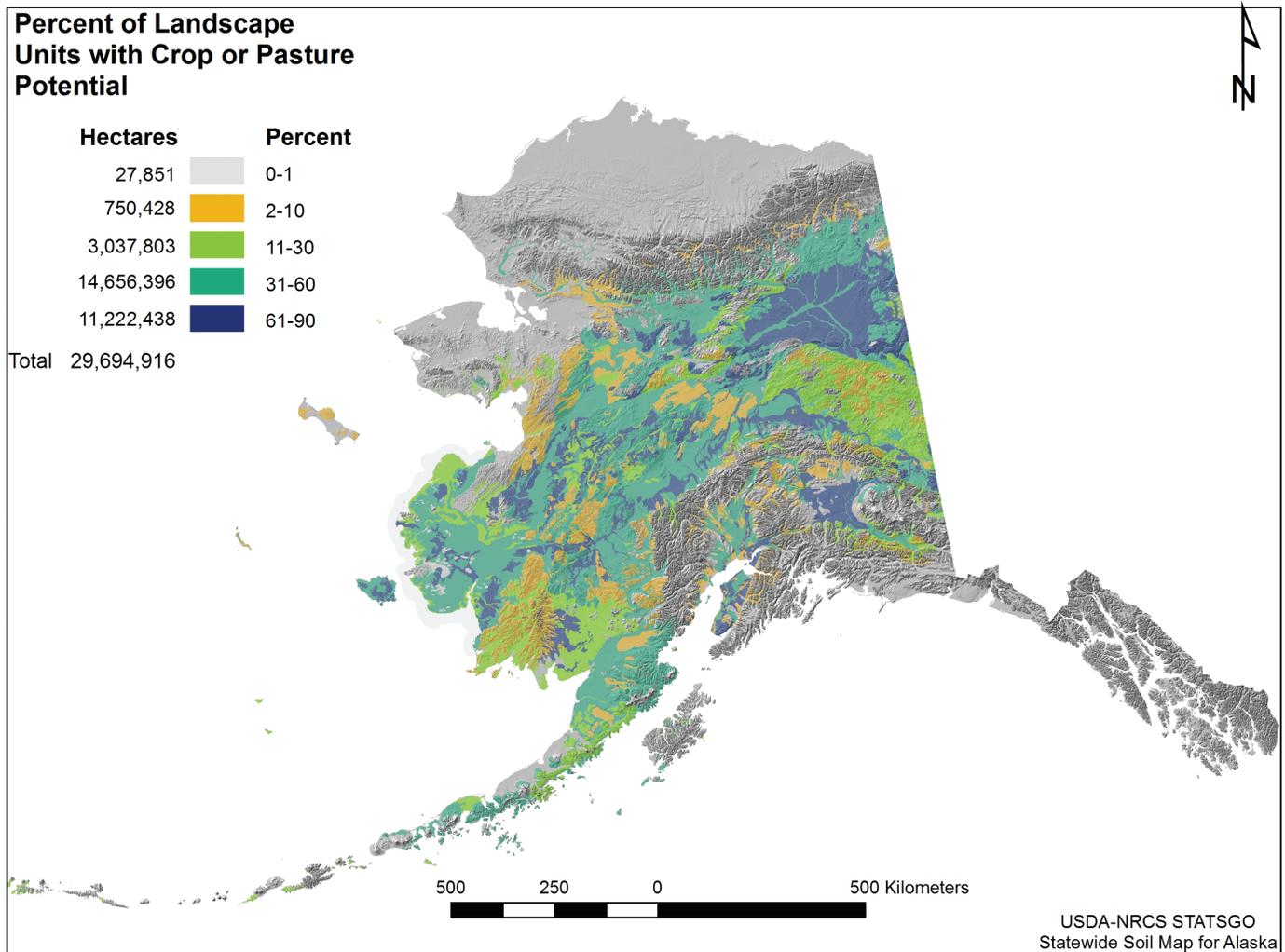


FIG. 2b. Landscape units with soils of agricultural potential for Alaska. Source: STATSGO, 2011.

of organizing and distributing fish wastes to where they are needed remains challenging (see Stevenson et al., 2014a for more details). Alaska's agricultural potential is immense (ARDC, 1974), and responsible development and expansion of the industry by the private sector, although not free from challenges, could provide many benefits to Alaska's communities. Such benefits could include helping to meet food demands, making fresh foods more available, lowering overall food costs and reducing food miles, improving health, reducing imports and outside dependencies, creating jobs and revenue, fostering partnerships within and among communities, and moving Alaska towards greater resilience and self-sufficiency (see Pearson and Lewis, 1989 for more details).

Organic Agriculture in Alaska

The organic sector is a key component of sustainable agriculture, although "organic" does not necessarily translate to sustainability (i.e., some organically grown products are not entirely sustainable, and some sustainable products

or practices are not entirely organic). In Alaska, organic certification is an expensive process. It costs approximately \$2000 per year for a farm to be certified under the USDA National Organic Program (NOP). One reason is that the State of Alaska has not pursued accreditation with the NOP, so it cannot certify organic produce. Instead, farms must be certified by inspectors flown up from the State of Washington at the expense of growers, who ultimately mark their Alaska-grown products as "Certified Organic by the State of Washington." Some non-certified farmers believe that this labeling would give the incorrect impression that their produce is not local, and it is an added expense. Non-certified farms have claimed that their practices and products meet or exceed standards of NOP certification.

In its Organic Production Survey in 2008, the USDA National Agricultural Statistics Service (NASS) reported that only 16 farms in Alaska were certified organic or exempt organic, only a fraction of the U.S. total of 14 540 certified farms (USDA, 2010). Only 178.5 hectares (441 acres) of cropland in Alaska were reported as certified or exempt organic, of which 61.1 hectares (151 acres) were

harvested. Surveys showed that about 87% of these farms planned to maintain or increase organic production over the next five years. Of the 16 certified or exempt organic farms in Alaska, two practiced biological pest control, three maintained beneficial insect or vertebrate habitat, and one released beneficial organisms. Five of these farms used no-till or minimum-till practices, and three used water management practices. Three farms selected planting locations to avoid pests, two chose pest-resistant varieties, two planned planting to avoid cross-contamination, one maintained buffer strips, and 11 produced or used organic mulch or compost. Ten farms used green or animal manures, three practiced rotational grazing, and three practiced free-range livestock production.

Nine of the 16 certified organic or exempt farms reported sales at farmers' markets, which accounted for an average of 60.2% of these farms' total sales. Six organic farms used on-site sales, three used community-supported agriculture, two used mail order or Internet sales, and one used other consumer-direct outlets. Approximately 95% of the first points of sales for certified or exempt organic farms were local, within 161 km (100 miles).

Pathways to Greater Sustainability in the North

By the year 2050, it is expected that the earth's population will approach nine billion people and that food production efforts will have to at least double. However, this increase in production will be able to occur only in association with increased availability of good-quality soils, ample freshwater, and more available nutrient inputs, as well as improvements in crop breeding technologies, integrative crop-livestock systems, sustainable intensification, and other inventive practices (Fedoroff et al., 2010; Godfray et al., 2010; Herrero et al., 2010; Tester and Langridge, 2010). Today, overconsumption and non-sustainable farming practices are widespread worldwide issues, and still global food demands are not being satisfied; instead, they are increasing (Ash et al., 2010). Already it is estimated that more than one billion people worldwide suffer from insufficient energy intake, and twice that number suffer from insufficient micronutrient intake (FAO, 2009; Barrett, 2010). Further malnourishment and starvation are likely to be forthcoming, and communities in Alaska or the rest of the circumpolar region may not escape them, but the continued progression of sustainable agriculture in the North could help to mitigate these effects.

For many circumpolar communities, sustainable solutions to the challenges accompanying northern agriculture have come about through several centuries of trial and error. Living at high latitudes often means cultivating a greater ethic of self-sufficiency and learning to achieve more with less (or simply to be satisfied with less). This can mean purchasing a smaller or more energy-efficient home (Stevenson, 2009b), using more locally available resources and fewer imported resources (Stevenson, 2009a;

Himelbloom et al., 2010), starting a personal garden (Roberts, 2000; UAF CES, 2004; Loring and Gerlach, 2010), or initiating a small farm or other agricultural enterprise (ARDC, 1974, 1983; MSB, 1983; Stevenson, 2009a).

Agriculture is relatively new in Alaska, whereas other circumpolar countries have farmed at high latitudes for millennia. It is an underdeveloped industry throughout much of the circumpolar North. Historically, agriculture has been highly subsidized to retain people on northern lands for defense purposes. In fact, defense may be a major reason why agriculture exists to the extent that it does today. Agriculture's beginnings and development in Alaska are unique and speak volumes about the state of the industry today. A composite picture of Alaska's farming history and current initiatives are important to understand future possibilities for local, sustainable agriculture and greater food security in the state.

DEVELOPMENT AND STATUS OF ALASKAN AGRICULTURE

Some aspects of Alaska's agricultural history and development have been described in past publications (e.g., ARDC, 1974, 1983; Shortridge, 1976; Wilson, 1978; Stern et al., 1980; MSB, 1983; Lewis et al., 1987; UAF AFES, 1998; Loring and Gerlach, 2010). The chronological review presented below also documents recent efforts toward sustainable farming and greater resilience.

Agriculture first reached Tlingit and Haida communities in Southeast Alaska as early as 1765 (Loring and Gerlach, 2010), presumably through interactions with early trappers and traders or with other Native peoples who shared their knowledge and experience. The first documented arrival of agriculture in Alaska from Russia occurred during the colonization efforts of Grigori Shelikof at Three Saints Bay (now Old Harbor) on Kodiak Island between 1783 and 1784 (ARDC, 1983; Loring and Gerlach, 2010), less than a decade after Captain Cook's famed expedition to Alaska. Shelikof brought seeds and livestock to the region and established gardens. In the following decades, the managers of the Russian-American Company made other attempts at agriculture. Both that company and the Hudson's Bay Company are known to have regularly acquired potatoes from the Haida people in Alaska as an export crop. Soon after, Alexander Baranof founded a short-lived agricultural colony at Yakutat. Russian records indicate the presence of small agricultural colonies at Ninilchik, Kasilof, Kenai, Tyonek, Knik, and Matanuska (ARDC, 1983). Early Russian fur traders and trappers settling in Alaska unfortunately chose some of the most marginal soils for agricultural production, with poor results. Although they had fully intended to support their trade through local food production, they had to import some foods from California.

Early settlers determined that cereals would not ripen in any coastal areas within the boundaries of the Russian fur trade, but some vegetables grew successfully.

Grazing animals thrived in many locations, but early on it was recorded that poultry and hogs acquired an unpleasant fish-like smell when seafood became a major component of their diet. In 1833, Baron Wrangell reported more than 200 head of cattle and other various livestock in Alaska, and he documented gardens at Sitka, Kodiak, Unalaska, Atka, Kenai, Sanak, Unga, and Attu (ARDC, 1983). In the 1840s, Bishop Veniaminoff described local gardens established in various locations across Alaska, including Isanotski Strait, False Pass, and nearly every island village west of Unalaska (ARDC, 1983). Some early Russian attempts at agriculture in Alaska failed because the pioneer landowners lacked significant farming expertise and because too few serfs could be enlisted (Loring and Gerlach, 2010). Others were successful, however, and during the 126 years of Russian exploration, occupation, and settlement of Alaska, northern subsistence agriculture generated an important seasonal supply of food that may have contributed to the disappearance of references to starvation and scurvy in Russian historical records.

By the mid-19th century, “outpost agriculture” had reached Athabascan communities of the Tanana Flats region, presumably through interactions with the Hudson’s Bay Company at Ft. Yukon (ca. 1847). This type of agriculture filled a niche within local foodways and provided one of many important components of a flexible and diversified subsistence strategy (Francis, 1967; Loring and Gerlach, 2010). In the late 1800s, family, school, and community gardens in Interior villages increased local economic diversity and food security through raising potato, vegetable, and cereal crops for trade and consumption (Loring and Gerlach, 2010). Gardens became a prevalent and successful strategy for coping with the natural variability and uncertainty of living in the remote territory, and they filled gaps created by variation in wild game harvests and the unpredictable food supply chain from the continental United States (Loring and Gerlach, 2010).

In 1867, U.S. Secretary of State William H. Seward orchestrated the acquisition of more than 148 million ha (366 million acres) of land from Russia for less than five cents per ha (< 2¢ per acre). Prior to the Klondike stampede of 1897, Americans perceived no need for settlement of the Alaska Territory. However, the gold rush that occurred in Alaska at the end of the 19th century elevated the non-Native population from about 4300 people in 1890 to more than 30 000 people by 1900 (Brooks, 1953; Shortridge, 1976). This population increase generated the first real market for a local agriculture industry in Alaska, prompting the U.S. government to establish experiment stations and test the resilience and efficacy of seed varieties, livestock, and cultivation practices in the territory. In 1898, the first agricultural experiment station was opened at Sitka, which was followed by several others at Kodiak, Kenai, Matanuska, Copper Center, Fairbanks, and Rampart over the next two decades (Mick and Johnson, 1954). In 1899, only a year after the exploration of the Copper River by Captains Glenn and Abercrombie and the exploration of the Matanuska

Valley by W.C. Mendenhall, the Cook Inlet region began receiving attention for its strong farming potential. A.C. True, USDA Director for Office of Experiment Stations, remarked that

...in the Cook Inlet region there are thousands of square miles that can be utilized for agricultural purposes... I believe this region to be more favorable for the development of agriculture than any other portion of the coast country... all that is required for the development of these resources is (1) the immigration of a hardy, industrious class of people who can readily adjust themselves to the conditions, and (2) adequate transportation facilities.

(MSB, 1983:5)

Thus was born the vision of a vast agrarian empire in Alaska, from the fertile soils of the Cook Inlet region, to promising cattle and sheep ranching on Kodiak Island and the Aleutians, to wheat farming in the Interior, to reindeer herding on the Seward Peninsula (Shortridge, 1976).

Domestic reindeer had been introduced into the Alaska territory in the late 19th century by Sheldon Jackson, a Christian missionary who also served as the Commissioner of Education for Alaska. Jackson wanted to provide a subsistence food source for the destitute Eskimo population, and the idea of reindeer came about during his travels to the Chukchi coast and Chukotka Peninsula in Siberia. Reindeer herding had been practiced for centuries in Siberian villages with good success, and Jackson argued before the U.S. Congress that reindeer would provide an invaluable source of meat and possibilities for economic development for the Inupiaq people. He was successful in his pursuit of obtaining reindeer on behalf of Native Alaskans, and from 1892 to 1901, the U.S. government purchased and transported 1280 reindeer from Russia to the Teller Reindeer Station at Port Clarence, Alaska (Stern et al., 1980; Ellanna and Sherrod, 2004; Finstad, 2008). The animals soon thrived, doubling their numbers every three years while being given only minimal care (Shortridge, 1976). The immense potential of the reindeer industry became quite visible, especially when a 1903 *National Geographic* article suggested that Alaska might be only a few decades away from being able to ship half a million to a million reindeer carcasses per year to the continental United States (Grosvenor, 1903).

Interest in agrarian colonization of Alaska continued to increase, with Scandinavian models for agriculture often held up as reasonable hope for success during Alaska’s settlement (Wilson, 1978). The rich agriculture that thrived overseas and the similarities in latitude and day length between Scandinavia and Alaska were undeniable. However, these similarities were offset by many important, but possibly less publicized, differences between locations, such as variability in microclimates, growing season lengths, physical and chemical properties of soils, coastal effects, infrastructure and roads, availability and accessibility of resources, and cultivar selection.

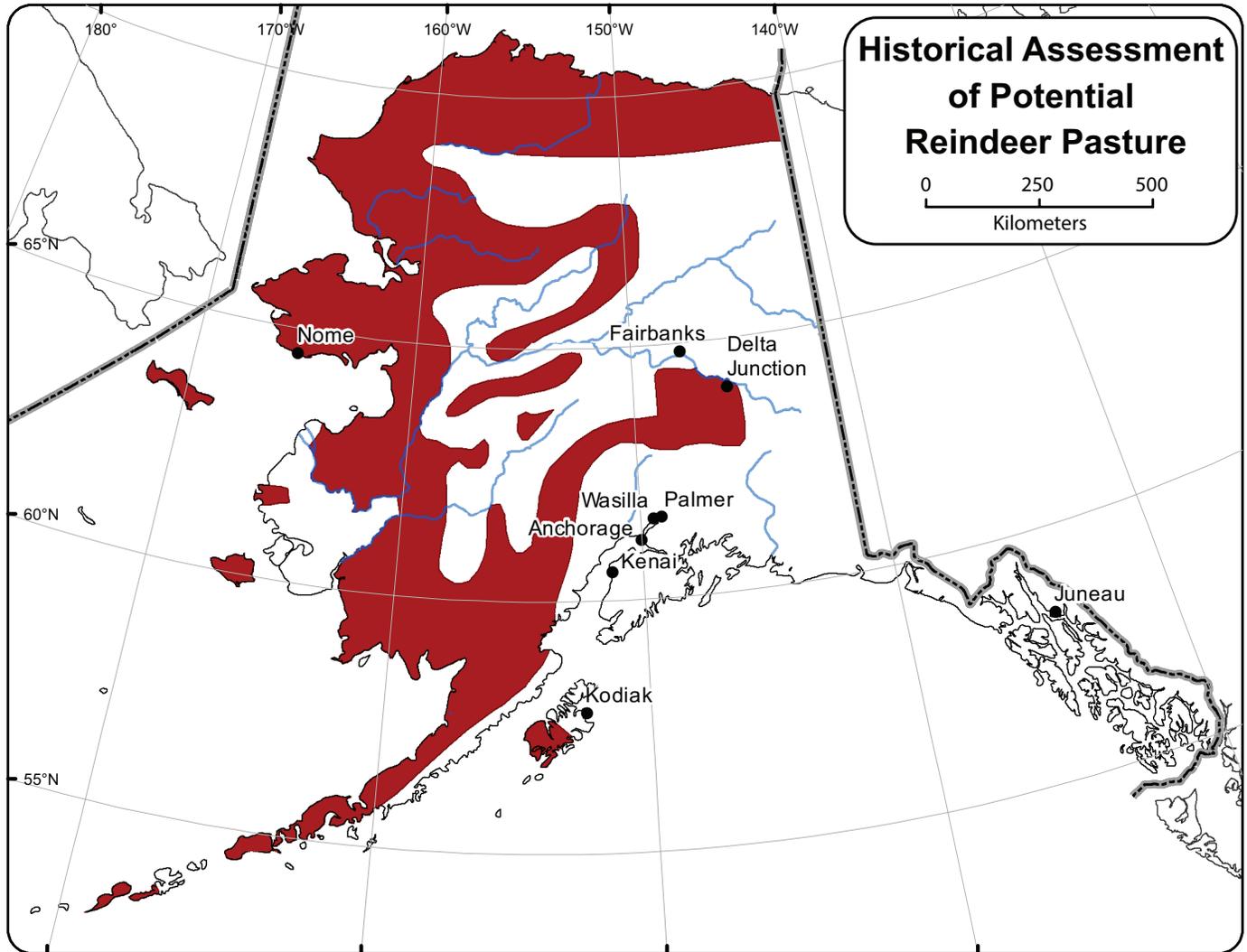


FIG. 3. A 1922 assessment of potential reindeer pasture in Alaska. Modified from Shortridge (1976: Fig. 2) and used with permission. The USDA NRCS maintains a more modern database of vegetative, soil, and climatic data.

In 1903, the Homestead Act (1898) was amended to encourage farming for profit through greater allowances of land grants and surveyed lands (MSB, 1983), and by 1910, an early estimate of potential agricultural lands was published in which several regions of the Alaska territory were reported as prime for agriculture (Mitchell, 1910). Agrarian hopes sagged slightly during the following decade until plans for the Alaska Railroad were announced in 1914. By 1915, farmers were making plans for marketing surplus, storing crops, and securing more seed. However, both farming and mining stagnated when many of Alaska's men answered the call to duty during World War I (MSB, 1983). Farms and mines were left partially developed, and the market for produce shrank so much that in 1917, a harvest of 1.18 million kg (about 1300 tons) of vegetables and 544 000 kg (about 600 tons) of potatoes was left to rot (MSB, 1983).

The post-war period of the 1920s became a fairly successful and ambitious time in Alaskan agriculture. Government wheat-breeding trials were deemed successful in the

early part of the decade, and a Fairbanks farmers' association constructed a grain mill in 1921. In 1922, an estimate of potential reindeer pasture was published in which the majority of lands in northern, western, and southwestern Alaska were determined to provide suitable habitat and valuable forage to support Alaska's reindeer herding economy (Hadwen and Palmer, 1922; Fig. 3). Soon, the largest reindeer herding operations in the Alaska Territory had lined up distributors in many major U.S. cities where quality meat could be delivered at one-quarter to one-half the cost of beef produced in the lower 48 states.

In 1924, the cumulative Alaskan reindeer population was reported to be 350 000 animals and increasing (Fig. 4). By the mid 1920s, thousands more head of livestock were introduced into the Aleutian Islands, and Congress began approving grazing leases on public lands (Shortridge, 1976). However, Alaska's immigrant population did not boom as expected from 1910 to 1930, and neither did its number of farms. The Great Depression that devastated the United States in 1929 had far-reaching effects on the livestock and

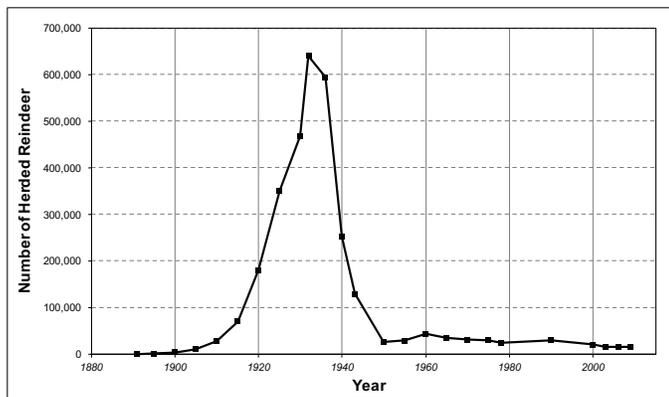


FIG. 4. Reindeer herding in Alaska (1890–2010). The figure is derived from data in Stern et al. (1980), Carlson (2005), and USDA (2009c).

grain industries in the Alaska Territory. The Alaska Railroad sent its colonization agent, M.D. Snodgrass, to various states to encourage families to stake land and settle in the Matanuska-Susitna Valley. While many did ultimately move to Alaska to obtain lands and establish farms, agrarian progress overall had faltered.

Reindeer operations, estimated to have reached herding levels of 600,000–700,000 head in 1931 and 1932 (Fig. 4), were doomed to fail by the end of the 1930s because of the lasting effects of the Great Depression on exports from the United States. For instance, market blockades were imposed by struggling American cattle herders against stores' purchase of cheaper reindeer meat imported from the Alaska Territory (Shortridge, 1976). Decreasing fur prices and an excess of Native-owned reindeer helped to drive down local demands for reindeer meat in Alaska. By 1937, new reindeer were not being purchased, range deterioration was becoming a bigger problem, and disease and predators were killing off large numbers of the remaining animals (Stern et al., 1980).

The Reindeer Act of 1937 attempted to resolve the problems that had arisen in the preceding decade. The act restricted reindeer ownership to Natives, provided for government aid, and authorized appropriations for purchasing all reindeer and improvements owned by non-Natives (Stern et al., 1980). However, Native interest in reindeer herding was generally in a decline in the late 1930s, and the dawn of World War II proved to be a crippling blow to the Alaskan reindeer industry. Many remaining Native herders abandoned their stocks for a more traditional hunting and fishing existence or for wartime jobs with the federal government that would provide a better way of life than reindeer herding (Shortridge, 1976).

Authority over Alaska's reindeer herding industry was granted to the Bureau of Indian Affairs in 1941, at which time a program to privatize and improve reindeer management on the Seward Peninsula was implemented (Stern et al., 1980). Individual grazing rights and areas were defined, and many new herds were established. An intensive herding management program was developed wherein herders would learn to travel with herds on a consistent basis and

continuously move them to new grazing areas (Finstad, 2008). The Bureau of Land Management would undertake supervision of ranges decades later, paving the way for important formal range management policies and practical preparations to improve sustainability of rangeland and lichens (Stern et al., 1980).

Under the Reindeer Service's jurisdiction, a series of village garden projects emerged in the 1930s. Many of these were managed by schoolteachers, and horticulture programs became an active component of Native communities, including those in some of the harshest and most northerly settlements (Loring and Gerlach, 2010). In general, village gardens were dominated by potatoes and other root crops, such as carrots, turnips, beets, radishes, and rutabagas. They also sometimes produced cabbage, lettuce, beans, celery, chard, kale, and peas (Loring and Gerlach 2010).

Federal interest in Alaskan agricultural projects languished in the early 1930s once it was demonstrated that farming was feasible in the territory. By mid-1932, only the Fairbanks and Matanuska experimental farms remained, and their operation was taken over by the University of Alaska (Mick and Johnson, 1954). The mining industry, which employed nearly 1000 men in the 1930s, should have provided a market for crops grown in the Cook Inlet region; however, merchants were reluctant to purchase local produce because imported foods shipped to Alaska retailed for a lower cost (MSB, 1983). In the mid-1930s, tractors began to replace horses in Alaska (MSB, 1983), which helped to make local produce more competitive.

As part of the nation's effort to recover from the Great Depression, a government-funded experiment sent more than 200 pioneering families to the Alaska Territory in 1935 to establish a colony and farm the land. Experienced farming families from the colder Midwest region of the United States were selected since they would be accustomed to farming in a cooler climate. It was a defining moment in Alaskan agriculture that was different from the sort of expansion that had occurred in some other areas of the circumpolar North in centuries past. There was no slow, natural progression of infrastructure or abundance of regionally specific, time-tested cultivars.

The colonization project attempted to inspire hope and new life to Americans in the post-Depression era, even though a stable market for agricultural products in Alaska was lacking at times. The determination and work ethic of the colonists would be critical for success. In 1935, colonization agent Snodgrass remarked to a reporter,

All these colonists have to do to make good is work. The soil is here, ready to produce. There are farmers in the Valley who showed it would produce by hard work. I suppose some of these new men will fail up here. They'll be the ones who didn't work like the rest of us have done. The ones who really dig in will soon find themselves coming out on top.

(MSB, 1983:12).

In accordance with Snodgrass's prediction, many colonists stayed permanently and made their livelihood in the territory. Others, however, gave up farming after just a few years and left to take on more modern, non-agrarian jobs. Some that left suggested that the original colony farm sizes (16.2 to 32.4 ha, or 40 to 80 acres) were too small to be profitable, while others blamed local markets for their failure. Results of the colonization of the Matanuska-Susitna Valley are mixed, and there is not a clear consensus as to the level of success achieved by the colonization venture (Shortridge, 1976).

The first half of the 20th century did not meet many of the hopeful expectations for Alaskan farming that were present in the late 1800s. Despite a temporary boost in agriculture that coincided with the military buildup in Alaska in 1939, the 1949 census reported that the picture of Alaskan agriculture at mid-century was only slightly better than it had been around the Great Depression. Homesteading increased regularly each year from 1946 to 1950, but agriculture was not keeping pace with the population influx into Alaska that followed World War II (Shortridge, 1976).

According to James Shortridge (1976:583), the collapse of frontier farming during the first half of the 20th century, both in Alaska and in the lower 48 states, may have reflected untimely changes in attitude:

Alaska was ripe for frontier agricultural settlement. The land was thought to be physically capable of supporting substantial agriculture and the nation as a whole was assumed to require a new pioneer fringe. Yet, somehow frontier farming failed to develop... The critical factor in the anomaly was a change in American attitudes toward pioneering that occurred nearly simultaneously with the expectations of Alaskan development. A gap was created between the collective American mind and the individual one; the symbol and idealization of the yeoman farmer survived long after individual Americans were willing to pioneer. From about 1900 to 1950 Alaska endured this quandary, suffering frustration as increasingly elaborate but largely futile government programs were proposed to attract farmers to this last frontier.... They represent a final chapter in the pioneer westward expansion of this country, a demonstration of the strength and resiliency of the agrarian yeoman vision to Alaskans and Americans generally.

In the 1950s, Alaska was developing its agriculture as a frontier, while the rest of the United States was moving into the post-industrial age and was less concerned about settling new territories. For Alaska, it was a period of expansionism in which agriculture followed the railroads and the development of infrastructure. However, the federal government had little interest in providing support for new agriculture at that time (in contrast to the pre-industrial period, when settlement of the frontier in the West had been a primary goal). By the mid-1950s, although agricultural

research maintained a steady pace, fewer than 100 full-time farmers remained in the Matanuska-Susitna Valley (Shortridge, 1976). Commercial farms were in a state of flux, and families were intermittently leaving the region after a few seasons. Some were not well adapted to the climate. Others were in poor health or simply growing old. Long-term farm management practices and the local food-producing economy were hindered by this constant state of change (Mick and Johnson, 1954).

In the middle of the 20th century, soil associations began to be studied more intensively in Alaska, and the first statewide reconnaissance of soil resources was published (Kellogg and Nygard, 1951). Over the next three decades, areas of Alaska accessible from the existing road system and having soils with potential for agriculture were surveyed by the USDA Soil Conservation Service, now the NRCS. These areas included the Kenai Peninsula, Matanuska and Susitna Valleys, Fairbanks, Nenana, and Delta Junction (USDA, 2011a). Such projects provided detailed soil maps with associated soil property information, primarily for agricultural applications. Farm size and the production of vegetables and dairy continued to grow steadily, peaking during the 1950s and 1960s (MSB, 1983).

In 1959, Alaska became the 49th state in the Union. Commercial oil exploration at Prudhoe Bay began in the 1960s, and the following period of wealth for the state triggered investments into state-run agriculture. Soon interest grew in documenting growing season lengths to better understand farming potentials and the efficacies of crops and cultivars in each region and microclimate of Alaska (Searby, 1968; Fig. 5).

During that time, farming was also progressing in smaller villages around the state. In Unalakleet, land clearing (by hand) began to open up farming, even allowing food production to reach commercial proportions (Dearborn, 1979). In some Athabascan villages, such as Venetie, gardens fueled by educational programs began to show great agricultural promise in the 1960s. However, a strange trend was sometimes observed. After several consecutive years of gardening success, villages would sometimes experience an almost complete interruption of agriculture and an abandonment of gardens and fields. According to Loring and Gerlach (2010:188–189):

The village gardens of Venetie... yielded a recorded twenty-four thousand pounds of potatoes (and another four thousand pounds of a variety of other produce) in 1961, and several Native gardeners won awards for their produce at the state fair in Palmer. Between 1961 and 1967, Venetie's gardens consistently produced at this level. However in 1970 the gardens were abandoned, reporting little more than two hundred pounds of potatoes.

Several explanations were proposed for the drastic interruption in production at Venetie. In that year, residents may have preferred to invest their time in securing food through

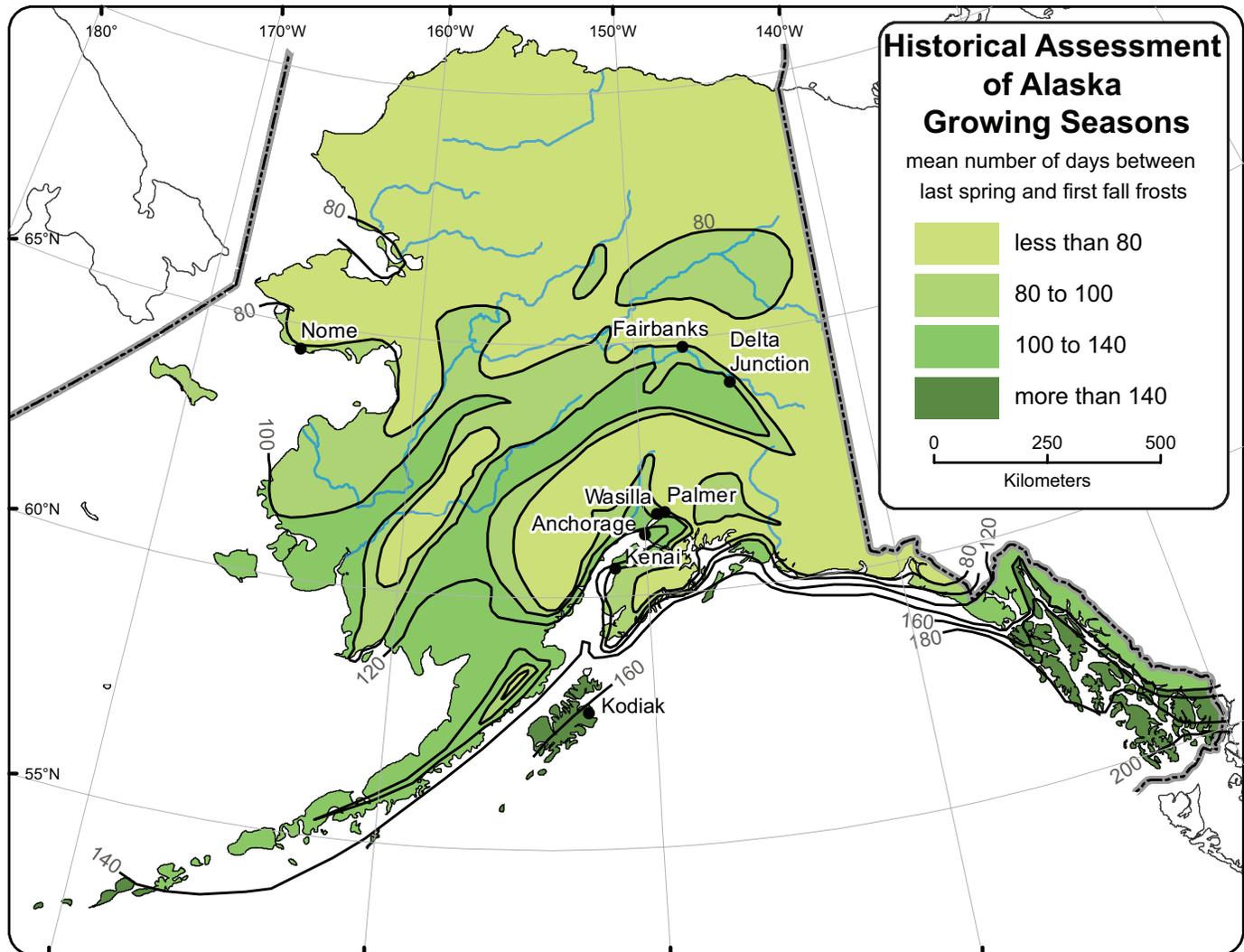


FIG. 5. A 1968 estimate of regional variation in length of growing seasons throughout Alaska. Source: Searby (1968), cited from Shortridge (1976). Published with permission. Growing season lengths have increased slightly, but the patterns remain as good estimates of the regional climatic variation across Alaska.

traditional subsistence fishing and hunting rather than agriculture; there may have been a lack of participation or motivation that year; or the ideals of village residents simply may not have been consistent with the traditional agrarian mindset. Soon afterwards, the Bureau of Indian Affairs (BIA) began to pursue further rural education and development; this initiative was rooted in a long-held belief in agriculture as a mechanism of economic development and civil progress. The Federally Recognized Tribes Extension Program currently provides funding for Agriculture Extension Programs that serve some tribes in Alaska.

In the late 1960s and early 1970s, dairy, vegetable, and potato farms in Alaska's major agricultural regions appeared to be dwindling. The Federal-State Land Use Planning Commission for Alaska conducted an in-depth study on the feasibility of agriculture in Alaska and recommended that "a large demonstration area be developed" and that "efforts be made to designate a considerable portion of land for agriculture" to show that large-scale agriculture was possible. This recommendation eventually led

to explorations of agricultural production in Delta Junction (Faris and Hildreth, 1975; Davies, 2007). From the late 1970s through the 1980s, in an attempt to wean the state from its heavy dependence upon imported foods and to display its large-scale possibilities for agriculture, Alaska invested millions of dollars in two state-run initiatives: the Delta Agricultural Project (see Lewis and Wooding, 1978) and the Point MacKenzie Dairy Project (see Lewis et al., 1980). Project goals were to broaden the economic base of the state through the responsible use of oil revenues to develop agricultural production as a renewable resource; to provide alternative job opportunities through an expansion of agriculture; to improve rural life by developing an economic base in agriculture; and to help meet national goals of increased food production for world needs (AAAC, 1981; reviewed in Davies, 2007). Specifically, the Point MacKenzie Project was to increase milk production to improve the efficiency of the Matanuska Maid Creamery in Anchorage. The Delta Project was to increase the feed base for the red meat and dairy industry and provide an export opportunity.

While these projects helped to stabilize food prices and increase food production in the state, events and policy decisions, including some that may have been made for economic and political reasons, did not allow them to meet their original expectations (Davies, 2007).

By the early 1990s, Alaska's reindeer industry had severely diminished. Only a small number of reindeer herders remained on the Seward Peninsula and in other areas of Western Alaska. They had experienced a complete loss of three reindeer herds from their ranges because of increasing interactions with migrating caribou herds. Co-mingling and assimilation into caribou herds led to the out-migration of at least 5000 reindeer in the 1990s (Carlson, 2005), and in 2000 and 2001 the reindeer population for all ranges on the peninsula was estimated at fewer than 20 000 head (Fig. 4). Herders from the eastern and central ranges of the Seward Peninsula reported that they could not locate or herd their reindeer (Finstad et al., 2002), and in 2003 it was estimated that only three commercially viable reindeer herds remained on the western ranges (Dau, 2003). Caribou today continue to winter on the Seward Peninsula, which will probably result in further losses from central and western herds.

The strongest reindeer herding presence remains on the Seward Peninsula, with an estimated 10 000 head still herded. Several thousand head are also herded on islands of southwestern and western Alaska. A few small, fenced herds are accessible via the Alaska road system. Communities or islands with Native herders today include Nome, Teller, Brevig Mission, Wales, Stebbins, St. Michael, Savoonga (St. Lawrence Island), Nunivak Island, St. George Island, and St. Paul Island. From 2003 to 2010, the total number of reindeer herded in Alaska was consistently estimated at 15 000 head (USDA, 2009c). Alaska's reindeer herds during the boom of the 1920s and 1930s, as well as today, have had very little hands-on management. There is typically little to no husbandry and little detailed data collection or management, except at harvest and in some university studies. In contrast, herds in Siberia are generally managed more tightly by crews that handle and move animals onto pasture, employing regular animal husbandry and domestication practices.

Alaska's food-related issues have gained increased attention since the turn of the 21st century. Proponents of sustainable agriculture have pointed to a number of factors, including the rising popularity of community-supported agriculture and subscription agriculture, the growing number of community greenhouses and gardens, increased attendance at the annual Sustainable Agriculture Research and Education Conference and Organic Growers School, the emergence of community food and health organizations, an increase in farmers' markets, and new efforts to incorporate agriculture into education (Helfferich and Tarnai, 2010). In 2010, House Bill 70, also known as the Farm to School Act, was unanimously passed by the Alaska State Senate and signed into law by Governor Sean Parnell. The

bill heightened the presence of locally grown produce in Alaska schools and created more opportunities for students to be involved in local agriculture. Also in 2010, the Alaska Food Policy Council was formed by stakeholders from across the state to work together with agencies and others to develop new ideas for more local food production, resulting in greater food security, job creation, and healthier communities (Consenstein, 2010; see Stevenson et al., 2014a for additional review).

Agricultural statistics from the last five years show increasing interest in rural Alaska for local production. For instance, the number of Tanana Chiefs Conference (TCC) villages and village gardeners requesting free seeds has steadily increased over the last few years, from 427 gardeners in 26 villages in 2008 to 521 gardeners in 36 villages in 2010 (H. Rader, TCC). In the last decade, very small commercial farms and community farming programs have been established in small towns or villages off the road system, including Ft. Yukon, Bethel, Cordova, Dillingham, Naknek, and several TCC villages. Results from investigations of soil resources are also available for more than 50 villages throughout Alaska (detailed inventories of agricultural resources elsewhere in Alaska are limited).

Alaska is currently not farming enough local food to be food secure, but it has the opportunity to direct the growth of its agriculture industry in a manner that will keep its surrounding environment pristine and wild, its economy strong, and its food demands met locally. If it can achieve this, its food self sufficiency ratio and its level of sustainable agricultural production are likely to improve, allowing it to develop into a more prominent agricultural presence in the North.

DEVELOPMENT AND STATUS OF AGRICULTURE IN THE CIRCUMPOLAR NORTH

Broader discussions of food security and resilience in the North are benefited by an understanding of how agriculture (especially sustainable agriculture) developed and exists today within delineated circumpolar regions. Countries and other entities that have a presence in the circumpolar region at 55° N or above can be delineated into three geographic regions: the Nordic Region (Greenland, Iceland, Scotland, Norway, Sweden, Denmark, and Finland), the Russian-Baltic Region (Russia, Estonia, Latvia, and Lithuania), and the North American Region (Alaska, Canada) (Fig. 6). While these regions share a similar latitude range and face some related physical and socioeconomic challenges, many inter- and intraregional differences exist (e.g., microclimate, soil properties, growing season length, crop or cultivar selection, infrastructure, markets, and economies). The countries and other entities that make up these regions likewise vary in their history, food policy, food security, and food self-sufficiency.



FIG. 6. Countries with an agricultural presence above 55° N (in green) in the three main agricultural regions of the circumpolar North: the Nordic Region, the Russian-Baltic Region, and the North American Region.

The Nordic Region

Basic permanent settlement agriculture is believed to have reached southern Scandinavia at least 3000 years ago. In the Middle Ages, it came to Iceland (ca. 900 AD) and Greenland (ca. 1000 AD) via the Norse—people closely related to the Vikings, who generations before had raided and settled in Britain and on the coasts of the European continent (Arneborg et al., 2002). Early recorded accounts of high-latitude agriculture stem from the writings and

tributes of the Bishopric in Greenland to the Catholic Church in Rome during this time (ARDC, 1983). The Viking colonies established in Greenland ca. 1000 AD were maintained until their collapse ca. 1450 AD. Agricultural production of livestock and crops probably provided a large part of settlers' diets early on in the life of the colonies; however, stable isotope analyses of settlers' bones excavated from the region suggest a change in food consumption over time. The shift is characterized by a declining dependency on a terrestrial ecosystem diet

(agriculture) from an initial level of about 80% dependence on agriculture to about 20% dependence on agriculture by the time the colonies collapsed 450 years later (Arneborg et al., 1999, 2002). Conversely, dependence upon marine resources in Greenland during this time appears to have grown from 20% to 80% (Arneborg et al., 1999, 2002). It is apparent that agriculture as the sole or primary food system was not sustainable and could not support the colony in Greenland. Marine resources were simply a more reliable and easier option that could be supplemented with some minimal agriculture.

In the small settlements around southern Greenland today, only a few private sheep herding operations and vegetable greenhouses exist, although many residents practice subsistence gardening. Like some Alaskan communities, towns in Greenland are supported by the fishing industry and imported foods. Greenland has been an autonomous country within the Kingdom of Denmark since it was granted home rule in 1979, so it benefits from the support of the Danish central government, as well as from trade with Denmark, which is one of the most agriculturally rich countries in the circumpolar region.

Iceland's settlers came from mainland Scandinavia and settlements in the British Isles in the late ninth century (Byock, 2001:7; Arneborg et al., 2002). They learned that the land allowed only a limited amount of field agriculture and was better suited for herding livestock. Settlements began relying upon cod fishing or harvests of hay. As populations grew, there were early challenges to sustainability in the form of erosion and overgrazing of natural grasslands by sheep, caused primarily by mismanagement of grazing areas prior to winter (Byock, 2001:53). By the 19th century, approximately 70% to 80% of Iceland's residents were involved in farming; however, less than 5% are involved today. Almost all cultivated arable land is confined to the country's peripheral lowlands, and organic farms are concentrated on the most productive of these lands, which contain well-drained soils high in organic matter. Local farmers produce various animal products and raise vegetables, sometimes in geothermal greenhouses (Dýrmundsson, 2004). Iceland's main agricultural products are meat, dairy, eggs, root vegetables, leafy vegetables, and fodder crops, and natural rangeland pastures are still used for summer grazing of sheep and horses. The use of agrochemicals and agricultural drugs in Iceland is minimal. As in Alaska, the relatively low numbers of agricultural pests in Iceland have had an indirect ecological benefit in that there is less need for herbicides or pesticides (Dýrmundsson, 2004).

The majority of Scotland's lands lie above 55° N, with agriculture most pronounced in its rural highland and island areas. Agriculture took shape earlier here than for some of Scotland's northern neighbors. As in Iceland, most of Scotland's agricultural products (~70%) derive from livestock. Much of its land is considered to be under production; hence, agriculture is important to the Scottish economy. Although the area of Scotland's farmland that produces certified organic products has been reduced slightly in recent

years, some government sectors and non-profit groups have generated interest and are making progress in local farming, rural issues, and sustainable development (FiBL, 2006; Scottish Government, 2014).

In the Nordic Region, Denmark and southern Sweden are known for having extensive areas of good agricultural land, whereas the rest of Scandinavia contains much less cultivable land.

Denmark, situated near the lower latitudinal boundary for the circumpolar region, is one of its strongest agricultural producers. Its large percentage of arable land, tempered climate with four distinct seasons, and advanced technology and infrastructure contribute to its agricultural prowess. Denmark's agricultural exports have consistently outweighed its imports, often by two to three times, and its food self-sufficiency ratio is far greater than 100% for dairy products and meat (FOE, 2010; Statistics Denmark, 2011). Its most important food products are generally at a supply rate greater than 100%. Danish agriculture is among the most successful, efficient, and technically advanced agricultural sectors in the world, a feat made possible by a high level of organization and agricultural education, as well as good agricultural soils throughout the country. Danish farmers have been able to own production and processing facilities through cooperative structures that have been present for 150 years (Christensen et al., 2007). Such cooperatives and cooperative activities have also been well documented throughout Scandinavia (Power, 1939; Ínan, 1983).

Although agriculture's role in the Danish economy has steadily decreased with the progress of industrialization and economic development, the country remains a stable producer of grains (which cover about 57% of Denmark's arable land), meat (particularly pork and beef), dairy products, and vegetables. While livestock concentration and average farm size in Denmark have been increasing in recent years, individual holdings have declined. Larger farms have been absorbing smaller ones, but the majority are still family-run. However, despite having a very large average farm size for the EU (55 ha per farm), Denmark accounts for less than 2% of the total EU-25 agricultural area (Christensen et al., 2007).

There is a growing national resolve in Denmark towards sustainable farming practices and food safety. Organic production covers approximately 6% of the country's total agricultural area. High levels of ammonia emission and runoff in Denmark and neighboring countries previously caused concern, but ongoing efforts over the past 20 years have helped to reduce these levels. It is expected that the governing body of the EU-25 will further tighten environmental requirements in the coming years for Denmark and other member states.

Of the three countries on the Scandinavian Peninsula, Sweden has the most abundant lands, extends farthest south, and provides the most suitable land base for agriculture. Consequently, its southern region is sizable and contains most of the country's preferred farmlands. In very general terms, the long, developed coastlines adjacent to

some Scandinavian farming communities invite relatively milder temperatures that can benefit longer-season cultivars. As is true in Alaska, Scandinavian communities have long combined agriculture with other seasonal or part-time industries and subsistence activities (e.g., fishing, hunting, forestry), thereby diversifying the food supply and benefiting resilience, sustainability, and security.

Finland maintains many small farms that produce milk, animal products, bread grains, cereals, fodder, potatoes, and sugar beets. It has increased its organic farming substantially since the 1960s. Finland also possesses a large number of bogs and generates substantial amounts of peat that can be used in improving soil structure. Often, Finns combine agriculture with forestry to generate additional revenue. The decimation of some of Finland's northern ranges by reindeer overgrazing has resulted, in part, from poor or non-sustainable rangeland management. Finland and Sweden are both EU members and are subject to its agricultural regulations. Norway, however, is not an EU member and acts independently to formulate its own agricultural regulations.

Norwegian and Alaskan farms have been compared previously (e.g., Smith, 1971). Both tend to be small, with relatively small individual land holdings. Norway, however, boasts many more individual farms than does Alaska. For instance, Norway reports approximately 48 000 farms, whereas Alaska maintains only 762 farms (Statistics Norway, 2007, 2010a; USDA, 2014; see also Fig. 1). Dairy products, meat, and various fodder crops are the most common agricultural products in Norway, although vegetables, potatoes, cereals, and berries are also produced.

Historically, the introduction of mechanized equipment in Scandinavia midway through the 20th century brought about a cascade of changes in Norway. Higher production and outlook of higher economic returns, in combination with introduced fertilizers, led to more productive cultivars. New areas, even some that were sub-par for agriculture, were opened and farmed. Calving periods for dairy cows in the region began to switch from summer to winter, and overall numbers increased. Thus, more fodder and grass were required, which in turn led to harvesting more frequently and closer to the time of first frost. Consequently, grasses not allowed to grow into winter hardiness became damaged under the snow (see Arnoldussen and Sveistrup, 1997). The increased use of heavy equipment on wet soils began to compact and damage grasses, further decreasing summer productivity. Winter ice build-up intensified, presumably because of increased use of heavy machinery in summer, hindering gas movement through the snow. The greater concentration of respiratory gases under the snow may subsequently have led to stronger winter kill. The agricultural industry ultimately made advances in sustainability to overcome this struggling period, implementing no-till drill, minimum tillage, and other practices.

In the last 20 years, organic agriculture in Norway has increased steadily and now constitutes 4.3% of all acreage grown (Statistics Norway, 2010a). As in Denmark,

individual land holdings have decreased steadily in recent decades, and farms are growing in size through the assimilation of other farms and lands. In the last 25 years, the total number of farms in Norway has dropped by 56%, while farm size has increased by 140% (Statistics Norway, 2007, 2010a).

The Russian-Baltic Region

Russia has the largest land area of any country in the world. It is often able to use more favorable farming conditions in the south to produce food for northern regions. As in Alaska, however, many towns and villages in Russia are not connected to the road system. For instance, parts of Siberia and other regions are not accessible by railroad or riverboat, thereby forcing residents to depend on local agriculture and imported foods or face malnutrition.

Political unrest in the latter portion of the 20th century necessitated greater self-sufficiency in local regions of the former Union of Soviet Socialist Republics (USSR), resulting in more local agriculture at all latitudes. Some leaders of the former Soviet Union embraced an ideology that included the challenge of conquering nature, and intense development required substantial agricultural research and experience in food production. A large number of agricultural institutes and experiment stations across Russia have helped to develop it into a stronger producer in the circumpolar region. For instance, reports from the 1970s indicate that the USSR had long been experimenting with agricultural intensification and season extension techniques for cold areas, including greenhouse fruit production, supplemental winter lighting, plastic films, soil heating through subterranean water pipes, and various animal husbandry practices (ARDC, 1974).

Like Alaska, Russia contains enormous reserves of unused arable land, but it does not produce enough local agriculture to meet the food demands of its 142 million residents. It must rely on imports, specifically potatoes and vegetables. However, both meat and grain production have increased considerably in Russia over the last decade through farm credit policies implemented by the Russian government. Beef and dairy production in the northern regions of the country are interwoven and represent a stable sector of the Russian livestock industry. The country also owns about two-thirds of the global stock of domestic reindeer.

The Baltic nations (Estonia, Latvia, and Lithuania) lie along Russia's western border just above 55° N (at approximately the same latitude as Denmark), directly south of Finland across the Baltic Sea. Their climate is influenced by close proximity to water and the intensive cyclonical processes of the Atlantic Ocean (Kalm and Laansalu, 2002). Seasons are characterized by moderately cold winters, moderately warm summers, cool springs, and long autumns. In the past century, political change has influenced agriculture in the Baltic nations; changes included conversion of forested lands to agricultural lands,

and vice versa. The region now known as Latvia played a key role in development of the Soviet Union in the mid-20th century, producing grain, meat, and dairy products for the USSR, as well as potatoes, flax, and vegetables. Estonia's initial independence from Russia led to positive agricultural development in the 1920s, but the late 1940s brought forced collectivization under conditions of Soviet occupation; lands were expropriated from their owners and made public, while farmers were forced to work on collective farms (Kalm and Laansalu, 2002).

Agricultural production in the Baltic nations intensified from the 1940s to 1990 under USSR control, but each state eventually regained its independence in 1991 through a struggle that contributed to the dissolution of the Soviet Union and the fall of communism in the region. In Estonia, the Farm Act (1989), the Land Reform Act (1991), and the Agricultural Reform Act (1992) paved the way for a return to agricultural development and progress, including the liquidation of collective farms or the return of seized lands to their prior owners.

Estonia, like Finland, contains a large number of bogs and exports substantial amounts of peat. Its soils are sometimes low or poor quality (Kalm and Laansalu, 2002), but its demand for potatoes is fully met by production within its own borders. Lithuanian land is strongly devoted to agriculture (about 46% of total land area is crop and pasture land), and organic farming is expanding rapidly in the region. In the last two decades, several small farms have emerged within the Baltic nations. These farms produce primarily grain, fodder, dairy products, and potatoes. Liberal export and trade of agricultural products among these Baltic nations is encouraged by their respective governments.

The North American Region

Agriculture first reached present-day southeastern Canada approximately 3000 years ago, with early peoples growing squash, maize, and potatoes. Today, Canada is one of the largest producers and exporters of agricultural products in the world. Its major production sectors are grains and oilseeds, red meats, dairy, horticulture, poultry, and eggs. Northwestern Canada alone contains millions of hectares of potentially arable land, along with large forest reserves (Ehlers, 1970; ARDC, 1974). All three of its territories and several of its provinces have lands north of 55° N.

Canada experienced an 11% decline in its number of farms from 1996 to 2001 (Statistics Canada, 2001) and a 7% decline from 2001 to 2006 (Statistics Canada, 2006). Almost 230 000 farms exist in the country today, but at its highest latitudes, farms are few. Canada's three territories, which all use the 60th parallel to define their southern borders, reported a total of only 181 farms: 148 in Yukon, 33 in the Northwest Territories (NWT), and zero in Nunavut (Statistics Canada, 2006). Hay accounts for three-quarters of total field crop production in Yukon and the NWT. Some farms in the NWT commercially harvest reindeer and muskoxen, and both territories raise horses. Farms appear to

be growing larger in size, with some small farms dropping out of the industry and being absorbed by others; yet, small farms still comprise the majority of all farms in Canada.

Since World War II, a large influx of immigrants from northern Europe has helped to boost settlement and agricultural development in northern regions of Canada and, indirectly, to encourage the development of hardier wheat varieties for northern climates, increase grain and grass seed production, and expand the popularity of mustard and oil crops (ARDC, 1974). Today, the Organic Agriculture Centre of Canada conducts organic farming research, offers educational opportunities, and provides extension services for organic farmers. It works towards advancing organic farming methods, organic pest and weed management, organic field crop and livestock production, composting, and transitions to organic farming.

Earlier we described the arrival and development of agriculture in Alaska from the latter half of the 18th century to its present state. Today, about 10% of Alaska's farmlands is cropland, 83.5% is rangeland, and 6.5% is reserved for other uses (USDA, 2014). Agronomic crops, namely perennial hay and grains, comprise the majority of what is grown on agricultural lands, but Alaska is also a major producer of potatoes, as well as carrots, turnips, green vegetables such as broccoli and cabbage, and other crops. Various season-extension techniques are employed to improve agricultural production and overcome field-based challenges (see Stevenson et al., 2014b). Alaska's Interior is particularly well suited for grain and oilseed crops, especially varieties that have been specifically bred for the short season. Livestock is raised on and off the road system, often on small family farms, for poultry, eggs, and other animal products. A small presence of mariculture exists in the form of about 25 active shellfish farmers, primarily in Southeast Alaska.

Alaska, the only state in the United States to have a Subarctic or Arctic presence, is also the largest state. It therefore encompasses a wide latitudinal range and regional variability in light exposure, temperature, precipitation, humidity, soil properties, and length of growing season (see Stevenson et al., 2014a). Discoveries of gold and oil have previously attracted large numbers of people to parts of Alaska for short periods, causing some regional instability in local food demands and economies. At times, however, gold discoveries have led to a stronger local agriculture industry, including the development of local infrastructure, such as a creamery and a flour mill. The strong military presence in Alaska provides a major market for Alaskan products, especially potatoes.

Unlike other U.S. states and some circumpolar nations, Alaska prohibits an entire sector of commercial agriculture: fish farming was made illegal in 1990 under Alaska Statute 16.40.210. The law is often credited with helping to protect wild salmon, improve commercial catches, and preserve Alaska's fishing economy. Canada and Norway derive a strong economic benefit from commercial farming of salmon, trout, and other species (Naylor et al., 2003; Statistics Norway, 2010b), but these countries must also

absorb any resulting ecological fallout, such as eutrophication or escapement (e.g., Norway reports over half a million escaped fish in 2009; Norway Statistics, 2010b), as well as impacts on commercial fishing and consumer health (Naylor et al., 2003; Ford and Meyers, 2008). There is an ongoing global debate over wild versus farmed salmon. Some studies show that farmed salmon have a higher fat content and a less beneficial fatty acid composition than wild salmon (van Vliet and Katan, 1990; George and Bhopal, 1995), while others suggest that farmed salmon are likely to contain more dangerous chemical substances than fish that feed naturally in the wild (Easton et al., 2002; Jacobs et al., 2002). The question of whether Alaska's agro-economic potential and food security are being limited by the absence of commercial finfish aquaculture has rarely been raised because the state's oceans and streams are well supplied with wild salmon.

INFLUENCE OF HISTORIC EVENTS ON FOOD SECURITY AND POLICY

Alaska's food insecurity and lack of an adequate food supply speak volumes about its level of preparedness and ability to provide for its residents in a time of crisis. However, an adequate or appropriate level of food self-sufficiency for different parts of Alaska has not been comprehensively assessed. Alaskans live in geographic isolation thousands of miles from the lower 48 contiguous states. Historically, residents have been challenged to take steps to secure and store their own food in diverse ways (e.g., refrigeration was challenging up through the 1950s). However, the introduction of jet aircraft has made it feasible to import goods from faraway areas at regular intervals and in a very short time.

At present, Alaska can afford to rely on its structural ties to the other U.S. states for agricultural imports, but history has shown that geographically isolated areas are typically the most vulnerable in times of hardship. Because of the distance that must be covered to reach Alaska, it could potentially suffer most. Since 90% of Alaska's consumer goods pass through Anchorage, and most of its produce originates in the western continental United States, a break in the supply chain could leave just three or four days' worth of food on Alaska's grocery shelves (as noted in Rosen, 2008).

Many of Alaska's smaller communities are spread out over very large areas of land, are accessible only by plane, and are literally situated at the end of the nation's food transportation system. But what could go wrong? Volcanic eruptions, earthquakes, and tsunamis all have the potential to disrupt food supply, as do other events and circumstances. Almost four decades ago, the Commerce Committee of the Alaska State Legislature noted,

...given any one of many possible natural disasters—prolonged drought, floods, virulent disease among plants

and animals, extreme climate change, unpredictable weather in the continental United States—Alaska, because it is at the end of the nation's food system, would suffer the most direct and immediate impact.

(Alaska State Senate, 1976:1)

Dearborn (1979:252) also reported that “[a] good reason for local production is that vegetables and fruits adapted to the region would be available in the villages if shipping lanes to or within Alaska were closed or crop failures in other regions resulted in short supplies.”

As an example of potential interruptions, questions over food supply loomed during the Federal Aviation Administration's grounding period enacted for all aircraft in U.S. airspace following the terrorist attacks on New York City and Washington on 11 September 2001. Although the grounding of aircraft lasted only a couple of days, it was a sobering reminder that interruptions to supply lines can occur with little warning. Shortages of certain food items are not predictable. For instance, in 2007 a California citrus freeze and a bagged-spinach *E. coli* scare led to short-term shortages of these foods in Fort Yukon, a rural regional center in Alaska's Interior region, as well as in surrounding communities in the Yukon Flats (Loring and Gerlach, 2009).

Countries like Norway have benefited from a longstanding ideological push towards national sovereignty and self-sufficiency. Norway could meet its demands by importing all of its food from Denmark, but the policies of its national government favor a moderate level of self-sufficiency, especially the capacity to provide for itself during extended periods of crisis (ARDC, 1983; Flaten, 2001; Flaten and Hisano, 2007). Alaska's state government does not have such a policy in place, implying that in a time of crisis, residents should expect to depend upon their own preparedness, planning, or ability to secure food, or that they should expect to depend upon aid from the state and federal governments or the charity of others. The contrast between the food self-sufficiency policy of Norway and that of Alaska is due in part to their different status as political entities (nation vs. state). However, other factors likely to influence policy include the individual experiences of crises that have affected residents' ability to secure food. Scandinavia and Alaska have had very different historical experiences with hardships, threats, blockades, political unrest, and military occupation.

Despite their official stances of neutrality during World War II, both Denmark and Norway were invaded and occupied by Nazi Germany in April 1940 (Riste, 1984). Although most Danes objected to the invasion, Denmark's government had little choice but to concede. The Danes were coerced into supplying thousands to hundreds of thousands of Nazi troops with their own locally produced foods. The impact upon the country's own food supply levels and distribution efforts was substantial. Germany's occupation of Denmark provided it with new access to the northern seas, especially strategically important Norway. When Nazi

troops invaded Norway, its king and parliament fled to London, where they continued to operate the country in exile. For the next several years, Norway became more dependent upon Germany for food and other supplies because of inadequate local food resources and the new restriction and monitoring of trading routes. According to Riste (1984:149), “Norway, during the first few years of the occupation, in fact, imported more foods from Germany than she exported. In particular, the Norwegian economy could not function without imported fuel, food, and fodder.”

A Norwegian uprising against the Nazi occupation, even if successful, could have threatened many of Norway’s citizens with starvation. The German presence in Denmark would have blocked any food imports to Norway. German blockades and air support operating from adjacent occupied countries would almost certainly have restricted allied forces from delivering needed food and supplies; many civilians would have become more food insecure and would have faced hunger or starvation. The lack of an adequate food security policy at that time left Norway in a state of dependency on whoever controlled or occupied Denmark. Near the end of the war, the Nazis actually destroyed many Norwegian farms, croplands, and livestock because Nazi brigades retreating out of the Soviet Union vowed to leave nothing usable for the Red Army that pursued them. The implementation of Hitler’s “scourged earth” policy meant that much of Norway’s food, any homes and all usable supplies on the path of retreat were burned or destroyed. Norway’s food policies have changed since World War II, resulting in much greater food self-sufficiency that would benefit it during times of national crisis (Flaten, 2001; Flaten and Hisano, 2007).

Norway’s experience provides an important lesson for geographically isolated Alaska. While Alaska can conceivably receive food and supplies from the lower 48 states or from U.S. allies during times of war or crisis, this expectation rests on a set of careless, if not dangerous, assumptions: that shipping routes will always be secure, that environmental conditions will always be suitable for barging vessels and aircraft to operate, that today’s allies will always be tomorrow’s allies, and that other states and countries will always be in a position to provide aid out of their own abundance.

The experiences of Sweden and Finland during this time provide additional examples of the importance of food self-sufficiency and highlight how political and military conflict can affect food security. Sweden, while also officially neutral during World War II, was rightfully apprehensive about a possible Nazi invasion and occupation after observing events in similarly neutral Denmark and Norway. The threat of an invasion or of a blockade of food and supply lines to Sweden may have influenced its government’s decision to comply with Germany’s demand to continue shipping iron ore through the Nazi-occupied port of Narvik in Norway, a strategic stronghold. Had Sweden been more food self-sufficient, the decision to comply might have had increased opposition.

Finland’s major interest in World War II was to maintain its independence from the Soviet Union. The Finnish government believed that siding with the Germans provided its best chance for achieving this, although Finland would eventually fight against Germany in order to clear the Nazi presence from its territory during the Lapland war of 1944–45. For most of World War II, Finland was dependent upon Germany for shipments of food, fuel, and armaments, but its eventual defeat at the hands of the Allies would have a stunning impact on its agriculture and land management. As a condition for peace with the Soviet Union under the Moscow Armistice of September 1944, Finland ceded some of its prime southeastern farmlands to the Soviets. In addition to losing these important agricultural lands, many Finnish residents were forced to resettle in the northern part of the country, causing other communities to adapt to an influx of residents. The changing population structure of some communities resulted in new land clearings, which subsequently elevated the dairying capability of northern Finland (ARDC, 1974). As land rights of the ceded areas shifted hands to the Soviets, management policies and regulations over these lands also changed.

In contrast to what was experienced in the Nordic Region during World War II, Alaska’s major population centers underwent only minor to moderate wartime threats to their overall food supply. A small portion of Alaska was attacked during the war: Attu and Kiska, two of the Aleutian Islands, were invaded and occupied by the Japanese Northern Army in 1942 (MacGarrigle, n.d.). Dutch Harbor was also attacked by Japanese air squadrons, but U.S. forces repelled the assault. Villagers on Attu were captured and either killed or imprisoned in Japan for the remainder of the war. The Aleutian Islands were regained the following year at the cost of several thousand American lives. Although occupied by a foreign enemy, the Aleutians were far enough removed from Alaska’s population centers that residents on the mainland never perceived a threat to major food and supply lines.

In the months following the initial occupation of Attu and Kiska, the Alaska-Canada Military Highway was completed, forming the first stable road supply route between Alaska and the rest of North America. The highway ensured that as long as Canada remained an ally, no blockade by air or sea could ever fully hinder the delivery of food and supplies or block an escape route. With respect to food security, the firsthand experiences of Alaskans during World War II were quite different from those of people living in the Nordic Region at that time. These differences may help to explain some of the disparity in food-related policies observed among circumpolar nations and entities today.

FUTURE DEVELOPMENT OF SUSTAINABLE AGRICULTURE IN ALASKA

Since agriculture provides only 5% or less of the foods consumed in Alaska today, the question of whether the state

can afford to remain so food insecure still stands. Given Alaska's abundant natural resources, available lands, and growing population, why hasn't agriculture taken off in the state? Why doesn't Alaska produce more than a small fraction of the food it consumes? Why is the number of farms in the state today approximately the same as it was in the 1940s and 1970s?

There are several possible answers to these questions, starting with the climate. Farmers must understand and attempt to mitigate the effects of a short growing season, cold temperatures, and unexpected frosts and other weather conditions. Potential hindrances to agriculture can be related to soil quality and moisture, slowed soil microbial activity, and insect and animal pests (Stevenson et al., 2014a). An even greater hindrance to Alaskan agriculture are socioeconomic challenges such as the cost of land, the cost of operations, land conservation issues, a lack of easily accessible markets, and a need for more agriculture education opportunities throughout the state (Stevenson et al., 2014b). The simple economics (i.e., the risks versus the rewards) present a challenge for local businesses, and it is plain to see that beginning a new operation in Alaska is difficult. In addition to the high costs associated with shipping materials and developing infrastructure and the seasonal time constraints, other issues are an uncertain labor force in some rural areas, a lack of nearby markets, and the simple fact that other summer jobs are more lucrative than farming. Yet, people working at jobs not related to food must also eat, and at present there seems to be a certain contentment with a near total dependency upon imported agricultural products. Other cultural and lifestyle challenges also exist, for example, attempts to introduce permanent settlement agriculture into areas where residents' recent ancestors lived in semi-nomadic hunter-gatherer societies.

Another obstacle to increased production, at least in rural areas of Alaska, is the lack of affordable energy. Today, most fuels and fertilizers are imported into the state, and their cost is increasing. Tractors cannot be powered and fertilizers cannot be made without sufficient energy. Year-round growing in greenhouses requires heat and power. Geothermal heat, greenhouses, and wind power could help make growing possible, but most villages lack the infrastructure needed to harness alternative energies.

Worldwide, the agrarian culture is disappearing and is quickly being replaced by commercial agriculture. Large agribusinesses seek out and find the largest contiguous areas of the most productive soils in the world to grow a commodity with the lowest risk. For example, many Florida citrus growers have relocated to Central America because of the rare frost events in Florida that plague their ability to provide a consistent supply of produce to their buyers. Similarly, local grocery stores in Alaska would rather buy produce from a source outside of the state because outside sellers provide a more reliable and consistent product regardless of the season. Hence, some believe that the success of agriculture in Alaska will always rest in the small, local growers who provide a high-quality product that can be sold locally.

One step towards growth in the agricultural industry in Alaska is a greater emphasis on private-sector ownership that includes the sale of prime government-owned agricultural lands to private citizens (Lewis et al., 1987; Pearson and Lewis, 1989). As Lewis and Thomas (1982:178) state,

The approach used to facilitate [the expansion of Alaskan agriculture] may serve as an example for other regions where the pressure for development stems from public interest groups. Alaskan agricultural development is tied to the disposal of government-owned land. If agriculture is to develop according to the United States farm production model, then large quantities of agricultural land must be sold to private citizens. Past federal policy in Alaska has not led to this outcome and thus the present-day development efforts spring from state government leadership.... The pivotal aspect of agricultural development efforts in the state of Alaska is the successful transfer of research and technology to private sector farmers. If this can be accomplished, then Alaskan agriculture is likely to flourish.

In addition to the transfer of more government-owned lands to private citizens, government and non-profit entities could provide a support network for entrepreneurship through cooperatives, farmers' markets, brokers and retailers, through loan programs tailored to agricultural enterprises that are often high-risk, and through appropriate policy, regulation, and zoning that will encourage agricultural production (Lewis, 2010).

Finally, grants and programs are needed that fit the needs and priorities of Alaskans. Often USDA grants and programs are designed around the needs of farmers and ranchers in the Lower 48, which are different from those of Alaskan subsistence gardeners, farmers, and ranchers. The Department of Agriculture is helping to provide Alaska with loan and grant opportunities for Alaskans interested in producing food or biomass; they have helped to compensate for the high costs of transportation, to advance conservation efforts on farms and ranchlands, and to promote Alaska-grown products to consumers (Consenstein, 2010). By encouraging further growth of sustainable agriculture and free enterprise in new regions, federal, state, tribal and municipal governments could help to elevate overall levels of local food production, increase on-hand food supply, and foster responsible business. These goals would be achieved mainly by limiting unnecessary restrictions, regulations, or taxes that might stifle agricultural and economic growth; providing more land leases; helping to provide greater infrastructure; and maintaining or elevating research through the University of Alaska Fairbanks Agricultural and Forestry Experiment Station, in cooperation with the Cooperative Extension Service, the USDA, and other entities. These efforts would likely result in a stronger economy, more diverse or better-quality products, greater ingenuity, more jobs, and increased local involvement.

CONCLUSIONS

Sustainable agriculture has the potential to combat food insecurity at high latitudes. The development of agriculture in Alaska and throughout the circumpolar North provides a basis for understanding the present state of agriculture and current policies. Further development of sustainable agriculture businesses and markets, along with policies that promote greater food self-sufficiency, are needed to advance the industry and improve food security.

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